Transforming UConn to a Zero Carbon Campus: A Path Forward

A report submitted to the President of the

University of Connecticut

from the

President's Working Group on Sustainability and the Environment

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1. Introduction

In the fall of 2019, over 1,000 students, motivated by unequivocal scientific evidence and a call for environmental justice, participated in a climate strike at UConn as part of the international Fridays For Future movement. The students urged action from the administration, presented carefully researched demands to the University (Appendix A), and were supported by a climate emergency resolution from the University Senate. They then held weekly sit-ins in Gulley Hall to make clear that the University must prioritize the climate emergency we are facing. In response, President Katsouleas accelerated UConn's emissions reduction goals, acknowledged that "*Climate change is more than an emergency; it is a global crisis worsening by the day*", and created this Working Group tasked with the question: "*What is achievable within the boundaries of our fiscal resources and the need to operate the university, and how quickly can we get there?*"

Students were able to mobilize effectively around this issue, and reach historic levels of engagement, because their future is at stake. Climate justice is a core motivating force because western nations, particularly the United States, are responsible for the majority of the historic carbon emissions that have led to this crisis, and the U.S. remains among the largest current polluters. Further, the climate crisis disproportionately affects marginalized communities in our country and abroad, exacerbating already existing inequities. We acknowledge our students' concerns that their health, heritage, communities, culture, and families will face increasing dangers from compounding threats resulting from extreme weather catastrophes.

For these reasons the Working Group recommendations do not represent optional improvements, but rather an emergency response that must be addressed as quickly and comprehensively as possible.

The crisis has only become more apparent with the advent of the COVID 19 pandemic. Now, one year into a global pandemic that has direct ties to climate change (Hamichi et al, 2021, 10.1007/s00417-020-04947-7), unstable climate conditions have been linked to shifts in pathogen hosts that are leading to an emergence of new infectious diseases. The recent net-zero pledges by major emitting countries and the potential for a "green recovery" from the COVID-19 pandemic present a unique opportunity for the world to close the growing gap between existing commitments and what is needed to limit global warming to meet the goals of the Paris Agreement (UNEP Emissions Gap Report, Dec 2020).

Connecticut Governor Ned Lamont, through Executive Orders 1 and 3, has set decarbonization deadlines for the state as well: 100% clean electric grid by 2040, 45% reduction in CO_2 emissions by 2030 and 80% by 2050. The US Federal Government under President Joseph Biden has proposed a decarbonization deadline for the U.S. electricity grid by 2035, with net-zero for the nation by 2050. Moreover, there is potential for sizable investments to catalyze the necessary energy transition in a manner that is guided by mandates for environmental justice.

UConn's transformation towards a zero-carbon campus began with the installation of an efficient Co-Generation (Co-Gen) power plant in 2005. University leadership and staff recognized that investment in an efficient natural gas Co-Gen facility would save operating costs, improve air quality, and reduce CO_2 emissions.

Since then, along with hundreds of our peers, the University signed the American College & University President's Climate Commitment, pledging to achieve carbon neutrality by 2050 and leading to the adoption of a Climate Action Plan (CAP), with nearly 200 recommended measures for achieving carbon reduction targets. In 2012, then-President Susan Herbst reaffirmed this commitment and added a CAP section on resilience and adaptation. Subsequently, in partnership with the Connecticut DEEP and EPA, UConn established the Connecticut Institute for Resilience & Climate Adaptation at Avery Point. Concurrently, the University developed a comprehensive energy efficiency program, incentivized by Eversource, its electric and gas utility, which has yielded many university-wide innovative energy and cost saving measures. In combination with deploying a fuel cell that provides electricity for the Depot Campus, installing several small-scale rooftop solar arrays, using Renewable Energy Credits (RECs) to offset carbon from all purchased power, adopting a Sustainable Design & Construction Policy for all new construction, and introducing hybrid and electric fleet vehicles, these Energy Conservation Measures (ECMs) have reduced emissions by 21%, from the CAP's 2007 baseline. The University achieved this interim 2020 CAP target despite more than 20% increases in both enrollment and building square footage during that same 12-year period.

These climate action, resilience and energy conservation measures, among many other sustainability practices, and along with our strong environmental education, research and outreach programs, have made UConn a top-ranked green campus, both nationally and globally throughout the past decade.

Halfway into the normal lifespan of the Co-Gen system, new realities and opportunities have emerged that require acceleration of the transformation underway. As an American institution, UConn has a responsibility to continue to provide leadership to ensure we achieve the goals set out by the Paris Climate Accord. In June 2020, this Working Group released a set of recommendations in *Planning for a Zero-Carbon Future* (see Fig. 1), which begins with an update to UConn's interim and mid-century emissions reduction goals to 60% by 2030 and to zero-carbon by 2040, respectively.

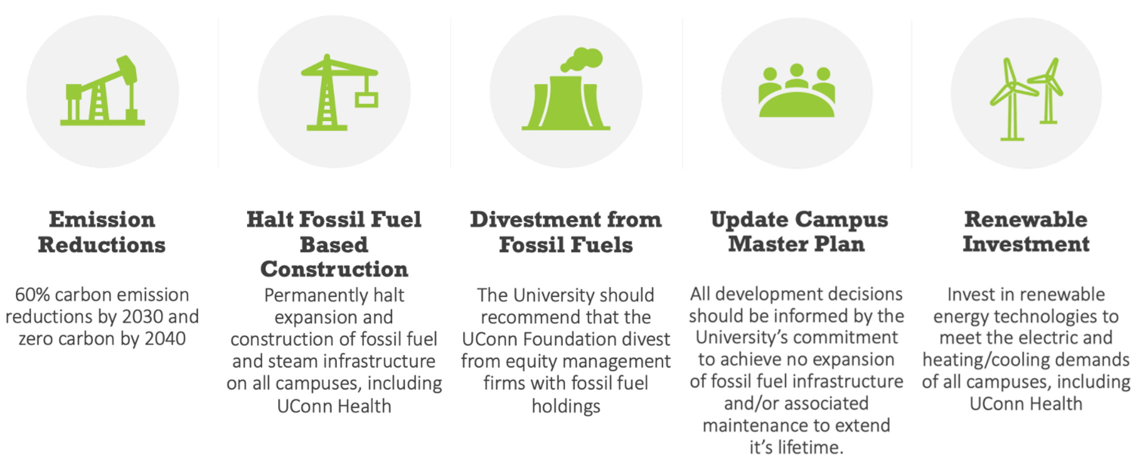

Figure 1: Recommendations from Spring 2020 Report

In this follow-up report, we describe potential pathways to achieve 60% reduction by 2030 and zero carbon by 2040. This report presents the culmination of work done by the group during the summer of 2020, the fall semester of 2020, and the spring semester of 2021.

The focus of this report is on implementation scenarios, as well as cost and benefit estimates for achieving a zero-carbon campus by 2040 through phased infrastructure updates at the Storrs Campus. Our faculty and student committee, with invaluable support from professional staff and BVH consultants, presents scenarios that will be referenced throughout the report. The primary scenarios are: (1) Zero Carbon by 2040 (ZC40) and (2) Climate Action Plan (CAP). Two additional scenarios are discussed in the Staff and Consultant reports: (3) Zero Carbon by 2050 (ZC50) and (4) Peak Plan. The scenarios include adoption of renewable technology options, infrastructure conversions, and plans to retire fossil fuel-powered infrastructure operating within the Central Utility Plant (CUP).

In discussions with other American universities currently pursuing zero-carbon plans, a common concern was the tradeoff between extending the lifetime of fossil fuel-based plants or retiring said plants and accepting that investments already made toward their extension may not be recouped. The University of Connecticut's principal tradeoff involves retiring the CUP by 2040 rather than extending its potential lifetime through maintenance and upgrades of the Co-Gen. Any maintenance extending its lifetime would add multiple decades of reliance on fossil fuel infrastructure that would continue to emit significant amounts of CO_2. A planned, phased CUP retirement maintains our integrity while providing numerous benefits along our path to a zero-carbon emissions campus.

Guiding Principles

Because of the many uncertainties in these scenarios (developing technologies, state and federal policy environments, costs, behavioral changes, etc.) and their timescales of two decades and beyond, it is important to identify essential principles that should guide decision-making along UConn's path to decarbonize.

- UConn's deep decarbonization plan should contribute to stabilizing global climate at ~1.5C of warming. Based on considerations of contemporary science, social justice, and environmental equity, members of the Working Group unanimously consider attainment of zero-carbon by 2040 as the overarching priority that must guide strategic investment by UConn.
- Although scenarios presented here are for the Storrs campus, all regional campuses should be involved in the process to achieve zero emissions by 2040, particularly as Avery Point and Stamford are vulnerable to sea level rise and coastal storms.
- Because greenhouse gases, particularly CO_2, have cumulative impacts on climate, larger emissions reductions that are implemented earlier will have a greater effect on limiting Earth's temperature increase. Thus, postponing emissions reductions (e.g., while awaiting technological progress) is not advisable. We must commit to ambitious and steady reductions now.
- For UConn to contribute meaningfully toward stabilizing global climate to safe levels, we must reduce our actual emissions, without the purchase of offsets (emissions reductions outside

of UConn control). Paying others so UConn can continue to pollute does not contribute to a global strategy to meet the goals of the Paris Accord, and can further exacerbate environmental injustice. In the case that some remaining emissions cannot be removed, off-campus initiatives may be considered if the reductions are additional, permanent, independently verifiable, and contribute to a scalable plan for global emissions reductions meeting stringent requirements for environmental integrity and social justice.

- The University must hold itself to a high ethical standard when procuring materials or technologies. Geopolitical turmoil in nations with raw material exports can potentially lead to scenarios in which forced labor is being used to produce the products that we purchase. There are accounts of these injustices currently occurring in the Xinjiang region of China, with persecuted Uighurs being used as forced labor to produce materials for the solar industry. We must never use zero-carbon emission infrastructure that is based on discounted pricing for materials derived from inhumane labor conditions abroad.
- Achieving a safe, stabilized climate will require decarbonization plans from all nations, states, and organizations that are both adequate and fair in meeting global goals. These are win-win strategies, whereas plans that are inadequate and do not reflect fairness result in zero-sum inequities.
- Roadmap to 2050 and beyond: Clear milestones are needed to achieve zero carbon emissions, but at current emissions rates, this will stabilize CO_2 at a level that is dangerously high. There is a long road beyond 2050 that will require CO_2 removal to reduce atmospheric CO_2 to levels that will keep temperatures well below 2°C. The amount of CO_2 removal needed after 2050 will depend on cumulative emissions until zero-carbon is achieved.

Twenty years to decarbonize UConn

This priority reflects a shared value among our students, faculty members, and staff members. UConn as a recognized international leader in sustainability, must continue to lead interdisciplinary collaborations among all stakeholders, partners, and community members to achieve a zero-carbon campus and to demonstrate pathways forward for other institutions (i.e., lead by example).

In 1881, UConn was founded in belief that a divided nation could emerge stronger with innovations in technology and agriculture. The first Huskies pioneered developments that established the University of Connecticut as a technological leader. With our society and ecosystems facing prolonged and worsening impacts due to climate change, UConn again has the opportunity and the responsibility to lead our state and nation. Our strong ties to the environment as a land grant, sea grant, and space grant university position us to innovate and forge a new clean energy economy for the state and beyond.

The work of the PWGSE only begins to address the demands that students have voiced and for which they will continue to advocate (Appendix A). Because the concerns raised are likely to intensify with each passing year, the University administration and Board of Trustees must be accountable for the consequences of prolonged inaction. This report highlights achievable zero-carbon pathways the University may undertake – none of which are easy, but demonstrate the expedited effort we must undertake in the next two decades to reach zero carbon emissions by 2040.

2. Carbon Reduction at Other Universities

The focus of this report is to provide a pathway forward for UConn. To inform our recommendations, the Working Group has investigated examples of other universities that are conducting or have completed comparable projects to those that we promote herein. These examples support planning regarding (1) technologies that can be used to decarbonize energy generation and (2) typical costs involved in the infrastructure conversions. We have examined three cases in some detail. Professional staff in support of the Working Group met with representatives of Princeton University, Stanford University, and the University of California-Davis to understand their carbon reduction projects. A brief summary of information gained from those meetings is provided hereafter.

All three of these universities, like UConn, have or had central Co-Gen plants that burn natural gas to generate electricity and capture waste heat to use for heating and cooling of campus buildings, with a network of steam pipes extending from the central plant throughout most or all of campus. A report summarizing their projects and a table comparing them with the plan developed for UConn are attached as Appendices D & E. The most salient features of each institution's plan are:

- Princeton University plans to convert their central campus steam heat distribution system to hot water by laying new hot water pipes, and install geothermal wells for heat exchange and for seasonal thermal storage in bedrock, supplemented with water tanks for short-term heat storage. Their plan calls for some on-campus solar photovoltaic (PV) generation, with the remainder of the electricity purchased from a local utility (assumed to decarbonize over time). Their Co-Gen plant will be repurposed as a peaking plant. The relatively few perimeter buildings not on the central steam distribution network will not be changed. The plan would reduce campus emissions of greenhouse gases by 75% by 2046, with offsets purchased for the remaining carbon. In 2016, this plan was budgeted at $1,065.5M, compared to a business as usual cost of $839.1M, for a net incremental cost of $226.4M, although subsequent costs have been revised upward.
- Stanford decommissioned their Co-Gen plant and replaced their steam distribution network with hot water pipes. Their entire campus is served by the central network. Their building needs are mainly cooling, now served by heat pumps that simultaneously generate hot water with the waste heat. Large water tanks provide short-term thermal storage. Electric boilers and natural gas boosters supplement the system. Substantial off-campus PV capacity was added with battery storage. Stanford began the project in 2011 and completed it in 2015 at a cost of $485M. This reduces Stanford's GHG output by 65% and is expected to result in $420M of savings in operating costs over 30 years.
- University of California-Davis replaced their steam distribution with hot water, cooled using heat pumps with a hot water massing well to reduce peak loads. This will reduce GHG emissions by 30% by 2035 at a cost of $296M.

The plan from UC-Davis is smaller in scale than what we envision for UConn and is the least relevant comparison point for UConn. Stanford's plan has the virtue of already being completed, since Stanford took on the task of decarbonizing much earlier than did most universities, and carried out their conversion on an aggressive timetable, although the result is well short of a zero-carbon campus. Both the Stanford and UC-Davis plans are in the context of a very different climate, where cooling loads are higher than heating loads, and the solar resource is more abundant. Princeton's context is the closest parallel to UConn's, given the similar climate, the comparable degree of carbon reduction, and the use of ground-source heating and cooling. Very recently, the University of Michigan announced its own plan, which would offset all emissions by 2025, and eliminate all on-campus emissions by 2040. This would be accomplished by retiring their Co-Gen plant and using electrically driven heat pumps exchanging against geothermal wells to meet heating and cooling needs, in conjunction with purchases of renewable electricity via PPA (power purchase agreements). The capital costs total $3.3 billion to cover all campuses, whose present total emissions are roughly triple those of UConn-Storrs.

3. Reaching Zero Carbon by 2040 at UConn

It is imperative that UConn join other universities in aggressive efforts to address the climate crisis. This section presents a possible pathway for UConn to follow that would place it among top universities leading the way in transitioning to a zero-carbon world, and in so doing advancing its mission as a flagship university in the nation while enhancing its reputation as an environmental leader and innovator. The basic components of this pathway are described in this section, with corresponding cost estimates presented in Section 4.

Description of Carbon Reduction Scenarios: The Working Group has worked with BVH, as well as professional staff in the University Office of Planning, Design and Construction and Facilities Operations and Building Services, to identify alternative carbon reduction scenarios that could be followed over the next three decades. Each of these scenarios included different projects and strategies, as well as associated emissions reductions, costs, and logistical challenges. The full report from BVH and a supplemental report prepared by UConn professional staff are included as appendices to this report. Here, we highlight and interpret some of the findings of those reports and discuss their implications.

At the request of the Working Group, BVH presented a scenario for meeting the 2040 zero carbon goal that was based, among other things, on a phased elimination of reliance on the CUP (including the Supplemental Utility Plant (SUP)) and conversion of steam heating and cooling to hot water using various geothermal systems (ground, water and air source). This plan, called the "Zero Carbon by 2040" Plan (ZC40), is the focus of the discussion here. For comparison, BVH also evaluated a scenario representing compliance with the Climate Action Plan (CAP).

Two additional scenarios are also discussed in the BVH report. Because of concerns about the impacts of the 2040 goal on campus disruption, BVH evaluated a plan that was analogous to ZC40, but with parts of the needed conversions delayed to take place over a longer period of time. Under this alternative, called the "Zero Carbon by 2050" plan (ZC50), achieving the zero-carbon goal would be delayed by 10 years (until 2050). BVH also developed a scenario for meeting the 2040 zero carbon goal that was based on meeting peak demand, but only using ground source geothermal (PP40). This plan is similar to ZC40, except that ZC40 is based on meeting an average load (70% of peak demand), supplemented by electric heating or cooling during peak periods, and a broader range of geothermal technologies.

In summary, the BVH and supplemental reports (Appendices C, D, & E) present information about the following four scenarios or plans:

- Zero Carbon by 2040 Plan (ZC40)
- Climate Action Plan (CAP)
- Zero Carbon by 2050 Plan (ZC50)
- Peak Plan for Zero Carbon by 2040 (PP40)

We focus here on the comparison between the ZC40 and CAP, which was adopted by the University in 2012 and has reduced emissions by approximately 20% to date. The other two plans primarily provide information about tradeoffs involved in (1) logistical issues associated with meeting the zero-carbon goal by 2040 vs. 2050, and (2) the costs of planning for peak rather than 70% peak demand, coupled with other geothermal options.

BVH developed a detailed list of projects that, if undertaken, would move the Storrs campus to zero carbon emissions. These projects were included in the ZC40 scenario and are listed in **Table 1**. **Table 1** also lists the projects that are scheduled to be undertaken as part of the implementation of the CAP, which are also included in the ZC40 plan.

Table 1. List of Projects Included under CAP and ZC40 Plans. See Appendix E for map of districts

		CLIMATE ACTION PLAN	ZERO CARBON BY 2040 PLAN
ECMS	Re-lamping and LED Light Fixture Replacement	X	X
	Anaerobic Digestion Facility	X	X
	CAHNR Sequestration Expansion	X	X
	Demo Torrey Life Science Building	X	X
	Lab Ventilation Replacement	X	X
	Other Energy Conservation Measures	X	X
	Pipe and Valve Insulation	X	X

Continuation of Table 1 on the following page

Table 1. (Continued) List of Specific Projects Included under CAP and ZC40 Plans. See Appendix E for Map of Districts

		CLIMATE ACTION PLAN	ZERO CARBON BY 2040 PLAN
Planning	Program Planning and Concept Designs	X	X
Campus Electrical Infrastructure / PV	6 MW Solar Arrays - On Campus	X	X
	10 MW Solar Array - Depot		X
	20 MW Off Campus PPA		X
	Load shedding platform for future expansion		X
	Complete North Eagleville Undergrounding		X
	Extend Storrs 38E Circuit #3		X

	Install new 50 MW base "Storrs 38E" transformer		X
	Ductbank for Substation 195 high capacity connection		X
	Install batteries to maintain campus resiliency		X
	New Electric Distribution/Energy Plant at West Sections		X
	New Electric Distribution/Energy Plant at East Sections		X
	New Electric Distribution/Energy Plant at North Sections		X
	New Electric Distribution/Energy Plant at South Sections		X
	Commence new Main Feeder from Willimantic		X
Central Core	Central North - Part 1		X
	Central North - Part 2		X
	Central South - Part 1		X
	Central South - Part 2		X
Perimeter Thermal Conversions	Spring Manor - Air or Water Source	X	X
	South B - Ground Source	X	X
	East B - Air or Water Source		X
	Northwest Part 2 - Ground Source		X
	Spring Hill - Air or Water Source		X
	West Part 1 -Ground Source		X
	Depot		X
	West Part 2		X
	West Part 5		X
	East A		X
	Northeast		X
	Northwest Independent		X
	Northwood		X
	South A		X
	Southeast		X
	West Part 3		X
	West Part 4		X
	Northwest Part 1		X
	Northwest Part 3		X
	Northwest Part 4		X

Table 1 explicitly demonstrates that the CAP includes a number of energy conservation measures (including an anaerobic digestion facility, a CAHNR sequestration expansion, demolition of Torrey Life Science Building, lab ventilation replacements, and installation of building insulation) as well as some initial projects to convert Spring Manor and South B to geothermal. However, these measures are well below what is needed to meet the 2040 zero carbon goal. In particular, the CAP did not include an explicit plan to eliminate use of the fossil fuel infrastructure operating in the CUP.

Currently, the CUP's Co-Gen plant burns mostly natural gas to power a turbine, which is used to generate electricity, with waste heat captured in a steam system that is used for additional electrical generation and also provides heating and cooling to campus buildings. When the waste heat is not sufficient, boilers provide additional steam. This system generates approximately 90% of the electrical energy for the Storrs campus and supplies 65% of its thermal energy through a network of buried pipes. The Co-Gen system came online in 2005. The “normal” life of a utility plant is 30-35 years, implying that without further investment, the Co-Gen would be at the end of its life between 2035-2040. The life of a utility plant can typically be extended, but this requires significant investment. Recent work has replaced about 50% of the aging steam pipes, and replaced boilers and chillers in 2020 to meet new air quality requirements.

To achieve zero carbon, maintaining and extending the life of the CUP and its associated infrastructure beyond 2035 is not acceptable. Indeed, reliance on the CUP for heating and cooling needs and electricity must be phased out and replaced with renewable energy sources, either generated on campus or in the form of renewably-generated electricity purchased from an electric utility. Thus, ZC40 has three major components:

- **Thermal conversion**: conversion of heating and cooling systems in all buildings from steam to hot water via renewable sources (primarily geothermal);
- **Increased purchase of renewable electricity from Eversource:** investment in new electrical infrastructure (including substations and distribution lines); and
- **Direct investment in renewable generation:** installation of additional solar capacity, including 6 MW of on-campus solar photo-voltaic (PV) generation and 30 MW of off-campus utility-level solar installation (through Power Purchase Agreements [PPAs]).

The first component, **thermal conversion**, will require conversion of heating and cooling systems for the approximately 330 buildings on the Storrs campus (60% in the perimeter zones and 40% in the central portion of campus). In its initial estimates of the costs of ZC40 (and other plans), BVH included the costs to connect and convert the mechanical systems within buildings to new thermal heating and cooling systems. However, the heating and cooling systems in buildings will require eventual replacement under any scenario as buildings age. The median age of buildings on the Storrs campus is 55 years. The buildings served by the CUP are generally older, averaging 70 years. Of these, 20% were constructed before 1940, 60% were constructed between 1940 and 1980, and 20% were constructed after 1980. The buildings on the perimeter of the campus are typically much younger than the average. The median age of perimeter buildings is 40 years. Based on these statistics, approximately 50% of the buildings on campus will likely need major mechanical replacements or refurbishments in the next 25-30 years. If campus-wide building management control systems can be implemented so that the conversions to renewable sources can occur at the end of the useful life of the equipment in each building (as is being done at other universities), then regular annual and deferred maintenance budgets should be able to address substantial capital needs of the conversions, thereby effectively reducing the capital costs of carbon reduction plans. Thus, in the capital cost estimates presented and discussed below, the costs associated with connecting and converting mechanical systems within buildings are not included.

In addition, a certain level of investment in existing infrastructure and buildings can be anticipated over time, and baseline operating costs will be incurred for the existing heating and cooling systems, regardless of any move toward renewable energy (i.e., under the “Normal Maintenance Plan”; see hereafter). Under the carbon reduction plans, to the extent possible these investments would go toward the transition to renewable heating and cooling sources based on hot water rather than toward maintaining the existing steam-based system. Thus, in the tables below these estimated expenses are deducted from the total capital and operating costs under the various plans to provide estimates of incremental costs beyond what would be required to maintain the current system (Normal Maintenance Plan). *These incremental costs are the relevant costs for identifying additional costs attributable to meeting the zero carbon by 2040 goal.*

In addition to thermal conversion, phasing out reliance on the CUP will require **replacement of on-site electricity generation**. This will necessitate significant increases in the existing 30 MW electrical capacity on campus, including construction of a new 50 MW substation and new electricity distribution lines, as well as additional utility-scale solar installations. Currently University Planning is beginning preparations to add a third substation (of 100 MW) scheduled for completion within the next decade. This substation will increase the capacity of the University to purchase additional of clean energy. Any additional investment that would otherwise be required to extend the life of the CUP beyond 2040 should be used to help to offset some of the costs of transitioning to increased electrical infrastructure in support of renewable energy. The costs of extending the life of the CUP are included in the capital cost estimates under the Normal Maintenance Plan below.

To achieve zero-carbon, partnerships with State Government, Eversource Energy, and University Planning & Facilities must be utilized to upgrade the grid. Electrical grid updates are not only beneficial to the University's zero-carbon plans but also positively serve Connecticut residents in this region. These benefits derive from the grid's ability to serve as an intermediary between renewable energy produced in one region to accommodate low production periods in other regions. This increased capacity not only eliminates the biggest hurdle to a carbon free future but encourages investments in this area of the state because of its ability to accommodate commercial production of renewable energy. Without increased electrical capacity, the University will *never* reach zero-carbon.

Importantly, the zero carbon plans include **investment in solar generation** of electricity: 6 MW directly on the central campus (e.g., in parking lots, on rooftops), 10 MW of solar panels on the Depot campus, and 20 MW of larger, utility-scale off-campus solar projects. Depot campus holds potential value for the University to generate on-campus electricity with 10 MW of ground-mounted solar photovoltaic arrays. The location of the Depot campus is situated in an historical district and a wetland preservation designation that limit the University's ability to convert the entire area into a solar array. However, if one or a few selected historical buildings were converted into a museum, while demolishing the majority of abandoned buildings, Depot campus would be able to accommodate an additional 20 MW of PV arrays (See Appendix C: Section 2.1). (This may be an appropriate location for a PPA, which would eliminate capital and maintenance costs with a contracted purchase price.) The museum would enhance the historical value of the site while the PV would help power UConn's sustainable future.

Emissions Reductions: Emissions attributable to UConn are categorized as Scope 1 (emissions from sources owned or controlled by UConn such as the CUP), Scope 2 (emissions resulting from the generation of electricity purchased by UConn), or Scope 3 (emissions from sources not directly owned or controlled by UConn but related to our activities such as commuting and travel). The Working Group decided in our June 2020 report to consider Scope 1 and 2 emissions in seeking the zero-carbon goal.

The ZC40 plan would reduce Scope 1 and 2 carbon emissions on the Storrs campus to zero by 2040. **Figures 2 and 3** present the associated annual and cumulative emissions over time for ZC40 as well as for CAP and ZC50. In 2020, annual Scope 1 and 2 carbon emissions from the Storrs campus were

98,083 tons/year. With no reduction over the next 30 years, this would imply cumulative emissions of 2.94 million tons. As shown, under the CAP, emissions will decrease from the 2020 level of 98,083 tons/year to 24,070 tons/year by 2050, with cumulative emissions over that period of 1.770 million tons. In contrast, emissions under ZC40 would be reduced to zero by 2040, with cumulative emissions of 1.021 million tons. Thus, between now and 2050, ZC40 would avoid nearly 2 million tons of carbon emissions relative to cumulative emissions at the current rate, and would reduce emissions by 750,000 more tons than would the CAP. In other words, **cumulative emissions over this period would be approximately 73% higher under the CAP than under ZC40.** If the timeline for calculation of avoided emissions were extended beyond 2050, the differences would be even larger (since beyond 2050 emissions would remain positive under the CAP but remain at zero under ZC40).

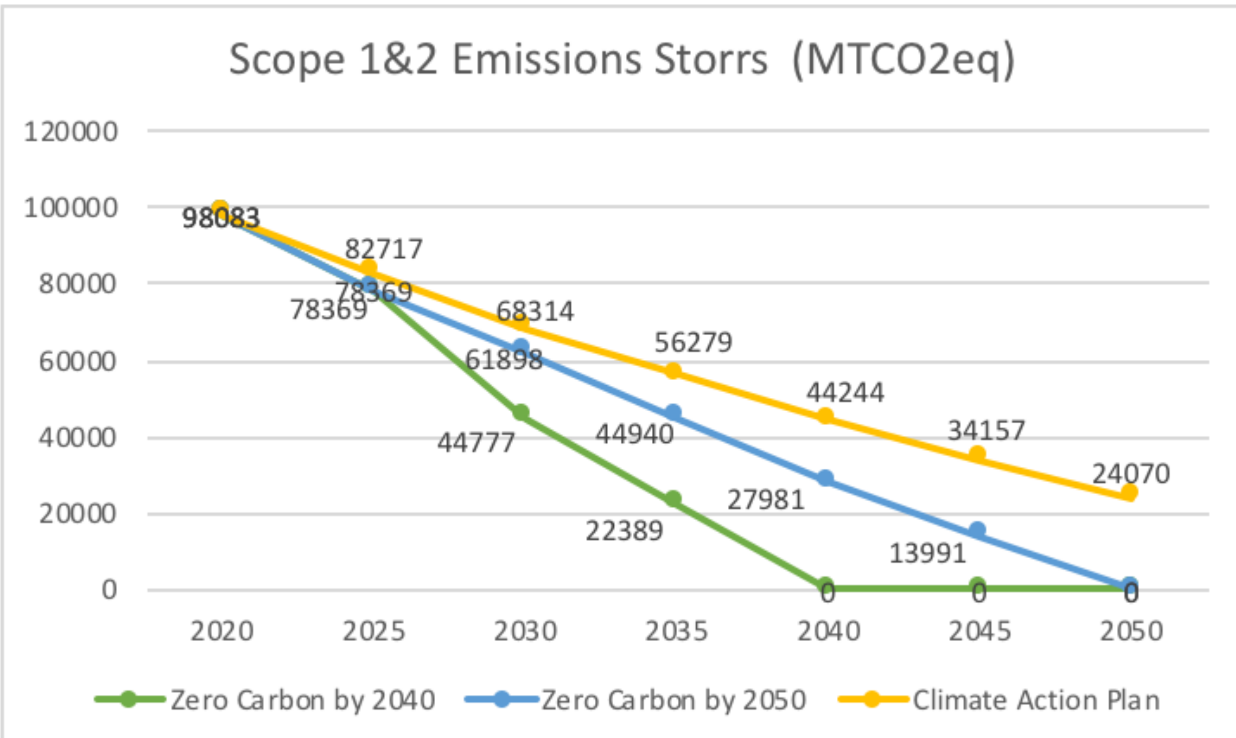

Figure 2. Scope 1 &2 Emissions (MTCO$_2$eq)

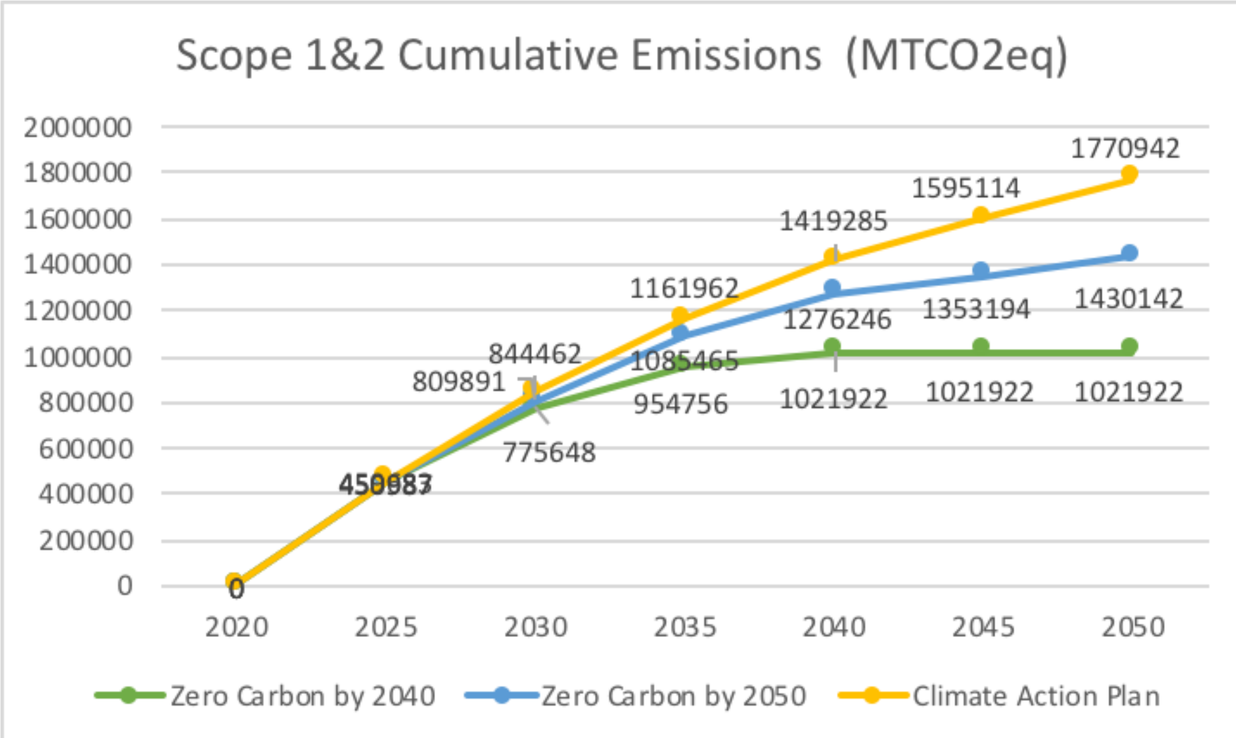

Figure 3. Scope 1 & 2 Cumulative Emissions ($MTCO_2eq$)

4. Cost Estimates for Carbon Reductions

The previous section describes a pathway for achieving the goal of reducing UConn's Scope 1 and 2 carbon emissions to zero by 2040 under ZC40. BVH, in conjunction with the professional staff from UConn's Office of Planning, Design and Construction, developed capital and operating cost estimates for this plan as well as for various alternatives. This section summarizes some of the key results from their cost analyses.

Total and Incremental Cost Estimates: **Table 2** summarizes the total cost estimates for the Normal Maintenance Plan (maintaining steam hot water for heating and cooling with reliance on the CUP), the CAP and ZC40. (More detailed cost estimates for individual projects are given in **Table 3**.) Importantly, **Table 2** also presents the incremental cost of ZC40, where incremental costs are calculated relative to both the Normal Maintenance Plan and the CAP. As noted above, the incremental costs relative to the CAP (which represents UConn's current emissions reduction plan) are the most relevant costs for identifying additional costs attributable to meeting the zero carbon by 2040 goal under ZC40.

Table 2: Total and Incremental Cost Estimates over 2021-2050

	Normal Maintenance Plan (A)	Climate Action Plan (CAP) (B)	Zero Carbon by 2040 Plan (ZC40) (C)	Incremental Cost of ZC40 Relative to NMP (C-A)	Incremental Cost of ZC40 Relative to CAP (C-B)
Emissions Avoided, MT CO_2 2021-2050		1,171,548	1,920,569		
Cumulative Capital Cost 2021-2050	$800M - $900M	$1.1B - $1.4B	$1.8B - $2.4B	$1.0B - $1.5B	$700M - $1B
Present Value of Cumulative Operating Cost 2021- 2050	$1.0B - $1.1B	$1.2B - $1.5B	$1.9B - $2.2B	$900M - $1.1B	$700M

As noted previously, in the absence of additional carbon reduction efforts (i.e., under the Normal Maintenance Plan) UConn would incur expenses associated with the maintenance of existing infrastructure and buildings, as well as with baseline operating costs. As shown in **Table 2**, the associated cumulative capital costs associated with this are $800–900 million over the period 2021-2050. In addition, the Normal Maintenance Plan involves operating costs. As is common in investment analysis, estimates of operating costs were converted to present values, using an annual discount rate of 4%. For the NMP, these are estimated to be $1.0–1.1 billion.

Column 2 of **Table 2** presents the corresponding estimates under the CAP, while Column 3 provides the estimates for ZC40. If the connection and conversion of mechanical systems within buildings are covered by regular annual and deferred maintenance budgets, the cumulative capital costs between 2021-2050 under the CAP would be $1.1–1.4 billion. As noted previously, these include costs for a number of energy conservation measures, some initial heating and cooling conversion projects, and the installation of infrastructure producing 6 MW of on-campus solar power (see **Table 1**). The corresponding cumulative capital costs under ZC40 are estimated to be $1.8–2.4 billion. These costs include the costs under the CAP, plus the additional costs of conversion of the thermal systems, installation of additional solar capacity, and upgrading the electrical infrastructure to allow greater purchases of renewable energy from Eversource. Note that the estimates of capital costs in **Table 2** do not include any escalation factor. It is possible that capital costs could escalate over time, but it is also possible that these costs could decrease over time. Possible factors that could drive cost decreases include the development of new renewable technologies as well as economies of scale and learning as adoption of existing technologies becomes more widespread. For example, the costs of solar energy have decreased substantially over the past decade. In addition to not including any escalation factor, the capital cost estimates have not been explicitly discounted (i.e., converted to present values) to account for the timing of the required investments. Cost escalation, if it were to occur, would increase the estimated capital costs, while discounting would decrease the cost estimates.

Table 2 also provides estimates of the present value of operating costs under the CAP and ZC40. The resulting estimates indicate that the cumulative present value of operating costs under the CAP would be $1.2–$1.5 billion, while under ZC40 those costs would be $1.9–$2.2 billion. The difference ($700 million) is attributable primarily to the added costs of purchasing electricity under ZC40 when the CUP is taken offline. **Table 2** includes estimates for both capital and operating costs. Critically, operating costs are explicitly discounted whereas capital costs are not. Consequently, the table does not include a row that sums these two values to obtain a total cost. Summing the capital and operating cost estimates would only be valid if the appropriate escalation factor is 4%, but not more generally. Thus, the estimates in **Table 2** should be used primarily for cross-plan comparisons of capital costs or of operating costs.

As noted, the costs attributable to the carbon reduction plans should be measured as the expenses that would be incurred beyond, or incremental to, what would be needed under current operating procedures. This reflects the fact that these costs would either be saved under ZC40 (e.g., the cost of extending the life of the CUP) or incurred under either NMP or ZC40. Thus, in addition to the estimated costs under each plan, Column 4 of **Table 4** presents these incremental cost estimates. However, given UConn's current commitments under the CAP, the cost estimates that are most relevant for evaluating decisions regarding adoption of ZC40 are the incremental costs above and beyond the costs under the CAP. These are reported in Column 5 of **Table 4**.

The incremental cost estimates show that, **relative to a normal maintenance plan, the incremental cumulative capital costs of the ZC40 would be $1.0–1.5 billion. This is $700 million to $1 billion more than the capital costs under the University's current commitment under the CAP.** As noted, these additional capital costs stem primarily from the combination of the cost of the new electrical capacity, the capital costs associated with the additional heating and cooling conversion to geothermal, and the costs of an additional 10 MW of solar power on the Depot Campus. In addition to the incremental capital costs, ZC40 assumes additional operating costs of $900 million to $1 billion above what would be required for normal maintenance and $700 million above the operating costs under the CAP. Again, the higher operating costs are due primarily to higher purchases of electricity from Eversource, which would be required once the University no longer generates its own electricity using the CUP. The additional actions associated with these costs would reduce cumulative carbon emissions over this period by 1.9 million tons beyond the normal maintenance plan and 749,020 tons beyond what the CAP would achieve.

Potential Tax Savings: It is clear from **Figures 1 and 2** that ZC40 would generate significant environmental benefits through avoided carbon emissions. Depending on the policy actions over the next two decades, these avoided emissions could also yield significant direct tax benefits. Although there currently is not a state-level or federal carbon tax in place, calls for the pricing of carbon emissions through either a carbon tax or a cap-and-trade system are increasing. In addition, even in the absence of an imposed carbon tax, some institutions are adopting an internal carbon tax as a means to account for carbon emissions in investment decisions. An externally or internally imposed carbon tax would produce additional cost savings from the ZC40 due to the tax savings. At a tax of $45/metric ton (constant over time), the present value of this tax savings through 2050 would be approximately $50 million. Under a graduated tax that started at $45/metric ton and annually increased to $200/metric ton over 30 years, the present value of the cumulative tax savings would be approximately $100 million. These tax savings would then offset part of the $900 million to $1.1 billion incremental operating costs for theZC40 (relative to the Normal Maintenance plan).

<u>Potential Negotiated Rate Savings:</u> Operating costs can potentially be reduced via negotiated agreements regarding electricity purchases from a large solar PPA. The operating cost estimates in **Table 2** are based on purchasing electricity at the current market rate of $0.08/kwh. Other universities have been able to enter into PPAs that include negotiated rates that are fixed over extended periods of time. If UConn were to negotiate a lower rate of $0.07/kwh, the net present value of operating costs under the ZC40 would be reduced by $100 million. These estimated savings would be doubled if the rate were $0.06/kwh or if the solar capacity were doubled to 60 MW.

<u>Alternative Prioritization of Building Conversions:</u> The cost estimates provided above are based on explicit assumptions by BVH about the order in which conversion of thermal heating and cooling systems would occur. That order was primarily based on either where electric capacity was available to undertake the work in the immediate future, or where areas could easily be separated from the balance of the campus and addressed early in a plan. The timing of particular projects (areas) included in the BVH estimates is shown in **Table 3**. For each project area, this table provides information about avoided emissions, mid-point capital cost estimates, and the implied cost per metric ton of avoided emissions. The table also identifies areas that are entirely served by the CUP (shaded in blue), as well as those partially served by the CUP (shaded in green). All other areas are independent of the CUP.

As can be seen, the projects identified by BVH for the initial 2025-2029 time period include both low cost and high cost areas in this first phase. With the exception of West-Part 2, these are areas that are not dependent at all on the CUP. Under the BVH plan, conversion of areas that rely fully or partially on the CUP would not begin until 2030.

Table 3 also allows an identification of (1) those projects that would be most cost-effective (in terms of lowest cost/MT avoided), and (2) those projects that would yield the greatest emissions reduction. The ranking of projects by unit cost and avoided emissions are given in **Table 4**. This table shows that Energy Conservation Measures (ECMs) are both the most cost-effective and yield the highest total emissions avoidance. These are included in both ZC40 and the CAP. Prioritizing projects by cost-effectiveness gives the most emissions avoidance for a given budget. **More generally, Table 4 shows that prioritizing conversion of areas that rely fully or partially on the CUP would contribute to both cost-effectiveness and total emissions reduction.**

Table 3: Project-specific Capital Costs, Emissions Reductions, and Cost per Metric Ton Avoided as Proposed under Timing Originally Proposed by BVH. See Appendix E for Map of Districts.

COST OF CARBON EMISSIONS AVOIDENCE BY CAMPUS AREA
ZERO CARBON BY 2040 PLAN

CAMPUS AREA	PERCENT OF THE AREA ON THE CUP	EMISSIONS AVOIDED IN METRIC TONS (MT)	MID-POINT CAPITAL COST ESTIMATE PER AREA	COST/MT EMISSIONS AVOIDED
2021 - 2024 Projects				
Campus Electric	N/A		$128,000,000	
ECMs - Campuswide	N/A	466,029	$146,100,000	$310
2025-2029 Projects				
Depot	0%	41,434	$114,200,000	$2,760
East B	0%	25,612	$45,000,000	$1,760
Northwest - Part 2	0%	43,920	$50,200,000	$1,140
South B	0%	32,994	$72,900,000	$2,210
Spring Hill	0%	4,367	$4,500,000	$1,030
Spring Manor	0%	666	$1,200,000	$1,800
West - Part 1	0%	44,410	$55,600,000	$1,250
West - Part 2	60%	82,495	$105,400,000	$1,280
West - Part 5	0%	14,275	$19,800,000	$1,390
2030 - 2035 Projects				
Central - North	100%	357,041	$384,000,000	$1,080
Northeast	80%	31,741	$94,200,000	$2,970
Northwest - Ind	0%	6,462	$16,500,000	$2,550
Northwood	0%	10,515	$20,500,000	$1,950
South A	90%	141,982	$107,400,000	$760
Southeast	80%	32,837	$49,700,000	$1,510
West - Part 3	100%	62,483	$47,000,000	$750
2035 - 2040 Projects				
Central - South	100%	225,652	$289,200,000	$1,280
East A - Part 1	100%	60,889	$59,500,000	$980
East A - Part 2	0%	15,222	$17,700,000	$1,160
Northwest - Part 1	100%	32,289	$40,400,000	$1,250
Northwest - Part 3	0%	23,262	$33,100,000	$1,420
Northwest - Part 4	70%	87,841	$98,300,000	$1,120
West - Part 4	90%	76,151	$99,600,000	$1,310
TOTALS		1,920,569	$2,100,000,000	$1,090

AREAS THAT ARE 100% ON THE CENTRAL UTILITY PLANT (blue)

AREAS THAT ARE PARTIALLY ON THE CENTRAL UTILITY PLANT AND PARTIALLY ON STAND-ALONE HEATING/COOLING SYSTEMS (green)

Table 4: Rankings of Specific Projects by Cost per MTon Avoided and Total Emissions Reductions. See Appendix E for Map of Districts

CARBON EMISSIONS BY AREA (LOWEST TO HIGHEST COST/MT)

		Cost/MT
LOWEST UNIT COST	ECMs - Campuswide	$310
	West - Part 3	$750
	South A	$760
	East A - Part 1	$980
	Spring Hill	$1,030
	Central - North	$1,080
	Northwest - Part 4	$1,120
	Northwest - Part 2	$1,140
	East A - Part 2	$1,160
	Northwest - Part 1	$1,250
	West - Part 1	$1,250
	Central - South	$1,280
	West - Part 2	$1,280
	West - Part 4	$1,310
	West - Part 5	$1,390
	Northwest - Part 3	$1,420
	Southeast	$1,510
	East B	$1,760
	Spring Manor	$1,800
	Northwood	$1,950
	South B	$2,210
	Northwest - Ind	$2,550
	Depot	$2,760
HIGHEST UNIT COST	Northeast	$2,970

CARBON EMISSIONS BY AREA (HIGHEST TO LOWEST BY AREA)

		Emissions
HIGHEST EMISSIONS BY AREA	ECMs - Campuswide	466,029
	Central - North	357,041
	Central - South	225,652
	South A	141,982
	Northwest - Part 4	87,841
	West - Part 2	82,495
	West - Part 4	76,151
	West - Part 3	62,483
	East A - Part 1	60,889
	West - Part 1	44,410
	Northwest - Part 2	43,920
	Depot	41,434
	South B	32,994
	Southeast	32,837
	Northwest - Part 1	32,289
	Northeast	31,741
	East B	25,612
	Northwest - Part 3	23,262
	East A - Part 2	15,222
	West - Part 5	14,275
	Northwood	10,515
	Northwest - Ind	6,462
LOWEST EMISSIONS BY AREA	Spring Hill	4,367
	Spring Manor	666

AREAS THAT ARE 100% ON THE CENTRAL UTILITY PLANT

AREAS THAT ARE PARTIALLY ON THE CENTRAL UTILITY PLANT AND PARTIALLY ON STAND-ALONE HEATING/COOLING SYSTEMS

<u>Cost Estimates for Other Plans:</u> BVH also provided analyses of other possible plans: Zero Carbon by 2050 (ZC50) and a 2040 plan based on peak capacity rather than 70% capacity (PP40). The associated costs are presented in the BVH and supplemental reports in the Appendices. Under these estimates, **the capital costs for ZC40 and ZC50 are identical. This equality arises because work required would be the same in both plans; it would simply be distributed over a longer time period under ZC50.** Thus, other than timing, the BVH estimates do not imply any capital cost advantage of delaying the goal of zero carbon from 2040 to 2050. Although the cost estimates are the same, cumulative emissions from 2021-2050 would be considerably higher under ZC50 than ZC40 (see **Figure 2**). ZC50 would imply lower operating costs because the retirement of the CUP would delay purchase of electricity from Eversource. However, the main advantage of ZC50 is that construction and conversion, as well as their associated costs, would be distributed over more time, implying less campus disruption at any particular time and reduced cash-flow demands. Under ZC40, the maximum number of buildings affected at any point in time is estimated to be 12-18% of total buildings (50-60 buildings) for a period of 10 years, while it would be only 6-9% of buildings (20-30 buildings) if the work were more distributed as under ZC50. Likewise, the maximum land area disrupted at any time would be 50% under ZC40 and only 20% under ZC50. However, under ZC50 the disruption would last for an additional 10 years (i.e., it would continue until 2050) compared to ZC40 for which it would end in 2040. Thus, a potential tradeoff exists between the length of the disruption and its maximum impact at any time.

The comparison between the ZC40 and PP40 indicates that planning for 100% peak capacity would be considerably more expensive, necessitating considerably higher capital costs and only slightly lower operating costs, without any additional gain in terms of emissions reduction.

Comparison to Other Universities: The above estimates indicate that UConn's ZC40 is much more expensive than those of Princeton, Stanford, and UC-Davis. (We were not able to complete a detailed comparison to the Michigan plan due to its recent release, but their costs relative to their campus size seem more in line with ours.) Much of this can be attributed to the large number of perimeter buildings at UConn that are not connected to the central steam system. The other universities changed only their central systems, which covered the entirety of campus in the case of Stanford and the vast majority of Princeton's campus, whereas the perimeter at UConn includes only slightly fewer buildings and square feet than the central campus area.

Some of the differences in the plans were matters of accounting. For example, Stanford and Princeton did not include costs for expanding electrical infrastructure, which were attributed to other programs, although the scale of the infrastructure expansion was necessitated by the electrification of heating or cooling capacity, and the shutdown of the campus gas-fired generation plants. Both of those universities did not budget for costs of converting the heating and cooling systems within particular buildings to systems compatible with hot water rather than steam service. Some costs are presented as "net present value" following discounting. We feel it is appropriate to include the costs of electrical and building infrastructure changes that are inherently part of the carbon-reduction plan. However, discounting can be appropriate when planning future expenditures.

One university's representatives mentioned in meetings that their plan expects a certain degree of cultural shift in the form of a wider temperature tolerance inside buildings (i.e. reduced cooling during summer and heating during winter). A similar expectation would enable UConn to convert currently CUP-connected buildings to a hot water system while delaying conversion of some buildings' internal heating systems. Many buildings currently receive steam from the CUP and convert it to hot water that is then circulated through the building's radiators or air handlers. In many cases, the hot water is at a higher temperature than what would be produced by a future zero-carbon system. Simply connecting the building to the new hot water would mean reduced space heating and cooler temperatures in winter. Achieving conventional temperatures would require substantial changes including larger radiators and piping throughout buildings. The overall capital costs of this plan can be significantly reduced if reduced heating can be tolerated for some time (i.e., behavior modification) and the building's heating system overhauled only when the time has come for a general renovation.

Both Princeton and Stanford employ significant thermal storage. In the case of Princeton, this includes large above-ground water tanks for day-to-day storage as well as "geo-exchange" wellfields that effectively use bedrock as a seasonal thermal reservoir, to be warmed during the summer to make cooling more efficient, and cooled during the winter to make heating more efficient.

Thus far, the comparisons have suggested consideration of two actual changes to UConn's zero-carbon plans:

- In as many as cases as possible, delay building system changes until renovation is needed for other reasons. This will not be possible in some buildings that need narrow temperature controls, such as laboratory buildings, animal care facilities, or greenhouses. However, in buildings that house dormitories, classrooms or offices, it may be reasonable to allow some deviation from usual temperature setpoints to avoid a costly mechanical conversion not associated with a general renovation.

- Consider thermal storage. Stanford and Princeton use thermal storage to reduce peak loads and allow maximal heating and cooling to be performed at off-peak electrical rates. The peak load reduction means fewer wells must be installed, reducing capital costs. UConn's plan so far has no thermal storage, and various means of incorporating thermal storage should be seriously considered in future design work.

5. 2020-2030 Actions

The ZC40 establishes a pathway for reaching zero emissions by 2040. The next decade is critical for achieving a safe stabilized climate. Infrastructure, which will influence how emissions accumulate over the next several decades, takes time to plan and implement. Here, we discuss actions that should be taken during this decade to catalyze UConn's transformation to a zero-carbon campus.

After reviewing the scenarios presented above (Sections 3 and 4) in the context of contemporary science, social justice, and environmental equity, the Working Group unanimously considers attainment of zero-carbon by 2040 as the overarching priority. Maintaining UConn's leadership in this energy transition will accrue many co-benefits as described in section 6. The PWGSE recommendation **to achieve 60% reduction by 2030 and zero emissions by 2040 will require that the fossil fuel burning Co-Gen and related steam infrastructure be phased out, with a transition to renewable electricity and thermal technologies.** As noted in the previous section, extending the timeline to 2050 (ZC50) would reduce campus disruption by extending the transition by an additional decade, and not affect overall costs. In opposition to our stated principles, delaying by a decade would substantially increase UConn's cumulative emissions and increase the burden of direct CO_2 removal later.

The 2040 timeline allows for a normal 35 years of Co-Gen system utilization. There have been some investments in the fossil fuel infrastructure, including replacement of ~50% of steam pipes and new boilers. The remaining half of the steam pipes are original from the 1960s. **This means the transition away from fossil fuel infrastructure can be completed with limited stranded assets (new boilers and the steam pipes that have already been replaced), if done with intention.** The transition will require careful coordination across multiple layers of campus planning (e.g., academic, housing, energy) to ensure that zero carbon goals are embedded in every decision to find synergies and opportunities to lower costs.

Here we present actions that should be undertaken in the 2020-2030 timeframe in accordance with these goals:

Install 6 MW of solar PV on campus, 10 MW on Depot Campus, and 20 MW off-campus. The BVH report identified 1 MW that could be installed on building roofs on campus and 5 MW in canopies over campus parking lots. We recommend building these by 2025. The remaining 30 MW is possible by incorporating unused areas of Depot campus and various external sites under consideration off-campus. These could be structured as PPAs to reduce capital costs. Addition of solar power generation on campus will help the University reduce its carbon emissions in the first five years with well-established technologies. The installations will also serve as a visible early indicator of UConn's commitment to reach its zero-carbon goals.

Continue implementation of energy conservation measures. The ECMs have a large impact on carbon emissions at relatively low cost and they have allowed for campus growth while reducing emissions. However, funds allocated for ECMs involving steam pipe replacement or lifecycle enhancements to fossil fuel infrastructure must be reconsidered to avoid stranding assets.

Incorporate heating system conversions into building renovations and prioritize renovations according to the timeline for converting from steam to hot water infrastructure. The future zero-carbon infrastructure will supply hot water at relatively low temperatures. Buildings currently connected to the CUP have heating systems designed around a steam source. Many of these systems are incompatible with the future infrastructure or would have insufficient heating capacity based on their existing systems. As old buildings are renovated, the renovations must include conversion to new systems compatible with low-temperature hot water. The timing of renovations should be made in light of the timeline for completing and commissioning new hot-water infrastructure, to enable retirement of the Co-Gen plant as early as possible. As the Carbon Emissions by CUP Area Only table in Appendix G shows, the aging CUP-connected buildings collectively account for a large share of total UConn carbon emissions. Further, discussion of **Table 4** in Section 3 above concludes that *prioritizing conversion of areas that rely fully or partially on the CUP would contribute to both cost-effectiveness and total emissions reduction.*

Install a third substation to add 100 MW of electrical capacity to the Storrs campus. Since decarbonization is achieved largely through electrification, a substantial increase in electrical capacity is essential for the entire zero-carbon plan, especially to replace the power generated by our fossil-fueled Co-Gen Plant. Unlike the peer institutions mentioned previously, UConn is located in a portion of Connecticut, with limited electrical infrastructure. A new 100 MW substation (SUB-195) to connect UConn to a new transmission line is in the planning phase, and this planning should be prioritized in the near term, as it will be crucial for the remainder of the zero-carbon efforts to have this substation in place by around 2030. (See **Appendix C, Section 2.1**).

Transparency in Planning and Organizational Structures

For students, transparency is among the most important aspects of this process. If there is a good faith, dedicated effort to maintain transparency and communication on our path to zero carbon, students are much more likely to support the progress being made and trust that the administration means well. It allows students and the larger community to actually feel that their perspectives are valued, and that the administration cares about collaborative progress in this area. The PWGSE recommends that the following recommendations be put into place to ensure this community trust:

- **This report must be made public by the University in a timely manner** (before the Board of Trustees creates their own report). A strong top-down commitment to uplifting student and faculty member voices would generate substantial trust on this topic for the entirety of UConn Nation. Trust starts with sharing this report on UConn social media accounts and in *UConn Today.*
- **Biannual town halls (once each fall and spring semester)** should be held by the President, the PWGSE (or equivalent), and the high-level administrative officer to discuss progress on our path to a zero-carbon campus by 2040. This allows a place for students, faculty members, and the broader

UConn community to have a voice in the process, and to receive on-the-record public feedback. These town halls should be advertised well in advance, recorded, and include detailed progress updates.

- **A webpage on the President's website dedicated to detailing the efforts of the ongoing planning process.** This would include an explanation of the current organizational entities and employees tasked with planning (including a Student and Faculty Member Standing Committee, any relevant Board of Trustees committees, and the highest-level administrative officer tasked with these responsibilities [along with contact information]). Such a website should include up-to-date and clear information on how and when interested persons may get involved in the process. The website should also archive meeting minutes from all relevant committees. Annual progress reports and other documents or statements released by the groups should be available on the webpage as well, along with a schedule for, and recordings of, the town hall meetings. Metrics to monitor progress (e.g. Scope 1&2, and also Scope 3 CO_2 emissions) should be highlighted and made visible on the website and displayed in public spaces on campus. Having a dedicated space on the President's website makes it accessible to the larger community and reinforces the top-to-bottom institutional commitment to this transition.
- **Increased funding for existing sustainability departments on campus.** The Office of Sustainability already successfully coordinates much of the sustainability efforts at the University, as well as leads many initiatives aimed at community behavior change, which is an important part of any pathway to zero carbon emissions. This office has also served as the bridge between the student body and those that work at the University (i.e. faculty members and staff members). Increasing the capacity of this office is key to ensuring success. It will be necessary to have in-reach and outreach capable staff to handle the accelerated rate of campus change that will accompany this plan. Our peers that do not share UConn's sustainability track record have more staff at the current moment than we do. This office has achieved valuable environmentally sustainable objectives and expansion of its staff should be prioritized accordingly.
- **Add a justice lens to existing and future sustainability efforts at UConn.** In this report, we emphasize leadership and pride in our institution, but part of that pride must be earned by understanding and making decisions that prioritize environmental justice for those bearing the unbalanced brunt of the environmental crisis. We must undertake this path forward in a just manner. We suggest environmental justice topics be incorporated into every decision and by all persons involved in the decision-making process. There should also be paid positions and trainings to help UConn faculty members, staff members, and students to understand the intersections of campus operations with equity and justice. Therefore, a climate-justice oriented position should be added to the Office of Sustainability that would be tasked with evaluating and improving upon existing processes, as well as spearheading environmental justice and diversity, equity, & inclusion (DEI) programming.

6. Education, Research and Engagement Synergies

The purpose of reducing greenhouse gas emissions is to decelerate climate change and mitigate its impacts, including those related to warming; the frequency and intensity of extreme climatic events such as droughts, wildfires, and high energy storms; ocean acidification; and sea level rise. All of these lead to major humanitarian disasters and increased geopolitical strife. Impacts on biodiversity, including rapid shifts in species distributions, species extinctions, and food web collapse, would combine to compromise the delivery of ecosystem services from both natural areas and managed areas of terrestrial and aquatic systems. A *direct benefit* of the actions recommended in this report is avoiding these negative impacts including their social and economic costs in agriculture, infrastructural adaptation, human health, and human suffering.

In addition to direct benefits, implementing the recommended changes to UConn's infrastructure has a number of *co-benefits*. These include new opportunities in research and education that would be enabled by acquisition of emerging technology and green infrastructure. In addition, the project to reduce UConn's climate impacts will have a major effect on the University's regional, national, and international reputation, which will be very important in recruiting faculty members and students especially, those who increasingly prioritize sustainability in their decisions about enrollment. Similarly, a strong commitment to sustainability and enduring leadership in climate action can be leveraged to increase philanthropic support for the University in general.

Research co-benefits

Groups of faculty members across all campuses and disciplines have come together to support this critical moment for climate action via several initiatives, including the UConn Reads and related events; a university wide pop-up course on climate change that has enrolled more than 1000 students and several hundred faculty and staff members: and the recent addition of an Environmental Literacy General Education requirement for undergraduate students. These faculty collectives are primed to innovate and seek federal, state, and private funding to advance the numerous facets of interdisciplinary research needed to establish pathways to equity and justice while stabilizing climate. There is also potential for increasing research budgets at federal granting agencies in the near term.

In addition, UConn has been a leader in innovative renewable technology research. The campus plans to build an anaerobic digester (AD) for the production of biofuel from organic wastes such as food waste. Besides organic waste generated on the UConn campus, farms in surrounding regions also generate waste materials, which could be processed at UConn's AD. The feasibility analysis of building an AD at UConn will be an excellent platform for research, education, and engagement, especially for undergraduates (senior design or independent research) and faculty members. DOE, NSF and USDA have increasingly high interest in renewable energy, GHG emission reduction, and carbon-zero action. An AD could serve as a hub for multi-disciplinary research, education, and engagement at UConn, and ultimately boost our reputation as a flagship institution for advancing environmental sustainability. Michigan State University and North Carolina State University already operate ADs on their campuses.

As noted previously, decarbonizing UConn will also include substantial investment in solar power generation. This will benefit a number of researchers at UConn investigating topics related to solar energy, ranging from the fundamental technologies of photovoltaic (PV) devices, to the power electronics that connect them to the grid, to modeling grid networks and innovating systems and devices for managing renewable energy distribution. For example, a team of UConn faculty members is pursuing federal funding for developing tools for monitoring and forecasting the performance of solar panels as they age; an installed base of PVs on campus would provide an ideal study platform for engaging in these critical areas of research.

Education and engagement co-benefits

Pursuing ZC40 would also generate significant education and engagement co-benefits. For example, given the enormous interest in bioresource recovery, carbon offsetting, and environmental sustainability across UConn, building an AD at UConn can not only support the University's research mission but also provide a collaborative platform as a living laboratory for community-oriented education. Numerous engagement activities could be arranged, including site visits, hands-on experiments, industrial partner forums, workshops, and training. Solar arrays could likewise be used for student research and analysis projects, as well as for concrete demonstrations for UConn students and the wider community of clean energy generation and its impacts.

UConn is a member of the University Climate Change Coalition (UC3), whose "Strategic Plan 2020-2025" includes a number of educational efforts that would be supported by the implementation of our recommendations:

- *Transform the campus into a hub for living lab initiatives, programs, or projects.* Service-learning projects allow for the integration of academic and operational sustainability into the academic curriculum, and offer students the opportunity to develop climate solutions that address real-world, campus challenges.
- *Establish pathways to incorporate concepts of climate action and sustainability across the curriculum.* These pathways stretch beyond a single class or program to integrate concepts of emissions mitigation, climate adaptation, and resilience into a wide array of courses, resulting in increased climate literacy in our students.
- *Support student participation in campus climate action activities and foster climate leadership.* Supporting student participation in strategic planning and other activities related to emissions mitigation and campus resilience empowers students to become leaders in their campus communities and beyond.

University Reputation

Sustainability is one of the overarching values that guides the evolving Strategic Plan for the University. Moreover, sustainability has long been a highly visible and critical issue for current and prospective students. According to the Princeton Review's College Hopes and Worries 2021 Report, 78% of college applicants said that a school's commitment to the environment would contribute to their application decisions, with 38% saying it would "very much" or "strongly" affect their decisions. UConn has been a prominent green campus, usually appearing among the Sierra Club's top 10, and faculty members on the Working Group have heard many students cite this as one of their reasons for applying to and subsequently choosing UConn. A bold plan to decarbonize the campus will maintain our strong position of leadership in this area and help UConn to recruit committed and concerned students who will themselves become future leaders.

7. Call to Action

We briefly return to the origins of this effort to better understand the context and motivation for our recommendations. Our students expect UConn to be a leader in the great transformation to become a more sustainable society. Their pressure on the administration to act now was clear and has not wavered over time. This is a sentiment shared by the faculty, and is embodied in the emerging consensus that identifies “sustainability” as a university-wide value that should guide university-wide strategic investment. Indeed, our students desire and deserve to be spared the worst of the climate future that they stand to inherit, and the faculty intellectually understands that the clock is running out for UConn to do its part to make significant reductions in its carbon footprint that are in step with worldwide scientific consensus.

UConn has successfully led and strategically promoted many aspects of sustainability, as evidenced by our green rankings and aggressive energy conservation measures. Nonetheless, we are already behind our competitors in perhaps the most important aspect of this great transformation — decarbonizing the institution’s energy production and consumption. As we write this report, UConn is continuing to construct new buildings connected to our fossil fuel energy infrastructure and is performing periodic maintenance on steam lines around campus that reduce near-term emissions but extend the lifespan of the carbon-emitting infrastructure. We acknowledge that a fundamental and complex transformation cannot happen overnight and that immediate needs must be met, resulting in tradeoffs. However, if we are to truly lead based on our stated values as a public flagship institution of higher learning, and be responsive to the expectations of our students (both matriculated and incoming) as well as to our faculty and staff, we must begin now to make decisions that differentially allocate resources towards the goal of reaching zero carbon emissions by 2040. There is no more time to delay, study, or wait for new technologies, yet untested, to emerge and provide the “silver bullet”. A significant institutional commitment is required to change business as usual and to make key decisions in the next five years that ensure we are on a course to achieve our goal. Of course, there is a chance we will not achieve all we desire by 2040, and the tasks outlined here are indeed large in scope and surrounded by uncertainty in the coming decades. However, one thing is certain: further delay on this endeavor is a betrayal of our aspirations and values, and an insult to our collective capabilities to rise up and meet the moment demanded by our highest purpose, which is to enrich the lives of coming generations.

A number of recommendations from the PWGSE follow:

1) **The University should publicly commit to retiring the Storrs campus fossil fuel energy infrastructure by 2040.** An informed, values-driven strategic decision needs to be made on when and how to execute a phased retirement. *This decision is imminent and important in setting the tone and planning for the coming decades.* We fully understand this cannot happen until other heating, cooling, and energy distribution infrastructure is in place. However, the Zero Carbon by 2050 plan pushes the retirement out to after 2040, with dire consequences to total emissions avoided. The Working Group sees this plan as simply unacceptable given our institutional values and ethical responsibilities. The Zero Carbon by 2040 plan we recommend phases in the retirement of the plant at an early date, and avoids far more actual emissions.

2) **We recommend that UConn not continue to invest in and carry out deferred maintenance of the fossil fuel energy infrastructure, including the Central Utility Plant and associated steam lines, which would create the potential for stranded assets when the fossil fuel infrastructure is retired.**

3) This report contains comparisons to other universities, all of which report working toward decarbonizing their energy infrastructure at much lower costs than was estimated for UConn. We have uncovered many points of disparity, which are outlined earlier in this report. We do not question the data themselves, and are sincerely grateful for the countless hours that the professional staff and the consultants have allocated to their reports. **It remains important to appropriately distinguish between additional costs versus costs that the institution would absorb in the absence of a zero-carbon plan for meeting energy needs.** Many buildings on campus are already aged, and most will be old by 2040. Many will either be replaced or taken offline for a period of time and thoroughly renovated: all of those costs cannot be mistakenly added into a decarbonization program "bill", even though those actions mark natural timings for energy conversion. We recognize this likely means considerable parsing of project expenses. *However, we believe it is critical to the sustained success of these efforts that decarbonization be afforded fair accounting across the board*.

4) **UConn's successful transformation to a zero carbon 21st century campus will require transparency and accountability in decision-making and progress reporting, and clear communication to all stakeholders of the University.**

5) The transformation needed will require a university-wide approach involving all levels of university operations and decision making. There must be increased communication among units on campus to ensure that decisions are made with an ever-vigilant eye on the strategic goal. We cannot expect to be smart and efficient while working in separate silos. Consequently, **we recommend a high-level administrative officer be tasked with ensuring progress between now and 2040.** We do have a longstanding successful Office of Sustainability, formerly the Office of Environmental Policy, whose director reported directly at the Executive Vice President for Administration level from 2002-2019. In late-2019, the OS was moved to the Institute of the Environment, reporting to the Executive Director, within the Provost's organization. We advocate that the administrative officer tasked with this role be situated at least at the level of Associate Vice President, not embedded within, or subordinate to, any other operational department, ideally with dual reporting responsibilities, in order to be able to influence decision-making across academics, research and operations and at all levels of the institution.

6) The long-term success of attaining zero carbon emissions by 2040 will be enhanced by the **establishment of a standing presidential committee comprising faculty members and students, with a charge of monitoring progress, evaluating alternatives, and assessing tactical decisions that are being planned in the short- and intermediate-term.** Here again, UConn has a longstanding, successful Environmental Policy Advisory Council (EPAC), comprised of a similar membership, which has partially served some of these functions. However, EPAC would need to be further empowered and provided with additional staff resources to fulfill this enhanced role. Annual progress reports to the University Senate and Student Body will help transform research, education and behaviors in addition to communicating operational changes. *The original list of student demands during the climate strike extend well beyond the scope of this*

report and deserve an official mechanism to ensure progress moving forward. We believe a standing committee will result in outcomes that are superior, more just, and ultimately better investments for the institution.

Finally, we recognize the tremendous amount of work that has been dedicated to this effort by the many involved in the Working Group's deliberations. Professional staff and consultants alike have continually refined and scoped different scenarios of the future of our campus. UConn has available at this time, multiple strategic points of entry (Section 5) to begin a sustained trajectory of transformation. We recommend with conviction that we must accelerate the pace of action. All plans are just that, plans. Most long-term plans necessarily adapt and change over time, especially in light of uncertainty (the essence of being strategic). What must be constant is the alignment of our institutional values, our identity and brand, and our responsibility to our students past, present, and future to decarbonize our institution by 2040. Members of this Working Group will likely not be at UConn in 2040, but we recognize that the time to act is now. Let our collective efforts set in motion the great transformation that will showcase UConn's leadership as we march with open eyes towards a more sustainable human existence that is characterized by justice and equability. Let us revel in the pride with which our successors will stride across our campuses, recognizing what can be achieved when clear purpose and clear goals are informed by the ever-expanding knowledge and scientific discoveries to which this great institution is dedicated and bound by mission to model for society.

Appendices:

A. 2019 Student Demands of the University
B. PWGSE June 2020 Report
C. Fall 2020 Report: Zero Carbon Alternative (Jan 2021)
D. Supplemental Report After Peer Institution Review (Mar 2021)
E. Map of UConn Storrs Districts for transition to renewable thermal technologies
F. Tables for Carbon Emissions by Area
G. ZC40-ZC50 Energy Consumption Graphs

Appendix A

2019 Student Demands of the University

UCONN FRIDAYS FOR FUTURE
DECLARATION OF CLIMATE ACTION

The climate crisis is a current and growing threat to the human epoch. Decades of credible science support this, as do testimonies from many of the world's indigenous peoples. The most recent IPCC report shows that if we do not act by 2030, the life-threatening effects of a warming earth will be irreversible. These effects include, but are not limited to:

a. Sea level rise and associated loss of coastal habitat and resources
b. Increasing occurrence of a sea-ice-free Arctic
c. Coral reef and other species extinction
d. Deforestation and wetland loss
e. More frequent and extreme precipitation events
f. Extended and severe droughts
g. Increase in vector-borne diseases
h. Overall lower agricultural yield
i. Negative mental and physical health outcomes
j. Increased immigration and refugee populations
k. Worsened global inequalities
l. Economic loss and political instability resulting from the above

The list of these devastating consequences has been laid out again and again in public appeals, which makes it easy to become numb to them. **Do not become numb to them. They are real, happening as we speak, and are rapidly increasing in severity.** As college students trying to create the best possible futures for ourselves and our communities, it's frightening to contemplate the catastrophic consequences of this crisis, and even more so because the people who have power don't seem to be as frightened as us — at least, their actions do not reflect the same level of urgency and concern that this emergency demands.

UConn can and should mitigate the impact of our large carbon footprint. However, the university's proposals to expand all campuses and its associated plans to power this expansion will only exacerbate the crisis by releasing even more carbon into the atmosphere.

Since 2008, the university has been committed to becoming a carbon neutral campus by 2050. President Hogan signed onto the American College & University Presidents' Climate Commitment in 2008. UConn established a Climate Action Plan in 2010 which also stated this 2050 commitment. This commitment is in our current Master Plan, which also proposes that we decrease our dependence on natural gas.

State-level efforts are also being made in order to reduce our environmental impact. This month, Governor Lamont signed an executive order mandating a zero-carbon electric grid in Connecticut by 2040. Additionally, his first executive order directed that state agencies reduce their energy consumption and act as leaders for the rest of the state.

This commitment at the University and statewide levels is in direct conflict with the planned implementation of a second natural gas cogeneration power plant. This particular decision by the university is especially disheartening as these types of power plants have a long lifespan, and natural gas, though considered by many to be a cleaner alternative to coal or oil, remains a carbon-emitting fuel. From fracking to transportation to burning, the process of employing natural gas on this campus is environmentally unsustainable. Thus, this decision not only increases our current fossil fuel use, but sets us on a path to be fossil fuel dependent well into the future. In 2050, we will be viewed not as the environmental leaders we are currently seen to be, but as an institution stuck in the past.

On a wider scale, and even *without* the implementation of a second cogeneration plant, the university is not positioned to follow through on our commitments to climate action. Our carbon emissions have not dropped, but remained alarmingly steady over recent years. As UConn continues to expand and build new infrastructure, our energy usage will only continue to grow. Our current efforts, including retrofitting and other energy efficiency projects, will not be sufficient to counteract this increased energy demand.

With all of this in mind, these are the steps we urge the university to take:

1. **DECLARE a climate emergency**
2. **STOP the expansion of all new fossil fuel infrastructure**
3. **DIVEST the UConn Foundation from all fossil fuel holdings**
4. **TRANSITION to 100% renewable energy as quickly as possible**
5. **INCREASE transparency, communication, & student decision-making power**
6. **COMMIT to carbon neutrality by 2030 and a zero-carbon campus by at least 2050**
7. **PRIORITIZE diversity in environmental spaces on campus**

We place emphasis on these seven demands, but they should be the minimum standard for future climate action at UConn. We have plenty of work to do in order to uphold our commitments, and our current goals lag far behind IPCC recommendations and Governor Lamont's expectations. Meeting our climate goals will require sustained, forward-thinking effort.

DEMANDS

Most immediately, we urge that President Katsouleas release a statement in which he recognizes that we are in the midst of a climate emergency, and affirms that sustainability is a top priority for the university. We urge that he commit the university to an update and acceleration of the UConn Climate Action Plan that reflects the content of this declaration, and that he dedicates the campus to a goal of carbon neutrality by 2030, the year that the IPCC report points to as the year by which Western institutions must be carbon neutral to have a chance at limiting emissions to 1.5 degrees Celsius.

Additionally, and as also supported by IPCC findings, we demand that the administration set a new goal of zero-carbon by 2050. There is no socially conscious alternative. Carbon neutrality allows for a loophole wherein the University can buy carbon offsets to "balance" their carbon emissions. Continuing to emit while employing carbon offsets is a model that merely shifts the work from us to someone else, and only prolongs environmental stress: carbon offsetting allows fossil fuel infrastructure to persist, and prolongs the inevitable need to switch. We must think globally and take full responsibility for our emissions. With our capability and visibility as Connecticut's flagship university, we should be leading this effort in the state.

STOP Expansion of Fossil Fuels:

We cannot continue to power our campuses with any variant of carbon-emitting fuel. Specifically, we cannot feasibly be powered by natural gas cogeneration and uphold our climate commitments.

- **No more natural gas-powered cogeneration plants, on any campus.** They have a lifespan of 30-40 years. It will be archaic to run on fossil fuels (even comparatively efficient ones) in 2050.

DIVEST From Fossil Fuels:

Divestment is the process by which an institution eliminates the investments that it holds in a certain company or institution. UConn, along with all universities in our nation, has investments in fossil fuels companies. These university investments have enabled fossil fuels companies to not only continue operating but to thrive. This isn't where UConn's money should be. This topic is complicated by mutual funds and a lack of publicly available information, yet is crucial to ensuring a sustainable future. We hope the new UConn Foundation President has a chance to settle in to his new position, and also urge him to divest from fossil fuel holdings as quickly as possible as he sets a new chapter in this institution's history.

- **Immediately make a statement that UConn will never again make a direct investment in coal.** As far as we know, the UConn Foundation currently holds no direct investments in coal companies, as they don't make financial sense to invest in. It would be an easy next step to make a statement committing to continue this in the future. Other colleges have taken this step, notably Stanford University.
- **Agree to make no new investments in fossil fuel companies or the mixed financial instruments that include them.** We understand that divesting from already held investments is difficult, but being strict with future investments should be achievable.
- **Determine where the university's investments in fossil fuel companies lie, including within mutual funds, and release that information to the UConn community.** Once this is done in a timely manner, the UConn foundation must devise and publish a plan to divest fully from all current fossil fuel holdings.

- **Make available to the public the university's Socially Responsible Investments.** This article on the Foundation website is a good start, but the UConn community should be able to access specifics, especially 1. Which companies UConn is investing in and 2. What percentage of investments are SRI investments. The University of New Hampshire offers a thorough example of this transparency.

TRANSITION to 100% Renewable Energy:

On the world stage, we have an F in renewables. We have a rating of **0.08/4.00** in the Clean and Renewable Energy section of our AASHE STARS report. The Sustainability Tracking Assessment and Rating System (STARS) compares the sustainability of universities across the world, and when it comes to renewables, we don't measure up. There are a huge variety of options for improving this, many of which have already been proposed in university documentation:

- **Sustainably energize the Northwest Science Quad**
  - **Re-evaluate and integrate alternative energy sources for this section of campus.** The Site Assessment and Development Plan for this area of campus includes an Alternative Energy section that assesses a single alternative, geothermal, as an energy source. UConn has since concluded that geothermal is not feasible in this area, however, more effort should be made to source energy for this large-scale project sustainably. Investigating geothermal alone does not count as a comprehensive analysis of all of the options.
  - **Follow through on plans for a 500kW solar panel array on the Northwest Science Building 1 roof.** These panels are included in current plans, but solar arrays have been removed from building designs at the last minute before on this campus.
  - **Investigate battery storage for this solar panel array.** Eversource provides an incentive for this, and other universities are taking full advantage of this benefit. With these incentives to make the project economically feasible, UMass Dartmouth recently installed a large battery storage system on its campus in order to complement on-site solar.
- **Fully transition to renewable energy sources**
  - **A Preliminary Feasibility Study and Strategic Deployment Plan was conducted in 2011, and many of its findings remain applicable.** This document should be revisited and the cost of implementation should be recalculated with the new, lower costs of renewables.
  - **Solar power in particular is the cheapest it's ever been, and UConn's infrastructure is ripe for implementation.** There are many locations that are suitable for solar installation as enumerated in the 2011 study. Generally, parking lots and garages are prime locations for solar. J Lot, in particular, was designed to be solar ready; conduits are in the ground right now awaiting use, so with a purchase power agreement, there would be no capital costs.
  - **Though it isn't a good fit for the new science quad, geothermal is feasible in certain parts of campus.** East campus is an especially good candidate for this energy source, and

the Center for Environmental Science and Engineering building behind Horsebarn Hill would function as an excellent geothermal demonstration project (as detailed in the 2011 study).
  - **Consider getting more energy via purchased power.** Right now, we only purchase ~5% of our energy. All of UConn's purchased power is required to be renewable, in the form of Renewable Energy Credits, purchased and retired by our contractual energy provider (Direct Energy) and delivered by CL&P.
  - **Alternatively, consider making purchased power agreements.** These agreements, which would consist of a company installing and owning a renewable energy project on university-owned land from which UConn would purchase their energy at a reduced rate, are less expensive than directly purchasing energy from the grid and are a viable option for sustainably energizing campus.
- **Electrify our vehicle fleet and offset emissions due to transportation.**
  - **Transition our buses from gas to electric.** As was publicly discussed this past spring, we are about to retire two buses in our fleet and have a grant from the state to receive two electric buses and two charging stations, provided we contribute one third of the money. It may cost more money to buy the two electric buses than two more regular ones, even with DEEP support, but including the social cost of carbon in the calculation is likely to change this conclusion. UConn's reasoning for not making this transition is that Windham Regional Transit District (WRTD) is poised to take over our bus fleet in the coming years. However, this is no reason not to improve the fleet we have, and if the charging stations we purchase are placed in Storrs Center, then WRTD will continue to have access if the fleet changes hands.
  - **Purchase carbon offsets for university-sponsored travel.**
- **Maintain current projects.** A symbolic example of a lack of maintenance is the Werth tower solar array. These panels are proudly touted by the university in tours and in other advertising capacities, but by all accounts, they have been broken in some way since last year and may or may not be currently providing energy to our campus.
- **Take the social cost of carbon into account when determining where to source our energy.** Social responsibility must be accounted for when we decide how to power our campus. The social cost of carbon — the dollar value associated with the long-term damage caused by emitting carbon dioxide — must be factored into all long-term investment decisions. At a minimum, the social cost of carbon must be computed using the EPA's conservative estimate. In 2020, that number will be $42 a ton.
- **Reduce consumption and expansion while fostering this mindset in students.** This last point is not strictly associated with renewables (though it does have to do with continuing to improve energy efficiency), but it should be the default consideration prior to every decision to expand our campus. In cases where it is deemed necessary to expand for the academic growth of the university, we urge the university to take care to sustainably source materials and to build as efficiently as possible. In cases where expansion is unnecessary and purely for the sake of expansion, **do not expand.** The environment and its inhabitants cannot afford unnecessary superficiality .

INCREASE Transparency and Communication:

UConn's plans and statistics need to be easily accessible to the UConn community. In keeping with this, students need to be brought into the university's decision-making process regarding energy. The information in this document was very hard to obtain and involved hunting down many different people across the university. While the Campus Master Plan and other documents are online, they are hard to locate, difficult to understand, and don't include everything needed for full comprehension. In order for students to truly participate in the decisions that the university is making on behalf of them, we need easy access to this information.

- **Follow through on creating the Student Sustainability Task Force.** We are excited that the UConn administration is planning on creating a task force of students and professors that will have a say in UConn sustainability decision-making. We urge them to follow through with this plan. In addition, we recommend that this task force release regular reports that are easily accessed and understood by the UConn community.
- **Post all UConn Foundation investments online.**
- **Ensure public monitoring and accounting of greenhouse gas emissions.** UConn's annual carbon dioxide emissions should be displayed **prominently**. For instance, a bulletin board or digital dashboard in the student union could be dedicated to these statistics, along with a countdown to 2030.

PRIORITIZE diversity in environmental spaces on campus

Diversify the white-centric environmental scene on campus. This looks like transferring decision-making power to students, faculty, and staff representative of all UConn's cultural, racial, and economic backgrounds. People of color and indigenous peoples have been fighting for climate justice for centuries, yet most mainstream environmental movements (including Fridays For Future at UConn and the UConn Office of Sustainability) are white-dominated spaces. We must take proactive steps to give all members of campus equal access to positions of power in the field of sustainability. There is clear passion and knowledge for addressing environmental issues from students of all different backgrounds across campus. It is incumbent upon the UConn administration and environmental student leaders to acknowledge their negligence and actively address the future of what the environmental movement needs. In the urgency of climate change, we need better and more creative solutions- this means more diversity of thought and background.

- **Be intentional in faculty hiring and promotions.** Almost all of the professors on campus in the environmental field are white. There is less than a handful of professors of color teaching in this realm. This is a critical initial step to addressing who is represented in who is teaching us.
- **Improve your coursework.** Few classes are offered that explicitly explains how climate change and environmental issues are inextricably linked with race and class struggles.
- **When implementing these changes, underrepresented groups should not only be included but be leaders in the decision making process.**

CONCLUSION

In recent years, UConn has been recognized as one of the most sustainable universities in the country. However, if UConn is to continue to be recognized as a leader in sustainability, we must adapt our climate action plan to correspond with our sobering reality.

We are in the midst of a climate emergency, and if we don't act quickly as a university, we will have contributed to severe and irreversible damage to the planet and its inhabitants. We cannot afford to bask in our current achievements; our only recently acquired recognition as an "environmentally friendly" university is not sufficient. We need action and we need it now.

When college students protest and produce lists of demands, we're usually patronized, patted on the head and sent on our way.

But not this time.

We demand change because we are experiencing the worst human-created catastrophe in the history of the world, and yet, UConn has failed to take action on anything approaching the necessary scale. We demand change because we recognize that without pressure from the student body, nothing will happen. We demand change because our lives, our future children's lives and the lives of vulnerable global communities are at stake.

We make these demands in solidarity with millions of other young people fighting for their future today. We make these demands because there is no alternate path, there is no plan B.

We want to work with the University to achieve our shared goals — after all, this planet belongs to President Katsouleas and his administration just as much as it belongs to us. But we are prepared, should we see inaction and false promises, to wield our collective power and push until the University agrees to act responsibly. Nothing else is sufficient. Nothing else will take us back from the brink except immediate and sweeping action.

That is why we demand what we demand. Our future is at stake.

Appendix B

PWGSE June 2020 Report

Planning for a Zero-Carbon Future

Recommendations and Strategies to Align UConn with International Scientific Consensus and the Goals of Climate Justice

FINAL REPORT

June 5, 2020

President's Working Group on Sustainability and the Environment

Planning for a Zero-Carbon Future

FINAL REPORT

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Planning for a Zero-Carbon Future

FINAL REPORT

A Preface

On September 20, 2019, students at UConn staged a large-scale climate strike to highlight the need for urgent action to slow climate change. This was followed by weekly student sit-ins at President Katsouleas' office demanding action. In response, among other things, President Katsouleas created this group of faculty, students, and ex officio staff — the President's Working Group on Sustainability and the Environment (PWGS). The committee was led by Office of the Executive Vice President for Administration and Chief Financial Officer, and supported by the Office of Sustainability, Environmental Health and Safety, Facilities Operations, and University Planning, Design and Construction. Over the course of the spring 2020 semester, the group held eight full working group meetings and eight additional sub-group meetings, culminating with the creation of this report by consensus of the group members.

This report contains recommendations that frame an energy and climate change strategy that enables the University to lower its carbon emissions and help slow climate change. These recommendations are designed to outline the steps necessary for UConn to align with state-wide initiatives, scientific consensus, international standards of climate justice, and UConn's mission as a leading research and educational institution. We view this report as the first step in a planning process that should continue through the fall, and into the months and years beyond. We lay out aggressive goals, principles to guide the planning to achieve those goals, and specific items for further planning and analysis.

Future strategic choices will require a better understanding and evaluation of the costs and benefits of alternative pathways for ensuring that the goals described here are met. Due to time constraints and the interruptions stemming from the global pandemic, we have only been able to begin to scratch the surface of this important task. We recognize that further work must be done, by this group and in collaboration with UConn's energy consultants, to produce more detailed, step-by-step plans to transition from the campus's present carbon footprint to the future zero-carbon campus, and to update the Campus Sustainability Framework Plan.

The ideal time to act on climate change has long passed, but there is still time to mitigate the worst damage. We hope that in this report we have effectively laid out *why* and *how* UConn must act decisively, *now.*

Respectfully,
Members of the President's Working Group on Sustainability and the Environment

Planning for a Zero-Carbon Future

FINAL REPORT

B Executive Summary and Recommendations

The Challenge

The scientific consensus is clear on two things: first, climate change is a human-made catastrophe of unprecedented scale, which is disproportionately affecting vulnerable and marginalized populations; second, governments, businesses and institutions across the world have failed to act on a scale necessary to limit the catastrophic effects.

UConn's Role

UConn is deeply committed to the mission of mobilizing its resources and research to address the most pressing problems facing humanity. Since 2001, UConn has reduced campus Greenhouse Gas Emissions by 39% and has integrated resilience into the curriculum, research, and campus operations. Although UConn has been consistently recognized as a campus sustainability leader due to achievements in areas such as water management and educational opportunities, the University has not performed as well in carbon emissions reductions. The University has failed to meet its 2020 near-term emissions reductions goals and is not currently on pace to meet its long-term goals. As a leader in the State of Connecticut, the country and in the international community, UConn has a responsibility to lead by example, and align itself with the scientific consensus and international standards of climate justice.

Major Recommendations

To meet its obligation to be a leader in addressing climate change, the PWGS has put forth six major recommendations. These recommendations are not exhaustive. Rather, they are intended to be the foundation and framework for UConn's strategies towards present and future energy use and the mitigation of climate change. Further work must be done to formulate detailed step-by-step plans for transitioning the campus from fossil fuels to clean, renewable energy.

1. **<u>Update Emissions Reduction Goals:</u>** UConn should update its emissions reductions goals to align with international scientific consensus and the goals of climate justice. We strongly recommend a new goal of 60 percent reductions in carbon emissions by 2030 compared to a 2010 baseline (including proportionate, five-year interim milestones) and zero-carbon emissions by 2040. "Carbon emissions" comprise greenhouse gas emissions from sources directly owned and/or controlled by UConn as well as those attributable to power purchased by UConn.

   Reaching zero-carbon emissions by 2040 will require bold action and strong leadership by UConn's administration. We recommend the following as steps toward meeting that goal:

2 **<u>Halt Fossil Fuel-based Construction:</u>** UConn should, with the exception of the Board approved projects listed in Appendix A, permanently halt the construction of new fossil fuel steam infrastructure at all campuses, including UConn Health. This should be accompanied by the zero-carbon transition of UConn's heating and cooling infrastructure by 2040 and will require a step-by-step timeline.

3 **<u>Increase Investment in Renewables:</u>** UConn should invest in utility-scale renewable energies such as solar, wind, anaerobic digestion and others, in order to meet these new goals.

4 **Incorporate Goals into Campus Development Plans:** All decisions related to campus development, including the use of existing space, new construction, renovation, and demolition, should be informed by the University's commitment to achieve zero-carbon campuses by 2040.

5 **Divest from Fossil Fuels:** UConn should recommend that the UConn Foundation divest its funds in fossil fuel holdings.

A Path Forward

Given the recommendations outlined above, reaching the goal of zero-carbon will require careful evaluation of specific strategies and a consideration and evaluation of each strategy's potential for reducing emissions and the associated costs, both monetary and non-monetary. Given time and resource constraints, this report has only begun to address that process. We are not able at this point to recommend specific projects or investments, since decisions at that level require more detailed analysis than we are able to provide. Nonetheless, we have begun to summarize some of the relevant information about individual strategies and projects in section six. These include strategies such as a roadmap to a campus-wide, zero-carbon heating and cooling system by 2040; site-specific assessments for renewable energy deployment; and an evaluation of technologies that ensure year-round reliability as the campus continues its zero-carbon transition. We suggest they be studied further and prioritized in fall 2020.

Because of the need for additional work on this second phase, we also recommend the following:

6 **Continuation of Planning Efforts:** The PWGS charge should be extended to continue in-depth planning of items prioritized for further study; and in order to address issues such as detailed energy planning, transportation emissions, behavioral change, outreach and engagement on environmental justice, diversity of faculty members in environmentally-related disciplines, etc. Additionally, accountability and communication mechanisms should be developed to accompany this report and representatives from the regional campuses and UConn Health should be engaged.

Planning for a Zero-Carbon Future

FINAL REPORT

1 Background: Working Group Origins

On September 20, 2019, students held a large-scale climate strike on the Student Union lawn and proceeded to march to President Katsouleas' office, demanding climate action at UConn. At his office, President Katsouleas spoke to the students and announced that the Board of Trustees would chair a Trustee-Administration-Faculty-Student (TAFS) committee, dedicated to tackling the issue of carbon mitigation at UConn. A week later, President Katsouleas sent a campus-wide email that accelerated UConn's emissions reductions targets and declared: "Climate change is more than an emergency; it is a global crisis worsening by the day."

Students continued to protest, primarily through weekly sit-ins at the President's office, because this email did not address all of their demands, which included: halting the construction of new fossil fuel infrastructure, divesting from fossil fuels, and increasing diversity within the environmental studies faculty. (The full "Fridays For Future Declaration of Climate Action" can be accessed in Appendix B, sec 1.) The continued protests, along with cooperation from UConn's senior administration, led to the creation of this group, the President's Working Group on Sustainability and the Environment (PWGS). Partially as a result of these protests, President Katsouleas agreed to suspend construction of phase 2 of the new Supplemental Utility Plant, which would have utilized natural gas tri-generation.

These protests were also backed by the University Senate, which issued two statements in support of University-wide climate action in the past year. The first, in September 2019, supported the climate strike and the second, in February 2020, supported divestment from fossil fuel holdings. In addition, student meetings with UConn Executive Vice President and Chief Financial Officer Scott Jordan prior to the climate strike contributed to the creation of this group.

Governor Lamont's Executive Orders (EO) in 2019 were also motivating factors. EO 1 mandated stricter emissions cuts at statewide agencies, a 45 percent reduction from their 2001 baseline by 2030, 34 percent reduction from 2014 baseline by 2030, and 80 percent below 2001 baseline by 2050. EO 3 ordered DEEP to plan for a zero-carbon electric grid by 2040.

2 University Mission and Values

2.1 University Mission

The University of Connecticut is guided by the University Mission Statement, the Academic Plan, the Campus Master Plan, and direction from the Administration and the Board of Trustees.

The University Mission Statement, adopted by the Board of Trustees in 2006, includes the following:

> *"…. As Connecticut's public research university, through freedom of academic inquiry and expression, we create and disseminate knowledge by means of scholarly and creative achievements, graduate and professional education, and outreach… As our state's flagship public university, and as a land and sea grant institution, we promote the health and well-being of Connecticut's citizens through enhancing the social, economic, cultural and natural environments of the state and beyond."*

In January 2017, UConn's then President Susan Herbst endorsed the 2020 Vision Plan for Climate Leadership and Sustainability. The President wrote: "Another *important UConn value is our commitment to sustainability*, especially when it comes to understanding and addressing the social, economic, environmental, and public health issues surrounding climate change." As part of this Plan, the President committed UConn to "…reduce its carbon footprint by more than 20 percent since 2007…".

In October 2019, President Katsouleas reaffirmed UConn's commitment to the environment in a letter to the University community. "Climate change is more than an emergency," he wrote, "it is a global crisis worsening by the day… This issue is of the utmost importance to the UConn community, including myself, and we have an obligation to explore setting more ambitious goals than we already have." President Katsouleas outlined the formation of several committees to analyze and discuss goals and policies "…in concert with discussions about resources and priorities, as one is dependent on the other and there is a natural tension between them."

The PWGS is guided by this direction, particularly with respect to institutional energy policies and use and the opportunities to reduce carbon emissions.

2.1.1 Academic Plan Core Values and Vision:

For more than a decade, the environment and sustainability have been focal themes in the university's strategic plans. These themes have motivated research, education, and engagement to address some of the most critical challenges to face society in the 21st Century. In further recognition of the importance of these multidisciplinary issues to UConn's mission as a land, sea, and space grant university, and as the State of Connecticut's flagship institution of higher learning, UConn's Board of Trustees established the Institute of the Environment (IoE) in January 2019. The IoE's role is to lead and catalyze efforts to address global challenges, like climate change, and to demonstrate leadership on these issues by integrating academic and operational initiatives, consistent with the values and goals specified in the 2014 Academic Plan, *Creating our Future: UConn's Path to Excellence*.

<u>2014 Academic Plan: Values and Vision.</u> Global change in general, and climate change in particular, if unabated, will compromise the ability of the world's ecosystems to provide the critical goods and services that ensure societal well-being. Because environmental sustainability and climate change are inherently global in nature, these themes provide an intellectual platform that advances two core values of the university: global engagement and leadership.

More specifically, the 2014 Academic Plan states, "[t]hrough outreach, research, and partnerships, we promote sustainable development and a happy, healthy, and inclusive society. This engagement is local and global, based on intercultural understanding and recognition of the transnational nature of the challenges and opportunities we face." Moreover, it states: "UConn's students will become well-educated leaders and global citizens who excel in addressing the challenges of the 21st century; in them, we will cultivate critical thinking, creativity, and joy in lifelong learning. We will serve the state, the nation, and the world through our research, teaching, and outreach."

Numerous Statements of UConn's Commitment to Climate Leadership & Sustainability may be found in the USG/EcoHusky letter re: the most recent Presidential Search and in the 2020 Vision Plan.

2.1.2 2015-2035 Campus Master Plan and its Sustainability Framework Plan

In the foreword to the Campus Master Plan, President Susan Herbst wrote:

> *"The Master Plan represents a comprehensive vision for the development of the campus over the twenty years and contains a well thought-out strategy for the sequential development of the University. The Master Plan achieves our goal of having an environment that inspires and educates, meets our sustainability goals for new development and future operations, and reflects the excellence of the programs and achievements of the institution."*

The President also wrote that the Master Plan is "…a living document…" and "….a framework that is flexible and responsive to the evolving needs of the University."

2.2 University Values

The University Mission Statement begins with "The University of Connecticut is dedicated to excellence demonstrated through national and international recognition." To achieve this goal requires leadership, and the global climate change crisis is an area in which UConn has the potential to lead efforts for global change.

2.2.1 Leadership

Michael M. Crow, President of Arizona State University, stated: "Our institutions have the opportunity to serve as transformational catalysts… to better guide the adaptation of our organizations to the sustainability-related needs and challenges faced by society."

Aligned with this aspiration, UConn is a sustainability leader among its peers, placing fifth in Sierra Club's Cool Schools 2019 Ranking. However, UConn ranks poorly in Energy, despite the fact that energy and carbon emissions have become focal points for nationwide public sentiment, Connecticut state policy, and UConn's community.

The Connecticut Department of Energy and Environmental Protection (DEEP)'s Lead By Example program strives to improve energy management at state facilities in an effort to catalyze a trend of clean and efficient energy use in CT, and UConn is playing a significant role in furthering this effort.

2.2.2 Prospective Students

In recent years, students have increasingly viewed colleges' commitments to environmental issues as important to their perception of those colleges. In a 2015

Princeton Review survey, 61 percent of students said it was important (20 percent "very much" or "strongly"). A continuation in this trend positions environmental commitment to assume an even larger role in the college decision process for students.

2.3 International Scientific Consensus and the Goals of Climate Justice:

In a landmark 2018 report, the Intergovernmental Panel on Climate Change (IPCC) concluded that global emissions need to be reduced by 45 percent from 2010 levels by 2030 to limit warming to 1.5°C over pre-industrial levels. The 2019 United Nations Environmental Programme Emission Gap report called for even more stringent cuts of 7.6 percent per year. It is important to note that even if we limit warming to 1.5°C, there will still be, and already are, catastrophic weather events and patterns associated with or strengthened by climate change. The IPCC report also concludes that: "Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (high confidence). These system transitions are unprecedented in terms of scale, but not necessarily in terms of speed…"

The report, and the wider body of climate change literature, also expresses support for the goals of climate justice. At its core, climate justice is the belief, backed by research and experience, that climate change's impacts will reflect the existing inequalities in our world. Wealthier, developed nations are responsible for the vast majority of cumulative carbon emissions, yet poorer, less developed nations (especially in the global south) are most impacted by the effects of climate change. Poor and marginalized communities within developed nations, such as racial minorities, indigenous people, women and low-income communities, will also experience the worst effects of climate change. The principles of climate justice argue that in order to deal with climate change in a just manner, we must be conscious of and constantly fight against this inequality. With this in mind, this report embraces larger emissions cuts than are recommended globally, in order to account for the United States 'disproportionate share of historical, cumulative emissions. The first recommendation in section five embodies these goals.

3 President's Working Group on Sustainability and the Environment

In his letter of October 2, 2019 (see Appendix A, sec 1a), President Katsouleas addressed the UConn community about the issue of environmental sustainability and the goal of further reducing UConn's carbon emissions. The President wrote that "… we have an obligation to explore setting more ambitious goals than we already have. But any commitment we make must be real. By that I mean it must be truly achievable and realistic based on data, analysis and the best estimates we are able to make about things like cost, technological capabilities and pace. Promises not backed by facts and strategy are empty, and I would always prefer honesty and realism to the alternative."

The President announced a special committee of the Board of Trustees known as the Trustee-Administration-Faculty-Student (TAFS) Committee with a sole agenda of emissions reduction and future sustainability. He also wrote of his plan "… to create a centralized working group to take responsibility for coordinated analysis, policy formulation and strategic planning on issues of sustainability, particularly reducing emissions."

The President's Working Group on Sustainability and the Environment (PWGS) was formed comprising faculty and students, chaired by the Executive Vice President and Chief Financial Officer and supported by ex officio staff. The charge to the PWGS was to:

> *"Examine UConn's current carbon emissions reduction goals and our progress to achieving them; assess whether or not accelerating those goals is feasible within the context of our budget and available technology; if so, recommend actions UConn can take to achieve that based on facts, data, sound strategies and the best estimates we are able to make."*

The PWGS held eight sessions during the spring 2020 semester, meeting in person on January 24, February 5, February 27 and March 10, and in response to the COVID-19 pandemic, by phone on March 25, April 9, April 30, and May 6. Group members presented and discussed goals, existing conditions and aspirations with ex-officio staff and professional consultants (see Appendix B for meeting minutes and presentations). A Sub-Group comprising three faculty, two students and two ex-officio staff, supported by two additional staff, worked together to compile this report and presented a draft to the full working group on April 9; a second draft on April 30; a third draft on May 6; and a final draft on May 8. On May 11, PWGS presented the final draft to the President and the Board of Trustees Chairpersons of the Buildings, Grounds and Environment Committee and the Trustee-Administration-Faculty-Student Committee; final edits were completed in late May 2020.

4 UConn Statistics and Current Sustainability Status

4.1 Current Carbon Reduction Commitments

In 2008, UConn's President Hogan signed the American College & University President's Climate Commitment (ACUPCC) whereby the University committed to achieve carbon neutrality by 2050.

In accordance with this commitment, by 2010 UConn developed a Climate Action Plan (CAP), which proposed nearly 200 actions for reducing greenhouse gas emissions (GHG), including interim milestones of 20 percent reductions by 2020 (versus a 2007 baseline), 30 percent by 2025, and 40 percent by 2030. In 2012, President Herbst reaffirmed UConn's commitment and endorsed the CAP.

Through December 2019, UConn had achieved a 16 percent reduction in total greenhouse gas emissions versus the 2007 baseline, despite growth in enrollment of more than 20 percent and the addition of nearly 800,000 square feet of new building space. As of April 2020, UConn has not achieved the 20 percent reduction from the 2007 baseline.

Since the adoption of the CAP, there have been a number of sustainability- and climate-related commitments and milestones (see Appendix A, sec 1b).

4.2 UConn Statistics for Storrs, Regionals, Law School, and Farmington campuses

4.2.1 Land and Buildings (see Appendix A for Storrs aerial)

The University of Connecticut comprises multiple campuses, and cooperative extensions throughout the State. Each campus is physically distinct in acreage and land use, and in the number and size of buildings and facilities.

Table A Summary of University Land by Campus or Location

CAMPUS/LOCATION	TOTAL ACREAGE[1]	MANAGED FOREST	MANAGED FARM/AG
Avery Point	73	0	0
Cooperative Extensions	21	0	0
Downtown Hartford	2	0	0
Health - Farmington	210	0	0
Law School	20	0	0
Stamford	9	0	0
Storrs (inc. Depot & Surrounding Towns)	3,900	2,100	550
Waterbury	2	0	0
TOTALS	**4,237**	2,100	550

[1] Approximate; includes all University-owned property identified in our records ***except*** leased land.

Table A summarizes total approximate area of land controlled by the University at its campus in Storrs, its five regional campuses, UConn Health's campus in Farmington, and its cooperative extension centers located throughout the state. The total land area for Storrs includes the Depot campus, as well as managed forest and agricultural land in the Towns of Coventry, Mansfield and Willington.

This information can assist in the interpretation of energy demands and use. When assessed with building footprints and other data, it can also be used to calculate space available for potential solar arrays.

Table B Summary of Facilities by Campus or Location

CAMPUS/LOCATION	NUMBER OF PROPERTIES[1]	TOTAL GSF	TOTAL ASF
Avery Point	16	421,871	213,098
Cooperative Extensions	9	59,547	36,694
Downtown Hartford	9	132,491	77,302
Health - Farmington	19	3,837,255	2,416,055
Law School	6	252,926	130,659
Stamford	3	502,324	296,494
Storrs (inc. Depot & Surrounding Towns)	339	11,291,970	6,869,322
Waterbury	3	256,366	136,490
TOTALS	**404**	**16,754,750**	**10,176,114**

[1] Includes **all** property types identified as "in service" or "occupied" in database.

Table B summarizes the total number of facilities operated by the University at its campus in Storrs, its five regional campuses, UConn Health's campus in Farmington, and its cooperative extension centers located throughout the state. These properties – buildings and other structures – are identified as "in service" or "occupied" in the space databases managed by UConn and UConn Health.

The total gross square feet (GSF) and assignable square feet (ASF) of each campus or location can be used to analyze the amount of energy needed to light, heat or cool interior space.

4.2.2 Energy: Current Demand and Sources

The 2015 Campus Master Plan considered the various options to supply required energy to existing and planned structures, focused on meeting the reliability and resiliency standards of a leading research university. All new infrastructure is designed for a 99.99 percent reliability and sufficient resiliency to protect the $5.3 billion dollars of research assets and provide shelter-in-place capabilities for students in the event of adverse conditions from natural or human initiated events. A Leadership in Energy and Environmental Design (LEED) Gold Standard is in place for new construction and comprehensive renovations. Each project is required to have an energy model that evaluates the availability of multiple energy sources to meet the program requirements for the project. Factors examined include the full life cycle costs of the source, market availability, operability and maintenance complexity of the source, and the ability to convert from the selected source at the end of the useful life to a future technology or method envisioned but perhaps not yet market ready or compliant with all project requirements.

Statistically, UConn purchases about 50% of all UConn campuses electric power as renewable power.

a) For the Storrs Campus only, the COGEN produces 90% of electric power (about 126,000 MWh) and about 65% of the thermal load and emits approximately 65% of the campus greenhouse gas emissions.
b) The 65% thermal load (heating and cooling) is produced from exhaust heat, which requires zero fuel.
c) Natural gas is typically 97% of the fuel supplied by CT Natural Gas (CNG) with curtailments averaging 3% ultra-low sulfur oil as fuel supplied from Energy New England (ENE).
d) For the Storrs Campus only, UConn purchases 10% grid power (about 10,000 MWh).
e) For all of UConn campuses, purchased power is about 115,000 MWh.

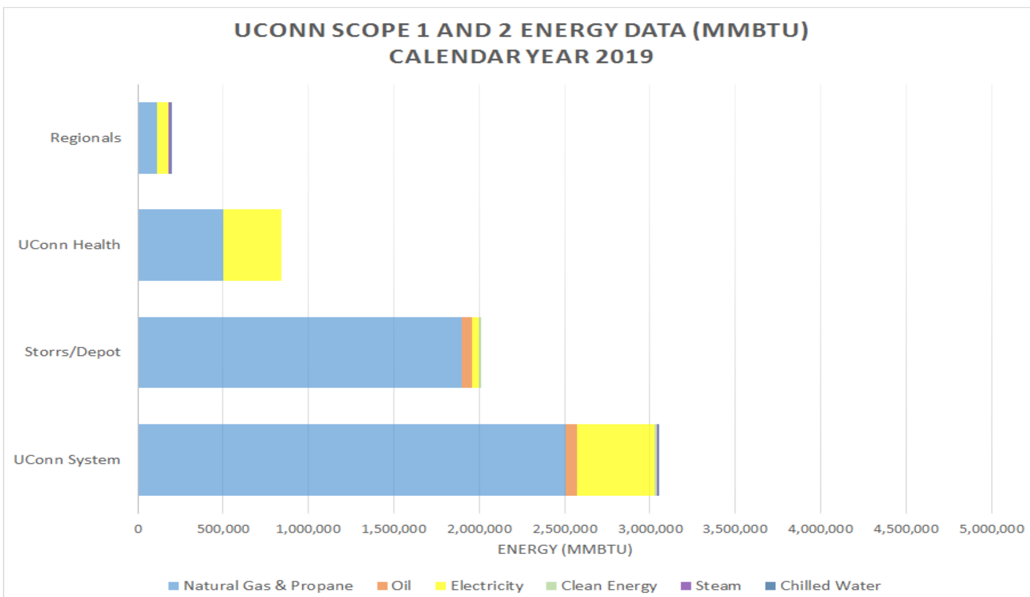
Emissions attributable to UConn are categorized according to these three scopes:

- Scope 1: Emissions from sources owned or controlled by UConn (e.g., the Central Utility Plant)
- Scope 2: Emissions resulting from the generation of energy purchased by UConn (e.g., from external fossil fuel-burning power plants)
- Scope 3: Emissions from sources not directly owned or controlled by UConn but related to our activities (e.g., commuting and travel)

Actual energy requirements and the method of supply as of 2019 are shown in **Figure 1.**

Figure 1

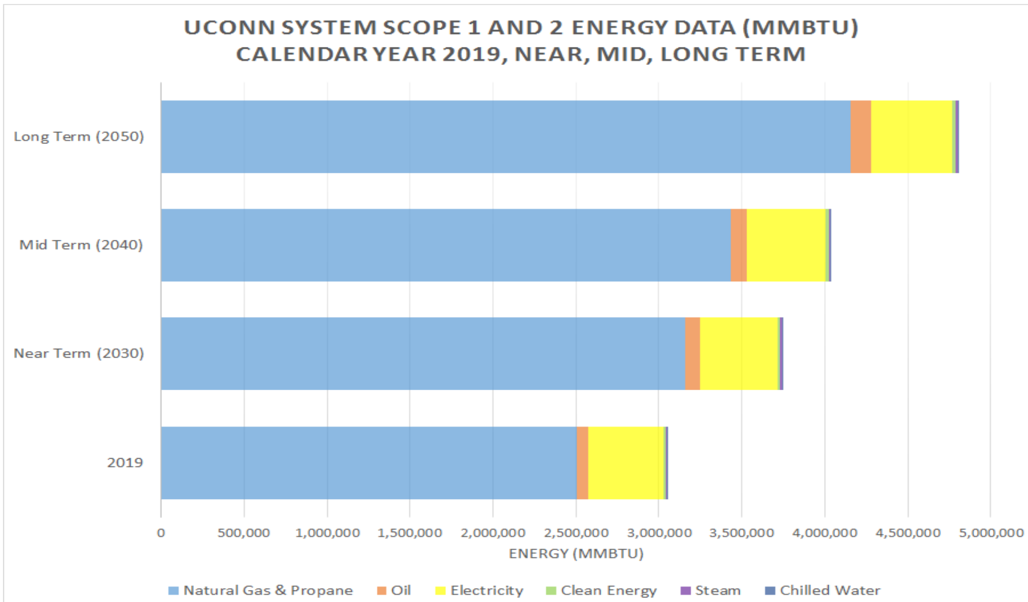
UConn Scope 1 and 2 energy data (MMBTU) in CY 2019



The 2015 Campus Master Plan projected energy requirements are shown in **Figure 2** for the Near, Mid, and Long Term (as defined in the Master Plan).

Figure 2

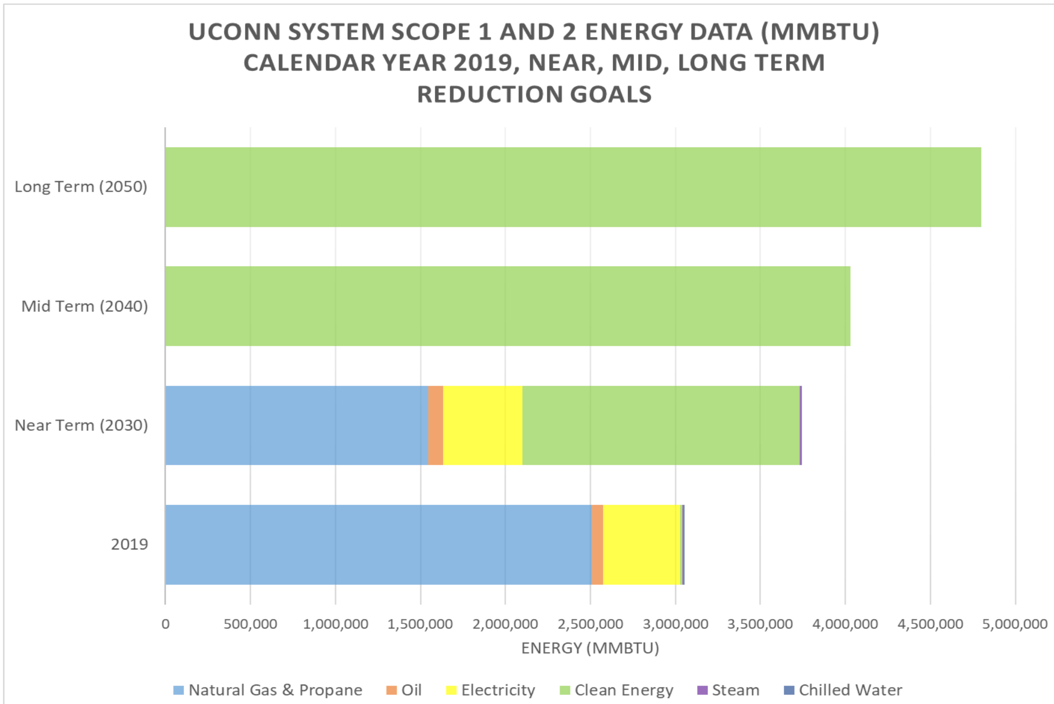
UConn system scope 1 and 2 energy data (MMBTU) in CY 2019
and near/mid/long-term projections



The PWGS revisited the various options to supply required energy in consideration of Governor Lamont's Executive Order 1 and President Katsouleas' commitments. The strategic implementation of clean, renewable energy resources to transition from fossil fuels at the end of useful life for existing assets is shown in **Figure 3**. This chart represents the fulfillment of UConn's existing commitments, not the emissions cuts recommended in section 5.1. For strategies and potential projects to enable this transition see Section 6.7 of this report.

Figure 3

UConn system scope 1 and 2 energy data (MMBTU) in CY 2019
and near/mid/long-term reduction goals



4.3 Human Behavioral Initiatives

Since 2002, the University's Office of Sustainability has led a wide variety of environmental engagement activities and events aimed at promoting sustainable behaviors among students, faculty and staff.

The most prominent programs include EcoMadness – in which student residence halls compete against each other to reduce energy and water usage – and the Green Office Certification Program – which allows offices to be certified "green" based on various adopted sustainable practices and behaviors at work. These programs have attracted significant participation from students, faculty and staff over the past 14 years. Numerous other successful and established UConn events, activities and organizations focused on environmentally sustainable outreach and engagement are listed in Appendix A, sec 1c.

4.4.1 UConn-Generated Renewable Energy Credits

Because the University's 25 MW cogeneration facility fits within the definition of a Class 3 renewable energy source under the State of Connecticut's Renewable Portfolio Standard (RPS) law, the University generates Class 3 renewable energy credits (RECs) simply by operating the Cogen facility. These RECs account for the economic value of the environmental attributes from the energy the Cogen plant produces. UConn also receives a lesser amount of revenue from class 1 RECs based on the much smaller amount of energy produced by the 400 kW fuel cell at the Depot Campus. The University monetizes these RECs, which generate approximately $2.5 million dollars in revenue annually. This REC revenue is then reinvested into energy efficiency projects throughout the UConn system to reduce future carbon emissions and energy demand. Combined with Eversource's energy efficiency rebates and incentives, this has resulted in an annual $5 million dollars spend on energy efficiency (EE), primarily at the main campus but increasingly applied to fund EE projects system-wide.

4.4.2 Purchased Power RECs

UConn's energy provider, Direct Energy, also buys RECs generated by out-of-state renewable energy sources (e.g., Texas wind power) to offset carbon from all of UConn's Scope 2 purchased power. This effectively makes 5 percent of the electricity used at the main campus, and all of the electricity used at the Health Center, the Law School, and the Hartford, Waterbury and Stamford Campuses, carbon neutral. The Avery Point Campus is served by Groton Utilities for electricity needs, and thus is not part of this long-term renewable energy purchased power contract with Direct Energy. This 100% renewable purchased power contract has been in place for 5 years and will be renewed.

4.2.3 Emissions Reduction Credits

In conducting its annual greenhouse gas inventory, using standardized guidance documents, UConn also accounts for emissions reductions credits (ERCs) from two activities that effectively reduce overall emissions. These credits are then deducted from our total Scope 1,2 and 3 emissions.

UConn Forest – ERCs account for the carbon sequestration that occurs in older-growth trees and undisturbed soils on designated UConn Forest parcels and other UConn-owned lands (e.g., the Hillside Environmental Education Park). UConn is committed to maintain these trees and lands in their natural state, either as a dedicated research forest or under conservation agreements.

Compost Facility – ERCs account for the reduction in emissions from composting 40% of CAHNR's manure at UConn's Agricultural Waste Compost Facility, located at Spring Manor Farm. Composting reduces methane emissions from anaerobic decomposition that would otherwise result from the standard farm practice of storing and spreading manure in the field.

4.5 Energy Market and Legislative Climate

CT's RPS law and DEEP's/Public Utility Regulatory Authority's accompanying table (see Appendix A, sec 3.c.i) call for an increased percentage of Class 1 RECs, from 20 percent to 40 percent, over the next ten years, while the percentage of Class 3 RECs will remain flat at 4 percent over that same time period. This may result in a significant corresponding increase in the demand for, and value of, Class 1 RECs (solar, wind, geothermal and fuel cells) and a potential decrease in the value of Class 3 RECs (cogeneration). UConn should plan now to replace the potential lost value from Class 3 RECs with Class 1 RECs, over the next five to 10 years. Energy conservation projects are the largest source of GHG reductions under the University's Climate Action Plan 2007 Baseline Year at 17% recorded since 2008. Executive Order EO-1 Baseline Year 2001 includes the 22% reduction in emissions due to operation of the UCONN Cogeneration Facility commencing in 2006, which is the largest overall continuing reduction recorded for a total reduction of 39%.

Public policy changes may include a state carbon tax on fossil fuels, and the extension or addition of state prohibitions (e.g., MA and NY) on any new pipeline project that would enable the import of "fracked" natural gas from producers in Pennsylvania and other states. These state, regional, and potentially national, environmental and energy related public policy trends provide a sound economic basis for UConn's energy source diversification and the recommendations that follow in section five.

5 Recommendations

These recommendations are a product of collaboration between the student, faculty, and administration members of the PWGS, supported by ex officio and additional staff, during the duration of the spring semester 2020. Detailed meeting minutes may be found in Appendix B.

Recommendation One: Update Emissions Reduction Goals

The University should adopt a new, institutionally binding goal of a 60 percent reduction in emissions from a 2010 baseline by 2030 and of a zero-carbon campus by 2040, which aligns with Governor Lamont's target for the State's electric grid.

a) The University should develop appropriate interim targets for reviews in 2025 and 2035 to ensure adequate progress toward these goals.
b) This timeline aligns with the IPCC's target of limiting global warming to 1.5 degrees Celsius, the outsized responsibility of developed nations (see section 2.3), and the risks of delayed action.
c) Our recommended goal of a zero-carbon campus by 2040 aligns with the phase-out of existing fossil fuel infrastructure, including the Central Utility Plant in 2035, provided we do not expand our capacity, which is addressed in recommendation two.
d) In addition, this recommendation aims to reduce the risk of stranded fossil fuel assets. According to the 2018 IPCC report: "challenges from delayed actions to reduce greenhouse gas emissions include the risk of cost escalation, lock-in of carbon-emitting infrastructure, stranded assets, and reduced flexibility in future response options."

The zero-carbon goal applies to scope 1 (direct on-campus) and scope 2 (purchased power) carbon dioxide-equivalent emissions from fossil fuels (coal, oil, and natural gas). We believe steps should also be taken to mitigate scope 3 emissions, such as those related to transportation, including a carbon neutral commuter program. Specific transportation-related recommendations should be developed as a future goal of this or subsequent PWGS, which is discussed in recommendation six.

Recommendation Two: Halt Fossil Fuel-based Construction

The University should, with the exception of the Board approved projects listed in Appendix A, sec 3.d, permanently halt expansion and construction of fossil fuel and steam infrastructure on all campuses, including UConn Health. All heating and cooling infrastructure should be fully converted to zero-carbon capable systems such as geothermally coupled electric heat pumps, with suitable electrical infrastructure installed by 2040.

a) A step-by-step timeline for the transition to a zero-carbon heating and cooling system by 2040 should be developed under the guidance of the PWGS by the end of the Fall 2020 semester. This timeline should include a plan to build the necessary electrical infrastructure to provide for electrical and heating/cooling loads from renewable energy sources. An example of a zero-carbon heating and cooling transition timeline from Princeton University is provided in Appendix A, 3.c.vi.
b) Full electrification and renewable energy deployment by 2040 will enable the University to align its efforts with those of Governor Lamont's EO 3 and meet emissions reductions targets outlined in recommendation one.
c) Emergency repairs to existing fossil fuel-powered steam infrastructure that do not extend the payback period of that infrastructure should be allowed. Wholesale replacements that extend the payback period of the existing steam infrastructure, however, should not be allowed.

Recommendation Three: Increase Investment in Renewables

UConn should invest in renewable energy technologies to meet the electric and heating/cooling demands of all campuses, including UConn Health. This will entail use of various green technologies:

a) Solar: Utility-scale installations will be needed on available land near UConn campuses, together with the transformer and transmission infrastructure for delivery of power to those campuses. Distributed solar (for example, on and near buildings and parking lots) should be installed where feasible. Solar power has strong seasonal variability and is especially suited to meeting summer cooling needs.
b) Wind: Offshore wind power is more consistent than solar, and peaks in the winter, making it complementary to solar power. Due to this winter generation profile, wind energy may serve as an integral part of UConn's long-term energy portfolio, especially as the CUP is retired. UConn should assess whether wind turbine installations are appropriate at the Avery Point Campus. For other locations, UConn should consider the purchase of or investment in wind energy from elsewhere in Connecticut.
c) Storage: Solar and wind are intermittent energy sources. On-campus energy storage will be needed to cope with routine fluctuations in these sources and to maintain resilience in the face of multi-day storm events or grid outages. Battery technologies remain unsatisfactory for this task but are rapidly improving. Other possibilities include

electrically powered splitting of water into hydrogen and oxygen, with the hydrogen stored as a fuel. Over the next one or two decades, technologies will likely become available to meet storage needs, and UConn will need to implement energy storage at all campuses.

Recommendation Four: Incorporate Goals into Campus Development Plans

All decisions related to campus development, including the use of existing space, new construction, renovation, and demolition, should be informed by the University's commitment to achieve no increase in overall energy use and zero-carbon campuses by 2040.

Steps to achieve this recommendation include, but are not limited to:

a) Establish a design guideline that new construction should be zero-carbon;
b) Employ a carbon proxy price that accounts for the social cost of carbon, minimizes risk to the University of potential carbon tax legislation, and guides planning toward use of lower carbon alternatives;
c) Complete building assessments and energy audits of all existing buildings;
d) Demolish old, energy-inefficient buildings and utilize demolition to offset new construction;
e) Include the maximum amount of distributed rooftop solar panels in the construction of new buildings; and
f) Prioritize geothermal heating and cooling for all new construction and renovations.

Recommendation Five: Divest from Fossil Fuels

The University should recommend that the UConn Foundation divest its funds in fossil fuel holdings. The reasoning is twofold: first, continued investment in fossil fuels is becoming an economic liability. Second, it is a moral imperative to stop support of fossil fuel companies, that play a large role in the continued exploitation and destruction of the environment.

Large public universities, like the University of California System and the University of Massachusetts, have announced plans to divest fully from fossil fuels for economic and moral reasons. Other schools that have fully or partially divested from fossil fuel holdings include the University of Maine System, Stanford University, Johns Hopkins University and the University of Oxford.

Recommendation Six: Continuation of Planning Efforts

Future iterations of the PWGS should perform the following functions:

a) Continue in-depth planning of items, including a roadmap to a campus-wide, zero-carbon heating and cooling system by 2040; site-specific assessments for renewable energy deployment; and an evaluation of technologies that ensure year-round reliability. These items were prioritized for further study due to their systemic and capital-intensive nature;
b) Develop an accountability mechanism to assess the University's progress towards these recommendations and its climate commitments. Ongoing assessment enables consistent, coordinated progress toward the University's goals and avoids major catastrophes, such as emissions target overshoots, loss of embedded carbon costs, and stranded assets;

c) Develop a communication mechanism for the PWGS to convey recommendations and progress assessments to the broader UConn community. This communication mechanism should utilize intermittent and permanent communication vehicles, such as coordinated media campaigns (intermittent) and online or physical infrastructure displaying up-to-date progress towards sustainability goals (permanent);

d) Tackle additional climate and sustainability issues, some of which have been outlined in the Fridays for Future Declaration of Climate Action (see Appendix B), including, but not limited to: transportation, behavioral change, outreach and engagement on environmental justice, diversity of faculty members in environmentally-related disciplines, etc. These additional tasks are identified due to their importance in reducing carbon emissions and committing the University to the goals of climate justice. The composition of the PWGS should be adjusted as necessary to address the Group's needs as shifts in primary topics emerge over time. Changes to the composition of the PWGS, however, should maintain its balance of students, faculty members, and staff members, and retain an open-application (crowd-sourced) recruitment method for students; and

e) Engage and collaborate, in fall 2020, with representatives from the regional campuses and UConn Health to identify and prioritize specific strategies for their campuses.

6 Strategies for Reducing Carbon by 2025, 2030, and 2040

As noted in the recommendations above, the University should lay out systematic strategies to reduce carbon emissions with the short-term goal of a 60 percent emissions reduction from a 2010 baseline by 2030, and a mid-term goal of zero -carbon campuses by 2040. Achieving such goals requires identification of significant emissions reduction leverages, as well as the feasibility of technology adoption and deployment. In accordance with recommendation six part (a), work to build out and adapt these strategies will continue in future iterations of the PWGS. All strategies must evaluate monetary and non-monetary risk to the University and to society.

6.1 On-going and Proposed Carbon Reductions by Facilities Operations

UConn is currently in the process of implementing various on-going carbon reduction projects and has proposed several other projects that are needed to meet UConn's Climate Action Plan carbon reduction goals. These projects are presented in Section 6.6 below and described in more detail in Appendix A Section 3.a, Technologies and Strategies.

6.2 Solar Deployment

Most solar panels are between 15 percent and 20 percent efficient**.** Solar panels usually range in wattage output from 250 watts to 400 watts. The most efficient mass-produced solar modules have power density values of up to 175 W/m2 (16.22 W/ft2).

6.2.1 Short Term (2020-2025)

a) Virtual Purchase Power Agreement (VPPA) at an off-campus location, first assessing the 160 acre plot of land for sale in Mansfield. This captures the current federal tax credit for solar developer.

b) Complete site assessment and plan for utility-scale installation at Depot Campus and other nearby locations where this is an appropriate technology.

d) Determine if existing buildings and structures can be retrofit with rooftop solar using existing lightweight technologies.

6.2.2 Mid Term (2025-2030)

a) Deploy University-owned, utility-scale solar at Depot Campus (federal tax credit expiry, lower cost of capital than a private developer).

b) Retrofit existing rooftops and other structures as more lightweight solar technologies becomes available.

6.2.3 Long Term (2030+)

a) Retrofit existing rooftops and other structures as more lightweight solar technologies becomes available.

6.3 Geothermal

The low energy intensity (and electricity only) requirement of geothermal heating/cooling systems make them particularly useful in the quest to achieve an electrified, zero-carbon campus (see Appendix A Sec 3.b.iii for details).

a) UConn should focus immediately on identifying off-the-CUP buildings, where geothermal retrofits are most beneficial (e.g., Bishop Center, Institute of the Environment in the Building 4 Annex). Installation of small geothermal systems at these buildings would replace stand-alone boilers and chillers, and immediately yield reduced energy costs and lower carbon emissions, with a fast payback period.

b) UConn should begin evaluating larger-scale geothermal closed loop wellfields, ground-source heat pumps and thermal storage systems at strategic locations on campus as part of the mid-term (2040) goal of a zero-carbon campus (see recommendation three above).

c) Geothermal should be prioritized for heating and cooling needs at all new construction projects.

6.4 Wind

Offshore wind available in the New England wind lease area is estimated as 14,000 MW. The State of Connecticut is pursuing offshore wind as an important, large-scale and local source of renewable energy. The state has legislated directives to procure around 2,000 MWs of offshore wind and have selected ~1,000 MWs with individual generator connections as a first step in meeting that goal. Strategic plans are required to enable the long-term development of wind energy harvest, sustain stronger long-term economic growth, improve HVDC transmission systems, while reducing costs, minimizing the environment footprint and impact.

6.4.1 Short Term (2020-2025)

a) Identify all planned wind projects within the region, such as the Constitution Wind project.

b) Communicate with the project developers to determine whether UConn could arrange a virtual PPA or a similar agreement to acquire wind energy.

c) If acquiring wind energy from planned projects is not feasible, assess whether the University could collaborate with project developers (and potentially other stakeholders/off-takers) to install and acquire wind power from a new project through a virtual PPA or similar agreement.

6.5 Carbon Offsets

Carbon offsets are a way to compensate for emissions by funding an equivalent carbon dioxide saving elsewhere. They are a form of trade that allows individuals, companies or institutions to invest in environmentally-beneficial projects locally or around the world to balance their own carbon emissions. Because climate change is a global problem, carbon offsets are international commodities. One carbon offset is equivalent to a reduction in emissions of one Metric Ton of CO_2 equivalent (MTCO2e).

Carbon offset projects implemented at remote locations must be done in close collaboration with indigenous populations and officials from the host community. Any carbon offset project must meet “additionality” requirements (see criteria below), meaning that it would not have occurred but for the carbon offset investment. Thus, projects in highly-regulated states and communities with strict regulations, standards, and controls, and extensive permit terms and conditions, may not meet the additionality requirement. Use of carbon offsets with respect to the transportation sector could help to achieve Scope 3 reductions.

The carbon market is well-regulated and has evolved over the past 25 to 30 years to be even more carefully restricted. This international regulatory regime includes standards, guidelines and protocols for qualified carbon offsets, along with officially recognized agencies, brokers and third-party verification organizations.

The annual price that UConn could expect to pay for a certifiable carbon offset project is approximately $10 - $15 per MTCO2e over a long-term period.

A strong consensus of the PWGS is that carbon offsets are best-suited for offsetting Scope 3 emissions, especially those from commuters, visitors and air travel. These transportation-related activities are inherent in the University’s mission, and generate a significant portion of UConn’s GHG emissions (15-25 percent). However, they derive from mobile sources owned and operated by third parties and are generally beyond UConn’s direct ability to reduce through operational control measures.

Carbon offsets may also be utilized to bridge gaps or shortfalls in achieving interim or 10-year carbon reduction goals. For example, UConn could purchase carbon offsets to meet the 2020 interim milestone goal of 20% reduction, as established in the Climate Action Plan (CAP). For additional information see Appendix A, sec 3c.x.

6.6 Greenhouse Gas Reduction Projections

A greenhouse gas reduction projection matrix was developed in order to determine if UConn’s Climate Action Plan carbon reduction goals could be achieved by the set milestone dates. The matrix table is presented in Section 6.7. A detailed description of specific greenhouse gas reduction projects that could be used to achieve these goals is presented in Appendix A, Section

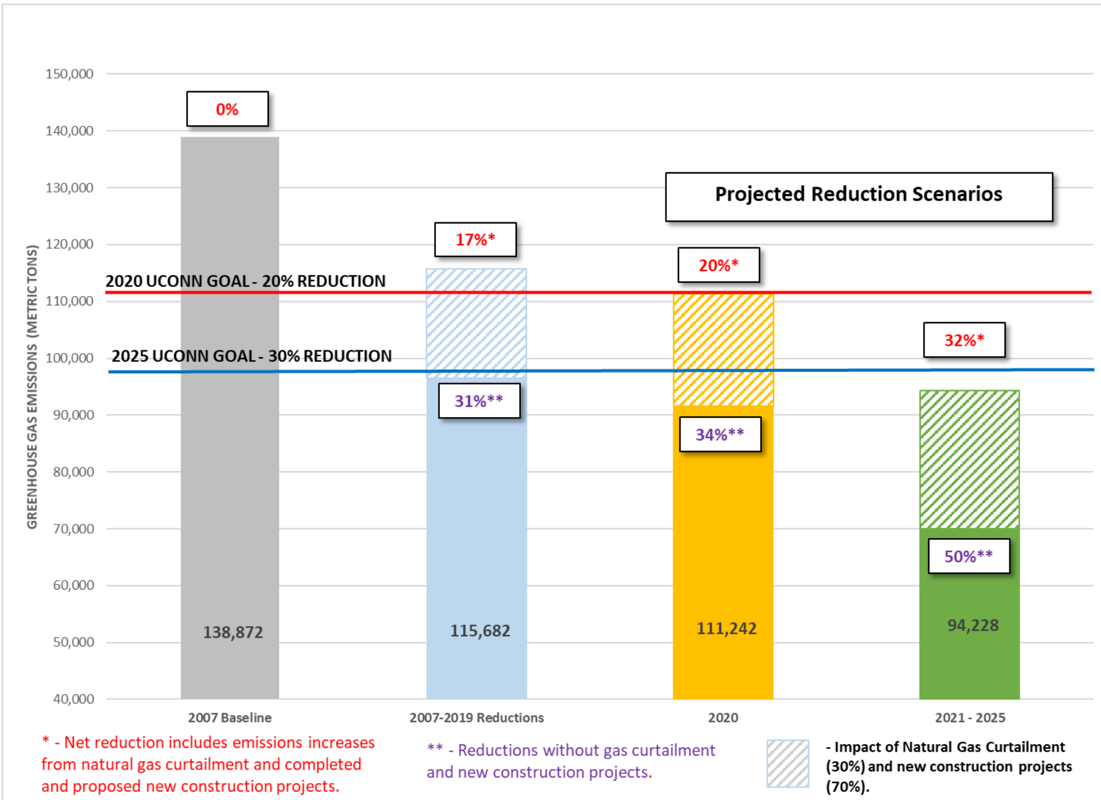
3, Technologies and Strategies. The greenhouse reduction goals that were evaluated in the projection matrix include:

a) 20% reduction by 2020 based on a 2007 baseline (UConn goal)
b) 30% reduction by 2025 based on a 2007 baseline (UConn goal)
c) 45% reduction by 2030 based on a 2001 baseline (Governor's Executive Order 1 goal)
d) 45% reduction by 2030 based on a 2010 baseline (IPCC goal)
e) 60% reduction by 2030 based on a 2010 baseline (proposed UConn goal)

Note that the evaluation presented below represents only one of many possible scenarios that could be implemented to reduce greenhouse gas emissions to achieve set carbon reduction goals. Further study is needed to determine the best path forward to achieve these goals.

The results of the evaluations that were conducted are presented in **Figures 4 through 6.** These figures present the baseline emissions, the reductions achieved to date through the end of 2019 and projected reductions for each milestone date. Reduction percentages achieved demonstrate 1) the impact of natural gas curtailment and new construction and 2) without natural gas curtailment and new construction for the Storrs campus. The impact of natural gas curtailment and new construction is shown in **Figures 4 through 6** with hatching on the bar charts. The specific greenhouse gas reduction projects needed to achieve the reduction goals listed above are presented in **Figures 7 through 10**. The actual greenhouse gas emissions, baselines (2001, 2007 and 2010) and current to date (2007 through 2019), include scopes 1, 2, and 3 emissions. Projected reductions primarily decrease scopes 1 and 2 emissions, although one of the reduction items in the 2020 timeframe, "Commuter Carbon Offsets" (**Figure 7**), would decrease scope 3 emissions.

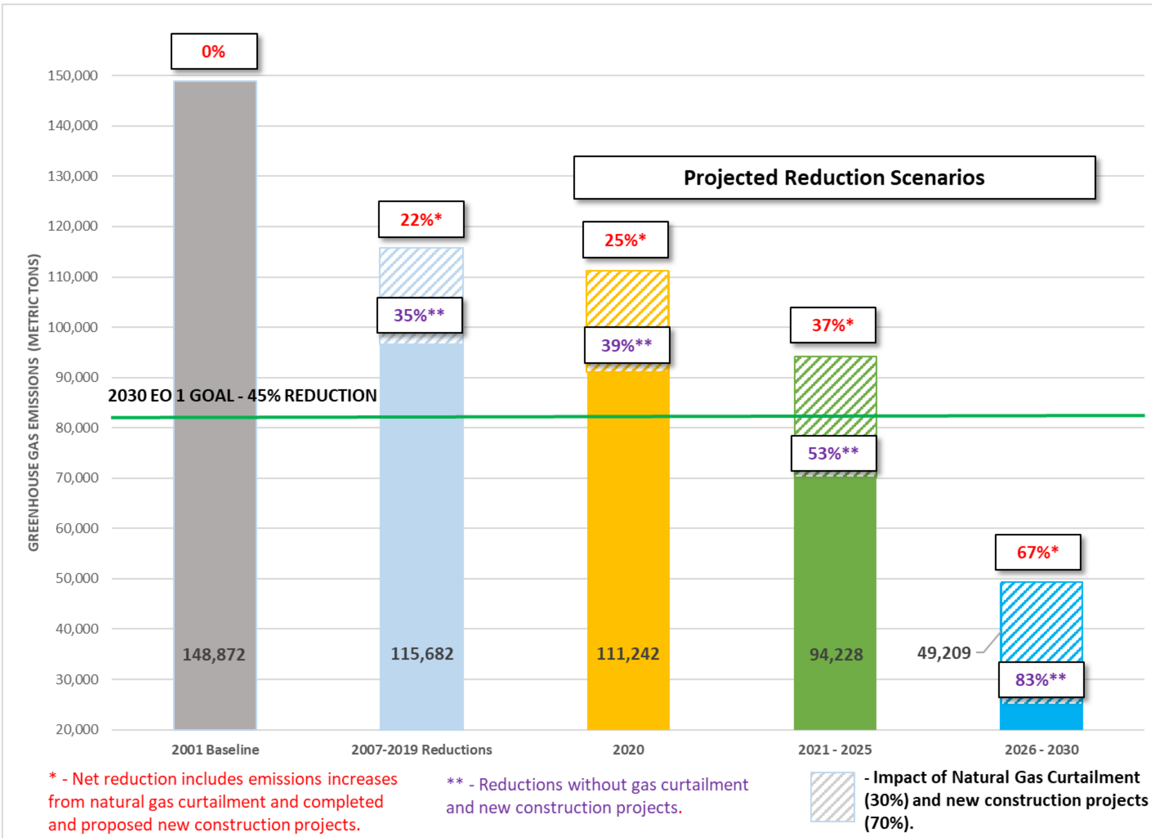
Figure 4
Greenhouse Gas Emissions Projected Reductions
that could meet UConn Goals



Greenhouse gas emissions reductions that could achieve UConn's reduction goals of 20% by 2020 and 30% by 2025 are based on a 2007 baseline (**Figure 4**). The net reduction percentages shown in red include emissions increases from natural gas curtailment and completed and proposed new construction projects. Reduction percentages shown in purple indicate what the reduction would have been without natural gas curtailment and new construction.

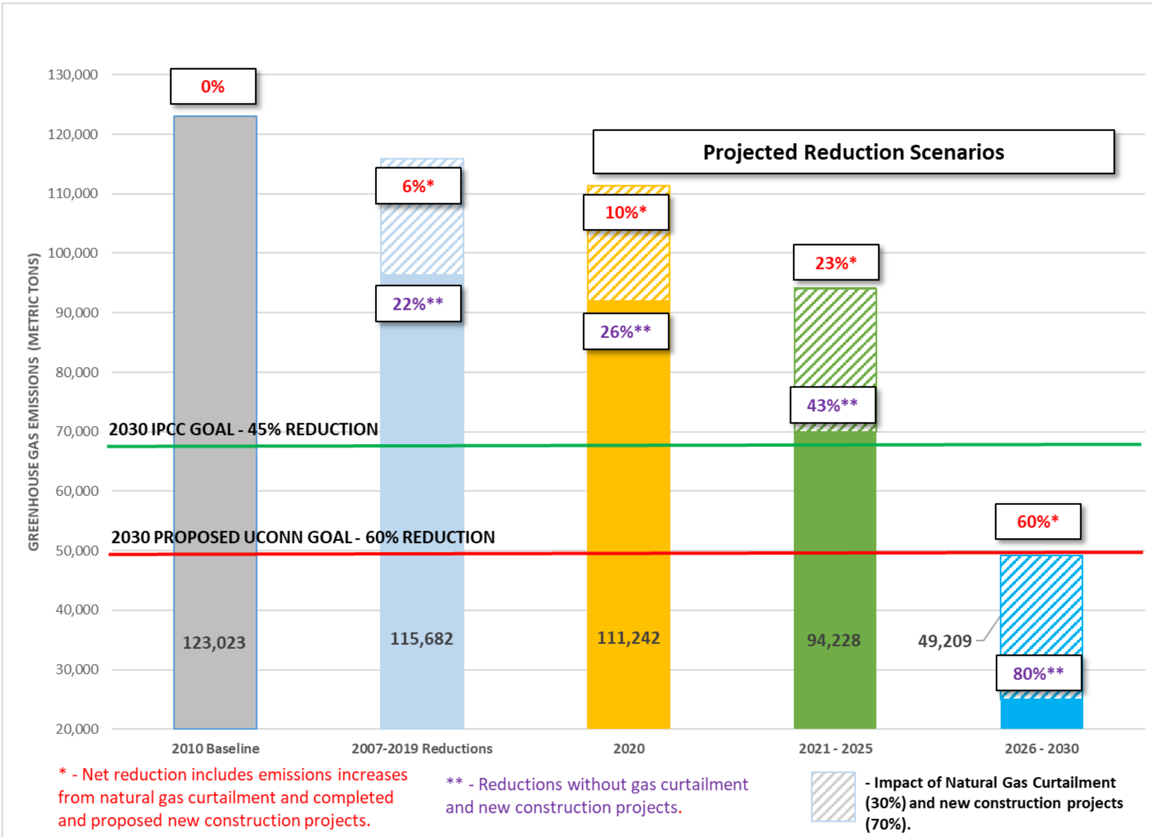
Figure 5

Greenhouse Gas Emissions Projected Reductions
that could exceed the Governor's Executive Order 1 Goal



Greenhouse gas emissions reductions that could exceed the Governor's EO 1 reduction goal of 45% by 2030 are based on a 2001 baseline (**Figure 5**).

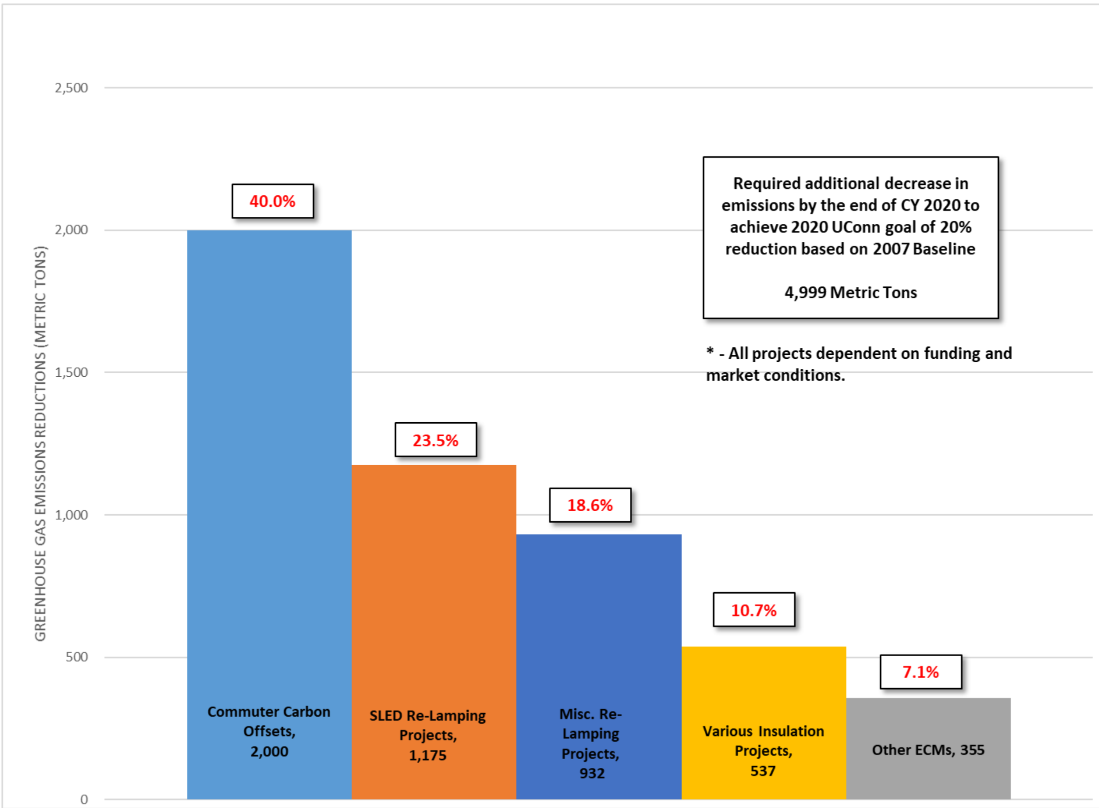
Figure 6
Greenhouse Gas Emissions Projected Reductions
that could exceed IPCC and UConn Goals



Greenhouse gas emissions reductions that exceed the IPCC reduction goal of 45% and could achieve the proposed UConn reduction goal of 60% by 2030 are based on a 2010 baseline (**Figure 6**).

Figure 7

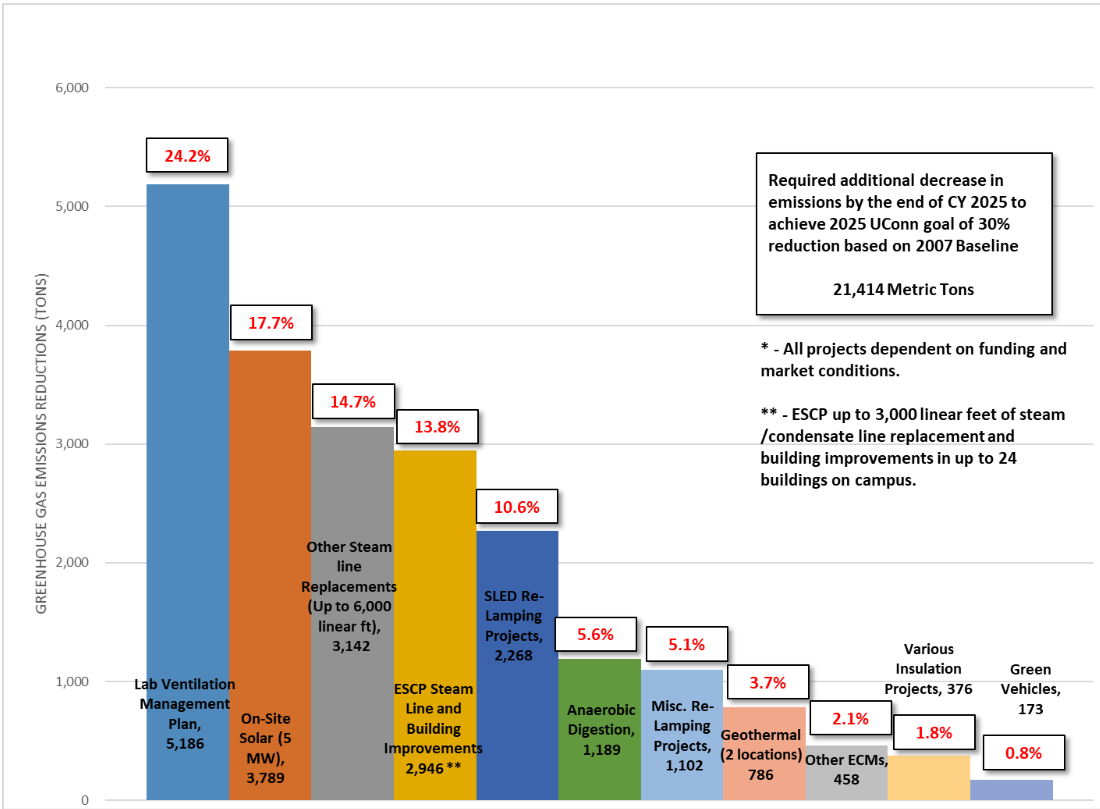
Required 2020 GHG Emissions Reductions – Proposed Projects*



An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 20% by 2020 based on a 2007 baseline is shown in **Figure 7**. To achieve this goal, emissions would need to be reduced by approximately 5,000 metric tons by the end of calendar 2020. The most predominant reductions in calendar year 2020 is estimated to come from commuter carbon offset at 40% with the SLED re-lamping projects being the second most at 23.5%.

Figure 8

Required 2021-2025 GHG Emissions Reductions – Proposed Projects*

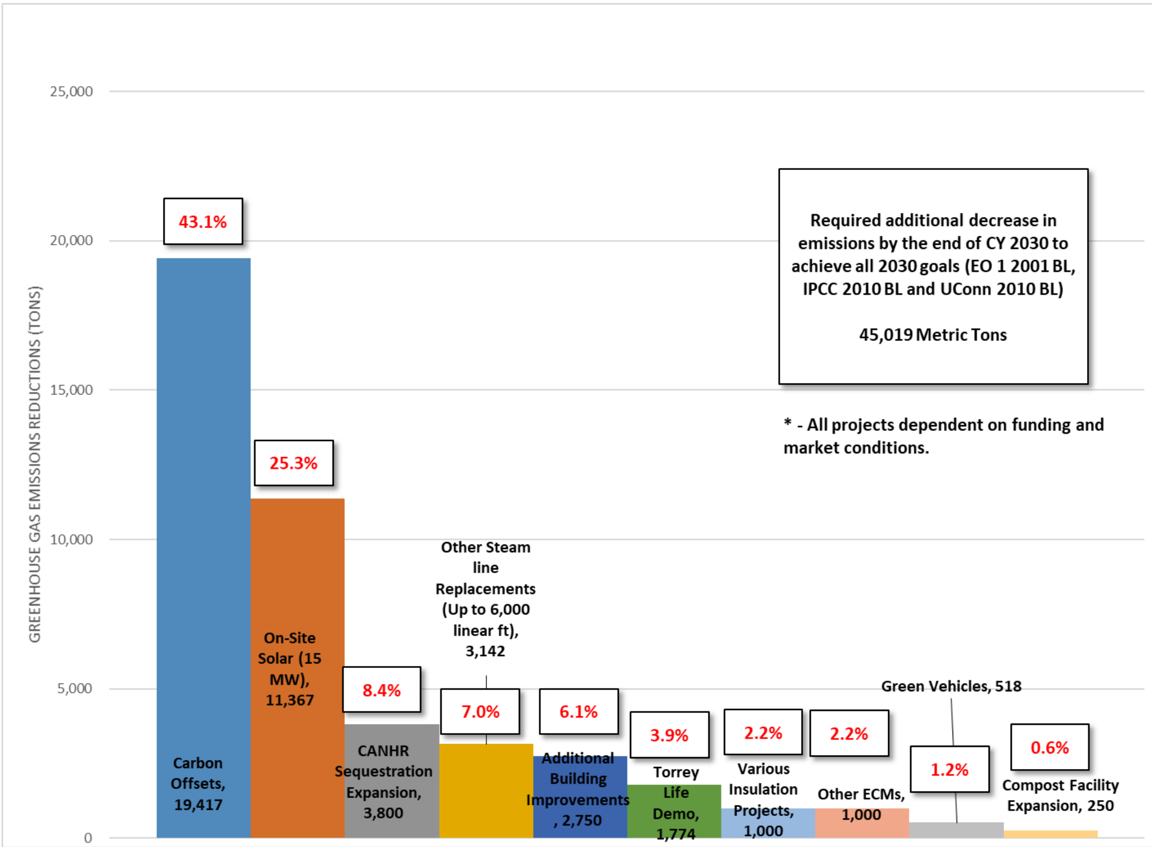


An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 25% by 2025 based on a 2007 baseline is shown in **Figure 8**. To achieve this goal, emissions would need to be reduced by 21,414 metric tons by the end of calendar year 2025 in addition to the 5,000 metric tons by the end of calendar 2020. The most predominant reductions in the 2021-2025 time-frame is estimated to come from lab ventilation management plan at 24.2% with on-site solar being the second at 17.7%.

NOTE: The Figures present one possible scenario to reach the end goals. Lab Ventilation is conceptual at this stage of our planning and cannot be included in **Figure 7** (Year 2020). It is included in **Figure 8** (Years 2021-2025) since if funded it should be possible to implement in that time. It is not included in **Figure 9** (Years 2026-2030) as it is expected to be completed.

Figure 9

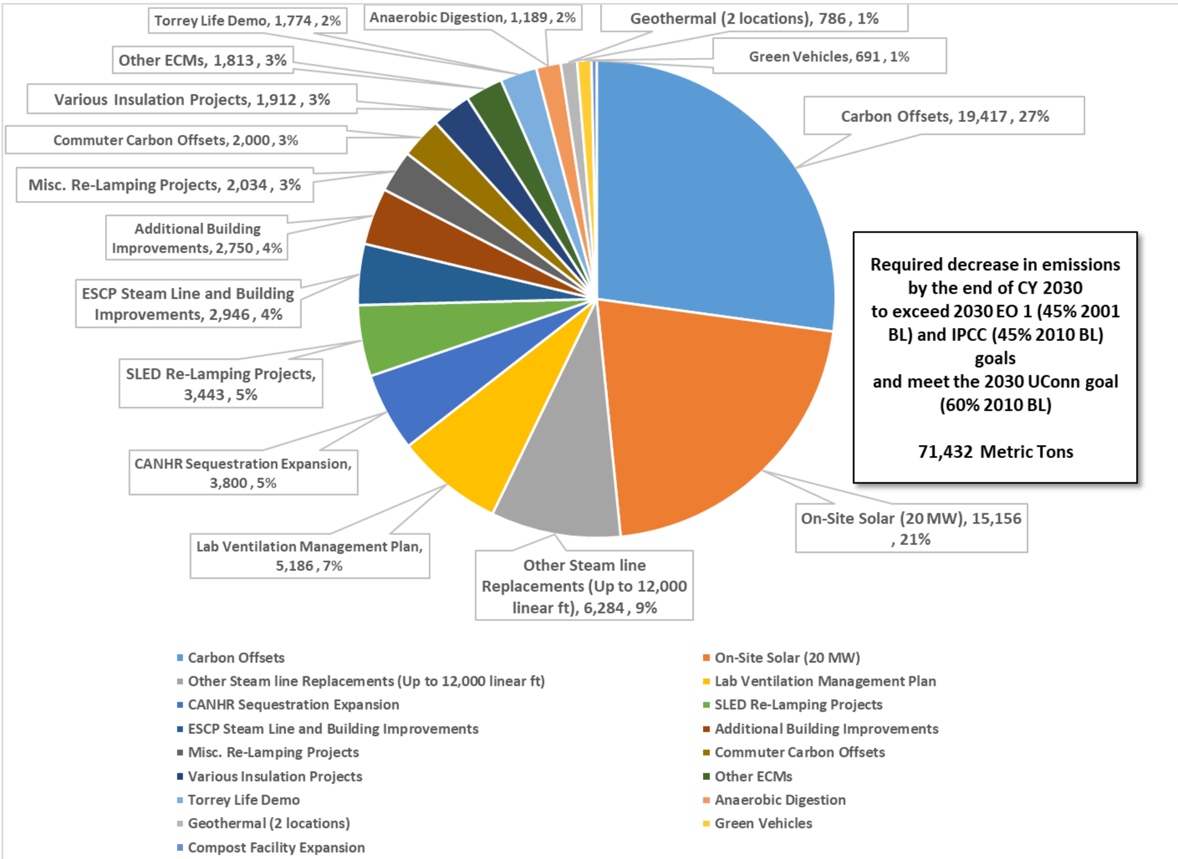
Required 2026-2030 GHG Emissions Reductions – Proposed Projects*



An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 60% by 2030 based on a 2010 baseline is shown in **Figure 9**. To achieve this goal, emissions would need to be reduced by 45,019 metric tons by the end of calendar year 2030. This is in addition to the 21,414 metric tons by the end of calendar year 2025 and the 5,000 metric tons by the end of calendar 2020. These reductions also achieve the Governor's EO 1 goal of 45% based on a 2001 baseline. The most predominant reductions in the 2026-2030 time-frame is estimated to come from carbon offsets at 43.1% with on-site solar being the second at 25.3%.

Figure 10

Required 2030 Total GHG Emissions Reductions Summary (Metric Tons)



An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 60% by 2030 based on a 2010 baseline is shown in **Figure 10**. The overall reductions would be 71,432 metric tons between 2020 and 2030. These reductions also achieve the Governor's Executive Order 1 goal of 45% based on a 2001 baseline. The most predominant reductions between 2020- 2030 timeframe are estimated to come from carbon offsets at 27% with on-site solar being the second at 21%.

6.7 **DRAFT Matrix of Potential Projects** in the Short-term, Mid-term, Long-term, with projections for reductions in greenhouse gas emissions

DRAFT MAY 8, 2020

6.7 DRAFT Matrix of Projects in the Short-term, Mid-term, Long-term, with projections for reductions in greenhouse gas emissions

University of Connecticut

Greenhouse Gas Reduction Targets	**2001 Baseline GHG Emissions (Metric Tons):**	**148,872**	
	2007 Baseline GHG Emissions (Metric Tons):	**138,872**	
	2010 Baseline GHG Emissions (Metric Tons):	**123,023**	
	45% of 2001 Baseline (Metric Tons):	**66,992**	**Governor's EO1 Goal**
	20% of 2007 Baseline (Metric Tons):	**27,774**	**UCONN Goal**
	30% of 2007 Baseline (Metric Tons):	**41,662**	**UCONN Goal**
	45% of 2010 Baseline (Metric Tons):	**55,360**	**IPCC Goal**
	60% of 2010 Baseline (Metric Tons):	**73,814**	**Proposed UCONN Goal**

Summary	**Time Period Emissions (Metric Tons)**			
	2007-2019	**2020**	**2021-2025**	**2026-2030**
Reductions from 2007 Baseline (Metric Tons)	**(23,190)**	**(4,440)**	**(17,013)**	**(45,019)**
Cumulative Totals		**(27,630)**	**(44,644)**	**(89,662)**
Percent Reduction/Increase (from 2007 Baseline)	**-17%**	**-20%**	**-32%**	**-65%**
Reductions from 2010 Baseline (Metric Tons)*	**(7,341)**	**(11,781)**	**(28,795)**	**(73,813)**
Percent Reduction/Increase (from 2010 Baseline)	**-6%**	**-10%**	**-23%**	**-60%**
Reductions from 2001 Baseline (Metric Tons)**	**(33,190)**	**(37,630)**	**(54,644)**	**(99,663)**
Percent Reduction/Increase (from 2001 Baseline)	**-22%**	**-25%**	**-37%**	**-67%**

* - Excludes emissions reductions achieved between 2007 and 2010.
** - Includes emissions reductions achieved between 2001 and 2007.

Project Description		**Time Period Emissions (Metric Tons)**			
		2007-2019	**2020**	**2021-2025**	**2026-2030**
Completed Projects					
Retro-Commissioning (23 Buildings in 4 Phases)	Eversource Modeling LOA Estimates	(11,806)			
Re-lamping (223 Projects)	Eversource Modeling LOA Estimates	(8,726)			
Other ECM's (81 Projects)	Eversource Modeling LOA Estimates	(3,918)			
Impact of Natural Gas Curtailment	Up to 30 days at 190 metric tons net increase per	5,700			
North Eagleville Road Area Steam/Condensate Replacement Phase I (2014)	Energy Savings (Estimated)	(132)			
North Eagleville Road Area Steam/Condensate Replacement Phase II (2015)	Energy Savings (Estimated)	(437)			
North Eagleville Road Area Steam/Condensate Replacement Phase IIIA (2016)	Energy Savings (Estimated)	(2,658)			
ESCO Steam/Condensate Replacement (2,639 feet of steam line. Completed in 2016)	ConEdison IGA Energy Savings	(1,571)			
Oak Hall (2012)	Energy Consumption (LEED Modeling Estimate)	818			
McHugh Hall (2012)	Energy Consumption (LEED Modeling Estimate)	405			
Basketball Facility (2014)	Energy Consumption (LEED Modeling Estimate)	690			
Reclaimed Water Facility (2014)	Energy Consumption (LEED Modeling Estimate)	721			
Central Utility Plant Steam Chiller Expansion (2015)	Energy Consumption (Estimated to generate	3,970			
Peter J. Werth Residence Tower (2016)	Energy Consumption (LEED Modeling Estimate)	1,258			
Main Accumulation Area (2017)	Energy Consumption (Estimated)	302			
New Engineering and Science Building (2017)	Energy Consumption (LEED Modeling Estimate)	1,578			
Innovative Partnership Building (2017)	Energy Consumption (LEED Modeling Estimate)	2,022			
Central Warehouse Boiler Renovations (2018)	Energy Consumption (Estimated)	455			
ITS Modular Building (2018)	Energy Consumption (Estimated)	203			
North Eagleville Road Area Steam/Condensate Replacement Phase IIIB (2018)	Energy Savings (Estimated)	(1,329)			
Koons, Family Studies, Manchester Steam/Condensate Lateral Replacements (2018)	Energy Savings (Estimated)	(818)			
Student Recreational Center (2019)	Energy Consumption (LEED Modeling Estimate)	1,247			
ESCO Building Improvements (7 Science Buildings. Completed in 2019)	ConEdison IGA Energy Savings	(2,750)			
Athletic Complex Lighting (6 Facilities) (Completed in 2019)	Energy Savings (Estimated)	(1,629)			
Various Insulation Projects (Completed 2019)	Energy Savings (Estimated)	(1,384)			

Project Description		Time Period Emissions (Metric Tons)			
		2007-2019	2020	2021-2025	2026-2030
Completed Projects					
On-Going Projects					
Impact of Natural Gas Curtailment	Up to 10 days at 190 metric tons net increase per			1,900	
Re-Lamping (Projects not covered under ESCO, SLED or ECSP. On-going)	Energy Savings (Estimated)		(932)	(1,102)	
100% Conversion of Light Duty Vehicles to Hybrid or Electric (On-going)	Energy Savings (Estimated)			(173)	(518)
Various Insulation Projects (On-going)	Energy Savings (Estimated)		(537)	(376)	(1,000)
Other ECM's (On-Going)	Energy Savings (Estimated)		(355)	(458)	(1,000)
Proposed Projects					
SLED Lighting Projects	Energy Savings (Estimated)		(1,175)	(2,268)	
Lab Ventilation Management Program Initiative	Energy Savings (Estimated)			(5,186)	
Stadia Complex Building (Anticipated construction completion in 2020)	Energy Consumption (LEED Modeling Estimate)		327		
Fine Arts Addition (Anticipated construction completion in 2020)	Energy Consumption (LEED Modeling Estimate)		232		
Public Safely Building Expansion (In Design. Anticipated construction completion in 2021)	Energy Savings (Estimated)			31	
New Ice Hockey Arena (In Design. Anticipated construction completion in 2021)	Energy Savings (Estimated)			873	
Science 1 (In Design. Anticipated Construction Completion 2022)	Energy Consumption (LEED Modeling Estimate)			1,596	
ECSP Steam/Condensate Replacement (2,000 to 3,000 feet of steam line. TBD)	Energy Savings (Estimated)			(1,571)	
Additional Building Improvements	Energy Savings (Estimated)			(1,375)	(2,750)
Steam/Condensate Replacement (4,000 to 6,000 feet of steam line. TBD)	Energy Savings (Estimated)			(3,142)	(3,142)
On-Site Solar Installations	Energy Savings (Estimated)			(3,789)	(11,367)
Geothermal Installations (CESE and Bishop)	Energy Savings (Estimated)			(786)	
Anaerobic Digestion	Energy Savings (Estimated)			(1,189)	
CANHR Sequestration Expansion	Energy Savings (Estimated)				(3,800)
Compost Facility Expansion	Energy Savings (Estimated)				(250)
Demolition of Torrey Life Science Building (Master Plan Concept)	Energy Savings (Estimated)				(1,774)
Science 2 (Master Plan Concept)	Net Zero Building				0
New Residence Hall (Master Plan Concept)	Net Zero Building				0
Offsets					
Misc. Offsets (Forest Preservation, Composting)	Energy Savings (Estimated)	(5,399)			(19,417)
Commuter Carbon Offsets (20% Participation Rate)	Energy Savings (Estimated)		(2,000)		

6.8 Future Work Plan

Based on the strategic plan laid out for carbon emission reduction, the PWGS will work with consulting firms in the summer and fall of 2020 to evaluate economic factors and budget of each strategy implementation, determine the cost associated with infrastructure renovation and retrofit, and assess the feasibility of resource allocation. It should be kept in mind that achieving zero-carbon emission in the long run will position UConn as the flagship institution for environmental sustainability, benefit everyone working and living around the campus, and ultimately convert UConn to "living laboratories" with multidisciplinary clusters of education, research and outreach.

Acknowledgements

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University of Connecticut Environmental Terminology/Acronyms

A

Adaptation – Activities that increase the resiliency of campus buildings and infrastructure to withstand system disruptions.

Air Pollution – Occurs when gases, smoke or dust particles are emitted into the atmosphere in any way that is harmful to people, animals or our environment. Air pollution includes greenhouse gas generation (GHG). *Source: UConn Air Quality Frequently Asked Questions*

B

British Thermal Unit (BTU) – A unit of measure for thermal energy which is defined as the amount of heat needed to raise the temperature of one pound of water at maximum density by one degree Fahrenheit. One million BTUs is often written as MMBTU. *Source: The Engineering ToolBox*

C

Carbon Dioxide (CO_2) – A naturally occurring gas, and also a by-product of burning fossil fuels, as well as land-use changes and other industrial processes. It is the principal greenhouse gas that affects the Earth's temperature because of its long atmospheric lifetime. It is the reference gas against which other greenhouse gases are measured and, therefore, has a global warming potential of one. *Source: U.S. Environmental Protection Agency*

Carbon Dioxide Equivalents (CO_2e) – A measure used to aggregate the effect of multiple greenhouse gases in terms of the reference greenhouse gas which is carbon dioxide. For example, the global warming potential of one metric ton of atmospheric methane is equivalent to that of 21 metric tons of carbon dioxide. Once the global warming potential is applied to each gas, the emissions can be summed to determine the overall impact of the greenhouse gases on the atmosphere. *Source: U.S. Environmental Protection Agency*

Carbon Emissions – Polluting carbon substances released into atmosphere. In the context of this report, this term refers to greenhouse gases, principally CO_2. *Source: Boston University Sustainability Glossary of Terms*

Carbon Footprint – An estimate of carbon emissions produced to support campus activities. Factors that contribute to a carbon footprint include fuel consumption from stationary sources and transportation. *Source: U.S. Environmental Protection Agency*

Carbon Neutrality – Equivalent to "net zero carbon emissions" (*quod vide)*.

Carbon Offsets – A reduction or removal of atmospheric carbon used to compensate for activities that generate carbon emissions on campus. Carbon offsets are typically purchased from a source of zero carbon emissions or an activity that sequesters carbon like reforestation projects. A purchased carbon offset represents a one-metric-ton reduction of carbon dioxide emissions *Source: U.S. Environmental Protection Agency*

Clean Energy – Energy derived from non-polluting sources. Some examples of clean energy sources are solar energy, wind energy, hydropower and geothermal energy. *Source: Department of Energy*

Climate Change – Climate change refers to any significant change in measures of climate (such as temperature, precipitation or wind) lasting for an extended period of time (decades or longer). Climate change may result from:

- Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun.
- Natural processes within the climate system (e.g. changes in ocean circulation).
- Human activities that change the atmosphere's composition (e.g., through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanization, desertification, etc.). *Source: Boston University Sustainability Glossary of Terms*

Cogeneration or Combined Heat and Power (CHP) – Electricity generation where the waste heat is recovered and used for heating and cooling. This is a highly efficient process.

E

Energy Conservation Measure (ECM) – Any type of project implemented to reduce energy consumption in a campus building. *Source: Wikipedia*

Energy Services Agreement (ESA) – A pay-for-performance, off-balance sheet financing solution that allows customers to implement energy efficiency projects with zero upfront expenditure. The ESA provider pays for all project development and construction costs. Once the project is operational, the customer makes service charge payments for actual realized savings. *Source: Department of Energy Office of Energy Efficiency and Renewable Energy.*

Energy Savings Performance Contract (ESPC) – A contract between a facility and a qualified Energy Service Company (ESCO) provider for evaluation, recommendation and implementation of one or more energy-savings measures. An energy-savings performance contract shall be a guaranteed energy-savings performance contract, which shall include, but not be limited to, (A) the design and installation of equipment and, if applicable, operation and maintenance of any of the measures implemented; and (B) guaranteed annual savings that meet or exceed the total annual contract payments made by the state agency or municipality for such contract, including financing charges to be incurred by the state agency or municipality over the life of the contract. *Source: Section 16a-37x of the Connecticut General Statutes*

Energy Use Intensity (EUI) – The measurement of annual energy consumption relative to gross square footage. This is typically measured in thousands of British Thermal Units per square foot (KBTU/ft^2/year). EUI allows for comparison of energy intensity of different types of buildings on campus. *Source: U.S. Environmental Protection Agency Energy Star*

G

Global Warming Potential (GWP) – The ratio of energy absorbed by one ton of a greenhouse gas over a given period of time (typically 100 years) relative to one ton of carbon dioxide. Applying the GWP to each greenhouse gas allows for the comparison of the impact of each gas on the atmosphere. The overall effect of a specific greenhouse gas depends on its atmospheric lifetime. *Source: U.S. Environmental Protection Agency*

Greenhouse Gases (GHG) – Gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone, organic chemicals (chlorofluorocarbons) and many others, which trap heat radiating from the Earth's surface causing warming in the lower atmosphere resulting in global warming. Greenhouse gas emissions from activities at a college campus are separated into the following categories:

- Scope 1 – On-campus fuel consumption from fuel burning stationary sources (turbines, boilers, chillers, generators, etc.), university-owned vehicles and equipment, agriculture sources (i.e., fertilizer applications) and refrigerants and other chemical uses that contain greenhouse gases (i.e., HCFC-22, HFC-134a).
- Scope 2 – Purchased imported electricity from the grid.
- Scope 3 – Indirect sources of emissions that occur from the operational activities on campus including employee and student commuting and business travel. *Source: U.S. Environmental Protection Agency*

Greenhouse Effect – The process that occurs when Greenhouse Gases in the Earth's atmosphere trap heat radiating from the Earth's surface and prevent heat loss to space. which makes the Earth warmer than it would be without this atmosphere. Humans are amplifying Earth's Greenhouse Effect by burning fossil fuels and adding carbon dioxide to the atmosphere at a rate unprecedented in the geologic record. *Source: U.S. Environmental Protection Agency*

H

Hillside Environmental Education Park (HEEP) – 165-acre preservation area located on UConn's North Campus. The preserve consists of uplands, meadows, woodlands, wetlands (including vernal pools) and riparian zones around Cedar Swamp Brook, which runs through the HEEP to Mansfield's Pink Ravine. The park includes a network of hiking trails extending north from a trailhead near the C-Lot to Hunting Lodge Road and Discovery Drive. *Source: UConn Office of Sustainability*

K

Kilowatt (kW) – A unit of measure for electrical power (energy per time) that is equivalent to one thousand watts.

Kilowatt-hour (kWh) – A unit of measure for electrical energy that is equivalent to operating at 1 kW for one hour.

M

Megawatt (MW) – A unit of measure for electrical power that is equivalent to one million watts or one thousand kilowatts.

Megawatt-hour (MWh) – A unit of measure for electrical energy that is equivalent to operating at 1 MW for 1 hour, or 1 kW for 1000 hours.

Methane (CH_4) – A colorless odorless flammable gaseous hydrocarbon which is a product of anaerobic biological decomposition of organic matter. Methane is the main constituent of natural gas and is also produced in anaerobic digesters. Combustion converts methane to carbon dioxide. Unburned methane released to the atmosphere is a far more potent greenhouse gas than CO_2. *Source: Merriam-Webster Dictionary*

Mitigation – Reduction of potential threats to the environment (e.g., reduction of greenhouse gas emissions to mitigate climate change).

N

Net Zero Carbon Emissions – The condition where all greenhouse gas emissions are offset by removal of atmospheric carbon dioxide or verifiable reductions of emissions elsewhere. *Source: U.S. Environmental Protection Agency*

Nitric Oxide (N2O) – A colorless gas formed by the oxidation of nitrogen or ammonia that is present in the atmosphere. It is also a by-product of burning fossil fuels and agricultural activities. *Source: Merriam-Webster Dictionary*

P

Power Purchase Agreement (PPA) – A contract for renewable energy between a third-party seller of that renewable energy system and the buyer of the generated electrical power. The buyer signs a long-term contract with a third-party seller who agrees to build, maintain and operate a renewable energy system either on-site or off-site. The buyer receives the delivery of electricity through the grid for a fixed monthly cost typically through a 20-year term. *Source: U.S. Environmental Protection Agency*

Public Utilities Regulatory Authority (PURA) – A Connecticut state agency statutorily charged with regulating the rates and services of Connecticut's investor owned electricity, natural gas, water and telecommunication companies and is the franchising authority for the state’s cable television companies. *Source: portal.ct.gov/PURA*

R

Renewable Energy – Energy source that can be continuously replenished. Examples of renewable energy include solar, wind, hydropower, geothermal and biomass energy. *Source: Penn State Extension*

Renewable Energy Certificates (RECs) – A market-based commodity that certifies the electricity represented by the REC was generated by a renewable energy source. A purchased renewable energy certificate represents one megawatt-hour of electricity used to reduce generated campus Scope 2 (purchased electricity) greenhouse gas emissions. *Source: U.S. Environmental Protection Agency*

Resiliency – The ability to recover from or adjust easily to adverse changes to campus operations or bad weather conditions. Energy resiliency, the ability to switch between different fuel types, avoids disruptions in the delivery of utility services.

Retro-commissioning (RCx) – A systematic process to improve an existing building’s operational performance. The implementation of RCx strategies ultimately leads to energy efficiencies which in turn reduces emissions. *Source: https://www.facilitiesnet.com/energyefficiency/article/Retrocommissioning-for-Better-Performance--4097*

S

Sustainability – The responsible interaction with the environment to find a balance between environmental, economic and social needs in the present without compromising the ability of future generations to meet their needs. *Source: UN World Commission on Environment and Development*

Z

Zero Carbon – Activities that emit no carbon emissions such as the generation of electricity utilizing solar, wind or nuclear power. *Source: https://cleantechrising.com/whats-the-difference-between-carbon-neutral-zero-carbon-and-negative-emissions/*

Planning for a Zero-Carbon Future

APPENDIX A

1) **BACKGROUND**

a) **President Katsouleas letter, dated October 2, 2019 (from Report sec 3)**

Climate change is more than an emergency; it is a global crisis worsening by the day. Though the world has been warned about our rapidly warming climate for decades, for much of that time many regarded it as a future problem, to be addressed by future people. Today, we are in the midst of that future.

This generation of Americans are seeing and experiencing the effects of climate change in our own lives and across the globe in ways past generations either did not, or were not aware of. And if warming continues unabated, we know that we will see ever-greater consequences in our own lifetimes, especially those born in more recent years.

This issue is of the utmost importance to the UConn community, including myself, and we have an obligation to explore setting more ambitious goals than we already have.

But any commitment we make must be real. By that I mean it must be truly achievable and realistic based on data, analysis and the best estimates we are able to make about things like cost, technological capabilities and pace.

There is widespread agreement on the imperative of reducing emissions. The questions for us, as always, are: What is achievable within the boundaries of our fiscal resources and the need to operate the university, and how quickly can we get there?

I believe that our analysis and discussions about our goals and policies must happen in concert with discussions about resources and priorities, as one is dependent on the other and there is a natural tension between them.

Setting priorities and aligning budgets to support them is always about making choices. It is not the case that certain priorities "cannot" be funded within reason;

It is the case that funding one often means taking resources from others, requiring trade-offs in the form of compromise and sacrifice;

These are difficult decisions that need to be made thoughtfully and transparently.

b) **Other UConn commitments (from Report sec 4.1)**

i) Spring 2015 – The Board of Trustees approved the 2015-2035 Campus Master Plan, including a Sustainability Framework (Appendix A), which proposed an acceleration of UConn's CAP and recommended planning goals to achieve this in Energy and Transportation Focus Areas
ii) Summer 2016 – The Board of Trustees approved an amendment to UConn's Sustainable Design & Construction Policy, requiring all new construction and major renovation projects

to achieve LEED Gold certification (revised from a minimum LEED Silver certification policy adopted in 2007)

iii) January 2017 – In a "welcome back" message to the University community, President Herbst reiterated UConn's commitment to sustainability as a core value and endorsed the *2020 Vision Plan for Campus Sustainability and Climate Leadership*

iv) February 2017 – President Herbst became a member of Second Nature's Climate Leadership Steering Committee, joining 17 other presidents and chancellors of colleges and universities across the country

v) June 2017 – UConn became a signatory member of the "*We Are Still In*" coalition, joining nearly 3,000 businesses, cities, states and universities pledging to uphold the commitments of the Paris Agreement on Climate Change, after the Trump Administration had announced the U.S.'s intentions to withdraw

vi) Spring 2018 – UConn held its first-ever Metanoia on the Environment, which featured 44 events held throughout the 2018 spring semester

vii) July 2018 – UConn joined Second Nature's University Climate Change Coalition (UC3,) a consortium of 18 prestigious North American research universities working together to apply research and share knowledge to advance multi-sector climate action and resilience

viii) October 2018 - The University Senate passed a three-credit environmental literacy general education requirement, which became effective for all UConn graduates last fall

ix) Fall 2018 – UConn's USG Executive Committee, along with EcoHusky and other student groups, wrote a letter (later endorsed by the Senate) urging the Presidential Search Committee to consider only candidates with a demonstrated commitment to sustainability in their previous positions

x) October 2019 – In response to events more fully described above (Section II), President Katsouleas issued a statement accelerating UConn's 2030 interim CAP carbon-reduction goal from 40% to 45%, extending that goal system-wide (beyond the main campus), and creating the President's Environmental & Sustainability Workgroup.

c) **Other successful and established UConn events,** activities and organizations focused on environmentally sustainable outreach and engagement

i) Carbon Neutral Green GameDays – a partnership with Athletics held at one UConn football and men's and women's basketball game each season; the OS organizes dozens of student volunteers and buys carbon offsets to make the basketball games at Gampel Pavilion carbon neutral

ii) Earth Day Spring Fling – but for COVID-19, April 21st would have marked the 12th annual celebration of environmental awareness held on Fairfield Way, which is co-hosted by Dining Services, EcoHusky and the OS, and features 50 exhibitors and sustainable product vendors

iii) Bicycle Workgroup; UConn CycleShare – begun informally a few years ago at the urging of the local "Bike Mansfield" organization (Mansfield is a certified Bicycle Friendly

Community), this group is now more officially recognized as a subcommittee of UConn's Transportation Advisory Committee and meets monthly to promote and recommend improved campus bike safety programs, amenities and services, including continued enhancements of UConn's bike loaner program, UConn CycleShare, administered by Recreational Services

iv) Green Campus Academic Network (GCAN) – a collaborative group of faculty members, including senior faculty members and new assistant professors, both tenure track and non-tenure track, convened by the OS to develop and help coordinate "living laboratory" projects and innovative experiential learning opportunities around sustainability-related education, research and outreach topics.

v) Digital Poster in McMahon Classroom Bldg.

vi) EcoHusky Student Group

vii) EcoHouse Living Learning Community

viii) Environmental Policy Advisory Council

ix) Biennial Environmental Leadership Awards – By recognizing and rewarding individuals and teams across the University for successful sustainability projects and efforts, UConn encourages continued innovation and increased awareness

x) EcoCaptains in 20+ dorms beginning Fall Semester 2020

xi) Collaboration with Residential Life

xii) In-house sustainability change agents

2) PARAMETERS AND REGULATIONS

a) Federal and State Regulations

i) Carbon Taxes Market-Based Greenhouse Gas Emission Reduction Legislation: 108th through 116th Congresses https://fas.org/sgp/crs/misc/R45472.pdf

ii) https://fas.org/sgp/crs/misc/R45625.pdf https://fas.org/sgp/crs/misc/R40242.pdf

iii) https://crsreports.congress.gov/product/pdf/IF/IF11103

iv) https://crsreports.congress.gov/product/pdf/R/R42731

v) Resource Compares All the Carbon Tax Proposals in Congress https://energypolicy.columbia.edu/what-you-need-know-about-federal-carbon-tax-united-states and https://energypolicy.columbia.edu/carbon-tax-initiative-research

vi) Carbon in the US https://www.eia.gov/environment/emissions/carbon/ Growth and Restrictions on Future Gas Supply https://www.cga.ct.gov/2016/rpt/2016-R-0161.htm and http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/32723b39b1c8b69885257fc6006cf337/$FILE/DEEP_Final%20Gas%20RFP_6.2.16.pdf http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/ffee9c54378d404a85257f710054fb32/$FILE/RFP_03-09-16_CLEAN.pdf DEEP Request for Proposals for Natural Gas Capacity, Liquefied Natural Gas, and Natural Gas Storage (http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/32723b39b1c8b69885257fc6006cf337/$FILE/DEEP_Final%20Gas%20RFP_6.2.16.pdf).

vii) DEEP, Energy Filings, PA 15-107, § 1(d) – Natural Gas Capacity , LNG, and Natural Gas Storage Procurement, Proposals (http://www.dpuc.state.ct.us/DEEPEnergy.nsf/$EnergyView?OpenForm&Start=30&Count=30&Expand=33.4&Seq=3).

viii) OLR Report 2014-R-0267 (https://www.cga.ct.gov/2014/rpt/pdf/2014-R-0267.pdf).

ix) OLR Report 2015-R-0108 (https://www.cga.ct.gov/2015/rpt/pdf/2015-R-0108.pdf).

x) Projected Value of Class 1 and Class 3 RECs https://poweradvisoryllc.com/new-england-class-i-rec-market-update/ and https://programs.dsireusa.org/system/program/detail/195 and https://www.evomarkets.com/content/news/reports_29_report_file.pdf

xi) CT Green New Deal https://www.cga.ct.gov/asp/cgabillstatus/cgabillstatus.asp?selBillType=Bill&which_year=2019&bill_num=5002&utm_source=Unknown+List&utm_campaign=df4c5771a3-EMAIL_CAMPAIGN_2019_02_21_06_18&utm_medium=email&utm_term=0_-df4c5771a3- and Carbon Tax Legislation https://www.cga.ct.gov/2018/rpt/pdf/2018-R-0327.pdf

(1) Carbon Price

b) Renewable Energy Benchmarks

i) National, Regional, State https://www.eia.gov/outlooks/aeo/ https://www.eia.gov/renewable/

ii) Other Higher Ed institutions https://www.nrel.gov/docs/fy17osti/67900.pdf and https://www.eia.gov/totalenergy/data/annual/ https://hub.aashe.org/browse/topics/energy/

3) TECHNOLOGIES AND STRATEGIES

a) **Current On-going and Proposed Carbon Reduction Projects**

i) Re-Lamping (Projects not covered under ESCO, SLED or ECSP) – Lighting projects to convert existing fixtures to LED. These projects are being completed by UConn Facilities Operations personnel. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource in coordination with UConn’s Memorandum of Understanding (MOU) agreement to reduce energy consumption over a three year period. If Eversource estimates were not available for certain proposed projects, energy savings factors per square foot were developed using completed lighting projects and the proposed project’s building area to be converted to LED.

ii) 100% Conversion of Light Duty Vehicles to Hybrid or Electric – Greenhouse gas reductions based on the difference in emissions between the gasoline-powered light duty vehicles in UConn’s fleet and replacement hybrid or electric vehicles.

iii) Various Insulation Projects – The installation of insulation around bare thermal piping and valves in various building locations. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.

iv) Other ECMs – Other Energy Conservation Measures (ECMs) includes the installation of Variable Air Valve (VAV) technology in HVAC systems to allow for variable control of flow, electric chiller replacement at Castleman Hall and replacement of dining hall cooking ventilation systems to reduce energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.

v) SLED Lighting Projects – Storrs LED lighting projects or SLED to convert existing fixtures to LED in approximately 3 million square feet of campus buildings. These projects will be completed by outside lighting contractors. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.

vi) Lab Ventilation Management Program Initiative – A program to develop, manage and maintain plans and procedures in consultation with EHS and Facilities Operations to ensure ventilation systems in laboratories and other work areas perform optimally, ensure worker safety and minimize energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings estimates were developed by UConn Facilities Operations energy consultant.

vii) Steam and Condensate Replacement projects – In order to maintain existing steam infrastructure in the short term, various repair/replacement projects may be required. Greenhouse gas reduction estimates are based on predicted energy savings for steam and condensate replacement projects consisting of approximately 2,000 to 3,000 linear feet were developed using a similar project completed under the ESCO project by ConEdison. That project resulted in the installation of approximately 2,600 linear feet of steam and condensate piping along Hillside Road.

viii) Additional Building Improvements – Building improvements can include retro-commissioning, lighting re-lamping projects, HVAC improvements among other identified ECMs. Greenhouse gas reduction estimates are based on predicted energy savings for building improvements were developed using a similar project completed under the ESCO project by ConEdison. That project included building improvements for seven energy intensive science buildings. The project in the 2021-2025 timeframe would be similar process to the ESCO project and would include up to 24 other building types such as administration, instructional and residential. Therefore, energy savings for these buildings was assumed to be half the science building energy savings. For the 2026-2030 timeframe, it is assumed that an additional 48 buildings may be identified for improvements based on the results of the proposed Building Assessments and Energy Audits to be completed by Facilities Operations.

ix) On-Site Solar Installations – A solar calculator developed by the National Renewable Energy Laboratory (NREL) was used to estimate the amount of kilowatt hours that would be generated by the proposed solar installation. Greenhouse gas reduction estimates are based on predicted energy savings from the amount of kilowatt hours generated by the solar installation. The estimates include 5 MW in the 2021-2025 timeframe and an additional 15 MW in the 2026-2030 timeframe.

x) Geothermal Installations – Geothermal installations are assumed to reduce energy consumption required for heating and cooling the building. Greenhouse gas reduction estimates are based on predicted energy savings developed by UConn's Framework consultant BVH. Two potential projects were identified at CESE and the Bishop Center.

xi) Anaerobic Digestion – A proposed anaerobic digestion facility is assumed to utilize 500 tons of food waster along with manure from 100 cows managed by farm services. The processing of these materials would result in reductions of CO2 and methane emissions. Greenhouse gas emissions reductions developed by UConn's Framework consultant BVH.

xii) CAHNR Sequestration Expansion – The setting side additional UConn forestland that can provide a carbon offset as a result of forest sequestration. Estimated reductions provided by the Sustainability Office.

xiii) Compost Facility Expansion – Greenhouse gas emissions reductions based on doubling the size of the existing composting facility. Estimated reductions provided by the Sustainability Office.

xiv) Demo of Torrey Life Science – Greenhouse gas reduction estimates are based on predicted energy savings from the elimination of energy consumption for this science building.

xv) Science 2 and New Residence Hall (Master Plan Concepts) – These are potential new construction projects identified in the Master Plan. If construction proceeds with these projects, it is assume both would implement strategies so that the buildings are net zero carbon.

xvi) Carbon offsets – In order to meet the 60% reduction goal by 2030, it is assumed the University would need to purchase over 19,000 metric tons of carbon offsets. This would be annual purchases until such time actual emissions are reduced below the 60% level.

b) **Current and Emerging Technologies**

i) Fossil Fuels: the current UConn strategy

ii) Solar

(1) Total energy consumption by humans is approaching 20 TW (terawatts). This is a large energy demand and it is largely met using fossil fuels today. But fossil fuels are not required. At any point in time, the total soar power incident on the Earth's surface is about 96,000 TW. The astounding abundance of this resource is sufficient to meet any conceivable human need, even after considering reasonable limits on its harvestability. For example, covering 1% of Earth's surface with solar panels having a solar-to-electric power conversion efficiency (PCE) of 15% would generate 144 TW.

(2) Use of the solar resource is complicated by significant temporal variability. There is significant seasonal variation, with more than twice as much sunlight in summer as in

winter. There is the predictable diurnal cycle, with obviously no power available at night. And there are unpredictable fluctuations due to weather. Fortunately, the diurnal cycle aligns well with summer cooling needs. Coping with the remaining variations of the solar resource requires either energy storage (e.g. batteries) or blending solar power with other energy sources that are stable or at least that have intermittencies that correlate poorly with that of solar power.

(3) The amount of harnessable solar energy at a particular site depends on latitude and atmospheric conditions. A database maintained by the National Renewable Energy Laboratory indicates that Storrs, CT has a year-averaged insolation (incident solar power) of 4.77 kWh/m^2/day, with the average power available rising to 6.42 kWh/m^2/day in the month of July and falling to 2.61 kWh/m^2/day in December. State-of-the-art solar panels with a PCE of 19% could generate about 5,350 kWh of electricity per square meter of panel per year.

iii) Geothermal

(1) At sufficient depths (e.g. 20 feet), the ground maintains a fairly stable temperature year-round of 50-55 °F. Circulating a fluid through the ground and then through a heat pump allows a substantial part of the thermal energy for heating and cooling to be sourced from the ground rather than by burning fossil fuels, dramatically reducing energy demands and costs. A small amount of electricity is required to run the circulation pumps and heat exchangers. Additional heat can be provided by electrically powered heat pumps. The low energy intensity (and electricity only) requirement of geothermal heating/cooling systems make them particularly useful in the quest to achieve an electrified, zero-carbon campus.

(2) UConn should focus immediately on identifying off-the-CUP buildings, where geothermal retrofits are most beneficial (e.g., Bishop Center, Institute of the Environment). Installation of small geothermal systems at these buildings would replace stand-alone boilers and chillers and immediately yield reduced energy costs and lower carbon emissions, with a fast payback period.

(3) Geothermal projects of any size would also generate marketable Class 1 RECs. UConn's revenue from the sale of these RECs could be dedicated to the purchase of carbon offsets or funding of ongoing energy efficiency initiatives at UConn.

(4) As part of the goal for a zero-carbon campus by 2040 (see Recommendation One in the Report), UConn should begin evaluating larger-scale geothermal closed loop wellfields, ground-source heat pumps and thermal storage systems at strategic locations on campus.

   (a) The combined heat and power Cogen facility currently generates 95 percent of the electricity used at the main campus, and is fueled by natural gas, with back-up oil and is a source of Scope 1 emissions. High-pressure steam, a byproduct of the Cogen's electric generating process, plus steam from fossil fuel- fired boilers at the

CUP and proposed SUP, currently is used for heating and cooling to meet 75 percent of thermal energy demand at the main campus.

(b) As the campus increases its use of renewable electricity and thermal energy technologies, larger scale geothermal systems may be a proven, low-cost, low-maintenance way to gradually replace high-cost, high-maintenance centralized steam systems as they age.

  (i) Larger geothermal systems may serve multiple buildings and provide district heating and cooling throughout campus and, where applicable, could make use of steam infrastructure that is retrofitted for low temperature hot water distribution systems, with low operating costs.

(c) Larger geothermal wellfields could be installed near the buildings they will be heating or cooling in order to minimize distribution infrastructure and construction costs. Open areas on campus are best-suited for such systems.

  (i) Since such wellfields are drilled at considerable depths and never need maintenance, they can be installed without impact on surficial or sub-surface stormwater management systems. This is especially true of the more natural LID/Green Stormwater Infrastructure features, like rain gardens and bio-retention basins.

(d) Geothermal should also be considered as an option for heating and cooling needs at all new construction projects, and potentially may be installed beneath buildings without impacting construction schedules.

(e) Below is a list of links describing a few of the geothermal systems and projects in higher education:
http://www.bu.edu/sustainability/what-were-doing/green-buildings/geothermal/
http://miamioh.edu/news/top-stories/2019/11/converting-campus-off-steam-by-2026.html
https://www.nd.edu/stories/going-geothermal/
https://www.usnews.com/news/best-states/illinois/articles/2019-05-16/university-of-illinois-set-to-install-new-geothermal-system
https://sustainability.illinois.edu/geothermal-energy-illinois-researchers-rocking-the-earths-surface-part-ii/
https://www.carleton.edu/community/news/carleton-shifts-to-geothermal-cooling-heating-for-east-side-of-campus/
https://www.carleton.edu/community/news/carleton-constructs-geothermal-well-fields/
https://www.hpac.com/archive/article/20926969/geothermal-the-new-big-man-on-campus
https://www.nwf.org/-/media/PDFs/Campus-Ecology/Reports/Geothermal-Guide-FINAL-3-1-11.ashx

iv) **Anaerobic Digestion/Biogas** - UConn does not have the volume of organic waste that would make owning and operating an anaerobic digester for large-scale production of biogas economically feasible. However, there are commercial entities who could provide UConn with greater volumes of biogas from large-scale anaerobic digesters as a method for reducing our carbon footprint.

(1) UConn could build small-scale digesters to create biogas. These digesters could be located near UConn-owned facilities and operations that generate or store larger sources of organic waste, such as the Kellogg Dairy Barn. (Note: UConn already composts about half of the manure from Agricultural Operations/Farm Services at our compost facility off of Rte. 32). This biogas could be mixed with natural gas in order to reduce GHG emissions from other stand-alone gas-burning sources on campus. This is because methane emissions from decomposing organic waste are 34 times more potent than CO2 as a GHG - anaerobic digesters not only eliminate these methane emissions but also displace the use of natural gas with renewable biogas. Food waste generated from the UConn Storrs campus is about 800 tons per year. In addition, UConn wastewater treatment plant generates over 5 million gallon waste sludge (250 metric tons volume) annually, which has been treated anaerobically off campus for methane production. Given 0.35 m3 methane production per ton organic wastes, the methane production from food waste and waste sludge generated from UConn is about 350 m3 annually, which can be converted to heating source and/or bioelectricity grid. This is an efficient way for carbon offset.

(a) Duke University mixes 11% biogas from anaerobic digesters with natural gas for this purpose. This approach could also reduce UConn's natural gas purchasing costs.

(b) Small scale digesters would also be excellent on-campus "living laboratories" serving both operational and academic needs related to education, research and outreach.

(2) There are other commercial entities who own and operate large-scale digesters or who will soon be developing large scale anaerobic digesters off-campus (e.g., Quantum BioPower, agricultural waste digesters under development in SE CT). They would be willing to supply UConn with larger volumes of renewable biogas. Ideally they would feed it directly into CNG's transmission and distribution infrastructure, which supplies UConn's campus, mixing it with natural gas in order to reduce our GHG emissions.

v) **Wind**

(1) Winter generation profile, which aligns better with peak campus demand and electrified heating

vi) **Hydrogen** is not an energy source but a means of energy storage and/or transport.

(1) When renewable sources are generating excess electrical power, some can be used to drive electrolysis of water: electrochemically splitting H_2O into hydrogen (H_2) and oxygen (O_2) gases. The hydrogen can be stored and later either burned for heat and/or thermoelectric generation, or fed to a fuel cell for electrochemical generation. With either use, water is the only product.

(2) Hydrogen can also be produced from natural gas. Hydrogen is therefore not inherently a clean fuel, but it can be if produced from renewable energy. Hydrogen infrastructure therefore provides some flexibility for using fossil-derived energy. This can be viewed as positive for campus resiliency or as negative for enforcing zero-carbon goals.

(3) There are significant energy losses associated with water electrolysis, pressurization or liquefaction of hydrogen for storage, and subsequent conversion to electrical power. Less than 40% of the original electrical power will be recovered after all of these steps in the best case.

(4) Depending on future evolution of this and other technologies, hydrogen may be a viable means of storing renewably generated electrical energy.

vii) Nuclear

(1) Nuclear plants generate electricity from the heat released from nuclear fission. This technology has been highly controversial due to (1) the risk of catastrophic failure and (2) hazards associated with the transport and disposal of long-lived radioactive waste. However, nuclear power plants can reliably generate large amounts of power with no air emissions, so they do not contribute to climate change. Furthermore, modern reactor designs have a good safety record. Technologies have been moving in the direction of smaller-scale plants that could conceivably be built to power a campus such as UConn Storrs or UConn Health. The obstacles from regulatory requirements and public acceptance are too great to make nuclear power a realistic option in the near-to-mid-term. But as the technology evolves, and especially if small nuclear plants proliferate and gain more public acceptance, nuclear power may become an option that the University should consider for carbon-free electrical power.

c) Methodologies

i) Renewable Energy Credits, with table of requirements from DEEP

Required Annual Renewable Energy Percentages:

Year	Class I	Class II or Class I (add'l)	Class III	Total
2018	17.0%	4.0%	4.0%	25.0%
2019	19.5%	4.0%	4.0%	27.5%
2020	21.0%	4.0%	4.0%	29.0%
2021	22.5%	4.0%	4.0%	30.5%
2022	24%	4.0%	4.0%	32%
2023	26%	4.0%	4.0%	34%
2024	28%	4.0%	4.0%	36%
2025	30%	4.0%	4.0%	38%
2026	32%	4.0%	4.0%	40%
2027	34%	4.0%	4.0%	42%
2028	36%	4.0%	4.0%	44%
2029	38%	4.0%	4.0%	46%
2030	40%	4.0%	4.0%	48%

ii) Funding Mechanisms
  (1) Incentives and Rebates
  (2) Voluntary and Mandatory Fees
  (3) Class 3 RECs/Green Revolving Fund

iii) Purchase Power Agreements
  (1) On-site solar or geothermal – third party installations
  (2) Remote solar, wind, digester (biogas) – third party developers
  (3) Behind-the meter
    (a) Delivery methods – fuel or electrons
    (b) Energy demands at remote UConn facilities
    (c) Installing remote meters

iv) Virtually Net Metered
  (1) Current Utility-Scale Projects
  (2) Planned Utility-Scale Projects
  (3) Co-sponsored/Partnership Opportunities
  (4) Many other higher ed institutions have used this
  (5) Eliminates the need for physical delivery of electricity
    (a) Our two most promising sites for solar near campus do not offer ideal conditions for physical delivery of electricity
  (6) Requires grid infrastructure assessments by Eversource (and potential upgrades)
    (a) Not as reliable as on-site generation

v) Portfolio-based approach

vi) Electrification
   (1) Conversion from Steam to Low Temp Hot Water
   (2) Long term plan: Example: The figure below depicts the first half of Princeton's electrification plan and is meant to serve as an example/potential template only.

Business as Usual Projects	Cost	Year	Cost	Alternate Case Projects
		2019	$ 8,400,000	Satellite Plant (20,000 sqft)
		2019	$ 6,500,000	Heat Pump Chiller 1 (1,700 Tons - Satellite Plant)
		2019	$ 6,500,000	Heat Pump Chiller 2 (1,700 Tons - Satellite Plant)
		2019	$ 18,500,000	Initial Well Field Buildout (800,000 sqft)
		2019	$ 1,700,000	Hot Water Boiler 1 (30 MMBtu - Satellite Plant)
		2019	$ 1,700,000	Hot Water Boiler 2 (30 MMBtu - Satellite Plant)
		2019	$ 5,300,000	Chilled Water TES (3,000,000 Gallons)
		2019	$ 1,800,000	Hot Water TES (1,000,000 Gallons)
Steam Distribution Replacement	$ 32,000,000	2020		
Steam Distribution Replacement	$ 9,800,000	2022	$ 200,000	STM-HW Heat Exchanger (150 kpph - Main Plant)
Chiller 3 Replacement (2200 ton STD)	$ 5,500,000	2022	$ 5,500,000	Chiller 3 (2200 ton steam centrifugal)
Chiller 4 Replacement(3400 ton STD)	$ 8,400,000	2022	$ 8,400,000	Chiller 4 (3400 ton steam centrifugal)
		2022	$ 6,500,000	Heat Pump Chiller 3 (1,700 tons - Main Plant)
		2022	$ 6,500,000	Heat Pump Chiller 4 (1,700 tons - Main Plant)
Chiller 5 (1600 ton elec centrifugal)	$ 3,700,000	2023		
Chiller 6 (1500 ton elec centrifugal)	$ 3,500,000	2023		
New Electrical Chiller (3,000 Tons)	$ 7,000,000	2024		
Replace GTG (18 MW), Replace 2 aux boilers	$108,000,000	2026	$ 48,800,000	Replace GTG (8 MW), Replace 1 aux boiler
		2026	$ 13,500,000	Steam Turbine Generator (7.4 MW)
Chilled Water Distribution	$ 6,000,000	2019-2026	$ 6,000,000	Chilled Water Distribution
		2019-2026	$ 93,000,000	Hot Water Distribution and Building Conversions
Total	**$183,900,000**		**$238,800,000**	**Total**

vii) Market Variability
   (1) Projected future natural gas costs and availability
   (2) Existing curtailment costs ($ and carbon)
   (3) Near term: Private developers can take advantage of federal tax credit (favors PPA/VPPA)
   (4) Mid/long term: as renewable project prices fall and fed tax credit expires, the University should favor behind-the-meter projects as our cost of capital is lower than a private developer's

viii) Carbon Pricing
   (1) Proxy Price
   (2) Incorporate social cost of carbon into planning decisions
   (3) Risk Management: prepares the university for a state-wide or country-wide carbon tax
      (a) Makes lower-carbon options
   (4) Internal Carbon Charge

ix) Behavioral
   (1) Zero-sum way to influence behavior and incentivize reduced energy usage

x) Other
   (1) Offsets, Credits, Funding Mechanisms & Carbon Pricing (2 Types: Proxy Price and Carbon Charge)
      (a) Carbon offsets are project-based. Many types of projects may generate offsets, including *sustainable forestry/reforestation, organic waste digesters (manure and food waste) and biogas, carbon capture, renewable energy, and peatland restoration.* In order to qualify as carbon offsets, reductions from offset projects must be:

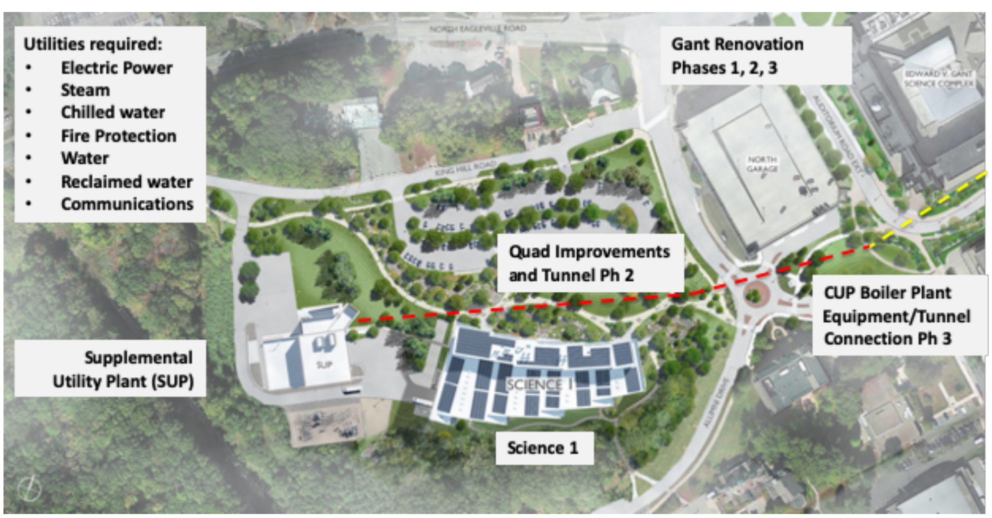
(i) **Permanent** – last in perpetuity
(ii) **Additional** – would not have occurred under business-as-usual scenario
(iii) **Verifiable** – by data and/or by accredited third party
(iv) **Enforceable** – offset can only be counted once, then must be retired

(b) Carbon offset projects are very attractive to colleges and universities because they have many valuable co-benefits, including:
(i) Research & Educational Opportunities
(ii) Experiential Learning
(iii) Community/Stakeholder Engagement & Partnerships
(iv) Additional Environmental Benefits – Land, Air, Water
(v) Values-Based Public Relations (e.g., Environmental Justice)
(vi) Scalable Projects Can Increase Benefits d

(c) Duke University has set the gold standard for carbon offset projects in higher education, partly because their GHG emissions have been so historically high (almost three times those of UConn during the 2007 ACUPCC baseline year) and their carbon neutrality goals are so ambitious (e.g., net carbon neutrality by 2024). Duke has several FTEs in their sustainability office dedicated to developing and implementing a variety of carbon offset projects and should be consulted as UConn moves forward with any carbon offset program or project.

(2) Water usage/wastewater generation, electric power saving? (Cutting down salt in diets and lower the salinity in wastewater for Co-Gen plant water reusage?)

d) Exceptions to Recommendation 2



NW Science Quad – Site Plan and 5 Projects

i) The renovation of the Gant Complex and the construction of STEM Research Center - Science 1 are the product of the Next Generation CT initiative and statute (2013/2014); the Academic Plan (2014); the Campus Master Plan (SOM/UPDC, 2015); and the Science Facilities Space Needs Assessment (ZGF/UPDC, 2016); all of which determined and stipulated the need for increased research facilities at UConn. Countless hours of faculty involvement over the course of several years supported this as well.

ii) All the projects shown on this Site Plan – Gant Renovation, Science 1, NW Quad Improvements and Tunnel, Supplemental Utility Plant, and Ph 2Boiler Plant Equipment/Tunnel Connection are linked, if one project is stopped then the others cannot be completed. All have been approved by the Board of Trustees for construction, Phase 3 of Gant will return once more to the Board for Final approval.

iii) The Gant Renovation, 285,000 gsf, just east of the Quad, began with the South wing in 2018 and continues with the West wing in 2019/2020. The North wing is in design and will begin renovation when Science 1 is complete in late fall 2022 and the Gant North wing is vacated. The Gant building is a major undergraduate teaching center, with research labs, and will house some or all of the departments of Physics, EEB, MCB and PNB. The renovation of the building includes hazmat remediation, complete reconstruction of the exterior envelope to reduce heat transmission, and new energy-efficient infrastructure appropriate to support the sciences, and it is designed to achieve LEED Gold.

iv) STEM Research Center - Science 1, 198,000 gsf, will begin construction in spring 2020 and complete in Fall 2022. The building is designed to LEED Gold standards and will have 500 kw of photovoltaics on its roof. Science 1 will house the Institute of Materials Science and the department of Materials Science Engineering, with teaching labs, research labs, core labs and UConn's first major clean room.

v) Gant and Science 1 are supported by 3 projects: the NW Science Quad Phase 2 Utilities and Site Improvements; the Supplemental Utility Plant (SUP); and the Boiler Plant Equipment Replacement and Utility Tunnel Connection.

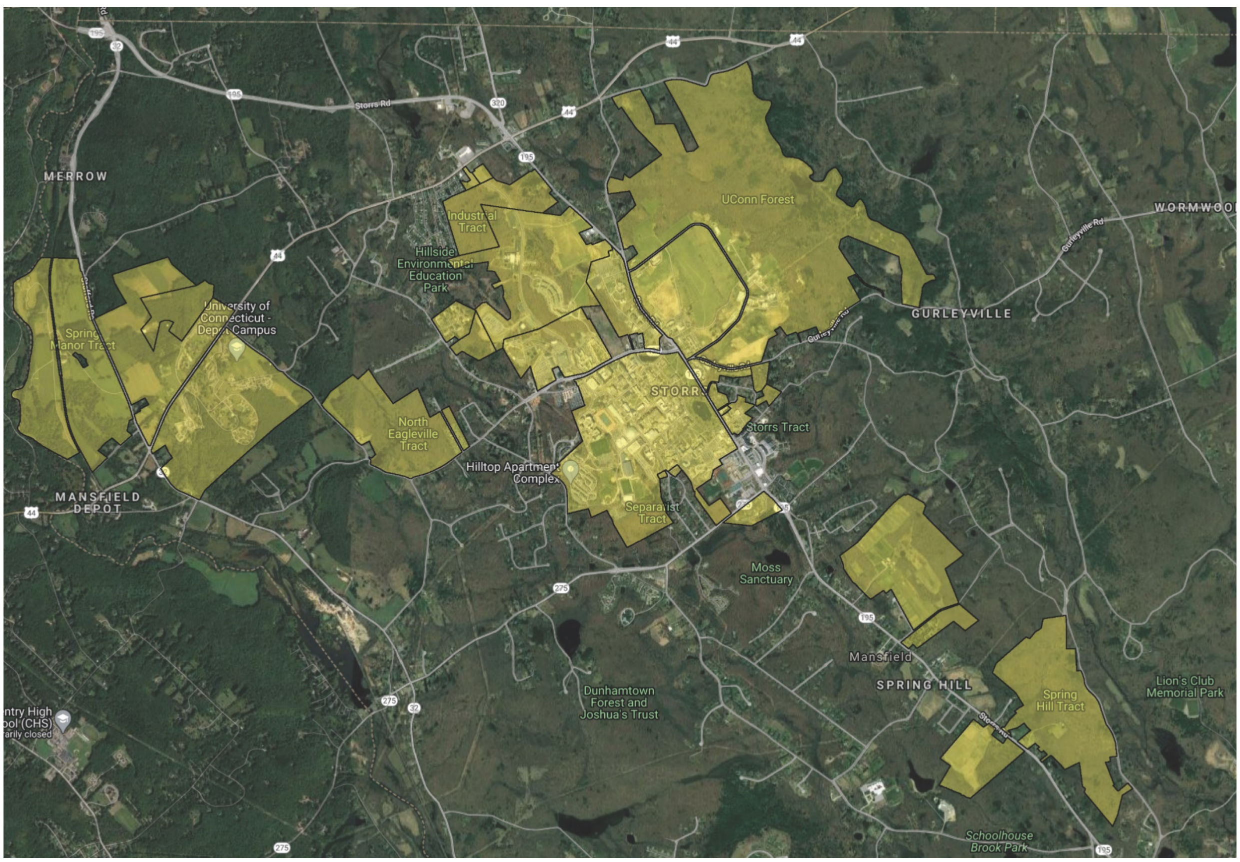
   (1) NW Science Quad Phase 2 Utilities and Site Improvements: site improvements for Science 1; extension of the existing Gant utility tunnel terminating at the new SUP; direct burial utilities for connections to the campus loop; woodland corridor extension and stormwater management; and King Hill Road and Alumni Drive improvements. The project is designed according to SITES standards and is scheduled to begin construction in spring 2020.

   (2) Supplemental Utility Plant: without the SUP, Science 1 cannot be completed because the Central Utility Plant (CUP) does not produce sufficient chilled water. The SUP and its equipment are sized to meet the needs of Gant and Science 1 ONLY, with 4 chillers, 1 boiler (a replacement for a boiler in the CUP, required to be decommissioned), and 2 emergency generators. **No work is proceeding on the Ph 2 building or the cogeneration turbines.** The SUP is scheduled to begin construction in spring 2020.

(3) Boiler Plant Equipment Replacement and Utility Tunnel Connection: This project is essential to the Science program as it is Ph 3 of the tunnel that connects the Supplemental Utility Plant, or SUP, to the Central Utility Plant, or CUP. It also replaces aged boilers, which are required to be decommissioned by 2023, with 3 new boilers one of which will be located in the SUP. The efficient new boilers will emit reduced metric tons of greenhouse gas. This project is scheduled to begin construction in spring 2020.

4) University-Controlled Property in Storrs-Mansfield, CT

This exhibit shows over 3,000 acres of land controlled by the University near its campus in Storrs, including the Depot campus and land managed as active agriculture or forest. Additional land holdings in the nearby towns of Coventry and Willington are not shown.



Planning for a Zero-Carbon Future

APPENDIX B

1) Fridays For Future Declaration of Climate Action

The climate crisis is a current and growing threat to the human epoch. Decades of credible science support this, as do testimonies from many of the world's indigenous peoples. The most recent IPCC report shows that if we do not act by 2030, the life-threatening effects of a warming earth will be irreversible. These effects include, but are not limited to:

1. Sea level rise and associated loss of coastal habitat and resources
2. Increasing occurrence of a sea-ice-free Arctic
3. Coral reef and other species extinction
4. Deforestation and wetland loss
5. More frequent and extreme precipitation events
6. Extended and severe droughts
7. Increase in vector-borne diseases
8. Overall lower agricultural yield
9. Negative mental and physical health outcomes
10. Increased immigration and refugee populations
11. Worsened global inequalities
12. Economic loss and political instability resulting from the above

The list of these devastating consequences has been laid out again and again in public appeals, which makes it easy to become numb to them. **Do not become numb to them. They are real, happening as we speak, and are rapidly increasing in severity.** As college students trying to create the best possible futures for ourselves and our communities, it's frightening to contemplate the catastrophic consequences of this crisis, and even more so because the people who have power don't seem to be as frightened as us — at least, their actions do not reflect the same level of urgency and concern that this emergency demands.

UConn can and should mitigate the impact of our large carbon footprint. However, the university's proposals to expand all campuses and its associated plans to power this expansion will only exacerbate the crisis by releasing even more carbon into the atmosphere.

Since 2008, the university has been committed to becoming a carbon neutral campus by 2050. President Hogan signed onto the American College & University Presidents' Climate Commitment in 2008. UConn established a Climate Action Plan in 2010 which also stated this 2050 commitment. This commitment is in our current Master Plan, which also proposes that we decrease our dependence on natural gas.

State-level efforts are also being made in order to reduce our environmental impact. This month, Governor Lamont signed an executive order mandating a zero-carbon electric grid in Connecticut by 2040. Additionally, his first executive order directed that state agencies reduce their energy consumption and act as leaders for the rest of the state.

This commitment at the University and statewide levels is in direct conflict with the planned implementation of a second natural gas cogeneration power plant. This particular decision by the university is especially disheartening as these types of power plants have a long lifespan, and natural gas, though considered by many to be a cleaner alternative to coal or oil, remains a carbon-emitting fuel. From fracking to transportation to burning, the process of employing natural gas on this campus is environmentally unsustainable. Thus, this decision not only increases our current fossil fuel use, but sets us on a path to be fossil fuel dependent well into the future. In 2050, we will be viewed not as the environmental leaders we are currently seen to be, but as an institution stuck in the past.

On a wider scale, and even *without* the implementation of a second cogeneration plant, the university is not positioned to follow through on our commitments to climate action. Our carbon emissions have not dropped, but remained alarmingly steady over recent years. As UConn continues to expand and build new infrastructure, our energy usage will only continue to grow. Our current efforts, including retrofitting and other energy efficiency projects, will not be sufficient to counteract this increased energy demand.

With all of this in mind, these are the steps we urge the university to take:

1. DECLARE a climate emergency
2. STOP the expansion of all new fossil fuel infrastructure
3. DIVEST the UConn Foundation from all fossil fuel holdings
4. TRANSITION to 100% renewable energy as quickly as possible
5. INCREASE transparency, communication, & student decision-making power
6. COMMIT to carbon neutrality by 2030 and a zero-carbon campus by at least 2050
7. PRIORITIZE diversity in environmental spaces on campus

We place emphasis on these six demands, but they should be the minimum standard for future climate action at UConn. We have plenty of work to do in order to uphold our commitments, and our current goals lag far behind IPCC recommendations and Governor Lamont's expectations. Meeting our climate goals will require sustained, forward-thinking effort.

DEMANDS

Most immediately, we urge that President Katsouleas release a statement in which he recognizes that we are in the midst of a climate emergency, and affirms that sustainability is a top priority for the university. We urge that he commit the university to an update and acceleration of the UConn Climate Action Plan that reflects the content of this declaration, and that he dedicates the campus to a goal of carbon neutrality by 2030, the year that the IPCC report points to as the year by which Western institutions must be carbon neutral to have a chance at limiting emissions to 1.5 degrees Celsius.

Additionally, and as also supported by IPCC findings, we demand that the administration set a new goal of zero-carbon by 2050. There is no socially conscious alternative. Carbon neutrality allows for a loophole wherein the University can buy carbon offsets to "balance" their carbon emissions. Continuing to emit while employing carbon offsets is a model that merely shifts the work from us to someone else, and only prolongs environmental stress: carbon offsetting allows fossil fuel infrastructure to persist, and prolongs the inevitable need to switch. We must think globally and take full responsibility for our emissions. With our capability and visibility as Connecticut's flagship university, we should be leading this effort in the state.

STOP Expansion of Fossil Fuels:

We cannot continue to power our campuses with any variant of carbon-emitting fuel. Specifically, we cannot feasibly be powered by natural gas cogeneration and uphold our climate commitments.

- **No more natural gas-powered cogeneration plants, on any campus.** They have a lifespan of 30-40 years. It will be archaic to run on fossil fuels (even comparatively efficient ones) in 2050.

DIVEST From Fossil Fuels:

Divestment is the process by which an institution eliminates the investments that it holds in a certain company or institution. UConn, along with all universities in our nation, has investments in fossil fuels companies. These university investments have enabled fossil fuels companies to not only continue operating but to thrive. This isn't where UConn's money should be. This topic is complicated by mutual funds and a lack of publicly available information, yet is crucial to ensuring a sustainable future. We hope the new UConn Foundation President has a chance to settle in to his new position, and also urge him to divest from fossil fuel holdings as quickly as possible as he sets a new chapter in this institution's history.

- **Immediately make a statement that UConn will never again make a direct investment in coal.** As far as we know, the UConn Foundation currently holds no direct investments in coal companies, as they don't make financial sense to invest in. It would be an easy next step to make a statement committing to continue this in the future. Other colleges have taken this step, notably Stanford University.
- **Agree to make no new investments in fossil fuel companies or the mixed financial instruments that include them.** We understand that divesting from already held investments is difficult, but being strict with future investments should be achievable.
- **Determine where the university's investments in fossil fuel companies lie, including within mutual funds, and release that information to the UConn community.** Once this is done in a timely manner, the UConn foundation must devise and publish a plan to divest fully from all current fossil fuel holdings.
- **Make available to the public the university's Socially Responsible Investments.** This article on the Foundation website is a good start, but the UConn community should be able to access specifics, especially 1. Which companies UConn is investing in and 2. What percentage of investments are SRI investments. The University of New Hampshire offers a thorough example of this transparency.

TRANSITION to 100% Renewable Energy:

On the world stage, we have an F in renewables. We have a rating of **0.08/4.00** in the Clean and Renewable Energy section of our AASHE STARS report. The Sustainability Tracking Assessment and Rating System (STARS) compares the sustainability of universities across the world, and when it comes to renewables, we don't measure up. There are a huge variety of options for improving this, many of which have already been proposed in university documentation:

- **Sustainably energize the Northwest Science Quad**
    - **Re-evaluate and integrate alternative energy sources for this section of campus.** The Site Assessment and Development Plan for this area of campus includes an Alternative Energy section that assesses a single alternative, geothermal, as an energy source. UConn has since concluded that geothermal is not feasible in this area, however, more effort should be made to source energy for this large-scale project sustainably. Investigating geothermal alone does not count as a comprehensive analysis of all of the options.
    - **Follow through on plans for a 500kW solar panel array on the Northwest Science Building 1 roof.** These panels are included in current plans, but solar arrays have been removed from building designs at the last minute before on this campus.
    - **Investigate battery storage for this solar panel array.** Eversource provides an incentive for this, and other universities are taking full advantage of this benefit. With these incentives to make the project economically feasible, UMass Dartmouth recently installed a large battery storage system on its campus in order to complement on-site solar.
- **Fully transition to renewable energy sources**
    - **A Preliminary Feasibility Study and Strategic Deployment Plan was conducted in 2011, and many of its findings remain applicable.** This document should be revisited and the cost of implementation should be recalculated with the new, lower costs of renewables.
    - **Solar power in particular is the cheapest it's ever been, and UConn's infrastructure is ripe for implementation.** There are many locations that are suitable for solar installation as enumerated in the 2011 study. Generally, parking lots and garages are prime locations for solar. J Lot, in particular, was designed to be solar ready; conduits are in the ground right now awaiting use, so with a purchase power agreement, there would be no capital costs.
    - **Though it isn't a good fit for the new science quad, geothermal is feasible in certain parts of campus.** East campus is an especially good candidate for this energy source, and the Center for Environmental Science and Engineering building behind Horsebarn Hill would function as an excellent geothermal demonstration project (as detailed in the 2011 study).
    - **Consider getting more energy via purchased power.** Right now, we only purchase ~5% of our energy. All of UConn's purchased power is required to be renewable, in the form of Renewable Energy Credits, purchased and retired by our contractual energy provider (Direct Energy) and delivered by CL&P.
    - **Alternatively, consider making purchased power agreements.** These agreements, which would consist of a company installing and owning a renewable energy project on university-owned land from which UConn would purchase their energy at a reduced rate, are less expensive than directly purchasing energy from the grid and are a viable option for sustainably energizing campus.
- **Electrify our vehicle fleet and offset emissions due to transportation.**

    - **Transition our buses from gas to electric.** As was publicly discussed this past spring, we are about to retire two buses in our fleet and have a grant from the state to receive two electric buses and two charging stations, provided we contribute one third of the money. It may cost more money to buy the two electric buses than two more regular ones, even with DEEP support, but including the social cost of carbon in the calculation is likely to change this conclusion. UConn's reasoning for not making this transition is that Windham Regional Transit District (WRTD) is poised to take over our bus fleet in the coming years. However, this is no reason not to improve the fleet we have, and if the charging stations we purchase are placed in Storrs Center, then WRTD will continue to have access if the fleet changes hands.
    - **Purchase carbon offsets for university-sponsored travel.**
- **Maintain current projects.** A symbolic example of a lack of maintenance is the Werth tower solar array. These panels are proudly touted by the university in tours and in other advertising capacities, but by all accounts, they have been broken in some way since last year and may or may not be currently providing energy to our campus.
- **Take the social cost of carbon into account when determining where to source our energy.** Social responsibility must be accounted for when we decide how to power our campus. The social cost of carbon — the dollar value associated with the long-term damage caused by emitting carbon dioxide — must be factored into all long-term investment decisions. At a minimum, the social cost of carbon must be computed using the EPA's conservative estimate. In 2020, that number will be $42 a ton.
- **Reduce consumption and expansion while fostering this mindset in students.** This last point is not strictly associated with renewables (though it does have to do with continuing to improve energy efficiency), but it should be the default consideration prior to every decision to expand our campus. In cases where it is deemed necessary to expand for the academic growth of the university, we urge the university to take care to sustainably source materials and to build as efficiently as possible. In cases where expansion is unnecessary and purely for the sake of expansion, **do not expand.** The environment and its inhabitants cannot afford unnecessary superficiality.

INCREASE Transparency and Communication:

UConn's plans and statistics need to be easily accessible to the UConn community. In keeping with this, students need to be brought into the university's decision-making process regarding energy. The information in this document was very hard to obtain and involved hunting down many different people across the university. While the Campus Master Plan and other documents are online, they are hard to locate, difficult to understand, and don't include everything needed for full comprehension. In order for students to truly participate in the decisions that the university is making on behalf of them, we need easy access to this information.

- **Follow through on creating the Student Sustainability Task Force.** We are excited that the UConn administration is planning on creating a task force of students and professors that will have a say in UConn sustainability decision-making. We urge them to follow through with this plan. In addition, we recommend that this task force release regular reports that are easily accessed and understood by the UConn community.

- **Post all UConn Foundation investments online.**
- **Ensure public monitoring and accounting of greenhouse gas emissions.** UConn's annual carbon dioxide emissions should be displayed **prominently**. For instance, a bulletin board or digital dashboard in the student union could be dedicated to these statistics, along with a countdown to 2030.

PRIORITIZE diversity in environmental spaces on campus

Diversify the white-centric environmental scene on campus. This looks like transferring decision-making power to students, faculty, and staff representative of all UConn's cultural, racial, and economic backgrounds. People of color and indigenous peoples have been fighting for climate justice for centuries, yet most mainstream environmental movements (including Fridays For Future at UConn and the UConn Office of Sustainability) are white-dominated spaces. We must take proactive steps to give all members of campus equal access to positions of power in the field of sustainability. There is clear passion and knowledge for addressing environmental issues from students of all different backgrounds across campus. It is incumbent upon the UConn administration and environmental student leaders to acknowledge their negligence and actively address the future of what the environmental movement needs.
In the urgency of climate change, we need better and more creative solutions- this means more diversity of thought and background.

- **Be intentional in faculty hiring and promotions.** Almost all of the professors on campus in the environmental field are white. There is less than a handful of professors of color teaching in this realm. This is a critical initial step to addressing who is represented in who is teaching us.
- **Improve your coursework.** Few classes are offered that explicitly explains how climate change and environmental issues are inextricably linked with race and class struggles.
- **When implementing these changes, underrepresented groups should not only be included but be leaders in the decision making process.**

CONCLUSION

In recent years, UConn has been recognized as one of the most sustainable universities in the country. However, if UConn is to continue to be recognized as a leader in sustainability, we must adapt our climate action plan to correspond with our sobering reality.

We are in the midst of a climate emergency, and if we don't act quickly as a university, we will have contributed to severe and irreversible damage to the planet and its inhabitants. We cannot afford to bask in our current achievements; our only recently acquired recognition as an "environmentally friendly" university is not sufficient. We need action and we need it now.

When college students protest and produce lists of demands, we're usually patronized, patted on the head and sent on our way.

But not this time.

We demand change because we are experiencing the worst human-created catastrophe in the history of the world, and yet, UConn has failed to take action on anything approaching the necessary scale. We demand change because we recognize that without pressure from the student body, nothing will happen. We demand change because our lives, our future children's lives and the lives of vulnerable global communities are at stake.

We make these demands in solidarity with millions of other young people fighting for their future today. We make these demands because there is no alternate path, there is no plan B.

We want to work with the University to achieve our shared goals — after all, this planet belongs to President Katsouleas and his administration just as much as it belongs to us. But we are prepared, should we see inaction and false promises, to wield our collective power and push until the University agrees to act responsibly. Nothing else is sufficient. Nothing else will take us back from the brink except immediate and sweeping action.

That is why we demand what we demand. Our future is at stake.

2) University Senate Declaration in Support of Divestment

University of Connecticut Senate Executive Committee
Report to the University Senate March 2, 2020

Resolution in support of the University of Connecticut Foundation Divesting from Fossil Fuel Companies

Whereas:

- The world is facing significant threats due to our continued use of fossil fuels: increasing temperatures will result in greater loss of life, livelihood and property from more extreme weather events, and loss of critical and irreplaceable ecosystems.
- Fossil fuel companies have known for decades that their business practices were putting the world at risk.
- The University of Connecticut has recognized the importance of the environmental threat by creating the President's Environmental & Sustainability Working Group, and by accelerating its interim carbon reduction goal for 2030 from 40% to 45%, consistent with Governor Lamont's Executive Order #1 in 2019.
- The University of Connecticut Foundation has recently chosen BlackRock to manage its investment portfolio and this company has stated that fossil fuel stocks are not a desirable investment option.
- Divesting from fossil fuels meets the Foundation's mission to ensure fiduciary responsibility given that a diversity of fossil fuel free financial instruments exist, and their returns are no different than investments which include fossil fuel companies.

Planning for a Zero-Carbon Future

APPENDIX B

This Senate resolves:

1. To encourage the UConn Foundation to terminate its direct and commingled investments in dominant fossil fuel companies (such as the top 200 publicly traded companies listed in the Carbon Underground 200).
2. To urge the Foundation to terminate these investments within five years or as soon as is reasonably possible.
3. To call on the Foundation President to announce publicly when such decisions have been made so that the University of Connecticut can set an example to others to likewise divest.
4. To encourage the Board to invest a minimum of 5% of its portfolio in sustainable companies or funds that mitigate climate change.

3) **Working Group & Subgroup Meeting Minutes**

President's Working Group on Sustainability and the Environment
UConn Facilities Operations Conference Room, Storrs, CT
January 24, 2020

ATTENDEES: See Attached

Meeting called to order at 1:05pm by Laura Cruickshank.

Committee member introductions; followed by discussion:

1. Working Group Charge
   a. Mike Kirk clarified that the President has requested the group start with studying energy and carbon emissions. After the work of the committee is complete and reported; the committee could potentially tackle additional sustainability and environment topics in the future.
   b. The work of the group is anticipated to inform the updating of the sustainability framework of the University Master Plan.
   c. Charge Suggestions:
      - What are the "values" of the group and what are the trade offs the group is willing to make?
      - Concern about the term "feasible" in the charge.
      - Suggest add "values" to the last sentence of the charge. "Actions UConn can take based on values, facts …"
      - Need a list of related values and where does sustainability fall on the list … good starting place.
      - Want explicit statement about risk the University is willing to take.

2. Planning
   a. Draft Schedule of Topics
      The committee engaged in a review of potential future discussion and process items as listed below:

      - Engage consultants and University staff to inform the work of the Committee
      - Energy use and generation for UConn Storrs, Regionals and UConn Health
      - Behavior Modification – Add to Energy Use discussions on schedule
      - Capital and operating costs to be shared with group
      - Policy change recommendations can be made by the group
      - Water and Waste Water to be discussed as part of energy
      - Landscape to be discussed
      - Market to be discussed
      - Food and Ag Waste; Anaerobic (current and future environmental effect)
      - Solar should be included in discussion

- Geothermal
- Funding and Prioritizing of Projects
- UConn and State policy change recommendations
- Targeted Small Opportunities, utilize existing infrastructure (e.g. green roof new construction)
- Sacrifice recognition for recommendations
- Depot Campus options
- Timing – what can we do now, in 10 years, and long term
- Monetize value (e.g. perception, teaching tool, indirect benefits)
- Procurement Policy / reduction strategy for consumption (behavior)
- UConn Pilot Program
- Survey suggested. Potential to recommend a survey within the final report.
- Bang for buck analysis vs value; and/or bang for buck informed by values
- Behavior related to carbon emission reduction; also behavior related decision making based on knowledge, attitudes, and beliefs.
- Utilize research already occurring on campus related to carbon emissions
- Request for next meeting on capital budget plan; available state bonding; and bonding schedule; to inform future discussions.
- Suggestion of future process: Professional presentation of data and framework/models with discussion of cost benefit analysis, values and scenario planning by the Committee.
- Alternative transportation and behavior

3. Climate Action at UConn Presentation

4. Carbon Emissions and Reductions at UConn Presentation

The group engaged in a discussion of where the baseline measurement should be or start date used for measuring carbon emissions. The discussion determined the baseline to be subjective. The group was asked to remember that the objective is zero by 2050 or before.

There being no additional agenda items the meeting was adjourned.

President's Working Group on Sustainability and the Environment
UConn Facilities Operations Conference Room, Storrs, CT
February 5, 2020

ATTENDEES: See Attached

Meeting called to order at 9:03 a.m. by Scott Jordan. He thanked the committee for all their ideas at the last meeting and stated that during the University Senate meeting the President had reiterated his vision for the Working Group to provide a matrix that will include recommended strategies and effectiveness in terms of carbon and greenhouse gas reduction, and cost.

The group discussed prioritizing recommendations; as well as including non-monetary trade offs and risks of the various recommendations.

Tom St. Denis, Principal with BVH, a framework engineering consultant, was introduced. His group assisted with the utilities framework master plan and other framework projects. Mr. St. Denis will be a consultant assisting with the working group.

Mr. Jordan requested that members present introduce themselves.

The members were directed to the minutes of the 1/24/20 meeting.

The Capital Budget Plan was detailed by Mr. Jordan and Laura Cruickshank. The discussion included project updates, master plans, and the future of the depot campus and prison properties. There was also a suggestion of the potential use of student fees to pay for continued environmental improvements.

A request was made for projections of energy use as buildings are built and renovated on campus. Ms. Cruickshank stated that this information is incorporated in the framework utility plan.

A presentation was made by students: Jonathan Ursillo, Harry Zehner, Brandon Hermoza-Ricci, Xinyu Lin and Himaja Nagireddy on "Energy Strategy Options". The group discussion included electric cooling and heating, solar, and anaerobic digestion. Additional options included geothermal, carbon offsets, wind and nuclear. It was noted that education and research should be considered and can be accomplished through campus engagement and campus wide communication. The student presentation listed the following as goals: "roadmap to 45% emissions reduction by 2030; plan for full implementation of renewables by 2050; commitment to no new natural gas infrastructure on any campus including UCH and regionals; and directive to UConn Foundation to audit for fossil fuel holdings". The University has done many things to reduce carbon and greenhouse gases but the community may be unaware of those efforts. It was recommended that those accomplishments be listed and communicated in the final report.

A reminder was made to include behavioral change to the final recommendations. It was suggested that increasing online courses could potentially effect campus space in the long term.

Stan Nolan provided a presentation on "Carbon Reduction Methods and Tradeoffs". The presentation included potential carbon reduction methods including conservation, renovation and demolition of existing buildings; solar photovoltaics; solar thermal; wind power; behavior modification; geothermal heat pumps; steam to hot water conversion; heating/cooling equipment; power off sets purchase; smart micro-grid; natural gas/propane emergency generators; fuel cells and tri-generation; anaerobic digestion; and transportation – bicycling/fleet electrification.

Mr. Jordan suggested that the presentation be put on the shared drive and be considered the master deck for the group to work from for review, evaluation, scale down, and be utilized for the final matrix. It was also suggested that the student's combine with this deck info with their deck info so the group would be working from one central document. It was recommended that a baseline be determined and utilized. Mr. Jordan agreed to work with internal staff and the President to determine the baseline. A request was made for scenarios to utilize land in different ways such as what would happen if a building were demolished; or if forest was cut down where permissible, etc.

There being no additional agenda items the meeting was adjourned.

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓					
Carnahan, Kerry	✓	✓					
Chen, Ming-Hui	✓						
Hermoza-Ricci, Brandon	✓	✓					
Jordan, Scott	✓	✓					
Li, Baikun	✓	✓					
Xinyu, Lin	✓	✓					
Nagireddy, Hamaja	✓	✓					
Roach, Natalie	✓						
Segerson, Kathleen	✓	✓					
Seth, Anji	✓	✓					
Ursillo, Jonathan	✓	✓					
Volin, John	✓	✓					
Willig, Michael	✓	✓					
Zehner, Harry	✓	✓					
Cruickshank, Laura	✓	✓					
Jednak, Mike	✓	✓					
Miller, Rich	✓	✓					
Ferri, Paul	✓	✓					
Nolan, Stan	✓	✓					
Carone, Debbie	✓	✓					
Mark Bolduc		✓					
KATIE MILARDO		✓					
Patrick McKee	✓	✓					
Tom St. Denis (BVH)		✓					

President's Sustainability Working Group Meeting Minutes
Thursday, February 27, 2020
3:00 pm – 5:00 pm
School of Business, Conference Room 321, Storrs, CT

Attendees: See Attached

Meeting called to order at 3:05 pm by Scott Jordan. He thanked the committee for all their efforts and ideas at the last meeting and explained that this meeting would be a presentation by consultants, BVH and CES. The presentations are not to be considered as the comprehensive list of options but will help with the decision making. The next session will allow input for evaluation by the team and to think of priorities of the campus, we're going from fact finding phase to drafting the report phase. He also reminded the group of the President's charge to produce a matrix to serve as the framework of the decision making going forward.

No other opening remarks or revisions to the last meeting minutes.

Introductions including the consultants, CES and BVH. CES: Zachary Bloom, Eben Perkins/BVH: Tom St. Denis, Ashley Patrylak, Scott Waitkus

A presentation was made by Facilities Operations, University Planning Presentation, CES and BVH.

The presentation included 6 potential projects and took into account feedback from previous meetings, concepts for potential and how it would impact the University.

CES presented the following topic: Campus Electrification (including the renewable energy credits and renewable energy profile discussion), Behind the Meter Solar (including the UConn Property map, Storrs Load versus Solar), Battery Demonstration, and Solar Parking Canopies (Lot D, J, G, T, Y, Z, Charter Oak Apartment and Hilltop Apartments). The discussion on these topics included Class 1 renewables and how they are determined, making a decision between ownership versus a PPA model, how RECs are a tracking mechanism, technical challenges, cost and what UConn's peers are and/or have done.

BVH discussed and presented the following topics: Geothermal Wells (McHugh, Bishop, CESE) including a discussion of Co-Use of PV and Farming, Anaerobic Digester and Compost Facility. It was noted that co-use for solar and agricultural activities would be a great opportunity to pursue and it could further science and technology. The group also discussed the thought process of approaching some of these topics, doing it in phases and making sure to not leave equipment and system stranded, retrofitting equipment when it's come to the end of its useful life and looking at campus from the outskirts in.

Mr. Jordan discussed that there will be two more sessions to talk about transportation and behavioral. And he noted that the group hasn't gone into too much detail on cost but we need to start including this and building the matrix with relation to cost. He's not sure how this will be completed as a group but he'll likely propose dividing up the various topics to the folks that worked on this for the write up. A discussion with the President to ensure the group is capturing all of the right information will also be done.

There being no additional agenda items the meeting was adjourned.

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓	✓				
Carnahan, Kerry	✓	✓	✓				
Chen, Ming-Hui	✓						
Hermoza-Ricci, Brandon	✓	✓					
Jordan, Scott	✓	✓	✓				
Li, Baikun	✓	✓	✓				
Xinyu, Lin	✓	✓	✓				
Nagireddy, Hamaja	✓	✓					
Roach, Natalie	✓	X	✓				
Segerson, Kathleen	✓	✓	✓				
Seth, Anji	✓	✓	✓				
Ursillo, Jonathan	✓	✓	✓				
Volin, John	✓	✓					
Willig, Michael	✓	✓	✓				
Zehner, Harry	✓	✓	✓				
Cruickshank, Laura	✓	✓	✓				
Jednak, Mike	✓	✓	✓				
Miller, Rich	✓	✓	✓				
Ferri, [redacted] Paul	✓	✓	✓				
Sean Vasington	✓		✓				
Nolan, Stan	✓	✓	✓				
Carone, Debbie	✓	✓					
Mark Bolduc		✓	✓				
KATIE MILARDO		✓	✓				
Patrick Mckee	✓	✓	✓				
Tom St. Denis (BVH)		✓	✓				
Ashley Patrylak (BVH)			✓				
SCOTT WAITKUS (BVH)			✓				
Zachary Bloom (CES)			✓				

Meeting minutes – 3/10/2020 9:00 am school of business conference room

Opening remarks:

SJ: overview of agenda which will include student presentation on draft final recommendations for energy, transportation and behavior discussion, and next steps.

Student Presentation:

1. Update emissions reduction goals
   - Aligning with IPCC guidance 45% by 2030 based on 2010 baseline
2. Permanent halt to new fossil fuel generation capacity/infrastructure at all campuses and health
   - Risk management - future of natural gas is at risk based on conversations
   - Compatibility with UConn's goals and image
   - Net zero in new buildings
     - SJ : every building needs to be a net zero building but we could off set somewhere else on campus? Harry: yes
     - Harry: not investing in new steam lines
     - Reminder from SJ – recommendations to president which could be recommendations for the university
     - John – carbon tax and University could be included
       - CES
3. Plan for campus wide electrification
     - Staged roll out
       - John – CES presentation, low temp hot water projects: start at South Campus and Hillside. Plan in place to be done logically and methodically. Understand it wont happen tomorrow. *Example – Princeton
4. Utility Scale solar, geothermal and other renewables
     - Project matrix – Depot campus property and Mansfield property. Grid analysis by Eversource for Eversource grid. Or a PPA – virtual. Other campuses are doing this. Uconn could own the land. BVH: liability. Backup power is Cogen but if we phase out and require Eversource to be the backup source. Ensure the source is there to keep the campus up and running 20 miles away. Major infrastructure investments to give redundancy for UConn (since we are a research facility). SN: discussion about recent weather events and Cogen was able to keep up.

   Renewables:
   - Utility scale solar
   - Geothermal energy – CESE, Bishop
   - Wind Energy – AP
   - Anaerobic Digestion – Storrs

Quantify #s to see where we should head.

This is not to replace cogen, this would supplement until the cogen reaches its useful life.

5. Divestment from Fossil Fuel Holdings

Conclusion

Proposed final meeting to April 28th BOT Mtg on April 29th

Arrangements to operate remotely if necessary

Meeting from Last meeting

- Question: Summary slide 4% was low relative to goals
    - SN: per unit obviously # would increase if it grew
    - SJ: summary with cost per unit and overall summary to President. Matrix will be multidimensional – cost per unit, cost over time, strategy
    - Harry: Princeton "business as usual" so you can see the comparison of the substitution of various costs. BOT slot to present is it feasible?
        - SJ: a few minutes to present and provide info but probably not enough time or place for voting or endorsing

BVH: drilling test wells for Bishop and CESE; potential for McHugh as a test well

- General SW management treating runoff from solar farms – problematic task force with DEEP. Potential new regulations
- RM: Permeable Asphalt editions – CLEAR thought permeable asphalt would be a solution to that
- BVH: maintenance issue, rain garden and will be included in the problematic GP, you still need to build infrastructure to handle storm events, cost issue to consider
- SJ: use best practice options and include engineered concerns and cost options

Contacting vendors for aerobic digestor and doing further investigation

Draft matrix putting this together

Transportation

- Ebike conversation? None on campus at this time
- WRTD 3 electric buses and potential new partnership with more routes to campus
    - SJ: faculty and staff to also ride
    - MJ: WRTD will only but electric buses; maintenance, storage, chargers, etc. will be part of the negation with this bus program
    - XXX prof –doesn't understand why buses need to be stored indoors

- Grant was transferred to DOT/WRTD
- Harry –bus routes and getting students involved with this program.
    - MJ: yes, DOT very interested and involved and wants to use students

XX – substituting parking ?

Underutilitzed

Angie – stops on 195 she would rider

XX – parking data

MJ – parking layout hasn't changed much but changes upcoming with closure of Xlot

LC – Master plan, accepted by BOT, conscious decision to not increase parking on campus looking forward to a reduced car parking

MJ – rt 44/384 commuter lot for bus route in Bolton

Harry – consideration of tram or light rail line for Willimantic/Manchester/Vernon/storrs , tracks that could be used.

MJ – haven't heard anything? But could mention

SJ – cost is a huge thing. Malloy's office is aware of the tracks.

LC –mutli state group – looking at rails in New England – connect RI, Boston, Springfield, Hartford, New Haven. Emphasis is on the coast and not inland. $$$$ has to work for every state for this to work. If you get everyone on board it could very much work.

Bikes

John: bike app for location and reminder for bikes tied to a pole similar to transportation

Angie : and electrification for the bike outlets

Travel info

Conversation about carbon reduction option in travel choice

Ongoing discussion

LC went to a conference and can share information

Shuttle included in hotel? Cost for rent, cab, etc.

USG –incentive and more compensation for university funding. Unsure if student travel uses the same system.

---- selling point for hotel in TX – Sinclair - Low voltage system Hotel – save energy and other

Think about installing more features in res halls and buildnigs on campus.

Carbon tax ----

Harry - $ go towards projects instead of offsets

Green Fund

*** Laura – 4-6 folks, students, faculty and staff to help with

***Can faculty and staff get involved with projects and information

SJ : two subcommittees

1. Draft with report
2. Technical support for matrix

SJ – working element layout and outline and narrow down strategy and what they should be and what they should be. Next meeting discuss this.

And also talk through some of the behavioral ideas at that time.

Mike Willig: want to reiterate Plate of options 4 day work week, telelearning, decreasing thermostats by 1 degree for winter/ summer,

Harry – meeting with Transportation folks to keep the discussion moving + thankful for the new bus lines.

SJ: Transportation advisory group that includes faculty and staff. And a very cool app created for car pool and similar to an uber. We now how data and analytics for transportation and bus routes. Credit to Mike's team. Increasing ridership.

President's Sustainability Working Group Meeting Minutes
Tuesday, March 10, 2020
9:00 am – 11:00 am
School of Business, Conference Room 321, Storrs, CT

Attendees: See Attached

Meeting called to order at 9:16 am by Scott Jordan. He provided the overview of the agenda which included student presentation on the draft final recommendations for energy, transportation, behavior discussion and next steps. Additionally Facilities will present on Transportation.

No other opening remarks or revisions to the last meeting minutes.

Student Presentation included a discussion on the following recommendations:

1. Updating emissions reduction goals and aligning with IPCC guidance 45% by 2030 (2010 baseline).

2. Permanent halt to new fossil fuel generation capacity/infrastructure at all campuses including the health center. A discussion on risk management and the future of natural gas at risk, compatibility with UConn's goals/image, and net zero for new buildings.

3. Plan for campus wide electrification and the discussion of a stage roll out based on the CES presentation, possibly using Princeton as an example.

4. Utility scale solar, geothermal and other renewables. A discussion of the project matrix and looking at the Depot campus property and additional Mansfield property. Grid analysis would need to be discussed and completed by Eversource for their grid. Also the discussion of a PPA. BVH also commented that liability should be taken into consideration, backup power is the Cogen but if it's phased out we would require Eversource and we would need to ensure the source is there to keep the campus up and running. It would include a major infrastructure investment to give UConn redundancy since the University is a research facility. Renewables were also discussed again, utility scale solar, geothermal energy (CESE and Bishop), Wind Energy at Avery Point, and anaerobic digestion.

5. Divestment from Fossil Fuel holdings

To conclude, the students would like to propose a final meeting to April 28th and attend the BOT meeting on April 29th. Also the discussion of moving meetings remotely with the COVID concerns.

To summarize the last meeting, BVH provided an update on items being worked on from the previous meeting. BVH is working on moving forward with drilling test wells for Bishop and CESE. General stormwater management treating runoff from solar farms is being closely followed with the task force formed by DEEP. BVH is also contacting vendors for anaerobic digesters and doing further investigation. The Draft matrix is also being worked on for review.

Facilities presented on the topic of Transportation which included electric vehicles including the bus and bicycle program on campus. A potential partnership is being discussed with WRTD to be responsible for the maintenance, storage, and charging busses. A discussion on parking and future of parking at UConn was discussed. Additionally, the conversation about carbon reduction option in travel choice was discussed. The Green Fund and carbon tax topics were also discussed.

Mr. Jordan discussed that there will be one more sessions to talk about behavioral and a working element layout which will outline/narrow the strategy. And he noted that the potentially two subcommittees will be created, one for the draft with report and another for technical support for the matrix. Laura Cruickshank will take the lead on drafting the report and if folks are interested in helping reach out to her.

There being no additional agenda items the meeting was adjourned.

D R A F T
President's Sustainability Working Group Meeting Minutes
Wednesday, March 25, 2020
1:00 p.m. – 3:00 p.m.
Via WebEx and Telephone

Attendees: See Attached

Meeting called to order at 1pm by Laura Cruickshank. She explained that Scott Jordan had been detained and had asked her to lead the meeting.

Harry Zehner stated that the COVID-19 crisis has reduced the energy load on campus; and one of the reasons for building the SUP was to replace the boilers to meet EPA regulations. He asked if there was a possibility to replace the boilers without building out the additional capacity. Ms. Cruickshank clarified the question to build the supplemental utility plant and add the extra square footage. Mr. Jednak stated that it is important to continue with the assumption that the University will return to normal in 3-6 months. Ms. Cruikshank stated that she is working with the engineers on whether there are alternative options for the boilers to fit in the CUP.

Rich Miller presented a PowerPoint Presentation on "Behavioral Change, Carbon Offsets, RECs, Credits and Funding Mechanisms". This included a group discussion of a possible voluntary fee structure for a Carbon Neutral Commuter Program to be launched in fall 2020 and linked to parking permits. Education and outreach are integral to the success of the program.

Discussion of internal carbon pricing including setting of proxy price (social cost of carbon); setting of carbon baseline for buildings; assessing carbon charge or return based on performance vs baseline. This would require extensive sub-metering. Potential to drive behavior change and innovation. Mr. Zehner clarified that this is a carbon fee model where departments compete against each other; the proxy price model is commonly used in institutional planning decisions including building design determination. It was stated that the proxy price is easier to implement at the institutional level as it is policy based. The concept is difficult to implement when University departments have minimal control over their buildings and emissions; and only have control over small behavioral actions.

It was acknowledged that there are a variety of targets and mechanisms identified to effect behavioral change that can enhance the ability to reduce carbon imprint. Is there a mechanism to do a strategic assessment of behavioral changes to institute by taking into account the speed, costs and benefits of implementation? Determine most effective changes to reduce the carbon imprint and enhance sustainability with limited time, energy and money. The draft of the Committee's report is planned to include identification of strategies of short term, midterm and long term; based on bang for the buck, feasibility, and ease of implementation and a strategic assessment of behavioral changes.

Carbon offsets to be utilized late in the process as a stop gap for capacity that cannot be covered as renewable. University administration utilizes as a last resort option. Desire to use carbon offsets in the long-term is tied to not spending capital funds on one-time offsets in the short-term.

Ms. Cruickshank directed the Committee to the subcommittee's draft outline report, introduced subcommittee members, and provided an overview of the subcommittee mission. She reviewed the President's expectation for the final report from the Committee.

Discussion of Draft Outline:

- Rough draft due to full Working Group by the 4/9.
- Rough draft report to be approximately 10-15 pages written. Much was moved to the appendix for technology info. Emphasis on recommendations and strategies for reducing carbon. Outline detailed to support recommendations of Working Group.
- Section III, University Mission and Values. Request that the concept of values be explicitly defined; especially with regard to how alternatives are evaluated in the final recommendations. Discussion of values in strategies.
- Section III B To be "University's Image and Responsibilities", perhaps also include substance.
- What is our value? How does funding play into that determination.
- Utilize University documents and statements already available on University values; demonstrate the values the University already has in place. Operationalize those values to make a decision.
- Discussion of tradeoffs. Value multiple things and cannot do them all. Reconcile recommendations with respect to greenhouse gas emissions and other values. Needs to be expressed … possibly in Section VII.
- Executive Summary should include short summary of recommendations.
- Strategies are decisions made in light of uncertainty, and uncertainty indicates risk and hope; include discussion of risk factors associated with recommended strategies.
- If want to explicitly recognize risk should include the concept of proxy pricing in an institutional way. Proxy price takes into account the social costs of carbon and uses it as a planning tool. Incorporates risk by planning for the potential of a carbon tax or governmental climate action, making proxy price tangible. Planning tool. Use to encourage the Board of Trustees to approve decisions that take risk factor of social costs of carbon into account. Request that this be included in the recommendations.
- Request suggestions for title of the Working Document. Future reports anticipated based on other areas students originally requested be addressed. Recommend the other areas be included in recommendations (e.g. topics for further analysis, next steps)
- The charge from the President was to produce a matrix. Difficult to produce matrix by deadline. Suggestion to split report into two parts; 1) institutional policy and 2) detailed project matrix (including costs, feasibility, etc) to be delivered in the fall. Section VII to include matrix of strategy as less in depth review of short term, midterm, long term recommendations. Include recommendations to be done right away including costs.

Future items require more thought for priority, feasibility and cost. Suggest including broader big picture context in strategies.

The subgroup will meeting again on March 31.

There being no additional agenda items the meeting was adjourned.

PWGSE Report May 2021 - Appendix B

PWGS Sub-Group Meeting – Draft Report and FacOps Slides
Wednesday, April 8, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Stan Nolan, Rich Miller, Alexander Agrios, Anji Seth, Baikun Li, John Ursillo, Harry Zehner, Mark Bolduc, Katie Milardo, Tom St.Denis, Scott Waitkus

This meeting was to discuss the draft report, specifically the recommendations section. Also, Mark Bolduc has graphs to share and Tom St.Denis/Scott Waitkus are available for any additional questions that may come up.

1 . Review of the PWGS – GHG Reduction Projections 4-8-20 slides (provided via email prior to meeting)

- M.Bolduc provided an overview of the slides
    - L.Cruickshank – to further summarize slide 1 is the 2007 baseline and UConn goal and slide 2 is the 2001 baseline and the Executive Order 1 45% reduction goal
- M.Bolduc explained the hatched sections of the bars in the graph indicating curtailment and projects and clarified what curtailment meant (gas contract, CUP needs to switch from gas to oil dur to restirctions, tupically winter weather related)
    - S.Nolan also added that the hatched includes new construction and typically curtailment is only 30 days and is 7-10% of the hatched data
- M.Bolduc explained slide 3 – 20% reduction and 2020 goal which includes commuter offsets that Patrick McKee (Sustainability Office) had previously discussed and that the goal is to have something in place by Fall 2020, lighting projects, insulation projects and energy projects (examples VFD control replacements on equipment)
    - L.Cruickshank – asked whether or not these project are approved and are they mainly FacOps
    - S.Nolan – yes, most are FacOps projects and SLED is approved and funded, most insulation is funded and partial approval for other ECM projects. COVID has delayed the schedule and impacted some of these projects.
- M.Bolduc reviewed slide 4 – 2025 goal reduce by 30% 2007 baseline and walked through the projects which include lab ventilation, SLED, and conceptual projects such as digester, geothermal, and onsite solar
    - S.Nolan – commented that this is just a potential path and some may be more robust than others. None of these projects (except SLED) are approved so this could change.
    - L.Cruickshank – added that this is just a strategy and we can do more or less
    - M.Bolduc – agreed, yes nothing is set in stone and this is just a mix and match of the various options previously discussed
    - R.Miller – asked about steam line replacements and the reductions in previous projects
        - S.Nolan –responded that this project is capturing leaking lines, example: south campus where there is major energy and water loss due to aged infrastructure and that we would complete this project to avoid further loss, gain on GHG
        - R.Miller –does this support growth?
        - S.Nolan – No, just a replacement
        - L.Cruickshank – the 19,000 tons from the previous slide shown does include growth on campus
    - R.Miller – asked about onsite solar and if sites were identified

    - S.Nolan/L.Cruickshank – both commented 10 acres = 1 MW, 50 -75 land needed, no sites have been determined but Depot campus is a candidate
  - R.Miller – asked about slide #2 and the 2001 baseline and how the emissions were calculated? Vermont Yankee? Includes coal plants being offline.
    - S.Nolan - discussion about the ISO NE produced information on today's carbon on the grid, etc. and that it would be difficult to create a CT specific one because of the imports but he would try to summarize.
- M.Bolduc review of next slide showing the 2030 reductions and includes the demo of Torrey Life science building, steam line repair, onsite solar and compost facility expansion
- M.Bolduc discussed the last slide which is a summary of all slides – 45% from 2001 in a pie chart form and includes info from slides 3-6

2. Comments and Discussion of the Slides

- A.Seth – asked about the low temperature/hot water lines moving toward electricity use?
  - S.Nolan – discussed the steam lines needing to be repaired in certain locations before transition to hot water and that buildings already utilize steam need to be kept online before the transition. We do not have reduction data for this transition yet because we still need to do a study with costs and available locations.
  - J.Ursillo – commented on the wholesale steam line replacements potentially locking this system and it's easy to mete the 2030 goals but asking about the transition to net zero on campus?
- S.Nolan – commented on the functionality and needing to do certain things to keep the buildings running. In the draft report (page 9-10 section 5.2) you'll see a series of slides with a potential transition plan using 2019 data. The draft report includes Scope 1 and 2, energy profile of the Storrs, Depot and Regional campuses. Summary graph with near, mid, and long term including the balance of technology changes, population growth, etc. it's our best understanding of the campus and based on the master plan providing one way we can get to clean energy by 2050 = zero carbon.
  - A.Seth – asked if the green = less electricity and natural gas and what it means?
  - S.Nolan –transition of season and needs in the Northeast. Again commented that this is just one possible way to reach the goal and there's variety of ways to get there.
  - L.Cruickshank – added that the graphs only go to 2030 and there are other assumptions
- J.Ursillo – two comments: 1) Adding solar and electric chillers? 2) Flexible technologies with leas investment?
  - L.Cruickshank – Do you mean steam lines? And investment of steam lines? It's a good point and something we should include in the recommendations. Added that we should be including and advocating for a real transition plan and what that all means in the report.
  - S.Nolan – approx. 30,000 LF of steam and added that several structures would have to come down and cannot use geothermal – not feasible

- J.Ursillo – yes, line with step by step approach. He had added that comment in Section 6.2 and to potentially look at other colleges and what they did/plan
- S.Nolan – thermal needs met at no cost responding to John's 1st question and buying solar = cleaners but still part of the emissions. There's a difference between net zero and zero carbon.

- L.Cruickshank – SharePoint will have all of these documents for review and further discussion but the focus for tomorrow's meeting should be the recommendations section of the draft report. One question that just needs to be verified is Laura's question she asked about next gen and academic planning.
  - J.Ursillo – no one will say no we can't fulfill expansion plans. We just need to make sure it's done in a smart way and put in the right policies and procedures
  - A.Seth – agrees with John and the question is will UConn be the example institution that's world class and cutting edge but also cutting out fossil fuels and setting an example for others in CT
  - L.Cruickshank – does that include Science 1?
  - A.Seth – not decided but we can't keep kicking the can. Does that building include chillers, electric? Solar?
  - L.Cruickshank -1 steam and 2 electric chillers and a ½ MW solar. And to answer Harry's question regarding equipment in the Cogen – we can't fit everything in that building.
  - S.Nolan – commented on the increase of GHG if we add electric chillers –it would be an increase not a decrease
- R.Miller –question about the slide with the regional campuses and if that includes RECs for carbon neutral?
  - S.Nolan – No, energy use n ot GHG. Energy bought for campuses doesn't include RECs
- L.Cruickshank – we're in the process of formulating a matric with reduction strategy. Tom St.Denis and Stank Nolan will circulate for review
  - T.StDenis –electric chillers are on campus – but to add to Stan and John's comments, the waste steam off generation system is clean. Once solar becomes available electric chillers will be switched over. The SUP is 50/50 electric and steam.
  - A.Seth – CO2 graph of slides and how much?
  - S.Nolan – did a walk-through of the graphs, cost/ton reduction will vary
- A.Seth – discussion of geothermal, understands that there will be 2 small test locations. She knows of many examples, 2 large complicates sites, not a high technology, has been around for a while, low operating costs. More test case are needed for next examples so that geothermal can be used for new construction, underneath the building.
  - L.Cruickshank – the need for a clump of building specific to do so. Another potential area would be AgBio buildings. Construction under buildings is fairly new –parking lots yes, buildings no. But this is a good point and should be reviewed and studied more.
  - R.Miller – BU recently did this and he can look into other universities such as Ohio State.

- T.St.Denis – Fairly recent, group of looped building including field with open space. Difficult at a UConn/Yale type of campus. Installation and/or maintenance of wells would be problematic potentially long term.

The last item discussed was that the work group meeting was tomorrow. New building net zero strategy and space allocation needs to be addressed. Laura thanked everyone for being on the call, apologize for the meeting running late but good comments and input. Discussion to be continued as this progresses.

Meeting concluded at 5:30 p.

President's Sustainability and Energy Workgroup Meeting
Thursday, April 9th 2020
2:00 – 4:00 pm
WebEx Meeting

Attendees: Deb Carone, Alex Agrios, Brandon Hermoza-Ricci, Scott Jordan, Xinyu Lin, Himaja Nagireddy, Natalie roach, Anji Seth, Jonathan Ursillo, John Volin, Mike Willig, Harry Zehner, Laura Cruickshank, Mike Jednak, Stan Nolan, Rich Miller, Patrick McKee, Paul Ferri, Mark Bolduc, Katie Milardo, and Tom St. Denis

Open Remarks:

LC– April 30th is the next meeting. The subcommittee has met on 3/31 and 4/8. We'll be meeting again on 4/18 and 4/20. Meeting Minutes from the last meeting approved. No comments, questions or concerns.

Discussion

LC: requested that Tuesday the 14th comments due, if possible and that works for everyone.

- JU : focus on the recommendations section, section 6. For next steps.
- LC: Presidents charge – SJ recommendation to change the charge slightly due to COVID 19 and other responsibilities and emergencies that have come up. Laura reminded everyone to keep the charge in mind. Read the charge from the report.
- RM: if amended would it be different phased approach discussed in sub group.
- LC: not part of conversation but possibly extension of schedule deadlines to Fall 2020.
- AA: also budget – cost goes out the window right now at this point. This is impossible at this point
- LC no funding or cost analysis. Correct, impossible question to answer
- JV: Delay report?
- LC: no report would still be provided.
- JV: to talk to Gene Gowan, discuss the June BOT? We don't want to wait until Fall
- LC: even by June, we won't have the cost included. We'll have something for the task group. Talk about it at the board meeting. April 29th. Only discussion, nothing would be handed over.
- JV: you need to make sure the Task Force – let's talk after this meeting.
- MW: talk about goals and delay cost benefit analysis. Some preliminary guidance on cost – expensive, cheap, super expensive, etc. or cost cannot be estimated. Discussion before committee is dispersed and people are no longer here.
- JU: lay out as much as possible we can in this moment in time. Best practices based on peers and consultants are saying. Strategic manner possible. Financially smart and meet our goals. We don't want to get too wrapped up in cost right now. Confine yourself from the jump when focus is cost. Short, mid and long term analysis.
- HZ: we understand now, stop fossil fuel capacity. But we can still offer thing that don't require detailed cost benefit analysis.

President's Sustainability and Energy Workgroup Meeting
Thursday, April 9th 2020
2:00 – 4:00 pm
WebEx Meeting

Draft Final Report – Recommendations Section 6.0 (meeting materials in the SharePoint)

Section 6.1

HZ: update emission reduction goals to align IPCC with ideas of climate justice and cumulative historical emissions that western countries hold

- AS: IPCC objective suggestions are really tougher than the Governor have provided. Harry has stated that nicely in the report. Climate Justice Issue – provided a talk at conference two years ago and discussion of climate challenges and discussion of needing net zero. And 1.5 globally, that means developed countries (responsible for present carbon) reduce emission well before 2050
- HZ: different baselines difficult to manage. Same goal but adjusting it to 2007 baseline. In effect same thing but tracked by a single baseline. Higher if that makes sense and to be determined in sub group.
- SN: developed comparison and will cover that and we looked at the different baselines and compared % so you're looking at it from different baseline and easier to look at.
- MW: different baselines informative and highlight recommendation makes it clear. The other stuff is historical. One question: important for the reader exactly what we mean that this is "institutionally binding goal" – who's responsible? What's the meaning behind that statement? Weight in action. Just be careful about choice of words.
- HZ: Still a draft, language with intent to discuss what that means. Personally, very important and aspirational and reaching for something high and binding. We shouldn't just shrug this off and we should be committed. Open for discussion.

LC: welcome comments and suggestion – emailing back and forth with Harry and John.

Section 6.2

HZ: power things in the short term, repairs of steam pipe. Build out a timeline to electrify the campus. Goal deadline is 2030. Taken on in the Fall as a workgroup charge or by Energy consultants (or both)

- JU: the intent, we're not going to invest more and more into the current system. If we're being told we need to fundamentally change the system to full electrification. Massive financial loss and stranded assets. Staged and strategic manner which is effective and financial responsible to mete the goal. If we keep investing with steam pipe today, we'll kick the can down the road.
- AA: different then full electrification by 2030 – no more burning anything and heating/cooling is done electrically. Is that the intent?
    - HZ: yes, but by the time the CUP is retired we'd be on a net zero playing field. We've invested in fossil fuel infrastructure and we don't want to invest more money into it and change to renewables. The date is up for discussion
    - AA: aggressive date to meet.
    - LC: recommending to how to accomplish with a strategy because right now we don't have a strategy in place by reaching this goal by 2030.
    - SN: we have not developed a strategy to achieve that and even Governors order has until 2040 to clean energy. Major undertaking. Changing way for central energy on

campus. So we'd be changing the method and strategy. One potential method would be to achieve by 2050, not 2030. The grid wouldn't be powered by 2030. Science 1 is needed for research. Brown houses demo – footprint. Balance act of this. We couldn't support fully – it's not even supported by the grid right now.
  - RM: definitely aspirational. PPA discussion and GHG inventory.
  - SN: fossil fuel underneath the RECs – 1/3 increase
  - RM: look at what other peers have done –Stanford example. California is greener for purchase power.

LC: more discussion of 2030 date.

JU: timeline discussion and using other colleges as a model –Princeton example. Adapt to the model and what other people are doing. PPA? We don't have to wait until 2040, something to consider.

<u>Section 6.3</u>

HZ: New construction net zero carbon

- JU: assign to stakeholders and implement how they'll be used. Carbon proxy price for carbon tax price down the line. Schedule and building use. Strengthening online infrastructure before building out physical footprint.
- HZ: sub bullets aren't hard recommendations, just possible ways to achieve net zero new construction
- LC: consider strengthen online classes. So we're not arguing whether there should be online classes All new construction should be net zero, this should be a tactic. The decision making process, acquisition, demo, space, renovation and new construction should be broadened because right now it's limited. And to take into account some of these issues. Should be a focused decision making process.
- AS: decision making campus development should consider net zero energy use or something more like that? Overall campus decision making process. Develop real estate and reduce fossil carbon and not increase.
- LC: NextGen program, that's it for UConn so the next phase is space allocation and renovations. Campus development is a good way to phrase. Not limit to just new construction.
- BH: Apart from rooftop solar – new studies from EPA. New research with solar on glass. Would it be possible to add them to the windows – change out windows on large buildings.
  - LC: we should look at it. Not sure if it's technical feasible or not?
  - AA: what is this? Research efforts towards this type of thing – 20 years ago looked at but not sure if it can be done today but if so that's great. Would just caution if this can be actually done.
  - BH: essentially windows, semi-conductors on polymer film on glass. Still transparent so acts as glass. Can send out study by EPA.
- RM: policies won't be Uconn buildings – could be other folks (e.g. Discovery Drive).
- PF: "maximum rooftop solar" focus on energy improvements will be the sacrifice of something else. Rooftops will be competing with green roofs. Is one better than the other? But we can't

have language in here that restricts us to only 1thing. Different projects impacts watershed, energy use, etc. Phrase it that solar is higher priority but you have to understand that there are other environmental and sustainable items that must be considered. DEEP is very groundwater focus – high level of groundwater in this state, regs and enforcement is constant. Theme to remember.

- HZ: obviously important. Language should be nuisanced. Rewrite 6.6.3 and we can't be making broad sweeping statements.
- LC: can't get so focused because there's a broader approach. Language with focus because there's other ecological things to consider

AA: making solar cells on flexible substrates – roll out over a rooftop. Not efficient, not as much power. Easy install but could be looked at for older rooftops.

<u>Section 6.4</u>

HZ: any objection to this section?

- SN: shelter in place. Investment in place that's beneficial in an adverse event. We need to maintain that capability. 2000 international students, still need to be taken care of. We need ability on campus to provide shelter in place, it's crucial for the university. Evaluate and take into account all paths.
- MJ: just took a call, UCONN will be prepping 1000 beds for the state to house first responders.

<u>Section 6.5</u>

HZ: unanimous agreement amongst sub group

<u>Section 6.6</u>

HZ: not just specifics of project by project analysis but also student demands –diversity, water resources, transportation, etc. We should continue this but there's more work to be done.

JU: Continuing assess progress towards climate commitments. Build out how we're going to assess the progress to create accountability so this report doesn't just end up on the shelf and nothing is implemented.

- MW: divide section 6.6. – Equally important and distinct from each other but we should split this up. Assessment
- AA: work out with president separately instead of having within the report to have an extension
- AS: for the assessment, biennial or annual assessment. But we should also have an ongoing set of metrics that we can display on campus so everyone knows where we are and watch it in real-time. Great education tool.
- LC: Section 6.2 assumption was that we are continuing NW Science quad projects because that has been planned and part of academic plan was completed 5 years ago. Does anyone disagree with this? No comments so move forward.

President's Sustainability and Energy Workgroup Meeting
Thursday, April 9th 2020
2:00 – 4:00 pm
WebEx Meeting

FacOps PowerPoint slides (meeting materials in the SharePoint)

LC: The subcommittee work group wants to make sure you are behind the recommendations. This goes to the presidents and has your name on it. Important to the sub group members that we go through the recommendations. Attachment to meeting – pdf with dates and climate initiatives of comparing and summarizes (completed by FacOps/Mark).

MB: review of slides – Governors goal, UConn goal and IPCC goal (45% but 60% was including other factors climate injustice, etc.)

- Slide 1 : how we would meet UConn goals by 2020 and 2025. Curtailment and new construction is the hatched mark.
- Slide 2 : governors goals
- Slide 3: breakdown showing how we would get to the goals based on 2007 baseline, reduce emissions by an additional 5800 tons. Proposed projects to get to the reduction goals.
  - LC: just a strategy for projects both funded and non-funded. There's a lot at play, some will be increased, decreased, and changed. Just keep in mind this is just a strategy on how to achieve.
  - AS: just for 2020 – plausible?
  - MB: at this point, they are do able. Delays with COVID. We're talking about SLED and ECM projects which are ongoing and we believe they will be in place and the commuter carbon offset is a sustainability initiative.
  - LC: funded projects correct?
  - SN: approved projects and we have funding in place but in various places in design, development and/or construction. SLED re-lamping on going phased project – this year it is funded and planned for May. Obvious may be some delays.
  - LC: change funding to approved
  - AS: is COVID going to modify commuter offset
  - SN: yes, likely it will. Tradeoffs. Previously mentioned any of these can be increased or decreased.
- Slide 5: additional reductions in 2025 time frame to meet 30% reductions. Additional 19,000 metric tons. In addition to the 2020. Projects listed is the lab ventilation, building improvements, SLED, ECM projects and the geothermal projects (CESE/BISHOP), green vehicle, and digester. Green Vehicle is to increase # of electric and hybrid in the light duty fleet. So again, this is what we need to do in addition to the 2020.
  - RM: ESCP project is the old ESCO project?
  - MB: Phase 2 of the ESCO and something we talked about previously. Phase 1 looked at science buildings and would include steam lines.
  - RM: where is the steam line?
  - SN: specific buildings and steam lines has not been determined. It would be based on a previous study for the utility steam lines that would need repair.
  - JU: steam line replacement put us in place for the electrification.

- SN: replacement of lines isn't that expensive compared to energy loss. We would be looking at existing and infrastructure to be maintained and continue to serve the existing buildings so they remain functional.
- JU: feasible to replace not with steam?
- SN: yes, we'd start to look at the area in fine arts. Good candidate for hot water conversion.But an assessment would need to be done. Conversion would be exterior campus and then work towards the inner parts of campus for conversion. That's how we would develop over time.

- Slide 6: additional projects for the next time frame to get to the 45% reduction based on the EO goal. This case we have an additional 10 MW solar (for a total of 15 MW), steam line repair, Torrey Life demo, and compost expansion. Again this is in addition to the other time frames in order to get to the 45% reduction goals.
  - MW: attempt to 60% goal – strategy similar to continue on.
  - MB: 60 % instead of 45%, it's a 15% reduction but we would need to just carry it along
  - AS: new construction be net zero , then only curtailment would be included in the hatched section
  - MB: yes, that section would be reduced
  - AS: we would be closer to 60% and the only effect is curtailment.
  - SN: diesel uses is based on unavailability of off campus uses. We would need to go to on campus diesel generators.
  - LC: new construction is done by 2025. Most of it will be renovation. We'll take another look
  - AS: the point is that the 60% is not unachievable – it's possible.
  - LC: if we align ourselves with IPCC. We don't want to set a goal, that's impossible and then not meet it at all.
  - RM: 5 MW and 10 mw scenario, does that include other types of renewable. Solar is cost competitive. But other forms are more competitive such as geothermal.
  - LC: just a strategy, will be adjusted and changed as this progresses. This is just a way to get to it.
- Slide 7: all of the previous slides and total emissions we'd need to reduce. Includes EO 1 reduction goals about 37,000 metric tons and the breakout of types of projects.
- Slide 8: same as previous slide but shows how to meet the IPCC goal. Again just a summary of the previous 3 slides.
  - JU: update to add the savings to include electrification and near term changes that are easier to achieve. Consultants try to figure out how to accommodate wind either here or elsewhere. As winter generation profile, it's pretty ideal regarding campus load and when it's peaking. We could include in potential options.

LC: the matrix that we discussed yesterday. It will be shared with the group and includes values in terms of carbon and will be helpful.

- TStD: behind the scenes, working with Stan and his group looking at projects and situational manner with regards to actual project on the university campus as opposed to global/national average and understand how the projects will play out. What are the real costs. Today we talked about electrification. Campus has been built out 140 years with combined thermal and electric energy distribution system. If we move all toward electric, it will put a big load on the electric system which we're already struggling with campus demand we're trying to meet today. Bigger strategy to achieve the right goal in the cost effect, most resilient and right way. Beginning discussions but will included in the next layer – later this year and what are the smart decisions on how to achieve. Not stranding assets is a key part and utilizing to full extent and not switching too quickly.

JU: grid structure analysis. We should make sure we're pushing that analysis further.

- TStD: framework master plan started in 2015, upgrading electrical system and coordinating with Eversource to understand how power enters campus. At this point we're about to embark on major construction and upgrade the system to bring it to the 21st century and upgrade so it can support growth. We'd need to further that plan and talking to Stan + group how to proceed. Right now to add another Eversource substation, type of electrification to move to a more renewable energy would require a 3rd substation to support wind energy over the Eversource grid.
- SN: control ability to switch between types of power – solar, Cogen, wind, etc. requires a sophisticated control system.

Closing Comments

LC: Discussion about the next few subcommittee workgroup meetings for Tuesday, April 14th and Tuesday April 21st 3:00 pm. Laura will send around the options.

HZ: as important individual discussion is. IPCC goal for global warming, should be the bare minimum to remember and think about. Not to think of it as a goal but the bare minimum but to ensure we have a shot at a livable planet in the future. Very important to remember the goals proposed are the bare minimum for a planet for us to live in.

LC: very important point and capture that in the report. Report will be on SharePoint and folder for comments to be added. Open up to editing again. Send over to Laura. Open to format and any other comments. Only first draft and we will continuously revising and updating. Deb will send around the link again.

SJ: Stated the meeting was very collaborative and going in the right direction. Thank you for leading this and everyone's participation.

Meeting adjourned.

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓	✓	✓	✓	✓	
Carnahan, Kerry	✓	✓	✓				
Chen, Ming-Hui	✓				✓		
Hermoza-Ricci, Brandon	✓	✓		✓	✓	✓	
Jordan, Scott	✓	✓	✓	✓		✓	✓
Li, Baikun	✓	✓	✓		✓	✓	
Xinyu, Lin	✓	✓	✓	✓	✓	✓	
Nagireddy, Hamaja	✓	✓		✓	✓	✓	
Roach, Natalie	✓	X	✓		✓	✓	
Segerson, Kathleen	✓	✓	✓	✓	✓		
Seth, Anji	✓	✓	✓	✓	✓	✓	
Ursillo, Jonathan	✓	✓	✓	✓	✓	✓	
Volin, John	✓	✓			✓	✓	
Willig, Michael	✓	✓	✓	✓	✓	✓	
Zehner, Harry	✓	✓	✓	✓	✓	✓	
Cruickshank, Laura	✓	✓	✓	✓	✓	✓	
Jednak, Mike	✓	✓	✓	✓	✓	✓	
Miller, Rich	✓	✓	✓	✓	✓	✓	
Ferri, [redacted] Paul	✓	✓	✓	✓	✓	✓	
Sean Vasington	✓		✓		✓	✓	
Nolan, Stan	✓	✓	✓	✓	✓	✓	
Carone, Debbie	✓	✓			✓	✓	
Mark Bolduc		✓	✓	✓		✓	
KATIE MILARDO		✓	✓	✓			
Patrick McKee	✓	✓	✓	✓	✓	✓	
Tom St. Denis (BVH)		✓	✓			✓	
Ashley Patrylak (BVH)			✓	✓			
Scott Waitkus (BVH)			✓				
Zachary Bloom (CES)			✓				

PWGSE Report May 2021 - Appendix B

PWGS Sub-Group Meeting – Revised Draft Report and FacOps Slides (revised 4/16/20)
Friday, April 17, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, John Ursillo, Harry Zehner, Mark Bolduc, Katie Milardo, Tom St.Denis, Scott Waitkus

This meeting was to discuss the documents sent yesterday (including the matrix) and the draft report (draft updated today and can be found on SharePoint)

1 . Review of the PWGS – GHG Reduction Projections 4-16-20 slides (provided via email prior to meeting)

- M.Bolduc provided an overview of the slides and the changes/updates
    - First 3 slides go through different goals and baselines
        - Figure 1 – UConn Goals based on the 2007 – 20% 2020 and 30% 2025
        - Hatched mark – curtailment and construction projects. Of the hatched marks 30% is curtailment and 70% is construction projects.
        - AS: does the % change overtime? New construction includes the SUP?
            - MB: Approximate but as we move forward the % may change. No, the new project doesn't include the SUP. Any new construction project that came online since 2012 (Oak Hall, Laurel Hall, Engineering Science Building, Werth Res Hall) Projections include Science I and a new Res Hall.
            - SN: worst case year and rounded up. Average is something similar to 7% but the 30% is the worst case – conservative view point for oil usage.
            - LC: only approval for Science I at this time.
        - AS: climate justice and IPCC report – actual goal. Science and the information about emissions and reductions requirements is changing annually (Emissions Gap Report). Language is getting more and more frantic each year. Wants to share the language in the report – included language in the comments. Move this language up towards the front. Critical to highlight not only reductions but emissions – net emissions and how are they declining over time.
            - HZ: use gap report as mentioned and measure how UConn is doing and update goals.
            - LC: Angie to draft language for the report
        - RM: Curtailment question – wont natural gas decrease over time? Wouldn't curtailment days increase over time. No new pipelines in the state and MA banned any frac gas. Should this be factored in the future if we're going to increase our use of natural gas – will affect price, frequency of curtailment and emissions.
            - SN: 30 days is just an estimate, there's no restriction we're prioritized in sequence with all other entities in the state. Home heating and medical is always #1.

LC: provide phone # so Laura can contact people to further discuss revisions. Move forward because we only have 30 minutes.

PWGS Sub-Group Meeting – Revised Draft Report and FacOps Slides (revised 4/16/20)
Friday, April 17, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

- M.Bolduc similar concept as first slide for the second slide. Figure 3 is the IPCC goal looking at 45% and looks like this will be changing based on this discussion.
- Figure 4 required reductions and the proposed projects included.
- Figure 5 is a summary showing what we need to do to get to 30% and includes types of projects we would need to look at to get the additional reductions.
- Figure 6 is for the 2026-2030 time frame and what we need to do to get to the 45% reduction and IPCC goal.
- Figure 7 is the summary slide – 30,000 metric tons reductions from this point to the end of 2030 to get to 45%. If we're talking to 60% we'll need additional reductions.
    - RM: carbon offset program, still a lot of planning that hasn't begun. Patrick had a conversation with University of Florida – they've done a lot less with the program than anticipated. We'll need to plan this with Facilities/Transportation and who knows what will happen next Fall. It's got a lot of potential but would caution that the program still has a lot of work.
    - JU: Governor is saying electric grid by 2040. Not get to caught up in interim goals but get in line with the 2040 goal and get too caught up with the baselines, etc.
- LC: any comments and/or thoughts on the slides because we'd like to include as an appendix.
    - AS: slides are great and we need to include to ensure funding is there
    - JU: electrification is new but we should try and incorporate something in the future.
    - AS: electrification as a separate item to address
    - LC: electrification isn't included in these slides. Yes, would involve a cost. Possibly include something for electrification in the next few weeks if we have time but it's very uncertain. The slides shown have straight forward slides.
    - MB: solar is included so some discussion is here. Preparing for electrification but no benefit until you get to that point.
    - SN: until we have green power available, electrification would increase emissions. So we need to solar panels.
    - AA: it's bad until you have a renewable source. Key point – electrification is good only if its paired with renewable.
    - TD: yes, exactly right. 15 MW of solar in the 2030 timeframe on the matrix.
    - JU: these need to be planed concurrently. Gains only happen with renewables but we need to make sure we're fast tracking and align with the electrification. We also create heat/cooling and create infrastructure to accept, this is key. Discussion about emissions with Cogen and creating more emissions, etc.
    - TD: get electricity to campus and then distribute around campus.

2 . Review of the Matrix and Strategy

- LC: includes baseline and reductions. By the time we get to 2030 we get to align with the 45%. Walk through of the matrix and explanation. Sent over to the group in an excel format.
    - MB: total is the net of the increase and decrease that Angie was talking about earlier

- LC: Review of projects and proposed that are funded. Worth second Science I and new residence hall if we tear down older residence hall but the square footage should net out to zero. Again it's a mix of funded and not funded projects.
- TS: 1000 ton benefit if we tear down Torrey and build a new one.
    - LC: conceptually shows you what an efficient building can do regarding emissions
- BL: explanation of the black – column E, 2025. Why is it still increasing in line 6, 7 and 8?
    - LC: increases with new buildings – heating/cooling, etc. explanation of the metric tons and new buildings, etc.
- LC: review and let Laura know if you have any questions and/or need to discuss as this matrix is reviewed during the course of the week.

3. Electrification Discussion

- LC: review of BVH's summary on what we need to do to electrify the UConn Storrs campus
- TS: prepare and impact of electrification for the campus. Working with FacOps, UPDC, and Eversource. Load shedding discussion and the ability to move energy around similar to steam energy right now. Computer operating system for electric is required for the electrification.
    - AS: Load shedding –move from campus to grid? What does it mean?
    - TS: No, ability to switch the way we feed electricity to buildings or groups of buildings – within campus. Two fold –distribution on campus and within eastern Connecticut as we become more and more of an all-electric campus (in order to keep labs open in emergencies)
    - SN: prioritization sequence for buildings – which building can go without building before it has adverse effects.
    - TS: For example, Gampel down but not a dorm during a winter storm. Right now we don't have that ability.
- TS: Transition from fossil fuels to electric as it was presented in the last meeting (last meeting and the charts shown). This isn't the only way to do this but it's one path. Time consuming and expensive –not sure how to put this into the matrix but we need to identify. It's very important for resiliency for campus.
    - AS: funding from the Feds? Renewable energy funds somewhere to help cover the cost?
    - TS: more than just $50 million dollars in various chunks. Substantial engineering project and cost to the state, university and it will take a lot of time. So we want to understand. Lots of coordination with utilities, etc.
    - AS: savings available based on the electrification.
    - LC: we haven't gotten to the $$$ part, right now we have placeholders for what we thought it might be. Starting to list the things and figure out a timeline. This is likely the next phase of this. We won't get anywhere if we get stuck in the cost aspect.

    - AS: the timeline should be by 2040.
- TS: 2025-2030 goal summary. We're trying to get these big picture projects into the sustainability timeline to try and meet that goal. Large transformer located at the SUP (2025 constructed) in order to prepare for the electrification goals in the overall sustainability goal. D
    - AS: further discussion regarding the current equipment – transformer and additional units. Renewable sources working with the equipment and what is needed and BVH provided clarification.
- TS: Cogen replacement date and the transition from fossil fuel/cogen system to electrification system. The system BVH has been looking at is ground source and heat pumps. Difficult with campus buildings – real estate might be complex. Technology might be different in the future or maybe other ways to create steam and not have a big carbon footprint.
    - AS: where is the SUP in all of this?
    - LC: everything is done by 2023. North wing of Gant is the last piece.
    - AS: gas fired generator installed at the SUP – when can we wind that down.
    - TS: backup right now for the boilers at the CUP. Original plan was 2 turbines in the SUP but no longer discussed.
    - LC: boiler, 2 diesel generators (emergency power), 2 electric and 2 steam chillers. As it's currently authorized.
    - TS: and steam service to heat the Science 1 building (steam from the CUP). Steam in the SUP is a backup.

<u>Closing Comments</u>

LC: Laura to discuss the report separately with people. Wanting to make sure the report is complete on time and she wants to go over it individually.

- Discussion about cutting parts of the report so actionable items are clearly seen
- Two more meetings – next Tuesday and the following week on Monday.
- Last meeting with the entire workgroup is the 4/30. The documents including the draft will be on SharePoint
- BOT meeting – some conversation with the board but the report would not be final until June.

No other thoughts and/or comments – meeting adjourned at 5:25 pm.

PWGS Sub-Group Meeting – Revised Draft Report
Tuesday, April 21, 2020
3:00 p – 4:30 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Alexander Agrios, Anji Seth, Baikun Li, John Ursillo, Harry Zehner, Mark Bolduc, Katie Milardo

LC: Agenda today is to focus on the report. Schedule for the report - any changes and/or revisions need to be completed by Friday, April 24th and final review and edits a few days later on Sunday/Monday. So that the final draft can be updated for the workgroup on Tuesday, April 28th.

1 . Review of the Draft Report including comments and revisions

General overview of the draft report. JU to make live edits within the document on SharePoint

- Sec 3.2.3 Climate justice and the Scientific Consensus
  - HZ: summarized and cleaned up the paragraph. AS to add any additional information.
- Sec 5.2.2 Energy : Current Demand and Sources
  - LC: Description of Scope 1, 2 and 3 and what they are. A sentence and/or a footnote is needed.
  - JU: add something in the appendix or foot note
  - AA: brief text definition or diagram to illustrate what they mean but it should be in the body of the paragraph.
  - SN: we can reference the term sheet and will keep it brief.
- Sec 5.2.3 Human Behavior
  - HZ: included a brief paragraph with info regarding the program, more concise
  - JU: will delete the subsequent paragraphs to avoid any confusion
- Sec 5.2.4 Emissions credits (revised paragraph)
  - JU: before we had included carbon offsets but wanted to include something that we do. RECS and funding for efficiency efforts. Stan assisted with the clarification and Rich regarding the UConn Forest and Compost info with regards to credits.
  - RM: clarification of rebates and RECS. Rich can include additional information regarding forest and compost.
  - SN: class 1 RECS received from Fuel Cell at the Depot campus and we should make note of that.
  - JU: this section is designed to be what the current status is and Section 7 includes the various options.
- Sec 5.2.5 Energy Market and Legislative Climate
  - JU: we haven't discussed the state of things, rapidly changing and will impact the options. If we're saying to wait for technology, we should explain what the current technology is so there's an understanding. Include legislation info and status of things.
  - LC: discussion of appendix with info already included
  - JU: reference the appendix and add a sentence to as such.
  - RM: consultants that should provide info?
  - SN: CES has projected current and future info but it would be an appendix item.
  - LC: Yes, and Rich to include any additional information that he feels there might be something that is left out. A lot of what we're doing in this report is the info we have, recommendations, etc. but there will be a lot of things that are uncertain because of the COVID pandemic. Everything right now is up in the air.
  - AA: not the optimal time for figuring out what to do in the future because everything is upside down and up in the air right now.

    - JU: paragraph to include uncertainty so there's an understanding. Also an ongoing assessment so recommendations can be fine-tuned over time and adjusted. Just because there's uncertainty we don't want to not suggest things, we should try and provide recommendations with the best knowledge we have.
    - LC: framework plan – living document with an option for change. There are absolutes and principles that you have to do but there's room for continued improvement.
    - AS: recommendations are based best available science and best available science is continuously being updated and an adaptive framework then it's built in.
- Recommendations Section 6.1
    - HZ: discussion of the goals, interim goals for tracking, 60% is aspirational and emphasize we should be doing more than what the standard is. Rewrote the section to make sure it was official, clear and concise.
  - LC: Question that has come up. Technically speaking, do we have a way to accomplish a 60% reduction by 2030? What would we have to do? Stan?
    - HZ: the most key is net zero by 2040, updating goals in terms of long term vision. UConn should be embracing goals with climate justice and international science conscience. 60% is just higher than 45%. We should have something in line or higher.
    - AS: UN Climate summit for a few years. 3 years ago –press conference in 2017, scientist presenting results was asked by a NY Times reporter: it sounds what you're saying to meet the 1.5 degree goal, we have to get to zero emission by 2050 and what does that mean for developed countries? And the scientist responded that developed countries need to get to net zero by 2030. Understood it's not ideal but just what the scientific community has said.
    - JU: 2040 deadline aligns with EO3. Good to have that perspective about where the ideal place is and where we are now and the compromise. 2040 seems to be like a good compromise.
    - AA: net zero by 2040 seems to make more sense. Countries and States seem to make goals that are unachievable. So, 60% by 2030 makes sense if we need to get to a certain place. It'll likely be harder as time goes on.
    - AS: question is how we address the hatched area.
    - JU: eases concerns to meet this but Tom (BVH) explained a general framework on a 2050 timeline and we're looking to bump the timeline up on a 2040 horizon. It'll require a more immediate action and sense of urgency.
    - SN: Electrification topic – until grid has green power available it doesn't make sense to not use waste heat from Cogen. Hydrogen based fuel seems to meet those goals. Lee Lankston – combustion jets are already being produced. We wouldn't need to do the full wire and change out of the entire campus. Wouldn't be such a constraint. It's not just UConn wires, it's also Eversource and how we would include that infrastructure. Turbine already using hydrogen up to 50% fuel supply – just converting fuel. Constraints: fuel storage. We should also include this as a potential path. WE should fully vet each and every option. The hydrogen is market ready technology we could use today.
        - BL: by 2030 60% emission reduction and 2040 net zero. Electrification and solar might not be able to achieve this goal and would we have to combine

hydrogen? Or can we just choose one of the options. Major concern is storage and how to store. Safety and cost issues.
    - AS: how is the hydrogen is generated?
    - AA: a lot of issues, storing/generating/pressurizing. In an aircraft not many options.
    - SN: approached previously through SECAT for fueling station. Possible concepts, storage and options already out there. Benefits and constraints need to be evaluated and reviewed. ISO wind power for 2040 is up in the air and it may not be met by that timeline.
    - JU: we don't have to wait for the grid, we should facilitate, invest and not wait. We need to keep the options open. IF we decide to make a transition, we're not fully committed either way.
    - SN: agreed. Likely a blend of various approaches and aspects of what is being discussed.
    - LC: include other technologies as it becomes available in Section 6.3.4.
- LC: revise the matrix in order to get to the 60% so we have a strategy and approach on what we'll need to do.
  - MB: we can review and what we would need to get there. Is it realistic, that's another question.
  - LC: we need to actually have something that says we can get to this goal and here's how. It's not talking about money and a definitive way, it's just a path and options.
  - HZ: 2050 goal – the 2040 will be an accelerated approach.
  - MB: matrix only goes to 2030 but other graphs for rate of reduction to 2050. Between 2030 and 2040, the assessment will need to be determined on how we will get to zero. Part of the recommendations – comprehensive study to determine the best strategy and technology available to get to zero by 2040.
  - RM: a good spot for carbon offsets. Example: DUKE and what programs they have done to meet carbon reduction goals.
  - MB: 60% goal, can we use the offsets as part of the path. Will be added as an option.
  - HZ: offsets is an option if we couldn't meet the goal, last resort to get to the goal. Eventually you're going to stop using offsets.
- Recommendation Section 6.2 Halt expansion and construction of fossil fuel capacity and steam infrastructure on campus, including regional campuses and UCHC.
  - HZ/JU/AA: clarification on the term "electrification" needs to be included
  - SN: careful about existing infrastructure and how it's worded.
  - JU: increase strategies and not just replacing steam pipe –huge costs that can't be used elsewhere.
  - SN: you might be able to take the carbon out of the equation but still have steam, existing infrastructure and not abandoning.
  - AA: you have other options and paths towards getting emissions decreased instead of electrification. Hydrogen is not an energy source, the option is a little bit late to the game and his opinion is that folks have been moving away from this and towards electrification.
  - SN: discussion about benefits and constraints with regards to serving campus 24/7.
  - LC: Alex + Stan conversation to add a recommendation or if there's something else that should be included as an option

- Recommendation Sec 6.3 Should we keep a reduced content but eliminate the bullets because they are now listed in Sec 7?
  - JC: shorten this up since it's already included.
  - JU: synergize and revise
  - JC: general statement and details are in strategy section. JU to revise.
  - RM: geothermal needs to be expanded especially if hydrogen is not a viable option. A way to replace the steam.
  - JC: should be in section 7 – details and information about geothermal in the later section. RM to write something up so it can be reviewed.
  - BL: wastewater and anaerobic digestion comments not included? Willing to include a section on this topic.
  - JC: Sean, archived comments included in a previous document? Baikun to include a brief write up.
- Recommendation Sec 6.4 Campus Development
  - JC: design guidelines language and additional information
- Recommendation Sec 6.6 Future Iterations of the Working Group
  - JU: in Section 4 reference of Section 6. Future and next steps for Working Group and the path forward.
- Strategies Sec 7.4 Carbon offsets – what does the 2nd paragraph mean?
  - JU: water resources management is included in future path. Finalizing electrification/energy planning and going through the long term planning. Adaptive management plan. Communication mechanism and how to get that out to the student body.
    *LC to send a separate email – with additional revisions, request, etc.
  - LC may not include anything else – strategy will need to be further looked at and include cost.

2 . Review of the Draft Report Appendix information
Appendix A:

- We need to assign who is responsible for starting to pull together this Appendix
- Should we include the DRAFT Matrix, the slide deck we reviewed on Friday, the chart that lists all the initiatives and baselines? It seems like a good idea to me.
- What other technical information should we include?
  - RM: we need an outside contractor to help tell us what the future will hold
  - LC: we likely won't get that in a weeks' time. Stan, can we get anything on this from Avant or CES?
  - SN: existing reports on portions of Class I and 3 RECS, Carbon price has been tabled until the next legislative year.
  - LC: these could be links but for right now it could be see Appendix B. Stan to pull what he can pull for #2 A and B.
- Current and Emerging Technologies with Development Timelines(A)
  - LC: listed as an alternative technology, hydrogen here.
  - SN: yes, should be included here
  - BL: discusses current/emerging and development timelines – do we need to include timelines?

    - LC: great point and no, we will remove.
- Section b – Strategies
    - LC: document and/or documents to be attached
    - RM: carbon offsets has been moved
    - LC: carbon offsets has been moved and fully discussed and we likely don't need to include. This would be additional strategies to include. For example: virtually net metering.
    - AS: additional strategy details is what this section is intended for.
    - LC: this section needs to be developed more and/or removed. We need a volunteer.
    - RM: move some of these into other discussions.
    - LC: in general this should remain as an appendix. We'd like to keep the other sections of the report concise.
    - RM: some of these approaches provide a way to meet the other strategies.
    - LC: instead use methodologies instead of strategies in this section.
    - SN/RM: continued discussion about virtual net metering and the grid.

3 . Additional Discussions

- HZ: Oxford University divested from fossil fuels.
- LC: spirit of transparency – will respond to the questions and responses to the group re: Rich's emails. And will be sent out to the subgroup.
- BL: comment and discussion about cost
    - LC: matrix includes cost? Cost will be phase 2 of this process.
    - MB: yes, it shows what we need to do to get to a certain % but doesn't include cost.
    - LC: if there's something that should be added, please add Baikun.

- AA: review on the document? Just do track changes.
    - LC: correct. Review button and showing the editing of "reviewing" document
    - RM: version of the document
    - LC: Version 3 all changes but will be updated for V4 and date will be updated

Conclusion

Any changes need to be included by Friday. So that the subgroup can review over the weekend.
4/28 final. Not perfect and will need more work but we just want to be as consistent as we can be.
Keep the report as short as possible.

Next meeting is next Monday – 3pm. One more discussion and uploaded on Tuesday for the rest of the workgroup.
Should anyone want to have a separate discussion, we can certainly do that.
Let Laura know by email if another meeting is needed for Friday 3pm.

***No other thoughts and/or comments – meeting adjourned at 4:45 pm ***

PWGSE Report May 2021 - Appendix B

PWGS Sub-Group Meeting – Revised Draft Report
Monday, April 27, 2020
3:00 p – 4:30 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, Harry Zehner, Mark Bolduc, Katie Milardo

Agenda today is to focus on the report: Executive Summary, Executive Recommendations, Section 6, Section 7, and Appendix A. Review of any changes and/or revisions need to be discussed and approved by group for final review and edits by Laura.

1 . Executive Summary

General overview of the section and the changes/comments

- HZ: self-explanatory, sets the stage for the rest of the report
    - RM: sentence regarding the senate strike
    - AS: strike was supported by the senate resolution - suggestion
    - HZ: to make the addition to the section
    - No other comments and/or revisions

2 . Executive Summary of Recommendations

General overview of the section and the changes/comments

- Term "renewable" to "clean" discussion
    - HZ: legal definition and meaning, would prefer to be more specific. Prefers the word renewable.
    - AA: adding "clean, renewable"
- Recommendation of halt new fossil fuel capacity and infrastructure at all campuses and full electrification of UConn's heating and cooling by 2040.
    - AA: Good conversation with S.Nolan Friday. Central Utility Plant and best way to use fossil fuels currently. Question is what are we doing beyond 2030 and 2040. Do we mean not burning fossil fuels or shutting down and going electric? What do we mean by zero by 2040. What's the vision and we need to decide that.
    - HZ: NetZero – you're not producing anything.
    - SN: Scope 2 (purchased power) emissions are dirtier than what we have currently.
    - LC: concern about timeline and schedule.
    - HZ: valid concern but as time goes on, stricter restrictions and more stringent in the future.
    - AA: future of the CUP and the reality of this statement.
    - SN: you'll always need a backup for full electric power. Example of winter and not being able to heat/cool the campus. Additionally, steam infrastructure is steam/condensate pipes. If you want to electrification campus – install new wires, you'll need to dig up the road and install or you can use the steam infrastructure tunnels and already in existence
    - AA: Regarding the roadway, wouldn't you need to replace over time anyways?
    - AS: Use geothermal heating/cooling ground source – the electricity required is small for pumps and heat exchanger. Why changing to geothermal would require so much?
    - SN: to do the core of campus – you don't have land area and would require more traditional method. The exterior part of campus has some availability.

  - AS: retrofit with new technology for drilling under the building.
  - HZ: revise electrification to use another term to include geothermal. We're consistently not taking into account is how dangerous it is to stay with using natural gas. Weigh both sides of acting vs. not acting in that sense.
  - AS: best available technologies and what it means? Revised to be specific to best available renewable technology.
    - SN: EPA term used in permitting for what is available in the market that's not beta tested.
- SN draft language in the comments to include in this section (Section 6.2) and discussion of the language.
  - HZ: doesn't accept the language. Makes it seem like this is a policy issue. This is our responsibility in a global sense and uphold something. Doesn't accept and should immediately halting. Sorry to be so blunt but the language needs to remain.
  - AS: we can't expand it.
  - LC: suggestion to different ways of expressing this item for the full workgroup Thursday. But ex-officio are not authors of this document so it's up to the professors and students on moving forward on the language in one particular way. It should be how you want to recommend to the working group.
  - HZ: aren't we already currently doing the statement? This is already a goal that the University has. Language is important – if the workgroup goes to the BOT, it looks like if we keep doing what we're doing then it's fine.
  - AA: Concern about resiliency and would like to have the CUP as a backup system. Netzero vs. zero? Language revisions to say zero Scope 1 and Scope 2 emissions.
  - AS: CUP is going to phase out. We're saying net zero because there are other sources of emission other than the CUP. R.Miller has written up a good summary. Offsets for Scope 3?
  - LC/SN: in the time of transition to get to zero we're not going to get there overnight we may want to increase offsets for awhile.
  - RM: interim milestones will help you get there. Ultimate goal zero Scope 1 and Scope 2. You're continually making progress towards hat ultimate zero but you can still use your RECs and offsets. Offsets should be used for Scope 3 because it's hard to manage/control. RECs can be used like we currently do – could be phased out by 2040.
  - AA: definition of Scope 1, 2, and 3 up front in the document.
  - LC: Baikun/Angie/Alex to re-write something for the report ----

<u>3. Section 6 Recommendations</u>

- Section 6.2 : Discussion about netzero or zero carbon. Zero for Scope 1 and Scope 2 – needs to be clarified.
  - RM: sentence for interim milestones should be included in this section. FacOps graphs and summaries for planning.
  - LC: unclear on defining the percentages and whether or not they can actually be included

    - AA: how finely does it need to be subdivided – 2030 is on the way to 2040.
    - AS: 5 year targets similar to Paris review. Interim targets to be specified.
    - LC: agreed, but unclear on what to specify if we don't know what should be included. Angie taking the lead to revise.
    - AS: definition on near term and long term so we understand what they mean.
    - LC: 2030/2040/2050 – specific dates to use for this?
    - SN: 2030 – near, 2040 – mid, 2050 – long is what was used for the slides and we would need to revise if the info.
    - AS: used the term "may include" and questioned and we need electrification to be changed to "mid term".
    - SN: we need additional information to determine viable locations, looking at other areas on campus.
    - AA: the use of "may" makes sense in the way we've described. Immediate steps vs near term and separate into two bullets.
- Section 6.3 : invest in utility scale solar and other renewables and investigate technology
    - BL: additional language for each bullet for term?
    - LC: too much stuff in the bullets because the two recommendations are different. Discussion of the section and bullets. And whether to merge or not.
    - HZ: connection between 6.2 and 6.3 and more specific to make the connection whether or not we're merging the sections. Language added in the executive summary of recommendations and also revised in Section 6.3.
- AA/AS/BL : Discussion of anaerobic digestion and methane.
- AA/BL/SN : hydrogen storage discussion to also be addressed in this area as part of a storage discussion
    - LC: move the conversation about hydrogen should be moved to the Appendix A Current and Emerging Technologies.
- HZ: loop Jon in for assisting with rewording and reworking this section
    - AS: add a link to the Appendix

4. Section 7

- LC: we don't have a concise pattern on how the strategies are addressed in Section 7.0. Originally we discussed Strategy A, B and C from the outline. We really only have 1 strategy. Discussion of graphs and tables.

5. What and how to present the report to the Working group Thursday.

- At the meeting, we'll discuss the executive summary, executive recommendations, recommendations and the graphs and matrix.
    - Executive Summary and Executive Recommendations will be discussed by Harry.
    - Recommendations will be discussed by Jon, Alex, Angie, Laura, Rich and Harry - as outlined in the report.

- Restructure of Section 7 and include an introduction statement for strategy. Baikun to write a summary for the introduction section. RMiller to slim down the carbon offsets discussion and to discuss Scope 3.
    - HZ: recommendation should be a format for Q+A style to the group
    - AS: yes, and take questions by discussion point
    - HZ: encourage the working group in its unfinished form and the entire version to be available on SharePoint.

6. Appendix Discussion

- Laura added info, Stan added links, and Mark added a summary of project info.
    - AS: will look at the appendix to see what makes sense to include or remove.
    - AA: to add in a hydrogen discussion
    - BL: appendix is too long and needs to be shortened
- LC: need to summary and make the appendix concise
- LC: methodologies discussion and should we eliminate this section? Some of the items are already discussed in the report. Will leave alone. Appendix B is already put together by Sean.
- RM: divestment question.
    - LC: hasn't seen a copy of the senate resolution?

Conclusion

Different sections assigned to different people. Revised sections due by 5pm tomorrow, Tuesday, April 28th. Laura will pull the report together and will work on it Wednesday and issues to the workgroup Wednesday late and/or Thursday morning.

Additional follow-up discussions after this submittal. The group will need to complete a final draft the first week of May. We'll need a good document to provide to the President/BOT. Another discussion with the Working Group to set something up for the June BOT, more information to be determined as far as schedule, etc. Also, May 13th to discuss this topic at BG +E.

***No other thoughts and/or comments – meeting adjourned at 5:22 pm ***

PWGSE Report May 2021 - Appendix B

Presidents Working Group Meeting
Thursday, April 30, 2020
2:00 p – 4:00 p
WebEx Teleconference Meeting

Attendees: Scott Jordan, Debbie Carone, Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Himaja Nagireddy, Paul Ferri, Anji Seth, Baikun Li, Harry Zehner, Natalie Roach, Michael Willig, John Volin, Kathy Segerson, Jon Ursillo, Xinyu Lin, Brandon Hermoza, Mark Bolduc, Katie Milardo

Introduction

Previous meeting minutes approved.

Agenda today is to go through the presentation of final draft executive summary and summary of recommendations with questions and answers. Also to discuss the next steps for final draft and presentation of the report scheduled for 5/11 to President Katsouleas and Board Chairs. Students invited and to take the lead members to join to help answer questions. Board will be meeting in June and potentially May. If time permits, a review of the Greenhouse Gas reduction projections and matrix will be completed.

1 . Executive Summary Review

General overview of the section and the changes/comments

- HZ: self-explanatory, sets the stage for the rest of the report
    - KS/JV: this section should be background, not executive summary. Suggestions on how to change. Background is redundant.
    - HZ: potential solution to cut it down to a sentence and use the space to provide an executive summary with the outline of the report.
    - AA/BL: suggestions on how to restructure. Essentially to cut it down to 1 paragraph.
    - KS/SJ/AS: Preface idea and cover letter or transmittal letter to be done.
    - HZ: revise the current executive summary to a preface or cover letter and executive summary should be the facts inside the document.
    - MW: 1st and last paragraph could be context for the executive summary. Guidance to UConn to basically walk the talk and be a leader.
    - LC: understands the request – will be revised. Could be a cover letter, transmittal or something similar. Reminder: when the document is updated into Sharepoint the formatting gets changed and messed up.

2 . Executive Summary of Recommendations Review

General overview of the section and the changes/comments

- LC: discussion of the formatting for the recommendations.
    - AA: remove section A and B.
    - HZ: agreed. Could likely be summarized in a few sentence. Details are in the report.
    - BL: combine and each recommendations #1-6. #1 we could revise so it's more concise with the others.
- HZ: brief review of the content of this section. Items haven't changed since the last meeting, basic goal are the same. Goal #1 goals with zero carbon emissions by 2040. Goal #2 stopping fossil fuel capacity and transitioning to electrification and geothermal by 2040. Goal #3 increase investment in renewable energy. Goal #4 is campus development and everything we're doing is

about zero carbon by 2040. Goal #5 is divestment. Goal #6 is the workgroup charge and next steps.

- JU: Goal #6 accountability and communication mechanisms but also using the phrase ongoing analysis. So this is a living document which is constantly being updated and staying on path to reach these goals rather than creating the goals and shelving it.
- MW: Question for Goal #2 – Law School a Regional Campus? Or should it be called out separately. We should be explicit and not exclude them.
- AA: all campuses is all campuses
- KS: formatting suggestion. Each recommendation should include a bolded summary. Phrase that captures what the recommendation is. So if someone looks quickly they can see.
- SJ: Question and clarification on Goal #2. WE want to understand this is the presidents working group

****KDM lost connection for 15 minutes*** was informed a discussion about Science 1, SUP, and future projects.*

- Discussion about matrix and projects.
  - PF : discussion about his opinion of certain items. UConn has and will continue to have great success implement green energy and can follow a similar model.
  - HZ: agreed but these are different problems – if we have mediocre stormwater infrastructure the world's ecology doesn't collapse. I f we don't transition to green energy in the next 10-20 years it's likely apocalyptic.
  - JU: opinion on comment and discussion about projects, tradeoff and the meaning behind the recommendations.
  - KS: executive summary does not have the matrix at all. Executive summary should include a note for tradeoffs and long run gains but nothing is recognized. :
  - AS: discussion and her understanding and transition, at no point has there been a suggestion that energy infrastructure is ended before its lifetime. Replacement at the useful end or potentially not making investments to lengthen infrastructure which may not be helpful towards goals.
  - SN: goes along with what Jon has stated. Causes of global warming has tradeoffs. Best available technology (regulated by authority and regulators) and should be a key thing. 2001 we reviewed and we needed to get off oil and transition to natural gas, and we've successfully complete that. Solar and wind is coming into play. Jon's point is that we aren't married to a single technology and we should be prepared to go into several different directions to get max use and taking advantage of what you have.
  - AA: tried to tread lightly against specific things but trying to move away from fossil fuels. Terminology should reflect that.
  - HZ: wanted to echo something Angie mentioned. Goals seem aspirational but in a lot of ways they are compromises. IPCC and what they are saying – this is a mid-range goal and

if we get there it would probably be pretty good but there's a lot of scientists that would argue we need to get net zero by 2030.

- LC: adjust recommendations section and rework formatting as discussed. We did not state anything in the report about Science 1, NW quad and SUP projects. If the group wants, something can be added in the body of the text. Documents can be updated and revised then put on Sharepoint for the group to review. Comments would need to be returned quickly.
  - SJ: can work with Debbie for another meeting to discuss. Expectation for ourselves – a few days given to consider the draft and provide any revisions and edits. Get edits to the Laura and the subgroup prior to the next meeting.
  - MW: hasn't had a chance to thoroughly review. We would need another meeting.
  - JU: How does Monday sounds for a subgroup meeting and Tuesday have the draft read for the group and then meet again next Friday.
  - LC: Friday/Saturday/Sunday review and some feedback for a subgroup meeting on Monday. Senate meets 4-6p and could work on this. Provide any additional comments that you'd like to send, please do so. The most important thing to review is the recommendations section. The remaining report is background. Where we are short is the strategy section – but we just aren't there yet. We haven't gone through all of the details. We know what we have to do but we don't know how to do it. Maybe we need to state that. More additional work on the matrix –ex more solar/less geothermal/more offsets, etc and that'll be in the Fall 2020.
    - AJ: critical is that this report is from the entire committee. Consensus among the subgroup but we need a consensus among the entire group. Strategies to reach goals. Disconnect between the group setting the recommendations and strategies. Strategies right now 60% by 2030 is using offsets and that's not the ideal way.
    - KS: Part of the issue there's not reference to strategies and maybe we need to include something in the executive summary about the strategies. We have science based goals but not science based strategies.
    - AS: we haven't been able to do that. FacOps has been working hard to get to these numbers. A lot of work but we're not there yet. Give and take, asking a lot of questions and looking at different things – we need more time.
    - KS: I think we can say that.
    - BL: we need to suggest strategies.
    - JU: we did suggest continuing work in the future and further analysis. Agree with Kathy that it needs to be more explicit. Useful in some of the recommendations, plans and information guiding the next semester has been included.
    - MW: 60% goal reduction is an overarching goal. We've seen during our discussion today, when we make decision about buildings and project –tradeoffs become particularly important. We need to convey this idea, otherwise we'll never get there.
    - AS: Laura has mentioned this in a statement capturing that.
    - KS: executive summary should be what we did, what we have not yet done so it paves the way for the next step. For many, they will only read the executive summary.

- BL : agreed. What we achieved and what we haven't achieved and where we are going.
- AS: put in everything you want them to know in the executive summary

3. Next Steps - Schedule

LC: as you read through this working group folks, if you have a way expresses what we're trying to say – please put it in an email and send it to Laura so we can include and it'll be really clear.

1. Subgroup we'll get together on Monday late afternoon.
2. Working group send thoughts and suggestions prior to Monday afternoon.
3. We'll try and revise and send it back out on Tuesday. We'll try to get the whole entire group again on Wednesday. We'll try to do a short power point/slides.

- SJ: power point as a prop. Single slide as talking points. Just something to put in front of Tom. Logistics of this for the meeting.

4. Power Point and Matrix

LC: Brief discussion of the slides and the matrix. Showing what Mark Bolduc (FacOps) has provided and where we are relative to specific baselines. It also provides what we would have to do to achieve the goals. The matrix shows some things that are already happening but there are some that are not. Some items are one time things and some are not. This is showing a way to achieve reductions. It'll be in the Fall 2020 when we get into details on what we can do and what we can't. This is background – recommendation is to spend more time on the previous discussions mentioned.

Conclusion

A thank you to the Subgroup and the work that has been done in a short amount of time to get the report drafted.

Subgroup will get together 3:00-4:30p on Monday May, 4th. And the report has to be issued next Friday.

SJ: thanking everyone showing real dedication.

***No other thoughts and/or comments – meeting adjourned at 3:48 pm ***

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  - JU: How does Monday sounds for a subgroup meeting and Tuesday have the draft read for the group and then meet again next Friday.
  - LC: Friday/Saturday/Sunday review and some feedback for a subgroup meeting on Monday. Senate meets 4-6p and could work on this. Provide any additional comments that you'd like to send, please do so. The most important thing to review is the recommendations section. The remaining report is background. Where we are short is the strategy section – but we just aren't there yet. We haven't gone through all of the details. We know what we have to do but we don't know how to do it. Maybe we need to state that. More additional work on the matrix –ex more solar/less geothermal/more offsets, etc and that'll be in the Fall 2020.
    - AJ: critical is that this report is from the entire committee. Consensus among the subgroup but we need a consensus among the entire group. Strategies to reach goals. Disconnect between the group setting the recommendations and strategies. Strategies right now 60% by 2030 is using offsets and that's not the ideal way.
    - KS: Part of the issue there's not reference to strategies and maybe we need to include something in the executive summary about the strategies. We have science based goals but not science based strategies.
    - AS: we haven't been able to do that. FacOps has been working hard to get to these numbers. A lot of work but we're not there yet. Give and take, asking a lot of questions and looking at different things – we need more time.
    - KS: I think we can say that.
    - BL: we need to suggest strategies.
    - JU: we did suggest continuing work in the future and further analysis. Agree with Kathy that it needs to be more explicit. Useful in some of the recommendations, plans and information guiding the next semester has been included.
    - MW: 60% goal reduction is an overarching goal. We've seen during our discussion today, when we make decision about buildings and project –tradeoffs become particularly important. We need to convey this idea, otherwise we'll never get there.
    - AS: Laura has mentioned this in a statement capturing that.
    - KS: executive summary should be what we did, what we have not yet done so it paves the way for the next step. For many, they will only read the executive summary.

- BL: agreed. What we achieved and what we haven't achieved and where we are going.
- AS: put in everything you want them to know in the executive summary

<u>3. Next Steps - Schedule</u>

LC: as you read through this working group folks, if you have a way expresses what we're trying to say – please put it in an email and send it to Laura so we can include and it'll be really clear.

1. Subgroup we'll get together on Monday late afternoon.
2. Working group send thoughts and suggestions prior to Monday afternoon.
3. We'll try and revise and send it back out on Tuesday. We'll try to get the whole entire group again on Wednesday. We'll try to do a short power point/slides.

- SJ: power point as a prop. Single slide as talking points. Just something to put in front of Tom. Logistics of this for the meeting.

<u>4. Power Point and Matrix</u>

LC: Brief discussion of the slides and the matrix. Showing what Mark Bolduc (FacOps) has provided and where we are relative to specific baselines. It also provides what we would have to do to achieve the goals. The matrix shows some things that are already happening but there are some that are not. Some items are one time things and some are not. This is showing a way to achieve reductions. It'll be in the Fall 2020 when we get into details on what we can do and what we can't. This is background – recommendation is to spend more time on the previous discussions mentioned.

<u>Conclusion</u>

A thank you to the Subgroup and the work that has been done in a short amount of time to get the report drafted.

Subgroup will get together 3:00-4:30p on Monday May, 4th. And the report has to be issued next Friday.

SJ: thanking everyone showing real dedication.

***No other thoughts and/or comments – meeting adjourned at 3:48 pm ***

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓	✓	✓	✓	✓	✓
Carnahan, Kerry	✓	✓	✓				
Chen, Ming-Hui	✓				✓		
Hermoza-Ricci, Brandon	✓	✓		✓	✓	✓	✓
Jordan, Scott	✓	✓	✓	✓		✓	✓
Li, Baikun	✓	✓	✓		✓	✓	✓
Xinyu, Lin	✓	✓	✓	✓	✓	✓	✓
Nagireddy, Hamaja	✓	✓		✓	✓	✓	✓
Roach, Natalie	✓	X	✓		✓	✓	✓
Segerson, Kathleen	✓	✓	✓	✓	✓		✓
Seth, Anji	✓	✓	✓	✓	✓	✓	✓
Ursillo, Jonathan	✓	✓	✓	✓	✓	✓	✓
Volin, John	✓	✓			✓	✓	✓
Willig, Michael	✓	✓	✓	✓	✓	✓	✓
Zehner, Harry	✓	✓	✓	✓	✓	✓	✓
Cruickshank, Laura	✓	✓	✓	✓	✓	✓	✓
Jednak, Mike	✓	✓	✓	✓	✓	✓	
Miller, Rich	✓	✓	✓	✓	✓	✓	✓
Ferri, [redacted] Paul	✓	✓	✓	✓	✓	✓	✓
Sean Vasington	✓		✓		✓	✓	✓
Nolan, Stan	✓	✓	✓	✓	✓	✓	✓
Carone, Debbie	✓	✓			✓	✓	✓
Mark Bolduc		✓	✓	✓		✓	✓
KATIE MILARDO		✓	✓	✓		✓	✓
Patrick McKee	✓	✓	✓	✓	✓	✓	✓
Tom St. Denis (BVH)		✓	✓			✓	
Ashley Patrylak (BVH)			✓	✓			
SCOTT WAITKUS (BVH)			✓				
Zachary Bloom (CES)			✓				

Presidents Working Group Meeting
Monday, May 4, 2020
3:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, Harry Zehner, Jon Ursillo, Mark Bolduc, Katie Milardo

Overview of the Executive Summary and Recommendations Report

LC: Prior to the meeting the final report version 9 was provided which included edits from Kathy Segerson, Baikun Li, Mike Willig, Rich Miller and Stan Nolan and put them all in one document. There are 2 versions of the Executive Summary and Recommendations, Option 1 revised by Kathy and Option2 revised by Laura and sent to Harry on Friday night – happy to work with either or a combination of both.

A few details to review:

- Rich – sec 2.1.1 – are these quotes? Can you compose an introduction and write more generally about the Academic Plan instead of quoting section? *Yes, Rich will review and address.*
- Sean – sec 4.2 – is the aerial ready to insert? *Yes, it's ready*
- Sean, Katie, and Patrick – would you 3 please work to assemble a pdf for Appendix A, and a pdf for Appendix B? if possible we should have it for the working group meeting on Wednesday and ready to go with the report on Friday. *Yes, Sean has that ready and will be in pdf format. Include Subgroup meetings minutes along with the working group meetings minutes. Include all of the consultant reports and information. Ex. Stan shared informational documents for windfarm and/or solar farms – that would've informed our decision. To date there's only been two official reports - Avant and BVH. The Eversource report should be attached.*

Next Steps

LC: Discussion of next steps. Let's discuss how we are structuring the conversation with the President and the 2 Chairs next week so that we can review it with the working group on Wednesday. Scott suggested a ppt but that is mostly to keep things organized (I know Scott!). We could put a very short summary of the Foreword on a slide, a very short summary of the Exec Sum on another slide, the recommendations one per slide. Or we could do something else, it's really up to you.

- BL: Agreed, good idea. Clarification of 1 or 2 slide per section or a slide for each recommendation? Recommendation and strategy is the priority and most important part of the report.
- JU: yes, likes that idea and include quotes or something that can summary the process and what was done.
- AA: Sounds good.
- AS: Yes, that's fine and likes that idea.

LC: Acknowledgements has been issued. Please review and send any revisions so it's correct in this document.

- AA: not a big deal but the acknowledgements with the school listed first. Should it even be included, seems unnecessary but in different.
- BL: Likes the current way it is and doesn't need the schools
- AS: college was listed to show the group was distributed but maybe list the college after not first.

- LC: Ask Deb Carone to have students identify majors and class year to be included. And will eliminate the faculty schools.
- RM: add Patrick McKee to the list.

LC: Terminology and discussion on which to use -“Foreword or Preface”. Kathy introduced both terms.

LC: Discussion of Option 1 or Option 2 discussion and going through the format sections.

- AA: option 1. Option 2 bullets are longer.
- BL: option 2. Use Kathy’s bolds on the full recommendations.
- JU: agrees with the overall opinion. Discussion about recommendations. Additions about tradeoffs. Include specific items (e.g. specific plans in the Fall) in the summary up front so those who don’t read the entire report will catch the details up front.
- LC: Project discussion - only projects approved by BOT is Science 1 and SUP phase 1. There aren’t any other projects there. Possibly not clear enough to other people and you would want to discuss tradeoffs. Will draft a write up for the appendix of projects.
    - JU: additional sentence about tradeoffs, accomplishing academic and research goals and our carbon emissions goals.
    - LC: verify Gant Phase 1 and Phase 2 approved projects but not Gant Phase 3. Potentially would need to figure out how to make that addition.
    - BL: do we need to list out the exact projects.
    - LC: no, staying away from that. BOT approved projects greater than $500M.
    - AA: put the projects in the appendix so it’s clear for people reading it to clarify
    - AS: there isn’t actually new gas powered generation in the phase of the SUP that’s been approved.
    - LC: two steam chillers and 2 electric chillers and 1 gas fired boiler. The reason is because the boilers being removed from the CUP is being decommissioned by DEEP and falling apart. Instead of putting back into the CUP because they won’t fit, we’re putting it in the SUP.
    - SN: discussion about the boiler being added for emergency and it’s not new capacity.
    - JU: discussion about expansion of campus and what COVID is teaching all of us right now.
    - LC: focus is research and getting them proper buildings for research. And the next buildings that come along need to be treated in a new way with regards to this topic. Personal opinion, if recommendations are too strong, nothing will move forward.
    - AS: Can we say something about Science 1 being a missed opportunity and that it came in a little too soon. Substantial study done in the Fall with this type of expertise and converting a campus over, they might come up with ways that make complete sense to incorporate Science 1 in that plan. Maybe it gets delayed but it doesn’t remove the project. It just seems that only including new construction is being risky. Understands funding also could be a challenge.

  - SN: discussion about beta test and demonstrating test should not be the core reliable technology for back up of buildings. Reminder: 500 kw on the roof of Science 1 – the most the roof could handle.
  - LC/AA/AS: geothermal discussion for Science I and II. Stormwater issues and land was an issue which is why geothermal wasn't designed in time. Desktop study was done at the time. But borings will be completed for the Bishop/CESE pilot project.
- LC: discussion of Mike Wiligs recommendations and the reformatting of this section
  - JU: yes, format similar to Kathy's recommendations and bullets items.
  - AS: will work on recommendation 2
  - AA: Alex to complete recommendation 1 and reorg into "A, B, C" and if it was already stated in another recommendation then remove. Repeated information in this section.
  - JU: to complete recommendation 1 and will provide a revised section tomorrow after his exam
  - LC: John to complete recommendation 1, Angie to do recommendation 2 and Laura to write a piece of the appendix for 2, leave recommendation 3, 4 and 5 alone.

- LC/AA/AS/BL : Discussions of emerging technologies including wind and battery storage.
  - MB: a few sentences to include the summary statement for Section 6 to state what it is. New wind and battery storage and emerging technologies – shouldn't we also list nuclear.
  - AS: wind and battery storage has a lot coming online and nuclear plants are being shut down and no substantial plans for building nuclear at this point. That may change and we can review later.
  - SN: more nuclear plants coming online nationally, zero carbon source and mainly located in Georgia.
  - AS: but not in New England and this report is for strategies in this area until it becomes more realistic.
  - LC: reminds about the charge to the group and what we can do to reduce carbon moving forward.

<u>Conclusion</u>

- LC: will send the revised draft version 10 to the working group for their revisions/comment. Everyone has tasked with sections for updating and revising. Additionally, between Wednesday and Friday, we'll need to get the powerpoint ready so Deb can send it. RM/SN/LC to help with the power point for Wednesday's meeting.

***No other thoughts and/or comments – meeting adjourned at 4:50 pm ***

Presidents Working Group Meeting
Wednesday May 6, 2020
2:00 p – 4:00 p
WebEx Teleconference Meeting

Attendees: Scott Jordan, Debbie Carone, Laura Cruickshank, Sean Vasington, Mike Jednak, Stan Nolan, Michael Willig, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Kathy Segerson, John Volin, Xinyu Lin, Baikun Li, Ming-Hui Chen, Harry Zehner, Jon Ursillo, Himaja Nagireddy, Ming-Hui Chen, Brandon Hermoza, Jon Ursillo, Mark Bolduc, Katie Milardo

1. Opening Remarks - Introduction

SJ: Thanking group for joining and in advance for the work being done. Scott will be pulled off mid-call for a fiscal meeting. Anticipating we will be working together in the future, this summer and certainly next semester. Drafting group to walk us through the draft and come to a consensus on the recommendations. Expect work to continue but if there are any objections or something that needs to be said, it should be voiced today before it gets submitted to the President.

2. Review of Report Preface, Executive Summary and Recommendations

- LC: You should have received the draft report yesterday. We will go through the report and subgroup folks will comment as needed.
- Preface updated and edited. Thank you to those who provided edits.
    - KS: 2nd paragraph for items prioritized I preface, great comment about specifics but didn't see it elsewhere in the document. We want to highlight and didn't see anything elsewhere.
    - JU: edited this to be formatted that way. Direct recommendation to item #2, the last portion is a synthesis of within based technology but didn't want to explicitly say only wind.
    - HZ: provide in next steps within the recommendations to include detailed planning for Fall
    - AS: recommendation 2, item A talks about a step by step transition schedule and it's included in the body of the report
    - LC: so are we saying we need to include this elsewhere?
    - KS: if we search for the prioritize language, would we find it elsewhere in the report or only in the preface?
- Executive Summary and Recommendations discussion regarding any changes/revisions
- A Path Forward section
    - KS: pulled information out of Section 6.0 and suggests that these are things we should prioritize in a path forward and in the next stage of the committee and what the work is. After looking at Section 6.0, unclear of what we want people to get out of this section.
    - LC: valid point and giving the time crunch, we were trying to nail down the recommendation and less about the strategy. We possibly need to be clearer and what the next phase will be about.
    - HZ: comment about this section. Personally to change to "reaching goals outlined here" rather than recommendations outlined. We've been specific about recommendations and they've been carefully considered. Just wants it to be very clear that we're saying beyond these recommendations will require more thought.

Presidents Working Group Meeting

Wednesday May 6, 2020

2:00 p – 4:00 p

WebEx Teleconference Meeting

- HN: Typo, at the top and regarding sentence on challenge. Clarifying that this is a "human made" catastrophe and not "man-made".
    - MW: adding language to include - identification of particular risks and mechanisms to reduce them
    - BL : good point and we should add risks and methods. We need to mention this in strategies as well.
    - AA: to phrase it the way Harry has suggested. The recommendations are how to get to zero carbon fundamentally.
    - LC: will rework the language in this section as discussed with the group.
- Background – not much to discuss, the text has generally stayed the same.
- Academic Core Value and Vision – Mike Willig and Rich Miller revised. If there's any comment on that, please forward to Laura.
- Campus Master Plan, University Value, Prospective Students, Climate Justice, Working Group and the Environments – no changes
- Statistics – Sean are we putting the aerial in this section?
    - SV: yes, we have it ready to insert.
    - LC: let's put it in the Appendix A and refer to it in the text so we're not messing with the format of the text.
- Current Demand and Sources – minor changes about having specific % of where power is obtained.
    - AS: greenhouse gas emissions from the power plant?
    - JU: Scope 1 graph
    - SN: it's in the graphic, but we can specifically call it out in this section.
- Graphs and Data – no changes to energy data
- Human Behavioral Initiatives – no changes
- RECs – minor changes
- Recommendation #2 - Laura to re-review on how this section is organized. There were some minor change to content, so it would be more easily readable. Formatted to an "a,b,c,d" outline. We made this short and to the point and matches the executive summary recommendations.
    - Recommendation 2 –Halt Fossil Fuel based construction. Added a clarification section that includes diagrams of project, description and why they are being done, they're all in sequence. Discussion on the structure of the text.
    - KS – first sentence says no exceptions.
    - AS – exceptions are in the points below.
    - JU – discuss during the subgroup meeting tomorrow.
    - HZ: committed University should as the lead in to recommendations. We could work with the exception of the projects listed in Appendix A. We would change the format but the exception would be listed first and people wouldn't have a false impression. Just leave permanently and take off "immediately".
    - BL: discussion about the campuses. But what about the other campuses?
    - AA: summed it up really well to include a statement for next steps to cover this part.

- JV: agreement with how Harry rephrased. Being in the provost office, shouldn't direct this. But need to play an ex-officio role.
- LC: consensus of the body of the group is that we're not recommending that all of these projects get stopped. If that's not the case, we may have a problem. Provide suggestions and we can discuss at the subgroup meeting tomorrow, 5/7.

- Recommendation #3- nothing too specific that people would have questions or disagree with.
- Recommendation #4 – minor comments
  - KS: liked recommendation except item G. this isn't the place to raise online teaching
  - HZ: unnecessary discussion point that takes away from the major point of this plan
  - AA: item F, where does 75% come from?
- Recommendation #5 – minor comments
  - KS: different rational and impact the industry and lead to contraction, unsure that's the case. Those are types of arguments that would come up.
  - HZ: investing in fossil fuels is getting more risky. It's more of a moral thing.
  - KS: recognizing risks and the point Mike had mentioned earlier.
  - BL: statement to recommend "fully" and "fully and partially". We definitely know that in the long run we want to fully divest but partially in the interim.
  - HZ: University of Maine does this and used both partially and fully. Personally feels that it should be fully.
  - LC: skip the issue and remove both terminology –fully/partially.
  - AA: economic liability and risk discussion should be included here it's a good place.
- Recommendation #6 – minor comments
  - AS/MW/KS/HZ – discussion on environmental justice and reworking the language here.
  - JV: outreach and engagement is a good way to phrase this. Very careful to put it to a specific department.
  - AS: is this where UConn Health and other campuses will be included?
  - LC: yes, this is where we would add this information and we'll add up front.
  - KS: water resources management only called out?
  - JV: wouldn't be so specific.
  - MW/JU/KS/LC: conversation about diversity of faculty members and the wording. Fridays Future document discussion and wording. Laura to offer some word smithing suggestions
- Strategies – what we're trying to prioritize and how to make it clear that this is something that we need to continue to work on as part of Phase 2 in Fall 2020.
  - JU: we need some more work. Added language about wind. And adding that we need to do more work and making this statement so it ties back into the beginning section of the report.
  - KS/LC: graphs and baseline reductions per year. No major discussion about the graphs. What are the take home messages for Section 6.0.
  - BL: good point, would be very happy to elaborate more on these figures working with Jon and Harry.
  - AA: yes, we need to talk through these figures.

  - LC: discuss with Stan and Mark too. Baseline and years and a method on achieving this. It's only an option for strategy. There is an information page in the Appendix.
  - KS: demonstrating this is feasible and if it's the best pathway, etc.
  - HZ: matrix comment. Last page on the matrix, 2021-2025 – there are two projects, steam condensate replacement projects – isn't this in direct contradiction to recommendation #2? Significant chunks of the reduction.
  - SN: background on this – aged steam line that has leaks. We won't be able to convert at once, we'll need to do this in phases. Distribution will need to be in place before it can be converted and these will need to be replaced in order to keep equipment and the process functional. We're not wasting heat and water to the ground, we're trying to capture that and make this a tight system. Fossil fuel isn't in the distribution method.

3. <u>Review of Appendices</u>
   - LC: Review of the Appendices - Appendix A and B – Sean has combine all documents to create these two appendices. This includes meeting minutes, consultant reports, etc. Additions including nuclear and hydrogen. Angie added geothermal. There's a lot of backup information. Not too worried about this but if we need to make adjustments, we can.

4. <u>Review of Presentation for May 11</u>
   - LC: General overview of PowerPoint and format
     - KS: made a comment to include an additional slide that Jon added to the preface about the prioritization. It's important and not showing up by just listing the recommendations.
     - HZ: intro slide about the group, who met and how often we met, what was done, general makeup of the group would all be useful.
     - BL: add committee members from different groups and background. Reiterated Harry's point.
     - KS: BGE acronym, bulleted format might be easier to read
     - BL/AA/KS/LC: bold or bullet the recommendations and strategy slides.

- LC: Who will be presenting – members and ex officio members will be attending this meeting. The president and Chairpersons of BGE and TAFs will receive am email, report, power point and link to where all of the documents will be.
  - BL: laura to control the slides
  - LC: Scott to lead the introductory remark (slide #1)
  - LC/DC: the meeting will be 2 hours. There are 12 slides to present.
  - KS: awkward to present slides between slides. Maybe Scott introduces but someone like Laura will continue to present the rest of the slides. Discussion and answering questions – the bigger group will chime in.
  - LC: Scott Jordan - doing the intro, faculty member - who we are and what we will talk about and student going through recommendations. Offline conversation for who will be going through the slides split between academic and students. If you want to set up another meeting to do a dry run, we can figure that out as well. Meeting is Monday.

Presidents Working Group Meeting
Wednesday May 6, 2020
2:00 p – 4:00 p
WebEx Teleconference Meeting

5. Next Steps/Discussion
   - LC: to revise and make changes to the Appendix. Laura will fix what she can tonight and tomorrow in the report and nothing to really change in the Appendix. Subgroup meeting - We'll meet tomorrow, 3p-5p to discuss any last minute items to finalize the report.
   - LC: timeline for editing – this has to go out on Friday morning so please provide everything as soon as possible (by tomorrow by noon).
   - AS: will this be presented to BGE?
     - LC: not at this time
   - MW: provide power point presentation so it can be reviewed
     - LC: yes, will send out after the sub group meeting
     - HZ: the draft version is already sent out with the packet.

***No other thoughts and/or comments – meeting adjourned at 3:53 pm ***

PWGSE Report May 2021 - Appendix B

Presidents Working Sub Group Meeting
Thursday, May 7, 2020
3:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, Harry Zehner, Jon Ursillo, Mark Bolduc, Katie Milardo

Overview
LC: Focus of today's meeting is the changes of the Executive Summary, Recommendation and Strategy. Highlighted in yellow are topics that need to be addressed from yesterday's meeting and some changes have been made.

1. Executive Summary and Recommendations Report
   - LC: Recommendation Section 6. Kathy's email and a section in the executive summary that may not be necessary to included. Include in recommendation 6 instead.
       - HZ: change wording to "future iterations of the working group", more direct, agree with the capitalization of the "Working Group"
       - AS: acronym PWGS used as an option, so that there is clarity of which group
     - JU: rewording to include a justification at the end of item A.
     - HZ: rewording on item D to include "additional tasks mentioned here due to their importance in reducing carbon emissions and committing the University's goals".
     - AS: remove "water resource management" item? Discussion to rewrite this sentence.
     - LC: UConn health and other campuses needs to be acknowledged in item E. Group agrees the text looks good to include.
     - LC: phase 2 analysis how do we decide a strategy note from Kathy – do we need to include something else or are we all set? Jon to include a few sentences to incorporate this comment under the Strategies for reducing carbon by 2025, 2030 and 2040 section 6.
         - AS: there's something in recommendation 2 making note of this
   - LC: Recommendation Section 2 – minor revisions and discussion.
     - AS/HZ/JU: discussion about the future plan and consultants. Working group sets the priority and consultants do the work on behalf.
     - LC: capital project through UPDC and using framework consultants BVH. But PWGS will be the client telling the engineers what the goal and parameters are.
     - HZ: project list in the Appendix and what projects are included. Wants the list to be specific as possible.
         - LC: projects included are: Gant, Cup equip, SUP, Science 1. Once the science projects are done, the rest will be renovations. The exception is the hockey rink which is still in design. It's not listed here because it's not an academic project, but that's the only new building that's an active project.
         - AA: revise title of clarification to board approve construction projects or something along those lines.
   - LC: Recommendation Section 3 – no major changes/revisions.
   - LC: Recommendation Section 4 – minor revisions and discussion.
     - AA: restructure and revise the sentence.
     - BL: where are we getting 75% data? Discussion of the use of this data point.
         - LC: it was randomly picked so we removed it. Rewording this section.

        - SN: not use all new construction, we would want to include renovation if possible.
- LC: Recommendation Section 5 – minor revisions and discussion on why we thought this.
    - JU/HZ/LC: discussion of restructure and adding a sentence or two.
    - AA: removal of a sentence that repeats itself

- LC: Strategies for Reducing Carbon by 2025, 2030, and 2040 – revisions. Mark and Baikun both sent text for the graphs and figures and what they mean.
    - BL: didn't read through the figures before today. Walkthrough of the additional text. Figures 1 through 7 talking about greenhouse gas and reduction and overall reduction. Figure 7 is pie versus bar figure? Figure 2 – lab ventilation and doesn't show up again?
    - JU: too many items for a bar graph – formatting wise.
    - SN: lab ventilation is just a conceptual stage and it's not included in later figures because we should have that info and implemented. Only 1 example method to increase/decrease of how to get there.
    - BL: can Mark input? Potential risk related to greenhouse gas emission. Merge with Mark's input and respond by tomorrow morning to Laura.
    - LC: take Marks and yours and Stan's response to the email – and merge this section.
    - HZ: a big chunk is commuter carbon Scope 3 reductions and this doesn't line up now re-reviewing the graphs. Recommendation #1 talks about scope 1 and 2, and graphs discuss scope 3. Wants to ensure the graphs and recommendations are matched.
    - SN: Scope 3 does count and we should reduce uniformly in all aspects
    - JU: goes along with the further study and we've stated that we'll be doing more work in the future and
    - MB: version of intro, discusses and states that this is one of many possible ways. As stated this is one scenario to get to this goal and that there will be additional studies. Baseline includes all 3 scopes.
    - SN: energy conservation is Scope 1 and 2. Transportation has fewer reductions – low hanging fruit and more readily available opportunities. At the end of the day, we'll achieve all 3 types.
    - AA: we should not be including scope 3 and we shouldn't be asking the University to go zero carbon in all three sections.
    - HZ: agrees with these programs. If the graphs demonstrate to achieve goals but they aren't matching. Understanding it's a late wrench in the discussion. Just want to make sure its coherent.
    - LC: add a footnote because this is too late in the game. Graph shows a lot of Scope 3 commuter offsets. Add a foot note, scope 3 reduction requires further studies.
    - JU: add language in the beginning of the section "many of these rely heavily on scope 3 reductions but not necessarily indicative of the goals and recommendations of item 1".
    - AA: the title needs to be revised, what does this mean. Figure 4 doesn't achieve this group's goal.
    - MB: what we need to do by the end of calendar year 2020 to meet the goals. It's a Uconn goal. If you only want to show what needs to be done for this report –then you should only

show the last pie graph. Yes, the matrix includes the offsets and whatever is listed in the graphs.
    - LC: So, to summarize – we should only include Figure 5 and Figure 6 and remove Figure 4?
    - JU: Alex is trying to create continuity for readability of this report. He doesn't necessarily disagree.
    - MB: additional note for Figure 4 with language similar to "although recommendations was focused on scope 1 and 2, the commuter program was potentially a project to be included in 2020 and we wanted it included". Also interim discussion goals ties back into the recommendations.
    - RM: discussion about the projects and that this takes us into the short term projects. It's not just one and done. This program would provide certain amount of carbon offsets through the 2040 timeframe.
- LC: A Path Forward section – review of comments and minor revisions.
    - AS: add language about how we discussed these strategies in recommendation ## suggest that they be analyzed further in the Fall for prioritization.

2. <u>PowerPoint - Planning for a Zero Carbon Future</u>
- LC: Technical question on size of font and if it presents well
    - RM: a lot of words, especially for the Board. Will people be reading so it will be distracting and redundant?
        - AS: it will be either Angie or Mike but she would prefer Mike to do the introduction.
        - RM: Mike will default to reading the slides and Angie has been in the meeting and probably can do more
        - AS/LC/RM/BL: discussion on the slides and bullet items, format, discussion points and who is presenting, etc.
    - LC: will revise the powerpoint and verify the changes agree with the report. Do we do another slide or make the photo of campus the last slide with the quote.
        - AS: do we want to ask them for questions
        - AA: likes the photo and quote page as the last page
        - HZ: ending with the quote. Angie and Harry tried to zoom it out at every meeting and to talk about specific ideas but also to think about the scale of it and why we're doing this. Easy to forget the reason why we're here and what the purpose of the group was.
        - AS: comment about administrators have to act boldly and doesn't remember it being in the document
        - SV: moved it to a bullet because it was on the other slide. Also has the first part of the quote on another slide.
        - LC: will fix the slides and out for review and then it'll get reworked again probably tomorrow.

Presidents Working Sub Group Meeting
Thursday, May 7, 2020
3:00 p – 5:00 p
WebEx Teleconference Meeting

Conclusion

- LC: will revise the powerpoint and send this out to the group for final review. She will also send out the graph/tables section to Baikun and Mark so this section can get revised/reworked. Please provide edits to Laura ASAP.
- BL: discussion zero carbon vs. netzero/carbon neutral. In the slides and final report, we've been saying zero carbon. The readers will have some discussion on this. Maybe Angie can relay what the definitions are so the group can understand.
    - AS: will add notes to the document for the presentation
    - HZ: Jon and Xinyu will be talking and presenting the recommendations. They are both seniors. They'll make sure there'll be notes to go off of for this.
    - JU: if we have two student presenters is that a problem? Or that's okay because we'll be switching between the two of us.
    - AS: questions that come up should be directed for certain folks answer
    - LC: certain people are tasked with recommendations and if anyone is uncomfortable and/or gaps in responding the group should feel comfortable to step in.
    - HZ: presenting in an organized fashion
    - LC: key people for recommendations - Harry #1 + #5, Jon #2+ #6, Alex #3, Laura #4
- LC: The meeting is 2 hours. Approximately 10 minutes for the overview, 5-10 minutes for the introduction, 5 minutes for each of the recommendations, and if the presentation ends early that's okay.

***No other thoughts and/or comments – meeting adjourned at 5:00 pm ***

PWGSE Report May 2021 - Appendix B

Presidents Working Group on Sustainability and the Environment Meeting
Wednesday, May 20, 2020
10:30 am – 12:30 pm
WebEx Teleconference Meeting

Attendees: Debbie Carone, Laura Cruickshank, Sean Vasington, Paul Ferri, Stan Nolan, Michael Willig, Rich Miller, Patrick McKee, Alexander Agrios, Kathy Segerson, Ming Hui Chen, Anji Seth, Baikun Li, Brandon Hermoza Ricci, Himaja Nagireddy, Xinyu Lin, Natalie Roach, Mark Bolduc, Katie Milardo, Alan Vanags, Scott Waitkus, and Tom St.Dennis

Overview
LC: Email sent yesterday and the agenda. No additional comments and/or final edits on that.

1. Final Edit of the Report
   - LC: Review of the final edits on the draft report. Review of K.Segerson's comments.
   - Preface – mainly grammatical/typo changes.
     - KS: explicit about cost and recognizing benefits and the statement included in this section and to make sure folks are comfortable with the phrasing.
     - MW: agrees and happy with the revision. Executing the activity that we are able to do and meets the spirit of the discussion.
     - AA/BL: both agree and like the edit and change made.
   - Section 4.2 – UConn Statistics for Storrs and Regional Campuses
     - Text for tables have been included. Intent was statistical background for additional information.
     - KS: still thinks there should be a sentence on what the tables are designed to show.
     - SV: sentences have been added to each and are they enough?
     - LC: sentence description of why the tables are there.
     - AA/BL: agrees with Kathy's comment.
     - MW: remove "main" campus and include just Storrs
     - RM: is it also understood that Storrs campus include Depot campus? Keep this consistent with the second table and include Depot.
   - LC: Acronym discussion and review of the document M.Bolduc provided. Document sent around includes descriptions, definitions and terminology for the Appendix. Important to define terms because others will be reading this report.
     - AA: not all of the terms need to be in the document. Difference between Cogen and CUP?
     - SN: walkthrough of Cogen vs CUP
     - LC: would it be better to just call it the central utility plant and update throughout the document. If we're referring specifically about the turbines we can use the term cogeneration.
     - HN/AA/SN: discussion about how to revise in the terminology/acronym document in agreement
     - AA/AS/LC/KS: discussion of the actual terms, what they mean and including terminology in the report and revising sources. Also removal of the CIGS terminology.
     - MB: to provide word document to the group so everyone can review and edit using track changes.
     - LC: Sean to provide the word document on Sharepoint so everyone can review and edit.

Mark, Rich, Baikun to review the document and only include terms used in the report and Angie will add net zero and greenhouse effect definitions.

- LC: appreciates Kathy and others for going through and revising for grammatical errors and updating as necessary. Other items within the report regarding changes/revisions/comments.
    - RM: minor typo to include EcoHusky in paragraph 2
    - KS: clarification in Figures section that needs to be done or needed to be done. Thought in the spirit of it was this was one pathway to get us there.
        - AS: clarified and tried to make this better. And agreement with Kathy that this reflects what Kathy was trying to clarify.
    - LC: Baikun wrote and added clarification for the figures.
        - BL: also added section about future work summary and benefits.
    - AA: comment and edit added about electrification in Recommendation two.
        - RM: delete the term zero carbon. Geothermal discussion which relates to this statement while grid is becoming renewable. You could use geothermal for electric as another option.
        - AA: we would only want to do this if we weren't using heating/cooling at the CUP. We wouldn't want to use natural gas. Math on this electric use from natural gas at CUP or natural gas for geothermal – unclear of how the #s would come out.
        - NR: consultants will review this and can provide additional information. Discussion for potential projects on the outskirts of campus.
        - AS: this statement sounds like its delaying. Wouldn't want this to hold up the process. Do not want to put a sentence that suggests that would say we should wait.
        - MW: we need to come back to the last sentence regarding authority for commissioning consultants and moving forward and the future of this working group and what its empowered to do or not.
        - LC: put this on hold and discuss further at a later time.

2. <u>Review Scope of work for Consultants Summer 2020 (BVH)</u>
    - LC: slide 1 – big picture of what we're trying to do in the summer and fall 2020. We know it will require more study of strategies, monetary and non-monetary options. Difficult timeline to have this all complete by December. We need consultants to be doing work this summer so we have something accomplished – background information and presented to PWGS in fall 2020. Assign a scope of work to BVH because they are position to do the work and they're already the framework engineer (last 5 years) to look at utilities on campus which is a mechanism for going forward.
        - AS: understands why we would be working with BVH and that it's set already and easy to do. To what extent does BVH have the expertise and experience in doing a transition like this? Who have they worked with before where they transitioned major infrastructure – steam to electrification? How do we know they have the proper experience? They did the utility framework and did an excellent job but we're doing something different and it's critical because we need experts.

  - MW: capacity monetary and non-monetary analysis and benefits (Bullet #2)? Not normally in the domain of what certain consultants do.
  - LC: this analysis would not be part of the scope of work. BVH would be looking at the background.
  - TS (BVH): we've been talking about this and what the program will look like. BVH will not be the full solution and will provide input from other consultants as well (e.g. CES). Laura and Stan have asked BVH have asked to look at more of the nuts and bolts aspects, conservation measures that we've been talking about and specific to the UConn campus. We've done a number of projects like this for other campuses – upgrading utilities, geothermal project, electrification upgrades and maintaining fossil fuel burning systems. BVH is not the complete solution but what we've outlined in scope – it will be instrumental to working group and moving beyond the theoretical and what it will really look like with regards to the scope.
  - AS: groundwork was plan to get zero carbon by 2040.
  - LC/TS: correct. CES and others will be participating for certain parts of the solution. Discussion of the plan for grid power not being clean – wind power to power part of the plan and running those building and convert over to clean power – at that point they'll bring over another consultant expert for this. Looking at overall cost, various solutions, pros and cons, etc. a lot of things to look at.
- LC: Goals (Slide 2) discussion. Plan for 60% reduction in emissions (2010 baseline) by 2030 and 2040. Scope 3 will be addressed outside of the scope study. Develop interim target goals for 2025 and 2035. Ensure reliability and resiliency expected as a leading research educational institution (base understanding and maybe not a goal).
  - AS: bullet 1 is from the report so it's fine
  - MW: goals for whom?
  - LC: goals for the report.
  - AS: to clarify this is what we're asking BVH to do.
  - LC: yes, that's correct.
  - MW: if we're going to ask them to do over the summer and they're not dealing the non-monetary items. It will be going down a rabbit hole, issues reaching short term goals, some input data will be available to assist.
  - BL: only can do monetary – is there another firm that can complete the non-monetary. Long term items cannot be achieved over the summer.
  - LC: BVH to provide options – different scenarios and different ways to achieve our goal by 2040. Working group's job would look at the value – added and lost – of strategies and scenarios.
  - MW/AS: timeline and scenarios
  - TS: confusion of timeline of study. We've been saying this summer timeline. What we're talking about is working with you this Fall. Process is lengthy – will take a year or more. UPDC and FacOps to do some of their homework and have background info prepared for the Fall so we understand the direction we're going. It will take entire academic year. It's really an update of the framework utility master plan.

- AV: recently presented at a conference (IDEA) – up to date and more than up to speed with what's out there and looking forward to working with UConn and bringing the university up to the next step. We are so familiar with campus – we can take those strategies and help.
- MW/AS: continue discussion about tradeoffs, risks and options to consider and have something for the working group to review in the fall.
- LC/AS/TS: 99.9% reliable/resiliency goal # is debatable. Should be met for this university and should be as high as I t can. Review of NIH and other funding agencies for requirements and availability for services to research facilities that can be reviewed.
- SN: at least as reliable as Eversource.
- BL: % to give to BVH and is it a UConn requirement or is it too high or too low? Do we need to do homework to determine % or will BVH provide this #?
- TS: comparable with other institutions and should be hung up on the number today. Benchmark would be looking at peer institutions. Complex questions and in a lot of cases the building by building or lab by lab
- LC: bullet #3 is just a basis not a goal.

- LC: plan scenario/development (Slide 3/4) develop timeline and roadmap scenarios to convert heating and cooling infrastructure to zero carbon by 2040. And nonmonetary discussion will come after BVH will review. Discuss and planning with utility companies – will probably be a discussion at a higher level.
  - NR: carbon proxy price and where will it come in? Economic analysis and will be important to use an expert to review. Concerned that we don't have any experts? How we are going to pull this item off.
  - LC: excellent question and we don't have a clear definition, so it will go to the Fall and evaluation and analysis of cost (non-monetary) benefit for pros/cons will be reviewed. Not considered background work but more of a discussion.
  - AS: proxy price developed timeline? Harry? His project goes through the Fall – so likely later to discuss with him
  - BL: consultant firm will develop this? Working group couldn't develop this. Maybe BVH?
  - LC: will need to discuss with BVH and also talk to Harry. BVH would need to put a value on what would include in a proxy price –example: social welfare of people in China where something is produced and used in the US.
- TS: (Slide 5/6) plan development for strategies and scenarios for reducing carbon. Identified in the matrix and looking at projects in more detail and looking at the requirements, assign cost and schedule to those projects. They can become building blocks for the plan and scenario. Projects include: solar on campus and near campus, geothermal for heating/cooling. Additional strategies and in order to accomplish by 2040 we may want to buy clean energy in other ways. Waiting for grid to become clean for the program goals or install additional equipment to meet goals.
  - AS: in which of these bullets of looking at low temp/hot water?
  - TS: item C – geothermal. Looking at how to potential mobilize equipment on campus. Converting existing equipment and/or creating district systems for areas of campus and

creating low temp hot water for certain areas, cooling season distribute water to those areas. How do strategies work, where does it make sense to do standalone buildings or group of buildings, equipment and end life use, phase into workable plan.
  - AS: item A – replacing steam pipe, but those projects could be effected if we can covers?
  - TS: in some cases it will be and sometimes it will not. But this will be reviewed.
  - LC: there will always be some repair to utility infrastructure.
  - AS: repairing steam pipes – reduces fossil fuel as Stan has stated multiple times.
- LC: Does this powerpoint seem like a good path going forward. This will be written up as document instead of a powerpoint? We will write this up and send it around for review.
- RM: PPA and virtual net metering. Hearing a lot about offshore wind in near term from Eversource.
- TS: scope is limited to Storrs campus. Last slide – forecasting the strategies and potentially will apply to regional and satellite campuses.

3. Final Next Steps for Turning in the PWGS Final Report

- LC: Glossary/definition document will be updated by certain people (Alex, Angie, Rich, Mark, Baikun). This will be added to Sharepoint for editing. Also, the report will be updated and revised based on discussions today and added to Sharepoint.
  - Everyone is in agreement that we'll be completely done with the report by May 29th ***Any changes people want/need to make – it needs to be made by **Friday, May 22nd** .
  - Additionally, the powerpoint we discussed today will be turned into a document and shared with the group.
  - Also, does the group want one more meeting? This will be added to the mail sent to the group and if needed, we can meet again next week.

Conclusion + Additional Comments

- NR: who will be involved with the process this summer for students? Possibly, the Office of Sustainability students could be involved. A sub group should be created of this working group and they could meet over the summer with the consultant for check in. It would be voluntary but Natalie and Harry would definitely be interested.
  - LC: okay, yes.
  - AS/MW: would be happy to check in as well to enhance and help facilitate the process
  - LC: Yes, but it would be completely voluntary.
- RM: When will there be a call for students next fall? Could they participate this summer to get their feet on the ground?

- LC: No, based on a time perspective – not working with the schedule. The student openings is based on an open solicitation for student involvement and it would go along with BVH's schedule.
- AS: Agreed with Laura, it's an open application process.
- MW: Agreed as well – we don't want to stop the progress of the consultants but agree with Rich that we want students full participation.

***No other thoughts and/or comments – meeting adjourned at 12:40 pm ***

4) Consultant Reports

DRAFT

University of Connecticut

Energy Supply Plan
50% Renewables

December 10, 2019

AVANT ENERGY

Table of Contents

Section 1. UConn Energy Supply Objectives

Energy supply is essential to the functioning of UConn Storrs campus. In 2006, UConn reduced its cost of electricity, steam and chilled water supply by the implementation of its Cogeneration Facility (Cogen). Cogen also reduced the emissions associated with its energy supply because of the efficiency of the cogeneration process.

Reduce CO_2 Emissions	UConn desires to further reduce its CO_2 emissions. As a leading university, UConn recognizes its responsibility to contribute to climate change mitigation. Further, Governor Lamont has called for 45% reduction in greenhouse gases by 2030.
Acceptable Cost	Accomplishing reduced CO_2 emissions must be accomplished at an acceptable cost. Alternative approaches to satisfying emissions reductions can carry widely different costs.
Reliable Energy Supply	For more than 15 years, UConn has been working to improve the reliability of electric supply to the Storrs campus. Any carbon reduction program should enhance reliability rather than diminish reliability.

Section 2. Reducing CO_2 Emissions

Natural Gas Primary Source of CO_2 Emissions

Natural gas is the primary source of UConn's CO_2 emissions. In addition, small amounts of fuel oil are burned as a backup fuel when natural gas supply is interrupted.

Uses 1.6 BCF of Natural Gas

UConn uses approximately 1.6 billion cubic feet (BCF) of natural gas annually. The natural gas is supplied by Connecticut Natural Gas from the Algonquin pipeline. Gas supply is interruptible because it is lower cost than firm supply.

Natural Gas Used for Cogeneration Plant

The largest use of natural gas is for the cogeneration plant. The cogeneration plant converts the natural gas into electricity with the byproduct of steam. The steam is then used to heat the campus and make chilled water for campus cooling with steam-drive chillers.

Natural Gas Used for Gas-Fired Chillers

UConn also uses natural gas to power gas-fired chillers for cooling. This use is during peak times in the summer.

Produces 187 Million Pounds CO_2

Combustion of 1.6 BCF of natural gas produces 187 million pounds of CO_2 annually. In addition, there are some CO_2 emissions associated with the generation of electricity purchased from Eversource.

Plan: Reduce 50% of Natural Gas Usage by Adding Renewable Electric Generation

Natural gas usage would be reduced approximately 50% by substituting renewable electric generation for electricity produced from the cogeneration system.

Convert Steam Drive Chillers to Electric Drive

Part of the reduction of natural gas use would be to make most chilled water for building cooling from renewable electricity. This requires the conversion of the existing chillers from steam turbine drives to electric drives.

This accomplishes two things. First, required steam production is reduced which allows the combustion turbines to be operated at lower outputs. Second, the electric drive chillers would use solar electricity so that it would not have to be stored in batteries.

Effect: To Reduce CO_2 Emissions by 50%

The effect of the reduction in natural gas use of 50% is to directly reduce UConn's direct CO_2 emissions by 50% to 93.5 million pounds.

Section 3. Description of the Project

Solar 37 MW

Solar generation of 37 MW alternating current (AC) would be constructed on land near UConn Storrs. Solar photovoltaic (PV) generation is direct current (DC) and would be sent to a battery or converted to AC by an inverter.

UConn-Owned Land

The project requires between 240 and 400 acres depending on suitability of each site for solar. Land currently owned by UConn might be intended for some other use or be too expensive to use. If so, other land would have to be acquired.

Ownership of land is preferred because UConn has a long time horizon. Although all projects have finite lives, electricity supply to the Storrs campus will be required in any currently contemplated US energy supply scenario. Even at the end of life of the proposed project, the generation would likely be replaced on the same sites.

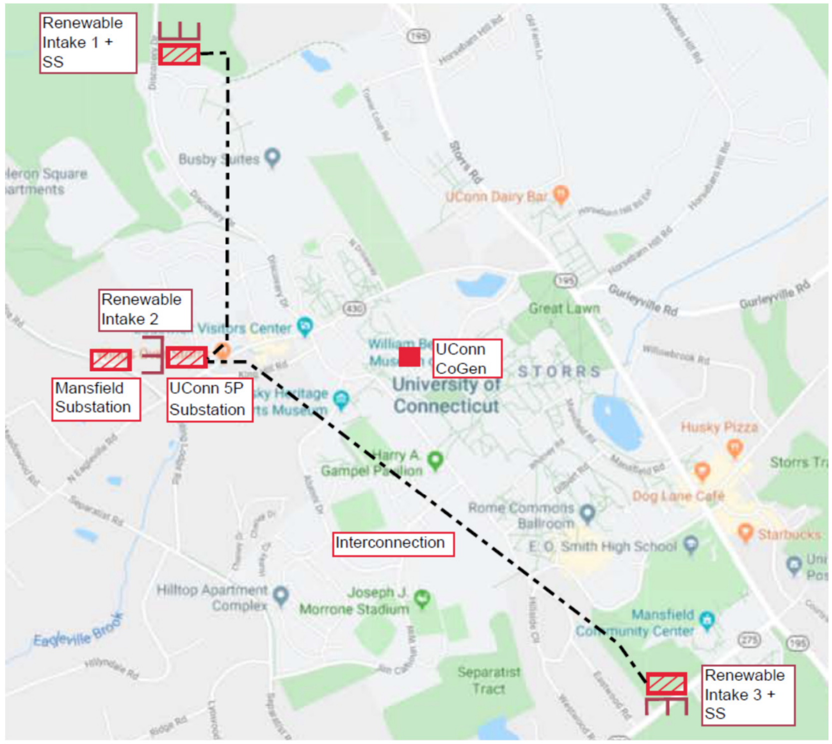
The following map shows land that UConn currently owns in the yellow highlighted areas.

Generation Connected at 3 Intake Points

Renewable electric generation would be connected at three points on UConn's existing electric distribution system because of the difficulty and cost of installing any feeder capacity greater than 20 MW. The paths between likely sites and campus connection points are narrow making construction difficult.

In addition, three renewable intake points would allow UConn to take electricity from more locations in the vicinity of the campus.

The following drawing shows the general location of proposed renewable intake points and the connections between them.



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3 Intake Points Connected

The 3 intake points would be connected because the renewable energy needs to be available to the full campus regardless of the load on any feeder.

Batteries 30 MW

Batteries would be located at the solar farms because both the solar generation and the battery storage are DC while the UConn distribution system is AC. Inverters would convert both solar generation and battery output to AC for delivery to the campus.

The battery capacity would be 30 MW with a sizing that would allow 30 MW capacity to be maintained for 4 hours for a total of 120 MWh storage.

This sizing is sufficient to store electricity produced in excess of consumption during peak solar production for 99 percent of generation.

Project Life 20 Years

The project life is assumed to be 20 years. Solar panels and related inverters are generally thought to have at least 20 year lives. Battery life depends on the extent to which they are cycled.

	Batteries should only be discharged in anticipation of a need to charge them because of generation in excess of consumption. Under this constraint, limiting battery cycling should extend life to approximately 20 years.
Assumed to be Owned by UConn	It is assumed that the project would be owned by UConn. Other ownership alternatives are possible although they might reduce UConn's long-term flexibility for continued operation of generation in the Storrs area.
Convert 4 Steam-Drive Chillers to Electric Drive	Conversion of the existing 4 steam-drive chillers to electric-drive chillers improves the plan by providing increased electric load both during the summer and during the hours the sun is shining. The effect of this is to reduce the amount of battery storage required to absorb electric generation in excess of consumption.
UConn Storrs would Use All Renewable Electricity from Solar	UConn Storrs' electric load with the addition of the electric drive chillers is sufficient to allow it use 99% of the solar electric generation.
Does not Require Conversion of Existing HVAC	The plan does not require the conversion of existing building HVAC systems to electric-sourced energy. However, the cooling needs of buildings would be provided by the electric-drive chillers rather than requiring steam from cogeneration for chiller operation.
Project Could be Constructed in Phases	The project could be constructed in phases. A phase could be as limited as a solar farm of 5 MW with a single feeder to a single intake point.
Land Acquisition and Permitting are Pacing Activities	Land for the project could come from either existing UConn-owned land or land purchased for the project. It is expected that competing interests in utilization of land owned by UConn will need to be resolved before the project can proceed. Similarly, purchase of land from others would require time to be accomplished. This project, like any other construction project, would require permits before construction.
Earliest Likely Date: 2023	The earliest likely date for any solar generation being in-service is 2023. Completion of a project of this complexity would likely require at least 3 to 4 years because of planning and permitting and

the need to construct significant intake structures and feeders, connection of intake points by an inground duct bank, and conversion of steam-drive chillers to electric-drive chillers.

Construction of solar installations is the least time consuming and most predictable of project implementation activities.

Section 4. Financial Analysis

This section describes the project related costs, savings, and net present value.

Projected Capital Cost: $149.5 Million

The projected capital cost for the Energy Supply Plan is $149.5 million and consists of four major elements, solar PV generation, battery storage, renewable collector and interconnection and conversion of centrifugal chillers to electric drives.

Component	**Projected Capital Costs ($ Million)**
37 MW Solar PV	$68.8
30 MW Battery Storage (120 MWh)	51.5
Renewable Collector & Interconnection System	26.8
Conversion of Four (4) Steam Driven Centrifugal Chillers to Electric Drives	2.4
Total Projected Capital Cost	**$149.5**

The projected capital cost is based on 2020 prices and includes a 10% project management related cost and a 30% contingency.

Projected O&M Cost: $282,000 per year

Solar operating costs are assumed to be $0.00435 per kWh for a total of $282,000 per year. These costs are assumed to escalate at 2.5% per year.

Projected NPV of O&M Costs: $5.0 Million

The net present value (NPV) of solar operating costs are projected to be $5.0 million at a discount rate of 3.5%.

Projected Operating Cost Savings: $7 Million per Year

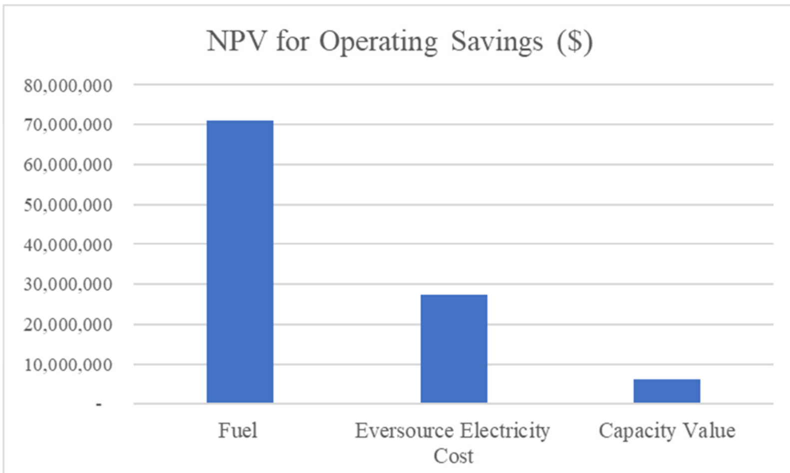
Projected operating savings are $7 million per year based on a 50% reduction in natural gas usage, elimination of Eversource electricity purchases and the capacity value of future avoided demand charges because of greater generation capacity.

Capacity value has been projected based on growth of 500 kW per year, which is approximately 2% per year. The value of capacity is assumed to be $100 per kW-year.

Component	**Projected Savings ($ Million)**
Fuel (Natural Gas)	$5.00
Eversource Electricity Cost	1.95
Capacity Value Increment per Year (because of Battery Storage Availability)	0.05
Total Projected Operating Cost Savings	**$7.00**

Projected NPV Operating Savings: $105 Million

The NPV of the operating savings is projected to be $104.7 million at a 3.5% discount rate.



Projected Economic Value of RECs: $3.2 Million per Year

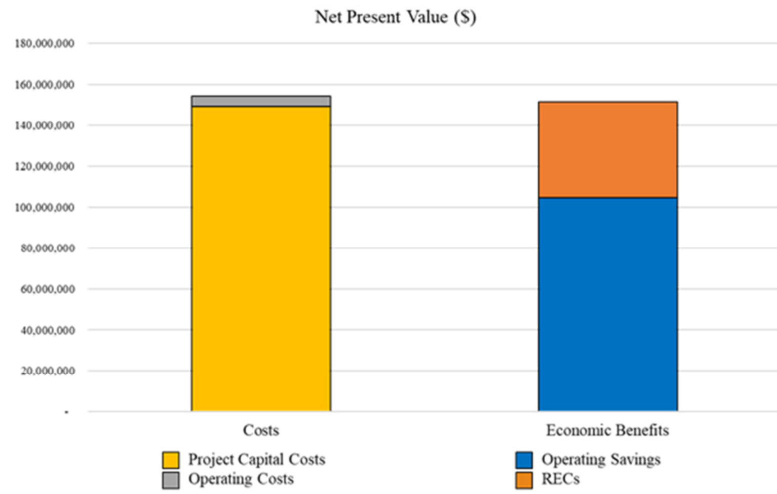
The projected economic value of RECs is $3.2 million per year based on an assumed value of $50 per MWh. A 37 MW Solar PV system is projected to generate 64,824 MWh per year with a total REC value of $3.2 million for the first year. In addition, it is assumed that the PV panels will degrade at 0.7% per year.

NPV of RECs $43.5 Million

The NPV of the RECs is projected to be $43.4 million at a 3.5% discount rate.

Net Present Value: Negative $6.5 Million

Net present value is projected to be negative $6.5 million. This reflects that capital costs exceed the economic value produced by the project.



All NPVs are based on a 3.5% discount rate and a 20-year project life.

Section 5. Reliability

Reliability of electricity to buildings on the UConn Storrs campus is determined by electric generation reliability, transmission reliability, and distribution system reliability.

Electric Supply Reliability Improved by Project

Electric generation reliability is improved by adding 37 MW of renewable solar generation during daylight hours which is greater than UConn's peak load. In addition, 30 MW of battery capacity provides the ability to ride-through short-term supply fluctuations which might trip the existing cogeneration facility.

Electric Supply Less Dependent on Eversource Transmission

UConn would be less dependent on Eversource transmission with the addition of 37 MW solar generation and 30 MW batteries.

Distribution System Reliability Improved by Project

The reliability of the distribution system would be improved by additional electricity inputs into the system at points other than the existing 5P substation.

Batteries could support recovery from a distribution trip because they would immediately be available, unlike the Cogen plant which would have some startup delay. In addition, current efforts to automate distribution system operation would shorten times for recovery after trips.

Section 6. Operational Considerations

Reduced Steam Demand	Steam demand would be reduced by conversion of steam-drive chillers to electric drive. This reduces the load on the cogeneration plant which should allow operation of only one gas turbine during summer months when solar-generated electricity is at its highest and steam demand at its lowest.
Increased Electric Demand for Chillers	Conversion of 8,000 tons of steam-drive chillers to electric drives would increase the connected load by approximately 8 MW. When combined with the existing 2,000 tons of electric drive chillers, UConn's peak summer electric load could be increased by up to 10 MW. This would reduce the need to charge batteries to store electricity in excess of consumption. Less cycling of batteries would extend battery life.
Summer Solar Generation would Exceed Demand	Summer solar generation would exceed campus electricity demand during peak periods. With the conversion of chillers from steam-drive to electric-drive, peak consumption would increase from approximately 25 MW to 30 MW. Peak solar electric generation would be 37 MW.
Excess Generation Would Be Stored in Batteries	Generation in excess of consumption would be stored in batteries located at each of the solar farms.
Stored Electricity would be Used Off-Peak	Stored electricity would be converted from DC to AC and sent to the Storrs campus intake points via feeders constructed for that purpose.
Cogeneration Plant Operation Reduced	Overall Cogen plant electric output would be reduced by 50%. This would occur in two ways. First, there would be no plant operation during time periods when renewable electric generation exceeds demand including electricity from batteries during non-daylight hours. It is projected that there could be weeks during the summer with little or no cogeneration plant operation. Second, combustion turbines would be operated at lower levels for the remainder of the year because of solar generation.
Boiler Operation may be Somewhat	During periods of no operation of combustion turbines, steam would be made by package boilers. This may be an increased use

Higher	over current levels.
Operate CT's as needed for Off-Peak Electricity and Steam	Off-peak during the summer and as required during the remainder of the year, the cogeneration plant combustion turbines would be operated as needed to meet both electricity and steam needs.
Increased Complexity	Overall, the addition of solar generation and batteries increases the complexity of operation of the cogeneration plant.

Section 7. Issues

Future Electric Loads

Future electric loads are uncertain. Since the construction of the cogeneration plant, conservation and load control have largely offset substantial increases in load from the addition of new buildings.

UConn intends to continue its substantial conservation efforts. However, continued conservation efforts will have diminishing returns and are unlikely to offset increased loads from new building additions. In addition, electric vehicle charging could also contribute to increased load.

Growth of 500 kW per year has been assumed which represents approximately 2% annual load growth.

Battery Life

Battery life is determined by the number of times batteries are cycled and the depth of the cycle. Daily deep discharges would shorten battery life to as little as 7 years while less frequent discharge would allow 20 years' life.

Power plant operators are not accustomed to making choices about operation of equipment based on the effects of operation on life of the equipment. Well-described rules for battery operation and management oversight are probably necessary to achieve a 20-year life.

Acquisition of Land for Solar

Between 240 and 400 acres of land is required for the project. Challenges exist in both designating UConn land for solar generation or purchasing land in close proximity to the Storrs campus.

Restrictions on Farmland Use for Solar

Connecticut statutes prohibit use of farmland for more than 2 MW of solar. Presumably, this prohibition is per installation. However, implementing 19 projects of 2 MW each would be both costly and difficult. Alternatively, construction on forested lands would cause higher capital costs for clearing. Legislative change allowing the use of farmland for the project might be sought.

Deferring Project Would Lower Cost

The cost of solar and battery projects is declining. The project would likely be lower cost in the future with better net present value.

Availability of Contractors in Connecticut

Construction costs could be higher because of a lack of competition among contractors experienced in utility-scale solar installations in Connecticut and surrounding states.

Project Funding

The project is assumed to be funded with debt at an interest rate of 3.5%. Alternative funding approaches could include a legislative grant or funding by alumni who might support a "Make UConn Green" campaign.

The project could be funded by a developer with an electricity purchase contract on land owned by UConn. UConn could have an option to purchase the project in the future. However, such options are typically at "fair market value" making financial returns and valuation risky.

Purchasing Rather Than Generating

As an alternative to the proposed project, UConn could purchase renewable energy from a remote larger project. Such projects could have lower direct energy costs but would incur transmission costs to deliver the project to UConn Storrs. The result would be higher projected costs that the proposed project. Further, these approaches result in a "cliff" problem when the purchase contract expires.

Adding a Chilled Water Storage Tank

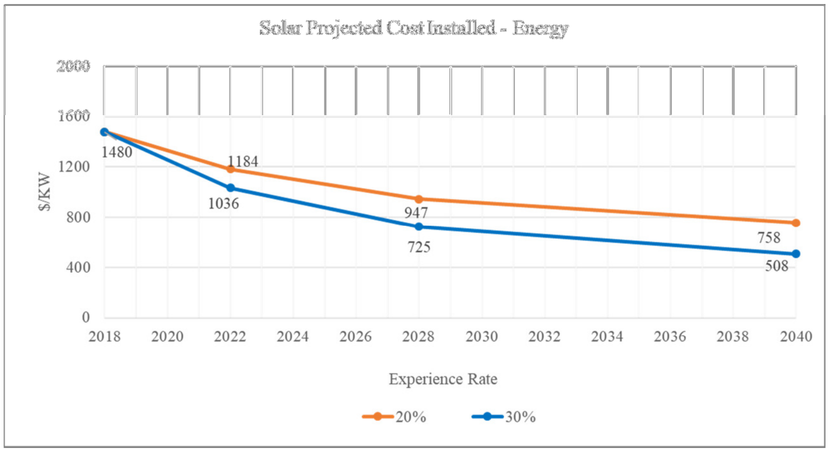
Adding a chilled water storage tank would have three distinct benefits. First, it would simplify chilled water production operation. Second, it would provide more certainty of chilled water availability. Third, increased use of renewable energy during daylight hours would reduce operation of electric storage batteries.

Section 8. Expansion Beyond 50% Renewable

Based on current technology, there are two alternatives for increased renewable production: solar and wind. Another possible alternative, hydro is unlikely because of the limited number of small sites near Storrs.

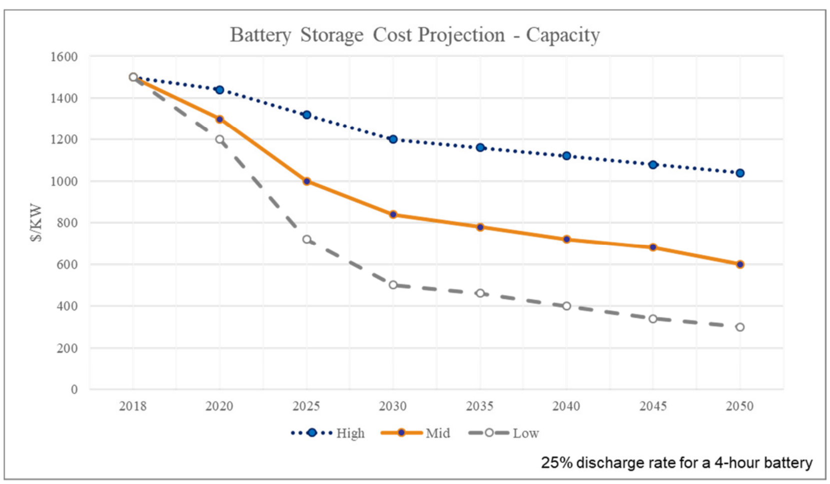
Declining Solar PV Generation Costs

Electric generation costs from solar PV have been declining and are projected to continue to decline with increased volume and experience. The following graph shows projected solar installed cost per kW for the period 2020 through 2040 for 20% and 30% experience rates.



Declining Storage Costs

Similarly, electric battery storage costs are projected to continue to decline. The following projection was prepared earlier this year. Actual results this year suggest that the lower projected cost is being achieved.



If future costs follow the lower projection, the current installed cost of $1,200 per kW is projected to decline to less than $800 per kW in 2025 for a four-hour battery.

Could Allow More Renewable Generation

Projected cost reductions in solar electric generation and battery storage could allow addition of economic renewable generation. Much of the infrastructure for additional renewable generation is included in the proposed project including intake points, feeders, and intake point connection.

Increased Summer Capacity for Export would provide more Winter Energy for Storrs

UConn Storrs could use more renewable energy in the winter. This could be accomplished through increasing the amount of capacity beyond what the Storrs campus needs in the summer and exporting it to other campuses.

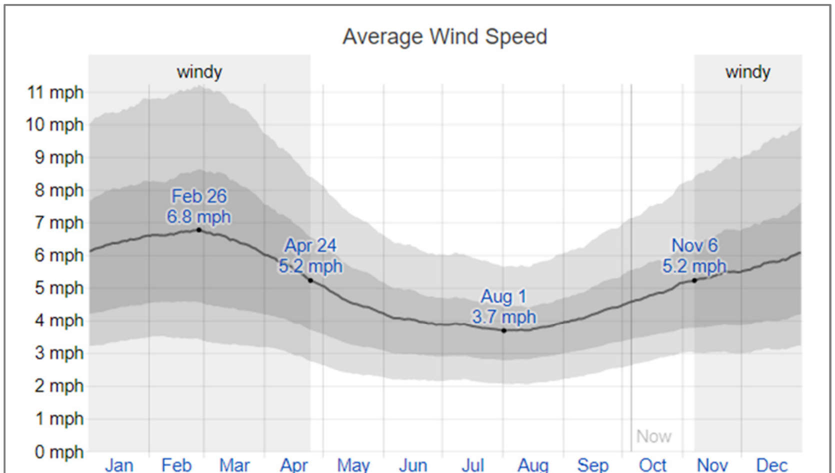
100% Renewable Complex

Achieving 100% renewable energy for Storrs would require substantial increases in renewable generation and battery storage.

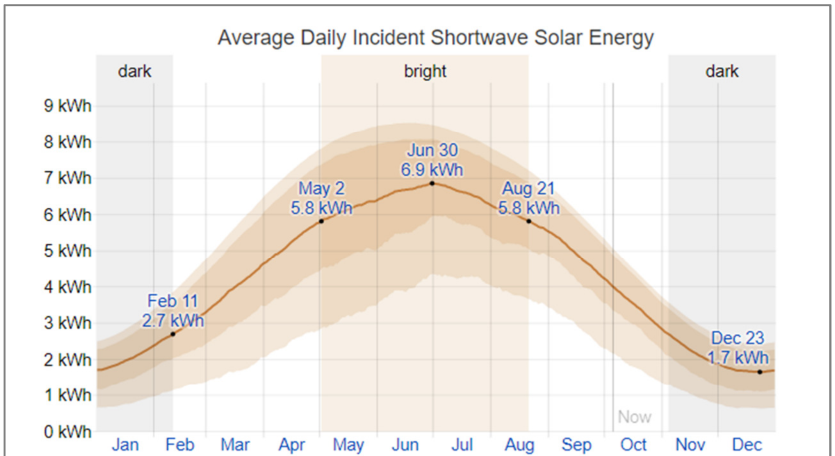
Because existing battery storage is not suitable for long-term storage, increased winter generation would be needed.

Wind has Better Winter Generation Profile

Wind has a better winter generation profile than solar. This occurs for two reasons. First, wind velocities are higher somewhat higher in winter than in summer. Second, solar generation is greater and for more hours in the summer than in the winter. This is shown by the following two graphs for wind velocities and solar insolation for Hartford.



The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.



The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands.

Wind More Costly

Wind is projected to cost \$.073 per kWh compared to \$.044 for solar generation for UConn. Construction costs would be high because any wind project would be much smaller than utility scale. It is unlikely that experienced wind contractors would be interested in a small project remote from most of their work.

Because of relatively low wind velocities, capacity factors for wind in Connecticut would be less than half those of projects being built in the Midwest. Therefore, fixed costs would be spread over less than half the output of commonly built wind farms.

Maintenance costs would likely be high because there is no Connecticut vendor infrastructure.

Alternatively, wind-generated electricity could be purchased and wheeled which would be even more costly because of transmission costs. Wind generation at prices competitive with solar or cogeneration would be difficult to find in the region.

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100 Percent Solar Doesn't Match Load

Solar sized to meet winter load with a large battery installation could meet UConn's load. However, excessive generation in the summer would be wasted. The result is the cost per MWh consumed by UConn would be excessive.

Conversion of Building Heating Systems to Electricity

To achieve 100% renewable energy supply, building heating systems would need to be converted to electricity. This could be accomplished with: ground source heat pumps, air source heat pumps, or electric boilers.

Ground Source Heat

Ground source heat pumps would be the most efficient technology

Pumps	for using electricity for space heating. During times of greatest winter heat needs, winter ground water temperatures are greater than air temperatures resulting in more efficiency in electricity utilization.
Air Source Heat Pumps	Air source heat pumps would rely on ambient air temperatures as the media from which heat would be extracted. Low air temperatures during peak heating times make this less desirable than ground source heat pumps.
Electric Boilers	Electric boilers would be the easiest approach to heating buildings with electricity. Boilers would have substantially lower efficiency than ground source heat pumps but would require little or no retrofit to the building heating system.
Could Require Costly Conversion of Buildings	Conversion of buildings to use lower temperature hot water from heat pumps for heating is likely costly. Existing building heating systems were designed with steam as the source of heat for the building. Although most buildings convert the steam to hot water, the hot water design temperatures are likely greater than those available from commercially available heat pumps.
Could Require Complex and Costly Energy Delivery System	If ground source heat pumps are used for space heating, a piping system for delivery of energy to each building on the central campus would be required. The piped source could be the ground source water or the piped water could have been heated by a central plant.

Section 9. Export of Electricity

Two Approaches to Export	There are two commercial approaches to export of energy from UConn Storrs generation. First, UConn could sell electricity to Independent System Operator New England (ISO-NE). Second, UConn could apply to participate in Eversource's Virtual Net Metering Program.
Sales to ISO-NE Under $40 per MWh	Sales to ISO-NE are not attractive. Prices for electricity would be less than $40 per MWh based on Mansfield locational marginal prices. UConn's costs for both the Cogen Plant and solar generation exceed existing ISO-NE prices. Cogeneration plant incremental costs are estimated to be between $43 and $70 per MWh. The incremental cost of solar generation is projected to be approximately $44 per MWh for solar farms of 5 MW and greater while 3 MW solar farms are projected to generate at a cost of $50 per MWh.
Virtual Net Metering Over $100 per MWh	Virtual net metering would produce a relatively high value per MWh. Eversource's most recent published VNM rates exceed $100 per MWh for both on-peak and off-peak prices.
Limited to 3 MW Generators	The Eversource program application is limited to 3 MW generators as required by statute and ordered by the Connecticut Public Utilities Regulatory Authority.
Program Participation is Limited	Connecticut's VNM program is available to state, municipal and agricultural customers. In September 2019, the maximum annual participation was increased from $8 million to $16 million for all Eversource customers.
Only Steam Turbine Generator at Cogen Plant might Qualify	The steam turbine generator might qualify because it is less than 2 MW. Output of the steam turbine generator is variable depending on steam load. Under the current program, the cogeneration plant combustion turbine generators would not be eligible because they are 7 MW each.

UConn could Build 3 MW Solar Farms to Supply VNM

To participate in the VNM program, UConn could build 3 MW solar farms and classify each as a generator. These would be connected to the UConn campus distribution system as described in this report with delivery of electricity to Eversource at its Mansfield substation.

VNM Solar Margins Projected to be $50 per MWh

Margins on solar VNM are projected to be approximately $50 per MWh for a 3 MW solar farm based on a $100 per MWh VNM price and an incremental cost $50 per MWh cost of solar production.

$85,000 Margin per MW of Solar Projects in VNM Program

UConn would generate annual margins of approximately $85,000 per MW of solar generation participating in VNM. This is based on a 20% capacity factor and $50 margin per MWh.

Storrs Likely More Attractive Generation Site

Storrs is more attractive for generation than other UConn locations because there is lower cost land available nearby and UConn operates a sophisticated electric generation facility.

Carbon Reduction Methods

Facilities Operations

Wednesday, February 5, 2020

UCONN

Top 10 Potential Carbon Reduction Methods

- Existing Buildings
  - Conservation
  - Renovation
  - Demolition
- Solar Power
  - Photovoltaics
  - Thermal
- Wind Power
- Behavior Modification
- Geothermal Heat Pumps
- Power - Offsets Purchase Agreements
- Smart Micro-Grid
- Natural Gas/Propane – Emergency Generators
- Fuel Cells and Tri-Generation
- Anaerobic Digestion
- Transportation – Bicycling/Fleet Electrification

Conservation of Existing Buildings

- BENEFITS :
  - Maximize life cycle value of existing assets
  - Reduce energy use intensity (EUI) of older, less efficient buildings
  - Improvement of building controls to reduce energy use/costs
  - MOU Partnerships lower capital needs

- ITEMS TO ADDRESS:
  - Revolving Green Fund
  - Availability of capital dollars to make improvements
  - Availability of capital dollars to cover the additional costs of net zero features.

Status: UConn currently has MOUs with Eversource and CNG which provide enhanced incentives. Comprehensive energy conservation measures maximize carbon reduction.

Renovation of Existing Buildings

- BENEFITS :
  - Update to current code and efficiency standards
  - Reduce energy use intensity (EUI) of older, less efficient buildings
  - Improvement of building controls to reduce energy use/costs
  - Saves 50-75% of embodied Carbon at 35-40 years

- ITEMS TO ADDRESS:
  - Availability of capital dollars to perform renovations
  - Availability of capital dollars to cover the additional costs of net zero features
  - Mechanical space conversion costs

Status: UConn currently implementing a three phase process to renovate the Gant Complex. Phase 1 is complete and Phase 2 is underway. Also, UConn is continuously evaluating buildings for potential renovation.

Demolition of Existing Buildings

- BENEFITS :
  - Eliminate older, less efficient buildings
  - Replace older buildings with newer less energy intensive buildings
  - Reuse or Recycling of building materials

- ITEMS TO ADDRESS:
  - Availability of capital dollars for replacement projects
  - Hazardous Materials Disposal
  - Ensure end of useful life to avoid new construction carbon

Status: UConn currently evaluating the potential removal of Torrey Life Science in the long term.

Solar Photovoltaics

- BENEFITS :
  - Reduced first cost capital available if installed through PPA
  - Project specific installations can be implemented (i.e., Science 1)
  - Help reduce campus electrical peak loads

- ITEMS TO ADDRESS :
  - Space constraints (i.e., 10 acres/MW needed)
  - Available locations
    - Existing buildings
    - Brownfield Sites
    - Farmland + Forests
  - Storage
  - Reliance on weather dependent systems requires fossil fuel backup

Status: Further analysis is needed for determine additional locations on or near the campuses.

Solar Photovoltaics Study

Depot Campus

Total Land Area	226 AC
Buildings in Service	7.55 AC
Contributing Resource	*0.6 AC*
Buildings Not in Service	0.25 AC
Buildings Uninhabitable	3.4 AC
Contributing Resource	*3.25 AC*
Athletic Fields	4.3 AC
Wetlands	32.2 AC
Approximate Total Study Area	**178.05 AC**

Bergin Campus

Total Land Area	38 AC
Buildings Not in Service	3.5 AC
Contractor Parking	2.1 AC
Wetlands	1.5 AC
Approximate Total Study Area	**30.9 AC**

NOTES:

DRAFT updated October 25, 2019

All locations and acreage (AC) are approximate for planning purposes only.

Wetland data from Town of Mansfield GIS layer may not accurately reflect field conditions.

Buildings that are contributing resources to the historic district are part of the acreage of buildings that are in service or uninhabitable.

Solar Thermal

- BENEFITS :
  - Reduced energy use for building hot water
  - Project specific installations can be implemented (i.e., Werth Tower)

- ITEMS TO ADDRESS:
  - Locations available to install solar thermal
  - Storage
  - Reliance on weather dependent systems requires fossil fuel backup

Status: Installed at Werth Residence Hall. Winterization during non-occupancy periods is challenging.

Wind Power

- BENEFITS :
  - Reduced first cost capital available if installed through PPA
  - Class 1 Resource

- ITEMS TO ADDRESS:
  - Available locations to install wind turbines
  - Reliance on weather dependent systems requires fossil fuel backup
  - Height and Noise Restrictions
  - Lack of on shore wind profile

Status: A wind review was completed for Storrs and the Torrington Campus. Test vertical Optiwind LLC 200 feet 50 KW windmill installed at Torrington in 2009 and removed in 2013.

Behavior Modification

- BENEFITS :
  - Engagement of the Campus
    - Administration
    - Students
    - Faculty
    - Staff
    - Community
  - Reduction of 19.9 – 36.8% is possible by 2050.

- ITEMS TO ADDRESS:
  - Campus Values
  - Personal Commitment
  - Ownership of Change
  - Knowledge Sharing
  - Leadership commitment
  - Messaging
  - Metrics

Status: Center for Behavior & The Environment 2018 Report is available on the website.

Geothermal Heat Pumps

- BENEFITS :
  - Produces one sixth the Carbon of equivalent natural gas
  - Increased energy efficiency for heating and cooling
  - Less maintenance than conventional fossil fuel systems

- ITEMS TO ADDRESS :
  - Large area requirements
  - Locations available to install geothermal
  - Proper soil conductivity for optimal operation
  - Heat transfer fluids biodegradability

Status: Feasibility study for Science 1 completed but determined not suitable at this location. Potential other areas on campus being discussed for further evaluation.

Steam to Hot Water Conversion

- BENEFITS:
  - Reduced maintenance/operational costs
  - Energy savings from steam to hot water conversion
  - Lower thermal loss
  - Closed loop hot water systems require no makeup water
- ITEMS TO ADDRESS:
  - Locations available for hot water conversion
  - Existing steam infrastructure in place life cycle value
  - All new steam pipe would need to be replaced due to condensate lines not being sized for water return

Status: AECOM study completed in 2015 recommended UConn continue to utilize steam as its thermal distribution system. Could become practical in areas where steam has not been extended, and boilers need replacement, such as Hale/Ellsworth/Putnam area pending further review.

Heating / Cooling Equipment

- BENEFITS :
  - New lower pressure units reduce leakage minimizing refrigerant loss
  - Utilize lower Global Warming Potential refrigerants
  - Efficiencies increase with more modern equipment

- ITEMS TO ADDRESS:
  - Capital costs for new versus converted equipment
  - Maximize life cycle value of existing assets
  - Recycle recovery of refrigerants
  - Hazardous waste disposal

Status: Design standards developed to ensure the selection of equipment with lowest global warming potential possible.

Power - Offsets Purchase Agreements

- BENEFITS :
  - Purchase Power to rebalance Scope 1, 2, and 3 Emissions
  - Purchase carbon offsets for emissions
  - Promote environmental reduction goals on a global scale

- ITEMS TO ADDRESS:
  - Line Losses increase emissions
  - Reliability and Resiliency Concerns
  - Availability of Offsets meeting Connecticut Renewable Portfolio Standards
  - ESA / PPA / ITC / Attributes

Status: UConn evaluates the purchase of Offsets with every power purchase as we work towards achieving our stated reduction goals.

Smart Micro-Grid

- BENEFITS:
  - Demand Response
  - Reduced maintenance/operational costs
  - Improved power system stability and quality
  - Increased Electrical Efficiency
  - Reducing KVA will reduce purchased power costs.

- ITEMS TO ADDRESS :
  - Identify additional heavily capacitive or inductive loads
  - Identify locations to install in existing buildings
  - Consider installation on circuits or utility connections
  - Metering

Status: Analysis completed by Center for Clean Energy Engineering. Further evaluation is needed.

Natural Gas/Propane Emergency Generators

- BENEFITS :
  - Slightly lower emissions

- ITEMS TO ADDRESS:
  - Code Response Times
  - Increase initial cost
  - Redesign of building and equipment
  - Reliability of Fuel Source
  - Concerns for large scale storage
  - Impact on overall carbon footprint is minimal

Status: Newly constructed buildings are evaluated for the type of emergency generator needed to meet the building fire and life safety code.

Fuel Cells and Tri-Generation

- BENEFITS :
  - Reduced electrical and thermal fuel requirements compared to stand alone sources
  - Lower emissions than current grid
  - High Reliability and Resiliency
  - Reduced Transmission and Distribution Line Losses

- ITEMS TO ADDRESS :
  - Maximize life cycle value of existing assets
  - Locations available to install fuel cells or tri-generation
  - Utilizes natural gas as intermediate step to full renewables

Status: UConn is currently evaluating submittals from several companies who responded to an “On-site Cogenerations and/or Fuel Cell Distributed Generation” RFP for the regional campuses and the Health Center. Further analysis is needed for determine any potential locations.

Anaerobic Digestion

- BENEFITS :
  - Uses of anaerobic digestion byproducts include electricity, fueling, soil improvement (fertilizers)
  - Diversion of organic wastes
  - Methane emission reductions
- ITEMS TO ADDRESS:
  - Locations available to install anaerobic digester to minimize transportation
  - Limited amount of material to feed the system
  - High Maintenance requirements
  - High land use area.

Status: Further analysis is needed for determine potential locations on the campuses. Currently, food waste from Dining Hall at the Storrs is being transported to Quantum BioPower.

Transportation – Bicycling/Fleet Electrification

- BENEFITS :
  - Reduce vehicle miles travelled
  - Reduce road congestion
  - Reduce land requirements for parking
  - Health benefits of physical activity
  - Consolidation of Public Transport Systems
  - Fleet Electrification

- ITEMS TO ADDRESS:
  - Maximize life cycle value of existing assets
  - Availability of capital dollars for replacement vehicles
  - Disability access
  - DOT/WRTD Contracts
  - Bike Lanes
  - Charging Points

Status: UConn is continuously evaluating vehicles for replacement using electric or hybrid options where feasible.

Next Steps…..

- Prioritization of Campus Interest in Reduction Methods
- Values Matrix by Group
- Affordability Cost Versus Benefit
- Engaging consultants for further evaluation as warranted
- Other?

Campus Carbon Reduction Options

UCONN Facilities Operations, BVH Engineering & Competitive Energy Services

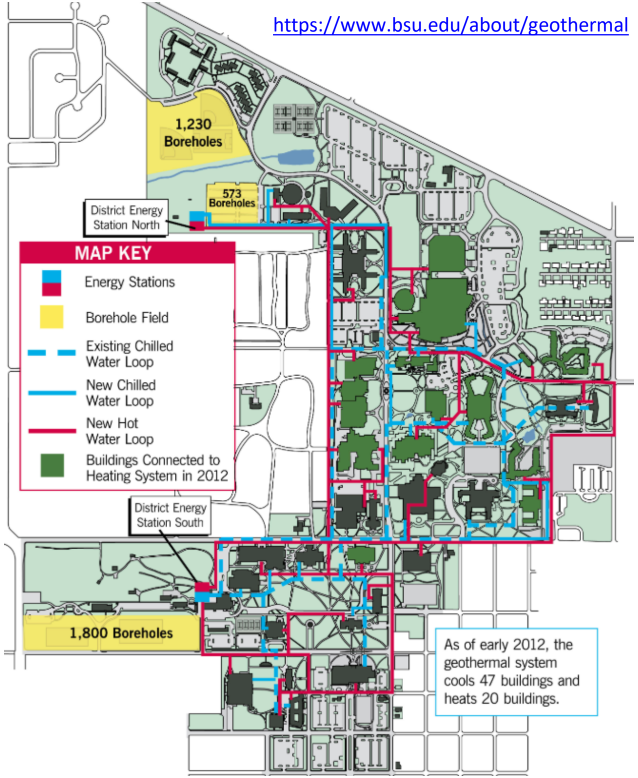
February 27, 2020

UCONN

Item #1: Campus Electrification

- A number of UCONN's peers have begun evaluating district energy conversions to electric-driven technologies.
- Few public higher eds in the U.S. have actually implemented such conversions to date. In 2014, Ball State University completed a major overhaul of its campus heating and cooling systems to utilize large-scale geothermal well fields
- Several key takeaways from peers' planning efforts
  - Campus electrification can require substantial capital investment (low-temperature hot water distribution, geothermal facilities, building thermal infrastructure conversion)
  - Designing a 100% electrified district energy system significantly increases capital requirements in order to meet peak campus heating needs
  - Those who have pursued electrification have done so with a phased implementation approach over time to avoid stranded energy assets on campus
  - Grid reliability remains a paramount concern for electrification efforts, with no economic silver bullet for backup power without using fossil fuels

https://www.bsu.edu/about/geothermal



Item #1: Renewable Energy Credits

OFFSITE PROJECT
Unbundled or Bundled RECs
(example: VPPA or CFD)

HIGHER: Risk, Complexity, Impact

-$10.00 to +$25.00 per MWh

COMPLIANCE MARKET
Unbundled RECs
(example: CT Class I)

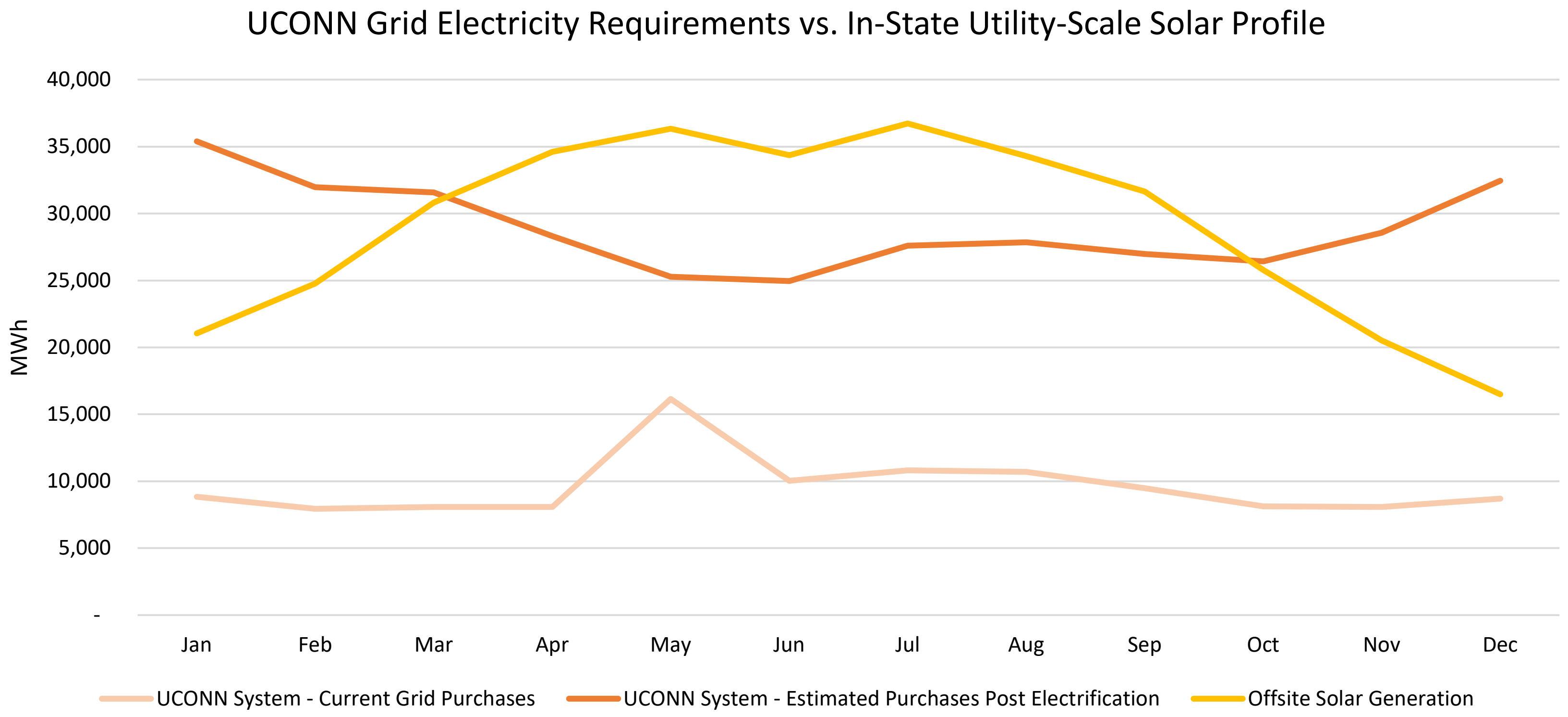
+$25.00 to $40.00 per MWh

VOLUNTARY MARKET
Unbundled RECs
(example: Green-e)

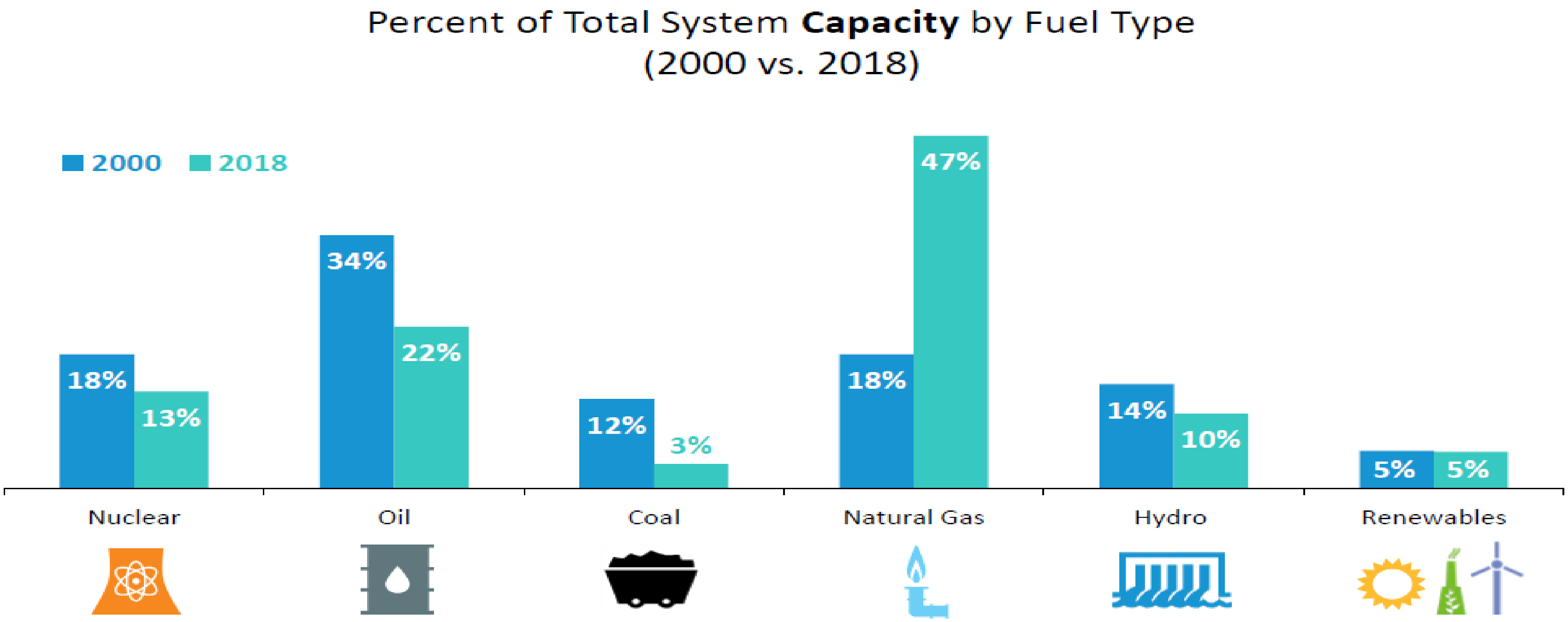
+$0.65 to $1.75 per MWh

LOWER: Cost, Complexity, Impact

Item #1: Renewable Energy Profile



Item #1: Renewable Energy Profile



Source: 2018 CELT Report, Summer Seasonal Claimed Capability (SCC) Capacity
Renewables include landfill gas, biomass, other biomass gas, wind, grid-scale solar, municipal solid waste, and miscellaneous fuels.

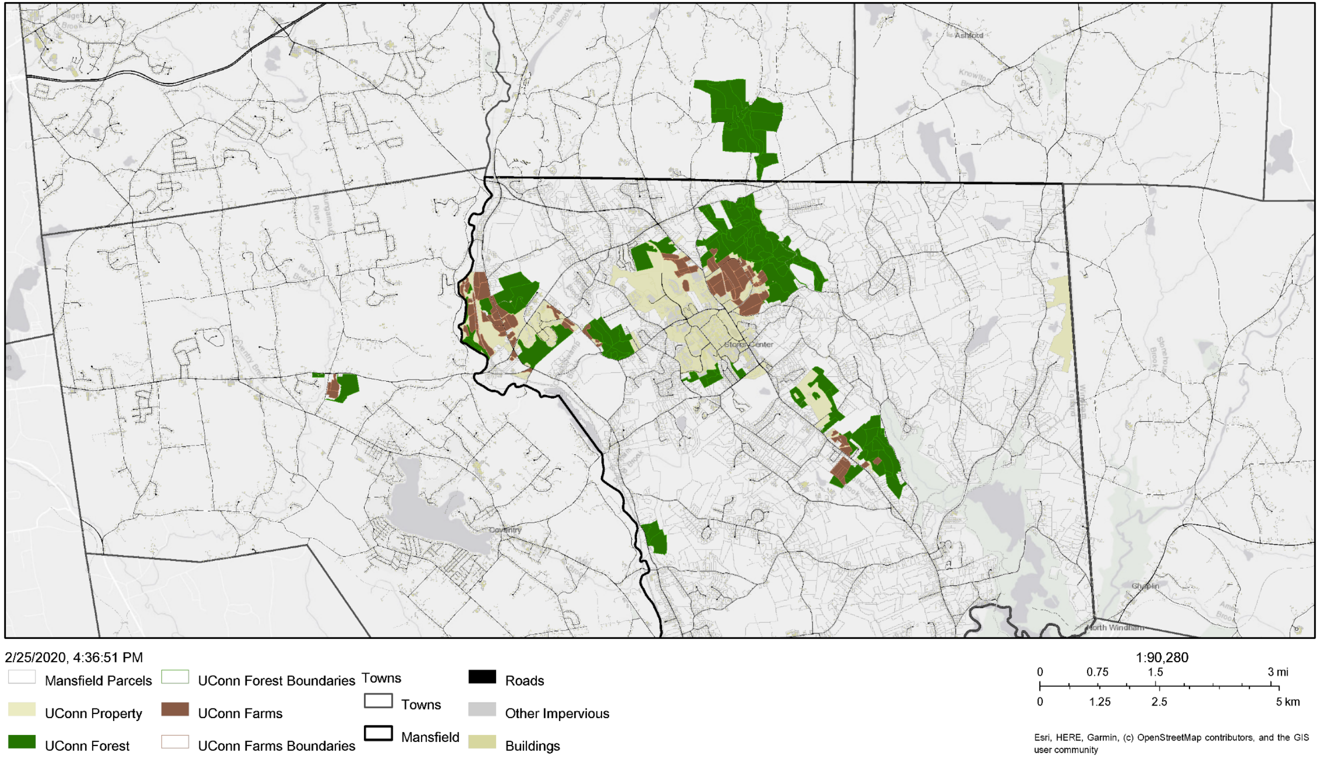
Item #2: Behind-the-Meter Solar

- Onsite solar costs vary widely depending on host site conditions, interconnection costs, and system ownership (i.e. tax credit monetization)
- The primary operational and cost variable for a large-scale solar installation at Storrs is likely the campus' electric load profile with the Central Utilities Plant operating, which may produce risks of excess energy generation
- Examining project economics for behind-the-meter solar, only 70% of UCONN's total grid electricity rate is avoidable from onsite solar due to the utility's electric rate design
- Utility incentives for solar generation can help reduce the cost of installing onsite solar to UCONN, however as a condition of receiving incentives UCONN cannot own and retire the RECs generated by a system

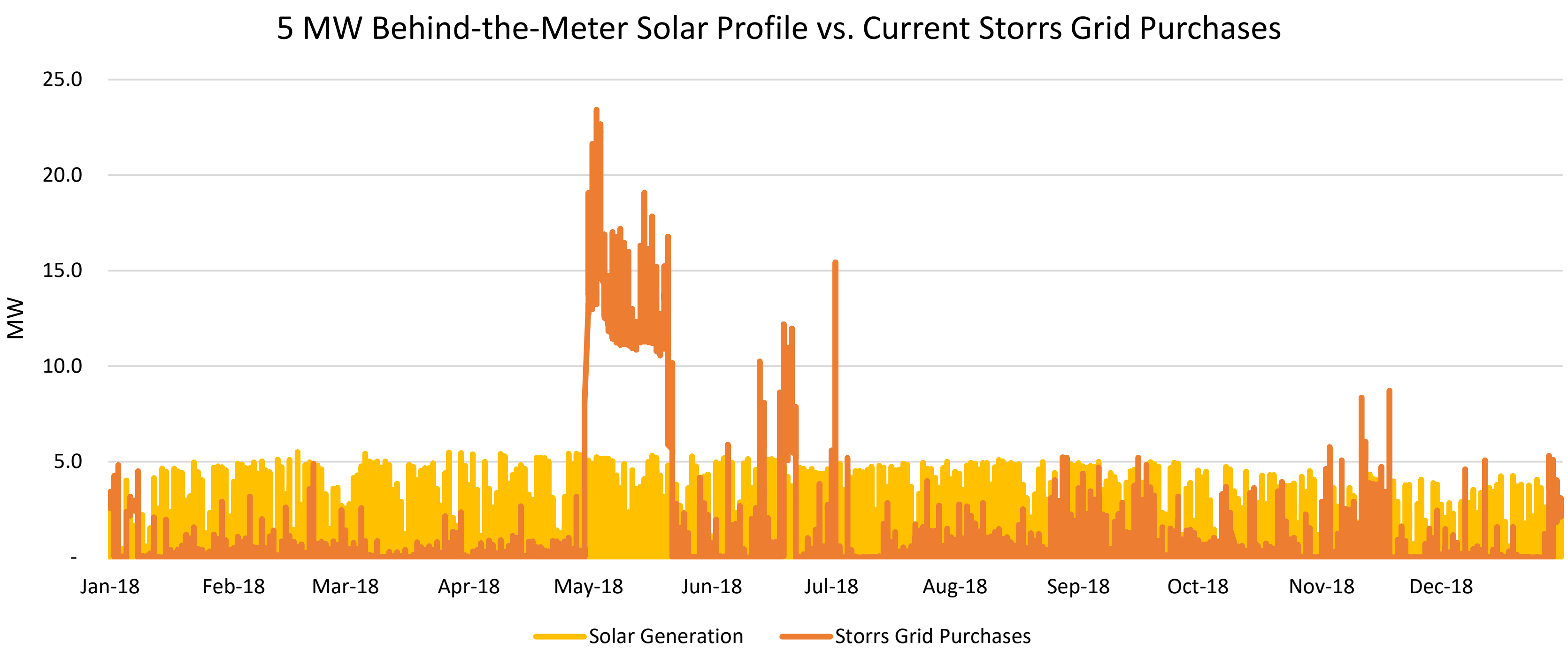
Item #2: Behind-the-Meter Solar

- Managed Forested Land = Approximately 1,940 AC total
  - Forest in Willington accounts for roughly 438 acres of the total
  - Forest in Coventry accounts for roughly 52 acres of the total
- Managed Agricultural Land = Approximately 490 AC total
  - The Lee Farm in Coventry accounts for roughly 20 acres of the total
- CAHNR is responsible to protect these land holdings for its operations, education and research
- Several parcels held in conservation or preservation agreements, and consist of unique natural features

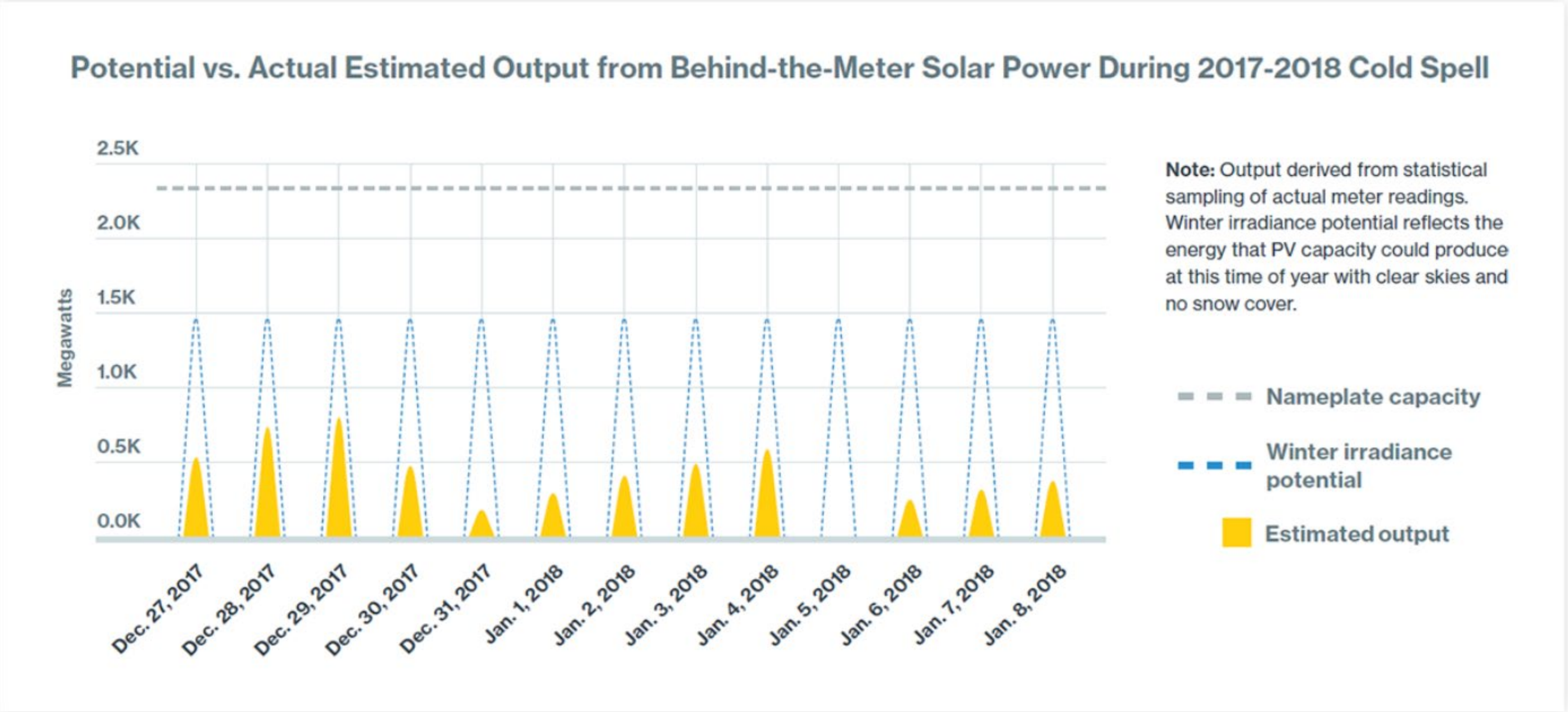
UConn CAHNR Property



Item #2: Storrs Load vs. Solar



Item #2: Storrs Load vs. Solar



Item #2: Battery Demonstrations

UMass Amherst – 1.32 MW/4 MWh storage plus solar & CHP
UMass Boston – 0.50 MW/2 MWh solar plus storage
UMass Dartmouth – 0.52 MW/1 MWh storage plus solar/wind
Brandeis University – 0.78 MW/1.5 MWh storage
Acushnet Company – 1.5 MW/3 MWh storage plus CHP

UMASS AMHERST

UMASS BOSTON

UMass Dartmouth

Brandeis TRUTH EVEN UNTO ITS INNERMOST PARTS אמת

ACUSHNET COMPANY

Titleist FootJoy Scotty Cameron BV Vokey Design PINNACLE

Item #2: Battery Demonstrations

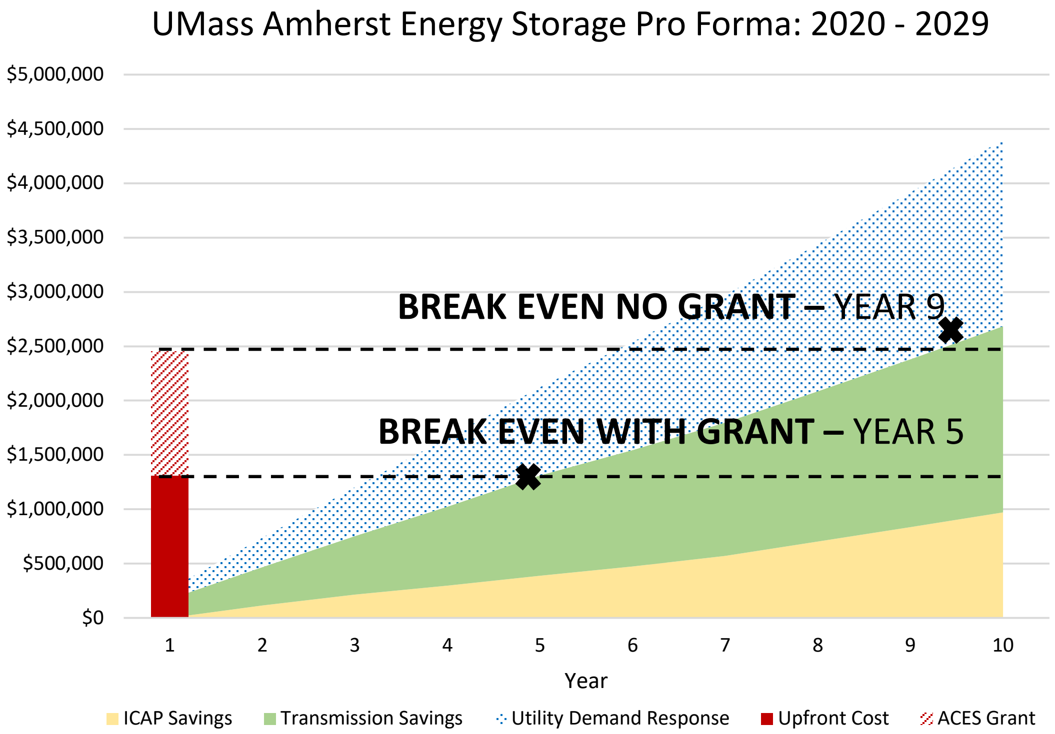
New Energy Storage Technologies Are Coming On Line

- **20 MW** of grid-scale battery storage projects have come on line since late 2015
- Proposals for **more than 1,300 MW** of grid-scale, stand-alone energy storage projects by 2022
- A first: **20 MW** home solar and battery storage cleared FCA #13 for 2022-2023
- Meanwhile, New England has operated two large pumped-storage facilities for 40 years
  - They can supply **1,800 MW** of power in 10 minutes, for up to 7 hours

shutterstock.com • 764274979

Item #2: UMass Case Study

- 1.32 MW / 4 MWh lithium ion battery commissioned in July 2019
- $1.1 million state grant covered nearly 50% of installation cost
- Two main goals of operations
  - Shave campus peak demand
  - Help integrate onsite solar
- One operating cycle covers 1% of the campus' average daily load
- UMass Amherst's unique electric rate design and external funding enables a financial payback on the system under 10 years
- Current battery costs and UCONN rate design make a short-term payback challenging for UCONN without external incentives/funding
- Battery operations increase the campus' Scope 2 emissions due to round-trip efficiency losses



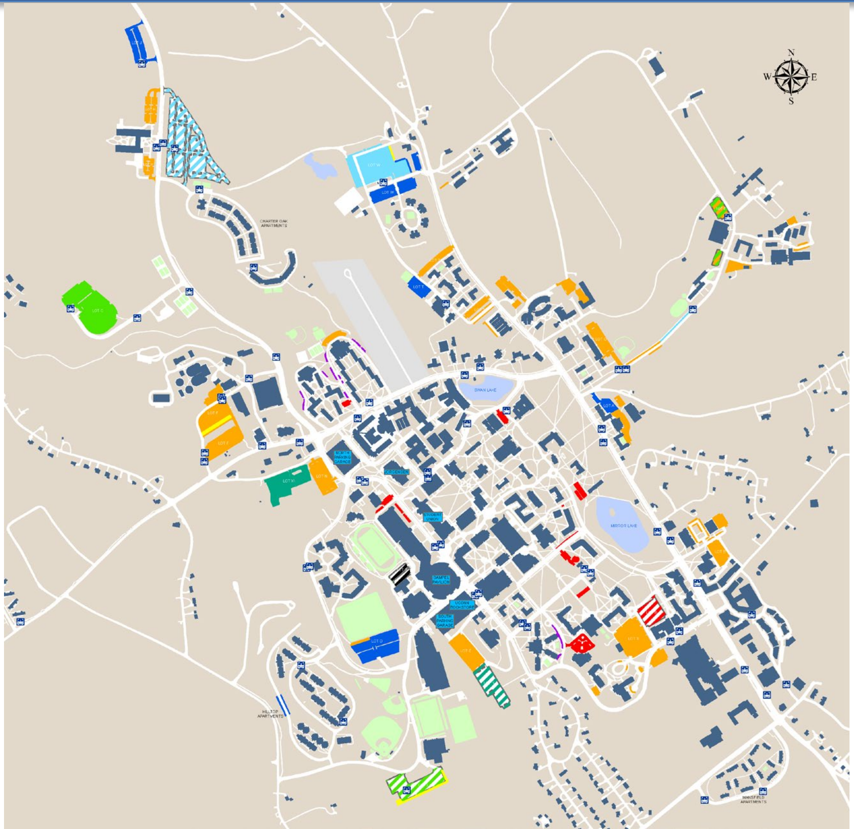
Item #3: Solar Parking Canopies

- In 2016, UMass Amherst installed 4.5 MW of solar parking canopies on campus under a third-party PPA
- UMass Amherst is currently evaluating installing an additional 3 MW of solar parking canopies on campus
- Solar parking canopies designed for Northeast winters may cost $175 - $250 per MWh on a levelized basis due to substantial costs of structural water management requirements
- UMass' projects have been enabled by generous state incentives that provide $150+ per MWh for solar generated by parking canopies

Item #3: Solar Parking Canopies

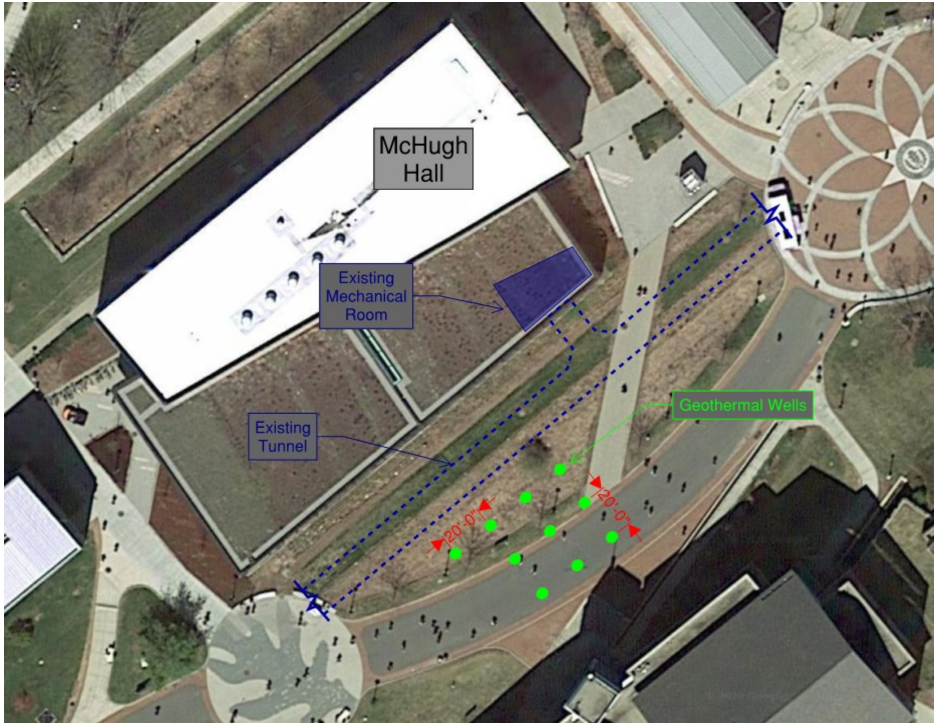
Potential Opportunities

- Charter Oak Apartments and Hilltop Apartments
  - Existing poor pavement conditions
- Lot D (Football Practice/Hilltop)
  - Existing poor pavement conditions
  - Deferred development option for a recreation field
- Lot J (Discovery Drive)
  - Center median sleeved when constructed in 2017
  - No future building proposed
- Lot G (Gampel/Sherman Field)
  - Center median sleeved when constructed in 2018
  - Designed to double when TAB reaches useful life
- Lower T (Towers)
  - Existing poor pavement conditions
  - No future building proposed)
- Lots Y & Z (McMahon)
  - Planned for resurfacing this summer
  - Unutilized option for siting the Student Recreation Center



Item #4: Geothermal Wells (McHugh)

- McHugh estimated to require:
  - 272 tons of cooling
  - 2720 MBH of heating
- 10 Wells
- Capable of offsetting 300 MBH of heating and 30 tons of cooling (approximately 11% reduction in building demand)
- Potential for more than 10 wells, amount dependent on available space in existing mechanical room
- 31 metric tons of carbon reduction estimated



Item #5: Geothermal Wells (Bishop)

- Bishop Center estimated to require:
  - 132 tons of cooling
  - 1320 MBH of heating
- Geothermal heat pump interface to be provided inside existing mechanical room
- 16,500 sq ft. well area is required. 45 wells at 20 feet on center
- 140 metric tons of carbon reduction estimated

Item #5: Geothermal Wells (CESE)

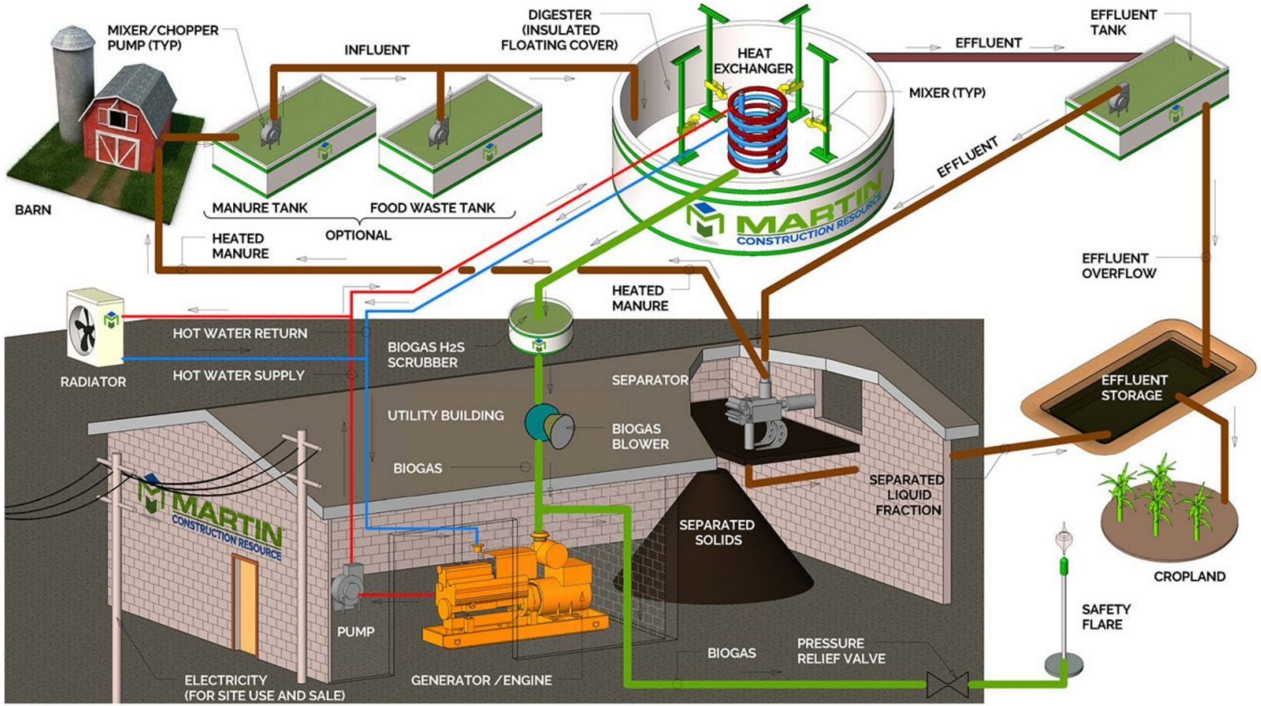
- CESE estimated to require:
  - 184 tons of cooling
  - 1840 MBH of heating
- Geothermal heat pump interface to be provided inside new addition to mechanical room
- 23,000 sq ft. well area is required. 60 wells at 20 feet on center
- PV area of 1.7 acres providing approximately 325 kW will be required
- 414 metric tons of carbon reduction estimated

Item #5: Co-Use PV/Farming (CESE)

- Geothermal wells and PV Solar can overlap
- Integrate farming/agricultural use with solar footprint
- Meet objectives of the East Campus Plan of Conservation and Development

Photos: The 2019 NACD Annual Meeting Presentation

Item #6: Anaerobic Digester

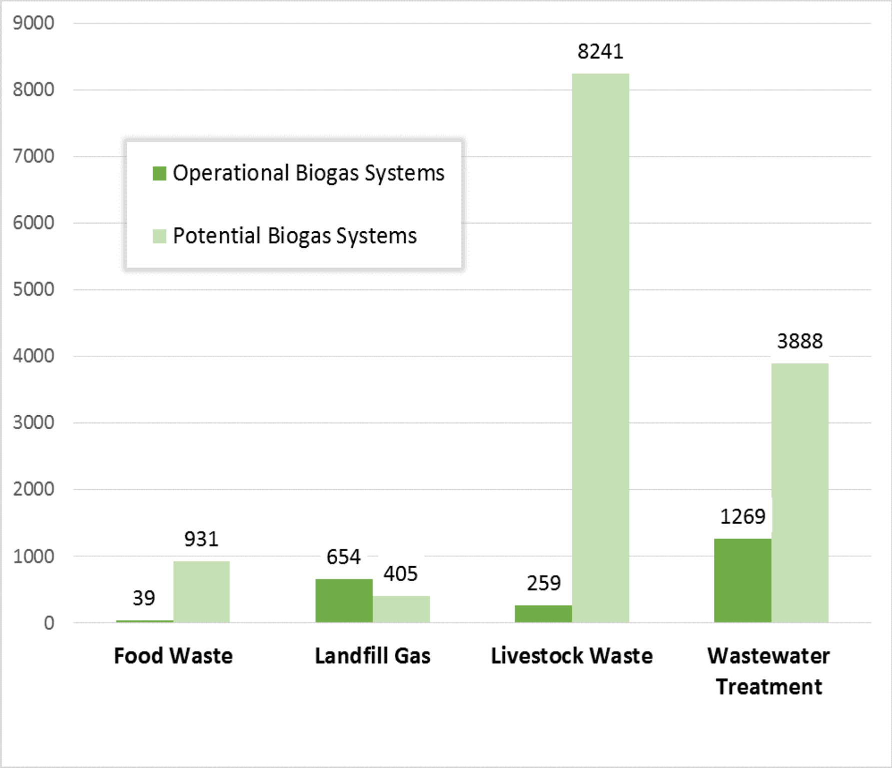


https://martinenergygroup.com/digesters/

Item #6: Anaerobic Digester

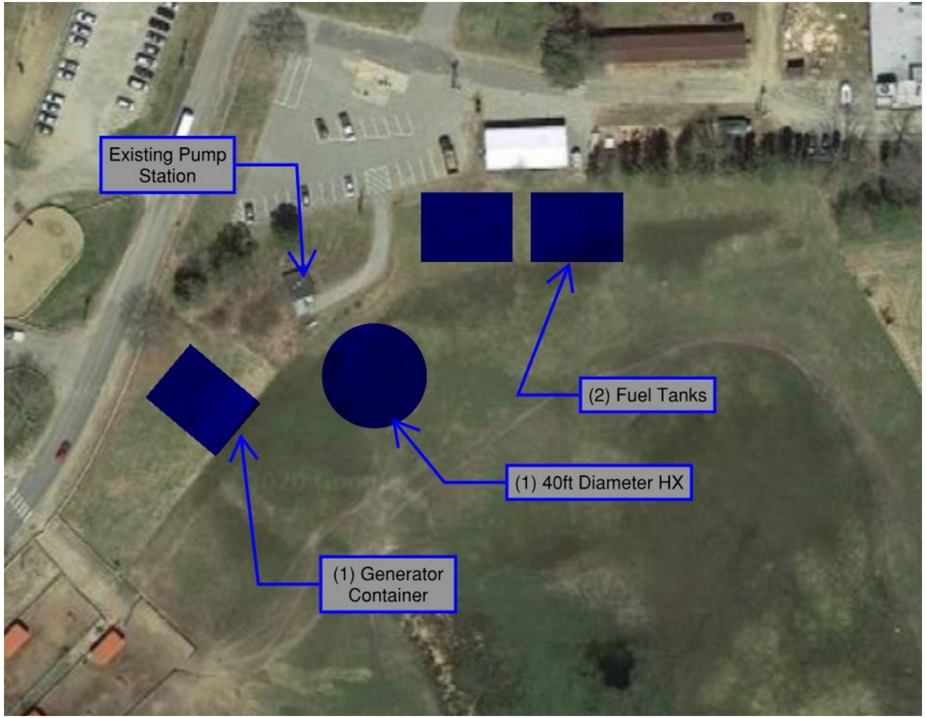
- 1000 lb Cow produces an average of 80 lbs of manure per day
- Wastewater Treatment Plants
- Biogas reduces GHG emissions via Methane Capture
- Biogas combustion is 65% Methane and 35% CO_2

https://doi.org/10.1080/10934529.2018.1459076



Item #6: Anaerobic Digester

- Anaerobic digestion is preferred over aerobic digestion because of decomposition control, odor control and useable fuel byproduct
- The fuel gas (biogas) must be scrubbed to remove hydrogen sulfide before can be effectively used as a reliable and renewable natural gas
- The gas can be burned in a boiler or reciprocating engine generator
- Incorporate PV on roof of generator container
- Methane is a 25x worse GHG than CO^2
- Available campus waste
    - 1000 tons agriculture waste annually
    - 500-700 tons food waste annually



Item #7: Compost Facility

- Reduction in Odor
- Reduction in Volume
- Suppression of plant pathogens
- Reduction of weed seeds in manure
- Reducing emissions of greenhouse gases
- Uses 50% of the 1,000 tons available agriculture waste annually

Carbon Value

- Solar Installations - **Up to 758 Metric Tons (0.6% of 2007 Baseline) for every 1 MW installed**
- CANHR Sequestration - **Up to 3,800 Metric Tons (2.7%) for forest lands**
- Geothermal **(0.4%):**
  - McHugh Hall – **Up to 31 Metric Tons**
  - Bishop Center – **Up to 140 Metric Tons**
  - CESE Building – **Up to 414 Metric Tons**
- Anaerobic Digestion – **Up to 82 Metric Tons (<0.1%)**
- Compost Facility Expansion – **Up to 200 Metric Tons (0.14%)**

Thank you!

Appendix C

Fall 2020 Report: Zero Carbon Alternative (Jan 2021)

UCONN
UNIVERSITY OF CONNECTICUT

ZERO CARBON SCENARIO PLANNING
(ZERO CARBON BY 2050 PLAN)

University of Connecticut
Storrs, Connecticut
Project #300192

January 2021
DRAFT

BVH integrated services

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Contents

1. EXECUTIVE SUMMARY

As consultants for the Working Group, BVH and CES examined the current carbon emissions reduction goals for the Storrs campus to assess whether or not accelerating those goals was feasible. This evaluation was conducted as part of two focused Working Group sessions over several weeks that involved decreasing the use of fossil fuels and increasing the development, use and purchase of renewable electricity to satisfy heating, cooling and power consumption on campus. The first effort resulted in a report prepared in September 2020 which required conversion of the campus and Central Utility Plant (CUP) to an electric ground source heat pump (GSHP) heating and cooling system by 2040 entitled **Zero Carbon Scenario Planning (Peak Plan)**. The Peak Plan determined that while it was technologically possible to attain zero-carbon emissions by 2040, it would be logistically infeasible to plan and construct in a 20-year period based on the extent of infrastructure and building conversions that would be required. Additionally, the conversion project would be accompanied by a high "rough order of magnitude" cost.

This report, being the result of the second round of Working Group sessions and identified as the **Zero Carbon by 2050 Plan**, began in the fall of 2020 and builds upon the Peak Plan while also seeking to accelerate and affirm greenhouse gas reduction goals along the current Climate Action Plan timeline. The Climate Action Plan will reduce greenhouse gas emissions in 2030 by 30% using a 2007 baseline by implementing Energy Conservation (ECM) strategies and through undefined 2% reductions per year thereafter to 2050. The Climate Action Plan does not specifically identify decommissioning of the CUP as a task that requires completion by 2050. The Zero Carbon by 2050 Plan adopts the ECMs in the Climate Action Plan and several new strategies from the Peak Plan to provide a viable path to attain zero-carbon emissions by 2050. The Zero Carbon by 2050 Plan includes ground source, water source and air source heat pump systems with supplemental thermal equipment, hybrid strategies for converting building systems in the campus periphery prior to the central campus, strategies for CUP conversion, projections of capital and operating costs, and means to reach net zero carbon by 2040 through offsets and renewable energy credits (RECs) and zero carbon by 2050.

1.1. Thermal Reduction Strategies

The Storrs campus currently has a several sources of energy available for serving electricity and thermal demands in the form of natural gas, diesel and Eversource grid electricity. This arrangement provides a high degree of redundancy and resiliency for a campus that is that is substantially an island unto itself, being located in a rural part of the state. Much of the campus electricity, steam and chilled water energy is distributed from the Cogeneration Facility at the CUP. An advantage of this arrangement is that it allows substantial resiliency and shelter in place of students, as well as operation of other critical infrastructure in a significant Eversource power outage. To achieve zero-carbon by 2050, the power and thermal energy produced in the CUP must be substantially divested from fossil fuels. In the Peak Plan, the campus was broken up into fourteen districts, with the two "core" districts closest to the Central Utility Plant identified as Central North and Central South. The Zero Carbon by 2050 Plan continues with this approach, such that multiple thermal electrification strategies are proposed in districts beyond the core to achieve the zero carbon goals. The thermal strategies chosen for each district are determined based on a number of different factors. These include, but are not limited to, ground source well field location and feasibility, existing underground utilities, existing standalone systems, and logistical feasibility. The timeline for the Zero Carbon by 2050 Plan is described in the following paragraphs.

During the 2021 to 2030 conversion period and in addition to the ECMs from the Climate Action Plan, a total of nine perimeter or outlier districts or sub-districts will be converted from systems reliant on fossil fuels to heat pump systems. These include Depot, East B, part of Northwest, Spring Hill, Spring Manor, South B, and three parts of West.

During the 2031 to 2040 conversion period, a total of eleven perimeter or outlier districts or sub-districts will be converted from systems reliant on fossil fuels to heat pump systems. These include Northeast, four parts of Northwest, Northwood, South A, Southeast, two parts of West, and East A.

During the 2041 to 2050 conversion period, the final two districts and CUP will be converted from systems reliant on fossil fuels to heat pump chillers, electric chillers, and electric boilers, or a combination thereof. Alternatively, new carbon capture (emissions) or carbon-free (hydrogen/other pipeline fuel) technology may be available by this time period for continued cogeneration.

Upon further discussion with Working Group members, it became apparent that the Zero Carbon by 2050 Plan could be compressed into the Peak Plan schedule but would have similar construction and implementation challenges as the Peak Plan. This compressed plan became known as the Zero Carbon by 2040 Plan and is presented for comparison purposes where appropriate in the report.

1.2. Electrical Infrastructure Improvements

In order to move away from fossil fuel energy sources, the electrical system capacity will need to grow to support the growing demand both within the campus and from external utility sources to the campus. With this change, the University's reliance on electricity will become critical, and redundancy will be a requirement for this conversion in order to properly maintain the campus electrical system. In support of this effort, a second Eversource grid connection as a 50 MVA substation (38E) will be added in the near future to provide redundancy to the existing 30 MVA substation (5P) near Parking Lot F. The second substation will supplement the resiliency provided by the CUP during the early stages of the thermal conversion process.

As the perimeter is converted up and through the year 2040 and energy from the central districts remains supplied from the CUP, the existing Eversource primary service will be upgraded along with further new campus distribution circuits to feed the new satellite electrical ground source plants. When the campus core is converted, there will be a large growth in imported electricity from the grid. To serve this increased electrical demand, a third new primary service with 100 MVA substation (SUB-195) capacity from a separate transmission source will be required from Eversource. Development of this new service will require between 10 to 15 years to complete; therefore, planning and construction for it will begin during the perimeter conversion time frame. This new SUB 195 Transmission primary electrical service will be energized in phases with some switchgear components in place prior to 2040 with transformer energization occurring between 2040 and 2050 to complete the overall electrification. The third substation will provide a separate utility transmission feed to the campus but will not provide the same level of resiliency from which the University currently benefits by having a cogeneration plant. On campus distributed energy resources such as electrical storage (batteries), fuel cells or solar farms will be incorporated as the available technology develops to increase resiliency where possible.

1.3. Construction and Operating Costs

Construction costs are estimated based on construction metrics using conventional unit costing methods. Such metrics include costs based on well quantities/coverage areas, linear feet of pipe, and equipment capacities. System takeoffs were done by district, building types and counts, and regional well areas. Construction costs in this report are forecasted in 2020 dollars and have not been escalated.

Operating costs are based on all utility bills (fuel, electric, water, sewer), staff and maintenance expenses. Energy purchases assume that the energy sources are not producing a net increase in global greenhouse gas emissions. UConn can achieve "net zero" emissions prior to eliminating fossil fuel use on campus through carbon offsets from emissions mitigation projects and/or through renewable energy credits ("RECs"). When RECs are purchased from a specific renewable energy project, this arrangement is referred to as a power purchase agreement ("PPA"). For the purposes of cost estimation and comparison in this report, RECs and offsets are treated as operating costs. Estimated energy costs, whether procured as "green" energy from the grid or by PPA, are forecasted in 2020 dollars. The following **Table ES-1** summarizes the emission reductions, construction cost and operating costs for each conversion period.

	Climate Action Plan			Peak Plan		
Year	Remaining Emissions, MTeCO2	Capital Cost Range	Annual Operating Cost Range	Remaining Emissions, MTeCO2	Capital Cost Range	Annual Operating Cost Range
2020	98,083	--	--	98,083	--	--
2021-2025	82,717	\$60-\$85M	\$50M	78,369	\$150-\$220M	\$50M
2026-2030	68,314	\$40-\$65M	\$64M	40,115	\$1,900-\$2,700M	\$70M
2031-2040	44,244	\$700-\$825M	\$105- \$115M	0	\$2,200-\$3,100M	\$140-\$150M
2041-2050	24,070	\$700-\$825M	\$160- \$170M	0	--	\$180- \$200M

	Zero Carbon by 2040 Plan			Zero Carbon by 2050 Plan		
Year	Remaining Emissions, MTeCO2	Capital Cost Range	Annual Operating Cost Range	Remaining Emissions, MTeCO2	Capital Cost Range	Annual Operating Cost Range
2020	98,083	--	--	98,083	--	--
2021-2025	78,369	\$150-\$220M	\$50M	78,369	\$150-\$220M	\$50M
2026-2030	44,777	\$1,000-\$1,300M	\$70M	61,898	\$700-\$850M	\$65M
2031-2040	0	\$1,250-\$1,700M	\$150-\$160M	27,981	\$800-\$1,100M	\$115- \$125M
2041-2050	0	--	\$200- \$220M	0	\$750-\$1,050M	\$200- \$220M

Table ES-1: Estimated Emissions, Construction and Operating Costs

As anticipated, the long term operating cost range for the Zero Carbon by 2040 Plan and Zero Carbon by 2050 Plan is more than the Climate Action Plan and the Peak Plan. This is a result of multiple types of technology to achieve zero carbon emission results. The Zero Carbon by 2050 Plan includes the costs of conversion of the Central Utility Plant to ground source heat pumps or other electrically derived thermal technology between 2040 and 2050, while the Climate Action Plan does not identify a similar conversion commitment. Not accounting for potential changes in the unit cost of electricity, the conversion to electric heating and cooling will likely increase the expenses for campus utilities by approximately four times the current budget. With all heating and cooling needs being met with electricity, the University will have large exposure to budget swings resulting from small changes in electric unit cost. Each of these estimates of cost includes numerous variables and assumptions that could be narrowed with additional design.

The effect of the expedited schedule in the Zero Carbon by 2040 Plan versus the Zero Carbon by 2050 Plan is that the higher annual costs associated with electrification of the campus occur earlier. **Table ES-2** shows the rate at which buildings would need to be converted and resulting cumulative operating and construction costs for three plans.

SUMMARY	CLIMATE ACTION PLAN	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
ZERO CARBON DATE	2060	2050	2040
BUILDINGS OFF-LINE CONCURRENTLY	10 - 20 BUILDINGS	20 - 30 BUILDINGS	50 - 60 BUILDINGS
CAMPUS SITE AREA EFFECTED	5% - 10%	10% - 20%	30% - 50%
OPERATING/CAPITAL COST THRU 2030	$670,000,000	$1,500,000,000	$1,900,000,000
CUM. OPERATING/CAPITAL COST THRU 2050	$4,500,000,000	$6,000,000,000	$6,400,000,000
INCREMENTAL ADD'L COST		*$1,500,000,000*	*$1,900,000,000*
CARBON AVOIDED AT 2050	1,171,548	1,512,349	1,920,569
INCREMENTAL ADD'L AVOIDANCE		*340,800*	*749,020*
COST PER INCREMENTAL TON THRU 2050		$4,400	$2,500

Table ES-2: Cumulative Conversion Cost and Carbon Avoidance

There are over three hundred buildings that would require thermal conversion to accept electric heating and cooling technology, with the majority occurring in the perimeter zones on campus. UConn evaluated construction logistics at a very high level and concluded that in order to complete all conversions by 2040 per the Zero Carbon by 2040 Plan, approximately 15% of the total number of buildings on campus would need to be closed and converted simultaneously on an annual basis for a 10-year period between 2028 and 2038. In addition, energy plant construction, sitework and infrastructure installations would likely require close to 50% of the land area on the active campus area to be closed and utilized during construction during this same time period.

The Zero Carbon by 2050 Plan sequences the work such that the perimeter areas are converted first (and by 2040), followed sequentially by the central areas of campus between 2040 and 2050. This Plan will also be considerably disruptive to the campus, but UConn estimates that the impact on building closures and campus area from the Zero Carbon by 2050 Plan would be half as disruptive as the Zero Carbon by 2040 Plan, although potentially extending for a longer period of time. For the Zero Carbon by 2050 Plan, approximately eight percent of the total number of buildings on campus would need to be closed and converted simultaneously on an annual basis between 2028 and 2044. In addition, approximately twenty percent of the land area of the campus would need to be utilized; however, as part of the Zero Carbon by 2050 Plan, time is reserved to allow technology to advance prior to committing to the removal of the Central Utility Plant which could contribute to much less disruption for the campus.

2. BACKGROUND

2.1. President's Working Group on Sustainability and the Environment

In the fall of 2019, UConn's President, Tom Katsouleas, created the President's Working Group on Sustainability and the Environment (Working Group), comprising students, faculty and ex officio support staff, to focus on the need for urgent action to slow climate change. The Working Group was chaired by the Executive Vice President for Administration and Chief Financial Officer, and supported by the Office of Sustainability (OEP), Environmental Health and Safety (EH&S), Facilities Operations (FO), and University Planning, Design and Construction (UPDC); and met weekly or biweekly over the course of the spring 2020 semester, continuing remotely after the campus moved online in mid-March due to the pandemic.

The charge from the President to the Working Group was to "Examine UConn's current carbon emissions reduction goals and our progress to achieving them; assess whether or not accelerating those goals is feasible within the context of our budget and available technology; if so, recommend actions UConn can take to achieve that based on facts, data, sound strategies and the best estimates we are able to make."

2.2. Connecticut Policy Developments

The Working Group's efforts have coincided with key legislative, executive, and administrative actions that aim to accelerate Connecticut's progress towards reducing statewide greenhouse gas emissions (GHG) in the coming decades. It is useful to consider the Working Group's scope of work in the context of Connecticut's evolving energy and climate policy and goals, including the following key milestones:

- In June 2018, Governor Malloy signed into law Public Act 18-82, which requires Connecticut to achieve a 45% reduction in statewide GHG emissions by 2030 (below 2001 levels). This 2030 requirement serves as a checkpoint for the state in progressing towards an 80% reduction in GHG emissions (below 2001 levels), as required in Connecticut's 2008 Global Warming Solutions Act.
- In April 2019, Governor Lamont issued Executive Order 1, which directs executive branch state office buildings and vehicle fleets to become greener and more energy efficient through an expanded "Lead by Example" sustainability initiative aimed at reducing the state's carbon footprint and reducing the cost of government operations.
- In September 2019, Governor Lamont issued Executive Order 3, which directs the Department of Energy and Environmental Protection (DEEP) to identify pathways for Connecticut to achieve a 100 percent zero carbon electric supply by 2040.

In December 2020, DEEP issued a draft of Connecticut's Integrated Resources Plan, in which the Department concludes there are multiple pathways available to achieve a

100% zero-carbon electricity supply for Connecticut and doing so will further the state's ability to meet its GHG emissions reduction goals. In the draft report, DEEP recommends that Connecticut should codify the requirement to achieve a 100% zero-carbon electric supply by 2040. Based on Connecticut's statutory GHG emissions reduction goals and DEEP's recommendation that the state aggressively pursue decarbonization of Connecticut's grid electricity supply, the following report has a primary focus on "electrification" and pathways to convert UConn's heating and cooling infrastructure to electrified technologies in order to reduce the use of fossil fuels on campus.

2.3. June 5, 2020 Report, Planning for a Zero Carbon Future

Members of the Working Group presented a Final Draft of the report **Planning for a Zero-Carbon Future: *Recommendations and Strategies to Align UConn with International Scientific Consensus and the Goals of Climate Justice*** to President Katsouleas and the Chairpersons of the Buildings, Grounds and Environment and the Trustees-Administrators-Faculty-Student Committees of the UConn Board of Trustees on May 11, 2020 and issued the Final Report on June 5, 2020. As stated in the Preface, the report "… contains recommendations that frame an energy and climate change strategy that enables the University to lower its carbon emissions and help slow climate change. These recommendations are designed to outline the steps necessary for UConn to align with state-wide initiatives, scientific consensus, international standards of climate justice, and UConn's mission as a leading research and educational institution."

There are six major recommendations in the report:

- Update Emissions Reduction Goals
- Halt Fossil Fuel-based Construction
- Increase Investment in Renewables
- Incorporate Goals into Campus Development Plans
- Divest from Fossil Fuels
- Continuation of Planning Efforts

Because of time and resource constraints, the Working Group did not recommend specific projects or strategies to achieve these recommendations but did suggest that further work be done with consultants to "…produce more detailed, step-by-step plans to transition from the campus's present carbon footprint to the future zero-carbon campus…".

The President and Committee Chairpersons agreed that the Working Group should continue to assess specific strategies, costs and timelines to achieve the recommendations, and to finish the response to the charge. Based on this direction, a sub-group of faculty, students and staff continued to meet during the summer of 2020 and to work with BVH Integrated Services, P.C. (BVH), UConn's Utility Framework Plan consultant engineers; Competitive Energy Services (CES), energy consultants retained by Facility Operations (FO); and GZA GeoEnvironmental Inc., geotechnical consultant retained by the University to provide three geothermal test wells.

At the first meeting on June 10th, the Working Group affirmed that the goals were unchanged:

- Plan for 60% reduction in emission from 2010 baseline by 2030
- Plan for zero-carbon from 2010 baseline by 2040
- Develop interim milestones for 2025 and 2035
- Maintain reliability and resiliency of new infrastructure to level of peer institutions

2.4. Summary of Zero Carbon Scenario Planning (Peak Plan) Consultant Report

BVH was retained by the University to assist with the development of a more detailed step-by-step conversion plan to transition the campus from fossil fuel generation sources to renewable, clean energy, in accordance with the Working Group's goals, by converting the campus to an electric geothermal heating and cooling system by 2040. The BVH methodology is considered a desktop or theoretical study, appropriate for a scope of this magnitude.

With support from SO, FO, and UPDC, BVH took the following steps:

- Synchronized the reductions in emissions required by various entities with multiple baselines
- Calculated the existing source, capacity and typical production loads of heating, cooling and electricity
- Calculated UConn's existing and future thermal and power needs
- Created scenarios for transitioning to ground source heat pumps, with updated infrastructure and distribution systems
- Generated options for purchase, installation and operation
- Calculated cost for the most likely scenario

The conversion plan includes studying what may be necessary to transform the campus's fossil fuels to clean, renewable sources for the Storrs campus. Currently, the Cogen Plant generates approximately 90% of the campus electrical energy and 65% of the thermal energy. Additionally, there are facilities on the perimeter of the main campus and facilities located further from the main campus, such as the Depot Campus, Spring Hill, Spring Manor, Northwood, and Mansfield Apartments that are served directly from the Eversource electrical grid and have standalone heating and cooling.

Below is a timeline for the Zero Carbon Plan from the Peak Plan Consultant Report, dated September 2020:

2020-2025: All of the Energy Conservation Measures (ECMs) planned to be completed by 2025 as outlined in the June 5, 2020 Working Group report. Installation of 6 MW (1 MW building roofs and 5 MW parking lots) of solar PV. Supporting electrical infrastructure improvements.

2026-2030: All of the ECMs planned to be completed by 2030 as outlined in the June 5, 2020 Working Group report. Conversion to ground source heat pump thermal systems in the perimeter areas as outlined in the BVH Peak Plan Consultant Report. Installation of 30 MW of solar PV to support increased electrical demand from ground source systems. Supporting electrical infrastructure improvements.

2031-2040: Completed conversion of all Storrs campus thermal energy to ground source heat pump systems. Supporting electrical infrastructure improvements.

2.5. Geothermal Test Well Study Summary

BVH retained GZA GeoEnvironmental Inc. (GZA) on behalf of the University to assist with evaluating the application of ground source heat pumps (GSHP) on the Storrs campus. GZA was contracted to install three 500-ft.-deep geothermal boreholes, install two types of geothermal loops (a single and double loop configuration), and to conduct thermal conductivity test at these three locations. Boreholes were completed at:

- TW-1 - Located in S Lot
- TW-2 - Located along Horsebarn Hill Road adjacent to Horsebarn Hill Arena Parking Lot
- TW-3 - Located in the open field near W-Lot and the Cell Tower

All three test wells provided a thermal conductivity between 1.85 and 2.06 BTU/hr-ft-°F with ground temperatures ranging from 50.4 and 54.8 deg F. These results confirm the thermal output assumptions that were developed based on the combination of the GZA Northwest Science Quad Geothermal Site Assessment and Air-Conditioning, Heating & Refrigeration Institute (AHRI) Standard 870 Performance Rating Criteria discussed in Appendix B of the summer report regarding expected thermal output per well. It is assumed this is a representation of the average performance of ground source wells throughout the entire Storrs campus. There does not appear to be a significant difference between the single and double-loop well systems. Further study would be required during the Design Phase to determine the proper well system for the specific installation. See **Appendix F** for full report.

3. CURRENT CLIMATE ACTION PLAN

The University of Connecticut has been implementing a Climate Action Plan since 2008 when then President Michael Hogan signed the American College & University Presidents Climate Commitment promising UConn would create an action plan to obtain carbon neutrality by 2050. An eight-member Climate Action Task Force (CATF), co-chaired by Rich Miller, was appointed to oversee the development of this Plan.

The original Climate Action Plan, adopted in 2010, contains over 200 strategies to reduce greenhouse gas emissions to achieve carbon neutrality by 2050 based on a 2007 baseline. The Plan was developed to assist UConn in its efforts to:

- Reduce greenhouse gas emissions by implementing a "2% Solution" to reduce emissions 2% per year specifically from fossil fuel and transportation sources
- Increase efficiency of campus operations
- Use green technologies when possible
- Increase the use of renewables
- Be an innovator and leader in sustainability
- Plan responsibly for future campus growth

Upon adoption of the Climate Action Plan, the Environmental Policy Advisory Council (EPAC) was charged with tracking implementation progress over time. The Plan was updated in 2012 to include a section on climate adaptation which provides guidance on how communities can be more resilient to the effects of climate change. In 2015, an Interim Assessment Report of UConn's Climate Action Plan was prepared setting interim greenhouse gas reduction goals of:

- 20% reduction by 2020 based on a 2007 baseline
- 30% reduction by 2030 based on a 2007 baseline

Additionally, this report summarized the progress that had been made up to that point to reduce greenhouse gas emissions while noting the challenges of achieving future reduction goals.

Overall, through 2019 to date, UConn has achieved a 17% reduction in greenhouse gas emissions based on the 2007 baseline plus has offset the NextGen program 14% growth in campus square footage. Current data indicates that UConn is on pace to achieving the 20% reduction interim goal established for calendar year 2020.

Proposed plans and timelines to achieving future reduction goals utilizing the current Climate Action Plan are summarized below:

2020-2025: All of the Energy Conservation Measures (ECMs) planned to be completed by 2025 as outlined in the June 5, 2020 Working Group report.

2026-2030: All of the ECMS planned to be completed by 2030 as outlined in the June 5, 2020 Working Group report.

2030-2050: An assumed 2% reduction in greenhouse gas emissions from the 2007 baseline per year for each of the 20 years in this time period.

4. ALTERNATE STRATEGIES TO ACHIEVE ZERO CARBON - ZERO CARBON BY 2050 PLAN

The Working Group, UConn support staff, and BVH reconvened in the fall of 2020 to compare the current Climate Action Plan and the Zero Carbon Peak Plan, and to investigate possible alternatives. The work included a basis of design change from peak load to average annual load (approximately 70% of peak load) for the heating and cooling systems, supplemented by other thermal equipment; comparisons of cumulative carbon emissions; potential for adding anaerobic digesters; strategies for converting building systems in the campus periphery prior to the central campus; projections of capital and operating costs; means to reduce capital cost such as Power Purchase Agreements (PPAs); and means to reach net zero carbon through offsets and RECs.

4.1. Potential Pathways to Goals

Below is a timeline of the Zero Carbon by 2050 Plan (Perimeter Conversion by 2040), which is described in greater detail in the following paragraphs in this report:

2020-2025: All of the Energy Conservation Measures (ECMs) planned to be completed by 2025 as outlined in the June 5, 2020 Working Group report. Installation of 6 MW (1 MW building roofs and 5 MW parking lots) of solar PV. Supporting electrical infrastructure improvements.

2026-2030: All of the ECMs planned to be completed by 2030 as outlined in the June 5, 2020 Working Group report. Conversion to heat pump thermal systems in select perimeter areas using a combination of air source, water source, and ground source type systems. It is assumed that the conversion to thermal heat pump systems occurs on a linear path for all perimeter areas from 2025-2040 such that one-third of the perimeter would be converted by 2030. Installation of 30 MW of solar PV to support increased electrical demand from ground source systems and supporting electrical infrastructure improvements.

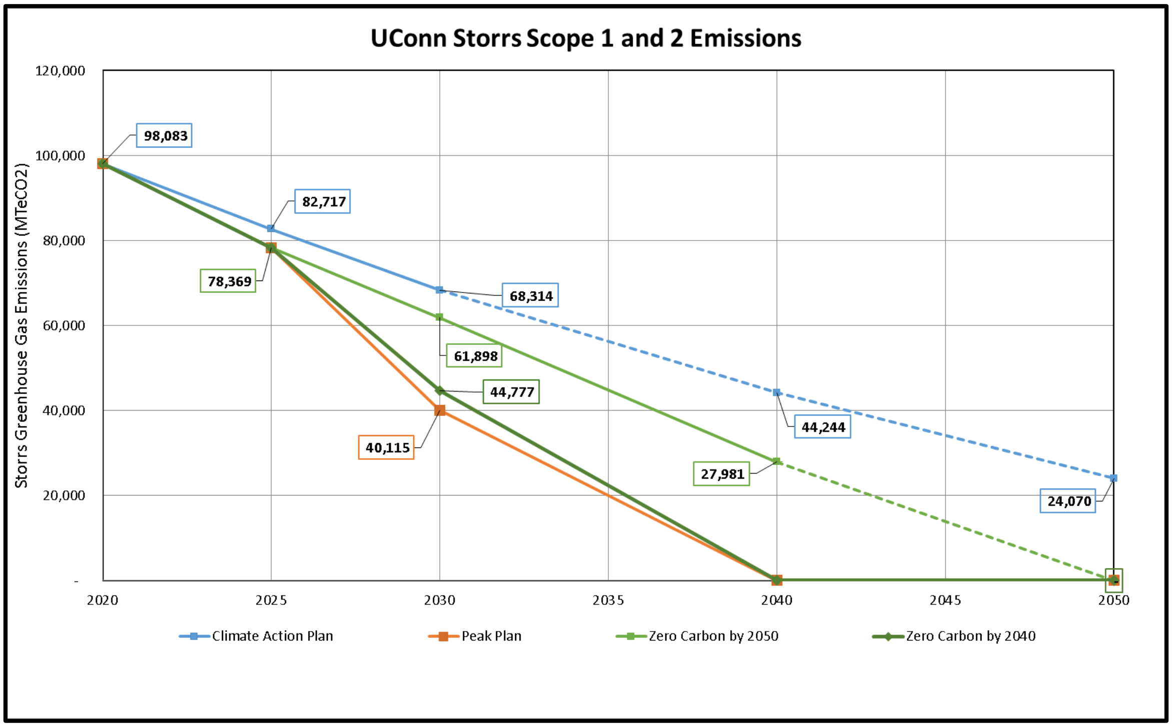
2031-2040: Completed conversion of all perimeter areas thermal energy to heat pump systems. It is assumed that the conversion to thermal heat pump systems occurs on a linear path for all perimeter areas from 2025-2040 such that the remaining two-thirds of the perimeter would be converted by 2040, supporting electrical infrastructure improvements.

2041-2050: Conversion of central utility plant/central campus core to zero carbon systems.

During collaborative sessions with the full Working Group, it became apparent that the Zero Carbon by 2050 Plan could be compressed into the Peak Plan schedule but would have similar construction and implementation challenges identified for the Peak Plan.

This compressed plan became known as the Zero Carbon by 2040 Plan, and its associated emissions reductions would be substantially the same as the Peak Plan as presented in the following paragraphs.

The following graph and table (**Graph 4.1** and **Table 4.1**) illustrate the campus emissions in MTeCO2 from 2020 through 2050 for each of the scenarios; Current Climate Action Plan, Zero Carbon Peak Plan, and Zero Carbon by 2050 Plan. In order to meet the Working Group goals of 60% by 2030 and 100% by 2040 with the Zero Carbon by 2050 Plan, the University would need to obtain carbon offsets for delta between the "green" line and "orange" line, approximately 22,000 MTeCO2 in 2030 and approximately 28,000 MTeCO2 in 2040. It is noted that the current Climate Action Plan included carbon offsets to reach net carbon zero at 2050 of approximately 24,000 MTeCO2.

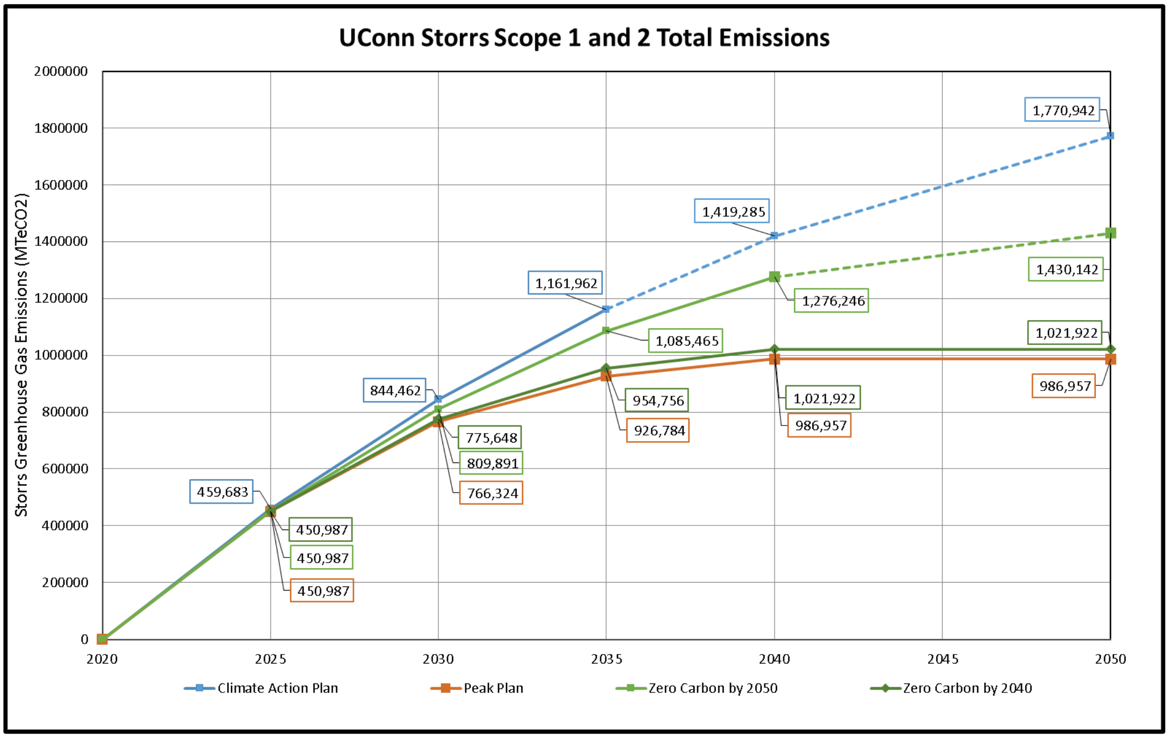


Graph 4.1: Emissions Comparison

Year	Climate Action Plan	Peak Plan	Zero Carbon by 2050	Zero Carbon by 2040
2020	98,083	98,083	98,083	98,083
2025	82,717	78,369	78,369	78,369
2030	68,314	40,115	61,898	44,777
2040	44,244	-	27,981	-
2050	24,070	-	-	-

Table 4.1: Emissions Comparison

The following graph and table (Graph 4.2 and Table 4.2) illustrate the cumulative campus emissions in MTeCO2 from 2020 through 2050 for each of the scenarios; Current Climate Action Plan, Zero Carbon Peak Plan, and Zero Carbon by 2050 Plan.



Graph 4.2: Cumulative Emissions Comparison

Year	Climate Action Plan	Peak Plan	Zero Carbon by 2050	Zero Carbon by 2040
2025	459,683	450,987	450,987	450,987
2030	844,462	766,324	809,891	775,648
2035	1,161,962	926,784	1,085,465	954,756
2040	1,419,285	986,957	1,276,246	1,021,922
2050	1,770,942	986,957	1,430,142	1,021,922

Table 4.2: Cumulative Emissions Comparison

4.2. Campus Perimeter and Central Campus Conversion

4.2.1 Campus District Identification

In the Peak Plan report, The UConn campus was broken up into districts based on campus location and well field location. In select districts, they were further broken up into sub-districts based on well field location and to reduce the amount of required underground piping. In the Zero Carbon by 2050 Plan, the same district and sub-district designations are used. See **Figure 4.1** for the campus district map and **Appendix C** for a full size map.

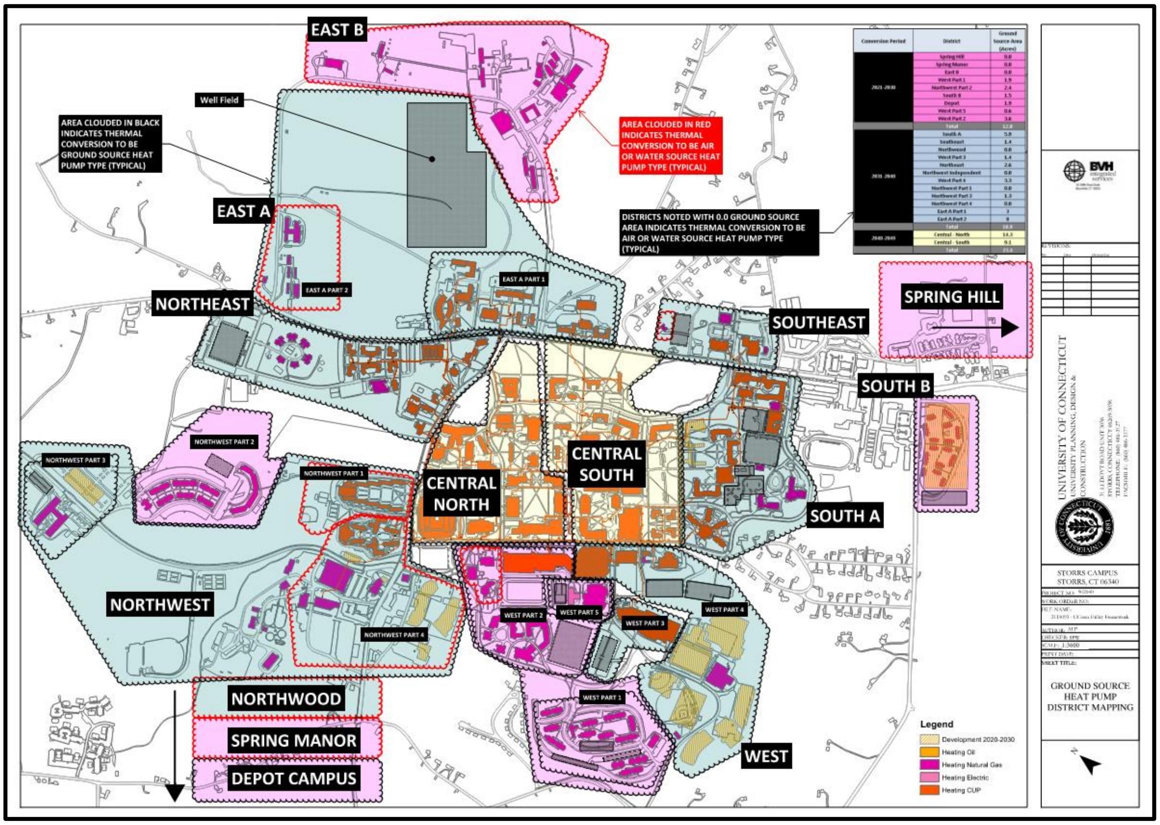


Figure 4.1: Campus District Map

Multiple thermal electrification strategies are utilized to reach the zero carbon goals. The thermal strategy chosen for each district was determined based on a number of different factors. These include, but are not limited to, ground source well field location and feasibility, existing underground utilities, existing standalone systems, and logistical feasibility. These designations are an assumed conversion type based on a broad overview of the campus. Further feasibility studies would need to be conducted to determine and optimize the exact systems in each district and building.

The perimeter conversions and their associated time period are described below. The descriptions are a broad generalization of the existing HVAC systems within the districts. They are not meant to describe every system in every building. The associated time periods are a recommendation to meet the emissions goals previously outlined which require 33% of the perimeter to be converted in each of the three milestone periods between 2021-2039. Any of the districts may be exchanged with another district in a different time frame to better coincide with campus development plans and logistical feasibility, provided that the aggregate reduction at the milestone period matches the emissions goals.

4.2.2 Conversion Period 2021-2030

A total of nine districts or sub-districts will be converted from systems reliant on fossil fuels to heat pump systems.

Depot

Existing Systems: Significant portion have dedicated hot water systems per building. Select buildings have direct hot air furnaces. Significant portion of cooling is done by direct expansion local to the building. Select buildings have chillers with chilled water distribution.

Conversion Option: 100% Hybrid Ground Source

East B

Existing Systems: Direct hot air furnaces and unit heaters. Select hot water distribution per building. Select direct expansion cooling per building. Singular building with chilled water distribution.

Conversion Option: 100% Air Source/Water Source

Northwest Part 2

Existing Systems: Combination of Hot water distribution per building and direct hot air furnaces. All cooling through local direct expansion cooling per building.

Conversion Option: 100% Hybrid Ground Source (26% of District)

Spring Hill

Existing Systems: Combination of hot water distribution and direct hot air furnaces. Select cooling from ductless mini-split air-to-air heat pumps.

Conversion Option: 100% Air Source/Water Source

Spring Manor

Existing Systems: Minimal electric heat.

Conversion Option: 100% Air Source/Water Source

South B

Existing Systems: Hot water distribution per building. No cooling. It is assumed as a part of this study, that the existing buildings would be demolished and replaced with a new building.

Conversion Option: 100% Hybrid Ground Source

West Part 1

Existing Systems: Hot water distribution serving multiple buildings through underground hot water piping. All cooling through local direct expansion cooling per building.

Conversion Option: 100% Hybrid Ground Source (18% of District)

West Part 2

Existing Systems: Hot water distribution individual to the building. Select direct hot air furnaces. Combination of chilled water distribution individual to the building and local direct expansion cooling.

Conversion Option: 100% Hybrid Ground Source (33% of District)

West Part 5

Existing Systems: Hot water distribution individual to the building. Chilled water distribution individual to the building.

Conversion Option: 100% Hybrid Ground Source (6% of District)

4.2.3 Conversion Period 2031-2040

A total of six districts or sub-districts will be converted from systems reliant on fossil fuels to heat pump systems.

Northeast

Existing Systems: Combination of direct hot air furnaces per building, local hot water distribution within the building, and steam-to-hot water heat exchangers from the CUP. Local direct expansion cooling per building where applicable. Select chilled water distribution from the CUP. Select cooling from ductless mini-split air-to-air heat pumps.

Conversion Option: 100% Hybrid Ground Source

Northwest Independent

Existing Systems: Combination of hot water distribution and direct hot air furnaces. Select cooling from ductless mini-split air-to-air heat pumps.

Conversion Option: 100% Air Source/Water Source (4% of District)

Northwood

Existing Systems: Hot water distribution individual to the building. No cooling.

Conversion Option: 100% Air Source/Water Source

South A

Existing Systems: Combination of hot water distribution from steam-to-hot water heat exchangers served from the CUP and individual hot water distribution per building. Combination of chilled water distribution from South Campus Chiller Plant and individual chilled water distribution per building.

Conversion Option: 100% Hybrid Ground Source

Southeast

Existing Systems: Hot water distribution individual to the building. Direct expansion cooling individual to the building. Singular building with chilled water distribution.

Conversion Option: 100% Hybrid Ground Source

West Part 3

Existing Systems: Hot water distribution from steam-to-hot water heat exchangers from the CUP. Chilled water distribution from Gampel Chiller Plant.

Conversion Option: 100% Hybrid Ground Source (13% of District)

A total of five districts or sub-districts will be converted from systems reliant on fossil fuels to heat pump systems.

East A

Existing Systems: Direct hot air furnaces and unit heaters. Select direct expansion cooling per building.

Conversion Option: 90% Hybrid Ground Source, 10% Air Source/Water Source

Northwest Part 1

Existing Systems: Hot water distribution from steam-to-hot water heat changers from the CUP. No cooling.

Conversion Option: 100% Air Source/Water Source (19% of District)

Northwest Part 3

Existing Systems: Hot water distribution and chilled water distribution per building.

Conversion Option: 100% Hybrid Ground Source (14% of District)

Northwest Part 4

Existing Systems: Combination of direct hot air furnaces per building, local hot water distribution within the building, and steam-to-hot water heat exchangers from the CUP.

Local direct expansion cooling per building where applicable. Select chilled water distribution from the CUP. Select cooling from ductless mini-split air-to-air heat pumps.

Conversion Option: 100% Air Source/Water Source (36% of District)

West Part 4

Existing Systems: Hot water distribution from steam-to-hot water heat changers from the CUP. Select direct hot air furnaces local to the building. Combination of chilled water distribution from the Gampel Chiller Plant and chilled water distribution individual to the building. Select local direct expansion cooling.

Conversion Option: 100% Hybrid Ground Source (31% of District)

4.2.4 Conversion Period 2041-2050

The final two districts will be converted to zero carbon systems. There are multiple different proposed options to complete this conversion as outlined below.

Central North

Existing Systems: Combination of hot water distribution from steam-to-hot water heat exchangers served from the CUP and individual hot water distribution per building. Combination of chilled water distribution from the CUP and individual chilled water distribution per building.

Conversion Option 1: CUP conversion to heat pump chillers and electric hot water boilers with steam distribution in core campus converted to hot water.

Conversion Option 2: CUP conversion to electric steam boilers and electric chillers, with steam distribution maintained in core campus.

Central South

Existing Systems: Combination of hot water distribution from steam-to-hot water heat exchangers served from the CUP and individual hot water distribution per building. Combination of chilled water distribution from the CUP and individual chilled water distribution per building.

Conversion Option 1: CUP conversion to heat pump chillers and electric hot water boilers with steam distribution in core campus converted to hot water.

Conversion Option 2: CUP conversion to electric steam boilers and electric chillers, with steam distribution maintained in core campus.

4.2.5 Zero Carbon by 2040 Plan

The Zero Carbon by 2040 Plan matches the Zero Carbon by 2050 Plan in all aspects except that two-thirds, or approximately ten, of the perimeter districts or sub-districts will be converted from 2021 to 2030, while the remaining one-third perimeter and entire central core districts will be converted from 2031 to 2040.

4.2.6 District Conversion Assumptions

For the purposes of this study, it is assumed that the ground source well fields are sized at 70% of the required peak thermal load and supplemental heating and cooling would be provided by other systems. These include electric boilers and chillers where required.

Each district and sub-district that is served by a hybrid ground source system will have a district plant. The underground pipes from the well fields will enter into each of these district plants. The plants will include heat pump chillers used to create hot water for heating and chilled water for cooling, multiple sets of pumps, piping, valves and hydronic accessories. These will also include a supplemental electric boiler and a cooling tower or fluid cooler. The plants will also include area to accommodate electrical requirements. The sizes of the plants will be determined based on the thermal load requirements of that district, the mechanical/electrical equipment requirements, and limitations while maintaining required clearances and accessibility. Underground hot water supply and return and chilled water supply and return piping will be distributed throughout the districts to each of the buildings. Actual footprint, equipment and layouts will require further study and design.

For all the buildings designated as air source or water source systems, these would be standalone systems per building, or group of buildings. The required indoor equipment would be placed within existing mechanical rooms, or existing space within buildings may need to be repurposed for mechanical space. The required outdoor equipment would be placed on the roof, or on grade nearby the existing building. The only underground piping that would be required would be if a water source system were implemented to serve multiple nearby buildings. Actual footprints, equipment and layouts will require further study and design.

4.2.7 Building Conversion Assumptions

Typical ground source systems produce a maximum of 140 deg. F hot water. The buildings on campus are generally served by a higher temperature water for heating. For the purposes of this plan, it is assumed that sufficient heating capacity will be provided within the district plants to increase the hot water temperature when needed.

As the individual buildings are renovated, it is assumed that they will be designed to accommodate lower temperature water such that the required supplemental would decrease and the efficiency of the ground source systems would increase.

All buildings that currently use direct steam heat will need to be converted to low-temperature hot water heat. All buildings that currently use a direct gas-fired furnace will need to be converted to low-temperature hot water heat.

The buildings currently served by chilled water will also need modification for a different chilled water temperature than what is currently supplied. All buildings that currently use Direct Expansion (DX) cooling will need to be converted to chilled water-cooling. These modifications may include, but are not limited to, changing coils within air-handler units, changing systems distributed throughout the building, including but not limited to Fan Coil Units (FCUs), valance units, chilled beams, perimeter radiation, and Variable Air Volume (VAV) boxes.

Each building that is served by a ground source system will need to be connected to the underground hot water supply and return and chilled water supply and return underground pipe distribution with valves and other accessories. In buildings currently heated with direct steam heat, hot water pumps will need to be installed at the building entrance. In buildings currently cooled with DX cooling, chilled water pumps will need to be installed at the building entrance.

Buildings that are outfitted with an air or water source Variable Refrigerant Flow (VRF) system will include installing new distributed terminal units and running new refrigerant piping throughout the building.

Further study and evaluation of the existing systems will need to be conducted at each individual building to determine the exact scope of work required for the building conversion.

4.2.8 Electrical Capacity Options

Eversource Grid

To support the conversion from natural gas for thermal loads, upgrades of incoming sources are required to maintain the resiliency required for a flagship research university. The electrical load of the Zero Carbon by 2050 Plan increases from the all ground source option developed over the summer. The reason is that the air source and electric boiler options are less efficient than the ground source system, although these new options offer more simple and cost effective capital implementation.

The campus electrical infrastructure includes the following improvements following the thermal conversion plan of nine perimeter districts which adds 14 MW to the present heating peak (electrical improvements through **2030**).

- Install a "High Capacity Feeder" connection to a new "Storrs 38E" and existing "14G" Trigen bus (already under contract).

- Develop a new "Storrs 38E" Substation at 50 MW base and up to 75 MW and associated distribution improvements adjacent to the future Supplemental Utility Plant.
- Increase the quantity of distribution circuits on the campus at approximately 15,000 lf of new ductbank.
- Create a load-shedding platform and control system.
- Provide redundant bus feeds to each of six new district plants, new electric services and feeders to mechanical equipment.
- Start siting the project for a new "SUB 195" Substation.
- Start the design coordination and planning to install a new transmission circuit from Willimantic to UConn (approximately eight miles).

The campus electrical infrastructure includes the following improvements following the thermal conversion plan of an additional six perimeter districts which adds another 15 MW to the 2030 heating season peak (electrical improvements through **2035**).

- Install a "High Capacity Feeder" connection from "Storrs 38E" to new/future SUB-195.
- Upgrade existing 5P to match the new Storrs 38E 50 MW transformer including 5P switchgear.
- Install approximately 7,000 lf of new electrical ductbank.
- Provide redundant bus feeds to each of four new district plants, new electric services and feeders to mechanical equipment.
- Add batteries to maintain resiliency with added load (installed next to the Supplemental Utility Plant or SUP).
- Start the project for a new "SUB 195" Substation and associated distribution improvements in the south campus. This will be built in increments of transformers with the first being 50 MW base output, and then a second matching transformer would be considered for the central conversion options with hybrid ground source and central heater chillers. This would give flexibility for growth and limit fault current.

See **Figure 4.2** for the proposed new Eversource transmission line, and **Figure 4.3** for proposed electrical infrastructure upgrades. (Full size map is included in **Appendix D.**)

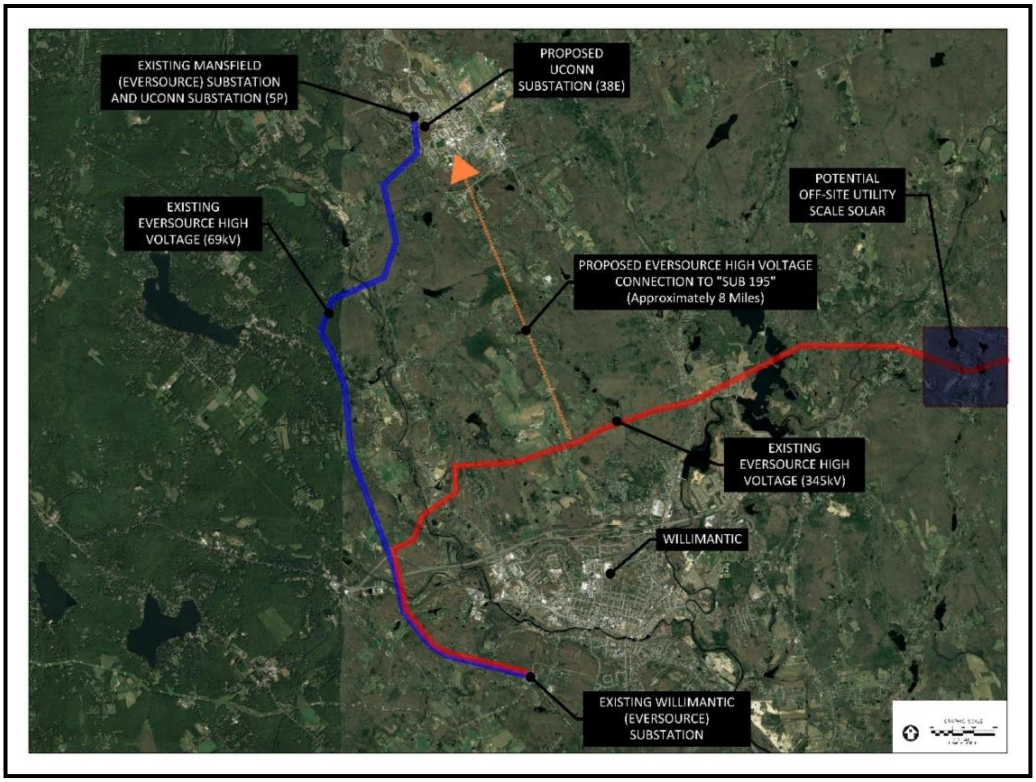


Figure 4.2: New Eversource Transmission Line

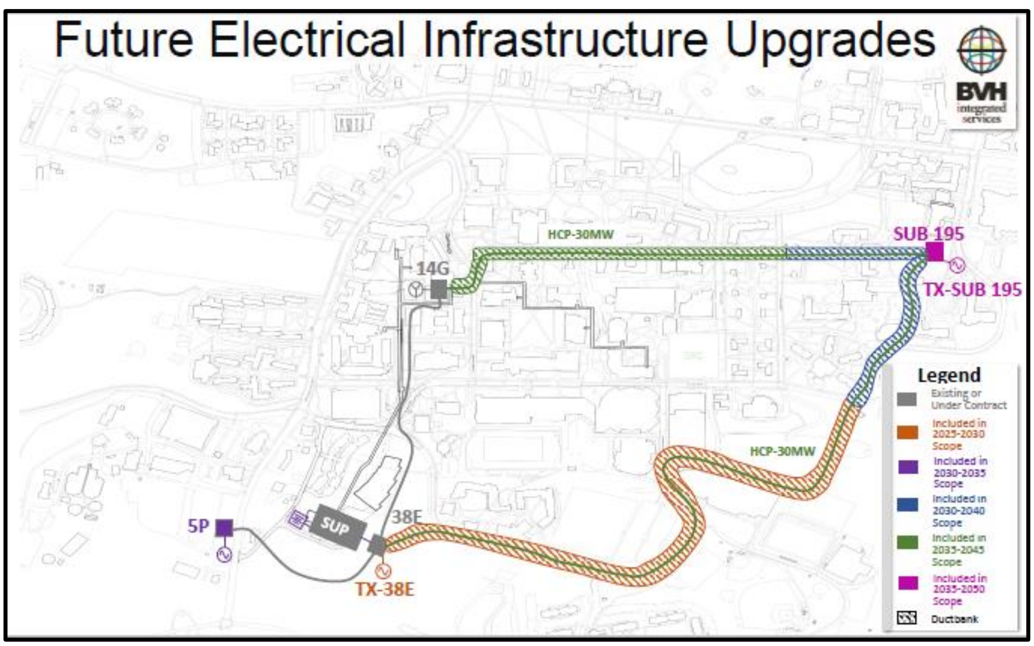


Figure 4.3: Future Electrical Infrastructure Upgrades

The campus electrical infrastructure includes the improvements below following the thermal conversion plan of an additional five perimeter districts adding 16 MW of load to the heating peak (electrical improvements through **2040**).

- Install approximately 5,000 lf of new electrical ductbank.
- Provide redundant bus feeds to each of three new district plants, new electric services and feeders to mechanical equipment.
- Continue development of the new "SUB 195" Substation and associated distribution improvements in the south campus. This timeframe will include the switchgear for SUB 195 while the eight-mile transmission line engineering, permitting and development takes place. Planning and development for the 50 MW base output transformers also continues.
- Install new controls and sectionalizing automation.

The campus electrical infrastructure includes the improvements below following the thermal conversion plan of the remaining two central districts (electrical improvements through **2050** – these would need to be accelerated for the Zero Carbon by 2040 Plan to be substantially underway or completed by 2040).

- Install new high capacity feeder from SUB 195 to the 14G Bus.
- Install approximately 17,000 lf of new electrical ductbank. This is the development of the new SUB 195 distribution circuits out to the site.
- Provide redundant bus feeds to the single large new district plants, new electric service and feeders to mechanical equipment.
- Install new controls and sectionalizing automation.
- Put the new "SUB 195" Substation transmission lines, transformers, and associated distribution improvements in the south campus in service. This will consist of two 50 MW base transformers to accommodate the central added load of approximately 30 MW for this stage of added conversion, giving a total 90 MW peak for the overall campus expected with the central conversion Option One and Two.
- The central conversion has an option to add a centralized electric steam boiler. This boiler would add approximately 50 MW of peak load to the campus. The benefit of this option is that it allows the steam piping to remain, which limits building conversion costs, but at the added expense of high electrical peak demand. This would require a third dedicated transformer at the new SUB 195 location.
- The centralized electric steam boiler option would also require dedicated feeds from the perimeter to the interior central plant or locating the boiler at the perimeter of the campus with steam lines to the middle.

On Campus Generation

The PV options remain as indicated in the Peak Plan summarized below:

The solar photovoltaic systems currently in construction or proposed for future projects.

Building-Mounted: Anticipated 1 MW installed capacity.

- The new STEM Science 1 facility currently under construction includes the installation of a 400 kW building-mounted PV system.
- The conversion plan assumes any new construction would include building-mounted PV and renovations of potential buildings to reach the potential 1 MW of renewable generation capacity.
- Electricity generated from building-mounted systems is assumed to be fed into the University electrical grid (behind the meter).

Parking Lot: Potential 5 MW renewable generation capacity.

- The existing parking areas were assessed for the potential to install solar canopies.
- Reviewing the existing "usable solar canopy area" (actual parking areas not including entrances/exits or circulation drives) resulted in approximately 30 acres of available area. Some of these areas may not be suitable for solar-given orientation, shaded conditions or underlying conditions (i.e., landfills).
- Utilizing a rating system to account for the suitability of the considered areas, a total 5 MW of renewable generation capacity may be expected.
- Similar to the building-mounted systems, the electricity generated from solar canopy systems is assumed to be fed into the University electrical grid (behind the meter).

Utility Scale Solar: Potential 30 MW renewable generation capacity.

4.2.9 Energy Conservation Measures (ECMs), Includes Anaerobic Digesters

As noted in the June 5th, Working Group report "UConn is currently in the process of implementing various on-going carbon reduction projects and has proposed several other projects that are needed to meet UConn’s Climate Action Plan carbon reduction plans."

These projects include various energy conservation measures to reduce energy consumption, thus reducing the overall campus carbon footprint. The list below includes the projects currently on-going or being considered for future implementation. The carbon reductions from these projects are included in meeting the target goals to achieve a zero-carbon campus by 2040.

- Re-lamping campuses to 100% LED (projects currently in progress including UConn in-house Trade Shop projects and the SLED lighting projects)
- Vehicle fleet conversion from fossil fuel driven to electric or hybrid
- Various insulation projects
- Other Energy Conservation Measures
- Lab Ventilation Management Program Initiative
- Steam/Condensate replacement (10,000 feet of steam line)
- Additional building improvements
- Anaerobic digestion (serving campus waste stream)
- CAHNR sequestration expansion
- Demolition of Torrey Life Science Building

A description of these projects is included in **Appendix E - Carbon Reduction Projects**.

4.2.10 Carbon Reduction Options

The previous section focuses on solutions to transition Storrs' energy infrastructure to new systems that reduce fossil fuel use on campus. In order to claim that these new systems are decarbonizing campus operations, UConn will need to structure its energy purchases in a manner such that the University can claim that the energy sources used to operate Storrs are not producing a net increase in global greenhouse gas emissions. The following section discusses UConn's options to purchase carbon offsets and renewable energy credits ("RECs") so that the University can make this claim.

UConn can achieve "net zero" emissions for Storrs' campus operations prior to eliminating fossil fuel use on campus through two procurement actions:

- Acquire and retire enough carbon offsets from emissions mitigation projects to offset 100% of Storrs' remaining emissions produced by fossil fuel combustion on campus (Scope 1 emissions).
- Acquire and retire enough renewable energy credits ("RECs") from renewable electricity generators to offset 100% of the emissions associated with Storrs' electricity purchases (Scope 2 emissions), an action that UConn currently takes on a voluntary basis.

The following section provides an overview of UConn's carbon offset and REC options and factors for UConn's consideration if the University aims to achieve net zero emissions for Storrs.

Carbon Offsets

Carbon offsets represent a unit of carbon dioxide-equivalent that can be avoided or sequestered to offset emissions being generated onsite at Storrs. The concept of carbon offsets is that if UConn financially supports an offset project, the University can achieve an equivalent global emissions outcome (i.e., no net increase in cumulative global emissions), as reducing Storrs' emissions through changes in campus operations and energy use. Carbon offset projects span a broad variety of actions that can be taken to avoid or sequester carbon emissions, including landfill gas capture and destruction, organic waste composting, agricultural methane capture, ozone depleting substance capture, and tree planting, to name but a few examples.

In developing an offset purchasing strategy, UConn will need to consider factors such as additionality (a carbon offset project that would not have happened without UConn's direct financial support, this also applies to RECs), price, registry characteristics, project location and type, and vintage. The cost of contracting terms for carbon offsets will vary depending on UConn's selection criteria. There are numerous providers of carbon offsets serving the voluntary offset market for colleges and universities, so these factors can be evaluated and compared in a competitive solicitation process that requests a wide range of offset options and projects. It is also possible UConn to directly invest in emissions mitigation projects that are not yet developed, although this can introduce uncertainty in the number and cost of associated offsets.

Renewable Energy Credits

A REC is a tradeable certificate that represents the environmental attributes of 1 MWh of electricity generated by a renewable energy source. One REC is produced for each MWh of renewable electricity generated. Storrs' Scope 2 emissions can be offset one-for-one with RECs. In other words, a REC must be acquired and retired by UConn for each MWh of electricity purchased for Storrs, be it from the power grid or from an onsite renewable generation source interconnected directly to the campus' electrical system.

While a REC must be acquired and retired to offset Storrs' Scope 2 emissions, the actual purchaser does not have to be UConn. In fact, a large share of the RECs that will need to be retired for UConn to eliminate Storrs' Scope 2 emissions in the coming years and decades will be acquired and retired by UConn's retail electricity supplier pursuant to the supplier's obligations under Connecticut's Renewable Portfolio Standard ("RPS") law and regulations. We refer to these as "compliance" RECs. Because the RPS percentage will be less than 100% until at least 2040, UConn must continue retiring "voluntary" RECs for that portion of its campus electricity purchases not covered by compliance RECs if UConn wants to continue offsetting 100% of Storrs' Scope 2 emissions. **Table 4.3** presents Storrs' estimated REC needs through 2040 based on BVH's campus electrification plan.

Year	Total Storrs Electricity Use (MWh)	Non-CUP (Eversource) Electricity Use (MWh)	Total RPS Compliance (%)	Compliance RECs	Voluntary RECs
2020	135,304	9,979	25%	2,495	7,484
2030 – current law	172,685	47,360	44%	20,838	26,522
2040 – current law	247,446	192,235	44%	84,583	107,652
2040 – change in law	247,446	192,235	80%	153,788	38,447
2040 – change in law	247,446	192,235	100%	192,235	0

Table 4.3: Storrs' Estimated REC Requirements: 2020 – 2040

Off-Campus Solar

UConn has three options to acquire and retire voluntary RECs in order to continue offsetting 100% of Storrs' electricity purchases - (1) install renewable electricity generation systems on campus and retain and retire the RECs generated by the systems, (2) purchase RECs from existing renewable generators located off campus through spot purchases or under short-term contracts, as UConn currently does through its retail electricity supply arrangement, and/or (3) purchase RECs from new generation projects located off campus under one or more long-term agreements. These options have varying cost, additionality, geographic, and contracting characteristics that will need careful consideration by UConn.

The first option for UConn to acquire voluntary RECs is from renewable generation located on campus. This type of renewable generation meets two important criteria - additionality and geographic proximity – and offers visible demonstration of UConn's efforts to campus stakeholders. To the extent that UConn elects to install behind-the-meter solar on campus in the coming years, which could include ground-mounted solar, rooftop solar, and/or solar parking canopies, UConn can choose whether to retain and retire the associated RECs or sell the RECs in order to reduce project costs. The challenge with this option is that the actual or implied costs of these RECs are quite high today. Due to economies of scale, installation costs for behind-the-meter solar, especially parking canopies, are higher than installation costs for utility-scale ground-mounted solar developed remotely from UConn's campuses. While behind-the-meter solar can help UConn avoid certain retail electricity charges that remotely-sited generation cannot, UConn's grid electricity rate design limits the value of behind-the-meter solar by assessing demand-based charges that cannot be reliability reduced by intermittent solar generation.

The second option is for UConn to purchase and retire RECs from existing renewable generators located off campus. UConn currently uses this option, purchasing low-cost Green-e RECs from utility-scale wind projects located in the U.S. Midwest for 100% of grid purchases at six of the University's seven campuses. The option to use out-of-region RECs from existing generators offers very low costs but sacrifices additionality and geographic proximity. UConn could similarly purchase unbundled RECs from existing utility-scale or community-scale wind, solar, or hydro projects located in New England, as contemplated in recent updates to Connecticut's voluntary Clean Energy Options Program. This in-region option comes with a significant cost premium compared to the Green-e option.

The third option is for UConn to execute a long-term virtual power purchase agreement ("VPPA") with a project developer to construct a new renewable generator located off campus in Connecticut or out of state. There are numerous examples of private companies executing VPPAs in recent years, and several examples of UConn's peers including the Massachusetts Institute of Technology executing a VPPA with a new utility-scale solar project in North Carolina and various colleges in New England executing a VPPA with a new utility-scale solar project in Maine. This option provides additionality and perhaps geographic proximity but is likely to cost significantly more than the lowest cost unbundled REC option.

Power Purchase Agreements

The cost for UConn to acquire and retire voluntary RECs may ultimately be an operating expense or a capital expense for UConn. UConn could purchase RECs from a third party that finances, owns, operates and maintains a project, in which case the cost would be an operating expense. This arrangement is referred to as a power purchase agreement ("PPA") for a renewable generation project located on campus and a VPPA for a renewable generation project located off campus. Conversely, UConn could choose to directly finance a renewable energy generation facility (or an emissions mitigation project in the case of carbon offsets), in which case the cost would be treated as a capital expense. Each approach has benefits and risks that UConn will need to consider. For the purposes of cost estimation and comparison of the investment cases studied in this report, RECs and offsets are treated as operating expenses.

UConn's peers that have pursued off campus solar opportunities have generally used VPPAs to contract with a private developer to finance, own, operate, and maintain the generator. Under this approach the developer acquires the land where the generator is sited, provides funding for the project, and is responsible for all aspects of system development and operations. This contracting structure enables a public offtaker like UConn to realize lower purchase pricing due to federal tax credits for solar and wind generation that are only available to project owners with tax liability. Furthermore, if the offtaker does not dictate where the generator needs to be sited, i.e., on property owned by the offtaker, developers can site generators where energy production (and economies of scale in development) can be maximized and interconnection costs can be minimized.

4.3. Cost of Conversion

Capital Costs

A Rough Order of Magnitude (ROM) of cost was developed for each conversion period based upon the electrical infrastructure improvements and the campus thermal conversion. Unit costs were developed and confirmed as reasonable by a third party consultant to the University. The range of costs highlights the uncertainty of a theoretical "desktop" study and the need for testing for practical feasibility and execution. All capital cost values were developed based upon the previously defined conversion strategies.

The costs presented are in today's dollars (2020) and do not account for construction escalation over time and should be considered approximate project costs for planning purposes only.

Deferred Maintenance Plan:

UPDC, FO, and BVH reviewed the costs that may be required to maintain the campus operations as they currently exist in addition to ongoing energy conversation measure projects which could be understood as the deferred maintenance plan. This review only included costs related to the campus's heating, cooling and electrical systems and fall into the following categories.

- Building HVAC system repairs or replacements
- Campus utility infrastructure repairs and/or replacements
- ECMs

These costs were estimated at approximately $300M for short term, $300M for mid term and $400M for long term totally approximately $1 Billion dollars from 2020 through 2040. It should be noted that a portion of these projections would be required regardless of which plan the University moves forward with to continue to maintain safe operations of the campus.

Climate Action Plan:

For the conversion period of 2021-2025 and 2026-2030, the capital cost includes only the ECMs. For the cost comparisons the conversion periods of 2031-2040 and 2041-2050, it is assumed the perimeter areas will be converted to zero carbon systems on a linear path to meet the 2% reduction. The costs associated with these conversions are assumed to match the Zero Carbon by 2050 Plan for perimeter conversions discussed next.

Peak Plan:

The Peak Plan is based upon a 100% conversion to ground source systems. Similar to the conversion costs discussed in the Zero Carbon by 2050 Plan, the capital costs associated with this conversion plan include, but are not limited to, drilling and installation of ground source wells, new district plants and mechanical equipment, new underground thermal piping, auxiliary equipment, electrical infrastructure, and thermal and electrical building conversions to utilize the thermal energy from the ground source systems. For the conversion period of 2021-2025 the capital costs include the ECMs previously discussed to be completed in this conversion period, 6 MW of onsite solar PV installations. For the conversion period of 2026-2030, the capital cost includes the ECMs and a significant portion of the perimeter conversion. For the conversion period of 2031-2040, the capital cost includes the final portion of the perimeter conversion and the conversion of the central core of campus. In each of these conversion periods various electrical distribution upgrades are included to support the thermal conversions.

Zero Carbon by 2050 Plan:

The hybrid conversion type for the Zero Carbon by 2050 Plan capital costs include, but are not limited to, ground source well drilling and installation, new district plants including mechanical equipment to supply thermal energy in conjunction with the wells, supplemental heating and cooling mechanical equipment to supplement the ground source systems, new underground piping throughout the districts, auxiliary equipment necessary for operation of district thermal systems, required electrical infrastructure to support the thermal conversions, building conversions to accept and distribute thermal energy from the heat pump systems and the associated electrical necessities, and independent zero carbon building systems. For the conversion period of 2021-2025 the capital costs include the ECMs previously discussed to be completed in this conversion period and 6 MW of onsite solar PV installations. For the conversion period of 2026-2030, the capital cost includes the ECMs and 1/3 of the perimeter conversion. For the conversion period of 2031-2040, the capital cost includes the final 2/3 of the perimeter conversion. The final conversion period of 2041-2050 includes the conversion of the central core campus. In each of these conversion periods various electrical distribution upgrades are included to support the thermal conversions. The conversion of the CUP is within this period and includes transitioning to heat pump chillers, electrical chillers, and electrical hot water boilers. An option to convert to large scale electric steam boilers and electrical chillers was reviewed. This option included additional electrical infrastructure improvements at the proposed SUB-195 substation. The capital cost range associated with this option for conversion period 2041-2050 is approximately $300 Million to $400 Million as compared to the heat pump option at $750 Million to $1 Billion.

Refer to **Table 4.4 Cost of Conversion Summary** at the end of this section for summary of the construction capital costs for each plan.

Operating Costs & Risks

The University's current annual operating budget in Fiscal Year 2020 for Utilities was approximately $50 Million. These operating costs include the costs of fuel and utility services, staffing and maintenance on the central plant and infrastructure, and the purchase of Renewable Energy Credits (RECs). Regardless of the establishment or attaining of sustainability goals, the annual cost of infrastructure maintenance is expected to increase gradually over the next 30 years, while the costs of staffing are anticipated to escalate at a moderate and steady rate. The projected increases in annual staffing and maintenance costs would require an approximately $25 Million increase in the Utilities operating budget over the next 30 years.

The Central Utility Plant generates approximately 90% of the current campus electric need as a byproduct of the production of heating and cooling on the campus. Over the last 30 years, the campus has converted most stand-alone heating and cooling systems to natural gas, while oil serves as the heating source for only about 2% of the buildings on campus. The University today has some small annual budget exposure to fluctuations in the price of natural gas, which are generally higher in the winter and lower in the summer. For example, if the cost of natural gas were to increase or decrease by 10% in any given year, the annual operating budget for Utilities would need to increase or decrease by approximately $1.2M to account for these changes.

Conversion of the campus systems to primarily electric will result in the phase-out the fossil fuel systems over time, which will drive down the expenses from natural gas and oil purchases to effectively zero by 2050. However, the electric costs and overall operating costs of the University will increase significantly since in addition to requiring more power to run the heating and cooling systems, the University will lose the "free" electric from the Central Utility Plant heating and cooling generation and have to pay for same as an additional annual expense. Not accounting for potential changes in the unit cost of electricity, the conversion to electric heating and cooling will likely increase the expenses for campus Utilities by approximately four (4) times the current budget (resulting in an overall cost range of $190 Million - $220 Million annually). With a total dependency on electricity, the University will also have large exposure to budget changes, either up or down, resulting from small changes in the unit cost of electricity. As an example, a budget change of $3 - $4 Million annually would be required for every $0.01 per kwh in electrical cost.

The underlying assumption in the Zero Carbon by 2050 Plan and in the operating budget estimates is that the source of the electricity (Eversource) will also be zero carbon by 2040. If Eversource does not reach zero carbon by 2040, the University would need to purchase a large number of RECs to off-set the carbon from the direct electric purchase. The current market value of those RECs in today's dollars could be in the range of $10 Million to $12 Million annually, but similar to electricity, the actual off-set amount could be much greater or much less depending on changing market pricing, supply and demand for these credits.

The Zero Carbon by 2040 Plan cost estimates are based on Zero Carbon by 2050 Plan technology, with an accelerated construction schedule to achieve zero carbon by 2040 instead of 2050. As shown in **Table 4.4,** the unescalated capital costs associated with the Zero Carbon by 2040 Plan and the Zero Carbon by 2050 Plan are essentially the same because the scope of work of both Plans is exactly the same, and only the timeline for the completion of the work is modified. Given the longer timeframe of the Zero Carbon by 2050 Plan work, this plan would be more susceptible to inflationary costs from annual construction cost escalations than the Zero Carbon by 2040 Plan, but the Zero Carbon by 2040 Plan may also create localized inflationary conditions due to the abundance of work being conducted simultaneously; so, whereas the actual capital costs associated with each Plan are not known, for the purposes of this study, they may effectively be considered equal.

	Climate Action Plan		Peak Plan	
Year	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	$60-$85M	$50M	$150-$220M	$50M
2026-2030	$40-$65M	$64M	$1,900-$2,700M	$70M
2031-2040	$700-$825M	$105- $115M	$2,200-$3,100M	$140-$150M
2041-2050	$700-$825M	$160- $170M	--	$180- $200M
Total	**$1,500-$1,800M**	N/A	**$4,250-$6,020M**	N/A

	Zero Carbon by 2040 Plan		Zero Carbon by 2050 Plan	
Year	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	\$150-\$220M	\$50M	\$150-\$220M	\$50M
2026-2030	\$1,000-\$1,300M	\$70M	\$700-\$850M	\$65M
2031-2040	\$1,250-\$1,700M	\$150-\$160M	\$800-\$1,100M	\$115- \$125M
2041-2050		\$200- \$220M	\$750-\$1,050M	\$200- \$220M
Total	**\$2,400-\$3,220M**	N/A	**\$2,400-\$3,220M**	N/A

Table 4.4: Cost of Conversion Summary

Although the Zero Carbon by 2040 Plan is technically possible, the implementation timeline on campus may be logistically unfeasible due to similar challenges as identified in the original Peak Plan. All conversion Plans rely on significant three-to-four times increases in the existing 30 MW electrical capacity, distribution and infrastructure systems both off-campus and on-campus. The needed additional electrical capacity increases from the utility supplier (Eversource) to the campus alone are estimated to require 5 to 12 years to complete, which will limit conversions in the early years of the program.

The effect of the expedited schedule in the Zero Carbon by 2040 Plan versus the Zero Carbon by 2050 Plan is that the higher annual costs associated with electrification of the campus occur earlier. The annual difference in operating costs between 2031 and 2040 is projected to be approximately \$35 Million, and the total additional operating cost to achieve zero carbon by 2040 is approximately \$400 Million.

The Zero Carbon by 2050 Plan includes the costs of conversion of the Central Utility Plant to ground source heat pumps between 2040 and 2050. An alternative would be to install electric boilers in the Central Utility Plant, which have a lower initial capital cost for installation, but would result in approximately 56,000,000 khr additional electric usage at an annual cost in the range of \$12 - \$15 Million each year (at today's average electric rate).

Table 4.5 shows the rate at which buildings would need to be converted and the resulting cumulative operating and construction costs for three plans.

SUMMARY	CLIMATE ACTION PLAN	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
ZERO CARBON DATE	2060	2050	2040
BUILDINGS OFF-LINE CONCURRENTLY	10 - 20 BUILDINGS	20 - 30 BUILDINGS	50 - 60 BUILDINGS
CAMPUS SITE AREA EFFECTED	5% - 10%	10% - 20%	30% - 50%
OPERATING/CAPITAL COST THRU 2030	$670,000,000	$1,500,000,000	$1,900,000,000
CUM. OPERATING/CAPITAL COST THRU 2050	$4,500,000,000	$6,000,000,000	$6,400,000,000
INCREMENTAL ADD'L COST		*$1,500,000,000*	*$1,900,000,000*
CARBON AVOIDED AT 2050	1,171,548	1,512,349	1,920,569
INCREMENTAL ADD'L AVOIDANCE		*340,800*	*749,020*
COST PER INCREMENTAL TON THRU 2050		$4,400	$2,500

Note: Table uses the mid-range of the capital and operating costs for comparison. Actual costs could be higher or lower than shown.

Table 4.5: Cumulative Conversion Cost and Carbon Avoidance

There are approximately 330 buildings on the Storrs campus that are heated or cooled that would require conversion, with about 60% in the perimeter zones and 40% in the central portion of the campus. UConn evaluated construction logistics at a very high level and concluded that in order to complete all conversions by 2040 per the Zero Carbon by 2040 Plan, between 50 and 60 buildings (or 12% - 18% of the total number of buildings on campus) would need to be closed simultaneously on an annual basis for a 10-year period between 2028 and 2038. In addition, energy plant construction, sitework and infrastructure installations would likely require close to 50% of the land area on the active campus area to be closed and utilized during construction during this same time period.

The Zero Carbon by 2050 Plan sequences the work such that the perimeter areas are converted first (and by 2040), followed sequentially by the central areas of campus between 2040 and 2050. This Plan will also be considerably disruptive to the campus, but UConn estimates that the impact on building closures and campus area from the Zero Carbon by 2050 Plan would be slightly less than half as great as the Zero Carbon by 2040 Plan; depending upon how the Central Utility Plant is addressed, disruptions may extend for a longer period of time (up to 16 years). For the Zero Carbon by 2050 Plan as currently contemplated, between 2028 and 2044, 20 to 30 buildings (or 6% to 9% of all buildings) would need to be closed and converted simultaneously on an annual basis and approximately 20% of the land area of the campus would need to be utilized. However, as part of the Zero Carbon by 2050 Plan, time is reserved to allow technology to advance prior to committing to the removal of the Central Utility Plant. If an alternate replacement option for the plant is pursued to maintain the current steam capacity, work in the central campus buildings would be reduced, and much less disruption for the campus after 2038 may eventually be achievable.

Table 4.5 also shows that in order to accomplish a greater avoidance in carbon emissions by 2050, a greater and earlier capital investment above the Climate Action

Plan would be required. Earlier high capital costs and more conversions of systems from fossil fuels to zero carbon systems require an additional $800M to $1.3B by 2030 in order to achieve higher long-term carbon avoidance for the Zero Carbon by 2050 Plan and Zero Carbon by 2040 Plan but will have an adverse effect on the operation of the campus, as large areas of the campus and campus buildings will need to be off-line for the conversions.

The Cost per Incremental Ton is the calculation of the additional avoidance in carbon emissions resulting from the additional expenditures required for the Zero Carbon by 2050 Plan or the Zero Carbon by 2040 Plan versus the anticipated emissions reduction and cost of the Climate Action Plan. On a cost per ton basis by 2050, the Zero Carbon by 2040 Plan is the most cost effective, since for the incremental mid-range cost of approximately $1.9B, the plan results in the most carbon emissions avoidance by 2050. Beyond 2050, the Zero Carbon by 2050 Plan and the Zero Carbon by 2040 Plan would be equivalent in annual carbon avoidance, since both plans reach the zero carbon goal, but would have significantly higher annual operating costs than today and be very sensitive to increases or decreases in the cost of electricity.

4.4. Potential Initial Carbon-Reducing Capital Projects

The following districts represent capital projects that could potentially be accelerated as advanced carbon-reducing measures on campus:

- *Air Source or Water Source* Projects: Spring Hill, Spring Manor, East B
- *Hybrid Ground Source:* West Part 1, Northwest Part 2, South B

These districts are proposed based upon multiple factors including, but not limited to, ground source well field location and feasibility, existing underground utilities, existing standalone systems, and logistical feasibility. These districts are located on the distant perimeter and would allow for minimal disruption on campus during construction. They are also are on the smaller side in comparison to central campus and allow for a quicker implementation and proof of concept.

The proposed districts have features that make them preferred candidates for advanced implementation; however, other districts may be completed prior to these suggestions if they are determined to be more feasible.

Spring Hill, Spring Manor, East B Conversion Strategies

Spring Hill

Existing Systems: Combination of hot water distribution and direct hot air furnaces. Select cooling from ductless mini-split air-to-air heat pumps.

Conversion Option: 100% Air Source/Water Source

Electrical Improvements: Electric service improvements to support the conversion to air or water source thermal.

Spring Manor

Existing Systems: Minimal electric heat.

Conversion Option: 100% Air Source/Water Source

Electrical Improvements: Electric service improvements to support the conversion to air or water source thermal.

East B

Existing Systems: Direct hot air furnaces and unit heaters. Select hot water distribution per building. Select direct expansion cooling per building. Singular building with chilled water distribution.

Conversion Option: 100% Air Source/Water Source

Electrical Improvements: Electric service improvements to support the conversion to air or water source thermal included upgrading overhead cabling.

Hybrid Ground Source: West Part 1, Northwest Part 2, South B

Northwest Part 2

Existing Systems: Combination of Hot water distribution per building and direct hot air furnaces. All cooling through local direct expansion cooling per building.

Conversion Option: 100% Hybrid Ground Source (26% of District)

Electrical Improvements: Electric service improvements to support the conversion to ground source thermal including building improvements and new service to district thermal plant. Installation of new electrical distribution (cable and ductbanks) to establish electrical district loop.

South B

Existing Systems: Hot water distribution per building. No cooling. It is assumed as a part of this study, that the existing buildings would be demolished and replaced with a new building.

Conversion Option: 100% Hybrid Ground Source

Electrical Improvements: Electric service improvements to support the conversion to ground source thermal.

West Part 1

Existing Systems: Hot water distribution serving multiple buildings through underground hot water piping. All cooling through local direct expansion cooling per building.

Conversion Option: 100% Hybrid Ground Source (18% of District)

Electrical Improvements: Electric service improvements to support the conversion to ground source thermal including building improvements and new service to district thermal plant. Installation of new electrical distribution (cable and ductbanks) to establish electrical district loop.

Campus Electrical Infrastructue Improvements

Complete the installation of a new “Storrs 38E” Substation at 50 MW base and up to 75 MW and associated distribution improvements adjacent to the future Supplemental Utility Plant.

Approximate Cost Range

A Rough Order of Magnitude (ROM) of cost was developed for these potential initial projects and is shown in **Table 4.6**. The range of costs highlights the uncertainty of a theoretical "desktop" study and the need for testing for practical feasibility and execution. All capital cost values were developed based upon the previously defined conversion strategies. If on-site solar projects are completed concurrently with these district conversions, the operating costs should not be greatly inflated over existing operating cost projections.

The costs presented are in today's dollars (2020) and do not account for construction escalation over time and should be considered approximate project costs for planning purposes only.

Capital Cost Range		
Campus Infastructure	$40,000,000	$45,000,000
Air or Water Source	$45,000,000	$55,000,000
Ground Source	$205,000,000	$220,000,000
Total	**$290,000,000**	**$320,000,000**

Table 4.6: Construction Estimate for Initial Carbon Reducing Capital Projects

5. RISKS AND CHALLENGES

The carbon reduction strategies outlined herein are subject to risks and challenges including, but not limited to, the following:

- Changes and advancements in technology
- Eversource timing and availability of electrical infrastructure improvements
- Ability to operate the campus on current fuel sources
- Ability to operate the campus with increase in electrical demands while maintaining resiliency

  Key operational concerns associated with campus electrification are power outages, loss of resilience, and the reliability of remote grid-based generation, and transmission and distribution system constraints to Storrs and Depot Campuses. As a shelter in place, critical infrastructure campus serving our university and the local community reliable power able to quickly recover from outages is mission critical.

- Unforeseen conditions that could affect the feasibility of alternatives
- Reputational risk associated with meeting interim plan goals
- Construction cost escalation
- Construction and site logistics
- Eversource meeting its 2030 goals for clean energy and an increased commitment to zero carbon by 2040
- Generation of more in-depth detailed feasibility studies for areas within the 2030 timeline
- Development of more detailed operating/life cycle costs
- Determination of impacts on occupied buildings and the University's operating budget if buildings and residential housing are unavailable
- Availability and Identification of Funding Sources: State, Federal, Grants, Student Fees
- Determination of scope and impacts on existing buildings to accommodate new HVAC and electrical systems
- Availability of trade labor
- Potential for changes in public policy and regulatory requirements
- Increase in electrical costs due to public demand for clean, renewable energy
- Further consideration should be given to total carbon emissions of selected solutions including carbon emissions from manufacturing (embedded carbon) and installation.

- Consideration should be given to infrastructure investments that have or are currently being installed that have not yet reached the extent of their useful life or financial payback as this could affect the true cost of system improvements or replacements.

6. CONCLUSION

In preparation of the Peak Plan to accelerate current carbon emissions reductions goals for the Storrs campus, BVH determined that it would be logistically infeasible to attain zero-carbon emissions by 2040 by converting thermal energy produced with fossil fuel to electric sources (primarily with ground source heat pumps). However, it became apparent that if the carbon reduction timeline was more consistent with the current Climate Action Plan, many of the strategies in the Peak Plan could more likely be implemented in a manner to achieve zero-carbon emissions by 2050. This new plan became known as the Zero Carbon by 2050 Plan and adopted all of the current strategies in the Climate Action Plan and many of the strategies in the Peak Plan. The major distinctions between each plan are identified below:

<u>Climate Action Plan</u>

- By 2020, a 20% reduction based on a 2007 baseline
- By 2030, a 30% Reduction based on a 2007 baseline through implementation of planned Energy Conservations Measures (ECMs), and addition of a new Eversource 50 MVA substation with medium voltage distribution ring bus extension
- 2% Reduction per year between 2030 and 2050 on average through undefined methods

<u>Peak Plan</u>

- By 2025, implementation of many Climate Action Plan ECMs and installation of 6 MW of solar photo-voltaic (PV) panels on campus
- By 2030, implementation of remaining Climate Action Plan ECMs, conversion of perimeter district ground source heat pump thermal systems, installation of 30 MW of solar PV panels under Power Purchase Agreement, and addition of a new Eversource 50 MVA substation with medium voltage distribution ring bus extension
- By 2040, conversion of all campus thermal energy to ground source heat pump systems, renewable electricity to be sourced from green grid power or Renewable Energy Credits (RECs), and development of new Eversource 100 MVA substation along Route 195.

<u>Zero Carbon by 2050 Plan</u>

- By 2025, implementation of many Climate Action Plan ECMs and installation of 6 MW of solar photo-voltaic (PV) panels on campus.
- By 2030, implementation of remaining Climate Action Plan ECMs, conversion of one-third of the perimeter district to a combination of heat pump thermal systems, installation of 30 MW of solar PV panels under Power Purchase Agreement, and addition of a new Eversource 50 MVA substation with medium voltage distribution ring bus extension
- By 2040, conversion of the remaining two-thirds of the perimeter district to a combination of heat pump systems, renewable electricity to be sourced from green grid

power or RECs, and development of new Eversource 100 MVA substation along Route 195.

- By 2050, conversion of campus central core to zero-carbon systems.

This report further defined the Zero Carbon by 2050 Plan for comparison to the Climate Action Plan and Peak Plan. From the energy use and emissions reductions predictions determined in prior studies and in this Zero Carbon by 2050 Plan development, the energy projections, construction cost, and operating cost estimates are summarized in the following tables:

The projected energy use and carbon reduction by plan in five to 10 year increments is shown in **Table 6.1.**

	Climate Action Plan			Peak Plan		
Year	Remaining Emissions, MTeCO2	Electric Use, MWH	Remaining Emissions, MT	Remaining Emissions, MTeCO2	Electric Use, MWH	Remaining Emissions, MT
2020	98,083	135,304	1,700,000	98,083	135,304	1,700,000
2025	82,717	130,163	1,504,000	78,369	130,163	1,504,000
2030	68,314	130,163	1,367,618	40,115	199,536	743,000
2040	44,244	191,375	954,575	0	263,168	0
2050	24,070	247,446	541,532	0	263,168	0

	Zero Carbon by 2040 Plan			Zero Carbon by 2050 Plan		
Year	Remaining Emissions, MTeCO2	Electric Use, MWH	Remaining Emissions, MT	Remaining Emissions, MTeCO2	Electric Use, MWH	Remaining Emissions, MT
2020	98,083	135,304	1,700,000	98,083	135,304	1,700,000
2025	78,369	130,163	1,504,000	78,369	130,163	1,504,000
2030	44,777	208,351	747,662	61,898	172,684	1,092,256
2040	0	282,561	0	27,981	247,446	541,531
2050	0	282,561	0	0	282,561	0

Table 6.1: Projected Annual Emissions Reduction and Energy Use by Plan

The projected construction capital cost and operating cost per plan is shown in **Table 6.2**.

	Climate Action Plan		Peak Plan	
Year	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	$60-$85M	$50M	$150-$220M	$50M
2026-2030	$40-$65M	$64M	$1,900-$2,700M	$70M
2031-2040	$700-$825M	$105- $115M	$2,200-$3,100M	$140-$150M
2041-2050	$700-$825M	$160- $170M	--	$180- $200M
Total	**$1,500-$1,800M**	N/A	**$4,250-$6,020M**	N/A

	Zero Carbon by 2040 Plan		Zero Carbon by 2050 Plan	
Year	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	$150-$220M	$50M	$150-$220M	$50M
2026-2030	$1,000-$1,300M	$70M	$700-$850M	$65M
2031-2040	$1,250-$1,700M	$150-$160M	$800-$1,100M	$115- $125M
2041-2050		$200- $220M	$750-$1,050M	$200- $220M
Total	**$2,400-$3,220M**	N/A	**$2,400-$3,220M**	N/A

Table 6.2: Estimated Construction Capital Cost and Operating Cost by Plan

Additional aspects of each plan are identified below:

- The Climate Action Plan has thus far been successful as a result of efficient operation of the Cogeneration Facility, building conservation efforts, and energy efficiency improvements in utility infrastructure.
- Implementation of the Climate Action Plan has been based on effective utilization of existing energy assets and ongoing modernization of existing buildings. This approach as created a highly resilient and reliable power and thermal distribution system on campus for enhancement of student life and shelter-in-place provisions.
- The Peak Plan will accelerate reduction of campus carbon emissions to zero by more than 10 years earlier than the Climate Action Plan, but it is not feasible to build due to planning and time constraints.
- Implementation of the Peak Plan would require establishment of 21 heating and cooling districts, well field in all districts for ground source heat pump systems, and conversion of all districts and buildings to low temperature hot water or electric heating.
- The Zero Carbon by 2050 Plan would reduce campus carbon emissions to zero by 2050 and sooner than the prescribed method of 2% per year identified the Climate Action Plan.

- Implementation of the Zero Carbon by 2050 Plan would require establishment of 21 heating and cooling districts, combination of air, water, and ground source heat pump systems, and conversion of at least the perimeter districts to low temperature hot water or electric heating. Utilization of different conversion technologies reduces the capital cost of the Zero Carbon by 2050 Plan compared to the Peak Plan. An extended construction schedule with a variety of conversion technologies makes the Zero Carbon by 2050 Plan a more achievable option for consideration.
- Implementation of the Zero Carbon by 2040 Plan would mimic the Zero Carbon by 2050 Plan but would be accelerated by ten years. In order to achieve all conversions by 2040, it is projected that between 50 and 60 buildings would need to be closed simultaneously on an annual basis for a 10-year period between 2028 and 2038, and approximately 50% of the land on the active campus would be closed due to construction.
- Conversion of the perimeter districts to heat pump systems is a viable strategy for all the plans. Construction and conversion in those regions would be less disruptive while the central districts in the core will be more difficult to convert.

Given the complexity and challenges in achieving a zero-carbon campus, there does not appear to be a clearly defined conversion path beyond the next fifteen to twenty years. Conversion strategies should be verified at time of project initiation as new renewable energy technology comes to market. New innovative options should be explored by the University, even as pilot or research projects, when their application can be substantiated on campus.

BVH integrated services

APPENDIX A

PWGS June 5th, 2020 Report

Planning for a Zero-Carbon Future

Recommendations and Strategies to Align UConn with International Scientific Consensus and the Goals of Climate Justice

FINAL REPORT

June 5, 2020

President's Working Group on Sustainability and the Environment

Planning for a Zero-Carbon Future

FINAL REPORT

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Planning for a Zero-Carbon Future

FINAL REPORT

A Preface

On September 20, 2019, students at UConn staged a large-scale climate strike to highlight the need for urgent action to slow climate change. This was followed by weekly student sit-ins at President Katsouleas' office demanding action. In response, among other things, President Katsouleas created this group of faculty, students, and ex officio staff — the President's Working Group on Sustainability and the Environment (PWGS). The committee was led by Office of the Executive Vice President for Administration and Chief Financial Officer, and supported by the Office of Sustainability, Environmental Health and Safety, Facilities Operations, and University Planning, Design and Construction. Over the course of the spring 2020 semester, the group held eight full working group meetings and eight additional sub-group meetings, culminating with the creation of this report by consensus of the group members.

This report contains recommendations that frame an energy and climate change strategy that enables the University to lower its carbon emissions and help slow climate change. These recommendations are designed to outline the steps necessary for UConn to align with state-wide initiatives, scientific consensus, international standards of climate justice, and UConn's mission as a leading research and educational institution. We view this report as the first step in a planning process that should continue through the fall, and into the months and years beyond. We lay out aggressive goals, principles to guide the planning to achieve those goals, and specific items for further planning and analysis.

Future strategic choices will require a better understanding and evaluation of the costs and benefits of alternative pathways for ensuring that the goals described here are met. Due to time constraints and the interruptions stemming from the global pandemic, we have only been able to begin to scratch the surface of this important task. We recognize that further work must be done, by this group and in collaboration with UConn's energy consultants, to produce more detailed, step-by-step plans to transition from the campus's present carbon footprint to the future zero-carbon campus, and to update the Campus Sustainability Framework Plan.

The ideal time to act on climate change has long passed, but there is still time to mitigate the worst damage. We hope that in this report we have effectively laid out *why* and *how* UConn must act decisively, *now.*

Respectfully,
Members of the President's Working Group on Sustainability and the Environment

Planning for a Zero-Carbon Future

FINAL REPORT

B Executive Summary and Recommendations

The Challenge

The scientific consensus is clear on two things: first, climate change is a human-made catastrophe of unprecedented scale, which is disproportionately affecting vulnerable and marginalized populations; second, governments, businesses and institutions across the world have failed to act on a scale necessary to limit the catastrophic effects.

UConn's Role

UConn is deeply committed to the mission of mobilizing its resources and research to address the most pressing problems facing humanity. Since 2001, UConn has reduced campus Greenhouse Gas Emissions by 39% and has integrated resilience into the curriculum, research, and campus operations. Although UConn has been consistently recognized as a campus sustainability leader due to achievements in areas such as water management and educational opportunities, the University has not performed as well in carbon emissions reductions. The University has failed to meet its 2020 near-term emissions reductions goals and is not currently on pace to meet its long-term goals. As a leader in the State of Connecticut, the country and in the international community, UConn has a responsibility to lead by example, and align itself with the scientific consensus and international standards of climate justice.

Major Recommendations

To meet its obligation to be a leader in addressing climate change, the PWGS has put forth six major recommendations. These recommendations are not exhaustive. Rather, they are intended to be the foundation and framework for UConn's strategies towards present and future energy use and the mitigation of climate change. Further work must be done to formulate detailed step-by-step plans for transitioning the campus from fossil fuels to clean, renewable energy.

1. **Update Emissions Reduction Goals:** UConn should update its emissions reductions goals to align with international scientific consensus and the goals of climate justice. We strongly recommend a new goal of 60 percent reductions in carbon emissions by 2030 compared to a 2010 baseline (including proportionate, five-year interim milestones) and zero-carbon emissions by 2040. "Carbon emissions" comprise greenhouse gas emissions from sources directly owned and/or controlled by UConn as well as those attributable to power purchased by UConn.

   Reaching zero-carbon emissions by 2040 will require bold action and strong leadership by UConn's administration. We recommend the following as steps toward meeting that goal:

2 **Halt Fossil Fuel-based Construction:** UConn should, with the exception of the Board approved projects listed in Appendix A, permanently halt the construction of new fossil fuel steam infrastructure at all campuses, including UConn Health. This should be accompanied by the zero-carbon transition of UConn's heating and cooling infrastructure by 2040 and will require a step-by-step timeline.

3 **Increase Investment in Renewables:** UConn should invest in utility-scale renewable energies such as solar, wind, anaerobic digestion and others, in order to meet these new goals.

4 **Incorporate Goals into Campus Development Plans:** All decisions related to campus development, including the use of existing space, new construction, renovation, and demolition, should be informed by the University's commitment to achieve zero-carbon campuses by 2040.

5 **Divest from Fossil Fuels:** UConn should recommend that the UConn Foundation divest its funds in fossil fuel holdings.

A Path Forward

Given the recommendations outlined above, reaching the goal of zero-carbon will require careful evaluation of specific strategies and a consideration and evaluation of each strategy's potential for reducing emissions and the associated costs, both monetary and non-monetary. Given time and resource constraints, this report has only begun to address that process. We are not able at this point to recommend specific projects or investments, since decisions at that level require more detailed analysis than we are able to provide. Nonetheless, we have begun to summarize some of the relevant information about individual strategies and projects in section six. These include strategies such as a roadmap to a campus-wide, zero-carbon heating and cooling system by 2040; site-specific assessments for renewable energy deployment; and an evaluation of technologies that ensure year-round reliability as the campus continues its zero-carbon transition. We suggest they be studied further and prioritized in fall 2020.

Because of the need for additional work on this second phase, we also recommend the following:

6 **Continuation of Planning Efforts:** The PWGS charge should be extended to continue in-depth planning of items prioritized for further study; and in order to address issues such as detailed energy planning, transportation emissions, behavioral change, outreach and engagement on environmental justice, diversity of faculty members in environmentally-related disciplines, etc. Additionally, accountability and communication mechanisms should be developed to accompany this report and representatives from the regional campuses and UConn Health should be engaged.

Planning for a Zero-Carbon Future

FINAL REPORT

1 Background: Working Group Origins

On September 20, 2019, students held a large-scale climate strike on the Student Union lawn and proceeded to march to President Katsouleas' office, demanding climate action at UConn. At his office, President Katsouleas spoke to the students and announced that the Board of Trustees would chair a Trustee-Administration-Faculty-Student (TAFS) committee, dedicated to tackling the issue of carbon mitigation at UConn. A week later, President Katsouleas sent a campus-wide email that accelerated UConn's emissions reductions targets and declared: "Climate change is more than an emergency; it is a global crisis worsening by the day."

Students continued to protest, primarily through weekly sit-ins at the President's office, because this email did not address all of their demands, which included: halting the construction of new fossil fuel infrastructure, divesting from fossil fuels, and increasing diversity within the environmental studies faculty. (The full "Fridays For Future Declaration of Climate Action" can be accessed in Appendix B, sec 1.) The continued protests, along with cooperation from UConn's senior administration, led to the creation of this group, the President's Working Group on Sustainability and the Environment (PWGS). Partially as a result of these protests, President Katsouleas agreed to suspend construction of phase 2 of the new Supplemental Utility Plant, which would have utilized natural gas tri-generation.

These protests were also backed by the University Senate, which issued two statements in support of University-wide climate action in the past year. The first, in September 2019, supported the climate strike and the second, in February 2020, supported divestment from fossil fuel holdings. In addition, student meetings with UConn Executive Vice President and Chief Financial Officer Scott Jordan prior to the climate strike contributed to the creation of this group.

Governor Lamont's Executive Orders (EO) in 2019 were also motivating factors. EO 1 mandated stricter emissions cuts at statewide agencies, a 45 percent reduction from their 2001 baseline by 2030, 34 percent reduction from 2014 baseline by 2030, and 80 percent below 2001 baseline by 2050. EO 3 ordered DEEP to plan for a zero-carbon electric grid by 2040.

2 University Mission and Values

2.1 University Mission

The University of Connecticut is guided by the University Mission Statement, the Academic Plan, the Campus Master Plan, and direction from the Administration and the Board of Trustees.

The University Mission Statement, adopted by the Board of Trustees in 2006, includes the following:

> *"…. As Connecticut's public research university, through freedom of academic inquiry and expression, we create and disseminate knowledge by means of scholarly and creative achievements, graduate and professional education, and outreach… As our state's flagship public university, and as a land and sea grant institution, we promote the health and well-being of Connecticut's citizens through enhancing the social, economic, cultural and natural environments of the state and beyond."*

Planning for a Zero-Carbon Future

FINAL REPORT

In January 2017, UConn's then President Susan Herbst endorsed the 2020 Vision Plan for Climate Leadership and Sustainability. The President wrote: "Another *important UConn value is our commitment to sustainability*, especially when it comes to understanding and addressing the social, economic, environmental, and public health issues surrounding climate change." As part of this Plan, the President committed UConn to "…reduce its carbon footprint by more than 20 percent since 2007…".

In October 2019, President Katsouleas reaffirmed UConn's commitment to the environment in a letter to the University community. "Climate change is more than an emergency," he wrote, "it is a global crisis worsening by the day… This issue is of the utmost importance to the UConn community, including myself, and we have an obligation to explore setting more ambitious goals than we already have." President Katsouleas outlined the formation of several committees to analyze and discuss goals and policies "…in concert with discussions about resources and priorities, as one is dependent on the other and there is a natural tension between them."

The PWGS is guided by this direction, particularly with respect to institutional energy policies and use and the opportunities to reduce carbon emissions.

2.1.1 Academic Plan Core Values and Vision:

For more than a decade, the environment and sustainability have been focal themes in the university's strategic plans. These themes have motivated research, education, and engagement to address some of the most critical challenges to face society in the 21st Century. In further recognition of the importance of these multidisciplinary issues to UConn's mission as a land, sea, and space grant university, and as the State of Connecticut's flagship institution of higher learning, UConn's Board of Trustees established the Institute of the Environment (IoE) in January 2019. The IoE's role is to lead and catalyze efforts to address global challenges, like climate change, and to demonstrate leadership on these issues by integrating academic and operational initiatives, consistent with the values and goals specified in the 2014 Academic Plan, *Creating our Future: UConn's Path to Excellence*.

<u>2014 Academic Plan: Values and Vision.</u> Global change in general, and climate change in particular, if unabated, will compromise the ability of the world's ecosystems to provide the critical goods and services that ensure societal well-being. Because environmental sustainability and climate change are inherently global in nature, these themes provide an intellectual platform that advances two core values of the university: global engagement and leadership.

More specifically, the 2014 Academic Plan states, "[t]hrough outreach, research, and partnerships, we promote sustainable development and a happy, healthy, and inclusive society. This engagement is local and global, based on intercultural understanding and recognition of the transnational nature of the challenges and opportunities we face." Moreover, it states: "UConn's students will become well-educated leaders and global citizens who excel in addressing the challenges of the 21st century; in them, we will cultivate critical thinking, creativity, and joy in lifelong learning. We will serve the state, the nation, and the world through our research, teaching, and outreach."

Numerous Statements of UConn's Commitment to Climate Leadership & Sustainability may be found in the USG/EcoHusky letter re: the most recent Presidential Search and in the 2020 Vision Plan.

2.1.2 2015-2035 Campus Master Plan and its Sustainability Framework Plan

In the foreword to the Campus Master Plan, President Susan Herbst wrote:

> *"The Master Plan represents a comprehensive vision for the development of the campus over the twenty years and contains a well thought-out strategy for the sequential development of the University. The Master Plan achieves our goal of having an environment that inspires and educates, meets our sustainability goals for new development and future operations, and reflects the excellence of the programs and achievements of the institution."*

The President also wrote that the Master Plan is "…a living document…" and "….a framework that is flexible and responsive to the evolving needs of the University."

2.2 University Values

The University Mission Statement begins with "The University of Connecticut is dedicated to excellence demonstrated through national and international recognition." To achieve this goal requires leadership, and the global climate change crisis is an area in which UConn has the potential to lead efforts for global change.

2.2.1 Leadership

Michael M. Crow, President of Arizona State University, stated: "Our institutions have the opportunity to serve as transformational catalysts… to better guide the adaptation of our organizations to the sustainability-related needs and challenges faced by society."

Aligned with this aspiration, UConn is a sustainability leader among its peers, placing fifth in Sierra Club's Cool Schools 2019 Ranking. However, UConn ranks poorly in Energy, despite the fact that energy and carbon emissions have become focal points for nationwide public sentiment, Connecticut state policy, and UConn's community.

The Connecticut Department of Energy and Environmental Protection (DEEP)'s Lead By Example program strives to improve energy management at state facilities in an effort to catalyze a trend of clean and efficient energy use in CT, and UConn is playing a significant role in furthering this effort.

2.2.2 Prospective Students

In recent years, students have increasingly viewed colleges' commitments to environmental issues as important to their perception of those colleges. In a 2015

Princeton Review survey, 61 percent of students said it was important (20 percent "very much" or "strongly"). A continuation in this trend positions environmental commitment to assume an even larger role in the college decision process for students.

2.3 International Scientific Consensus and the Goals of Climate Justice:

In a landmark 2018 report, the Intergovernmental Panel on Climate Change (IPCC) concluded that global emissions need to be reduced by 45 percent from 2010 levels by 2030 to limit warming to 1.5°C over pre-industrial levels. The 2019 United Nations Environmental Programme Emission Gap report called for even more stringent cuts of 7.6 percent per year. It is important to note that even if we limit warming to 1.5°C, there will still be, and already are, catastrophic weather events and patterns associated with or strengthened by climate change. The IPCC report also concludes that: "Pathways limiting global warming to 1.5°C with no or limited overshoot would require rapid and far-reaching transitions in energy, land, urban and infrastructure (including transport and buildings), and industrial systems (high confidence). These system transitions are unprecedented in terms of scale, but not necessarily in terms of speed…"

The report, and the wider body of climate change literature, also expresses support for the goals of climate justice. At its core, climate justice is the belief, backed by research and experience, that climate change's impacts will reflect the existing inequalities in our world. Wealthier, developed nations are responsible for the vast majority of cumulative carbon emissions, yet poorer, less developed nations (especially in the global south) are most impacted by the effects of climate change. Poor and marginalized communities within developed nations, such as racial minorities, indigenous people, women and low-income communities, will also experience the worst effects of climate change. The principles of climate justice argue that in order to deal with climate change in a just manner, we must be conscious of and constantly fight against this inequality. With this in mind, this report embraces larger emissions cuts than are recommended globally, in order to account for the United States 'disproportionate share of historical, cumulative emissions. The first recommendation in section five embodies these goals.

3 President's Working Group on Sustainability and the Environment

In his letter of October 2, 2019 (see Appendix A, sec 1a), President Katsouleas addressed the UConn community about the issue of environmental sustainability and the goal of further reducing UConn's carbon emissions. The President wrote that "… we have an obligation to explore setting more ambitious goals than we already have. But any commitment we make must be real. By that I mean it must be truly achievable and realistic based on data, analysis and the best estimates we are able to make about things like cost, technological capabilities and pace. Promises not backed by facts and strategy are empty, and I would always prefer honesty and realism to the alternative."

The President announced a special committee of the Board of Trustees known as the Trustee-Administration-Faculty-Student (TAFS) Committee with a sole agenda of emissions reduction and future sustainability. He also wrote of his plan "… to create a centralized working group to take responsibility for coordinated analysis, policy formulation and strategic planning on issues of sustainability, particularly reducing emissions."

The President's Working Group on Sustainability and the Environment (PWGS) was formed comprising faculty and students, chaired by the Executive Vice President and Chief Financial Officer and supported by ex officio staff. The charge to the PWGS was to:

> *"Examine UConn's current carbon emissions reduction goals and our progress to achieving them; assess whether or not accelerating those goals is feasible within the context of our budget and available technology; if so, recommend actions UConn can take to achieve that based on facts, data, sound strategies and the best estimates we are able to make."*

The PWGS held eight sessions during the spring 2020 semester, meeting in person on January 24, February 5, February 27 and March 10, and in response to the COVID-19 pandemic, by phone on March 25, April 9, April 30, and May 6. Group members presented and discussed goals, existing conditions and aspirations with ex-officio staff and professional consultants (see Appendix B for meeting minutes and presentations). A Sub-Group comprising three faculty, two students and two ex-officio staff, supported by two additional staff, worked together to compile this report and presented a draft to the full working group on April 9; a second draft on April 30; a third draft on May 6; and a final draft on May 8. On May 11, PWGS presented the final draft to the President and the Board of Trustees Chairpersons of the Buildings, Grounds and Environment Committee and the Trustee-Administration-Faculty-Student Committee; final edits were completed in late May 2020.

4 UConn Statistics and Current Sustainability Status

4.1 Current Carbon Reduction Commitments

In 2008, UConn's President Hogan signed the American College & University President's Climate Commitment (ACUPCC) whereby the University committed to achieve carbon neutrality by 2050.

In accordance with this commitment, by 2010 UConn developed a Climate Action Plan (CAP), which proposed nearly 200 actions for reducing greenhouse gas emissions (GHG), including interim milestones of 20 percent reductions by 2020 (versus a 2007 baseline), 30 percent by 2025, and 40 percent by 2030. In 2012, President Herbst reaffirmed UConn's commitment and endorsed the CAP.

Through December 2019, UConn had achieved a 16 percent reduction in total greenhouse gas emissions versus the 2007 baseline, despite growth in enrollment of more than 20 percent and the addition of nearly 800,000 square feet of new building space. As of April 2020, UConn has not achieved the 20 percent reduction from the 2007 baseline.

Since the adoption of the CAP, there have been a number of sustainability- and climate-related commitments and milestones (see Appendix A, sec 1b).

4.2 UConn Statistics for Storrs, Regionals, Law School, and Farmington campuses

4.2.1 Land and Buildings (see Appendix A for Storrs aerial)

The University of Connecticut comprises multiple campuses, and cooperative extensions throughout the State. Each campus is physically distinct in acreage and land use, and in the number and size of buildings and facilities.

Table A Summary of University Land by Campus or Location

CAMPUS/LOCATION	TOTAL ACREAGE[1]	MANAGED FOREST	MANAGED FARM/AG
Avery Point	73	0	0
Cooperative Extensions	21	0	0
Downtown Hartford	2	0	0
Health - Farmington	210	0	0
Law School	20	0	0
Stamford	9	0	0
Storrs (inc. Depot & Surrounding Towns)	3,900	2,100	550
Waterbury	2	0	0
TOTALS	**4,237**	2,100	550

[1] Approximate; includes all University-owned property identified in our records ***except*** leased land.

Table A summarizes total approximate area of land controlled by the University at its campus in Storrs, its five regional campuses, UConn Health's campus in Farmington, and its cooperative extension centers located throughout the state. The total land area for Storrs includes the Depot campus, as well as managed forest and agricultural land in the Towns of Coventry, Mansfield and Willington.

This information can assist in the interpretation of energy demands and use. When assessed with building footprints and other data, it can also be used to calculate space available for potential solar arrays.

Table B Summary of Facilities by Campus or Location

CAMPUS/LOCATION	NUMBER OF PROPERTIES[1]	TOTAL GSF	TOTAL ASF
Avery Point	16	421,871	213,098
Cooperative Extensions	9	59,547	36,694
Downtown Hartford	9	132,491	77,302
Health - Farmington	19	3,837,255	2,416,055
Law School	6	252,926	130,659
Stamford	3	502,324	296,494
Storrs (inc. Depot & Surrounding Towns)	339	11,291,970	6,869,322
Waterbury	3	256,366	136,490
TOTALS	**404**	**16,754,750**	**10,176,114**

[1] Includes **all** property types identified as "in service" or "occupied" in database.

Table B summarizes the total number of facilities operated by the University at its campus in Storrs, its five regional campuses, UConn Health's campus in Farmington, and its cooperative extension centers located throughout the state. These properties – buildings and other structures – are identified as "in service" or "occupied" in the space databases managed by UConn and UConn Health.

The total gross square feet (GSF) and assignable square feet (ASF) of each campus or location can be used to analyze the amount of energy needed to light, heat or cool interior space.

4.2.2 Energy: Current Demand and Sources

The 2015 Campus Master Plan considered the various options to supply required energy to existing and planned structures, focused on meeting the reliability and resiliency standards of a leading research university. All new infrastructure is designed for a 99.99 percent reliability and sufficient resiliency to protect the $5.3 billion dollars of research assets and provide shelter-in-place capabilities for students in the event of adverse conditions from natural or human initiated events. A Leadership in Energy and Environmental Design (LEED) Gold Standard is in place for new construction and comprehensive renovations. Each project is required to have an energy model that evaluates the availability of multiple energy sources to meet the program requirements for the project. Factors examined include the full life cycle costs of the source, market availability, operability and maintenance complexity of the source, and the ability to convert from the selected source at the end of the useful life to a future technology or method envisioned but perhaps not yet market ready or compliant with all project requirements.

Statistically, UConn purchases about 50% of all UConn campuses electric power as renewable power.

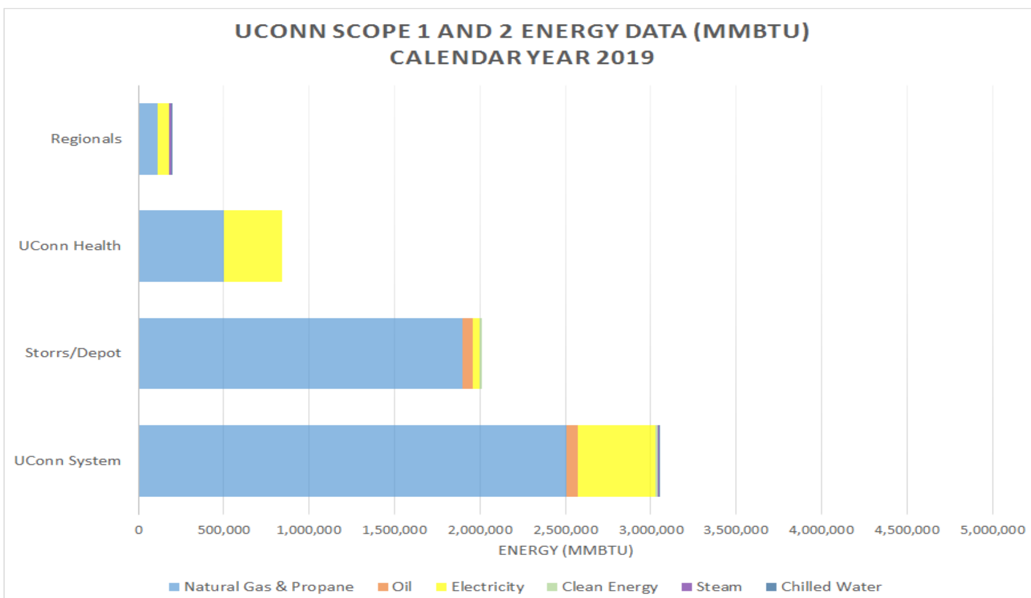
a) For the Storrs Campus only, the COGEN produces 90% of electric power (about 126,000 MWh) and about 65% of the thermal load and emits approximately 65% of the campus greenhouse gas emissions.
b) The 65% thermal load (heating and cooling) is produced from exhaust heat, which requires zero fuel.
c) Natural gas is typically 97% of the fuel supplied by CT Natural Gas (CNG) with curtailments averaging 3% ultra-low sulfur oil as fuel supplied from Energy New England (ENE).
d) For the Storrs Campus only, UConn purchases 10% grid power (about 10,000 MWh).
e) For all of UConn campuses, purchased power is about 115,000 MWh.

Emissions attributable to UConn are categorized according to these three scopes:

- Scope 1: Emissions from sources owned or controlled by UConn (e.g., the Central Utility Plant)
- Scope 2: Emissions resulting from the generation of energy purchased by UConn (e.g., from external fossil fuel-burning power plants)
- Scope 3: Emissions from sources not directly owned or controlled by UConn but related to our activities (e.g., commuting and travel)

Actual energy requirements and the method of supply as of 2019 are shown in **Figure 1.**

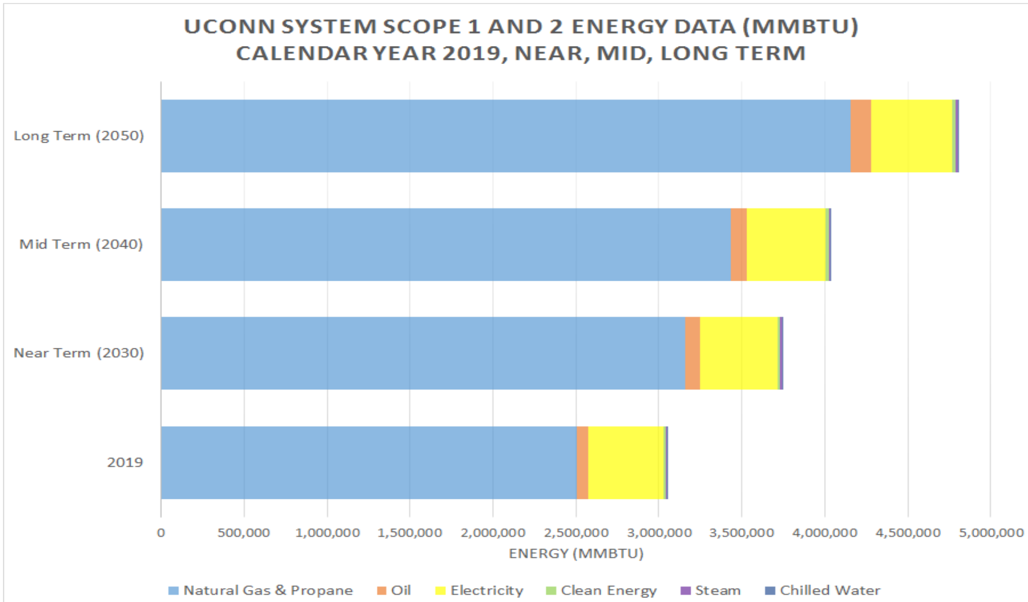
Figure 1
UConn Scope 1 and 2 energy data (MMBTU) in CY 2019



The 2015 Campus Master Plan projected energy requirements are shown in **Figure 2** for the Near, Mid, and Long Term (as defined in the Master Plan).

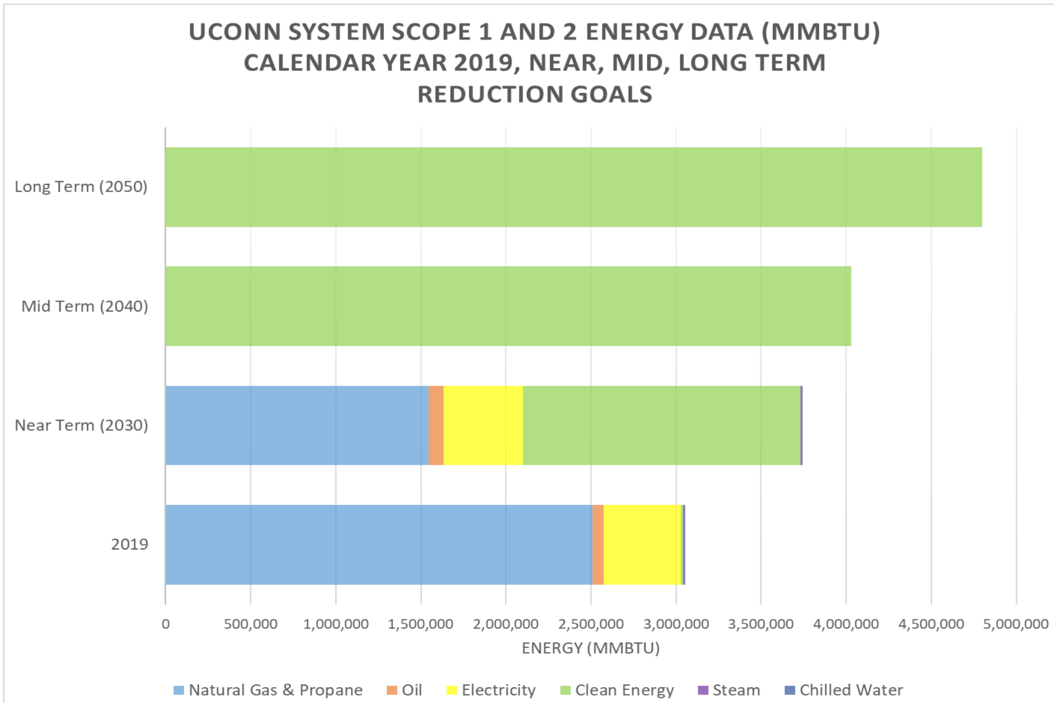
Figure 2

UConn system scope 1 and 2 energy data (MMBTU) in CY 2019
and near/mid/long-term projections



The PWGS revisited the various options to supply required energy in consideration of Governor Lamont's Executive Order 1 and President Katsouleas' commitments. The strategic implementation of clean, renewable energy resources to transition from fossil fuels at the end of useful life for existing assets is shown in **Figure 3**. This chart represents the fulfillment of UConn's existing commitments, not the emissions cuts recommended in section 5.1. For strategies and potential projects to enable this transition see Section 6.7 of this report.

Figure 3
UConn system scope 1 and 2 energy data (MMBTU) in CY 2019
and near/mid/long-term reduction goals



4.3 Human Behavioral Initiatives

Since 2002, the University's Office of Sustainability has led a wide variety of environmental engagement activities and events aimed at promoting sustainable behaviors among students, faculty and staff.

The most prominent programs include EcoMadness – in which student residence halls compete against each other to reduce energy and water usage – and the Green Office Certification Program – which allows offices to be certified "green" based on various adopted sustainable practices and behaviors at work. These programs have attracted significant participation from students, faculty and staff over the past 14 years. Numerous other successful and established UConn events, activities and organizations focused on environmentally sustainable outreach and engagement are listed in Appendix A, sec 1c.

4.4.1 UConn-Generated Renewable Energy Credits

Because the University's 25 MW cogeneration facility fits within the definition of a Class 3 renewable energy source under the State of Connecticut's Renewable Portfolio Standard (RPS) law, the University generates Class 3 renewable energy credits (RECs) simply by operating the Cogen facility. These RECs account for the economic value of the environmental attributes from the energy the Cogen plant produces. UConn also receives a lesser amount of revenue from class 1 RECs based on the much smaller amount of energy produced by the 400 kW fuel cell at the Depot Campus. The University monetizes these RECs, which generate approximately $2.5 million dollars in revenue annually. This REC revenue is then reinvested into energy efficiency projects throughout the UConn system to reduce future carbon emissions and energy demand. Combined with Eversource's energy efficiency rebates and incentives, this has resulted in an annual $5 million dollars spend on energy efficiency (EE), primarily at the main campus but increasingly applied to fund EE projects system-wide.

4.4.2 Purchased Power RECs

UConn's energy provider, Direct Energy, also buys RECs generated by out-of-state renewable energy sources (e.g., Texas wind power) to offset carbon from all of UConn's Scope 2 purchased power. This effectively makes 5 percent of the electricity used at the main campus, and all of the electricity used at the Health Center, the Law School, and the Hartford, Waterbury and Stamford Campuses, carbon neutral. The Avery Point Campus is served by Groton Utilities for electricity needs, and thus is not part of this long-term renewable energy purchased power contract with Direct Energy. This 100% renewable purchased power contract has been in place for 5 years and will be renewed.

4.2.3 Emissions Reduction Credits

In conducting its annual greenhouse gas inventory, using standardized guidance documents, UConn also accounts for emissions reductions credits (ERCs) from two activities that effectively reduce overall emissions. These credits are then deducted from our total Scope 1,2 and 3 emissions.

UConn Forest – ERCs account for the carbon sequestration that occurs in older-growth trees and undisturbed soils on designated UConn Forest parcels and other UConn-owned lands (e.g., the Hillside Environmental Education Park). UConn is committed to maintain these trees and lands in their natural state, either as a dedicated research forest or under conservation agreements.

Compost Facility – ERCs account for the reduction in emissions from composting 40% of CAHNR's manure at UConn's Agricultural Waste Compost Facility, located at Spring Manor Farm. Composting reduces methane emissions from anaerobic decomposition that would otherwise result from the standard farm practice of storing and spreading manure in the field.

4.5 Energy Market and Legislative Climate

CT's RPS law and DEEP's/Public Utility Regulatory Authority's accompanying table (see Appendix A, sec 3.c.i) call for an increased percentage of Class 1 RECs, from 20 percent to 40 percent, over the next ten years, while the percentage of Class 3 RECs will remain flat at 4 percent over that same time period. This may result in a significant corresponding increase in the demand for, and value of, Class 1 RECs (solar, wind, geothermal and fuel cells) and a potential decrease in the value of Class 3 RECs (cogeneration). UConn should plan now to replace the potential lost value from Class 3 RECs with Class 1 RECs, over the next five to 10 years. Energy conservation projects are the largest source of GHG reductions under the University's Climate Action Plan 2007 Baseline Year at 17% recorded since 2008. Executive Order EO-1 Baseline Year 2001 includes the 22% reduction in emissions due to operation of the UCONN Cogeneration Facility commencing in 2006, which is the largest overall continuing reduction recorded for a total reduction of 39%.

Public policy changes may include a state carbon tax on fossil fuels, and the extension or addition of state prohibitions (e.g., MA and NY) on any new pipeline project that would enable the import of "fracked" natural gas from producers in Pennsylvania and other states. These state, regional, and potentially national, environmental and energy related public policy trends provide a sound economic basis for UConn's energy source diversification and the recommendations that follow in section five.

5 Recommendations

These recommendations are a product of collaboration between the student, faculty, and administration members of the PWGS, supported by ex officio and additional staff, during the duration of the spring semester 2020. Detailed meeting minutes may be found in Appendix B.

Recommendation One: Update Emissions Reduction Goals

The University should adopt a new, institutionally binding goal of a 60 percent reduction in emissions from a 2010 baseline by 2030 and of a zero-carbon campus by 2040, which aligns with Governor Lamont's target for the State's electric grid.

a) The University should develop appropriate interim targets for reviews in 2025 and 2035 to ensure adequate progress toward these goals.
b) This timeline aligns with the IPCC's target of limiting global warming to 1.5 degrees Celsius, the outsized responsibility of developed nations (see section 2.3), and the risks of delayed action.
c) Our recommended goal of a zero-carbon campus by 2040 aligns with the phase-out of existing fossil fuel infrastructure, including the Central Utility Plant in 2035, provided we do not expand our capacity, which is addressed in recommendation two.
d) In addition, this recommendation aims to reduce the risk of stranded fossil fuel assets. According to the 2018 IPCC report: "challenges from delayed actions to reduce greenhouse gas emissions include the risk of cost escalation, lock-in of carbon-emitting infrastructure, stranded assets, and reduced flexibility in future response options."

The zero-carbon goal applies to scope 1 (direct on-campus) and scope 2 (purchased power) carbon dioxide-equivalent emissions from fossil fuels (coal, oil, and natural gas). We believe steps should also be taken to mitigate scope 3 emissions, such as those related to transportation, including a carbon neutral commuter program. Specific transportation-related recommendations should be developed as a future goal of this or subsequent PWGS, which is discussed in recommendation six.

Recommendation Two: Halt Fossil Fuel-based Construction

The University should, with the exception of the Board approved projects listed in Appendix A, sec 3.d, permanently halt expansion and construction of fossil fuel and steam infrastructure on all campuses, including UConn Health. All heating and cooling infrastructure should be fully converted to zero-carbon capable systems such as geothermally coupled electric heat pumps, with suitable electrical infrastructure installed by 2040.

a) A step-by-step timeline for the transition to a zero-carbon heating and cooling system by 2040 should be developed under the guidance of the PWGS by the end of the Fall 2020 semester. This timeline should include a plan to build the necessary electrical infrastructure to provide for electrical and heating/cooling loads from renewable energy sources. An example of a zero-carbon heating and cooling transition timeline from Princeton University is provided in Appendix A, 3.c.vi.
b) Full electrification and renewable energy deployment by 2040 will enable the University to align its efforts with those of Governor Lamont's EO 3 and meet emissions reductions targets outlined in recommendation one.
c) Emergency repairs to existing fossil fuel-powered steam infrastructure that do not extend the payback period of that infrastructure should be allowed. Wholesale replacements that extend the payback period of the existing steam infrastructure, however, should not be allowed.

Recommendation Three: Increase Investment in Renewables

UConn should invest in renewable energy technologies to meet the electric and heating/cooling demands of all campuses, including UConn Health. This will entail use of various green technologies:

a) Solar: Utility-scale installations will be needed on available land near UConn campuses, together with the transformer and transmission infrastructure for delivery of power to those campuses. Distributed solar (for example, on and near buildings and parking lots) should be installed where feasible. Solar power has strong seasonal variability and is especially suited to meeting summer cooling needs.
b) Wind: Offshore wind power is more consistent than solar, and peaks in the winter, making it complementary to solar power. Due to this winter generation profile, wind energy may serve as an integral part of UConn's long-term energy portfolio, especially as the CUP is retired. UConn should assess whether wind turbine installations are appropriate at the Avery Point Campus. For other locations, UConn should consider the purchase of or investment in wind energy from elsewhere in Connecticut.
c) Storage: Solar and wind are intermittent energy sources. On-campus energy storage will be needed to cope with routine fluctuations in these sources and to maintain resilience in the face of multi-day storm events or grid outages. Battery technologies remain unsatisfactory for this task but are rapidly improving. Other possibilities include

electrically powered splitting of water into hydrogen and oxygen, with the hydrogen stored as a fuel. Over the next one or two decades, technologies will likely become available to meet storage needs, and UConn will need to implement energy storage at all campuses.

Recommendation Four: Incorporate Goals into Campus Development Plans

All decisions related to campus development, including the use of existing space, new construction, renovation, and demolition, should be informed by the University's commitment to achieve no increase in overall energy use and zero-carbon campuses by 2040.

Steps to achieve this recommendation include, but are not limited to:

a) Establish a design guideline that new construction should be zero-carbon;
b) Employ a carbon proxy price that accounts for the social cost of carbon, minimizes risk to the University of potential carbon tax legislation, and guides planning toward use of lower carbon alternatives;
c) Complete building assessments and energy audits of all existing buildings;
d) Demolish old, energy-inefficient buildings and utilize demolition to offset new construction;
e) Include the maximum amount of distributed rooftop solar panels in the construction of new buildings; and
f) Prioritize geothermal heating and cooling for all new construction and renovations.

Recommendation Five: Divest from Fossil Fuels

The University should recommend that the UConn Foundation divest its funds in fossil fuel holdings. The reasoning is twofold: first, continued investment in fossil fuels is becoming an economic liability. Second, it is a moral imperative to stop support of fossil fuel companies, that play a large role in the continued exploitation and destruction of the environment.

Large public universities, like the University of California System and the University of Massachusetts, have announced plans to divest fully from fossil fuels for economic and moral reasons. Other schools that have fully or partially divested from fossil fuel holdings include the University of Maine System, Stanford University, Johns Hopkins University and the University of Oxford.

Recommendation Six: Continuation of Planning Efforts

Future iterations of the PWGS should perform the following functions:

a) Continue in-depth planning of items, including a roadmap to a campus-wide, zero-carbon heating and cooling system by 2040; site-specific assessments for renewable energy deployment; and an evaluation of technologies that ensure year-round reliability. These items were prioritized for further study due to their systemic and capital-intensive nature;
b) Develop an accountability mechanism to assess the University's progress towards these recommendations and its climate commitments. Ongoing assessment enables consistent, coordinated progress toward the University's goals and avoids major catastrophes, such as emissions target overshoots, loss of embedded carbon costs, and stranded assets;

c) Develop a communication mechanism for the PWGS to convey recommendations and progress assessments to the broader UConn community. This communication mechanism should utilize intermittent and permanent communication vehicles, such as coordinated media campaigns (intermittent) and online or physical infrastructure displaying up-to-date progress towards sustainability goals (permanent);

d) Tackle additional climate and sustainability issues, some of which have been outlined in the Fridays for Future Declaration of Climate Action (see Appendix B), including, but not limited to: transportation, behavioral change, outreach and engagement on environmental justice, diversity of faculty members in environmentally-related disciplines, etc. These additional tasks are identified due to their importance in reducing carbon emissions and committing the University to the goals of climate justice. The composition of the PWGS should be adjusted as necessary to address the Group's needs as shifts in primary topics emerge over time. Changes to the composition of the PWGS, however, should maintain its balance of students, faculty members, and staff members, and retain an open-application (crowd-sourced) recruitment method for students; and

e) Engage and collaborate, in fall 2020, with representatives from the regional campuses and UConn Health to identify and prioritize specific strategies for their campuses.

6 Strategies for Reducing Carbon by 2025, 2030, and 2040

As noted in the recommendations above, the University should lay out systematic strategies to reduce carbon emissions with the short-term goal of a 60 percent emissions reduction from a 2010 baseline by 2030, and a mid-term goal of zero -carbon campuses by 2040. Achieving such goals requires identification of significant emissions reduction leverages, as well as the feasibility of technology adoption and deployment. In accordance with recommendation six part (a), work to build out and adapt these strategies will continue in future iterations of the PWGS. All strategies must evaluate monetary and non-monetary risk to the University and to society.

6.1 On-going and Proposed Carbon Reductions by Facilities Operations

UConn is currently in the process of implementing various on-going carbon reduction projects and has proposed several other projects that are needed to meet UConn's Climate Action Plan carbon reduction goals. These projects are presented in Section 6.6 below and described in more detail in Appendix A Section 3.a, Technologies and Strategies.

6.2 Solar Deployment

Most solar panels are between 15 percent and 20 percent efficient**.** Solar panels usually range in wattage output from 250 watts to 400 watts. The most efficient mass-produced solar modules have power density values of up to 175 W/m2 (16.22 W/ft2).

6.2.1 Short Term (2020-2025)

a) Virtual Purchase Power Agreement (VPPA) at an off-campus location, first assessing the 160 acre plot of land for sale in Mansfield. This captures the current federal tax credit for solar developer.

b) Complete site assessment and plan for utility-scale installation at Depot Campus and other nearby locations where this is an appropriate technology.

d) Determine if existing buildings and structures can be retrofit with rooftop solar using existing lightweight technologies.

6.2.2 Mid Term (2025-2030)

a) Deploy University-owned, utility-scale solar at Depot Campus (federal tax credit expiry, lower cost of capital than a private developer).
b) Retrofit existing rooftops and other structures as more lightweight solar technologies becomes available.

6.2.3 Long Term (2030+)

a) Retrofit existing rooftops and other structures as more lightweight solar technologies becomes available.

6.3 Geothermal

The low energy intensity (and electricity only) requirement of geothermal heating/cooling systems make them particularly useful in the quest to achieve an electrified, zero-carbon campus (see Appendix A Sec 3.b.iii for details).

a) UConn should focus immediately on identifying off-the-CUP buildings, where geothermal retrofits are most beneficial (e.g., Bishop Center, Institute of the Environment in the Building 4 Annex). Installation of small geothermal systems at these buildings would replace stand-alone boilers and chillers, and immediately yield reduced energy costs and lower carbon emissions, with a fast payback period.
b) UConn should begin evaluating larger-scale geothermal closed loop wellfields, ground-source heat pumps and thermal storage systems at strategic locations on campus as part of the mid-term (2040) goal of a zero-carbon campus (see recommendation three above).
c) Geothermal should be prioritized for heating and cooling needs at all new construction projects.

6.4 Wind

Offshore wind available in the New England wind lease area is estimated as 14,000 MW. The State of Connecticut is pursuing offshore wind as an important, large-scale and local source of renewable energy. The state has legislated directives to procure around 2,000 MWs of offshore wind and have selected ~1,000 MWs with individual generator connections as a first step in meeting that goal. Strategic plans are required to enable the long-term development of wind energy harvest, sustain stronger long-term economic growth, improve HVDC transmission systems, while reducing costs, minimizing the environment footprint and impact.

6.4.1 Short Term (2020-2025)

a) Identify all planned wind projects within the region, such as the Constitution Wind project.
b) Communicate with the project developers to determine whether UConn could arrange a virtual PPA or a similar agreement to acquire wind energy.
c) If acquiring wind energy from planned projects is not feasible, assess whether the University could collaborate with project developers (and potentially other

stakeholders/off-takers) to install and acquire wind power from a new project through a virtual PPA or similar agreement.

6.5 Carbon Offsets

Carbon offsets are a way to compensate for emissions by funding an equivalent carbon dioxide saving elsewhere. They are a form of trade that allows individuals, companies or institutions to invest in environmentally-beneficial projects locally or around the world to balance their own carbon emissions. Because climate change is a global problem, carbon offsets are international commodities. One carbon offset is equivalent to a reduction in emissions of one Metric Ton of CO_2 equivalent (MTCO2e).

Carbon offset projects implemented at remote locations must be done in close collaboration with indigenous populations and officials from the host community. Any carbon offset project must meet "additionality" requirements (see criteria below), meaning that it would not have occurred but for the carbon offset investment. Thus, projects in highly-regulated states and communities with strict regulations, standards, and controls, and extensive permit terms and conditions, may not meet the additionality requirement. Use of carbon offsets with respect to the transportation sector could help to achieve Scope 3 reductions.

The carbon market is well-regulated and has evolved over the past 25 to 30 years to be even more carefully restricted. This international regulatory regime includes standards, guidelines and protocols for qualified carbon offsets, along with officially recognized agencies, brokers and third-party verification organizations.

The annual price that UConn could expect to pay for a certifiable carbon offset project is approximately $10 - $15 per MTCO2e over a long-term period.

A strong consensus of the PWGS is that carbon offsets are best-suited for offsetting Scope 3 emissions, especially those from commuters, visitors and air travel. These transportation-related activities are inherent in the University's mission, and generate a significant portion of UConn's GHG emissions (15-25 percent). However, they derive from mobile sources owned and operated by third parties and are generally beyond UConn's direct ability to reduce through operational control measures.

Carbon offsets may also be utilized to bridge gaps or shortfalls in achieving interim or 10-year carbon reduction goals. For example, UConn could purchase carbon offsets to meet the 2020 interim milestone goal of 20% reduction, as established in the Climate Action Plan (CAP). For additional information see Appendix A, sec 3c.x.

6.6 Greenhouse Gas Reduction Projections

A greenhouse gas reduction projection matrix was developed in order to determine if UConn's Climate Action Plan carbon reduction goals could be achieved by the set milestone dates. The matrix table is presented in Section 6.7. A detailed description of specific greenhouse gas reduction projects that could be used to achieve these goals is presented in Appendix A, Section

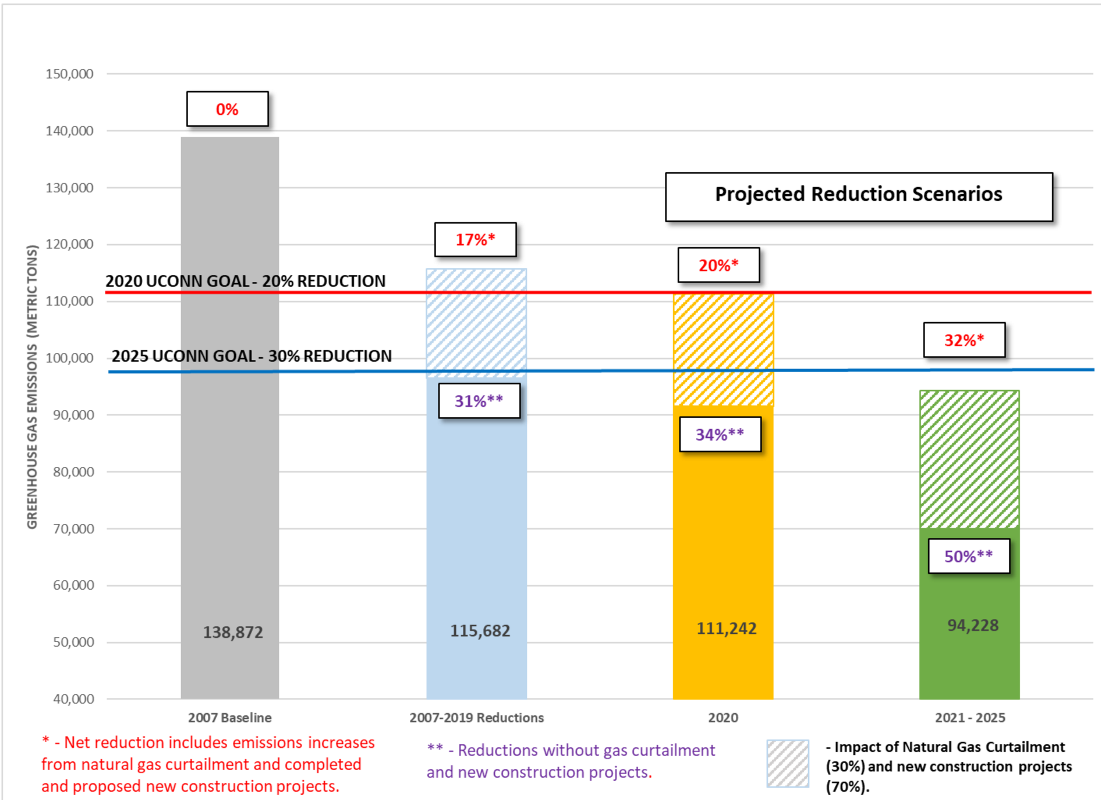
3, Technologies and Strategies. The greenhouse reduction goals that were evaluated in the projection matrix include:

a) 20% reduction by 2020 based on a 2007 baseline (UConn goal)
b) 30% reduction by 2025 based on a 2007 baseline (UConn goal)
c) 45% reduction by 2030 based on a 2001 baseline (Governor's Executive Order 1 goal)
d) 45% reduction by 2030 based on a 2010 baseline (IPCC goal)
e) 60% reduction by 2030 based on a 2010 baseline (proposed UConn goal)

Note that the evaluation presented below represents only one of many possible scenarios that could be implemented to reduce greenhouse gas emissions to achieve set carbon reduction goals. Further study is needed to determine the best path forward to achieve these goals.

The results of the evaluations that were conducted are presented in **Figures 4 through 6.** These figures present the baseline emissions, the reductions achieved to date through the end of 2019 and projected reductions for each milestone date. Reduction percentages achieved demonstrate 1) the impact of natural gas curtailment and new construction and 2) without natural gas curtailment and new construction for the Storrs campus. The impact of natural gas curtailment and new construction is shown in **Figures 4 through 6** with hatching on the bar charts. The specific greenhouse gas reduction projects needed to achieve the reduction goals listed above are presented in **Figures 7 through 10**. The actual greenhouse gas emissions, baselines (2001, 2007 and 2010) and current to date (2007 through 2019), include scopes 1, 2, and 3 emissions. Projected reductions primarily decrease scopes 1 and 2 emissions, although one of the reduction items in the 2020 timeframe, "Commuter Carbon Offsets" (**Figure 7**), would decrease scope 3 emissions.

Figure 4
Greenhouse Gas Emissions Projected Reductions
that could meet UConn Goals



Greenhouse gas emissions reductions that could achieve UConn's reduction goals of 20% by 2020 and 30% by 2025 are based on a 2007 baseline (**Figure 4**). The net reduction percentages shown in red include emissions increases from natural gas curtailment and completed and proposed new construction projects. Reduction percentages shown in purple indicate what the reduction would have been without natural gas curtailment and new construction.

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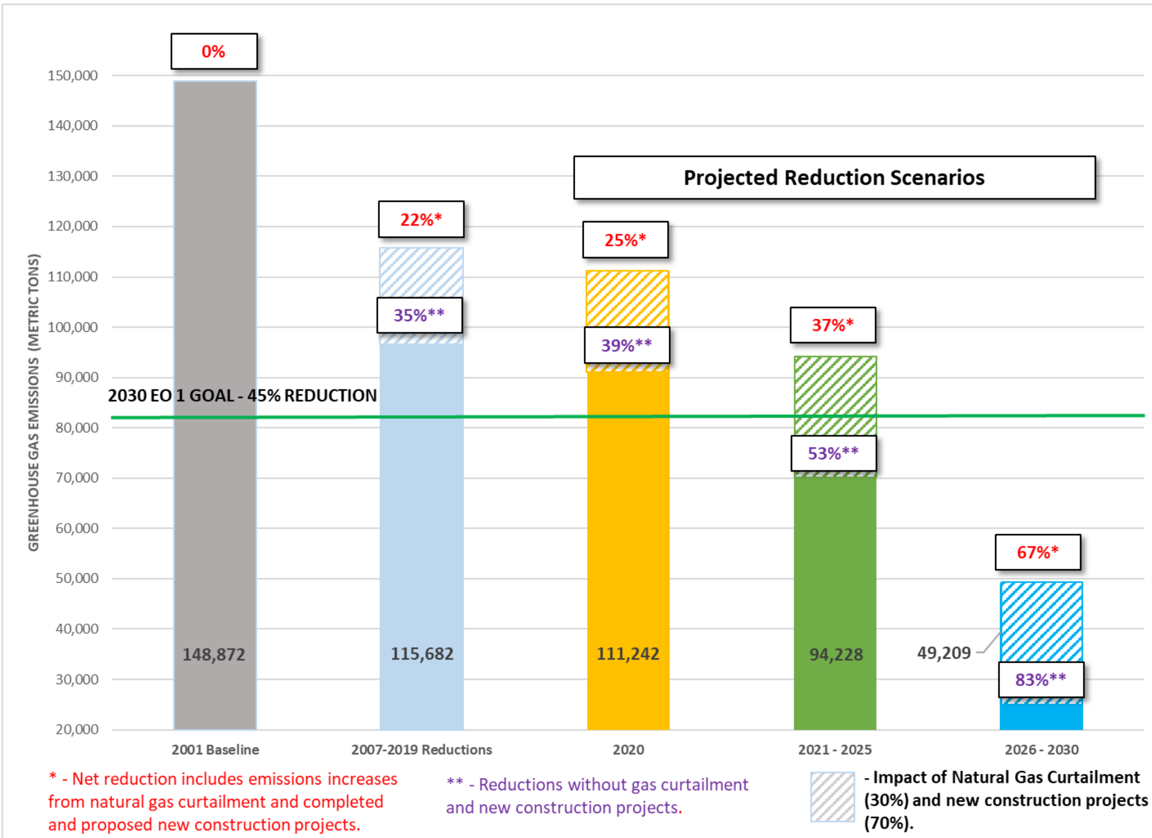
Figure 5

Greenhouse Gas Emissions Projected Reductions
that could exceed the Governor's Executive Order 1 Goal



Greenhouse gas emissions reductions that could exceed the Governor's EO 1 reduction goal of 45% by 2030 are based on a 2001 baseline (**Figure 5**).

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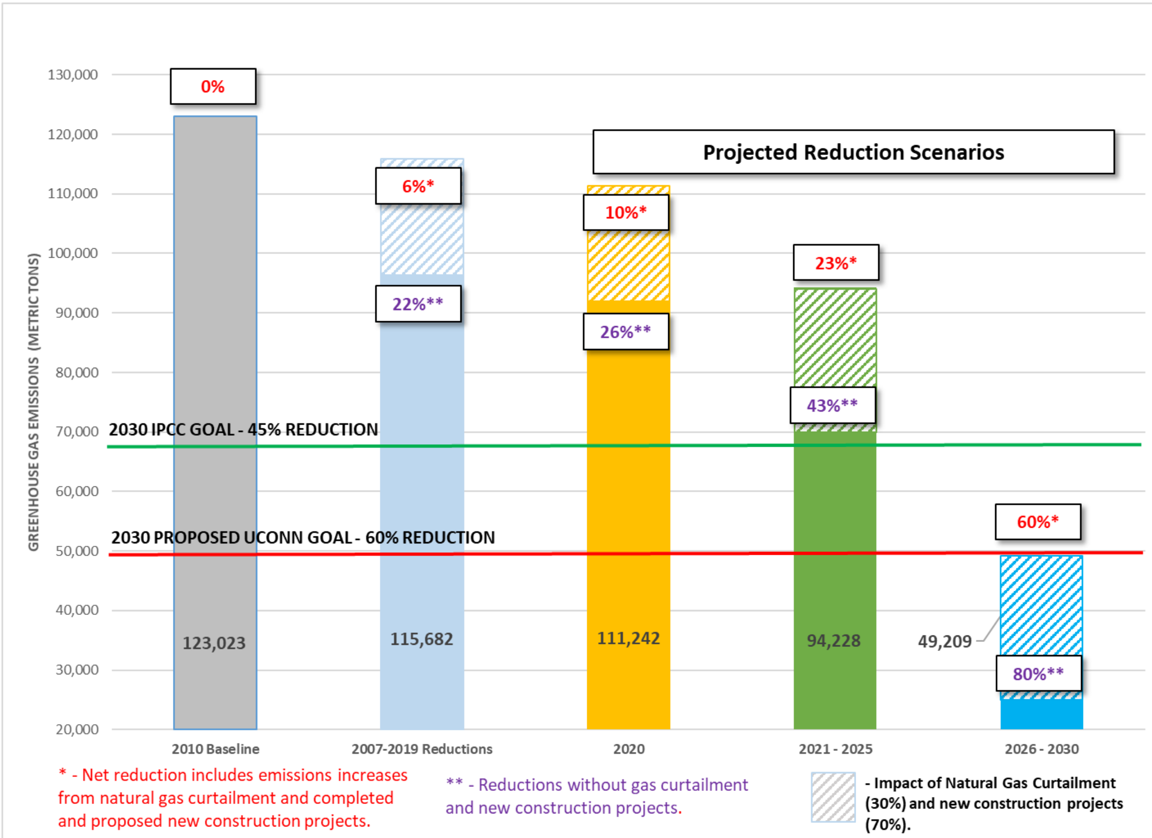
Figure 6

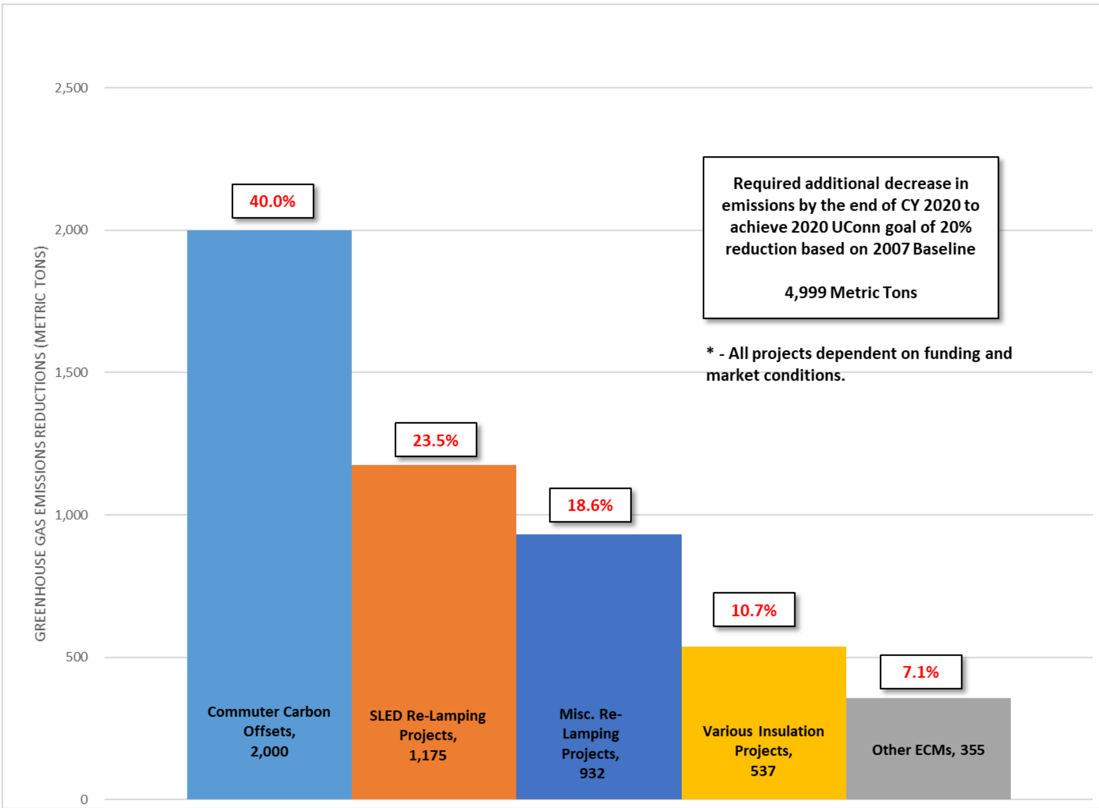
Greenhouse Gas Emissions Projected Reductions
that could exceed IPCC and UConn Goals



Greenhouse gas emissions reductions that exceed the IPCC reduction goal of 45% and could achieve the proposed UConn reduction goal of 60% by 2030 are based on a 2010 baseline (**Figure 6**).

Figure 7

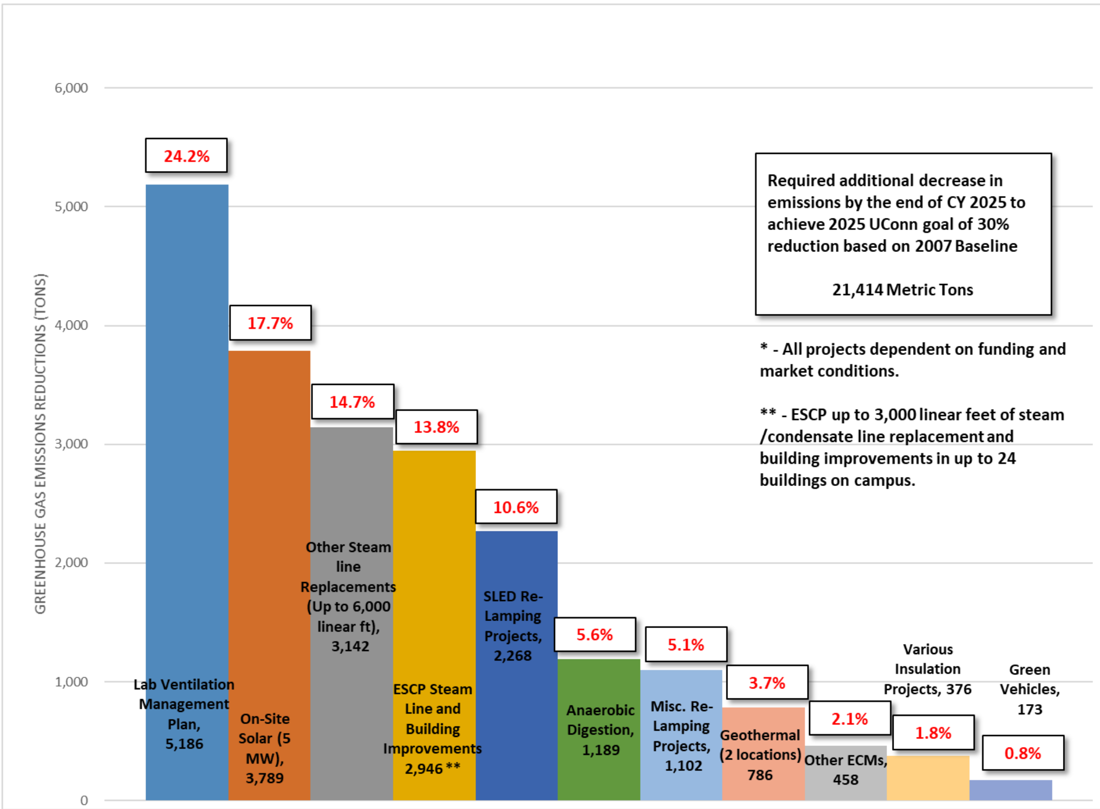
Required 2020 GHG Emissions Reductions – Proposed Projects*



An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 20% by 2020 based on a 2007 baseline is shown in **Figure 7**. To achieve this goal, emissions would need to be reduced by approximately 5,000 metric tons by the end of calendar 2020. The most predominant reductions in calendar year 2020 is estimated to come from commuter carbon offset at 40% with the SLED re-lamping projects being the second most at 23.5%.

Figure 8

Required 2021-2025 GHG Emissions Reductions – Proposed Projects*

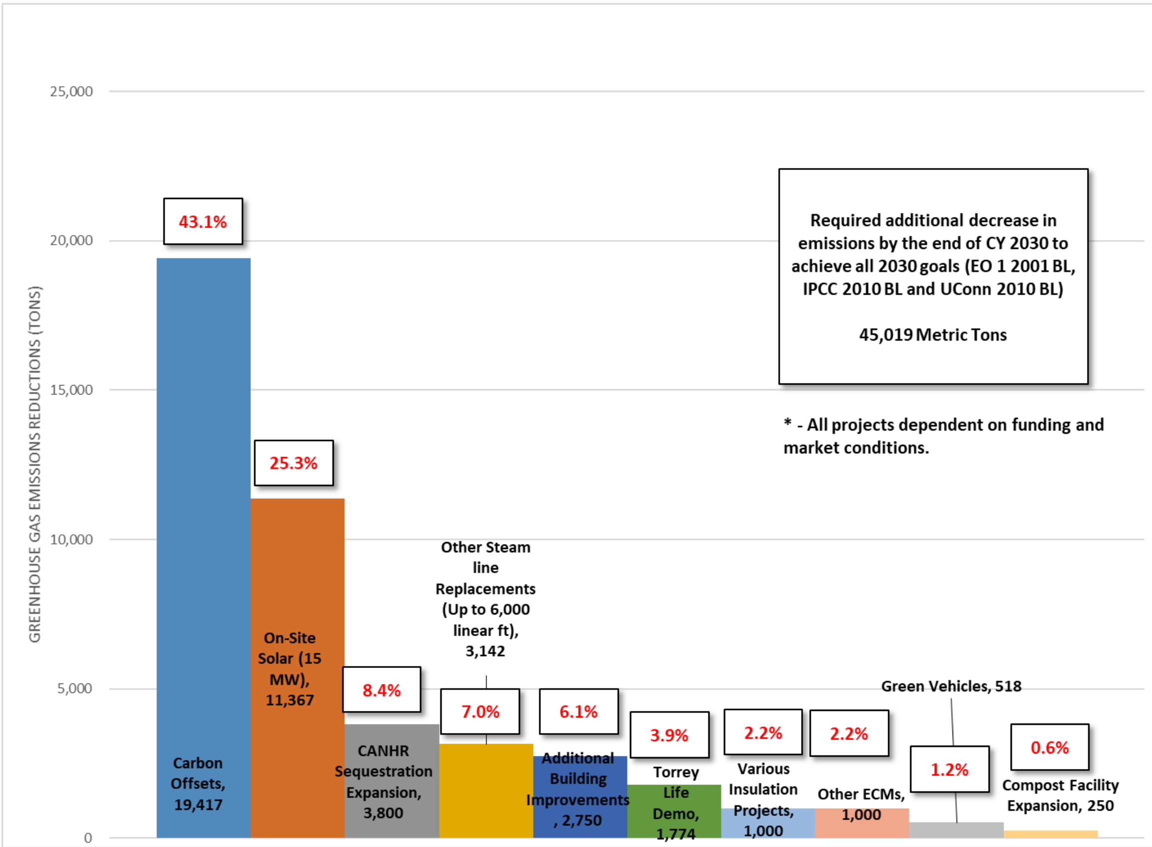


An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 25% by 2025 based on a 2007 baseline is shown in **Figure 8**. To achieve this goal, emissions would need to be reduced by 21,414 metric tons by the end of calendar year 2025 in addition to the 5,000 metric tons by the end of calendar 2020. The most predominant reductions in the 2021-2025 time-frame is estimated to come from lab ventilation management plan at 24.2% with on-site solar being the second at 17.7%.

NOTE: The Figures present one possible scenario to reach the end goals. Lab Ventilation is conceptual at this stage of our planning and cannot be included in **Figure 7** (Year 2020). It is included in **Figure 8** (Years 2021-2025) since if funded it should be possible to implement in that time. It is not included in **Figure 9** (Years 2026-2030) as it is expected to be completed.

Figure 9

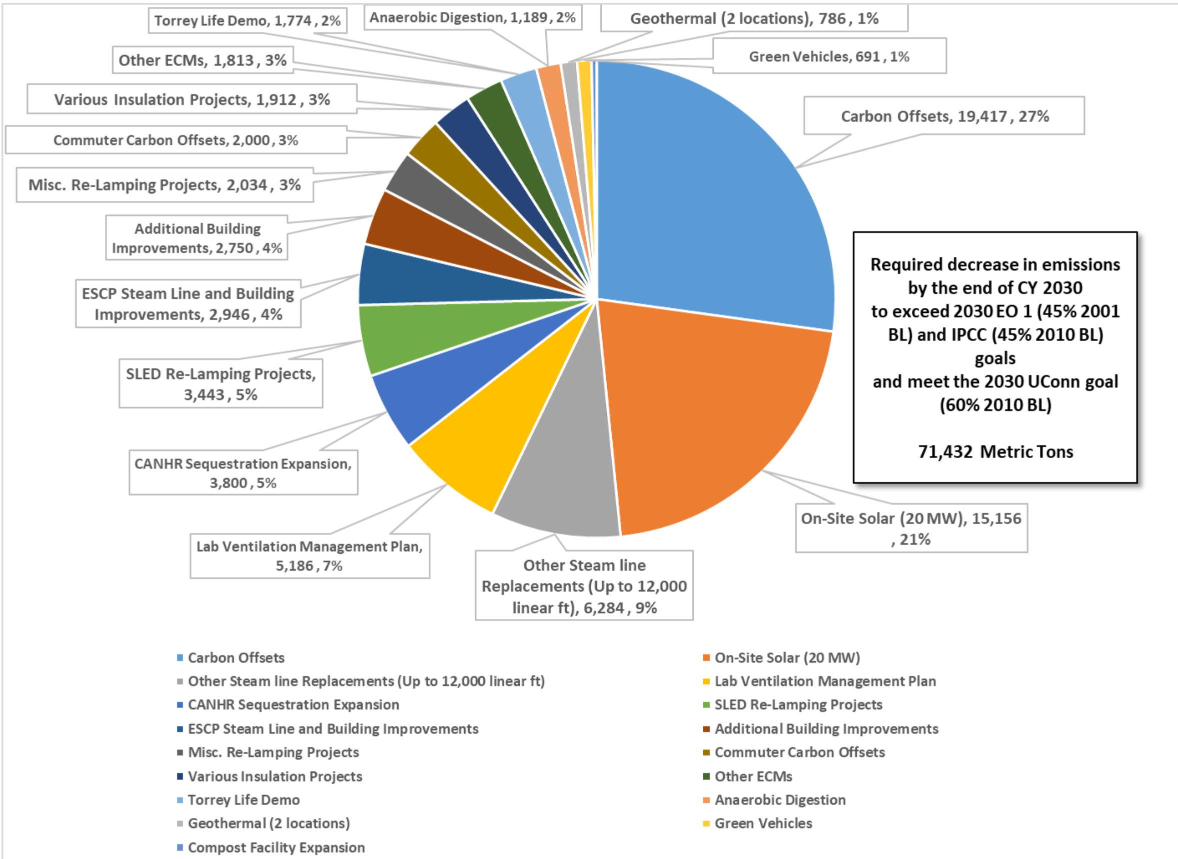
Required 2026-2030 GHG Emissions Reductions – Proposed Projects*



An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 60% by 2030 based on a 2010 baseline is shown in **Figure 9**. To achieve this goal, emissions would need to be reduced by 45,019 metric tons by the end of calendar year 2030. This is in addition to the 21,414 metric tons by the end of calendar year 2025 and the 5,000 metric tons by the end of calendar 2020. These reductions also achieve the Governor's EO 1 goal of 45% based on a 2001 baseline. The most predominant reductions in the 2026-2030 time-frame is estimated to come from carbon offsets at 43.1% with on-site solar being the second at 25.3%.

Figure 10

Required 2030 Total GHG Emissions Reductions Summary (Metric Tons)



An example of specific greenhouse gas reduction projects that could achieve the UConn goal of 60% by 2030 based on a 2010 baseline is shown in **Figure 10**. The overall reductions would be 71,432 metric tons between 2020 and 2030. These reductions also achieve the Governor's Executive Order 1 goal of 45% based on a 2001 baseline. The most predominant reductions between 2020- 2030 timeframe are estimated to come from carbon offsets at 27% with on-site solar being the second at 21%.

6.7 **DRAFT Matrix of Potential Projects** in the Short-term, Mid-term, Long-term, with projections for reductions in greenhouse gas emissions

DRAFT MAY 8, 2020

6.7 DRAFT Matrix of Projects in the Short-term, Mid-term, Long-term, with projections for reductions in greenhouse gas emissions

University of Connecticut

Greenhouse Gas Reduction Targets	**2001 Baseline GHG Emissions (Metric Tons):**	**148,872**	
	2007 Baseline GHG Emissions (Metric Tons):	**138,872**	
	2010 Baseline GHG Emissions (Metric Tons):	**123,023**	
	45% of 2001 Baseline (Metric Tons):	**66,992**	**Governor's EO1 Goal**
	20% of 2007 Baseline (Metric Tons):	**27,774**	**UCONN Goal**
	30% of 2007 Baseline (Metric Tons):	**41,662**	**UCONN Goal**
	45% of 2010 Baseline (Metric Tons):	**55,360**	**IPCC Goal**
	60% of 2010 Baseline (Metric Tons):	**73,814**	**Proposed UCONN Goal**

Summary	**Time Period Emissions (Metric Tons)**			
	2007-2019	**2020**	**2021-2025**	**2026-2030**
Reductions from 2007 Baseline (Metric Tons)	**(23,190)**	**(4,440)**	**(17,013)**	**(45,019)**
Cumulative Totals		**(27,630)**	**(44,644)**	**(89,662)**
Percent Reduction/Increase (from 2007 Baseline)	**-17%**	**-20%**	**-32%**	**-65%**
Reductions from 2010 Baseline (Metric Tons)*	**(7,341)**	**(11,781)**	**(28,795)**	**(73,813)**
Percent Reduction/Increase (from 2010 Baseline)	**-6%**	**-10%**	**-23%**	**-60%**
Reductions from 2001 Baseline (Metric Tons)**	**(33,190)**	**(37,630)**	**(54,644)**	**(99,663)**
Percent Reduction/Increase (from 2001 Baseline)	**-22%**	**-25%**	**-37%**	**-67%**

* - Excludes emissions reductions achieved between 2007 and 2010.
** - Includes emissions reductions achieved between 2001 and 2007.

Project Description		**Time Period Emissions (Metric Tons)**			
		2007-2019	**2020**	**2021-2025**	**2026-2030**
Completed Projects					
Retro-Commissioning (23 Buildings in 4 Phases)	Eversource Modeling LOA Estimates	(11,806)			
Re-lamping (223 Projects)	Eversource Modeling LOA Estimates	(8,726)			
Other ECM's (81 Projects)	Eversource Modeling LOA Estimates	(3,918)			
Impact of Natural Gas Curtailment	Up to 30 days at 190 metric tons net increase per	5,700			
North Eagleville Road Area Steam/Condensate Replacement Phase I (2014)	Energy Savings (Estimated)	(132)			
North Eagleville Road Area Steam/Condensate Replacement Phase II (2015)	Energy Savings (Estimated)	(437)			
North Eagleville Road Area Steam/Condensate Replacement Phase IIIA (2016)	Energy Savings (Estimated)	(2,658)			
ESCO Steam/Condensate Replacement (2,639 feet of steam line. Completed in 2016)	ConEdison IGA Energy Savings	(1,571)			
Oak Hall (2012)	Energy Consumption (LEED Modeling Estimate)	818			
McHugh Hall (2012)	Energy Consumption (LEED Modeling Estimate)	405			
Basketball Facility (2014)	Energy Consumption (LEED Modeling Estimate)	690			
Reclaimed Water Facility (2014)	Energy Consumption (LEED Modeling Estimate)	721			
Central Utility Plant Steam Chiller Expansion (2015)	Energy Consumption (Estimated to generate	3,970			
Peter J. Werth Residence Tower (2016)	Energy Consumption (LEED Modeling Estimate)	1,258			
Main Accumulation Area (2017)	Energy Consumption (Estimated)	302			
New Engineering and Science Building (2017)	Energy Consumption (LEED Modeling Estimate)	1,578			
Innovative Partnership Building (2017)	Energy Consumption (LEED Modeling Estimate)	2,022			
Central Warehouse Boiler Renovations (2018)	Energy Consumption (Estimated)	455			
ITS Modular Building (2018)	Energy Consumption (Estimated)	203			
North Eagleville Road Area Steam/Condensate Replacement Phase IIIB (2018)	Energy Savings (Estimated)	(1,329)			
Koons, Family Studies, Manchester Steam/Condensate Lateral Replacements (2018)	Energy Savings (Estimated)	(818)			
Student Recreational Center (2019)	Energy Consumption (LEED Modeling Estimate)	1,247			
ESCO Building Improvements (7 Science Buildings. Completed in 2019)	ConEdison IGA Energy Savings	(2,750)			
Athletic Complex Lighting (6 Facilities) (Completed in 2019)	Energy Savings (Estimated)	(1,629)			
Various Insulation Projects (Completed 2019)	Energy Savings (Estimated)	(1,384)			

Project Description		Time Period Emissions (Metric Tons)			
		2007-2019	2020	2021-2025	2026-2030
Completed Projects					
On-Going Projects					
Impact of Natural Gas Curtailment	Up to 10 days at 190 metric tons net increase per			1,900	
Re-Lamping (Projects not covered under ESCO, SLED or ECSP. On-going)	Energy Savings (Estimated)		(932)	(1,102)	
100% Conversion of Light Duty Vehicles to Hybrid or Electric (On-going)	Energy Savings (Estimated)			(173)	(518)
Various Insulation Projects (On-going)	Energy Savings (Estimated)		(537)	(376)	(1,000)
Other ECM's (On-Going)	Energy Savings (Estimated)		(355)	(458)	(1,000)
Proposed Projects					
SLED Lighting Projects	Energy Savings (Estimated)		(1,175)	(2,268)	
Lab Ventilation Management Program Initiative	Energy Savings (Estimated)			(5,186)	
Stadia Complex Building (Anticipated construction completion in 2020)	Energy Consumption (LEED Modeling Estimate)		327		
Fine Arts Addition (Anticipated construction completion in 2020)	Energy Consumption (LEED Modeling Estimate)		232		
Public Safely Building Expansion (In Design. Anticipated construction completion in 2021)	Energy Savings (Estimated)			31	
New Ice Hockey Arena (In Design. Anticipated construction completion in 2021)	Energy Savings (Estimated)			873	
Science 1 (In Design. Anticipated Construction Completion 2022)	Energy Consumption (LEED Modeling Estimate)			1,596	
ECSP Steam/Condensate Replacement (2,000 to 3,000 feet of steam line. TBD)	Energy Savings (Estimated)			(1,571)	
Additional Building Improvements	Energy Savings (Estimated)			(1,375)	(2,750)
Steam/Condensate Replacement (4,000 to 6,000 feet of steam line. TBD)	Energy Savings (Estimated)			(3,142)	(3,142)
On-Site Solar Installations	Energy Savings (Estimated)			(3,789)	(11,367)
Geothermal Installations (CESE and Bishop)	Energy Savings (Estimated)			(786)	
Anaerobic Digestion	Energy Savings (Estimated)			(1,189)	
CANHR Sequestration Expansion	Energy Savings (Estimated)				(3,800)
Compost Facility Expansion	Energy Savings (Estimated)				(250)
Demolition of Torrey Life Science Building (Master Plan Concept)	Energy Savings (Estimated)				(1,774)
Science 2 (Master Plan Concept)	Net Zero Building				0
New Residence Hall (Master Plan Concept)	Net Zero Building				0
Offsets					
Misc. Offsets (Forest Preservation, Composting)	Energy Savings (Estimated)	(5,399)			(19,417)
Commuter Carbon Offsets (20% Participation Rate)	Energy Savings (Estimated)		(2,000)		

6.8 Future Work Plan

Based on the strategic plan laid out for carbon emission reduction, the PWGS will work with consulting firms in the summer and fall of 2020 to evaluate economic factors and budget of each strategy implementation, determine the cost associated with infrastructure renovation and retrofit, and assess the feasibility of resource allocation. It should be kept in mind that achieving zero-carbon emission in the long run will position UConn as the flagship institution for environmental sustainability, benefit everyone working and living around the campus, and ultimately convert UConn to "living laboratories" with multidisciplinary clusters of education, research and outreach.

Acknowledgements

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University of Connecticut Environmental Terminology/Acronyms

A

Adaptation – Activities that increase the resiliency of campus buildings and infrastructure to withstand system disruptions.

Air Pollution – Occurs when gases, smoke or dust particles are emitted into the atmosphere in any way that is harmful to people, animals or our environment. Air pollution includes greenhouse gas generation (GHG). *Source: UConn Air Quality Frequently Asked Questions*

B

British Thermal Unit (BTU) – A unit of measure for thermal energy which is defined as the amount of heat needed to raise the temperature of one pound of water at maximum density by one degree Fahrenheit. One million BTUs is often written as MMBTU. *Source: The Engineering ToolBox*

C

Carbon Dioxide (CO_2) – A naturally occurring gas, and also a by-product of burning fossil fuels, as well as land-use changes and other industrial processes. It is the principal greenhouse gas that affects the Earth's temperature because of its long atmospheric lifetime. It is the reference gas against which other greenhouse gases are measured and, therefore, has a global warming potential of one. *Source: U.S. Environmental Protection Agency*

Carbon Dioxide Equivalents (CO_2e) – A measure used to aggregate the effect of multiple greenhouse gases in terms of the reference greenhouse gas which is carbon dioxide. For example, the global warming potential of one metric ton of atmospheric methane is equivalent to that of 21 metric tons of carbon dioxide. Once the global warming potential is applied to each gas, the emissions can be summed to determine the overall impact of the greenhouse gases on the atmosphere. *Source: U.S. Environmental Protection Agency*

Carbon Emissions – Polluting carbon substances released into atmosphere. In the context of this report, this term refers to greenhouse gases, principally CO_2. *Source: Boston University Sustainability Glossary of Terms*

Carbon Footprint – An estimate of carbon emissions produced to support campus activities. Factors that contribute to a carbon footprint include fuel consumption from stationary sources and transportation. *Source: U.S. Environmental Protection Agency*

Carbon Neutrality – Equivalent to "net zero carbon emissions" (*quod vide)*.

Carbon Offsets – A reduction or removal of atmospheric carbon used to compensate for activities that generate carbon emissions on campus. Carbon offsets are typically purchased from a source of zero carbon emissions or an activity that sequesters carbon like reforestation projects. A purchased carbon offset represents a one-metric-ton reduction of carbon dioxide emissions *Source: U.S. Environmental Protection Agency*

Clean Energy – Energy derived from non-polluting sources. Some examples of clean energy sources are solar energy, wind energy, hydropower and geothermal energy. *Source: Department of Energy*

Climate Change – Climate change refers to any significant change in measures of climate (such as temperature, precipitation or wind) lasting for an extended period of time (decades or longer). Climate change may result from:

- Natural factors, such as changes in the sun's intensity or slow changes in the Earth's orbit around the sun.
- Natural processes within the climate system (e.g. changes in ocean circulation).
- Human activities that change the atmosphere's composition (e.g., through burning fossil fuels) and the land surface (e.g. deforestation, reforestation, urbanization, desertification, etc.). *Source: Boston University Sustainability Glossary of Terms*

Cogeneration or Combined Heat and Power (CHP) – Electricity generation where the waste heat is recovered and used for heating and cooling. This is a highly efficient process.

E

Energy Conservation Measure (ECM) – Any type of project implemented to reduce energy consumption in a campus building. *Source: Wikipedia*

Energy Services Agreement (ESA) – A pay-for-performance, off-balance sheet financing solution that allows customers to implement energy efficiency projects with zero upfront expenditure. The ESA provider pays for all project development and construction costs. Once the project is operational, the customer makes service charge payments for actual realized savings. *Source: Department of Energy Office of Energy Efficiency and Renewable Energy.*

Energy Savings Performance Contract (ESPC) – A contract between a facility and a qualified Energy Service Company (ESCO) provider for evaluation, recommendation and implementation of one or more energy-savings measures. An energy-savings performance contract shall be a guaranteed energy-savings performance contract, which shall include, but not be limited to, (A) the design and installation of equipment and, if applicable, operation and maintenance of any of the measures implemented; and (B) guaranteed annual savings that meet or exceed the total annual contract payments made by the state agency or municipality for such contract, including financing charges to be incurred by the state agency or municipality over the life of the contract. *Source: Section 16a-37x of the Connecticut General Statutes*

Energy Use Intensity (EUI) – The measurement of annual energy consumption relative to gross square footage. This is typically measured in thousands of British Thermal Units per square foot (KBTU/ft^2/year). EUI allows for comparison of energy intensity of different types of buildings on campus. *Source: U.S. Environmental Protection Agency Energy Star*

G

Global Warming Potential (GWP) – The ratio of energy absorbed by one ton of a greenhouse gas over a given period of time (typically 100 years) relative to one ton of carbon dioxide. Applying the GWP to each greenhouse gas allows for the comparison of the impact of each gas on the atmosphere. The overall effect of a specific greenhouse gas depends on its atmospheric lifetime. *Source: U.S. Environmental Protection Agency*

Greenhouse Gases (GHG) – Gases, such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone, organic chemicals (chlorofluorocarbons) and many others, which trap heat radiating from the Earth's surface causing warming in the lower atmosphere resulting in global warming. Greenhouse gas emissions from activities at a college campus are separated into the following categories:

- Scope 1 – On-campus fuel consumption from fuel burning stationary sources (turbines, boilers, chillers, generators, etc.), university-owned vehicles and equipment, agriculture sources (i.e., fertilizer applications) and refrigerants and other chemical uses that contain greenhouse gases (i.e., HCFC-22, HFC-134a).
- Scope 2 – Purchased imported electricity from the grid.
- Scope 3 – Indirect sources of emissions that occur from the operational activities on campus including employee and student commuting and business travel. *Source: U.S. Environmental Protection Agency*

Greenhouse Effect – The process that occurs when Greenhouse Gases in the Earth's atmosphere trap heat radiating from the Earth's surface and prevent heat loss to space. which makes the Earth warmer than it would be without this atmosphere. Humans are amplifying Earth's Greenhouse Effect by burning fossil fuels and adding carbon dioxide to the atmosphere at a rate unprecedented in the geologic record. *Source: U.S. Environmental Protection Agency*

H

Hillside Environmental Education Park (HEEP) – 165-acre preservation area located on UConn's North Campus. The preserve consists of uplands, meadows, woodlands, wetlands (including vernal pools) and riparian zones around Cedar Swamp Brook, which runs through the HEEP to Mansfield's Pink Ravine. The park includes a network of hiking trails extending north from a trailhead near the C-Lot to Hunting Lodge Road and Discovery Drive. *Source: UConn Office of Sustainability*

K

Kilowatt (kW) – A unit of measure for electrical power (energy per time) that is equivalent to one thousand watts.

Kilowatt-hour (kWh) – A unit of measure for electrical energy that is equivalent to operating at 1 kW for one hour.

M

Megawatt (MW) – A unit of measure for electrical power that is equivalent to one million watts or one thousand kilowatts.

Megawatt-hour (MWh) – A unit of measure for electrical energy that is equivalent to operating at 1 MW for 1 hour, or 1 kW for 1000 hours.

Methane (CH_4) – A colorless odorless flammable gaseous hydrocarbon which is a product of anaerobic biological decomposition of organic matter. Methane is the main constituent of natural gas and is also produced in anaerobic digesters. Combustion converts methane to carbon dioxide. Unburned methane released to the atmosphere is a far more potent greenhouse gas than CO_2. *Source: Merriam-Webster Dictionary*

Mitigation – Reduction of potential threats to the environment (e.g., reduction of greenhouse gas emissions to mitigate climate change).

N

Net Zero Carbon Emissions – The condition where all greenhouse gas emissions are offset by removal of atmospheric carbon dioxide or verifiable reductions of emissions elsewhere. *Source: U.S. Environmental Protection Agency*

Nitric Oxide (N2O) – A colorless gas formed by the oxidation of nitrogen or ammonia that is present in the atmosphere. It is also a by-product of burning fossil fuels and agricultural activities. *Source: Merriam-Webster Dictionary*

P

Power Purchase Agreement (PPA) – A contract for renewable energy between a third-party seller of that renewable energy system and the buyer of the generated electrical power. The buyer signs a long-term contract with a third-party seller who agrees to build, maintain and operate a renewable energy system either on-site or off-site. The buyer receives the delivery of electricity through the grid for a fixed monthly cost typically through a 20-year term. *Source: U.S. Environmental Protection Agency*

Public Utilities Regulatory Authority (PURA) – A Connecticut state agency statutorily charged with regulating the rates and services of Connecticut's investor owned electricity, natural gas, water and telecommunication companies and is the franchising authority for the state's cable television companies. *Source: portal.ct.gov/PURA*

R

Renewable Energy – Energy source that can be continuously replenished. Examples of renewable energy include solar, wind, hydropower, geothermal and biomass energy. *Source: Penn State Extension*

Renewable Energy Certificates (RECs) – A market-based commodity that certifies the electricity represented by the REC was generated by a renewable energy source. A purchased renewable energy certificate represents one megawatt-hour of electricity used to reduce generated campus Scope 2 (purchased electricity) greenhouse gas emissions. *Source: U.S. Environmental Protection Agency*

Resiliency – The ability to recover from or adjust easily to adverse changes to campus operations or bad weather conditions. Energy resiliency, the ability to switch between different fuel types, avoids disruptions in the delivery of utility services.

Retro-commissioning (RCx) – A systematic process to improve an existing building's operational performance. The implementation of RCx strategies ultimately leads to energy efficiencies which in turn reduces emissions. *Source: https://www.facilitiesnet.com/energyefficiency/article/Retrocommissioning-for-Better-Performance--4097*

S

Sustainability – The responsible interaction with the environment to find a balance between environmental, economic and social needs in the present without compromising the ability of future generations to meet their needs. *Source: UN World Commission on Environment and Development*

Z

Zero Carbon – Activities that emit no carbon emissions such as the generation of electricity utilizing solar, wind or nuclear power. *Source: https://cleantechrising.com/whats-the-difference-between-carbon-neutral-zero-carbon-and-negative-emissions/*

Planning for a Zero-Carbon Future

APPENDIX A

1) BACKGROUND

a) President Katsouleas letter, dated October 2, 2019 (from Report sec 3)

Climate change is more than an emergency; it is a global crisis worsening by the day. Though the world has been warned about our rapidly warming climate for decades, for much of that time many regarded it as a future problem, to be addressed by future people. Today, we are in the midst of that future.

This generation of Americans are seeing and experiencing the effects of climate change in our own lives and across the globe in ways past generations either did not, or were not aware of. And if warming continues unabated, we know that we will see ever-greater consequences in our own lifetimes, especially those born in more recent years.

This issue is of the utmost importance to the UConn community, including myself, and we have an obligation to explore setting more ambitious goals than we already have.

But any commitment we make must be real. By that I mean it must be truly achievable and realistic based on data, analysis and the best estimates we are able to make about things like cost, technological capabilities and pace.

There is widespread agreement on the imperative of reducing emissions. The questions for us, as always, are: What is achievable within the boundaries of our fiscal resources and the need to operate the university, and how quickly can we get there?

I believe that our analysis and discussions about our goals and policies must happen in concert with discussions about resources and priorities, as one is dependent on the other and there is a natural tension between them.

Setting priorities and aligning budgets to support them is always about making choices. It is not the case that certain priorities "cannot" be funded within reason;

It is the case that funding one often means taking resources from others, requiring trade-offs in the form of compromise and sacrifice;

These are difficult decisions that need to be made thoughtfully and transparently.

b) Other UConn commitments (from Report sec 4.1)

i) Spring 2015 – The Board of Trustees approved the 2015-2035 Campus Master Plan, including a Sustainability Framework (Appendix A), which proposed an acceleration of UConn's CAP and recommended planning goals to achieve this in Energy and Transportation Focus Areas

ii) Summer 2016 – The Board of Trustees approved an amendment to UConn's Sustainable Design & Construction Policy, requiring all new construction and major renovation projects to achieve LEED Gold certification (revised from a minimum LEED Silver certification policy adopted in 2007)

iii) January 2017 – In a "welcome back" message to the University community, President Herbst reiterated UConn's commitment to sustainability as a core value and endorsed the *2020 Vision Plan for Campus Sustainability and Climate Leadership*

iv) February 2017 – President Herbst became a member of Second Nature's Climate Leadership Steering Committee, joining 17 other presidents and chancellors of colleges and universities across the country

v) June 2017 – UConn became a signatory member of the "*We Are Still In*" coalition, joining nearly 3,000 businesses, cities, states and universities pledging to uphold the commitments of the Paris Agreement on Climate Change, after the Trump Administration had announced the U.S.'s intentions to withdraw

vi) Spring 2018 – UConn held its first-ever Metanoia on the Environment, which featured 44 events held throughout the 2018 spring semester

vii) July 2018 – UConn joined Second Nature's University Climate Change Coalition (UC3,) a consortium of 18 prestigious North American research universities working together to apply research and share knowledge to advance multi-sector climate action and resilience

viii) October 2018 - The University Senate passed a three-credit environmental literacy general education requirement, which became effective for all UConn graduates last fall

ix) Fall 2018 – UConn's USG Executive Committee, along with EcoHusky and other student groups, wrote a letter (later endorsed by the Senate) urging the Presidential Search Committee to consider only candidates with a demonstrated commitment to sustainability in their previous positions

x) October 2019 – In response to events more fully described above (Section II), President Katsouleas issued a statement accelerating UConn's 2030 interim CAP carbon-reduction goal from 40% to 45%, extending that goal system-wide (beyond the main campus), and creating the President's Environmental & Sustainability Workgroup.

c) **Other successful and established UConn events,** activities and organizations focused on environmentally sustainable outreach and engagement

i) Carbon Neutral Green GameDays – a partnership with Athletics held at one UConn football and men's and women's basketball game each season; the OS organizes dozens of student volunteers and buys carbon offsets to make the basketball games at Gampel Pavilion carbon neutral

ii) Earth Day Spring Fling – but for COVID-19, April 21st would have marked the 12th annual celebration of environmental awareness held on Fairfield Way, which is co-hosted by Dining Services, EcoHusky and the OS, and features 50 exhibitors and sustainable product vendors

iii) Bicycle Workgroup; UConn CycleShare – begun informally a few years ago at the urging of the local "Bike Mansfield" organization (Mansfield is a certified Bicycle Friendly

Community), this group is now more officially recognized as a subcommittee of UConn's Transportation Advisory Committee and meets monthly to promote and recommend improved campus bike safety programs, amenities and services, including continued enhancements of UConn's bike loaner program, UConn CycleShare, administered by Recreational Services

iv) Green Campus Academic Network (GCAN) – a collaborative group of faculty members, including senior faculty members and new assistant professors, both tenure track and non-tenure track, convened by the OS to develop and help coordinate "living laboratory" projects and innovative experiential learning opportunities around sustainability-related education, research and outreach topics.
v) Digital Poster in McMahon Classroom Bldg.
vi) EcoHusky Student Group
vii) EcoHouse Living Learning Community
viii) Environmental Policy Advisory Council
ix) Biennial Environmental Leadership Awards – By recognizing and rewarding individuals and teams across the University for successful sustainability projects and efforts, UConn encourages continued innovation and increased awareness
x) EcoCaptains in 20+ dorms beginning Fall Semester 2020
xi) Collaboration with Residential Life
xii) In-house sustainability change agents

2) PARAMETERS AND REGULATIONS

a) Federal and State Regulations

i) Carbon Taxes Market-Based Greenhouse Gas Emission Reduction Legislation: 108th through 116th Congresses https://fas.org/sgp/crs/misc/R45472.pdf
ii) https://fas.org/sgp/crs/misc/R45625.pdf https://fas.org/sgp/crs/misc/R40242.pdf
iii) https://crsreports.congress.gov/product/pdf/IF/IF11103
iv) https://crsreports.congress.gov/product/pdf/R/R42731
v) Resource Compares All the Carbon Tax Proposals in Congress https://energypolicy.columbia.edu/what-you-need-know-about-federal-carbon-tax-united-states and https://energypolicy.columbia.edu/carbon-tax-initiative-research
vi) Carbon in the US https://www.eia.gov/environment/emissions/carbon/ Growth and Restrictions on Future Gas Supply https://www.cga.ct.gov/2016/rpt/2016-R-0161.htm and http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/32723b39b1c8b69885257fc6006cf337/$FILE/DEEP_Final%20Gas%20RFP_6.2.16.pdf http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/ffee9c54378d404a85257f710054fb32/$FILE/RFP_03-09-16_CLEAN.pdf DEEP Request for Proposals for Natural Gas Capacity, Liquefied Natural Gas, and Natural Gas Storage

(http://www.dpuc.state.ct.us/DEEPEnergy.nsf/c6c6d525f7cdd1168525797d0047c5bf/32723b39b1c8b69885257fc6006cf337/$FILE/DEEP_Final%20Gas%20RFP_6.2.16.pdf).

vii) DEEP, Energy Filings, PA 15-107, § 1(d) – Natural Gas Capacity , LNG, and Natural Gas Storage Procurement, Proposals (http://www.dpuc.state.ct.us/DEEPEnergy.nsf/$EnergyView?OpenForm&Start=30&Count=30&Expand=33.4&Seq=3).

viii) OLR Report 2014-R-0267 (https://www.cga.ct.gov/2014/rpt/pdf/2014-R-0267.pdf).

ix) OLR Report 2015-R-0108 (https://www.cga.ct.gov/2015/rpt/pdf/2015-R-0108.pdf).

x) Projected Value of Class 1 and Class 3 RECs https://poweradvisoryllc.com/new-england-class-i-rec-market-update/ and https://programs.dsireusa.org/system/program/detail/195 and https://www.evomarkets.com/content/news/reports_29_report_file.pdf

xi) CT Green New Deal https://www.cga.ct.gov/asp/cgabillstatus/cgabillstatus.asp?selBillType=Bill&which_year=2019&bill_num=5002&utm_source=Unknown+List&utm_campaign=df4c5771a3-EMAIL_CAMPAIGN_2019_02_21_06_18&utm_medium=email&utm_term=0_-df4c5771a3- and Carbon Tax Legislation https://www.cga.ct.gov/2018/rpt/pdf/2018-R-0327.pdf

(1) Carbon Price

b) Renewable Energy Benchmarks

i) National, Regional, State https://www.eia.gov/outlooks/aeo/ https://www.eia.gov/renewable/

ii) Other Higher Ed institutions https://www.nrel.gov/docs/fy17osti/67900.pdf and https://www.eia.gov/totalenergy/data/annual/ https://hub.aashe.org/browse/topics/energy/

3) TECHNOLOGIES AND STRATEGIES

a) **Current On-going and Proposed Carbon Reduction Projects**

i) Re-Lamping (Projects not covered under ESCO, SLED or ECSP) – Lighting projects to convert existing fixtures to LED. These projects are being completed by UConn Facilities Operations personnel. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource in coordination with UConn's Memorandum of Understanding (MOU) agreement to reduce energy consumption over a three year period. If Eversource estimates were not available for certain proposed projects, energy savings factors per square foot were developed using completed lighting projects and the proposed project's building area to be converted to LED.

ii) 100% Conversion of Light Duty Vehicles to Hybrid or Electric – Greenhouse gas reductions based on the difference in emissions between the gasoline-powered light duty vehicles in UConn's fleet and replacement hybrid or electric vehicles.

iii) Various Insulation Projects – The installation of insulation around bare thermal piping and valves in various building locations. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.

iv) Other ECMs – Other Energy Conservation Measures (ECMs) includes the installation of Variable Air Valve (VAV) technology in HVAC systems to allow for variable control of flow, electric chiller replacement at Castleman Hall and replacement of dining hall cooking ventilation systems to reduce energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.

v) SLED Lighting Projects – Storrs LED lighting projects or SLED to convert existing fixtures to LED in approximately 3 million square feet of campus buildings. These projects will be completed by outside lighting contractors. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.

vi) Lab Ventilation Management Program Initiative – A program to develop, manage and maintain plans and procedures in consultation with EHS and Facilities Operations to ensure ventilation systems in laboratories and other work areas perform optimally, ensure worker safety and minimize energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings estimates were developed by UConn Facilities Operations energy consultant.

vii) Steam and Condensate Replacement projects – In order to maintain existing steam infrastructure in the short term, various repair/replacement projects may be required. Greenhouse gas reduction estimates are based on predicted energy savings for steam and condensate replacement projects consisting of approximately 2,000 to 3,000 linear feet were developed using a similar project completed under the ESCO project by ConEdison. That project resulted in the installation of approximately 2,600 linear feet of steam and condensate piping along Hillside Road.

viii) Additional Building Improvements – Building improvements can include retro-commissioning, lighting re-lamping projects, HVAC improvements among other identified ECMs. Greenhouse gas reduction estimates are based on predicted energy savings for building improvements were developed using a similar project completed under the ESCO project by ConEdison. That project included building improvements for seven energy intensive science buildings. The project in the 2021-2025 timeframe would be similar process to the ESCO project and would include up to 24 other building types such as administration, instructional and residential. Therefore, energy savings for these buildings was assumed to be half the science building energy savings. For the 2026-2030 timeframe, it is assumed that an additional 48 buildings may be identified for improvements based on the results of the proposed Building Assessments and Energy Audits to be completed by Facilities Operations.

ix) On-Site Solar Installations – A solar calculator developed by the National Renewable Energy Laboratory (NREL) was used to estimate the amount of kilowatt hours that would be generated by the proposed solar installation. Greenhouse gas reduction estimates are based on predicted energy savings from the amount of kilowatt hours generated by the solar installation. The estimates include 5 MW in the 2021-2025 timeframe and an additional 15 MW in the 2026-2030 timeframe.

x) Geothermal Installations – Geothermal installations are assumed to reduce energy consumption required for heating and cooling the building. Greenhouse gas reduction estimates are based on predicted energy savings developed by UConn's Framework consultant BVH. Two potential projects were identified at CESE and the Bishop Center.

xi) Anaerobic Digestion – A proposed anaerobic digestion facility is assumed to utilize 500 tons of food waster along with manure from 100 cows managed by farm services. The processing of these materials would result in reductions of CO2 and methane emissions. Greenhouse gas emissions reductions developed by UConn's Framework consultant BVH.

xii) CAHNR Sequestration Expansion – The setting side additional UConn forestland that can provide a carbon offset as a result of forest sequestration. Estimated reductions provided by the Sustainability Office.

xiii) Compost Facility Expansion – Greenhouse gas emissions reductions based on doubling the size of the existing composting facility. Estimated reductions provided by the Sustainability Office.

xiv) Demo of Torrey Life Science – Greenhouse gas reduction estimates are based on predicted energy savings from the elimination of energy consumption for this science building.

xv) Science 2 and New Residence Hall (Master Plan Concepts) – These are potential new construction projects identified in the Master Plan. If construction proceeds with these projects, it is assume both would implement strategies so that the buildings are net zero carbon.

xvi) Carbon offsets – In order to meet the 60% reduction goal by 2030, it is assumed the University would need to purchase over 19,000 metric tons of carbon offsets. This would be annual purchases until such time actual emissions are reduced below the 60% level.

b) **Current and Emerging Technologies**

i) Fossil Fuels: the current UConn strategy

ii) Solar

(1) Total energy consumption by humans is approaching 20 TW (terawatts). This is a large energy demand and it is largely met using fossil fuels today. But fossil fuels are not required. At any point in time, the total soar power incident on the Earth's surface is about 96,000 TW. The astounding abundance of this resource is sufficient to meet any conceivable human need, even after considering reasonable limits on its harvestability. For example, covering 1% of Earth's surface with solar panels having a solar-to-electric power conversion efficiency (PCE) of 15% would generate 144 TW.

(2) Use of the solar resource is complicated by significant temporal variability. There is significant seasonal variation, with more than twice as much sunlight in summer as in

winter. There is the predictable diurnal cycle, with obviously no power available at night. And there are unpredictable fluctuations due to weather. Fortunately, the diurnal cycle aligns well with summer cooling needs. Coping with the remaining variations of the solar resource requires either energy storage (e.g. batteries) or blending solar power with other energy sources that are stable or at least that have intermittencies that correlate poorly with that of solar power.

(3) The amount of harnessable solar energy at a particular site depends on latitude and atmospheric conditions. A database maintained by the National Renewable Energy Laboratory indicates that Storrs, CT has a year-averaged insolation (incident solar power) of 4.77 kWh/m^2/day, with the average power available rising to 6.42 kWh/m^2/day in the month of July and falling to 2.61 kWh/m^2/day in December. State-of-the-art solar panels with a PCE of 19% could generate about 5,350 kWh of electricity per square meter of panel per year.

iii) Geothermal

(1) At sufficient depths (e.g. 20 feet), the ground maintains a fairly stable temperature year-round of 50-55 °F. Circulating a fluid through the ground and then through a heat pump allows a substantial part of the thermal energy for heating and cooling to be sourced from the ground rather than by burning fossil fuels, dramatically reducing energy demands and costs. A small amount of electricity is required to run the circulation pumps and heat exchangers. Additional heat can be provided by electrically powered heat pumps. The low energy intensity (and electricity only) requirement of geothermal heating/cooling systems make them particularly useful in the quest to achieve an electrified, zero-carbon campus.

(2) UConn should focus immediately on identifying off-the-CUP buildings, where geothermal retrofits are most beneficial (e.g., Bishop Center, Institute of the Environment). Installation of small geothermal systems at these buildings would replace stand-alone boilers and chillers and immediately yield reduced energy costs and lower carbon emissions, with a fast payback period.

(3) Geothermal projects of any size would also generate marketable Class 1 RECs. UConn's revenue from the sale of these RECs could be dedicated to the purchase of carbon offsets or funding of ongoing energy efficiency initiatives at UConn.

(4) As part of the goal for a zero-carbon campus by 2040 (see Recommendation One in the Report), UConn should begin evaluating larger-scale geothermal closed loop wellfields, ground-source heat pumps and thermal storage systems at strategic locations on campus.

(a) The combined heat and power Cogen facility currently generates 95 percent of the electricity used at the main campus, and is fueled by natural gas, with back-up oil and is a source of Scope 1 emissions. High-pressure steam, a byproduct of the Cogen's electric generating process, plus steam from fossil fuel- fired boilers at the

CUP and proposed SUP, currently is used for heating and cooling to meet 75 percent of thermal energy demand at the main campus.

(b) As the campus increases its use of renewable electricity and thermal energy technologies, larger scale geothermal systems may be a proven, low-cost, low-maintenance way to gradually replace high-cost, high-maintenance centralized steam systems as they age.
    (i) Larger geothermal systems may serve multiple buildings and provide district heating and cooling throughout campus and, where applicable, could make use of steam infrastructure that is retrofitted for low temperature hot water distribution systems, with low operating costs.

(c) Larger geothermal wellfields could be installed near the buildings they will be heating or cooling in order to minimize distribution infrastructure and construction costs. Open areas on campus are best-suited for such systems.
    (i) Since such wellfields are drilled at considerable depths and never need maintenance, they can be installed without impact on surficial or sub-surface stormwater management systems. This is especially true of the more natural LID/Green Stormwater Infrastructure features, like rain gardens and bio-retention basins.

(d) Geothermal should also be considered as an option for heating and cooling needs at all new construction projects, and potentially may be installed beneath buildings without impacting construction schedules.

(e) Below is a list of links describing a few of the geothermal systems and projects in higher education:
http://www.bu.edu/sustainability/what-were-doing/green-buildings/geothermal/
http://miamioh.edu/news/top-stories/2019/11/converting-campus-off-steam-by-2026.html
https://www.nd.edu/stories/going-geothermal/
https://www.usnews.com/news/best-states/illinois/articles/2019-05-16/university-of-illinois-set-to-install-new-geothermal-system
https://sustainability.illinois.edu/geothermal-energy-illinois-researchers-rocking-the-earths-surface-part-ii/
https://www.carleton.edu/community/news/carleton-shifts-to-geothermal-cooling-heating-for-east-side-of-campus/
https://www.carleton.edu/community/news/carleton-constructs-geothermal-well-fields/
https://www.hpac.com/archive/article/20926969/geothermal-the-new-big-man-on-campus
https://www.nwf.org/-/media/PDFs/Campus-Ecology/Reports/Geothermal-Guide-FINAL-3-1-11.ashx

iv) **Anaerobic Digestion/Biogas** - UConn does not have the volume of organic waste that would make owning and operating an anaerobic digester for large-scale production of biogas economically feasible. However, there are commercial entities who could provide UConn with greater volumes of biogas from large-scale anaerobic digesters as a method for reducing our carbon footprint.

   (1) UConn could build small-scale digesters to create biogas. These digesters could be located near UConn-owned facilities and operations that generate or store larger sources of organic waste, such as the Kellogg Dairy Barn. (Note: UConn already composts about half of the manure from Agricultural Operations/Farm Services at our compost facility off of Rte. 32). This biogas could be mixed with natural gas in order to reduce GHG emissions from other stand-alone gas-burning sources on campus. This is because methane emissions from decomposing organic waste are 34 times more potent than CO2 as a GHG - anaerobic digesters not only eliminate these methane emissions but also displace the use of natural gas with renewable biogas. Food waste generated from the UConn Storrs campus is about 800 tons per year. In addition, UConn wastewater treatment plant generates over 5 million gallon waste sludge (250 metric tons volume) annually, which has been treated anaerobically off campus for methane production. Given 0.35 m3 methane production per ton organic wastes, the methane production from food waste and waste sludge generated from UConn is about 350 m3 annually, which can be converted to heating source and/or bioelectricity grid. This is an efficient way for carbon offset.

      (a) Duke University mixes 11% biogas from anaerobic digesters with natural gas for this purpose. This approach could also reduce UConn's natural gas purchasing costs.

      (b) Small scale digesters would also be excellent on-campus "living laboratories" serving both operational and academic needs related to education, research and outreach.

   (2) There are other commercial entities who own and operate large-scale digesters or who will soon be developing large scale anaerobic digesters off-campus (e.g., Quantum BioPower, agricultural waste digesters under development in SE CT). They would be willing to supply UConn with larger volumes of renewable biogas. Ideally they would feed it directly into CNG's transmission and distribution infrastructure, which supplies UConn's campus, mixing it with natural gas in order to reduce our GHG emissions.

v) **Wind**

   (1) Winter generation profile, which aligns better with peak campus demand and electrified heating

vi) **Hydrogen** is not an energy source but a means of energy storage and/or transport.

   (1) When renewable sources are generating excess electrical power, some can be used to drive electrolysis of water: electrochemically splitting H_2O into hydrogen (H_2) and oxygen (O_2) gases. The hydrogen can be stored and later either burned for heat and/or thermoelectric generation, or fed to a fuel cell for electrochemical generation. With either use, water is the only product.

(2) Hydrogen can also be produced from natural gas. Hydrogen is therefore not inherently a clean fuel, but it can be if produced from renewable energy. Hydrogen infrastructure therefore provides some flexibility for using fossil-derived energy. This can be viewed as positive for campus resiliency or as negative for enforcing zero-carbon goals.

(3) There are significant energy losses associated with water electrolysis, pressurization or liquefaction of hydrogen for storage, and subsequent conversion to electrical power. Less than 40% of the original electrical power will be recovered after all of these steps in the best case.

(4) Depending on future evolution of this and other technologies, hydrogen may be a viable means of storing renewably generated electrical energy.

vii) Nuclear

(1) Nuclear plants generate electricity from the heat released from nuclear fission. This technology has been highly controversial due to (1) the risk of catastrophic failure and (2) hazards associated with the transport and disposal of long-lived radioactive waste. However, nuclear power plants can reliably generate large amounts of power with no air emissions, so they do not contribute to climate change. Furthermore, modern reactor designs have a good safety record. Technologies have been moving in the direction of smaller-scale plants that could conceivably be built to power a campus such as UConn Storrs or UConn Health. The obstacles from regulatory requirements and public acceptance are too great to make nuclear power a realistic option in the near-to-mid-term. But as the technology evolves, and especially if small nuclear plants proliferate and gain more public acceptance, nuclear power may become an option that the University should consider for carbon-free electrical power.

c) Methodologies

i) Renewable Energy Credits, with table of requirements from DEEP

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APPENDIX A

Required Annual Renewable Energy Percentages:

Year	Class I	Class II or Class I (add'l)	Class III	Total
2018	17.0%	4.0%	4.0%	25.0%
2019	19.5%	4.0%	4.0%	27.5%
2020	21.0%	4.0%	4.0%	29.0%
2021	22.5%	4.0%	4.0%	30.5%
2022	24%	4.0%	4.0%	32%
2023	26%	4.0%	4.0%	34%
2024	28%	4.0%	4.0%	36%
2025	30%	4.0%	4.0%	38%
2026	32%	4.0%	4.0%	40%
2027	34%	4.0%	4.0%	42%
2028	36%	4.0%	4.0%	44%
2029	38%	4.0%	4.0%	46%
2030	40%	4.0%	4.0%	48%

ii) Funding Mechanisms
  (1) Incentives and Rebates
  (2) Voluntary and Mandatory Fees
  (3) Class 3 RECs/Green Revolving Fund

iii) Purchase Power Agreements
  (1) On-site solar or geothermal – third party installations
  (2) Remote solar, wind, digester (biogas) – third party developers
  (3) Behind-the meter
    (a) Delivery methods – fuel or electrons
    (b) Energy demands at remote UConn facilities
    (c) Installing remote meters

iv) Virtually Net Metered
  (1) Current Utility-Scale Projects
  (2) Planned Utility-Scale Projects
  (3) Co-sponsored/Partnership Opportunities
  (4) Many other higher ed institutions have used this
  (5) Eliminates the need for physical delivery of electricity
    (a) Our two most promising sites for solar near campus do not offer ideal conditions for physical delivery of electricity
  (6) Requires grid infrastructure assessments by Eversource (and potential upgrades)
    (a) Not as reliable as on-site generation

v) Portfolio-based approach

vi) Electrification
  (1) Conversion from Steam to Low Temp Hot Water
  (2) Long term plan: Example: The figure below depicts the first half of Princeton's electrification plan and is meant to serve as an example/potential template only.

Business as Usual Projects	Cost	Year	Cost	Alternate Case Projects
		2019	$ 8,400,000	Satellite Plant (20,000 sqft)
		2019	$ 6,500,000	Heat Pump Chiller 1 (1,700 Tons - Satellite Plant)
		2019	$ 6,500,000	Heat Pump Chiller 2 (1,700 Tons - Satellite Plant)
		2019	$ 18,500,000	Initial Well Field Buildout (800,000 sqft)
		2019	$ 1,700,000	Hot Water Boiler 1 (30 MMBtu - Satellite Plant)
		2019	$ 1,700,000	Hot Water Boiler 2 (30 MMBtu - Satellite Plant)
		2019	$ 5,300,000	Chilled Water TES (3,000,000 Gallons)
		2019	$ 1,800,000	Hot Water TES (1,000,000 Gallons)
Steam Distribution Replacement	$ 32,000,000	2020		
Steam Distribution Replacement	$ 9,800,000	2022	$ 200,000	STM-HW Heat Exchanger (150 kpph - Main Plant)
Chiller 3 Replacement (2200 ton STD)	$ 5,500,000	2022	$ 5,500,000	Chiller 3 (2200 ton steam centrifugal)
Chiller 4 Replacement(3400 ton STD)	$ 8,400,000	2022	$ 8,400,000	Chiller 4 (3400 ton steam centrifugal)
		2022	$ 6,500,000	Heat Pump Chiller 3 (1,700 tons - Main Plant)
		2022	$ 6,500,000	Heat Pump Chiller 4 (1,700 tons - Main Plant)
Chiller 5 (1600 ton elec centrifugal)	$ 3,700,000	2023		
Chiller 6 (1500 ton elec centrifugal)	$ 3,500,000	2023		
New Electrical Chiller (3,000 Tons)	$ 7,000,000	2024		
Replace GTG (18 MW), Replace 2 aux boilers	$108,000,000	2026	$ 48,800,000	Replace GTG (8 MW), Replace 1 aux boiler
		2026	$ 13,500,000	Steam Turbine Generator (7.4 MW)
Chilled Water Distribution	$ 6,000,000	2019-2026	$ 6,000,000	Chilled Water Distribution
		2019-2026	$ 93,000,000	Hot Water Distribution and Building Conversions
Total	**$183,900,000**		**$238,800,000**	**Total**

vii) Market Variability
  (1) Projected future natural gas costs and availability
  (2) Existing curtailment costs ($ and carbon)
  (3) Near term: Private developers can take advantage of federal tax credit (favors PPA/VPPA)
  (4) Mid/long term: as renewable project prices fall and fed tax credit expires, the University should favor behind-the-meter projects as our cost of capital is lower than a private developer's

viii) Carbon Pricing
  (1) Proxy Price
  (2) Incorporate social cost of carbon into planning decisions
  (3) Risk Management: prepares the university for a state-wide or country-wide carbon tax
    (a) Makes lower-carbon options
  (4) Internal Carbon Charge

ix) Behavioral
  (1) Zero-sum way to influence behavior and incentivize reduced energy usage

x) Other
  (1) Offsets, Credits, Funding Mechanisms & Carbon Pricing (2 Types: Proxy Price and Carbon Charge)
    (a) Carbon offsets are project-based. Many types of projects may generate offsets, including *sustainable forestry/reforestation, organic waste digesters (manure and food waste) and biogas, carbon capture, renewable energy, and peatland restoration.* In order to qualify as carbon offsets, reductions from offset projects must be:

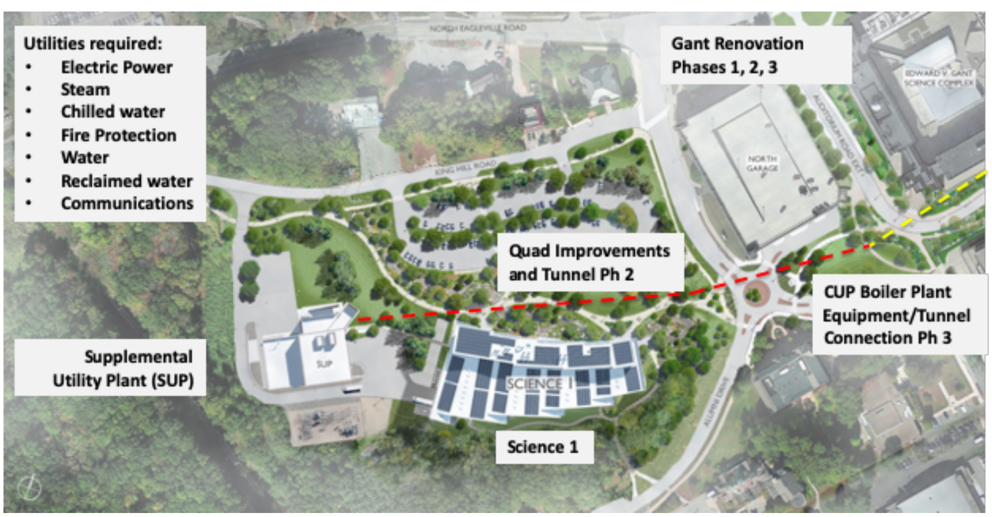
(i) **Permanent** – last in perpetuity
(ii) **Additional** – would not have occurred under business-as-usual scenario
(iii) **Verifiable** – by data and/or by accredited third party
(iv) **Enforceable** – offset can only be counted once, then must be retired

(b) Carbon offset projects are very attractive to colleges and universities because they have many valuable co-benefits, including:
(i) Research & Educational Opportunities
(ii) Experiential Learning
(iii) Community/Stakeholder Engagement & Partnerships
(iv) Additional Environmental Benefits – Land, Air, Water
(v) Values-Based Public Relations (e.g., Environmental Justice)
(vi) Scalable Projects Can Increase Benefits d

(c) Duke University has set the gold standard for carbon offset projects in higher education, partly because their GHG emissions have been so historically high (almost three times those of UConn during the 2007 ACUPCC baseline year) and their carbon neutrality goals are so ambitious (e.g., net carbon neutrality by 2024). Duke has several FTEs in their sustainability office dedicated to developing and implementing a variety of carbon offset projects and should be consulted as UConn moves forward with any carbon offset program or project.

(2) Water usage/wastewater generation, electric power saving? (Cutting down salt in diets and lower the salinity in wastewater for Co-Gen plant water reusage?)

d) Exceptions to Recommendation 2



NW Science Quad – Site Plan and 5 Projects

Planning for a Zero-Carbon Future

APPENDIX A

i) The renovation of the Gant Complex and the construction of STEM Research Center - Science 1 are the product of the Next Generation CT initiative and statute (2013/2014); the Academic Plan (2014); the Campus Master Plan (SOM/UPDC, 2015); and the Science Facilities Space Needs Assessment (ZGF/UPDC, 2016); all of which determined and stipulated the need for increased research facilities at UConn. Countless hours of faculty involvement over the course of several years supported this as well.

ii) All the projects shown on this Site Plan – Gant Renovation, Science 1, NW Quad Improvements and Tunnel, Supplemental Utility Plant, and Ph 2Boiler Plant Equipment/Tunnel Connection are linked, if one project is stopped then the others cannot be completed. All have been approved by the Board of Trustees for construction, Phase 3 of Gant will return once more to the Board for Final approval.

iii) The Gant Renovation, 285,000 gsf, just east of the Quad, began with the South wing in 2018 and continues with the West wing in 2019/2020. The North wing is in design and will begin renovation when Science 1 is complete in late fall 2022 and the Gant North wing is vacated. The Gant building is a major undergraduate teaching center, with research labs, and will house some or all of the departments of Physics, EEB, MCB and PNB. The renovation of the building includes hazmat remediation, complete reconstruction of the exterior envelope to reduce heat transmission, and new energy-efficient infrastructure appropriate to support the sciences, and it is designed to achieve LEED Gold.

iv) STEM Research Center - Science 1, 198,000 gsf, will begin construction in spring 2020 and complete in Fall 2022. The building is designed to LEED Gold standards and will have 500 kw of photovoltaics on its roof. Science 1 will house the Institute of Materials Science and the department of Materials Science Engineering, with teaching labs, research labs, core labs and UConn's first major clean room.

v) Gant and Science 1 are supported by 3 projects: the NW Science Quad Phase 2 Utilities and Site Improvements; the Supplemental Utility Plant (SUP); and the Boiler Plant Equipment Replacement and Utility Tunnel Connection.

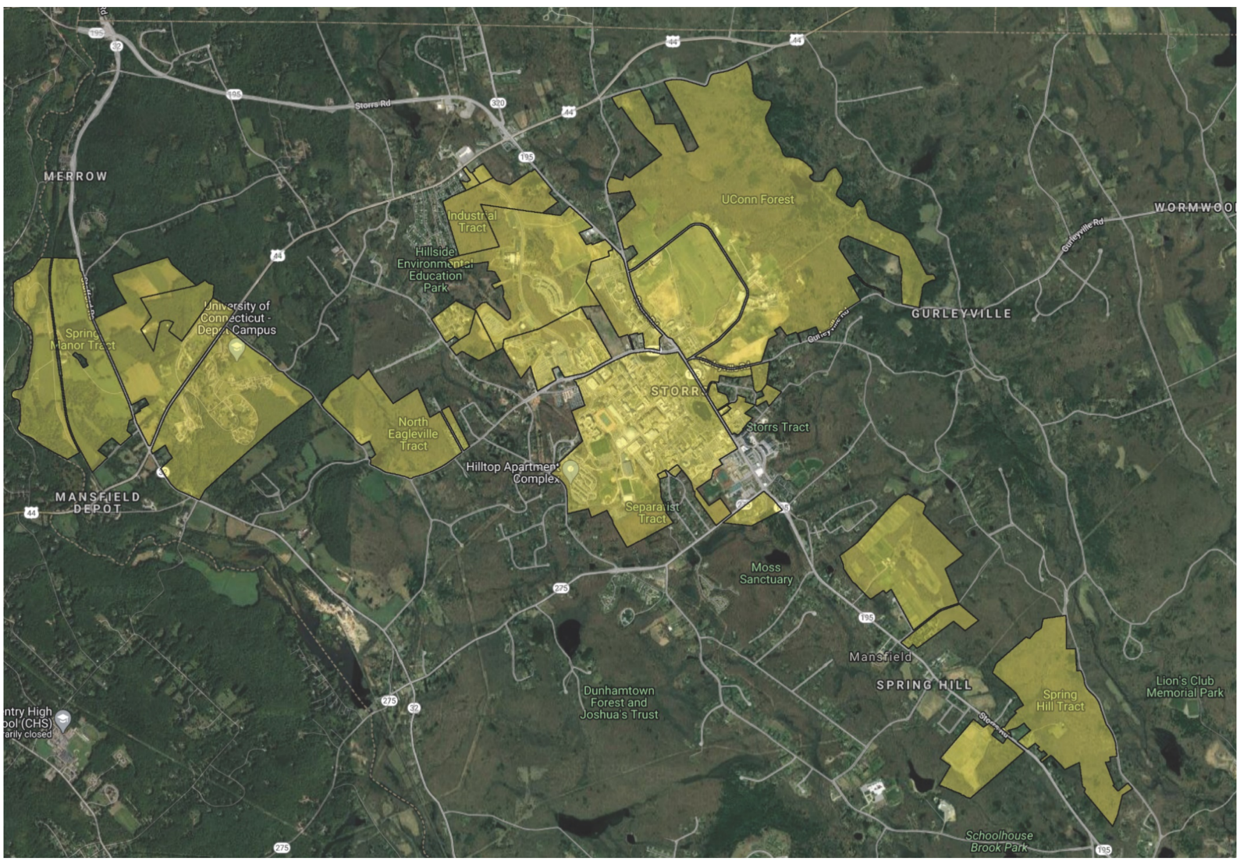
   (1) NW Science Quad Phase 2 Utilities and Site Improvements: site improvements for Science 1; extension of the existing Gant utility tunnel terminating at the new SUP; direct burial utilities for connections to the campus loop; woodland corridor extension and stormwater management; and King Hill Road and Alumni Drive improvements. The project is designed according to SITES standards and is scheduled to begin construction in spring 2020.

   (2) Supplemental Utility Plant: without the SUP, Science 1 cannot be completed because the Central Utility Plant (CUP) does not produce sufficient chilled water. The SUP and its equipment are sized to meet the needs of Gant and Science 1 ONLY, with 4 chillers, 1 boiler (a replacement for a boiler in the CUP, required to be decommissioned), and 2 emergency generators. **No work is proceeding on the Ph 2 building or the cogeneration turbines.** The SUP is scheduled to begin construction in spring 2020.

(3) Boiler Plant Equipment Replacement and Utility Tunnel Connection: This project is essential to the Science program as it is Ph 3 of the tunnel that connects the Supplemental Utility Plant, or SUP, to the Central Utility Plant, or CUP. It also replaces aged boilers, which are required to be decommissioned by 2023, with 3 new boilers one of which will be located in the SUP. The efficient new boilers will emit reduced metric tons of greenhouse gas. This project is scheduled to begin construction in spring 2020.

4) University-Controlled Property in Storrs-Mansfield, CT

This exhibit shows over 3,000 acres of land controlled by the University near its campus in Storrs, including the Depot campus and land managed as active agriculture or forest. Additional land holdings in the nearby towns of Coventry and Willington are not shown.



Planning for a Zero-Carbon Future

APPENDIX B

1) Fridays For Future Declaration of Climate Action

The climate crisis is a current and growing threat to the human epoch. Decades of credible science support this, as do testimonies from many of the world's indigenous peoples. The most recent IPCC report shows that if we do not act by 2030, the life-threatening effects of a warming earth will be irreversible. These effects include, but are not limited to:

1. Sea level rise and associated loss of coastal habitat and resources
2. Increasing occurrence of a sea-ice-free Arctic
3. Coral reef and other species extinction
4. Deforestation and wetland loss
5. More frequent and extreme precipitation events
6. Extended and severe droughts
7. Increase in vector-borne diseases
8. Overall lower agricultural yield
9. Negative mental and physical health outcomes
10. Increased immigration and refugee populations
11. Worsened global inequalities
12. Economic loss and political instability resulting from the above

The list of these devastating consequences has been laid out again and again in public appeals, which makes it easy to become numb to them. **Do not become numb to them. They are real, happening as we speak, and are rapidly increasing in severity.** As college students trying to create the best possible futures for ourselves and our communities, it's frightening to contemplate the catastrophic consequences of this crisis, and even more so because the people who have power don't seem to be as frightened as us — at least, their actions do not reflect the same level of urgency and concern that this emergency demands.

UConn can and should mitigate the impact of our large carbon footprint. However, the university's proposals to expand all campuses and its associated plans to power this expansion will only exacerbate the crisis by releasing even more carbon into the atmosphere.

Since 2008, the university has been committed to becoming a carbon neutral campus by 2050. President Hogan signed onto the American College & University Presidents' Climate Commitment in 2008. UConn established a Climate Action Plan in 2010 which also stated this 2050 commitment. This commitment is in our current Master Plan, which also proposes that we decrease our dependence on natural gas.

State-level efforts are also being made in order to reduce our environmental impact. This month, Governor Lamont signed an executive order mandating a zero-carbon electric grid in Connecticut by 2040. Additionally, his first executive order directed that state agencies reduce their energy consumption and act as leaders for the rest of the state.

This commitment at the University and statewide levels is in direct conflict with the planned implementation of a second natural gas cogeneration power plant. This particular decision by the university is especially disheartening as these types of power plants have a long lifespan, and natural gas, though considered by many to be a cleaner alternative to coal or oil, remains a carbon-emitting fuel. From fracking to transportation to burning, the process of employing natural gas on this campus is environmentally unsustainable. Thus, this decision not only increases our current fossil fuel use, but sets us on a path to be fossil fuel dependent well into the future. In 2050, we will be viewed not as the environmental leaders we are currently seen to be, but as an institution stuck in the past.

On a wider scale, and even *without* the implementation of a second cogeneration plant, the university is not positioned to follow through on our commitments to climate action. Our carbon emissions have not dropped, but remained alarmingly steady over recent years. As UConn continues to expand and build new infrastructure, our energy usage will only continue to grow. Our current efforts, including retrofitting and other energy efficiency projects, will not be sufficient to counteract this increased energy demand.

With all of this in mind, these are the steps we urge the university to take:

1. DECLARE a climate emergency
2. STOP the expansion of all new fossil fuel infrastructure
3. DIVEST the UConn Foundation from all fossil fuel holdings
4. TRANSITION to 100% renewable energy as quickly as possible
5. INCREASE transparency, communication, & student decision-making power
6. COMMIT to carbon neutrality by 2030 and a zero-carbon campus by at least 2050
7. PRIORITIZE diversity in environmental spaces on campus

We place emphasis on these six demands, but they should be the minimum standard for future climate action at UConn. We have plenty of work to do in order to uphold our commitments, and our current goals lag far behind IPCC recommendations and Governor Lamont's expectations. Meeting our climate goals will require sustained, forward-thinking effort.

DEMANDS

Most immediately, we urge that President Katsouleas release a statement in which he recognizes that we are in the midst of a climate emergency, and affirms that sustainability is a top priority for the university. We urge that he commit the university to an update and acceleration of the UConn Climate Action Plan that reflects the content of this declaration, and that he dedicates the campus to a goal of carbon neutrality by 2030, the year that the IPCC report points to as the year by which Western institutions must be carbon neutral to have a chance at limiting emissions to 1.5 degrees Celsius.

Additionally, and as also supported by IPCC findings, we demand that the administration set a new goal of zero-carbon by 2050. There is no socially conscious alternative. Carbon neutrality allows for a loophole wherein the University can buy carbon offsets to "balance" their carbon emissions. Continuing to emit while employing carbon offsets is a model that merely shifts the work from us to someone else, and only prolongs environmental stress: carbon offsetting allows fossil fuel infrastructure to persist, and prolongs the inevitable need to switch. We must think globally and take full responsibility for our emissions. With our capability and visibility as Connecticut's flagship university, we should be leading this effort in the state.

STOP Expansion of Fossil Fuels:

We cannot continue to power our campuses with any variant of carbon-emitting fuel. Specifically, we cannot feasibly be powered by natural gas cogeneration and uphold our climate commitments.

- **No more natural gas-powered cogeneration plants, on any campus.** They have a lifespan of 30-40 years. It will be archaic to run on fossil fuels (even comparatively efficient ones) in 2050.

DIVEST From Fossil Fuels:

Divestment is the process by which an institution eliminates the investments that it holds in a certain company or institution. UConn, along with all universities in our nation, has investments in fossil fuels companies. These university investments have enabled fossil fuels companies to not only continue operating but to thrive. This isn't where UConn's money should be. This topic is complicated by mutual funds and a lack of publicly available information, yet is crucial to ensuring a sustainable future. We hope the new UConn Foundation President has a chance to settle in to his new position, and also urge him to divest from fossil fuel holdings as quickly as possible as he sets a new chapter in this institution's history.

- **Immediately make a statement that UConn will never again make a direct investment in coal.** As far as we know, the UConn Foundation currently holds no direct investments in coal companies, as they don't make financial sense to invest in. It would be an easy next step to make a statement committing to continue this in the future. Other colleges have taken this step, notably Stanford University.
- **Agree to make no new investments in fossil fuel companies or the mixed financial instruments that include them.** We understand that divesting from already held investments is difficult, but being strict with future investments should be achievable.
- **Determine where the university's investments in fossil fuel companies lie, including within mutual funds, and release that information to the UConn community.** Once this is done in a timely manner, the UConn foundation must devise and publish a plan to divest fully from all current fossil fuel holdings.
- **Make available to the public the university's Socially Responsible Investments.** This article on the Foundation website is a good start, but the UConn community should be able to access specifics, especially 1. Which companies UConn is investing in and 2. What percentage of investments are SRI investments. The University of New Hampshire offers a thorough example of this transparency.

TRANSITION to 100% Renewable Energy:

On the world stage, we have an F in renewables. We have a rating of **0.08/4.00** in the Clean and Renewable Energy section of our AASHE STARS report. The Sustainability Tracking Assessment and Rating System (STARS) compares the sustainability of universities across the world, and when it comes to renewables, we don't measure up. There are a huge variety of options for improving this, many of which have already been proposed in university documentation:

- **Sustainably energize the Northwest Science Quad**
    - **Re-evaluate and integrate alternative energy sources for this section of campus.** The Site Assessment and Development Plan for this area of campus includes an Alternative Energy section that assesses a single alternative, geothermal, as an energy source. UConn has since concluded that geothermal is not feasible in this area, however, more effort should be made to source energy for this large-scale project sustainably. Investigating geothermal alone does not count as a comprehensive analysis of all of the options.
    - **Follow through on plans for a 500kW solar panel array on the Northwest Science Building 1 roof.** These panels are included in current plans, but solar arrays have been removed from building designs at the last minute before on this campus.
    - **Investigate battery storage for this solar panel array.** Eversource provides an incentive for this, and other universities are taking full advantage of this benefit. With these incentives to make the project economically feasible, UMass Dartmouth recently installed a large battery storage system on its campus in order to complement on-site solar.
- **Fully transition to renewable energy sources**
    - **A Preliminary Feasibility Study and Strategic Deployment Plan was conducted in 2011, and many of its findings remain applicable.** This document should be revisited and the cost of implementation should be recalculated with the new, lower costs of renewables.
    - **Solar power in particular is the cheapest it's ever been, and UConn's infrastructure is ripe for implementation.** There are many locations that are suitable for solar installation as enumerated in the 2011 study. Generally, parking lots and garages are prime locations for solar. J Lot, in particular, was designed to be solar ready; conduits are in the ground right now awaiting use, so with a purchase power agreement, there would be no capital costs.
    - **Though it isn't a good fit for the new science quad, geothermal is feasible in certain parts of campus.** East campus is an especially good candidate for this energy source, and the Center for Environmental Science and Engineering building behind Horsebarn Hill would function as an excellent geothermal demonstration project (as detailed in the 2011 study).
    - **Consider getting more energy via purchased power.** Right now, we only purchase ~5% of our energy. All of UConn's purchased power is required to be renewable, in the form of Renewable Energy Credits, purchased and retired by our contractual energy provider (Direct Energy) and delivered by CL&P.
    - **Alternatively, consider making purchased power agreements.** These agreements, which would consist of a company installing and owning a renewable energy project on university-owned land from which UConn would purchase their energy at a reduced rate, are less expensive than directly purchasing energy from the grid and are a viable option for sustainably energizing campus.
- **Electrify our vehicle fleet and offset emissions due to transportation.**

    - **Transition our buses from gas to electric.** As was publicly discussed this past spring, we are about to retire two buses in our fleet and have a grant from the state to receive two electric buses and two charging stations, provided we contribute one third of the money. It may cost more money to buy the two electric buses than two more regular ones, even with DEEP support, but including the social cost of carbon in the calculation is likely to change this conclusion. UConn's reasoning for not making this transition is that Windham Regional Transit District (WRTD) is poised to take over our bus fleet in the coming years. However, this is no reason not to improve the fleet we have, and if the charging stations we purchase are placed in Storrs Center, then WRTD will continue to have access if the fleet changes hands.
    - **Purchase carbon offsets for university-sponsored travel.**
- **Maintain current projects.** A symbolic example of a lack of maintenance is the Werth tower solar array. These panels are proudly touted by the university in tours and in other advertising capacities, but by all accounts, they have been broken in some way since last year and may or may not be currently providing energy to our campus.
- **Take the social cost of carbon into account when determining where to source our energy.** Social responsibility must be accounted for when we decide how to power our campus. The social cost of carbon — the dollar value associated with the long-term damage caused by emitting carbon dioxide — must be factored into all long-term investment decisions. At a minimum, the social cost of carbon must be computed using the EPA's conservative estimate. In 2020, that number will be $42 a ton.
- **Reduce consumption and expansion while fostering this mindset in students.** This last point is not strictly associated with renewables (though it does have to do with continuing to improve energy efficiency), but it should be the default consideration prior to every decision to expand our campus. In cases where it is deemed necessary to expand for the academic growth of the university, we urge the university to take care to sustainably source materials and to build as efficiently as possible. In cases where expansion is unnecessary and purely for the sake of expansion, **do not expand.** The environment and its inhabitants cannot afford unnecessary superficiality.

INCREASE Transparency and Communication:

UConn's plans and statistics need to be easily accessible to the UConn community. In keeping with this, students need to be brought into the university's decision-making process regarding energy. The information in this document was very hard to obtain and involved hunting down many different people across the university. While the Campus Master Plan and other documents are online, they are hard to locate, difficult to understand, and don't include everything needed for full comprehension. In order for students to truly participate in the decisions that the university is making on behalf of them, we need easy access to this information.

- **Follow through on creating the Student Sustainability Task Force.** We are excited that the UConn administration is planning on creating a task force of students and professors that will have a say in UConn sustainability decision-making. We urge them to follow through with this plan. In addition, we recommend that this task force release regular reports that are easily accessed and understood by the UConn community.

- **Post all UConn Foundation investments online.**
- **Ensure public monitoring and accounting of greenhouse gas emissions.** UConn's annual carbon dioxide emissions should be displayed **prominently**. For instance, a bulletin board or digital dashboard in the student union could be dedicated to these statistics, along with a countdown to 2030.

PRIORITIZE diversity in environmental spaces on campus

Diversify the white-centric environmental scene on campus. This looks like transferring decision-making power to students, faculty, and staff representative of all UConn's cultural, racial, and economic backgrounds. People of color and indigenous peoples have been fighting for climate justice for centuries, yet most mainstream environmental movements (including Fridays For Future at UConn and the UConn Office of Sustainability) are white-dominated spaces. We must take proactive steps to give all members of campus equal access to positions of power in the field of sustainability. There is clear passion and knowledge for addressing environmental issues from students of all different backgrounds across campus. It is incumbent upon the UConn administration and environmental student leaders to acknowledge their negligence and actively address the future of what the environmental movement needs.
In the urgency of climate change, we need better and more creative solutions- this means more diversity of thought and background.

- **Be intentional in faculty hiring and promotions.** Almost all of the professors on campus in the environmental field are white. There is less than a handful of professors of color teaching in this realm. This is a critical initial step to addressing who is represented in who is teaching us.
- **Improve your coursework.** Few classes are offered that explicitly explains how climate change and environmental issues are inextricably linked with race and class struggles.
- **When implementing these changes, underrepresented groups should not only be included but be leaders in the decision making process.**

CONCLUSION

In recent years, UConn has been recognized as one of the most sustainable universities in the country. However, if UConn is to continue to be recognized as a leader in sustainability, we must adapt our climate action plan to correspond with our sobering reality.

We are in the midst of a climate emergency, and if we don't act quickly as a university, we will have contributed to severe and irreversible damage to the planet and its inhabitants. We cannot afford to bask in our current achievements; our only recently acquired recognition as an "environmentally friendly" university is not sufficient. We need action and we need it now.

When college students protest and produce lists of demands, we're usually patronized, patted on the head and sent on our way.

But not this time.

We demand change because we are experiencing the worst human-created catastrophe in the history of the world, and yet, UConn has failed to take action on anything approaching the necessary scale. We demand change because we recognize that without pressure from the student body, nothing will happen. We demand change because our lives, our future children's lives and the lives of vulnerable global communities are at stake.

We make these demands in solidarity with millions of other young people fighting for their future today. We make these demands because there is no alternate path, there is no plan B.

We want to work with the University to achieve our shared goals — after all, this planet belongs to President Katsouleas and his administration just as much as it belongs to us. But we are prepared, should we see inaction and false promises, to wield our collective power and push until the University agrees to act responsibly. Nothing else is sufficient. Nothing else will take us back from the brink except immediate and sweeping action.

That is why we demand what we demand. Our future is at stake.

2) University Senate Declaration in Support of Divestment

University of Connecticut Senate Executive Committee
Report to the University Senate March 2, 2020

Resolution in support of the University of Connecticut Foundation Divesting from Fossil Fuel Companies

Whereas:

- The world is facing significant threats due to our continued use of fossil fuels: increasing temperatures will result in greater loss of life, livelihood and property from more extreme weather events, and loss of critical and irreplaceable ecosystems.
- Fossil fuel companies have known for decades that their business practices were putting the world at risk.
- The University of Connecticut has recognized the importance of the environmental threat by creating the President's Environmental & Sustainability Working Group, and by accelerating its interim carbon reduction goal for 2030 from 40% to 45%, consistent with Governor Lamont's Executive Order #1 in 2019.
- The University of Connecticut Foundation has recently chosen BlackRock to manage its investment portfolio and this company has stated that fossil fuel stocks are not a desirable investment option.
- Divesting from fossil fuels meets the Foundation's mission to ensure fiduciary responsibility given that a diversity of fossil fuel free financial instruments exist, and their returns are no different than investments which include fossil fuel companies.

Planning for a Zero-Carbon Future

APPENDIX B

This Senate resolves:

1. To encourage the UConn Foundation to terminate its direct and commingled investments in dominant fossil fuel companies (such as the top 200 publicly traded companies listed in the Carbon Underground 200).
2. To urge the Foundation to terminate these investments within five years or as soon as is reasonably possible.
3. To call on the Foundation President to announce publicly when such decisions have been made so that the University of Connecticut can set an example to others to likewise divest.
4. To encourage the Board to invest a minimum of 5% of its portfolio in sustainable companies or funds that mitigate climate change.

3) Working Group & Subgroup Meeting Minutes

President's Working Group on Sustainability and the Environment
UConn Facilities Operations Conference Room, Storrs, CT
January 24, 2020

ATTENDEES: See Attached

Meeting called to order at 1:05pm by Laura Cruickshank.

Committee member introductions; followed by discussion:

1. Working Group Charge
    a. Mike Kirk clarified that the President has requested the group start with studying energy and carbon emissions. After the work of the committee is complete and reported; the committee could potentially tackle additional sustainability and environment topics in the future.
    b. The work of the group is anticipated to inform the updating of the sustainability framework of the University Master Plan.
    c. Charge Suggestions:
        - What are the "values" of the group and what are the trade offs the group is willing to make?
        - Concern about the term "feasible" in the charge.
        - Suggest add "values" to the last sentence of the charge. "Actions UConn can take based on values, facts …"
        - Need a list of related values and where does sustainability fall on the list … good starting place.
        - Want explicit statement about risk the University is willing to take.

2. Planning
    a. Draft Schedule of Topics
    The committee engaged in a review of potential future discussion and process items as listed below:

        - Engage consultants and University staff to inform the work of the Committee
        - Energy use and generation for UConn Storrs, Regionals and UConn Health
        - Behavior Modification – Add to Energy Use discussions on schedule
        - Capital and operating costs to be shared with group
        - Policy change recommendations can be made by the group
        - Water and Waste Water to be discussed as part of energy
        - Landscape to be discussed
        - Market to be discussed
        - Food and Ag Waste; Anaerobic (current and future environmental effect)
        - Solar should be included in discussion

- Geothermal
- Funding and Prioritizing of Projects
- UConn and State policy change recommendations
- Targeted Small Opportunities, utilize existing infrastructure (e.g. green roof new construction)
- Sacrifice recognition for recommendations
- Depot Campus options
- Timing – what can we do now, in 10 years, and long term
- Monetize value (e.g. perception, teaching tool, indirect benefits)
- Procurement Policy / reduction strategy for consumption (behavior)
- UConn Pilot Program
- Survey suggested. Potential to recommend a survey within the final report.
- Bang for buck analysis vs value; and/or bang for buck informed by values
- Behavior related to carbon emission reduction; also behavior related decision making based on knowledge, attitudes, and beliefs.
- Utilize research already occurring on campus related to carbon emissions
- Request for next meeting on capital budget plan; available state bonding; and bonding schedule; to inform future discussions.
- Suggestion of future process: Professional presentation of data and framework/models with discussion of cost benefit analysis, values and scenario planning by the Committee.
- Alternative transportation and behavior

3. Climate Action at UConn Presentation

4. Carbon Emissions and Reductions at UConn Presentation

The group engaged in a discussion of where the baseline measurement should be or start date used for measuring carbon emissions. The discussion determined the baseline to be subjective. The group was asked to remember that the objective is zero by 2050 or before.

There being no additional agenda items the meeting was adjourned.

President's Working Group on Sustainability and the Environment
UConn Facilities Operations Conference Room, Storrs, CT
February 5, 2020

ATTENDEES: See Attached

Meeting called to order at 9:03 a.m. by Scott Jordan. He thanked the committee for all their ideas at the last meeting and stated that during the University Senate meeting the President had reiterated his vision for the Working Group to provide a matrix that will include recommended strategies and effectiveness in terms of carbon and greenhouse gas reduction, and cost.

The group discussed prioritizing recommendations; as well as including non-monetary trade offs and risks of the various recommendations.

Tom St. Denis, Principal with BVH, a framework engineering consultant, was introduced. His group assisted with the utilities framework master plan and other framework projects. Mr. St. Denis will be a consultant assisting with the working group.

Mr. Jordan requested that members present introduce themselves.

The members were directed to the minutes of the 1/24/20 meeting.

The Capital Budget Plan was detailed by Mr. Jordan and Laura Cruickshank. The discussion included project updates, master plans, and the future of the depot campus and prison properties. There was also a suggestion of the potential use of student fees to pay for continued environmental improvements.

A request was made for projections of energy use as buildings are built and renovated on campus. Ms. Cruickshank stated that this information is incorporated in the framework utility plan.

A presentation was made by students: Jonathan Ursillo, Harry Zehner, Brandon Hermoza-Ricci, Xinyu Lin and Himaja Nagireddy on "Energy Strategy Options". The group discussion included electric cooling and heating, solar, and anaerobic digestion. Additional options included geothermal, carbon offsets, wind and nuclear. It was noted that education and research should be considered and can be accomplished through campus engagement and campus wide communication. The student presentation listed the following as goals: "roadmap to 45% emissions reduction by 2030; plan for full implementation of renewables by 2050; commitment to no new natural gas infrastructure on any campus including UCH and regionals; and directive to UConn Foundation to audit for fossil fuel holdings". The University has done many things to reduce carbon and greenhouse gases but the community may be unaware of those efforts. It was recommended that those accomplishments be listed and communicated in the final report.

A reminder was made to include behavioral change to the final recommendations. It was suggested that increasing online courses could potentially effect campus space in the long term.

Stan Nolan provided a presentation on "Carbon Reduction Methods and Tradeoffs". The presentation included potential carbon reduction methods including conservation, renovation and demolition of existing buildings; solar photovoltaics; solar thermal; wind power; behavior modification; geothermal heat pumps; steam to hot water conversion; heating/cooling equipment; power off sets purchase; smart micro-grid; natural gas/propane emergency generators; fuel cells and tri-generation; anaerobic digestion; and transportation – bicycling/fleet electrification.

Mr. Jordan suggested that the presentation be put on the shared drive and be considered the master deck for the group to work from for review, evaluation, scale down, and be utilized for the final matrix. It was also suggested that the student's combine with this deck info with their deck info so the group would be working from one central document. It was recommended that a baseline be determined and utilized. Mr. Jordan agreed to work with internal staff and the President to determine the baseline. A request was made for scenarios to utilize land in different ways such as what would happen if a building were demolished; or if forest was cut down where permissible, etc.

There being no additional agenda items the meeting was adjourned.

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓					
Carnahan, Kerry	✓	✓					
Chen, Ming-Hui	✓						
Hermoza-Ricci, Brandon	✓	✓					
Jordan, Scott	✓	✓					
Li, Baikun	✓	✓					
Xinyu, Lin	✓	✓					
Nagireddy, Hamaja	✓	✓					
Roach, Natalie	✓						
Segerson, Kathleen	✓	✓					
Seth, Anji	✓	✓					
Ursillo, Jonathan	✓	✓					
Volin, John	✓	✓					
Willig, Michael	✓	✓					
Zehner, Harry	✓	✓					
Cruickshank, Laura	✓	✓					
Jednak, Mike	✓	✓					
Miller, Rich	✓	✓					
Ferri, ~~[illegible]~~ Paul	✓	✓					
Nolan, Stan	✓	✓					
Carone, Debbie	✓	✓					
Mark Bolduc		✓					
KATIE MILARDO		✓					
Patrick McKee	✓	✓					
Tom St. Denis (BVH)		✓					

President's Sustainability Working Group Meeting Minutes
Thursday, February 27, 2020
3:00 pm – 5:00 pm
School of Business, Conference Room 321, Storrs, CT

Attendees: See Attached

Meeting called to order at 3:05 pm by Scott Jordan. He thanked the committee for all their efforts and ideas at the last meeting and explained that this meeting would be a presentation by consultants, BVH and CES. The presentations are not to be considered as the comprehensive list of options but will help with the decision making. The next session will allow input for evaluation by the team and to think of priorities of the campus, we're going from fact finding phase to drafting the report phase. He also reminded the group of the President's charge to produce a matrix to serve as the framework of the decision making going forward.

No other opening remarks or revisions to the last meeting minutes.

Introductions including the consultants, CES and BVH. CES: Zachary Bloom, Eben Perkins/BVH: Tom St. Denis, Ashley Patrylak, Scott Waitkus

A presentation was made by Facilities Operations, University Planning Presentation, CES and BVH.

The presentation included 6 potential projects and took into account feedback from previous meetings, concepts for potential and how it would impact the University.

CES presented the following topic: Campus Electrification (including the renewable energy credits and renewable energy profile discussion), Behind the Meter Solar (including the UConn Property map, Storrs Load versus Solar), Battery Demonstration, and Solar Parking Canopies (Lot D, J, G, T, Y, Z, Charter Oak Apartment and Hilltop Apartments). The discussion on these topics included Class 1 renewables and how they are determined, making a decision between ownership versus a PPA model, how RECs are a tracking mechanism, technical challenges, cost and what UConn's peers are and/or have done.

BVH discussed and presented the following topics: Geothermal Wells (McHugh, Bishop, CESE) including a discussion of Co-Use of PV and Farming, Anaerobic Digester and Compost Facility. It was noted that co-use for solar and agricultural activities would be a great opportunity to pursue and it could further science and technology. The group also discussed the thought process of approaching some of these topics, doing it in phases and making sure to not leave equipment and system stranded, retrofitting equipment when it's come to the end of its useful life and looking at campus from the outskirts in.

Mr. Jordan discussed that there will be two more sessions to talk about transportation and behavioral. And he noted that the group hasn't gone into too much detail on cost but we need to start including this and building the matrix with relation to cost. He's not sure how this will be completed as a group but he'll likely propose dividing up the various topics to the folks that worked on this for the write up. A discussion with the President to ensure the group is capturing all of the right information will also be done.

There being no additional agenda items the meeting was adjourned.

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓	✓				
Carnahan, Kerry	✓	✓	✓				
Chen, Ming-Hui	✓						
Hermoza-Ricci, Brandon	✓	✓					
Jordan, Scott	✓	✓	✓				
Li, Baikun	✓	✓	✓				
Xinyu, Lin	✓	✓	✓				
Nagireddy, Hamaja	✓	✓					
Roach, Natalie	✓	X	✓				
Segerson, Kathleen	✓	✓	✓				
Seth, Anji	✓	✓	✓				
Ursillo, Jonathan	✓	✓	✓				
Volin, John	✓	✓					
Willig, Michael	✓	✓	✓				
Zehner, Harry	✓	✓	✓				
Cruickshank, Laura	✓	✓	✓				
Jednak, Mike	✓	✓	✓				
Miller, Rich	✓	✓	✓				
Ferri, Paul	✓	✓	✓				
Sean Vasington	✓		✓				
Nolan, Stan	✓	✓	✓				
Carone, Debbie	✓	✓					
Mark Bolduc		✓	✓				
KATIE MILARDO		✓	✓				
Patrick McKee	✓	✓	✓				
Tom St. Denis (BVH)		✓	✓				
Ashley Patrylak (BVH)			✓				
Scott Waitkus (BVH)			✓				
Zachary Bloom (CES)			✓				

Meeting minutes – 3/10/2020 9:00 am school of business conference room

Opening remarks:

SJ: overview of agenda which will include student presentation on draft final recommendations for energy, transportation and behavior discussion, and next steps.

Student Presentation:

1. Update emissions reduction goals
   - Aligning with IPCC guidance 45% by 2030 based on 2010 baseline
2. Permanent halt to new fossil fuel generation capacity/infrastructure at all campuses and health
   - Risk management - future of natural gas is at risk based on conversations
   - Compatibility with UConn's goals and image
   - Net zero in new buildings
     - SJ : every building needs to be a net zero building but we could off set somewhere else on campus? Harry: yes
     - Harry: not investing in new steam lines
     - Reminder from SJ – recommendations to president which could be recommendations for the university
     - John – carbon tax and University could be included
       - CES
3. Plan for campus wide electrification
     - Staged roll out
       - John – CES presentation, low temp hot water projects: start at South Campus and Hillside. Plan in place to be done logically and methodically. Understand it wont happen tomorrow. *Example – Princeton
4. Utility Scale solar, geothermal and other renewables
     - Project matrix – Depot campus property and Mansfield property. Grid analysis by Eversource for Eversource grid. Or a PPA – virtual. Other campuses are doing this. Uconn could own the land. BVH: liability. Backup power is Cogen but if we phase out and require Eversource to be the backup source. Ensure the source is there to keep the campus up and running 20 miles away. Major infrastructure investments to give redundancy for UConn (since we are a research facility). SN: discussion about recent weather events and Cogen was able to keep up.

   Renewables:
   - Utility scale solar
   - Geothermal energy – CESE, Bishop
   - Wind Energy – AP
   - Anaerobic Digestion – Storrs

Quantify #s to see where we should head.

This is not to replace cogen, this would supplement until the cogen reaches its useful life.

5. Divestment from Fossil Fuel Holdings

Conclusion

Proposed final meeting to April 28th BOT Mtg on April 29th

Arrangements to operate remotely if necessary

Meeting from Last meeting

- Question: Summary slide 4% was low relative to goals
    - SN: per unit obviously # would increase if it grew
    - SJ: summary with cost per unit and overall summary to President. Matrix will be multidimensional – cost per unit, cost over time, strategy
    - Harry: Princeton "business as usual" so you can see the comparison of the substitution of various costs. BOT slot to present is it feasible?
        - SJ: a few minutes to present and provide info but probably not enough time or place for voting or endorsing

BVH: drilling test wells for Bishop and CESE; potential for McHugh as a test well

- General SW management treating runoff from solar farms – problematic task force with DEEP. Potential new regulations
- RM: Permeable Asphalt editions – CLEAR thought permeable asphalt would be a solution to that
- BVH: maintenance issue, rain garden and will be included in the problematic GP, you still need to build infrastructure to handle storm events, cost issue to consider
- SJ: use best practice options and include engineered concerns and cost options

Contacting vendors for aerobic digestor and doing further investigation

Draft matrix putting this together

Transportation

- Ebike conversation? None on campus at this time
- WRTD 3 electric buses and potential new partnership with more routes to campus
    - SJ: faculty and staff to also ride
    - MJ: WRTD will only but electric buses; maintenance, storage, chargers, etc. will be part of the negation with this bus program
    - XXX prof –doesn't understand why buses need to be stored indoors

- Grant was transferred to DOT/WRTD
- Harry –bus routes and getting students involved with this program.
    - MJ: yes, DOT very interested and involved and wants to use students

XX – substituting parking ?

Underutilitzed

Angie – stops on 195 she would rider

XX – parking data

MJ – parking layout hasn't changed much but changes upcoming with closure of Xlot

LC – Master plan, accepted by BOT, conscious decision to not increase parking on campus looking forward to a reduced car parking

MJ – rt 44/384 commuter lot for bus route in Bolton

Harry – consideration of tram or light rail line for Willimantic/Manchester/Vernon/storrs , tracks that could be used.

MJ – haven't heard anything? But could mention

SJ – cost is a huge thing. Malloy's office is aware of the tracks.

LC –mutli state group – looking at rails in New England – connect RI, Boston, Springfield, Hartford, New Haven. Emphasis is on the coast and not inland. $$$$ has to work for every state for this to work. If you get everyone on board it could very much work.

Bikes

John: bike app for location and reminder for bikes tied to a pole similar to transportation

Angie : and electrification for the bike outlets

Travel info

Conversation about carbon reduction option in travel choice

Ongoing discussion

LC went to a conference and can share information

Shuttle included in hotel? Cost for rent, cab, etc.

USG –incentive and more compensation for university funding. Unsure if student travel uses the same system.

---- selling point for hotel in TX – Sinclair - Low voltage system Hotel – save energy and other

Think about installing more features in res halls and buildnigs on campus.

Carbon tax ----

Harry - $ go towards projects instead of offsets

Green Fund

*** Laura – 4-6 folks, students, faculty and staff to help with

***Can faculty and staff get involved with projects and information

SJ : two subcommittees

1. Draft with report
2. Technical support for matrix

SJ – working element layout and outline and narrow down strategy and what they should be and what they should be. Next meeting discuss this.

And also talk through some of the behavioral ideas at that time.

Mike Willig: want to reiterate Plate of options 4 day work week, telelearning, decreasing thermostats by 1 degree for winter/ summer,

Harry – meeting with Transportation folks to keep the discussion moving + thankful for the new bus lines.

SJ: Transportation advisory group that includes faculty and staff. And a very cool app created for car pool and similar to an uber. We now how data and analytics for transportation and bus routes. Credit to Mike's team. Increasing ridership.

President's Sustainability Working Group Meeting Minutes
Tuesday, March 10, 2020
9:00 am – 11:00 am
School of Business, Conference Room 321, Storrs, CT

Attendees: See Attached

Meeting called to order at 9:16 am by Scott Jordan. He provided the overview of the agenda which included student presentation on the draft final recommendations for energy, transportation, behavior discussion and next steps. Additionally Facilities will present on Transportation.

No other opening remarks or revisions to the last meeting minutes.

Student Presentation included a discussion on the following recommendations:

1. Updating emissions reduction goals and aligning with IPCC guidance 45% by 2030 (2010 baseline).

2. Permanent halt to new fossil fuel generation capacity/infrastructure at all campuses including the health center. A discussion on risk management and the future of natural gas at risk, compatibility with UConn's goals/image, and net zero for new buildings.

3. Plan for campus wide electrification and the discussion of a stage roll out based on the CES presentation, possibly using Princeton as an example.

4. Utility scale solar, geothermal and other renewables. A discussion of the project matrix and looking at the Depot campus property and additional Mansfield property. Grid analysis would need to be discussed and completed by Eversource for their grid. Also the discussion of a PPA. BVH also commented that liability should be taken into consideration, backup power is the Cogen but if it's phased out we would require Eversource and we would need to ensure the source is there to keep the campus up and running. It would include a major infrastructure investment to give UConn redundancy since the University is a research facility. Renewables were also discussed again, utility scale solar, geothermal energy (CESE and Bishop), Wind Energy at Avery Point, and anaerobic digestion.

5. Divestment from Fossil Fuel holdings

To conclude, the students would like to propose a final meeting to April 28th and attend the BOT meeting on April 29th. Also the discussion of moving meetings remotely with the COVID concerns.

To summarize the last meeting, BVH provided an update on items being worked on from the previous meeting. BVH is working on moving forward with drilling test wells for Bishop and CESE. General stormwater management treating runoff from solar farms is being closely followed with the task force formed by DEEP. BVH is also contacting vendors for anaerobic digesters and doing further investigation. The Draft matrix is also being worked on for review.

Facilities presented on the topic of Transportation which included electric vehicles including the bus and bicycle program on campus. A potential partnership is being discussed with WRTD to be responsible for the maintenance, storage, and charging busses. A discussion on parking and future of parking at UConn was discussed. Additionally, the conversation about carbon reduction option in travel choice was discussed. The Green Fund and carbon tax topics were also discussed.

Mr. Jordan discussed that there will be one more sessions to talk about behavioral and a working element layout which will outline/narrow the strategy. And he noted that the potentially two subcommittees will be created, one for the draft with report and another for technical support for the matrix. Laura Cruickshank will take the lead on drafting the report and if folks are interested in helping reach out to her.

There being no additional agenda items the meeting was adjourned.

D R A F T
President's Sustainability Working Group Meeting Minutes
Wednesday, March 25, 2020
1:00 p.m. – 3:00 p.m.
Via WebEx and Telephone

Attendees: See Attached

Meeting called to order at 1pm by Laura Cruickshank. She explained that Scott Jordan had been detained and had asked her to lead the meeting.

Harry Zehner stated that the COVID-19 crisis has reduced the energy load on campus; and one of the reasons for building the SUP was to replace the boilers to meet EPA regulations. He asked if there was a possibility to replace the boilers without building out the additional capacity. Ms. Cruickshank clarified the question to build the supplemental utility plant and add the extra square footage. Mr. Jednak stated that it is important to continue with the assumption that the University will return to normal in 3-6 months. Ms. Cruikshank stated that she is working with the engineers on whether there are alternative options for the boilers to fit in the CUP.

Rich Miller presented a PowerPoint Presentation on "Behavioral Change, Carbon Offsets, RECs, Credits and Funding Mechanisms". This included a group discussion of a possible voluntary fee structure for a Carbon Neutral Commuter Program to be launched in fall 2020 and linked to parking permits. Education and outreach are integral to the success of the program.

Discussion of internal carbon pricing including setting of proxy price (social cost of carbon); setting of carbon baseline for buildings; assessing carbon charge or return based on performance vs baseline. This would require extensive sub-metering. Potential to drive behavior change and innovation. Mr. Zehner clarified that this is a carbon fee model where departments compete against each other; the proxy price model is commonly used in institutional planning decisions including building design determination. It was stated that the proxy price is easier to implement at the institutional level as it is policy based. The concept is difficult to implement when University departments have minimal control over their buildings and emissions; and only have control over small behavioral actions.

It was acknowledged that there are a variety of targets and mechanisms identified to effect behavioral change that can enhance the ability to reduce carbon imprint. Is there a mechanism to do a strategic assessment of behavioral changes to institute by taking into account the speed, costs and benefits of implementation? Determine most effective changes to reduce the carbon imprint and enhance sustainability with limited time, energy and money. The draft of the Committee's report is planned to include identification of strategies of short term, midterm and long term; based on bang for the buck, feasibility, and ease of implementation and a strategic assessment of behavioral changes.

Carbon offsets to be utilized late in the process as a stop gap for capacity that cannot be covered as renewable. University administration utilizes as a last resort option. Desire to use carbon offsets in the long-term is tied to not spending capital funds on one-time offsets in the short-term.

Ms. Cruickshank directed the Committee to the subcommittee's draft outline report, introduced subcommittee members, and provided an overview of the subcommittee mission. She reviewed the President's expectation for the final report from the Committee.

Discussion of Draft Outline:

- Rough draft due to full Working Group by the 4/9.
- Rough draft report to be approximately 10-15 pages written. Much was moved to the appendix for technology info. Emphasis on recommendations and strategies for reducing carbon. Outline detailed to support recommendations of Working Group.
- Section III, University Mission and Values. Request that the concept of values be explicitly defined; especially with regard to how alternatives are evaluated in the final recommendations. Discussion of values in strategies.
- Section III B To be "University's Image and Responsibilities", perhaps also include substance.
- What is our value? How does funding play into that determination.
- Utilize University documents and statements already available on University values; demonstrate the values the University already has in place. Operationalize those values to make a decision.
- Discussion of tradeoffs. Value multiple things and cannot do them all. Reconcile recommendations with respect to greenhouse gas emissions and other values. Needs to be expressed … possibly in Section VII.
- Executive Summary should include short summary of recommendations.
- Strategies are decisions made in light of uncertainty, and uncertainty indicates risk and hope; include discussion of risk factors associated with recommended strategies.
- If want to explicitly recognize risk should include the concept of proxy pricing in an institutional way. Proxy price takes into account the social costs of carbon and uses it as a planning tool. Incorporates risk by planning for the potential of a carbon tax or governmental climate action, making proxy price tangible. Planning tool. Use to encourage the Board of Trustees to approve decisions that take risk factor of social costs of carbon into account. Request that this be included in the recommendations.
- Request suggestions for title of the Working Document. Future reports anticipated based on other areas students originally requested be addressed. Recommend the other areas be included in recommendations (e.g. topics for further analysis, next steps)
- The charge from the President was to produce a matrix. Difficult to produce matrix by deadline. Suggestion to split report into two parts; 1) institutional policy and 2) detailed project matrix (including costs, feasibility, etc) to be delivered in the fall. Section VII to include matrix of strategy as less in depth review of short term, midterm, long term recommendations. Include recommendations to be done right away including costs.

Future items require more thought for priority, feasibility and cost. Suggest including broader big picture context in strategies.

The subgroup will meeting again on March 31.

There being no additional agenda items the meeting was adjourned.

PWGSE Report May 2021 - Appendix C

PWGS Sub-Group Meeting – Draft Report and FacOps Slides
Wednesday, April 8, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Stan Nolan, Rich Miller, Alexander Agrios, Anji Seth, Baikun Li, John Ursillo, Harry Zehner, Mark Bolduc, Katie Milardo, Tom St.Denis, Scott Waitkus

This meeting was to discuss the draft report, specifically the recommendations section. Also, Mark Bolduc has graphs to share and Tom St.Denis/Scott Waitkus are available for any additional questions that may come up.

1 . Review of the PWGS – GHG Reduction Projections 4-8-20 slides (provided via email prior to meeting)

- M.Bolduc provided an overview of the slides
    - L.Cruickshank – to further summarize slide 1 is the 2007 baseline and UConn goal and slide 2 is the 2001 baseline and the Executive Order 1 45% reduction goal
- M.Bolduc explained the hatched sections of the bars in the graph indicating curtailment and projects and clarified what curtailment meant (gas contract, CUP needs to switch from gas to oil dur to restirctions, tupically winter weather related)
    - S.Nolan also added that the hatched includes new construction and typically curtailment is only 30 days and is 7-10% of the hatched data
- M.Bolduc explained slide 3 – 20% reduction and 2020 goal which includes commuter offsets that Patrick McKee (Sustainability Office) had previously discussed and that the goal is to have something in place by Fall 2020, lighting projects, insulation projects and energy projects (examples VFD control replacements on equipment)
    - L.Cruickshank – asked whether or not these project are approved and are they mainly FacOps
    - S.Nolan – yes, most are FacOps projects and SLED is approved and funded, most insulation is funded and partial approval for other ECM projects. COVID has delayed the schedule and impacted some of these projects.
- M.Bolduc reviewed slide 4 – 2025 goal reduce by 30% 2007 baseline and walked through the projects which include lab ventilation, SLED, and conceptual projects such as digester, geothermal, and onsite solar
    - S.Nolan – commented that this is just a potential path and some may be more robust than others. None of these projects (except SLED) are approved so this could change.
    - L.Cruickshank – added that this is just a strategy and we can do more or less
    - M.Bolduc – agreed, yes nothing is set in stone and this is just a mix and match of the various options previously discussed
    - R.Miller – asked about steam line replacements and the reductions in previous projects
        - S.Nolan –responded that this project is capturing leaking lines, example: south campus where there is major energy and water loss due to aged infrastructure and that we would complete this project to avoid further loss, gain on GHG
        - R.Miller –does this support growth?
        - S.Nolan – No, just a replacement
        - L.Cruickshank – the 19,000 tons from the previous slide shown does include growth on campus
    - R.Miller – asked about onsite solar and if sites were identified

PWGS Sub-Group Meeting – Draft Report and FacOps Slides
Wednesday, April 8, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

        - S.Nolan/L.Cruickshank – both commented 10 acres = 1 MW, 50 -75 land needed, no sites have been determined but Depot campus is a candidate
    - R.Miller – asked about slide #2 and the 2001 baseline and how the emissions were calculated? Vermont Yankee? Includes coal plants being offline.
        - S.Nolan - discussion about the ISO NE produced information on today's carbon on the grid, etc. and that it would be difficult to create a CT specific one because of the imports but he would try to summarize.
- M.Bolduc review of next slide showing the 2030 reductions and includes the demo of Torrey Life science building, steam line repair, onsite solar and compost facility expansion
- M.Bolduc discussed the last slide which is a summary of all slides – 45% from 2001 in a pie chart form and includes info from slides 3-6

2. Comments and Discussion of the Slides

- A.Seth – asked about the low temperature/hot water lines moving toward electricity use?
    - S.Nolan – discussed the steam lines needing to be repaired in certain locations before transition to hot water and that buildings already utilize steam need to be kept online before the transition. We do not have reduction data for this transition yet because we still need to do a study with costs and available locations.
    - J.Ursillo – commented on the wholesale steam line replacements potentially locking this system and it's easy to mete the 2030 goals but asking about the transition to net zero on campus?
- S.Nolan – commented on the functionality and needing to do certain things to keep the buildings running. In the draft report (page 9-10 section 5.2) you'll see a series of slides with a potential transition plan using 2019 data. The draft report includes Scope 1 and 2, energy profile of the Storrs, Depot and Regional campuses. Summary graph with near, mid, and long term including the balance of technology changes, population growth, etc. it's our best understanding of the campus and based on the master plan providing one way we can get to clean energy by 2050 = zero carbon.
    - A.Seth – asked if the green = less electricity and natural gas and what it means?
    - S.Nolan –transition of season and needs in the Northeast. Again commented that this is just one possible way to reach the goal and there's variety of ways to get there.
    - L.Cruickshank – added that the graphs only go to 2030 and there are other assumptions
- J.Ursillo – two comments: 1) Adding solar and electric chillers? 2) Flexible technologies with leas investment?
    - L.Cruickshank – Do you mean steam lines? And investment of steam lines? It's a good point and something we should include in the recommendations. Added that we should be including and advocating for a real transition plan and what that all means in the report.
    - S.Nolan – approx. 30,000 LF of steam and added that several structures would have to come down and cannot use geothermal – not feasible

    - J.Ursillo – yes, line with step by step approach. He had added that comment in Section 6.2 and to potentially look at other colleges and what they did/plan
    - S.Nolan – thermal needs met at no cost responding to John's 1st question and buying solar = cleaners but still part of the emissions. There's a difference between net zero and zero carbon.
- L.Cruickshank – SharePoint will have all of these documents for review and further discussion but the focus for tomorrow's meeting should be the recommendations section of the draft report. One question that just needs to be verified is Laura's question she asked about next gen and academic planning.
    - J.Ursillo – no one will say no we can't fulfill expansion plans. We just need to make sure it's done in a smart way and put in the right policies and procedures
    - A.Seth – agrees with John and the question is will UConn be the example institution that's world class and cutting edge but also cutting out fossil fuels and setting an example for others in CT
    - L.Cruickshank – does that include Science 1?
    - A.Seth – not decided but we can't keep kicking the can. Does that building include chillers, electric? Solar?
    - L.Cruickshank -1 steam and 2 electric chillers and a ½ MW solar. And to answer Harry's question regarding equipment in the Cogen – we can't fit everything in that building.
    - S.Nolan – commented on the increase of GHG if we add electric chillers –it would be an increase not a decrease
- R.Miller –question about the slide with the regional campuses and if that includes RECs for carbon neutral?
    - S.Nolan – No, energy use n ot GHG. Energy bought for campuses doesn't include RECs
- L.Cruickshank – we're in the process of formulating a matric with reduction strategy. Tom St.Denis and Stank Nolan will circulate for review
    - T.StDenis –electric chillers are on campus – but to add to Stan and John's comments, the waste steam off generation system is clean. Once solar becomes available electric chillers will be switched over. The SUP is 50/50 electric and steam.
    - A.Seth – CO2 graph of slides and how much?
    - S.Nolan – did a walk-through of the graphs, cost/ton reduction will vary
- A.Seth – discussion of geothermal, understands that there will be 2 small test locations. She knows of many examples, 2 large complicates sites, not a high technology, has been around for a while, low operating costs. More test case are needed for next examples so that geothermal can be used for new construction, underneath the building.
    - L.Cruickshank – the need for a clump of building specific to do so. Another potential area would be AgBio buildings. Construction under buildings is fairly new –parking lots yes, buildings no. But this is a good point and should be reviewed and studied more.
    - R.Miller – BU recently did this and he can look into other universities such as Ohio State.

PWGS Sub-Group Meeting – Draft Report and FacOps Slides
Wednesday, April 8, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

- T.St.Denis – Fairly recent, group of looped building including field with open space. Difficult at a UConn/Yale type of campus. Installation and/or maintenance of wells would be problematic potentially long term.

The last item discussed was that the work group meeting was tomorrow. New building net zero strategy and space allocation needs to be addressed. Laura thanked everyone for being on the call, apologize for the meeting running late but good comments and input. Discussion to be continued as this progresses.

Meeting concluded at 5:30 p.

President's Sustainability and Energy Workgroup Meeting
Thursday, April 9th 2020
2:00 – 4:00 pm
WebEx Meeting

Attendees: Deb Carone, Alex Agrios, Brandon Hermoza-Ricci, Scott Jordan, Xinyu Lin, Himaja Nagireddy, Natalie roach, Anji Seth, Jonathan Ursillo, John Volin, Mike Willig, Harry Zehner, Laura Cruickshank, Mike Jednak, Stan Nolan, Rich Miller, Patrick McKee, Paul Ferri, Mark Bolduc, Katie Milardo, and Tom St. Denis

Open Remarks:

LC– April 30th is the next meeting. The subcommittee has met on 3/31 and 4/8. We'll be meeting again on 4/18 and 4/20. Meeting Minutes from the last meeting approved. No comments, questions or concerns.

Discussion

LC: requested that Tuesday the 14th comments due, if possible and that works for everyone.

- JU : focus on the recommendations section, section 6. For next steps.
- LC: Presidents charge – SJ recommendation to change the charge slightly due to COVID 19 and other responsibilities and emergencies that have come up. Laura reminded everyone to keep the charge in mind. Read the charge from the report.
- RM: if amended would it be different phased approach discussed in sub group.
- LC: not part of conversation but possibly extension of schedule deadlines to Fall 2020.
- AA: also budget – cost goes out the window right now at this point. This is impossible at this point
- LC no funding or cost analysis. Correct, impossible question to answer
- JV: Delay report?
- LC: no report would still be provided.
- JV: to talk to Gene Gowan, discuss the June BOT? We don't want to wait until Fall
- LC: even by June, we won't have the cost included. We'll have something for the task group. Talk about it at the board meeting. April 29th. Only discussion, nothing would be handed over.
- JV: you need to make sure the Task Force – let's talk after this meeting.
- MW: talk about goals and delay cost benefit analysis. Some preliminary guidance on cost – expensive, cheap, super expensive, etc. or cost cannot be estimated. Discussion before committee is dispersed and people are no longer here.
- JU: lay out as much as possible we can in this moment in time. Best practices based on peers and consultants are saying. Strategic manner possible. Financially smart and meet our goals. We don't want to get too wrapped up in cost right now. Confine yourself from the jump when focus is cost. Short, mid and long term analysis.
- HZ: we understand now, stop fossil fuel capacity. But we can still offer thing that don't require detailed cost benefit analysis.

President's Sustainability and Energy Workgroup Meeting
Thursday, April 9th 2020
2:00 – 4:00 pm
WebEx Meeting

<u>Draft Final Report – Recommendations Section 6.0 (meeting materials in the SharePoint)</u>

<u>Section 6.1</u>

HZ: update emission reduction goals to align IPCC with ideas of climate justice and cumulative historical emissions that western countries hold

- AS: IPCC objective suggestions are really tougher than the Governor have provided. Harry has stated that nicely in the report. Climate Justice Issue – provided a talk at conference two years ago and discussion of climate challenges and discussion of needing net zero. And 1.5 globally, that means developed countries (responsible for present carbon) reduce emission well before 2050
- HZ: different baselines difficult to manage. Same goal but adjusting it to 2007 baseline. In effect same thing but tracked by a single baseline. Higher if that makes sense and to be determined in sub group.
- SN: developed comparison and will cover that and we looked at the different baselines and compared % so you're looking at it from different baseline and easier to look at.
- MW: different baselines informative and highlight recommendation makes it clear. The other stuff is historical. One question: important for the reader exactly what we mean that this is "institutionally binding goal" – who's responsible? What's the meaning behind that statement? Weight in action. Just be careful about choice of words.
- HZ: Still a draft, language with intent to discuss what that means. Personally, very important and aspirational and reaching for something high and binding. We shouldn't just shrug this off and we should be committed. Open for discussion.

LC: welcome comments and suggestion – emailing back and forth with Harry and John.

<u>Section 6.2</u>

HZ: power things in the short term, repairs of steam pipe. Build out a timeline to electrify the campus. Goal deadline is 2030. Taken on in the Fall as a workgroup charge or by Energy consultants (or both)

- JU: the intent, we're not going to invest more and more into the current system. If we're being told we need to fundamentally change the system to full electrification. Massive financial loss and stranded assets. Staged and strategic manner which is effective and financial responsible to mete the goal. If we keep investing with steam pipe today, we'll kick the can down the road.
- AA: different then full electrification by 2030 – no more burning anything and heating/cooling is done electrically. Is that the intent?
    - HZ: yes, but by the time the CUP is retired we'd be on a net zero playing field. We've invested in fossil fuel infrastructure and we don't want to invest more money into it and change to renewables. The date is up for discussion
    - AA: aggressive date to meet.
    - LC: recommending to how to accomplish with a strategy because right now we don't have a strategy in place by reaching this goal by 2030.
    - SN: we have not developed a strategy to achieve that and even Governors order has until 2040 to clean energy. Major undertaking. Changing way for central energy on

campus. So we'd be changing the method and strategy. One potential method would be to achieve by 2050, not 2030. The grid wouldn't be powered by 2030. Science 1 is needed for research. Brown houses demo – footprint. Balance act of this. We couldn't support fully – it's not even supported by the grid right now.
  - RM: definitely aspirational. PPA discussion and GHG inventory.
  - SN: fossil fuel underneath the RECs – 1/3 increase
  - RM: look at what other peers have done –Stanford example. California is greener for purchase power.

LC: more discussion of 2030 date.

JU: timeline discussion and using other colleges as a model –Princeton example. Adapt to the model and what other people are doing. PPA? We don't have to wait until 2040, something to consider.

<u>Section 6.3</u>

HZ: New construction net zero carbon

- JU: assign to stakeholders and implement how they'll be used. Carbon proxy price for carbon tax price down the line. Schedule and building use. Strengthening online infrastructure before building out physical footprint.
- HZ: sub bullets aren't hard recommendations, just possible ways to achieve net zero new construction
- LC: consider strengthen online classes. So we're not arguing whether there should be online classes All new construction should be net zero, this should be a tactic. The decision making process, acquisition, demo, space, renovation and new construction should be broadened because right now it's limited. And to take into account some of these issues. Should be a focused decision making process.
- AS: decision making campus development should consider net zero energy use or something more like that? Overall campus decision making process. Develop real estate and reduce fossil carbon and not increase.
- LC: NextGen program, that's it for UConn so the next phase is space allocation and renovations. Campus development is a good way to phrase. Not limit to just new construction.
- BH: Apart from rooftop solar – new studies from EPA. New research with solar on glass. Would it be possible to add them to the windows – change out windows on large buildings.
  - LC: we should look at it. Not sure if it's technical feasible or not?
  - AA: what is this? Research efforts towards this type of thing – 20 years ago looked at but not sure if it can be done today but if so that's great. Would just caution if this can be actually done.
  - BH: essentially windows, semi-conductors on polymer film on glass. Still transparent so acts as glass. Can send out study by EPA.
- RM: policies won't be Uconn buildings – could be other folks (e.g. Discovery Drive).
- PF: "maximum rooftop solar" focus on energy improvements will be the sacrifice of something else. Rooftops will be competing with green roofs. Is one better than the other? But we can't

have language in here that restricts us to only 1thing. Different projects impacts watershed, energy use, etc. Phrase it that solar is higher priority but you have to understand that there are other environmental and sustainable items that must be considered. DEEP is very groundwater focus – high level of groundwater in this state, regs and enforcement is constant. Theme to remember.

  - HZ: obviously important. Language should be nuisanced. Rewrite 6.6.3 and we can't be making broad sweeping statements.
  - LC: can't get so focused because there's a broader approach. Language with focus because there's other ecological things to consider

AA: making solar cells on flexible substrates – roll out over a rooftop. Not efficient, not as much power. Easy install but could be looked at for older rooftops.

Section 6.4

HZ: any objection to this section?

- SN: shelter in place. Investment in place that's beneficial in an adverse event. We need to maintain that capability. 2000 international students, still need to be taken care of. We need ability on campus to provide shelter in place, it's crucial for the university. Evaluate and take into account all paths.
- MJ: just took a call, UCONN will be prepping 1000 beds for the state to house first responders.

Section 6.5

HZ: unanimous agreement amongst sub group

Section 6.6

HZ: not just specifics of project by project analysis but also student demands –diversity, water resources, transportation, etc. We should continue this but there's more work to be done.

JU: Continuing assess progress towards climate commitments. Build out how we're going to assess the progress to create accountability so this report doesn't just end up on the shelf and nothing is implemented.

- MW: divide section 6.6. – Equally important and distinct from each other but we should split this up. Assessment
- AA: work out with president separately instead of having within the report to have an extension
- AS: for the assessment, biennial or annual assessment. But we should also have an ongoing set of metrics that we can display on campus so everyone knows where we are and watch it in real-time. Great education tool.
- LC: Section 6.2 assumption was that we are continuing NW Science quad projects because that has been planned and part of academic plan was completed 5 years ago. Does anyone disagree with this? No comments so move forward.

President's Sustainability and Energy Workgroup Meeting
Thursday, April 9th 2020
2:00 – 4:00 pm
WebEx Meeting

FacOps PowerPoint slides (meeting materials in the SharePoint)

LC: The subcommittee work group wants to make sure you are behind the recommendations. This goes to the presidents and has your name on it. Important to the sub group members that we go through the recommendations. Attachment to meeting – pdf with dates and climate initiatives of comparing and summarizes (completed by FacOps/Mark).

MB: review of slides – Governors goal, UConn goal and IPCC goal (45% but 60% was including other factors climate injustice, etc.)

- Slide 1 : how we would meet UConn goals by 2020 and 2025. Curtailment and new construction is the hatched mark.
- Slide 2 : governors goals
- Slide 3: breakdown showing how we would get to the goals based on 2007 baseline, reduce emissions by an additional 5800 tons. Proposed projects to get to the reduction goals.
    - LC: just a strategy for projects both funded and non-funded. There's a lot at play, some will be increased, decreased, and changed. Just keep in mind this is just a strategy on how to achieve.
    - AS: just for 2020 – plausible?
    - MB: at this point, they are do able. Delays with COVID. We're talking about SLED and ECM projects which are ongoing and we believe they will be in place and the commuter carbon offset is a sustainability initiative.
    - LC: funded projects correct?
    - SN: approved projects and we have funding in place but in various places in design, development and/or construction. SLED re-lamping on going phased project – this year it is funded and planned for May. Obvious may be some delays.
    - LC: change funding to approved
    - AS: is COVID going to modify commuter offset
    - SN: yes, likely it will. Tradeoffs. Previously mentioned any of these can be increased or decreased.
- Slide 5: additional reductions in 2025 time frame to meet 30% reductions. Additional 19,000 metric tons. In addition to the 2020. Projects listed is the lab ventilation, building improvements, SLED, ECM projects and the geothermal projects (CESE/BISHOP), green vehicle, and digester. Green Vehicle is to increase # of electric and hybrid in the light duty fleet. So again, this is what we need to do in addition to the 2020.
    - RM: ESCP project is the old ESCO project?
    - MB: Phase 2 of the ESCO and something we talked about previously. Phase 1 looked at science buildings and would include steam lines.
    - RM: where is the steam line?
    - SN: specific buildings and steam lines has not been determined. It would be based on a previous study for the utility steam lines that would need repair.
    - JU: steam line replacement put us in place for the electrification.

President's Sustainability and Energy Workgroup Meeting
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2:00 – 4:00 pm
WebEx Meeting

  - SN: replacement of lines isn't that expensive compared to energy loss. We would be looking at existing and infrastructure to be maintained and continue to serve the existing buildings so they remain functional.
  - JU: feasible to replace not with steam?
  - SN: yes, we'd start to look at the area in fine arts. Good candidate for hot water conversion.But an assessment would need to be done. Conversion would be exterior campus and then work towards the inner parts of campus for conversion. That's how we would develop over time.
- Slide 6: additional projects for the next time frame to get to the 45% reduction based on the EO goal. This case we have an additional 10 MW solar (for a total of 15 MW), steam line repair, Torrey Life demo, and compost expansion. Again this is in addition to the other time frames in order to get to the 45% reduction goals.
  - MW: attempt to 60% goal – strategy similar to continue on.
  - MB: 60 % instead of 45%, it's a 15% reduction but we would need to just carry it along
  - AS: new construction be net zero , then only curtailment would be included in the hatched section
  - MB: yes, that section would be reduced
  - AS: we would be closer to 60% and the only effect is curtailment.
  - SN: diesel uses is based on unavailability of off campus uses. We would need to go to on campus diesel generators.
  - LC: new construction is done by 2025. Most of it will be renovation. We'll take another look
  - AS: the point is that the 60% is not unachievable – it's possible.
  - LC: if we align ourselves with IPCC. We don't want to set a goal, that's impossible and then not meet it at all.
  - RM: 5 MW and 10 mw scenario, does that include other types of renewable. Solar is cost competitive. But other forms are more competitive such as geothermal.
  - LC: just a strategy, will be adjusted and changed as this progresses. This is just a way to get to it.
- Slide 7: all of the previous slides and total emissions we'd need to reduce. Includes EO 1 reduction goals about 37,000 metric tons and the breakout of types of projects.
- Slide 8: same as previous slide but shows how to meet the IPCC goal. Again just a summary of the previous 3 slides.
  - JU: update to add the savings to include electrification and near term changes that are easier to achieve. Consultants try to figure out how to accommodate wind either here or elsewhere. As winter generation profile, it's pretty ideal regarding campus load and when it's peaking. We could include in potential options.

LC: the matrix that we discussed yesterday. It will be shared with the group and includes values in terms of carbon and will be helpful.

  - TStD: behind the scenes, working with Stan and his group looking at projects and situational manner with regards to actual project on the university campus as opposed to global/national average and understand how the projects will play out. What are the real costs. Today we talked about electrification. Campus has been built out 140 years with combined thermal and electric energy distribution system. If we move all toward electric, it will put a big load on the electric system which we're already struggling with campus demand we're trying to meet today. Bigger strategy to achieve the right goal in the cost effect, most resilient and right way. Beginning discussions but will included in the next layer – later this year and what are the smart decisions on how to achieve. Not stranding assets is a key part and utilizing to full extent and not switching too quickly.

JU: grid structure analysis. We should make sure we're pushing that analysis further.

- TStD: framework master plan started in 2015, upgrading electrical system and coordinating with Eversource to understand how power enters campus. At this point we're about to embark on major construction and upgrade the system to bring it to the 21st century and upgrade so it can support growth. We'd need to further that plan and talking to Stan + group how to proceed. Right now to add another Eversource substation, type of electrification to move to a more renewable energy would require a 3rd substation to support wind energy over the Eversource grid.
- SN: control ability to switch between types of power – solar, Cogen, wind, etc. requires a sophisticated control system.

Closing Comments

LC: Discussion about the next few subcommittee workgroup meetings for Tuesday, April 14th and Tuesday April 21st 3:00 pm. Laura will send around the options.

HZ: as important individual discussion is. IPCC goal for global warming, should be the bare minimum to remember and think about. Not to think of it as a goal but the bare minimum but to ensure we have a shot at a livable planet in the future. Very important to remember the goals proposed are the bare minimum for a planet for us to live in.

LC: very important point and capture that in the report. Report will be on SharePoint and folder for comments to be added. Open up to editing again. Send over to Laura. Open to format and any other comments. Only first draft and we will continuously revising and updating. Deb will send around the link again.

SJ: Stated the meeting was very collaborative and going in the right direction. Thank you for leading this and everyone's participation.

Meeting adjourned.

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓	✓	✓	✓	✓	
Carnahan, Kerry	✓	✓	✓				
Chen, Ming-Hui	✓				✓		
Hermoza-Ricci, Brandon	✓	✓		✓	✓	✓	
Jordan, Scott	✓	✓	✓	✓		✓	
Li, Baikun	✓	✓	✓		✓	✓	
Xinyu, Lin	✓	✓	✓	✓	✓	✓	
Nagireddy, Hamaja	✓	✓		✓	✓	✓	
Roach, Natalie	✓	X	✓		✓	✓	
Segerson, Kathleen	✓	✓	✓	✓	✓		
Seth, Anji	✓	✓	✓	✓	✓	✓	
Ursillo, Jonathan	✓	✓	✓	✓	✓	✓	
Volin, John	✓	✓			✓	✓	
Willig, Michael	✓	✓	✓	✓	✓	✓	
Zehner, Harry	✓	✓	✓	✓	✓	✓	
Cruickshank, Laura	✓	✓	✓	✓	✓	✓	
Jednak, Mike	✓	✓	✓	✓	✓	✓	
Miller, Rich	✓	✓	✓	✓	✓	✓	
Ferri, Paul	✓	✓	✓	✓	✓	✓	
Sean Vasington	✓		✓		✓	✓	
Nolan, Stan	✓	✓	✓	✓	✓	✓	
Carone, Debbie	✓	✓			✓	✓	
Mark Bolduc		✓	✓	✓		✓	
KATIE MILARDO		✓	✓	✓			
Patrick McKee	✓	✓	✓	✓	✓	✓	
Tom St. Denis (BVH)		✓	✓			✓	
Ashley Patrylak (BVH)			✓	✓			
Scott Waitkus (BVH)			✓				
Zachary Bloom (CES)			✓				

PWGS Sub-Group Meeting – Revised Draft Report and FacOps Slides (revised 4/16/20)
Friday, April 17, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, John Ursillo, Harry Zehner, Mark Bolduc, Katie Milardo, Tom St.Denis, Scott Waitkus

This meeting was to discuss the documents sent yesterday (including the matrix) and the draft report (draft updated today and can be found on SharePoint)

1 . Review of the PWGS – GHG Reduction Projections 4-16-20 slides (provided via email prior to meeting)

- M.Bolduc provided an overview of the slides and the changes/updates
    - First 3 slides go through different goals and baselines
        - Figure 1 – UConn Goals based on the 2007 – 20% 2020 and 30% 2025
        - Hatched mark – curtailment and construction projects. Of the hatched marks 30% is curtailment and 70% is construction projects.
        - AS: does the % change overtime? New construction includes the SUP?
            - MB: Approximate but as we move forward the % may change. No, the new project doesn't include the SUP. Any new construction project that came online since 2012 (Oak Hall, Laurel Hall, Engineering Science Building, Werth Res Hall) Projections include Science I and a new Res Hall.
            - SN: worst case year and rounded up. Average is something similar to 7% but the 30% is the worst case – conservative view point for oil usage.
            - LC: only approval for Science I at this time.
        - AS: climate justice and IPCC report – actual goal. Science and the information about emissions and reductions requirements is changing annually (Emissions Gap Report). Language is getting more and more frantic each year. Wants to share the language in the report – included language in the comments. Move this language up towards the front. Critical to highlight not only reductions but emissions – net emissions and how are they declining over time.
            - HZ: use gap report as mentioned and measure how UConn is doing and update goals.
            - LC: Angie to draft language for the report
        - RM: Curtailment question – wont natural gas decrease over time? Wouldn't curtailment days increase over time. No new pipelines in the state and MA banned any frac gas. Should this be factored in the future if we're going to increase our use of natural gas – will affect price, frequency of curtailment and emissions.
            - SN: 30 days is just an estimate, there's no restriction we're prioritized in sequence with all other entities in the state. Home heating and medical is always #1.

LC: provide phone # so Laura can contact people to further discuss revisions. Move forward because we only have 30 minutes.

PWGS Sub-Group Meeting – Revised Draft Report and FacOps Slides (revised 4/16/20)
Friday, April 17, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

- M.Bolduc similar concept as first slide for the second slide. Figure 3 is the IPCC goal looking at 45% and looks like this will be changing based on this discussion.
- Figure 4 required reductions and the proposed projects included.
- Figure 5 is a summary showing what we need to do to get to 30% and includes types of projects we would need to look at to get the additional reductions.
- Figure 6 is for the 2026-2030 time frame and what we need to do to get to the 45% reduction and IPCC goal.
- Figure 7 is the summary slide – 30,000 metric tons reductions from this point to the end of 2030 to get to 45%. If we're talking to 60% we'll need additional reductions.
    - RM: carbon offset program, still a lot of planning that hasn't begun. Patrick had a conversation with University of Florida – they've done a lot less with the program than anticipated. We'll need to plan this with Facilities/Transportation and who knows what will happen next Fall. It's got a lot of potential but would caution that the program still has a lot of work.
    - JU: Governor is saying electric grid by 2040. Not get to caught up in interim goals but get in line with the 2040 goal and get too caught up with the baselines, etc.
- LC: any comments and/or thoughts on the slides because we'd like to include as an appendix.
    - AS: slides are great and we need to include to ensure funding is there
    - JU: electrification is new but we should try and incorporate something in the future.
    - AS: electrification as a separate item to address
    - LC: electrification isn't included in these slides. Yes, would involve a cost. Possibly include something for electrification in the next few weeks if we have time but it's very uncertain. The slides shown have straight forward slides.
    - MB: solar is included so some discussion is here. Preparing for electrification but no benefit until you get to that point.
    - SN: until we have green power available, electrification would increase emissions. So we need to solar panels.
    - AA: it's bad until you have a renewable source. Key point – electrification is good only if its paired with renewable.
    - TD: yes, exactly right. 15 MW of solar in the 2030 timeframe on the matrix.
    - JU: these need to be planed concurrently. Gains only happen with renewables but we need to make sure we're fast tracking and align with the electrification. We also create heat/cooling and create infrastructure to accept, this is key. Discussion about emissions with Cogen and creating more emissions, etc.
    - TD: get electricity to campus and then distribute around campus.

2 . Review of the Matrix and Strategy

- LC: includes baseline and reductions. By the time we get to 2030 we get to align with the 45%. Walk through of the matrix and explanation. Sent over to the group in an excel format.
    - MB: total is the net of the increase and decrease that Angie was talking about earlier

PWGS Sub-Group Meeting – Revised Draft Report and FacOps Slides (revised 4/16/20)
Friday, April 17, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

- LC: Review of projects and proposed that are funded. Worth second Science I and new residence hall if we tear down older residence hall but the square footage should net out to zero. Again it's a mix of funded and not funded projects.
- TS: 1000 ton benefit if we tear down Torrey and build a new one.
    - LC: conceptually shows you what an efficient building can do regarding emissions
- BL: explanation of the black – column E, 2025. Why is it still increasing in line 6, 7 and 8?
    - LC: increases with new buildings – heating/cooling, etc. explanation of the metric tons and new buildings, etc.
- LC: review and let Laura know if you have any questions and/or need to discuss as this matrix is reviewed during the course of the week.

3. Electrification Discussion

- LC: review of BVH's summary on what we need to do to electrify the UConn Storrs campus
- TS: prepare and impact of electrification for the campus. Working with FacOps, UPDC, and Eversource. Load shedding discussion and the ability to move energy around similar to steam energy right now. Computer operating system for electric is required for the electrification.
    - AS: Load shedding –move from campus to grid? What does it mean?
    - TS: No, ability to switch the way we feed electricity to buildings or groups of buildings – within campus. Two fold –distribution on campus and within eastern Connecticut as we become more and more of an all-electric campus (in order to keep labs open in emergencies)
    - SN: prioritization sequence for buildings – which building can go without building before it has adverse effects.
    - TS: For example, Gampel down but not a dorm during a winter storm. Right now we don't have that ability.
- TS: Transition from fossil fuels to electric as it was presented in the last meeting (last meeting and the charts shown). This isn't the only way to do this but it's one path. Time consuming and expensive –not sure how to put this into the matrix but we need to identify. It's very important for resiliency for campus.
    - AS: funding from the Feds? Renewable energy funds somewhere to help cover the cost?
    - TS: more than just $50 million dollars in various chunks. Substantial engineering project and cost to the state, university and it will take a lot of time. So we want to understand. Lots of coordination with utilities, etc.
    - AS: savings available based on the electrification.
    - LC: we haven't gotten to the $$$ part, right now we have placeholders for what we thought it might be. Starting to list the things and figure out a timeline. This is likely the next phase of this. We won't get anywhere if we get stuck in the cost aspect.

PWGS Sub-Group Meeting – Revised Draft Report and FacOps Slides (revised 4/16/20)
Friday, April 17, 2020
4:00 p – 5:00 p
WebEx Teleconference Meeting

  - AS: the timeline should be by 2040.
- TS: 2025-2030 goal summary. We're trying to get these big picture projects into the sustainability timeline to try and meet that goal. Large transformer located at the SUP (2025 constructed) in order to prepare for the electrification goals in the overall sustainability goal. D
  - AS: further discussion regarding the current equipment – transformer and additional units. Renewable sources working with the equipment and what is needed and BVH provided clarification.
- TS: Cogen replacement date and the transition from fossil fuel/cogen system to electrification system. The system BVH has been looking at is ground source and heat pumps. Difficult with campus buildings – real estate might be complex. Technology might be different in the future or maybe other ways to create steam and not have a big carbon footprint.
  - AS: where is the SUP in all of this?
  - LC: everything is done by 2023. North wing of Gant is the last piece.
  - AS: gas fired generator installed at the SUP – when can we wind that down.
  - TS: backup right now for the boilers at the CUP. Original plan was 2 turbines in the SUP but no longer discussed.
  - LC: boiler, 2 diesel generators (emergency power), 2 electric and 2 steam chillers. As it's currently authorized.
  - TS: and steam service to heat the Science 1 building (steam from the CUP). Steam in the SUP is a backup.

<u>Closing Comments</u>

LC: Laura to discuss the report separately with people. Wanting to make sure the report is complete on time and she wants to go over it individually.

- Discussion about cutting parts of the report so actionable items are clearly seen
- Two more meetings – next Tuesday and the following week on Monday.
- Last meeting with the entire workgroup is the 4/30. The documents including the draft will be on SharePoint
- BOT meeting – some conversation with the board but the report would not be final until June.

No other thoughts and/or comments – meeting adjourned at 5:25 pm.

PWGS Sub-Group Meeting – Revised Draft Report
Tuesday, April 21, 2020
3:00 p – 4:30 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Alexander Agrios, Anji Seth, Baikun Li, John Ursillo, Harry Zehner, Mark Bolduc, Katie Milardo

LC: Agenda today is to focus on the report. Schedule for the report - any changes and/or revisions need to be completed by Friday, April 24th and final review and edits a few days later on Sunday/Monday. So that the final draft can be updated for the workgroup on Tuesday, April 28th.

1 . Review of the Draft Report including comments and revisions

General overview of the draft report. JU to make live edits within the document on SharePoint

- Sec 3.2.3 Climate justice and the Scientific Consensus
  - HZ: summarized and cleaned up the paragraph. AS to add any additional information.
- Sec 5.2.2 Energy : Current Demand and Sources
  - LC: Description of Scope 1, 2 and 3 and what they are. A sentence and/or a footnote is needed.
  - JU: add something in the appendix or foot note
  - AA: brief text definition or diagram to illustrate what they mean but it should be in the body of the paragraph.
  - SN: we can reference the term sheet and will keep it brief.
- Sec 5.2.3 Human Behavior
  - HZ: included a brief paragraph with info regarding the program, more concise
  - JU: will delete the subsequent paragraphs to avoid any confusion
- Sec 5.2.4 Emissions credits (revised paragraph)
  - JU: before we had included carbon offsets but wanted to include something that we do. RECS and funding for efficiency efforts. Stan assisted with the clarification and Rich regarding the UConn Forest and Compost info with regards to credits.
  - RM: clarification of rebates and RECS. Rich can include additional information regarding forest and compost.
  - SN: class 1 RECS received from Fuel Cell at the Depot campus and we should make note of that.
  - JU: this section is designed to be what the current status is and Section 7 includes the various options.
- Sec 5.2.5 Energy Market and Legislative Climate
  - JU: we haven't discussed the state of things, rapidly changing and will impact the options. If we're saying to wait for technology, we should explain what the current technology is so there's an understanding. Include legislation info and status of things.
  - LC: discussion of appendix with info already included
  - JU: reference the appendix and add a sentence to as such.
  - RM: consultants that should provide info?
  - SN: CES has projected current and future info but it would be an appendix item.
  - LC: Yes, and Rich to include any additional information that he feels there might be something that is left out. A lot of what we're doing in this report is the info we have, recommendations, etc. but there will be a lot of things that are uncertain because of the COVID pandemic. Everything right now is up in the air.
  - AA: not the optimal time for figuring out what to do in the future because everything is upside down and up in the air right now.

- JU: paragraph to include uncertainty so there's an understanding. Also an ongoing assessment so recommendations can be fine-tuned over time and adjusted. Just because there's uncertainty we don't want to not suggest things, we should try and provide recommendations with the best knowledge we have.
- LC: framework plan – living document with an option for change. There are absolutes and principles that you have to do but there's room for continued improvement.
- AS: recommendations are based best available science and best available science is continuously being updated and an adaptive framework then it's built in.

- Recommendations Section 6.1
  - HZ: discussion of the goals, interim goals for tracking, 60% is aspirational and emphasize we should be doing more than what the standard is. Rewrote the section to make sure it was official, clear and concise.
  - LC: Question that has come up. Technically speaking, do we have a way to accomplish a 60% reduction by 2030? What would we have to do? Stan?
    - HZ: the most key is net zero by 2040, updating goals in terms of long term vision. UConn should be embracing goals with climate justice and international science conscience. 60% is just higher than 45%. We should have something in line or higher.
    - AS: UN Climate summit for a few years. 3 years ago –press conference in 2017, scientist presenting results was asked by a NY Times reporter: it sounds what you're saying to meet the 1.5 degree goal, we have to get to zero emission by 2050 and what does that mean for developed countries? And the scientist responded that developed countries need to get to net zero by 2030. Understood it's not ideal but just what the scientific community has said.
    - JU: 2040 deadline aligns with EO3. Good to have that perspective about where the ideal place is and where we are now and the compromise. 2040 seems to be like a good compromise.
    - AA: net zero by 2040 seems to make more sense. Countries and States seem to make goals that are unachievable. So, 60% by 2030 makes sense if we need to get to a certain place. It'll likely be harder as time goes on.
    - AS: question is how we address the hatched area.
    - JU: eases concerns to meet this but Tom (BVH) explained a general framework on a 2050 timeline and we're looking to bump the timeline up on a 2040 horizon. It'll require a more immediate action and sense of urgency.
    - SN: Electrification topic – until grid has green power available it doesn't make sense to not use waste heat from Cogen. Hydrogen based fuel seems to meet those goals. Lee Lankston – combustion jets are already being produced. We wouldn't need to do the full wire and change out of the entire campus. Wouldn't be such a constraint. It's not just UConn wires, it's also Eversource and how we would include that infrastructure. Turbine already using hydrogen up to 50% fuel supply – just converting fuel. Constraints: fuel storage. We should also include this as a potential path. WE should fully vet each and every option. The hydrogen is market ready technology we could use today.
      - BL: by 2030 60% emission reduction and 2040 net zero. Electrification and solar might not be able to achieve this goal and would we have to combine

hydrogen? Or can we just choose one of the options. Major concern is storage and how to store. Safety and cost issues.
        - AS: how is the hydrogen is generated?
        - AA: a lot of issues, storing/generating/pressurizing. In an aircraft not many options.
        - SN: approached previously through SECAT for fueling station. Possible concepts, storage and options already out there. Benefits and constraints need to be evaluated and reviewed. ISO wind power for 2040 is up in the air and it may not be met by that timeline.
        - JU: we don't have to wait for the grid, we should facilitate, invest and not wait. We need to keep the options open. IF we decide to make a transition, we're not fully committed either way.
        - SN: agreed. Likely a blend of various approaches and aspects of what is being discussed.
        - LC: include other technologies as it becomes available in Section 6.3.4.
- LC: revise the matrix in order to get to the 60% so we have a strategy and approach on what we'll need to do.
    - MB: we can review and what we would need to get there. Is it realistic, that's another question.
    - LC: we need to actually have something that says we can get to this goal and here's how. It's not talking about money and a definitive way, it's just a path and options.
    - HZ: 2050 goal – the 2040 will be an accelerated approach.
    - MB: matrix only goes to 2030 but other graphs for rate of reduction to 2050. Between 2030 and 2040, the assessment will need to be determined on how we will get to zero. Part of the recommendations – comprehensive study to determine the best strategy and technology available to get to zero by 2040.
    - RM: a good spot for carbon offsets. Example: DUKE and what programs they have done to meet carbon reduction goals.
    - MB: 60% goal, can we use the offsets as part of the path. Will be added as an option.
    - HZ: offsets is an option if we couldn't meet the goal, last resort to get to the goal. Eventually you're going to stop using offsets.
- Recommendation Section 6.2 Halt expansion and construction of fossil fuel capacity and steam infrastructure on campus, including regional campuses and UCHC.
    - HZ/JU/AA: clarification on the term "electrification" needs to be included
    - SN: careful about existing infrastructure and how it's worded.
    - JU: increase strategies and not just replacing steam pipe –huge costs that can't be used elsewhere.
    - SN: you might be able to take the carbon out of the equation but still have steam, existing infrastructure and not abandoning.
    - AA: you have other options and paths towards getting emissions decreased instead of electrification. Hydrogen is not an energy source, the option is a little bit late to the game and his opinion is that folks have been moving away from this and towards electrification.
    - SN: discussion about benefits and constraints with regards to serving campus 24/7.
    - LC: Alex + Stan conversation to add a recommendation or if there's something else that should be included as an option

PWGS Sub-Group Meeting – Revised Draft Report
Tuesday, April 21, 2020
3:00 p – 4:30 p
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- Recommendation Sec 6.3 Should we keep a reduced content but eliminate the bullets because they are now listed in Sec 7?
    - JC: shorten this up since it's already included.
    - JU: synergize and revise
    - JC: general statement and details are in strategy section. JU to revise.
    - RM: geothermal needs to be expanded especially if hydrogen is not a viable option. A way to replace the steam.
    - JC: should be in section 7 – details and information about geothermal in the later section. RM to write something up so it can be reviewed.
    - BL: wastewater and anaerobic digestion comments not included? Willing to include a section on this topic.
    - JC: Sean, archived comments included in a previous document? Baikun to include a brief write up.
- Recommendation Sec 6.4 Campus Development
    - JC: design guidelines language and additional information
- Recommendation Sec 6.6 Future Iterations of the Working Group
    - JU: in Section 4 reference of Section 6. Future and next steps for Working Group and the path forward.
- Strategies Sec 7.4 Carbon offsets – what does the 2nd paragraph mean?
    - JU: water resources management is included in future path. Finalizing electrification/energy planning and going through the long term planning. Adaptive management plan. Communication mechanism and how to get that out to the student body.
      *LC to send a separate email – with additional revisions, request, etc.
    - LC may not include anything else – strategy will need to be further looked at and include cost.

2 . Review of the Draft Report Appendix information
Appendix A:

- We need to assign who is responsible for starting to pull together this Appendix
- Should we include the DRAFT Matrix, the slide deck we reviewed on Friday, the chart that lists all the initiatives and baselines? It seems like a good idea to me.
- What other technical information should we include?
    - RM: we need an outside contractor to help tell us what the future will hold
    - LC: we likely won't get that in a weeks' time. Stan, can we get anything on this from Avant or CES?
    - SN: existing reports on portions of Class I and 3 RECS, Carbon price has been tabled until the next legislative year.
    - LC: these could be links but for right now it could be see Appendix B. Stan to pull what he can pull for #2 A and B.
- Current and Emerging Technologies with Development Timelines(A)
    - LC: listed as an alternative technology, hydrogen here.
    - SN: yes, should be included here
    - BL: discusses current/emerging and development timelines – do we need to include timelines?

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- LC: great point and no, we will remove.
- Section b – Strategies
    - LC: document and/or documents to be attached
    - RM: carbon offsets has been moved
    - LC: carbon offsets has been moved and fully discussed and we likely don't need to include. This would be additional strategies to include. For example: virtually net metering.
    - AS: additional strategy details is what this section is intended for.
    - LC: this section needs to be developed more and/or removed. We need a volunteer.
    - RM: move some of these into other discussions.
    - LC: in general this should remain as an appendix. We'd like to keep the other sections of the report concise.
    - RM: some of these approaches provide a way to meet the other strategies.
    - LC: instead use methodologies instead of strategies in this section.
    - SN/RM: continued discussion about virtual net metering and the grid.

3 . Additional Discussions

- HZ: Oxford University divested from fossil fuels.
- LC: spirit of transparency – will respond to the questions and responses to the group re: Rich's emails. And will be sent out to the subgroup.
- BL: comment and discussion about cost
    - LC: matrix includes cost? Cost will be phase 2 of this process.
    - MB: yes, it shows what we need to do to get to a certain % but doesn't include cost.
    - LC: if there's something that should be added, please add Baikun.

- AA: review on the document? Just do track changes.
    - LC: correct. Review button and showing the editing of "reviewing" document
    - RM: version of the document
    - LC: Version 3 all changes but will be updated for V4 and date will be updated

<u>Conclusion</u>

Any changes need to be included by <u>Friday.</u> So that the subgroup can review over the weekend.
4/28 final. Not perfect and will need more work but we just want to be as consistent as we can be.
Keep the report as short as possible.

Next meeting is next Monday – 3pm. One more discussion and uploaded on Tuesday for the rest of the workgroup.
Should anyone want to have a separate discussion, we can certainly do that.
Let Laura know by email if another meeting is needed for Friday 3pm.

***No other thoughts and/or comments – meeting adjourned at 4:45 pm ***

PWGS Sub-Group Meeting – Revised Draft Report
Monday, April 27, 2020
3:00 p – 4:30 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, Harry Zehner, Mark Bolduc, Katie Milardo

Agenda today is to focus on the report: Executive Summary, Executive Recommendations, Section 6, Section 7, and Appendix A. Review of any changes and/or revisions need to be discussed and approved by group for final review and edits by Laura.

1 . Executive Summary

General overview of the section and the changes/comments

- HZ: self-explanatory, sets the stage for the rest of the report
  - RM: sentence regarding the senate strike
  - AS: strike was supported by the senate resolution - suggestion
  - HZ: to make the addition to the section
  - No other comments and/or revisions

2 . Executive Summary of Recommendations

General overview of the section and the changes/comments

- Term “renewable” to “clean” discussion
  - HZ: legal definition and meaning, would prefer to be more specific. Prefers the word renewable.
  - AA: adding “clean, renewable”
- Recommendation of halt new fossil fuel capacity and infrastructure at all campuses and full electrification of UConn’s heating and cooling by 2040.
  - AA: Good conversation with S.Nolan Friday. Central Utility Plant and best way to use fossil fuels currently. Question is what are we doing beyond 2030 and 2040. Do we mean not burning fossil fuels or shutting down and going electric? What do we mean by zero by 2040. What’s the vision and we need to decide that.
  - HZ: NetZero – you’re not producing anything.
  - SN: Scope 2 (purchased power) emissions are dirtier than what we have currently.
  - LC: concern about timeline and schedule.
  - HZ: valid concern but as time goes on, stricter restrictions and more stringent in the future.
  - AA: future of the CUP and the reality of this statement.
  - SN: you’ll always need a backup for full electric power. Example of winter and not being able to heat/cool the campus. Additionally, steam infrastructure is steam/condensate pipes. If you want to electrification campus – install new wires, you’ll need to dig up the road and install or you can use the steam infrastructure tunnels and already in existence
  - AA: Regarding the roadway, wouldn’t you need to replace over time anyways?
  - AS: Use geothermal heating/cooling ground source – the electricity required is small for pumps and heat exchanger. Why changing to geothermal would require so much?
  - SN: to do the core of campus – you don’t have land area and would require more traditional method. The exterior part of campus has some availability.

- AS: retrofit with new technology for drilling under the building.
- HZ: revise electrification to use another term to include geothermal. We're consistently not taking into account is how dangerous it is to stay with using natural gas. Weigh both sides of acting vs. not acting in that sense.
- AS: best available technologies and what it means? Revised to be specific to best available renewable technology.
  - SN: EPA term used in permitting for what is available in the market that's not beta tested.

- SN draft language in the comments to include in this section (Section 6.2) and discussion of the language.
  - HZ: doesn't accept the language. Makes it seem like this is a policy issue. This is our responsibility in a global sense and uphold something. Doesn't accept and should immediately halting. Sorry to be so blunt but the language needs to remain.
  - AS: we can't expand it.
  - LC: suggestion to different ways of expressing this item for the full workgroup Thursday. But ex-officio are not authors of this document so it's up to the professors and students on moving forward on the language in one particular way. It should be how you want to recommend to the working group.
  - HZ: aren't we already currently doing the statement? This is already a goal that the University has. Language is important – if the workgroup goes to the BOT, it looks like if we keep doing what we're doing then it's fine.
  - AA: Concern about resiliency and would like to have the CUP as a backup system. Netzero vs. zero? Language revisions to say zero Scope 1 and Scope 2 emissions.
  - AS: CUP is going to phase out. We're saying net zero because there are other sources of emission other than the CUP. R.Miller has written up a good summary. Offsets for Scope 3?
  - LC/SN: in the time of transition to get to zero we're not going to get there overnight we may want to increase offsets for awhile.
  - RM: interim milestones will help you get there. Ultimate goal zero Scope 1 and Scope 2. You're continually making progress towards hat ultimate zero but you can still use your RECs and offsets. Offsets should be used for Scope 3 because it's hard to manage/control. RECs can be used like we currently do – could be phased out by 2040.
  - AA: definition of Scope 1, 2, and 3 up front in the document.
  - LC: Baikun/Angie/Alex to re-write something for the report ----

<u>3. Section 6 Recommendations</u>

- Section 6.2 : Discussion about netzero or zero carbon. Zero for Scope 1 and Scope 2 – needs to be clarified.
  - RM: sentence for interim milestones should be included in this section. FacOps graphs and summaries for planning.
  - LC: unclear on defining the percentages and whether or not they can actually be included

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- AA: how finely does it need to be subdivided – 2030 is on the way to 2040.
- AS: 5 year targets similar to Paris review. Interim targets to be specified.
- LC: agreed, but unclear on what to specify if we don't know what should be included. Angie taking the lead to revise.
- AS: definition on near term and long term so we understand what they mean.
- LC: 2030/2040/2050 – specific dates to use for this?
- SN: 2030 – near, 2040 – mid, 2050 – long is what was used for the slides and we would need to revise if the info.
- AS: used the term "may include" and questioned and we need electrification to be changed to "mid term".
- SN: we need additional information to determine viable locations, looking at other areas on campus.
- AA: the use of "may" makes sense in the way we've described. Immediate steps vs near term and separate into two bullets.

- Section 6.3 : invest in utility scale solar and other renewables and investigate technology
    - BL: additional language for each bullet for term?
    - LC: too much stuff in the bullets because the two recommendations are different. Discussion of the section and bullets. And whether to merge or not.
    - HZ: connection between 6.2 and 6.3 and more specific to make the connection whether or not we're merging the sections. Language added in the executive summary of recommendations and also revised in Section 6.3.
- AA/AS/BL : Discussion of anaerobic digestion and methane.
- AA/BL/SN : hydrogen storage discussion to also be addressed in this area as part of a storage discussion
    - LC: move the conversation about hydrogen should be moved to the Appendix A Current and Emerging Technologies.
- HZ: loop Jon in for assisting with rewording and reworking this section
    - AS: add a link to the Appendix

<u>4. Section 7</u>

- LC: we don't have a concise pattern on how the strategies are addressed in Section 7.0. Originally we discussed Strategy A, B and C from the outline. We really only have 1 strategy. Discussion of graphs and tables.

<u>5. What and how to present the report to the Working group Thursday.</u>

- At the meeting, we'll discuss the executive summary, executive recommendations, recommendations and the graphs and matrix.
    - Executive Summary and Executive Recommendations will be discussed by Harry.
    - Recommendations will be discussed by Jon, Alex, Angie, Laura, Rich and Harry - as outlined in the report.

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- Restructure of Section 7 and include an introduction statement for strategy. Baikun to write a summary for the introduction section. RMiller to slim down the carbon offsets discussion and to discuss Scope 3.
    - HZ: recommendation should be a format for Q+A style to the group
    - AS: yes, and take questions by discussion point
    - HZ: encourage the working group in its unfinished form and the entire version to be available on SharePoint.

6. Appendix Discussion

- Laura added info, Stan added links, and Mark added a summary of project info.
    - AS: will look at the appendix to see what makes sense to include or remove.
    - AA: to add in a hydrogen discussion
    - BL: appendix is too long and needs to be shortened
- LC: need to summary and make the appendix concise
- LC: methodologies discussion and should we eliminate this section? Some of the items are already discussed in the report. Will leave alone. Appendix B is already put together by Sean.
- RM: divestment question.
    - LC: hasn't seen a copy of the senate resolution?

Conclusion

Different sections assigned to different people. Revised sections due by 5pm tomorrow, Tuesday, April 28th. Laura will pull the report together and will work on it Wednesday and issues to the workgroup Wednesday late and/or Thursday morning.

Additional follow-up discussions after this submittal. The group will need to complete a final draft the first week of May. We'll need a good document to provide to the President/BOT. Another discussion with the Working Group to set something up for the June BOT, more information to be determined as far as schedule, etc. Also, May 13th to discuss this topic at BG +E.

***No other thoughts and/or comments – meeting adjourned at 5:22 pm ***

Presidents Working Group Meeting
Thursday, April 30, 2020
2:00 p – 4:00 p
WebEx Teleconference Meeting

Attendees: Scott Jordan, Debbie Carone, Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Himaja Nagireddy, Paul Ferri, Anji Seth, Baikun Li, Harry Zehner, Natalie Roach, Michael Willig, John Volin, Kathy Segerson, Jon Ursillo, Xinyu Lin, Brandon Hermoza, Mark Bolduc, Katie Milardo

Introduction

Previous meeting minutes approved.

Agenda today is to go through the presentation of final draft executive summary and summary of recommendations with questions and answers. Also to discuss the next steps for final draft and presentation of the report scheduled for 5/11 to President Katsouleas and Board Chairs. Students invited and to take the lead members to join to help answer questions. Board will be meeting in June and potentially May. If time permits, a review of the Greenhouse Gas reduction projections and matrix will be completed.

1 . Executive Summary Review
General overview of the section and the changes/comments

- HZ: self-explanatory, sets the stage for the rest of the report
    - KS/JV: this section should be background, not executive summary. Suggestions on how to change. Background is redundant.
    - HZ: potential solution to cut it down to a sentence and use the space to provide an executive summary with the outline of the report.
    - AA/BL: suggestions on how to restructure. Essentially to cut it down to 1 paragraph.
    - KS/SJ/AS: Preface idea and cover letter or transmittal letter to be done.
    - HZ: revise the current executive summary to a preface or cover letter and executive summary should be the facts inside the document.
    - MW: 1st and last paragraph could be context for the executive summary. Guidance to UConn to basically walk the talk and be a leader.
    - LC: understands the request – will be revised. Could be a cover letter, transmittal or something similar. Reminder: when the document is updated into Sharepoint the formatting gets changed and messed up.

2 . Executive Summary of Recommendations Review
General overview of the section and the changes/comments

- LC: discussion of the formatting for the recommendations.
    - AA: remove section A and B.
    - HZ: agreed. Could likely be summarized in a few sentence. Details are in the report.
    - BL: combine and each recommendations #1-6. #1 we could revise so it's more concise with the others.
- HZ: brief review of the content of this section. Items haven't changed since the last meeting, basic goal are the same. Goal #1 goals with zero carbon emissions by 2040. Goal #2 stopping fossil fuel capacity and transitioning to electrification and geothermal by 2040. Goal #3 increase investment in renewable energy. Goal #4 is campus development and everything we're doing is

about zero carbon by 2040. Goal #5 is divestment. Goal #6 is the workgroup charge and next steps.

- JU: Goal #6 accountability and communication mechanisms but also using the phrase ongoing analysis. So this is a living document which is constantly being updated and staying on path to reach these goals rather than creating the goals and shelving it.
- MW: Question for Goal #2 – Law School a Regional Campus? Or should it be called out separately. We should be explicit and not exclude them.
- AA: all campuses is all campuses
- KS: formatting suggestion. Each recommendation should include a bolded summary. Phrase that captures what the recommendation is. So if someone looks quickly they can see.
- SJ: Question and clarification on Goal #2. WE want to understand this is the presidents working group

****KDM lost connection for 15 minutes*** was informed a discussion about Science 1, SUP, and future projects.*

- Discussion about matrix and projects.
    - PF : discussion about his opinion of certain items. UConn has and will continue to have great success implement green energy and can follow a similar model.
    - HZ: agreed but these are different problems – if we have mediocre stormwater infrastructure the world's ecology doesn't collapse. I f we don't transition to green energy in the next 10-20 years it's likely apocalyptic.
    - JU: opinion on comment and discussion about projects, tradeoff and the meaning behind the recommendations.
    - KS: executive summary does not have the matrix at all. Executive summary should include a note for tradeoffs and long run gains but nothing is recognized. :
    - AS: discussion and her understanding and transition, at no point has there been a suggestion that energy infrastructure is ended before its lifetime. Replacement at the useful end or potentially not making investments to lengthen infrastructure which may not be helpful towards goals.
    - SN: goes along with what Jon has stated. Causes of global warming has tradeoffs. Best available technology (regulated by authority and regulators) and should be a key thing. 2001 we reviewed and we needed to get off oil and transition to natural gas, and we've successfully complete that. Solar and wind is coming into play. Jon's point is that we aren't married to a single technology and we should be prepared to go into several different directions to get max use and taking advantage of what you have.
    - AA: tried to tread lightly against specific things but trying to move away from fossil fuels. Terminology should reflect that.
    - HZ: wanted to echo something Angie mentioned. Goals seem aspirational but in a lot of ways they are compromises. IPCC and what they are saying – this is a mid-range goal and

if we get there it would probably be pretty good but there's a lot of scientists that would argue we need to get net zero by 2030.

- LC: adjust recommendations section and rework formatting as discussed. We did not state anything in the report about Science 1, NW quad and SUP projects. If the group wants, something can be added in the body of the text. Documents can be updated and revised then put on Sharepoint for the group to review. Comments would need to be returned quickly.
    - SJ: can work with Debbie for another meeting to discuss. Expectation for ourselves – a few days given to consider the draft and provide any revisions and edits. Get edits to the Laura and the subgroup prior to the next meeting.
    - MW: hasn't had a chance to thoroughly review. We would need another meeting.
    - JU: How does Monday sounds for a subgroup meeting and Tuesday have the draft read for the group and then meet again next Friday.
    - LC: Friday/Saturday/Sunday review and some feedback for a subgroup meeting on Monday. Senate meets 4-6p and could work on this. Provide any additional comments that you'd like to send, please do so. The most important thing to review is the recommendations section. The remaining report is background. Where we are short is the strategy section – but we just aren't there yet. We haven't gone through all of the details. We know what we have to do but we don't know how to do it. Maybe we need to state that. More additional work on the matrix –ex more solar/less geothermal/more offsets, etc and that'll be in the Fall 2020.
        - AJ: critical is that this report is from the entire committee. Consensus among the subgroup but we need a consensus among the entire group. Strategies to reach goals. Disconnect between the group setting the recommendations and strategies. Strategies right now 60% by 2030 is using offsets and that's not the ideal way.
        - KS: Part of the issue there's not reference to strategies and maybe we need to include something in the executive summary about the strategies. We have science based goals but not science based strategies.
        - AS: we haven't been able to do that. FacOps has been working hard to get to these numbers. A lot of work but we're not there yet. Give and take, asking a lot of questions and looking at different things – we need more time.
        - KS: I think we can say that.
        - BL: we need to suggest strategies.
        - JU: we did suggest continuing work in the future and further analysis. Agree with Kathy that it needs to be more explicit. Useful in some of the recommendations, plans and information guiding the next semester has been included.
        - MW: 60% goal reduction is an overarching goal. We've seen during our discussion today, when we make decision about buildings and project –tradeoffs become particularly important. We need to convey this idea, otherwise we'll never get there.
        - AS: Laura has mentioned this in a statement capturing that.
        - KS: executive summary should be what we did, what we have not yet done so it paves the way for the next step. For many, they will only read the executive summary.

- BL : agreed. What we achieved and what we haven't achieved and where we are going.
- AS: put in everything you want them to know in the executive summary

3. Next Steps - Schedule

LC: as you read through this working group folks, if you have a way expresses what we're trying to say – please put it in an email and send it to Laura so we can include and it'll be really clear.

1. Subgroup we'll get together on Monday late afternoon.
2. Working group send thoughts and suggestions prior to Monday afternoon.
3. We'll try and revise and send it back out on Tuesday. We'll try to get the whole entire group again on Wednesday. We'll try to do a short power point/slides.

- SJ: power point as a prop. Single slide as talking points. Just something to put in front of Tom. Logistics of this for the meeting.

4. Power Point and Matrix

LC: Brief discussion of the slides and the matrix. Showing what Mark Bolduc (FacOps) has provided and where we are relative to specific baselines. It also provides what we would have to do to achieve the goals. The matrix shows some things that are already happening but there are some that are not. Some items are one time things and some are not. This is showing a way to achieve reductions. It'll be in the Fall 2020 when we get into details on what we can do and what we can't. This is background – recommendation is to spend more time on the previous discussions mentioned.

Conclusion

A thank you to the Subgroup and the work that has been done in a short amount of time to get the report drafted.

Subgroup will get together 3:00-4:30p on Monday May, 4th. And the report has to be issued next Friday.

SJ: thanking everyone showing real dedication.

***No other thoughts and/or comments – meeting adjourned at 3:48 pm ***

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WebEx Teleconference Meeting

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    - BL: combine and each recommendations #1-6. #1 we could revise so it's more concise with the others.
- HZ: brief review of the content of this section. Items haven't changed since the last meeting, basic goal are the same. Goal #1 goals with zero carbon emissions by 2040. Goal #2 stopping fossil fuel capacity and transitioning to electrification and geothermal by 2040. Goal #3 increase investment in renewable energy. Goal #4 is campus development and everything we're doing is

about zero carbon by 2040. Goal #5 is divestment. Goal #6 is the workgroup charge and next steps.

- JU: Goal #6 accountability and communication mechanisms but also using the phrase ongoing analysis. So this is a living document which is constantly being updated and staying on path to reach these goals rather than creating the goals and shelving it.
- MW: Question for Goal #2 – Law School a Regional Campus? Or should it be called out separately. We should be explicit and not exclude them.
- AA: all campuses is all campuses
- KS: formatting suggestion. Each recommendation should include a bolded summary. Phrase that captures what the recommendation is. So if someone looks quickly they can see.
- SJ: Question and clarification on Goal #2. WE want to understand this is the presidents working group

****KDM lost connection for 15 minutes**** *was informed a discussion about Science 1, SUP, and future projects.*

- Discussion about matrix and projects.
    - PF: discussion about his opinion of certain items. UConn has and will continue to have great success implement green energy and can follow a similar model.
    - HZ: agreed but these are different problems – if we have mediocre stormwater infrastructure the world's ecology doesn't collapse. I f we don't transition to green energy in the next 10-20 years it's likely apocalyptic.
    - JU: opinion on comment and discussion about projects, tradeoff and the meaning behind the recommendations.
    - KS: executive summary does not have the matrix at all. Executive summary should include a note for tradeoffs and long run gains but nothing is recognized. :
    - AS: discussion and her understanding and transition, at no point has there been a suggestion that energy infrastructure is ended before its lifetime. Replacement at the useful end or potentially not making investments to lengthen infrastructure which may not be helpful towards goals.
    - SN: goes along with what Jon has stated. Causes of global warming has tradeoffs. Best available technology (regulated by authority and regulators) and should be a key thing. 2001 we reviewed and we needed to get off oil and transition to natural gas, and we've successfully complete that. Solar and wind is coming into play. Jon's point is that we aren't married to a single technology and we should be prepared to go into several different directions to get max use and taking advantage of what you have.
    - AA: tried to tread lightly against specific things but trying to move away from fossil fuels. Terminology should reflect that.
    - HZ: wanted to echo something Angie mentioned. Goals seem aspirational but in a lot of ways they are compromises. IPCC and what they are saying – this is a mid-range goal and

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if we get there it would probably be pretty good but there's a lot of scientists that would argue we need to get net zero by 2030.

- LC: adjust recommendations section and rework formatting as discussed. We did not state anything in the report about Science 1, NW quad and SUP projects. If the group wants, something can be added in the body of the text. Documents can be updated and revised then put on Sharepoint for the group to review. Comments would need to be returned quickly.
  - SJ: can work with Debbie for another meeting to discuss. Expectation for ourselves – a few days given to consider the draft and provide any revisions and edits. Get edits to the Laura and the subgroup prior to the next meeting.
  - MW: hasn't had a chance to thoroughly review. We would need another meeting.
  - JU: How does Monday sounds for a subgroup meeting and Tuesday have the draft read for the group and then meet again next Friday.
  - LC: Friday/Saturday/Sunday review and some feedback for a subgroup meeting on Monday. Senate meets 4-6p and could work on this. Provide any additional comments that you'd like to send, please do so. The most important thing to review is the recommendations section. The remaining report is background. Where we are short is the strategy section – but we just aren't there yet. We haven't gone through all of the details. We know what we have to do but we don't know how to do it. Maybe we need to state that. More additional work on the matrix –ex more solar/less geothermal/more offsets, etc and that'll be in the Fall 2020.
    - AJ: critical is that this report is from the entire committee. Consensus among the subgroup but we need a consensus among the entire group. Strategies to reach goals. Disconnect between the group setting the recommendations and strategies. Strategies right now 60% by 2030 is using offsets and that's not the ideal way.
    - KS: Part of the issue there's not reference to strategies and maybe we need to include something in the executive summary about the strategies. We have science based goals but not science based strategies.
    - AS: we haven't been able to do that. FacOps has been working hard to get to these numbers. A lot of work but we're not there yet. Give and take, asking a lot of questions and looking at different things – we need more time.
    - KS: I think we can say that.
    - BL: we need to suggest strategies.
    - JU: we did suggest continuing work in the future and further analysis. Agree with Kathy that it needs to be more explicit. Useful in some of the recommendations, plans and information guiding the next semester has been included.
    - MW: 60% goal reduction is an overarching goal. We've seen during our discussion today, when we make decision about buildings and project –tradeoffs become particularly important. We need to convey this idea, otherwise we'll never get there.
    - AS: Laura has mentioned this in a statement capturing that.
    - KS: executive summary should be what we did, what we have not yet done so it paves the way for the next step. For many, they will only read the executive summary.

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- BL: agreed. What we achieved and what we haven't achieved and where we are going.
- AS: put in everything you want them to know in the executive summary

3. Next Steps - Schedule

LC: as you read through this working group folks, if you have a way expresses what we're trying to say – please put it in an email and send it to Laura so we can include and it'll be really clear.

1. Subgroup we'll get together on Monday late afternoon.
2. Working group send thoughts and suggestions prior to Monday afternoon.
3. We'll try and revise and send it back out on Tuesday. We'll try to get the whole entire group again on Wednesday. We'll try to do a short power point/slides.

- SJ: power point as a prop. Single slide as talking points. Just something to put in front of Tom. Logistics of this for the meeting.

4. Power Point and Matrix

LC: Brief discussion of the slides and the matrix. Showing what Mark Bolduc (FacOps) has provided and where we are relative to specific baselines. It also provides what we would have to do to achieve the goals. The matrix shows some things that are already happening but there are some that are not. Some items are one time things and some are not. This is showing a way to achieve reductions. It'll be in the Fall 2020 when we get into details on what we can do and what we can't. This is background – recommendation is to spend more time on the previous discussions mentioned.

Conclusion

A thank you to the Subgroup and the work that has been done in a short amount of time to get the report drafted.

Subgroup will get together 3:00-4:30p on Monday May, 4th. And the report has to be issued next Friday.

SJ: thanking everyone showing real dedication.

***No other thoughts and/or comments – meeting adjourned at 3:48 pm ***

President's Working Group on Sustainability and the Environment

ATTENDANCE	1/24/2020	2/5/2020	2/27/2020	3/10/2020	3/25/2020	4/9/2020	4/30/2020
Agrios, Alexander	✓	✓	✓	✓	✓	✓	✓
Carnahan, Kerry	✓	✓	✓				
Chen, Ming-Hui	✓				✓		
Hermoza-Ricci, Brandon	✓	✓		✓	✓	✓	✓
Jordan, Scott	✓	✓	✓	✓		✓	✓
Li, Baikun	✓	✓	✓		✓	✓	✓
Xinyu, Lin	✓	✓	✓	✓	✓	✓	✓
Nagireddy, Hamaja	✓	✓		✓	✓	✓	✓
Roach, Natalie	✓	X	✓		✓	✓	✓
Segerson, Kathleen	✓	✓	✓	✓	✓		✓
Seth, Anji	✓	✓	✓	✓	✓	✓	✓
Ursillo, Jonathan	✓	✓	✓	✓	✓	✓	✓
Volin, John	✓	✓			✓	✓	✓
Willig, Michael	✓	✓	✓	✓	✓	✓	✓
Zehner, Harry	✓	✓	✓	✓	✓	✓	✓
Cruickshank, Laura	✓	✓	✓	✓	✓	✓	✓
Jednak, Mike	✓	✓	✓	✓	✓	✓	
Miller, Rich	✓	✓	✓	✓	✓	✓	✓
Ferri, [redacted] Paul	✓	✓	✓	✓	✓	✓	✓
Sean Vasington	✓		✓		✓	✓	✓
Nolan, Stan	✓	✓	✓	✓	✓	✓	✓
Carone, Debbie	✓	✓			✓	✓	✓
Mark Bolduc		✓	✓	✓		✓	✓
KATIE MILARDO		✓	✓	✓		✓	✓
Patrick McKee	✓	✓	✓	✓	✓	✓	✓
Tom St. Denis (BVH)		✓	✓			✓	
Ashley Patrylak (BVH)			✓	✓			
SCOTT WAITKUS (BVH)			✓				
Zachary Bloom (CES)			✓				

Presidents Working Group Meeting
Monday, May 4, 2020
3:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, Harry Zehner, Jon Ursillo, Mark Bolduc, Katie Milardo

Overview of the Executive Summary and Recommendations Report
LC: Prior to the meeting the final report version 9 was provided which included edits from Kathy Segerson, Baikun Li, Mike Willig, Rich Miller and Stan Nolan and put them all in one document. There are 2 versions of the Executive Summary and Recommendations, Option 1 revised by Kathy and Option2 revised by Laura and sent to Harry on Friday night – happy to work with either or a combination of both.

A few details to review:

- Rich – sec 2.1.1 – are these quotes? Can you compose an introduction and write more generally about the Academic Plan instead of quoting section? *Yes, Rich will review and address.*
- Sean – sec 4.2 – is the aerial ready to insert? *Yes, it's ready*
- Sean, Katie, and Patrick – would you 3 please work to assemble a pdf for Appendix A, and a pdf for Appendix B? if possible we should have it for the working group meeting on Wednesday and ready to go with the report on Friday. *Yes, Sean has that ready and will be in pdf format. Include Subgroup meetings minutes along with the working group meetings minutes. Include all of the consultant reports and information. Ex. Stan shared informational documents for windfarm and/or solar farms – that would've informed our decision. To date there's only been two official reports - Avant and BVH. The Eversource report should be attached.*

Next Steps
LC: Discussion of next steps. Let's discuss how we are structuring the conversation with the President and the 2 Chairs next week so that we can review it with the working group on Wednesday. Scott suggested a ppt but that is mostly to keep things organized (I know Scott!). We could put a very short summary of the Foreword on a slide, a very short summary of the Exec Sum on another slide, the recommendations one per slide. Or we could do something else, it's really up to you.

- BL: Agreed, good idea. Clarification of 1 or 2 slide per section or a slide for each recommendation? Recommendation and strategy is the priority and most important part of the report.
- JU: yes, likes that idea and include quotes or something that can summary the process and what was done.
- AA: Sounds good.
- AS: Yes, that's fine and likes that idea.

LC: Acknowledgements has been issued. Please review and send any revisions so it's correct in this document.

- AA: not a big deal but the acknowledgements with the school listed first. Should it even be included, seems unnecessary but in different.
- BL: Likes the current way it is and doesn't need the schools
- AS: college was listed to show the group was distributed but maybe list the college after not first.

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- LC: Ask Deb Carone to have students identify majors and class year to be included. And will eliminate the faculty schools.
- RM: add Patrick McKee to the list.

LC: Terminology and discussion on which to use -"Foreword or Preface". Kathy introduced both terms.

LC: Discussion of Option 1 or Option 2 discussion and going through the format sections.

- AA: option 1. Option 2 bullets are longer.
- BL: option 2. Use Kathy's bolds on the full recommendations.
- JU: agrees with the overall opinion. Discussion about recommendations. Additions about tradeoffs. Include specific items (e.g. specific plans in the Fall) in the summary up front so those who don't read the entire report will catch the details up front.
- LC: Project discussion - only projects approved by BOT is Science 1 and SUP phase 1. There aren't any other projects there. Possibly not clear enough to other people and you would want to discuss tradeoffs. Will draft a write up for the appendix of projects.
    - JU: additional sentence about tradeoffs, accomplishing academic and research goals and our carbon emissions goals.
    - LC: verify Gant Phase 1 and Phase 2 approved projects but not Gant Phase 3. Potentially would need to figure out how to make that addition.
    - BL: do we need to list out the exact projects.
    - LC: no, staying away from that. BOT approved projects greater than $500M.
    - AA: put the projects in the appendix so it's clear for people reading it to clarify
    - AS: there isn't actually new gas powered generation in the phase of the SUP that's been approved.
    - LC: two steam chillers and 2 electric chillers and 1 gas fired boiler. The reason is because the boilers being removed from the CUP is being decommissioned by DEEP and falling apart. Instead of putting back into the CUP because they won't fit, we're putting it in the SUP.
    - SN: discussion about the boiler being added for emergency and it's not new capacity.
    - JU: discussion about expansion of campus and what COVID is teaching all of us right now.
    - LC: focus is research and getting them proper buildings for research. And the next buildings that come along need to be treated in a new way with regards to this topic. Personal opinion, if recommendations are too strong, nothing will move forward.
    - AS: Can we say something about Science 1 being a missed opportunity and that it came in a little too soon. Substantial study done in the Fall with this type of expertise and converting a campus over, they might come up with ways that make complete sense to incorporate Science 1 in that plan. Maybe it gets delayed but it doesn't remove the project. It just seems that only including new construction is being risky. Understands funding also could be a challenge.

    - SN: discussion about beta test and demonstrating test should not be the core reliable technology for back up of buildings. Reminder: 500 kw on the roof of Science 1 – the most the roof could handle.
    - LC/AA/AS: geothermal discussion for Science I and II. Stormwater issues and land was an issue which is why geothermal wasn't designed in time. Desktop study was done at the time. But borings will be completed for the Bishop/CESE pilot project.
- LC: discussion of Mike Wiligs recommendations and the reformatting of this section
    - JU: yes, format similar to Kathy's recommendations and bullets items.
    - AS: will work on recommendation 2
    - AA: Alex to complete recommendation 1 and reorg into "A, B, C" and if it was already stated in another recommendation then remove. Repeated information in this section.
    - JU: to complete recommendation 1 and will provide a revised section tomorrow after his exam
    - LC: John to complete recommendation 1, Angie to do recommendation 2 and Laura to write a piece of the appendix for 2, leave recommendation 3, 4 and 5 alone.

- LC/AA/AS/BL : Discussions of emerging technologies including wind and battery storage.
    - MB: a few sentences to include the summary statement for Section 6 to state what it is. New wind and battery storage and emerging technologies – shouldn't we also list nuclear.
    - AS: wind and battery storage has a lot coming online and nuclear plants are being shut down and no substantial plans for building nuclear at this point. That may change and we can review later.
    - SN: more nuclear plants coming online nationally, zero carbon source and mainly located in Georgia.
    - AS: but not in New England and this report is for strategies in this area until it becomes more realistic.
    - LC: reminds about the charge to the group and what we can do to reduce carbon moving forward.

<u>Conclusion</u>

- LC: will send the revised draft version 10 to the working group for their revisions/comment. Everyone has tasked with sections for updating and revising. Additionally, between Wednesday and Friday, we'll need to get the powerpoint ready so Deb can send it. RM/SN/LC to help with the power point for Wednesday's meeting.

***No other thoughts and/or comments – meeting adjourned at 4:50 pm ***

Presidents Working Group Meeting
Wednesday May 6, 2020
2:00 p – 4:00 p
WebEx Teleconference Meeting

Attendees: Scott Jordan, Debbie Carone, Laura Cruickshank, Sean Vasington, Mike Jednak, Stan Nolan, Michael Willig, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Kathy Segerson, John Volin, Xinyu Lin, Baikun Li, Ming-Hui Chen, Harry Zehner, Jon Ursillo, Himaja Nagireddy, Ming-Hui Chen, Brandon Hermoza, Jon Ursillo, Mark Bolduc, Katie Milardo

1. Opening Remarks - Introduction

SJ: Thanking group for joining and in advance for the work being done. Scott will be pulled off mid-call for a fiscal meeting. Anticipating we will be working together in the future, this summer and certainly next semester. Drafting group to walk us through the draft and come to a consensus on the recommendations. Expect work to continue but if there are any objections or something that needs to be said, it should be voiced today before it gets submitted to the President.

2. Review of Report Preface, Executive Summary and Recommendations

- LC: You should have received the draft report yesterday. We will go through the report and subgroup folks will comment as needed.
- Preface updated and edited. Thank you to those who provided edits.
    - KS: 2nd paragraph for items prioritized I preface, great comment about specifics but didn't see it elsewhere in the document. We want to highlight and didn't see anything elsewhere.
    - JU: edited this to be formatted that way. Direct recommendation to item #2, the last portion is a synthesis of within based technology but didn't want to explicitly say only wind.
    - HZ: provide in next steps within the recommendations to include detailed planning for Fall
    - AS: recommendation 2, item A talks about a step by step transition schedule and it's included in the body of the report
    - LC: so are we saying we need to include this elsewhere?
    - KS: if we search for the prioritize language, would we find it elsewhere in the report or only in the preface?
- Executive Summary and Recommendations discussion regarding any changes/revisions
- A Path Forward section
    - KS: pulled information out of Section 6.0 and suggests that these are things we should prioritize in a path forward and in the next stage of the committee and what the work is. After looking at Section 6.0, unclear of what we want people to get out of this section.
    - LC: valid point and giving the time crunch, we were trying to nail down the recommendation and less about the strategy. We possibly need to be clearer and what the next phase will be about.
    - HZ: comment about this section. Personally to change to "reaching goals outlined here" rather than recommendations outlined. We've been specific about recommendations and they've been carefully considered. Just wants it to be very clear that we're saying beyond these recommendations will require more thought.

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  - HN: Typo, at the top and regarding sentence on challenge. Clarifying that this is a "human made" catastrophe and not "man-made".
  - MW: adding language to include - identification of particular risks and mechanisms to reduce them
  - BL : good point and we should add risks and methods. We need to mention this in strategies as well.
  - AA: to phrase it the way Harry has suggested. The recommendations are how to get to zero carbon fundamentally.
  - LC: will rework the language in this section as discussed with the group.
- Background – not much to discuss, the text has generally stayed the same.
- Academic Core Value and Vision – Mike Willig and Rich Miller revised. If there's any comment on that, please forward to Laura.
- Campus Master Plan, University Value, Prospective Students, Climate Justice, Working Group and the Environments – no changes
- Statistics – Sean are we putting the aerial in this section?
  - SV: yes, we have it ready to insert.
  - LC: let's put it in the Appendix A and refer to it in the text so we're not messing with the format of the text.
- Current Demand and Sources – minor changes about having specific % of where power is obtained.
  - AS: greenhouse gas emissions from the power plant?
  - JU: Scope 1 graph
  - SN: it's in the graphic, but we can specifically call it out in this section.
- Graphs and Data – no changes to energy data
- Human Behavioral Initiatives – no changes
- RECs – minor changes
- Recommendation #2 - Laura to re-review on how this section is organized. There were some minor change to content, so it would be more easily readable. Formatted to an "a,b,c,d" outline. We made this short and to the point and matches the executive summary recommendations.
  - Recommendation 2 –Halt Fossil Fuel based construction. Added a clarification section that includes diagrams of project, description and why they are being done, they're all in sequence. Discussion on the structure of the text.
  - KS – first sentence says no exceptions.
  - AS – exceptions are in the points below.
  - JU – discuss during the subgroup meeting tomorrow.
  - HZ: committed University should as the lead in to recommendations. We could work with the exception of the projects listed in Appendix A. We would change the format but the exception would be listed first and people wouldn't have a false impression. Just leave permanently and take off "immediately".
  - BL: discussion about the campuses. But what about the other campuses?
  - AA: summed it up really well to include a statement for next steps to cover this part.

  - JV: agreement with how Harry rephrased. Being in the provost office, shouldn't direct this. But need to play an ex-officio role.
  - LC: consensus of the body of the group is that we're not recommending that all of these projects get stopped. If that's not the case, we may have a problem. Provide suggestions and we can discuss at the subgroup meeting tomorrow, 5/7.
- Recommendation #3- nothing too specific that people would have questions or disagree with.
- Recommendation #4 – minor comments
  - KS: liked recommendation except item G. this isn't the place to raise online teaching
  - HZ: unnecessary discussion point that takes away from the major point of this plan
  - AA: item F, where does 75% come from?
- Recommendation #5 – minor comments
  - KS: different rational and impact the industry and lead to contraction, unsure that's the case. Those are types of arguments that would come up.
  - HZ: investing in fossil fuels is getting more risky. It's more of a moral thing.
  - KS: recognizing risks and the point Mike had mentioned earlier.
  - BL: statement to recommend "fully" and "fully and partially". We definitely know that in the long run we want to fully divest but partially in the interim.
  - HZ: University of Maine does this and used both partially and fully. Personally feels that it should be fully.
  - LC: skip the issue and remove both terminology –fully/partially.
  - AA: economic liability and risk discussion should be included here it's a good place.
- Recommendation #6 – minor comments
  - AS/MW/KS/HZ – discussion on environmental justice and reworking the language here.
  - JV: outreach and engagement is a good way to phrase this. Very careful to put it to a specific department.
  - AS: is this where UConn Health and other campuses will be included?
  - LC: yes, this is where we would add this information and we'll add up front.
  - KS: water resources management only called out?
  - JV: wouldn't be so specific.
  - MW/JU/KS/LC: conversation about diversity of faculty members and the wording. Fridays Future document discussion and wording. Laura to offer some word smithing suggestions
- Strategies – what we're trying to prioritize and how to make it clear that this is something that we need to continue to work on as part of Phase 2 in Fall 2020.
  - JU: we need some more work. Added language about wind. And adding that we need to do more work and making this statement so it ties back into the beginning section of the report.
  - KS/LC: graphs and baseline reductions per year. No major discussion about the graphs. What are the take home messages for Section 6.0.
  - BL: good point, would be very happy to elaborate more on these figures working with Jon and Harry.
  - AA: yes, we need to talk through these figures.

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- LC: discuss with Stan and Mark too. Baseline and years and a method on achieving this. It's only an option for strategy. There is an information page in the Appendix.
- KS: demonstrating this is feasible and if it's the best pathway, etc.
- HZ: matrix comment. Last page on the matrix, 2021-2025 – there are two projects, steam condensate replacement projects – isn't this in direct contradiction to recommendation #2? Significant chunks of the reduction.
- SN: background on this – aged steam line that has leaks. We won't be able to convert at once, we'll need to do this in phases. Distribution will need to be in place before it can be converted and these will need to be replaced in order to keep equipment and the process functional. We're not wasting heat and water to the ground, we're trying to capture that and make this a tight system. Fossil fuel isn't in the distribution method.

3. <u>Review of Appendices</u>
   - LC: Review of the Appendices - Appendix A and B – Sean has combine all documents to create these two appendices. This includes meeting minutes, consultant reports, etc. Additions including nuclear and hydrogen. Angie added geothermal. There's a lot of backup information. Not too worried about this but if we need to make adjustments, we can.

4. <u>Review of Presentation for May 11</u>
   - LC: General overview of PowerPoint and format
     - KS: made a comment to include an additional slide that Jon added to the preface about the prioritization. It's important and not showing up by just listing the recommendations.
     - HZ: intro slide about the group, who met and how often we met, what was done, general makeup of the group would all be useful.
     - BL: add committee members from different groups and background. Reiterated Harry's point.
     - KS: BGE acronym, bulleted format might be easier to read
     - BL/AA/KS/LC: bold or bullet the recommendations and strategy slides.

- LC: Who will be presenting – members and ex officio members will be attending this meeting. The president and Chairpersons of BGE and TAFs will receive am email, report, power point and link to where all of the documents will be.
  - BL: laura to control the slides
  - LC: Scott to lead the introductory remark (slide #1)
  - LC/DC: the meeting will be 2 hours. There are 12 slides to present.
  - KS: awkward to present slides between slides. Maybe Scott introduces but someone like Laura will continue to present the rest of the slides. Discussion and answering questions – the bigger group will chime in.
  - LC: Scott Jordan - doing the intro, faculty member - who we are and what we will talk about and student going through recommendations. Offline conversation for who will be going through the slides split between academic and students. If you want to set up another meeting to do a dry run, we can figure that out as well. Meeting is Monday.

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5. Next Steps/Discussion
   - LC: to revise and make changes to the Appendix. Laura will fix what she can tonight and tomorrow in the report and nothing to really change in the Appendix. Subgroup meeting - We'll meet tomorrow, 3p-5p to discuss any last minute items to finalize the report.
   - LC: timeline for editing – this has to go out on Friday morning so please provide everything as soon as possible (by tomorrow by noon).
   - AS: will this be presented to BGE?
     - LC: not at this time
   - MW: provide power point presentation so it can be reviewed
     - LC: yes, will send out after the sub group meeting
     - HZ: the draft version is already sent out with the packet.

***No other thoughts and/or comments – meeting adjourned at 3:53 pm ***

Presidents Working Sub Group Meeting
Thursday, May 7, 2020
3:00 p – 5:00 p
WebEx Teleconference Meeting

Attendees: Laura Cruickshank, Sean Vasington, Stan Nolan, Rich Miller, Patrick McKee, Alexander Agrios, Anji Seth, Baikun Li, Harry Zehner, Jon Ursillo, Mark Bolduc, Katie Milardo

Overview
LC: Focus of today's meeting is the changes of the Executive Summary, Recommendation and Strategy. Highlighted in yellow are topics that need to be addressed from yesterday's meeting and some changes have been made.

1. Executive Summary and Recommendations Report
   - LC: Recommendation Section 6. Kathy's email and a section in the executive summary that may not be necessary to included. Include in recommendation 6 instead.
         - HZ: change wording to "future iterations of the working group", more direct, agree with the capitalization of the "Working Group"
         - AS: acronym PWGS used as an option, so that there is clarity of which group
     - JU: rewording to include a justification at the end of item A.
     - HZ: rewording on item D to include "additional tasks mentioned here due to their importance in reducing carbon emissions and committing the University's goals".
     - AS: remove "water resource management" item? Discussion to rewrite this sentence.
     - LC: UConn health and other campuses needs to be acknowledged in item E. Group agrees the text looks good to include.
     - LC: phase 2 analysis how do we decide a strategy note from Kathy – do we need to include something else or are we all set? Jon to include a few sentences to incorporate this comment under the Strategies for reducing carbon by 2025, 2030 and 2040 section 6.
         - AS: there's something in recommendation 2 making note of this
   - LC: Recommendation Section 2 – minor revisions and discussion.
     - AS/HZ/JU: discussion about the future plan and consultants. Working group sets the priority and consultants do the work on behalf.
     - LC: capital project through UPDC and using framework consultants BVH. But PWGS will be the client telling the engineers what the goal and parameters are.
     - HZ: project list in the Appendix and what projects are included. Wants the list to be specific as possible.
         - LC: projects included are: Gant, Cup equip, SUP, Science 1. Once the science projects are done, the rest will be renovations. The exception is the hockey rink which is still in design. It's not listed here because it's not an academic project, but that's the only new building that's an active project.
         - AA: revise title of clarification to board approve construction projects or something along those lines.
   - LC: Recommendation Section 3 – no major changes/revisions.
   - LC: Recommendation Section 4 – minor revisions and discussion.
     - AA: restructure and revise the sentence.
     - BL: where are we getting 75% data? Discussion of the use of this data point.
         - LC: it was randomly picked so we removed it. Rewording this section.

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    - SN: not use all new construction, we would want to include renovation if possible.
- LC: Recommendation Section 5 – minor revisions and discussion on why we thought this.
    - JU/HZ/LC: discussion of restructure and adding a sentence or two.
    - AA: removal of a sentence that repeats itself

- LC: Strategies for Reducing Carbon by 2025, 2030, and 2040 – revisions. Mark and Baikun both sent text for the graphs and figures and what they mean.
    - BL: didn't read through the figures before today. Walkthrough of the additional text. Figures 1 through 7 talking about greenhouse gas and reduction and overall reduction. Figure 7 is pie versus bar figure? Figure 2 – lab ventilation and doesn't show up again?
    - JU: too many items for a bar graph – formatting wise.
    - SN: lab ventilation is just a conceptual stage and it's not included in later figures because we should have that info and implemented. Only 1 example method to increase/decrease of how to get there.
    - BL: can Mark input? Potential risk related to greenhouse gas emission. Merge with Mark's input and respond by tomorrow morning to Laura.
    - LC: take Marks and yours and Stan's response to the email – and merge this section.
    - HZ: a big chunk is commuter carbon Scope 3 reductions and this doesn't line up now re-reviewing the graphs. Recommendation #1 talks about scope 1 and 2, and graphs discuss scope 3. Wants to ensure the graphs and recommendations are matched.
    - SN: Scope 3 does count and we should reduce uniformly in all aspects
    - JU: goes along with the further study and we've stated that we'll be doing more work in the future and
    - MB: version of intro, discusses and states that this is one of many possible ways. As stated this is one scenario to get to this goal and that there will be additional studies. Baseline includes all 3 scopes.
    - SN: energy conservation is Scope 1 and 2. Transportation has fewer reductions – low hanging fruit and more readily available opportunities. At the end of the day, we'll achieve all 3 types.
    - AA: we should not be including scope 3 and we shouldn't be asking the University to go zero carbon in all three sections.
    - HZ: agrees with these programs. If the graphs demonstrate to achieve goals but they aren't matching. Understanding it's a late wrench in the discussion. Just want to make sure its coherent.
    - LC: add a footnote because this is too late in the game. Graph shows a lot of Scope 3 commuter offsets. Add a foot note, scope 3 reduction requires further studies.
    - JU: add language in the beginning of the section "many of these rely heavily on scope 3 reductions but not necessarily indicative of the goals and recommendations of item 1".
    - AA: the title needs to be revised, what does this mean. Figure 4 doesn't achieve this group's goal.
    - MB: what we need to do by the end of calendar year 2020 to meet the goals. It's a Uconn goal. If you only want to show what needs to be done for this report –then you should only

show the last pie graph. Yes, the matrix includes the offsets and whatever is listed in the graphs.
  - LC: So, to summarize – we should only include Figure 5 and Figure 6 and remove Figure 4?
  - JU: Alex is trying to create continuity for readability of this report. He doesn't necessarily disagree.
  - MB: additional note for Figure 4 with language similar to "although recommendations was focused on scope 1 and 2, the commuter program was potentially a project to be included in 2020 and we wanted it included". Also interim discussion goals ties back into the recommendations.
  - RM: discussion about the projects and that this takes us into the short term projects. It's not just one and done. This program would provide certain amount of carbon offsets through the 2040 timeframe.
- LC: A Path Forward section – review of comments and minor revisions.
  - AS: add language about how we discussed these strategies in recommendation ## suggest that they be analyzed further in the Fall for prioritization.

2. PowerPoint - Planning for a Zero Carbon Future
- LC: Technical question on size of font and if it presents well
  - RM: a lot of words, especially for the Board. Will people be reading so it will be distracting and redundant?
    - AS: it will be either Angie or Mike but she would prefer Mike to do the introduction.
    - RM: Mike will default to reading the slides and Angie has been in the meeting and probably can do more
    - AS/LC/RM/BL: discussion on the slides and bullet items, format, discussion points and who is presenting, etc.
  - LC: will revise the powerpoint and verify the changes agree with the report. Do we do another slide or make the photo of campus the last slide with the quote.
    - AS: do we want to ask them for questions
    - AA: likes the photo and quote page as the last page
    - HZ: ending with the quote. Angie and Harry tried to zoom it out at every meeting and to talk about specific ideas but also to think about the scale of it and why we're doing this. Easy to forget the reason why we're here and what the purpose of the group was.
    - AS: comment about administrators have to act boldly and doesn't remember it being in the document
    - SV: moved it to a bullet because it was on the other slide. Also has the first part of the quote on another slide.
    - LC: will fix the slides and out for review and then it'll get reworked again probably tomorrow.

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Conclusion

- LC: will revise the powerpoint and send this out to the group for final review. She will also send out the graph/tables section to Baikun and Mark so this section can get revised/reworked. Please provide edits to Laura ASAP.
- BL: discussion zero carbon vs. netzero/carbon neutral. In the slides and final report, we've been saying zero carbon. The readers will have some discussion on this. Maybe Angie can relay what the definitions are so the group can understand.
    - AS: will add notes to the document for the presentation
    - HZ: Jon and Xinyu will be talking and presenting the recommendations. They are both seniors. They'll make sure there'll be notes to go off of for this.
    - JU: if we have two student presenters is that a problem? Or that's okay because we'll be switching between the two of us.
    - AS: questions that come up should be directed for certain folks answer
    - LC: certain people are tasked with recommendations and if anyone is uncomfortable and/or gaps in responding the group should feel comfortable to step in.
    - HZ: presenting in an organized fashion
    - LC: key people for recommendations - Harry #1 + #5, Jon #2+ #6, Alex #3, Laura #4
- LC: The meeting is 2 hours. Approximately 10 minutes for the overview, 5-10 minutes for the introduction, 5 minutes for each of the recommendations, and if the presentation ends early that's okay.

***No other thoughts and/or comments – meeting adjourned at 5:00 pm ***

Presidents Working Group on Sustainability and the Environment Meeting
Wednesday, May 20, 2020
10:30 am – 12:30 pm
WebEx Teleconference Meeting

Attendees: Debbie Carone, Laura Cruickshank, Sean Vasington, Paul Ferri, Stan Nolan, Michael Willig, Rich Miller, Patrick McKee, Alexander Agrios, Kathy Segerson, Ming Hui Chen, Anji Seth, Baikun Li, Brandon Hermoza Ricci, Himaja Nagireddy, Xinyu Lin, Natalie Roach, Mark Bolduc, Katie Milardo, Alan Vanags, Scott Waitkus, and Tom St.Dennis

Overview
LC: Email sent yesterday and the agenda. No additional comments and/or final edits on that.

1. Final Edit of the Report
    - LC: Review of the final edits on the draft report. Review of K.Segerson's comments.
    - Preface – mainly grammatical/typo changes.
        - KS: explicit about cost and recognizing benefits and the statement included in this section and to make sure folks are comfortable with the phrasing.
        - MW: agrees and happy with the revision. Executing the activity that we are able to do and meets the spirit of the discussion.
        - AA/BL: both agree and like the edit and change made.
    - Section 4.2 – UConn Statistics for Storrs and Regional Campuses
        - Text for tables have been included. Intent was statistical background for additional information.
        - KS: still thinks there should be a sentence on what the tables are designed to show.
        - SV: sentences have been added to each and are they enough?
        - LC: sentence description of why the tables are there.
        - AA/BL: agrees with Kathy's comment.
        - MW: remove "main" campus and include just Storrs
        - RM: is it also understood that Storrs campus include Depot campus? Keep this consistent with the second table and include Depot.
    - LC: Acronym discussion and review of the document M.Bolduc provided. Document sent around includes descriptions, definitions and terminology for the Appendix. Important to define terms because others will be reading this report.
        - AA: not all of the terms need to be in the document. Difference between Cogen and CUP?
        - SN: walkthrough of Cogen vs CUP
        - LC: would it be better to just call it the central utility plant and update throughout the document. If we're referring specifically about the turbines we can use the term cogeneration.
        - HN/AA/SN: discussion about how to revise in the terminology/acronym document in agreement
        - AA/AS/LC/KS: discussion of the actual terms, what they mean and including terminology in the report and revising sources. Also removal of the CIGS terminology.
        - MB: to provide word document to the group so everyone can review and edit using track changes.
        - LC: Sean to provide the word document on Sharepoint so everyone can review and edit.

Mark, Rich, Baikun to review the document and only include terms used in the report and Angie will add net zero and greenhouse effect definitions.

- LC: appreciates Kathy and others for going through and revising for grammatical errors and updating as necessary. Other items within the report regarding changes/revisions/comments.
    - RM: minor typo to include EcoHusky in paragraph 2
    - KS: clarification in Figures section that needs to be done or needed to be done. Thought in the spirit of it was this was one pathway to get us there.
        - AS: clarified and tried to make this better. And agreement with Kathy that this reflects what Kathy was trying to clarify.
    - LC: Baikun wrote and added clarification for the figures.
        - BL: also added section about future work summary and benefits.
    - AA: comment and edit added about electrification in Recommendation two.
        - RM: delete the term zero carbon. Geothermal discussion which relates to this statement while grid is becoming renewable. You could use geothermal for electric as another option.
        - AA: we would only want to do this if we weren't using heating/cooling at the CUP. We wouldn't want to use natural gas. Math on this electric use from natural gas at CUP or natural gas for geothermal – unclear of how the #s would come out.
        - NR: consultants will review this and can provide additional information. Discussion for potential projects on the outskirts of campus.
        - AS: this statement sounds like its delaying. Wouldn't want this to hold up the process. Do not want to put a sentence that suggests that would say we should wait.
        - MW: we need to come back to the last sentence regarding authority for commissioning consultants and moving forward and the future of this working group and what its empowered to do or not.
        - LC: put this on hold and discuss further at a later time.

2. <u>Review Scope of work for Consultants Summer 2020 (BVH)</u>
    - LC: slide 1 – big picture of what we're trying to do in the summer and fall 2020. We know it will require more study of strategies, monetary and non-monetary options. Difficult timeline to have this all complete by December. We need consultants to be doing work this summer so we have something accomplished – background information and presented to PWGS in fall 2020. Assign a scope of work to BVH because they are position to do the work and they're already the framework engineer (last 5 years) to look at utilities on campus which is a mechanism for going forward.
        - AS: understands why we would be working with BVH and that it's set already and easy to do. To what extent does BVH have the expertise and experience in doing a transition like this? Who have they worked with before where they transitioned major infrastructure – steam to electrification? How do we know they have the proper experience? They did the utility framework and did an excellent job but we're doing something different and it's critical because we need experts.

- MW: capacity monetary and non-monetary analysis and benefits (Bullet #2)? Not normally in the domain of what certain consultants do.
- LC: this analysis would not be part of the scope of work. BVH would be looking at the background.
- TS (BVH): we've been talking about this and what the program will look like. BVH will not be the full solution and will provide input from other consultants as well (e.g. CES). Laura and Stan have asked BVH have asked to look at more of the nuts and bolts aspects, conservation measures that we've been talking about and specific to the UConn campus. We've done a number of projects like this for other campuses – upgrading utilities, geothermal project, electrification upgrades and maintaining fossil fuel burning systems. BVH is not the complete solution but what we've outlined in scope – it will be instrumental to working group and moving beyond the theoretical and what it will really look like with regards to the scope.
- AS: groundwork was plan to get zero carbon by 2040.
- LC/TS: correct. CES and others will be participating for certain parts of the solution. Discussion of the plan for grid power not being clean – wind power to power part of the plan and running those building and convert over to clean power – at that point they'll bring over another consultant expert for this. Looking at overall cost, various solutions, pros and cons, etc. a lot of things to look at.

- LC: Goals (Slide 2) discussion. Plan for 60% reduction in emissions (2010 baseline) by 2030 and 2040. Scope 3 will be addressed outside of the scope study. Develop interim target goals for 2025 and 2035. Ensure reliability and resiliency expected as a leading research educational institution (base understanding and maybe not a goal).
  - AS: bullet 1 is from the report so it's fine
  - MW: goals for whom?
  - LC: goals for the report.
  - AS: to clarify this is what we're asking BVH to do.
  - LC: yes, that's correct.
  - MW: if we're going to ask them to do over the summer and they're not dealing the non-monetary items. It will be going down a rabbit hole, issues reaching short term goals, some input data will be available to assist.
  - BL: only can do monetary – is there another firm that can complete the non-monetary. Long term items cannot be achieved over the summer.
  - LC: BVH to provide options – different scenarios and different ways to achieve our goal by 2040. Working group's job would look at the value – added and lost – of strategies and scenarios.
  - MW/AS: timeline and scenarios
  - TS: confusion of timeline of study. We've been saying this summer timeline. What we're talking about is working with you this Fall. Process is lengthy – will take a year or more. UPDC and FacOps to do some of their homework and have background info prepared for the Fall so we understand the direction we're going. It will take entire academic year. It's really an update of the framework utility master plan.

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- AV: recently presented at a conference (IDEA) – up to date and more than up to speed with what's out there and looking forward to working with UConn and bringing the university up to the next step. We are so familiar with campus – we can take those strategies and help.
- MW/AS: continue discussion about tradeoffs, risks and options to consider and have something for the working group to review in the fall.
- LC/AS/TS: 99.9% reliable/resiliency goal # is debatable. Should be met for this university and should be as high as I t can. Review of NIH and other funding agencies for requirements and availability for services to research facilities that can be reviewed.
- SN: at least as reliable as Eversource.
- BL: % to give to BVH and is it a UConn requirement or is it too high or too low? Do we need to do homework to determine % or will BVH provide this #?
- TS: comparable with other institutions and should be hung up on the number today. Benchmark would be looking at peer institutions. Complex questions and in a lot of cases the building by building or lab by lab
- LC: bullet #3 is just a basis not a goal.

- LC: plan scenario/development (Slide 3/4) develop timeline and roadmap scenarios to convert heating and cooling infrastructure to zero carbon by 2040. And nonmonetary discussion will come after BVH will review. Discuss and planning with utility companies – will probably be a discussion at a higher level.
    - NR: carbon proxy price and where will it come in? Economic analysis and will be important to use an expert to review. Concerned that we don't have any experts? How we are going to pull this item off.
    - LC: excellent question and we don't have a clear definition, so it will go to the Fall and evaluation and analysis of cost (non-monetary) benefit for pros/cons will be reviewed. Not considered background work but more of a discussion.
    - AS: proxy price developed timeline? Harry? His project goes through the Fall – so likely later to discuss with him
    - BL: consultant firm will develop this? Working group couldn't develop this. Maybe BVH?
    - LC: will need to discuss with BVH and also talk to Harry. BVH would need to put a value on what would include in a proxy price –example: social welfare of people in China where something is produced and used in the US.
- TS: (Slide 5/6) plan development for strategies and scenarios for reducing carbon. Identified in the matrix and looking at projects in more detail and looking at the requirements, assign cost and schedule to those projects. They can become building blocks for the plan and scenario. Projects include: solar on campus and near campus, geothermal for heating/cooling. Additional strategies and in order to accomplish by 2040 we may want to buy clean energy in other ways. Waiting for grid to become clean for the program goals or install additional equipment to meet goals.
    - AS: in which of these bullets of looking at low temp/hot water?
    - TS: item C – geothermal. Looking at how to potential mobilize equipment on campus. Converting existing equipment and/or creating district systems for areas of campus and

creating low temp hot water for certain areas, cooling season distribute water to those areas. How do strategies work, where does it make sense to do standalone buildings or group of buildings, equipment and end life use, phase into workable plan.

- AS: item A – replacing steam pipe, but those projects could be effected if we can covers?
- TS: in some cases it will be and sometimes it will not. But this will be reviewed.
- LC: there will always be some repair to utility infrastructure.
- AS: repairing steam pipes – reduces fossil fuel as Stan has stated multiple times.

- LC: Does this powerpoint seem like a good path going forward. This will be written up as document instead of a powerpoint? We will write this up and send it around for review.
- RM: PPA and virtual net metering. Hearing a lot about offshore wind in near term from Eversource.
- TS: scope is limited to Storrs campus. Last slide – forecasting the strategies and potentially will apply to regional and satellite campuses.

3. Final Next Steps for Turning in the PWGS Final Report

- LC: Glossary/definition document will be updated by certain people (Alex, Angie, Rich, Mark, Baikun). This will be added to Sharepoint for editing. Also, the report will be updated and revised based on discussions today and added to Sharepoint.
  - Everyone is in agreement that we'll be completely done with the report by May 29th ***Any changes people want/need to make – it needs to be made by **Friday, May 22nd** .
  - Additionally, the powerpoint we discussed today will be turned into a document and shared with the group.
  - Also, does the group want one more meeting? This will be added to the mail sent to the group and if needed, we can meet again next week.

Conclusion + Additional Comments

- NR: who will be involved with the process this summer for students? Possibly, the Office of Sustainability students could be involved. A sub group should be created of this working group and they could meet over the summer with the consultant for check in. It would be voluntary but Natalie and Harry would definitely be interested.
  - LC: okay, yes.
  - AS/MW: would be happy to check in as well to enhance and help facilitate the process
  - LC: Yes, but it would be completely voluntary.
- RM: When will there be a call for students next fall? Could they participate this summer to get their feet on the ground?

- LC: No, based on a time perspective – not working with the schedule. The student openings is based on an open solicitation for student involvement and it would go along with BVH's schedule.
- AS: Agreed with Laura, it's an open application process.
- MW: Agreed as well – we don't want to stop the progress of the consultants but agree with Rich that we want students full participation.

***No other thoughts and/or comments – meeting adjourned at 12:40 pm ***

4) Consultant Reports

DRAFT

University of Connecticut

Energy Supply Plan
50% Renewables

December 10, 2019

AVANT ENERGY

Table of Contents

Section 1. UConn Energy Supply Objectives

Energy supply is essential to the functioning of UConn Storrs campus. In 2006, UConn reduced its cost of electricity, steam and chilled water supply by the implementation of its Cogeneration Facility (Cogen). Cogen also reduced the emissions associated with its energy supply because of the efficiency of the cogeneration process.

Reduce CO_2 Emissions	UConn desires to further reduce its CO_2 emissions. As a leading university, UConn recognizes its responsibility to contribute to climate change mitigation. Further, Governor Lamont has called for 45% reduction in greenhouse gases by 2030.
Acceptable Cost	Accomplishing reduced CO_2 emissions must be accomplished at an acceptable cost. Alternative approaches to satisfying emissions reductions can carry widely different costs.
Reliable Energy Supply	For more than 15 years, UConn has been working to improve the reliability of electric supply to the Storrs campus. Any carbon reduction program should enhance reliability rather than diminish reliability.

Section 2. Reducing CO_2 Emissions

Natural Gas Primary Source of CO_2 Emissions

Natural gas is the primary source of UConn's CO_2 emissions. In addition, small amounts of fuel oil are burned as a backup fuel when natural gas supply is interrupted.

Uses 1.6 BCF of Natural Gas

UConn uses approximately 1.6 billion cubic feet (BCF) of natural gas annually. The natural gas is supplied by Connecticut Natural Gas from the Algonquin pipeline. Gas supply is interruptible because it is lower cost than firm supply.

Natural Gas Used for Cogeneration Plant

The largest use of natural gas is for the cogeneration plant. The cogeneration plant converts the natural gas into electricity with the byproduct of steam. The steam is then used to heat the campus and make chilled water for campus cooling with steam-drive chillers.

Natural Gas Used for Gas-Fired Chillers

UConn also uses natural gas to power gas-fired chillers for cooling. This use is during peak times in the summer.

Produces 187 Million Pounds CO_2

Combustion of 1.6 BCF of natural gas produces 187 million pounds of CO_2 annually. In addition, there are some CO_2 emissions associated with the generation of electricity purchased from Eversource.

Plan: Reduce 50% of Natural Gas Usage by Adding Renewable Electric Generation

Natural gas usage would be reduced approximately 50% by substituting renewable electric generation for electricity produced from the cogeneration system.

Convert Steam Drive Chillers to Electric Drive

Part of the reduction of natural gas use would be to make most chilled water for building cooling from renewable electricity. This requires the conversion of the existing chillers from steam turbine drives to electric drives.

This accomplishes two things. First, required steam production is reduced which allows the combustion turbines to be operated at lower outputs. Second, the electric drive chillers would use solar electricity so that it would not have to be stored in batteries.

Effect: To Reduce CO_2 Emissions by 50%

The effect of the reduction in natural gas use of 50% is to directly reduce UConn's direct CO_2 emissions by 50% to 93.5 million pounds.

Section 3. Description of the Project

Solar 37 MW

Solar generation of 37 MW alternating current (AC) would be constructed on land near UConn Storrs. Solar photovoltaic (PV) generation is direct current (DC) and would be sent to a battery or converted to AC by an inverter.

UConn-Owned Land

The project requires between 240 and 400 acres depending on suitability of each site for solar. Land currently owned by UConn might be intended for some other use or be too expensive to use. If so, other land would have to be acquired.

Ownership of land is preferred because UConn has a long time horizon. Although all projects have finite lives, electricity supply to the Storrs campus will be required in any currently contemplated US energy supply scenario. Even at the end of life of the proposed project, the generation would likely be replaced on the same sites.

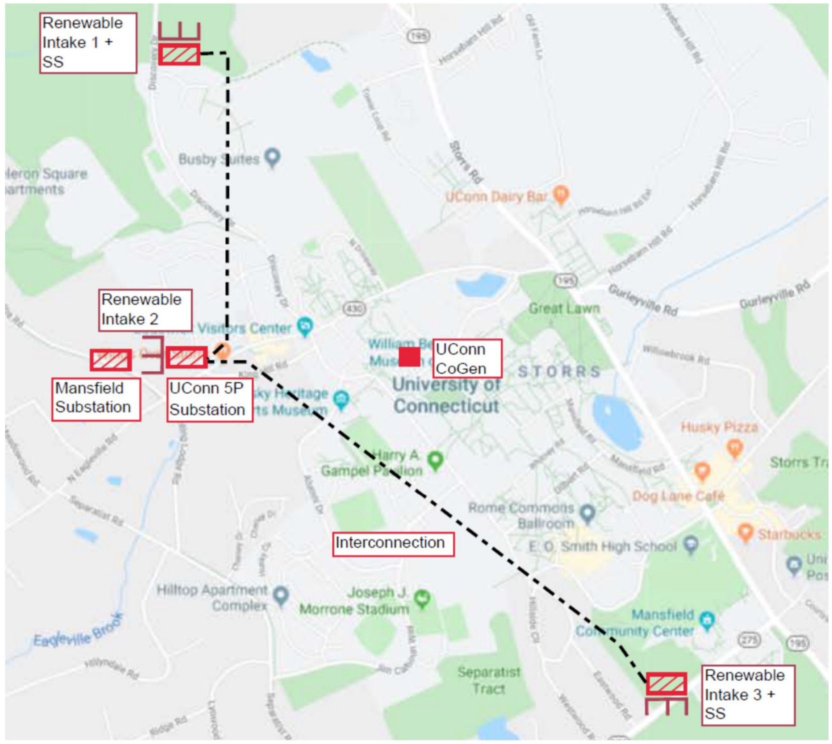
The following map shows land that UConn currently owns in the yellow highlighted areas.

Generation Connected at 3 Intake Points

Renewable electric generation would be connected at three points on UConn's existing electric distribution system because of the difficulty and cost of installing any feeder capacity greater than 20 MW. The paths between likely sites and campus connection points are narrow making construction difficult.

In addition, three renewable intake points would allow UConn to take electricity from more locations in the vicinity of the campus.

The following drawing shows the general location of proposed renewable intake points and the connections between them.



3 Intake Points Connected

The 3 intake points would be connected because the renewable energy needs to be available to the full campus regardless of the load on any feeder.

Batteries 30 MW

Batteries would be located at the solar farms because both the solar generation and the battery storage are DC while the UConn distribution system is AC. Inverters would convert both solar generation and battery output to AC for delivery to the campus.

The battery capacity would be 30 MW with a sizing that would allow 30 MW capacity to be maintained for 4 hours for a total of 120 MWh storage.

This sizing is sufficient to store electricity produced in excess of consumption during peak solar production for 99 percent of generation.

Project Life 20 Years

The project life is assumed to be 20 years. Solar panels and related inverters are generally thought to have at least 20 year lives. Battery life depends on the extent to which they are cycled.

	Batteries should only be discharged in anticipation of a need to charge them because of generation in excess of consumption. Under this constraint, limiting battery cycling should extend life to approximately 20 years.
Assumed to be Owned by UConn	It is assumed that the project would be owned by UConn. Other ownership alternatives are possible although they might reduce UConn's long-term flexibility for continued operation of generation in the Storrs area.
Convert 4 Steam-Drive Chillers to Electric Drive	Conversion of the existing 4 steam-drive chillers to electric-drive chillers improves the plan by providing increased electric load both during the summer and during the hours the sun is shining. The effect of this is to reduce the amount of battery storage required to absorb electric generation in excess of consumption.
UConn Storrs would Use All Renewable Electricity from Solar	UConn Storrs' electric load with the addition of the electric drive chillers is sufficient to allow it use 99% of the solar electric generation.
Does not Require Conversion of Existing HVAC	The plan does not require the conversion of existing building HVAC systems to electric-sourced energy. However, the cooling needs of buildings would be provided by the electric-drive chillers rather than requiring steam from cogeneration for chiller operation.
Project Could be Constructed in Phases	The project could be constructed in phases. A phase could be as limited as a solar farm of 5 MW with a single feeder to a single intake point.
Land Acquisition and Permitting are Pacing Activities	Land for the project could come from either existing UConn-owned land or land purchased for the project. It is expected that competing interests in utilization of land owned by UConn will need to be resolved before the project can proceed. Similarly, purchase of land from others would require time to be accomplished. This project, like any other construction project, would require permits before construction.
Earliest Likely Date: 2023	The earliest likely date for any solar generation being in-service is 2023. Completion of a project of this complexity would likely require at least 3 to 4 years because of planning and permitting and

the need to construct significant intake structures and feeders, connection of intake points by an inground duct bank, and conversion of steam-drive chillers to electric-drive chillers.

Construction of solar installations is the least time consuming and most predictable of project implementation activities.

Section 4. Financial Analysis

This section describes the project related costs, savings, and net present value.

Projected Capital Cost: $149.5 Million

The projected capital cost for the Energy Supply Plan is $149.5 million and consists of four major elements, solar PV generation, battery storage, renewable collector and interconnection and conversion of centrifugal chillers to electric drives.

Component	**Projected Capital Costs ($ Million)**
37 MW Solar PV	$68.8
30 MW Battery Storage (120 MWh)	51.5
Renewable Collector & Interconnection System	26.8
Conversion of Four (4) Steam Driven Centrifugal Chillers to Electric Drives	2.4
Total Projected Capital Cost	**$149.5**

The projected capital cost is based on 2020 prices and includes a 10% project management related cost and a 30% contingency.

Projected O&M Cost: $282,000 per year

Solar operating costs are assumed to be $0.00435 per kWh for a total of $282,000 per year. These costs are assumed to escalate at 2.5% per year.

Projected NPV of O&M Costs: $5.0 Million

The net present value (NPV) of solar operating costs are projected to be $5.0 million at a discount rate of 3.5%.

Projected Operating Cost Savings: $7 Million per Year

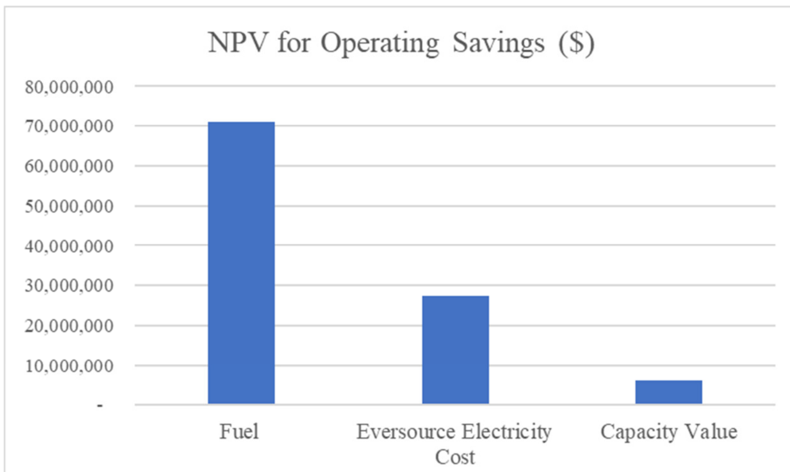
Projected operating savings are $7 million per year based on a 50% reduction in natural gas usage, elimination of Eversource electricity purchases and the capacity value of future avoided demand charges because of greater generation capacity.

Capacity value has been projected based on growth of 500 kW per year, which is approximately 2% per year. The value of capacity is assumed to be $100 per kW-year.

Component	**Projected Savings ($ Million)**
Fuel (Natural Gas)	$5.00
Eversource Electricity Cost	1.95
Capacity Value Increment per Year (because of Battery Storage Availability)	0.05
Total Projected Operating Cost Savings	**$7.00**

Projected NPV Operating Savings: $105 Million

The NPV of the operating savings is projected to be $104.7 million at a 3.5% discount rate.



Projected Economic Value of RECs: $3.2 Million per Year

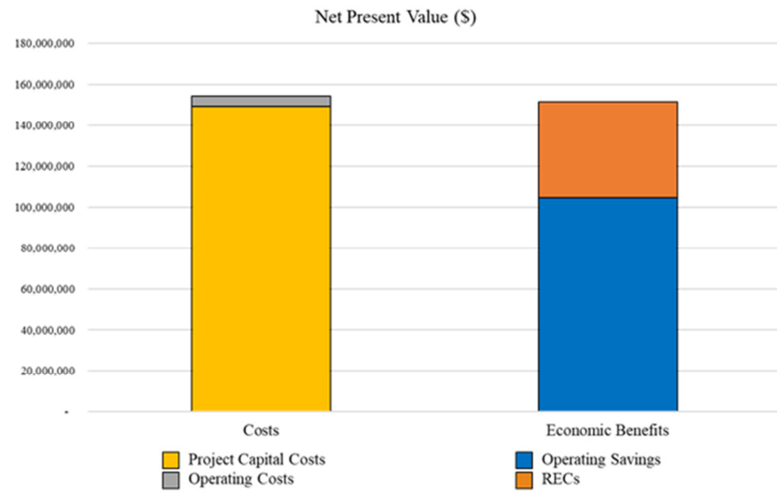
The projected economic value of RECs is $3.2 million per year based on an assumed value of $50 per MWh. A 37 MW Solar PV system is projected to generate 64,824 MWh per year with a total REC value of $3.2 million for the first year. In addition, it is assumed that the PV panels will degrade at 0.7% per year.

NPV of RECs $43.5 Million

The NPV of the RECs is projected to be $43.4 million at a 3.5% discount rate.

Net Present Value: Negative $6.5 Million

Net present value is projected to be negative $6.5 million. This reflects that capital costs exceed the economic value produced by the project.



All NPVs are based on a 3.5% discount rate and a 20-year project life.

Section 5. Reliability

Reliability of electricity to buildings on the UConn Storrs campus is determined by electric generation reliability, transmission reliability, and distribution system reliability.

Electric Supply Reliability Improved by Project

Electric generation reliability is improved by adding 37 MW of renewable solar generation during daylight hours which is greater than UConn's peak load. In addition, 30 MW of battery capacity provides the ability to ride-through short-term supply fluctuations which might trip the existing cogeneration facility.

Electric Supply Less Dependent on Eversource Transmission

UConn would be less dependent on Eversource transmission with the addition of 37 MW solar generation and 30 MW batteries.

Distribution System Reliability Improved by Project

The reliability of the distribution system would be improved by additional electricity inputs into the system at points other than the existing 5P substation.

Batteries could support recovery from a distribution trip because they would immediately be available, unlike the Cogen plant which would have some startup delay. In addition, current efforts to automate distribution system operation would shorten times for recovery after trips.

Section 6. Operational Considerations

Reduced Steam Demand	Steam demand would be reduced by conversion of steam-drive chillers to electric drive. This reduces the load on the cogeneration plant which should allow operation of only one gas turbine during summer months when solar-generated electricity is at its highest and steam demand at its lowest.
Increased Electric Demand for Chillers	Conversion of 8,000 tons of steam-drive chillers to electric drives would increase the connected load by approximately 8 MW. When combined with the existing 2,000 tons of electric drive chillers, UConn's peak summer electric load could be increased by up to 10 MW. This would reduce the need to charge batteries to store electricity in excess of consumption. Less cycling of batteries would extend battery life.
Summer Solar Generation would Exceed Demand	Summer solar generation would exceed campus electricity demand during peak periods. With the conversion of chillers from steam-drive to electric-drive, peak consumption would increase from approximately 25 MW to 30 MW. Peak solar electric generation would be 37 MW.
Excess Generation Would Be Stored in Batteries	Generation in excess of consumption would be stored in batteries located at each of the solar farms.
Stored Electricity would be Used Off-Peak	Stored electricity would be converted from DC to AC and sent to the Storrs campus intake points via feeders constructed for that purpose.
Cogeneration Plant Operation Reduced	Overall Cogen plant electric output would be reduced by 50%. This would occur in two ways. First, there would be no plant operation during time periods when renewable electric generation exceeds demand including electricity from batteries during non-daylight hours. It is projected that there could be weeks during the summer with little or no cogeneration plant operation. Second, combustion turbines would be operated at lower levels for the remainder of the year because of solar generation.
Boiler Operation may be Somewhat	During periods of no operation of combustion turbines, steam would be made by package boilers. This may be an increased use

Higher	over current levels.
Operate CT's as needed for Off-Peak Electricity and Steam	Off-peak during the summer and as required during the remainder of the year, the cogeneration plant combustion turbines would be operated as needed to meet both electricity and steam needs.
Increased Complexity	Overall, the addition of solar generation and batteries increases the complexity of operation of the cogeneration plant.

Section 7. Issues

Future Electric Loads

Future electric loads are uncertain. Since the construction of the cogeneration plant, conservation and load control have largely offset substantial increases in load from the addition of new buildings.

UConn intends to continue its substantial conservation efforts. However, continued conservation efforts will have diminishing returns and are unlikely to offset increased loads from new building additions. In addition, electric vehicle charging could also contribute to increased load.

Growth of 500 kW per year has been assumed which represents approximately 2% annual load growth.

Battery Life

Battery life is determined by the number of times batteries are cycled and the depth of the cycle. Daily deep discharges would shorten battery life to as little as 7 years while less frequent discharge would allow 20 years' life.

Power plant operators are not accustomed to making choices about operation of equipment based on the effects of operation on life of the equipment. Well-described rules for battery operation and management oversight are probably necessary to achieve a 20-year life.

Acquisition of Land for Solar

Between 240 and 400 acres of land is required for the project. Challenges exist in both designating UConn land for solar generation or purchasing land in close proximity to the Storrs campus.

Restrictions on Farmland Use for Solar

Connecticut statutes prohibit use of farmland for more than 2 MW of solar. Presumably, this prohibition is per installation. However, implementing 19 projects of 2 MW each would be both costly and difficult. Alternatively, construction on forested lands would cause higher capital costs for clearing. Legislative change allowing the use of farmland for the project might be sought.

Deferring Project Would Lower Cost

The cost of solar and battery projects is declining. The project would likely be lower cost in the future with better net present value.

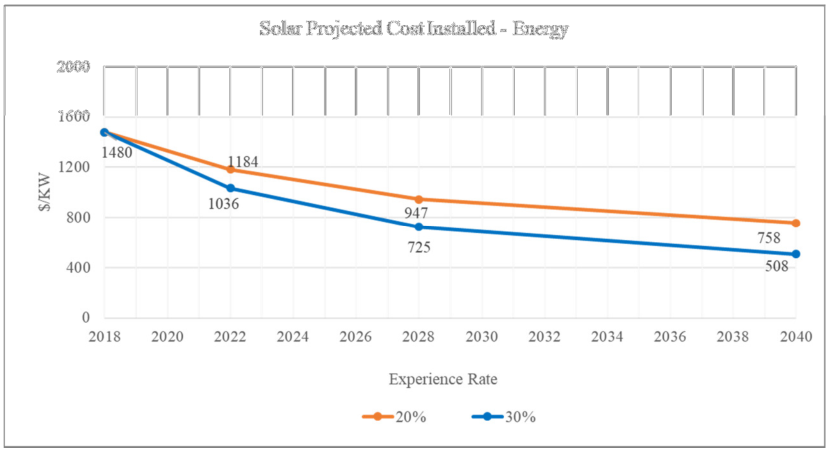
Availability of Contractors in Connecticut	Construction costs could be higher because of a lack of competition among contractors experienced in utility-scale solar installations in Connecticut and surrounding states.
Project Funding	The project is assumed to be funded with debt at an interest rate of 3.5%. Alternative funding approaches could include a legislative grant or funding by alumni who might support a "Make UConn Green" campaign. The project could be funded by a developer with an electricity purchase contract on land owned by UConn. UConn could have an option to purchase the project in the future. However, such options are typically at "fair market value" making financial returns and valuation risky.
Purchasing Rather Than Generating	As an alternative to the proposed project, UConn could purchase renewable energy from a remote larger project. Such projects could have lower direct energy costs but would incur transmission costs to deliver the project to UConn Storrs. The result would be higher projected costs that the proposed project. Further, these approaches result in a "cliff" problem when the purchase contract expires.
Adding a Chilled Water Storage Tank	Adding a chilled water storage tank would have three distinct benefits. First, it would simplify chilled water production operation. Second, it would provide more certainty of chilled water availability. Third, increased use of renewable energy during daylight hours would reduce operation of electric storage batteries.

Section 8. Expansion Beyond 50% Renewable

Based on current technology, there are two alternatives for increased renewable production: solar and wind. Another possible alternative, hydro is unlikely because of the limited number of small sites near Storrs.

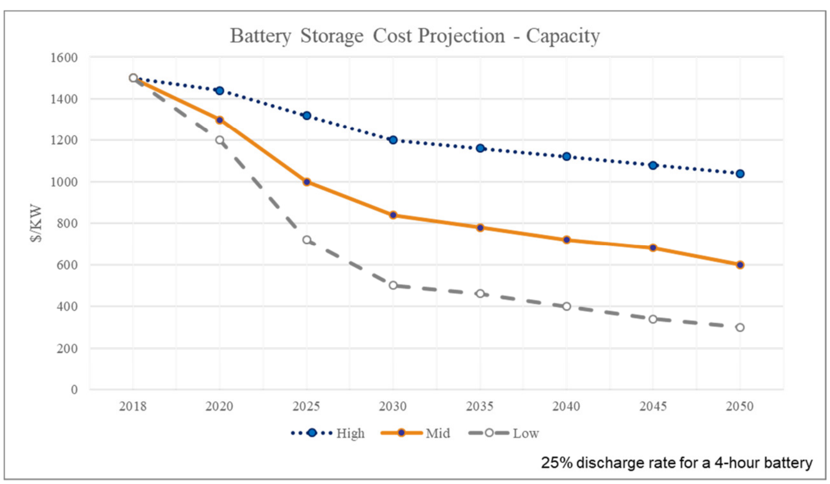
Declining Solar PV Generation Costs

Electric generation costs from solar PV have been declining and are projected to continue to decline with increased volume and experience. The following graph shows projected solar installed cost per kW for the period 2020 through 2040 for 20% and 30% experience rates.



Declining Storage Costs

Similarly, electric battery storage costs are projected to continue to decline. The following projection was prepared earlier this year. Actual results this year suggest that the lower projected cost is being achieved.



If future costs follow the lower projection, the current installed cost of $1,200 per kW is projected to decline to less than $800 per kW in 2025 for a four-hour battery.

Could Allow More Renewable Generation

Projected cost reductions in solar electric generation and battery storage could allow addition of economic renewable generation. Much of the infrastructure for additional renewable generation is included in the proposed project including intake points, feeders, and intake point connection.

Increased Summer Capacity for Export would provide more Winter Energy for Storrs

UConn Storrs could use more renewable energy in the winter. This could be accomplished through increasing the amount of capacity beyond what the Storrs campus needs in the summer and exporting it to other campuses.

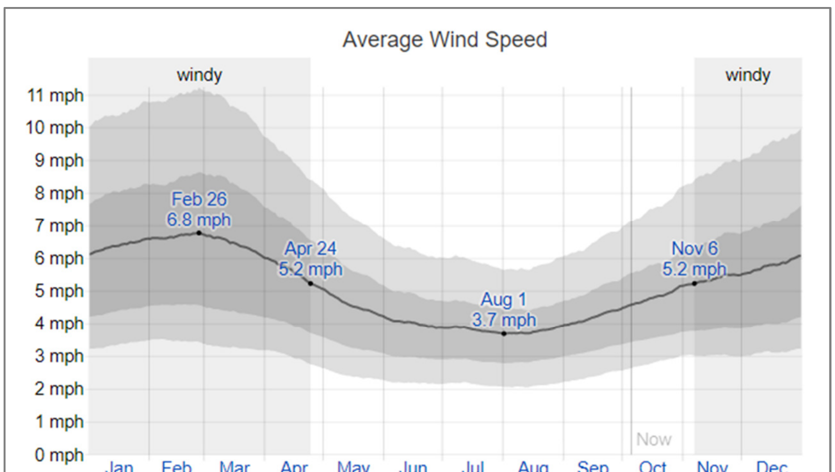
100% Renewable Complex

Achieving 100% renewable energy for Storrs would require substantial increases in renewable generation and battery storage.

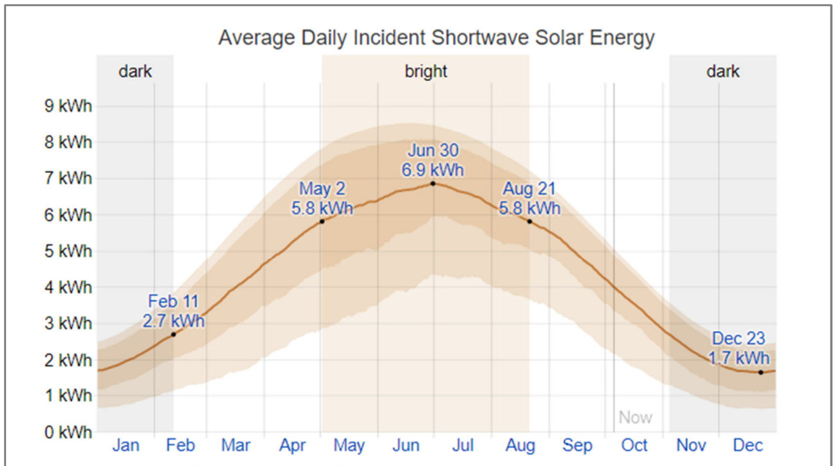
Because existing battery storage is not suitable for long-term storage, increased winter generation would be needed.

Wind has Better Winter Generation Profile

Wind has a better winter generation profile than solar. This occurs for two reasons. First, wind velocities are higher somewhat higher in winter than in summer. Second, solar generation is greater and for more hours in the summer than in the winter. This is shown by the following two graphs for wind velocities and solar insolation for Hartford.



The average of mean hourly wind speeds (dark gray line), with 25th to 75th and 10th to 90th percentile bands.



The average daily shortwave solar energy reaching the ground per square meter (orange line), with 25th to 75th and 10th to 90th percentile bands.

Wind More Costly

Wind is projected to cost $.073 per kWh compared to $.044 for solar generation for UConn. Construction costs would be high because any wind project would be much smaller than utility scale. It is unlikely that experienced wind contractors would be interested in a small project remote from most of their work.

Because of relatively low wind velocities, capacity factors for wind in Connecticut would be less than half those of projects being built in the Midwest. Therefore, fixed costs would be spread over less than half the output of commonly built wind farms.

Maintenance costs would likely be high because there is no Connecticut vendor infrastructure.

Alternatively, wind-generated electricity could be purchased and wheeled which would be even more costly because of transmission costs. Wind generation at prices competitive with solar or cogeneration would be difficult to find in the region.

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100 Percent Solar Doesn't Match Load

Solar sized to meet winter load with a large battery installation could meet UConn's load. However, excessive generation in the summer would be wasted. The result is the cost per MWh consumed by UConn would be excessive.

Conversion of Building Heating Systems to Electricity

To achieve 100% renewable energy supply, building heating systems would need to be converted to electricity. This could be accomplished with: ground source heat pumps, air source heat pumps, or electric boilers.

Ground Source Heat

Ground source heat pumps would be the most efficient technology

Pumps	for using electricity for space heating. During times of greatest winter heat needs, winter ground water temperatures are greater than air temperatures resulting in more efficiency in electricity utilization.
Air Source Heat Pumps	Air source heat pumps would rely on ambient air temperatures as the media from which heat would be extracted. Low air temperatures during peak heating times make this less desirable than ground source heat pumps.
Electric Boilers	Electric boilers would be the easiest approach to heating buildings with electricity. Boilers would have substantially lower efficiency than ground source heat pumps but would require little or no retrofit to the building heating system.
Could Require Costly Conversion of Buildings	Conversion of buildings to use lower temperature hot water from heat pumps for heating is likely costly. Existing building heating systems were designed with steam as the source of heat for the building. Although most buildings convert the steam to hot water, the hot water design temperatures are likely greater than those available from commercially available heat pumps.
Could Require Complex and Costly Energy Delivery System	If ground source heat pumps are used for space heating, a piping system for delivery of energy to each building on the central campus would be required. The piped source could be the ground source water or the piped water could have been heated by a central plant.

Section 9. Export of Electricity

Two Approaches to Export

There are two commercial approaches to export of energy from UConn Storrs generation. First, UConn could sell electricity to Independent System Operator New England (ISO-NE). Second, UConn could apply to participate in Eversource's Virtual Net Metering Program.

Sales to ISO-NE Under $40 per MWh

Sales to ISO-NE are not attractive. Prices for electricity would be less than $40 per MWh based on Mansfield locational marginal prices.

UConn's costs for both the Cogen Plant and solar generation exceed existing ISO-NE prices. Cogeneration plant incremental costs are estimated to be between $43 and $70 per MWh. The incremental cost of solar generation is projected to be approximately $44 per MWh for solar farms of 5 MW and greater while 3 MW solar farms are projected to generate at a cost of $50 per MWh.

Virtual Net Metering Over $100 per MWh

Virtual net metering would produce a relatively high value per MWh. Eversource's most recent published VNM rates exceed $100 per MWh for both on-peak and off-peak prices.

Limited to 3 MW Generators

The Eversource program application is limited to 3 MW generators as required by statute and ordered by the Connecticut Public Utilities Regulatory Authority.

Program Participation is Limited

Connecticut's VNM program is available to state, municipal and agricultural customers. In September 2019, the maximum annual participation was increased from $8 million to $16 million for all Eversource customers.

Only Steam Turbine Generator at Cogen Plant might Qualify

The steam turbine generator might qualify because it is less than 2 MW. Output of the steam turbine generator is variable depending on steam load.

Under the current program, the cogeneration plant combustion turbine generators would not be eligible because they are 7 MW each.

UConn could Build 3 MW Solar Farms to Supply VNM

To participate in the VNM program, UConn could build 3 MW solar farms and classify each as a generator. These would be connected to the UConn campus distribution system as described in this report with delivery of electricity to Eversource at its Mansfield substation.

VNM Solar Margins Projected to be $50 per MWh

Margins on solar VNM are projected to be approximately $50 per MWh for a 3 MW solar farm based on a $100 per MWh VNM price and an incremental cost $50 per MWh cost of solar production.

$85,000 Margin per MW of Solar Projects in VNM Program

UConn would generate annual margins of approximately $85,000 per MW of solar generation participating in VNM. This is based on a 20% capacity factor and $50 margin per MWh.

Storrs Likely More Attractive Generation Site

Storrs is more attractive for generation than other UConn locations because there is lower cost land available nearby and UConn operates a sophisticated electric generation facility.

Carbon Reduction Methods

Facilities Operations

Wednesday, February 5, 2020

UCONN

Top 10 Potential Carbon Reduction Methods

- Existing Buildings
  - Conservation
  - Renovation
  - Demolition
- Solar Power
  - Photovoltaics
  - Thermal
- Wind Power
- Behavior Modification
- Geothermal Heat Pumps
- Power - Offsets Purchase Agreements
- Smart Micro-Grid
- Natural Gas/Propane – Emergency Generators
- Fuel Cells and Tri-Generation
- Anaerobic Digestion
- Transportation – Bicycling/Fleet Electrification

Conservation of Existing Buildings

- BENEFITS :
  - Maximize life cycle value of existing assets
  - Reduce energy use intensity (EUI) of older, less efficient buildings
  - Improvement of building controls to reduce energy use/costs
  - MOU Partnerships lower capital needs

- ITEMS TO ADDRESS:
  - Revolving Green Fund
  - Availability of capital dollars to make improvements
  - Availability of capital dollars to cover the additional costs of net zero features.

Status: UConn currently has MOUs with Eversource and CNG which provide enhanced incentives. Comprehensive energy conservation measures maximize carbon reduction.

Renovation of Existing Buildings

- BENEFITS :
  - Update to current code and efficiency standards
  - Reduce energy use intensity (EUI) of older, less efficient buildings
  - Improvement of building controls to reduce energy use/costs
  - Saves 50-75% of embodied Carbon at 35-40 years

- ITEMS TO ADDRESS:
  - Availability of capital dollars to perform renovations
  - Availability of capital dollars to cover the additional costs of net zero features
  - Mechanical space conversion costs

Status: UConn currently implementing a three phase process to renovate the Gant Complex. Phase 1 is complete and Phase 2 is underway. Also, UConn is continuously evaluating buildings for potential renovation.

Demolition of Existing Buildings

- BENEFITS :
  - Eliminate older, less efficient buildings
  - Replace older buildings with newer less energy intensive buildings
  - Reuse or Recycling of building materials

- ITEMS TO ADDRESS:
  - Availability of capital dollars for replacement projects
  - Hazardous Materials Disposal
  - Ensure end of useful life to avoid new construction carbon

Status: UConn currently evaluating the potential removal of Torrey Life Science in the long term.

Solar Photovoltaics

- BENEFITS :
  - Reduced first cost capital available if installed through PPA
  - Project specific installations can be implemented (i.e., Science 1)
  - Help reduce campus electrical peak loads

- ITEMS TO ADDRESS :
  - Space constraints (i.e., 10 acres/MW needed)
  - Available locations
    - Existing buildings
    - Brownfield Sites
    - Farmland + Forests
  - Storage
  - Reliance on weather dependent systems requires fossil fuel backup

Status: Further analysis is needed for determine additional locations on or near the campuses.

Solar Photovoltaics Study

Depot Campus

Total Land Area	226 AC
Buildings in Service	7.55 AC
Contributing Resource	*0.6 AC*
Buildings Not in Service	0.25 AC
Buildings Uninhabitable	3.4 AC
Contributing Resource	*3.25 AC*
Athletic Fields	4.3 AC
Wetlands	32.2 AC
Approximate Total Study Area	**178.05 AC**

Bergin Campus

Total Land Area	38 AC
Buildings Not in Service	3.5 AC
Contractor Parking	2.1 AC
Wetlands	1.5 AC
Approximate Total Study Area	**30.9 AC**

NOTES:

DRAFT updated October 25, 2019

All locations and acreage (AC) are approximate for planning purposes only.

Wetland data from Town of Mansfield GIS layer may not accurately reflect field conditions.

Buildings that are contributing resources to the historic district are part of the acreage of buildings that are in service or uninhabitable.

Solar Thermal

- BENEFITS :
  - Reduced energy use for building hot water
  - Project specific installations can be implemented (i.e., Werth Tower)
- ITEMS TO ADDRESS:
  - Locations available to install solar thermal
  - Storage
  - Reliance on weather dependent systems requires fossil fuel backup

Status: Installed at Werth Residence Hall. Winterization during non-occupancy periods is challenging.

Wind Power

- BENEFITS :
  - Reduced first cost capital available if installed through PPA
  - Class 1 Resource

- ITEMS TO ADDRESS:
  - Available locations to install wind turbines
  - Reliance on weather dependent systems requires fossil fuel backup
  - Height and Noise Restrictions
  - Lack of on shore wind profile

Status: A wind review was completed for Storrs and the Torrington Campus. Test vertical Optiwind LLC 200 feet 50 KW windmill installed at Torrington in 2009 and removed in 2013.

Behavior Modification

- BENEFITS :
  - Engagement of the Campus
    - Administration
    - Students
    - Faculty
    - Staff
    - Community
  - Reduction of 19.9 – 36.8% is possible by 2050.

- ITEMS TO ADDRESS:
  - Campus Values
  - Personal Commitment
  - Ownership of Change
  - Knowledge Sharing
  - Leadership commitment
  - Messaging
  - Metrics

Status: Center for Behavior & The Environment 2018 Report is available on the website.

Geothermal Heat Pumps

- BENEFITS :
  - Produces one sixth the Carbon of equivalent natural gas
  - Increased energy efficiency for heating and cooling
  - Less maintenance than conventional fossil fuel systems

- ITEMS TO ADDRESS :
  - Large area requirements
  - Locations available to install geothermal
  - Proper soil conductivity for optimal operation
  - Heat transfer fluids biodegradability

Status: Feasibility study for Science 1 completed but determined not suitable at this location. Potential other areas on campus being discussed for further evaluation.

Steam to Hot Water Conversion

- BENEFITS:
  - Reduced maintenance/operational costs
  - Energy savings from steam to hot water conversion
  - Lower thermal loss
  - Closed loop hot water systems require no makeup water

- ITEMS TO ADDRESS:
  - Locations available for hot water conversion
  - Existing steam infrastructure in place life cycle value
  - All new steam pipe would need to be replaced due to condensate lines not being sized for water return

Status: AECOM study completed in 2015 recommended UConn continue to utilize steam as its thermal distribution system. Could become practical in areas where steam has not been extended, and boilers need replacement, such as Hale/Ellsworth/Putnam area pending further review.

Heating / Cooling Equipment

- BENEFITS :
  - New lower pressure units reduce leakage minimizing refrigerant loss
  - Utilize lower Global Warming Potential refrigerants
  - Efficiencies increase with more modern equipment

- ITEMS TO ADDRESS:
  - Capital costs for new versus converted equipment
  - Maximize life cycle value of existing assets
  - Recycle recovery of refrigerants
  - Hazardous waste disposal

Status: Design standards developed to ensure the selection of equipment with lowest global warming potential possible.

Power - Offsets Purchase Agreements

- BENEFITS :
  - Purchase Power to rebalance Scope 1, 2, and 3 Emissions
  - Purchase carbon offsets for emissions
  - Promote environmental reduction goals on a global scale

- ITEMS TO ADDRESS:
  - Line Losses increase emissions
  - Reliability and Resiliency Concerns
  - Availability of Offsets meeting Connecticut Renewable Portfolio Standards
  - ESA / PPA / ITC / Attributes

Status: UConn evaluates the purchase of Offsets with every power purchase as we work towards achieving our stated reduction goals.

Smart Micro-Grid

- BENEFITS:
  - Demand Response
  - Reduced maintenance/operational costs
  - Improved power system stability and quality
  - Increased Electrical Efficiency
  - Reducing KVA will reduce purchased power costs.

- ITEMS TO ADDRESS :
  - Identify additional heavily capacitive or inductive loads
  - Identify locations to install in existing buildings
  - Consider installation on circuits or utility connections
  - Metering

Status: Analysis completed by Center for Clean Energy Engineering. Further evaluation is needed.

Natural Gas/Propane Emergency Generators

- BENEFITS :
  - Slightly lower emissions

- ITEMS TO ADDRESS:
  - Code Response Times
  - Increase initial cost
  - Redesign of building and equipment
  - Reliability of Fuel Source
  - Concerns for large scale storage
  - Impact on overall carbon footprint is minimal

Status: Newly constructed buildings are evaluated for the type of emergency generator needed to meet the building fire and life safety code.

Fuel Cells and Tri-Generation

- BENEFITS :
  - Reduced electrical and thermal fuel requirements compared to stand alone sources
  - Lower emissions than current grid
  - High Reliability and Resiliency
  - Reduced Transmission and Distribution Line Losses

- ITEMS TO ADDRESS :
  - Maximize life cycle value of existing assets
  - Locations available to install fuel cells or tri-generation
  - Utilizes natural gas as intermediate step to full renewables

Status: UConn is currently evaluating submittals from several companies who responded to an "On-site Cogenerations and/or Fuel Cell Distributed Generation" RFP for the regional campuses and the Health Center. Further analysis is needed for determine any potential locations.

Anaerobic Digestion

- BENEFITS :
  - Uses of anaerobic digestion byproducts include electricity, fueling, soil improvement (fertilizers)
  - Diversion of organic wastes
  - Methane emission reductions

- ITEMS TO ADDRESS:
  - Locations available to install anaerobic digester to minimize transportation
  - Limited amount of material to feed the system
  - High Maintenance requirements
  - High land use area.

Status: Further analysis is needed for determine potential locations on the campuses. Currently, food waste from Dining Hall at the Storrs is being transported to Quantum BioPower.

Transportation – Bicycling/Fleet Electrification

- BENEFITS :
  - Reduce vehicle miles travelled
  - Reduce road congestion
  - Reduce land requirements for parking
  - Health benefits of physical activity
  - Consolidation of Public Transport Systems
  - Fleet Electrification

- ITEMS TO ADDRESS:
  - Maximize life cycle value of existing assets
  - Availability of capital dollars for replacement vehicles
  - Disability access
  - DOT/WRTD Contracts
  - Bike Lanes
  - Charging Points

Status: UConn is continuously evaluating vehicles for replacement using electric or hybrid options where feasible.

Next Steps…..

- Prioritization of Campus Interest in Reduction Methods
- Values Matrix by Group
- Affordability Cost Versus Benefit
- Engaging consultants for further evaluation as warranted
- Other?

Campus Carbon Reduction Options

UCONN Facilities Operations, BVH Engineering & Competitive Energy Services

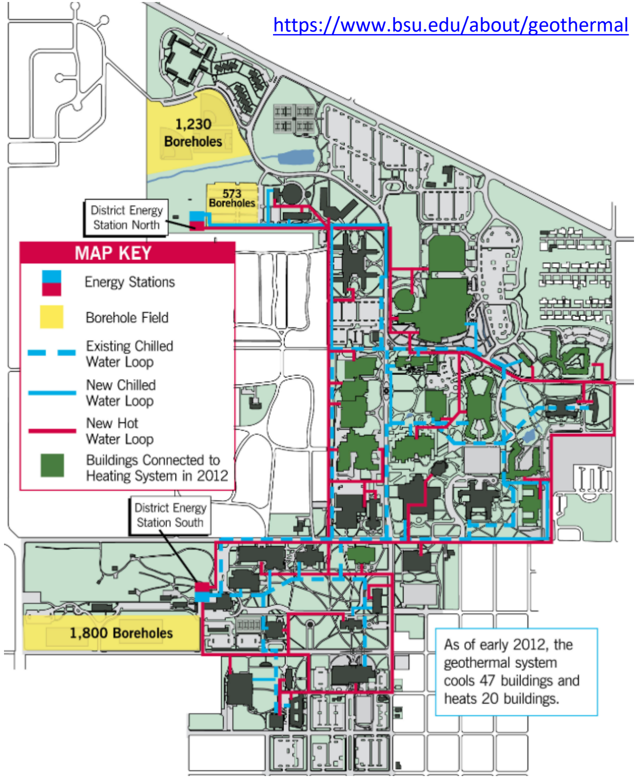
February 27, 2020

UCONN

Item #1: Campus Electrification

- A number of UCONN's peers have begun evaluating district energy conversions to electric-driven technologies.
- Few public higher eds in the U.S. have actually implemented such conversions to date. In 2014, Ball State University completed a major overhaul of its campus heating and cooling systems to utilize large-scale geothermal well fields
- Several key takeaways from peers' planning efforts
  - Campus electrification can require substantial capital investment (low-temperature hot water distribution, geothermal facilities, building thermal infrastructure conversion)
  - Designing a 100% electrified district energy system significantly increases capital requirements in order to meet peak campus heating needs
  - Those who have pursued electrification have done so with a phased implementation approach over time to avoid stranded energy assets on campus
  - Grid reliability remains a paramount concern for electrification efforts, with no economic silver bullet for backup power without using fossil fuels

https://www.bsu.edu/about/geothermal

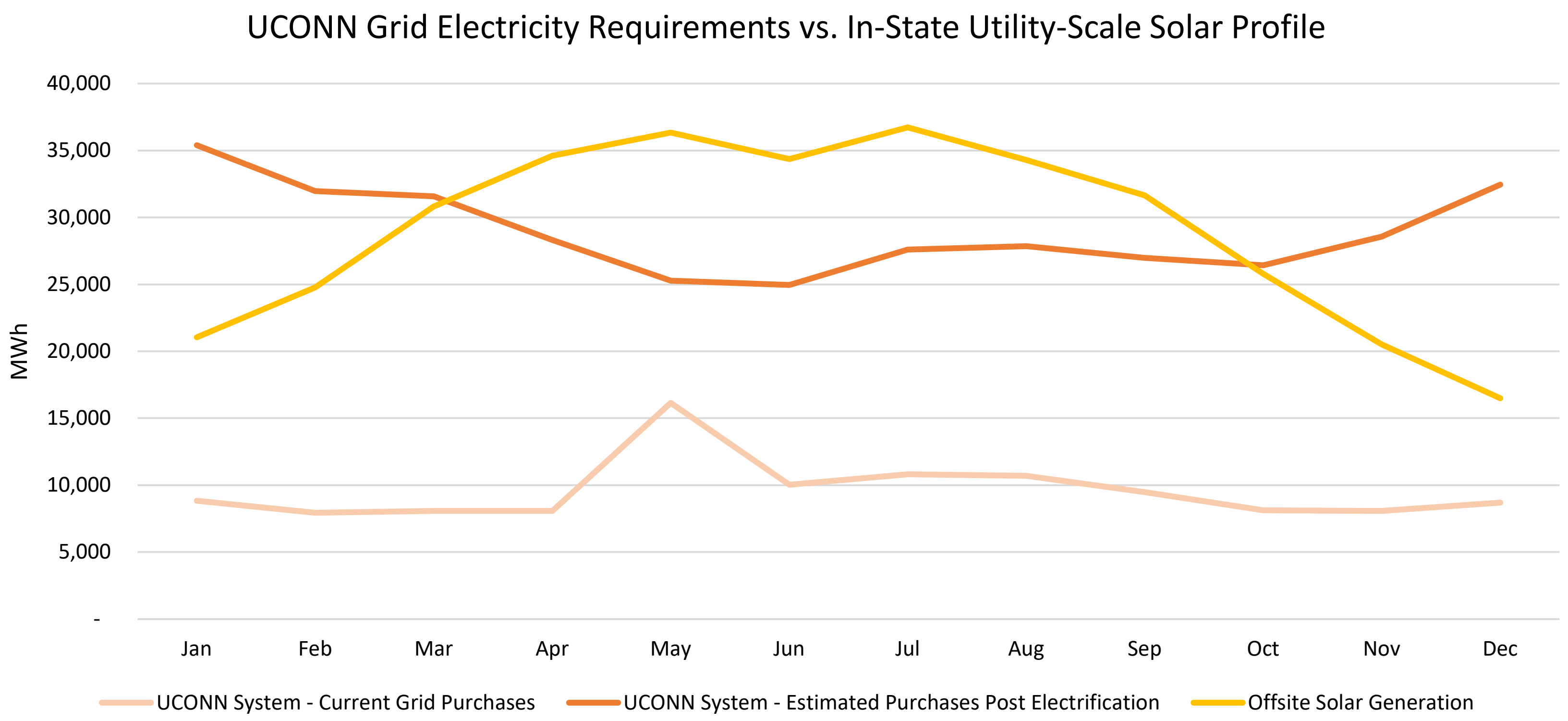


Item #1: Renewable Energy Credits

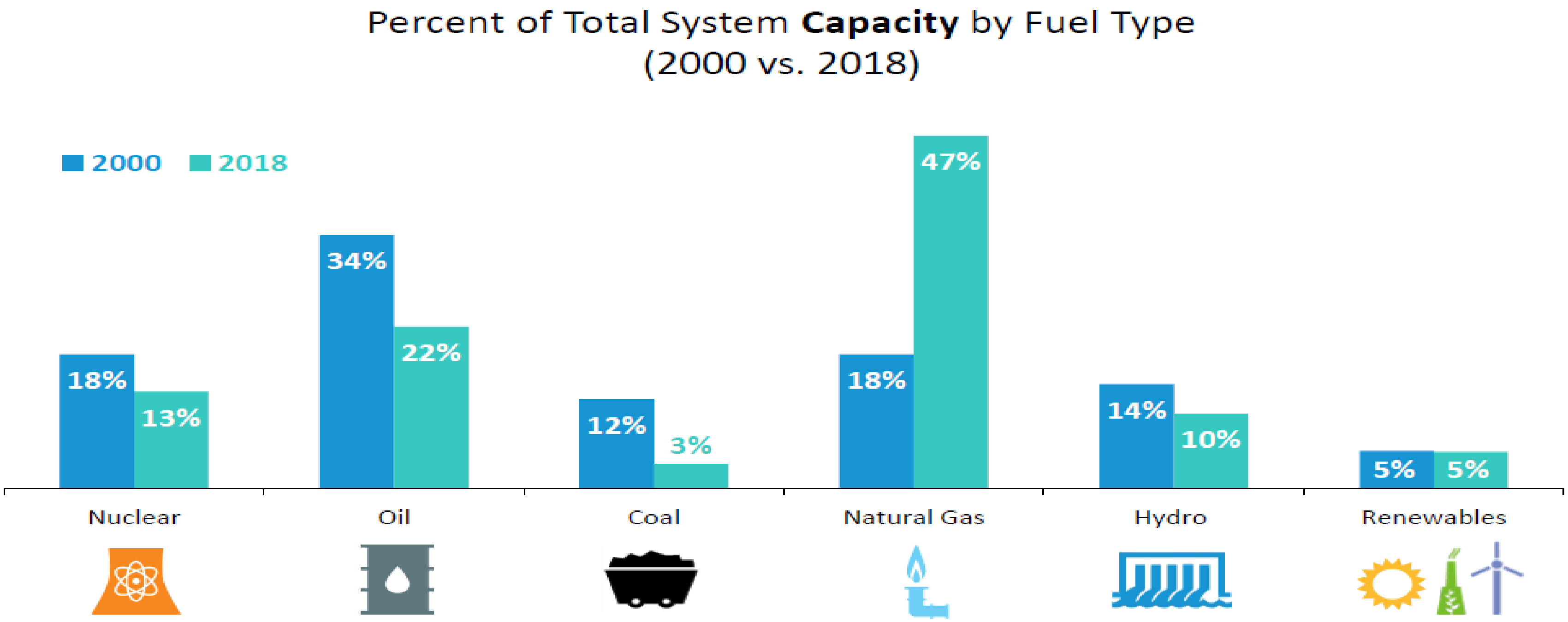
OFFSITE PROJECT Unbundled or Bundled RECs (example: VPPA or CFD)	**HIGHER:** Risk, Complexity, Impact -$10.00 to +$25.00 per MWh
COMPLIANCE MARKET Unbundled RECs (example: CT Class I)	+$25.00 to $40.00 per MWh
VOLUNTARY MARKET Unbundled RECs (example: Green-e)	+$0.65 to $1.75 per MWh **LOWER:** Cost, Complexity, Impact

PWGSE Report May 2021 - Appendix C

Item #1: Renewable Energy Profile



Item #1: Renewable Energy Profile



Source: [2018 CELT Report](), Summer Seasonal Claimed Capability (SCC) Capacity
Renewables include landfill gas, biomass, other biomass gas, wind, grid-scale solar, municipal solid waste, and miscellaneous fuels.

Item #2: Behind-the-Meter Solar

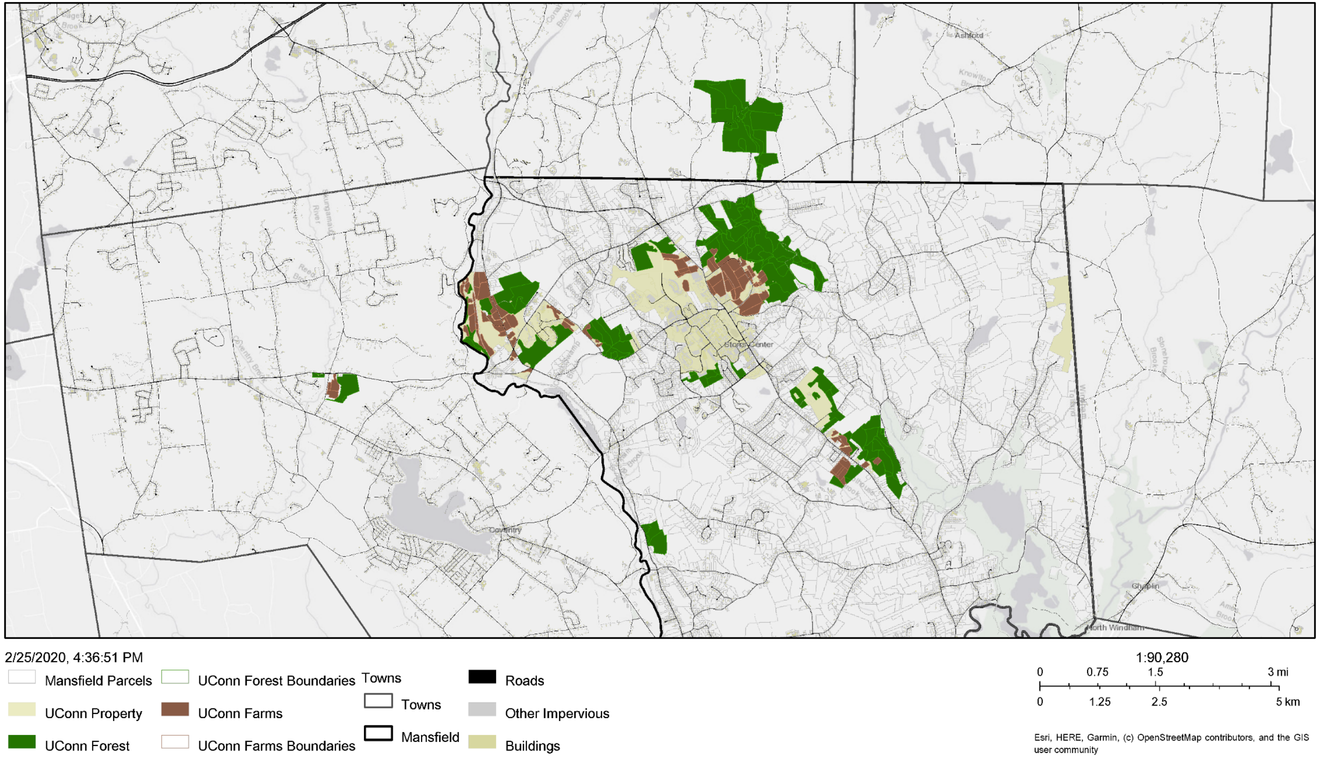
- Onsite solar costs vary widely depending on host site conditions, interconnection costs, and system ownership (i.e. tax credit monetization)
- The primary operational and cost variable for a large-scale solar installation at Storrs is likely the campus' electric load profile with the Central Utilities Plant operating, which may produce risks of excess energy generation
- Examining project economics for behind-the-meter solar, only 70% of UCONN's total grid electricity rate is avoidable from onsite solar due to the utility's electric rate design
- Utility incentives for solar generation can help reduce the cost of installing onsite solar to UCONN, however as a condition of receiving incentives UCONN cannot own and retire the RECs generated by a system

PWGSE Report May 2021 - Appendix C

Item #2: Behind-the-Meter Solar

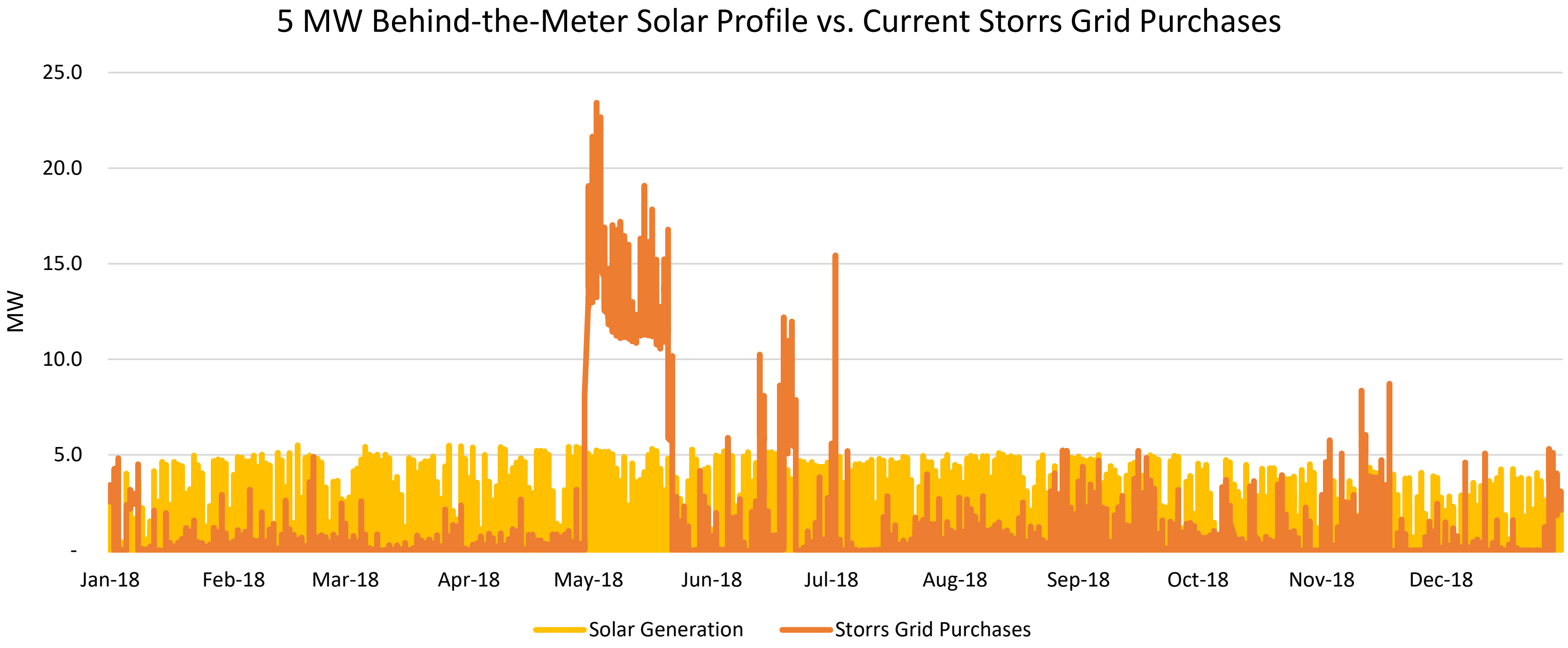
- Managed Forested Land = Approximately 1,940 AC total
  - Forest in Willington accounts for roughly 438 acres of the total
  - Forest in Coventry accounts for roughly 52 acres of the total
- Managed Agricultural Land = Approximately 490 AC total
  - The Lee Farm in Coventry accounts for roughly 20 acres of the total
- CAHNR is responsible to protect these land holdings for its operations, education and research
- Several parcels held in conservation or preservation agreements, and consist of unique natural features

UConn CAHNR Property

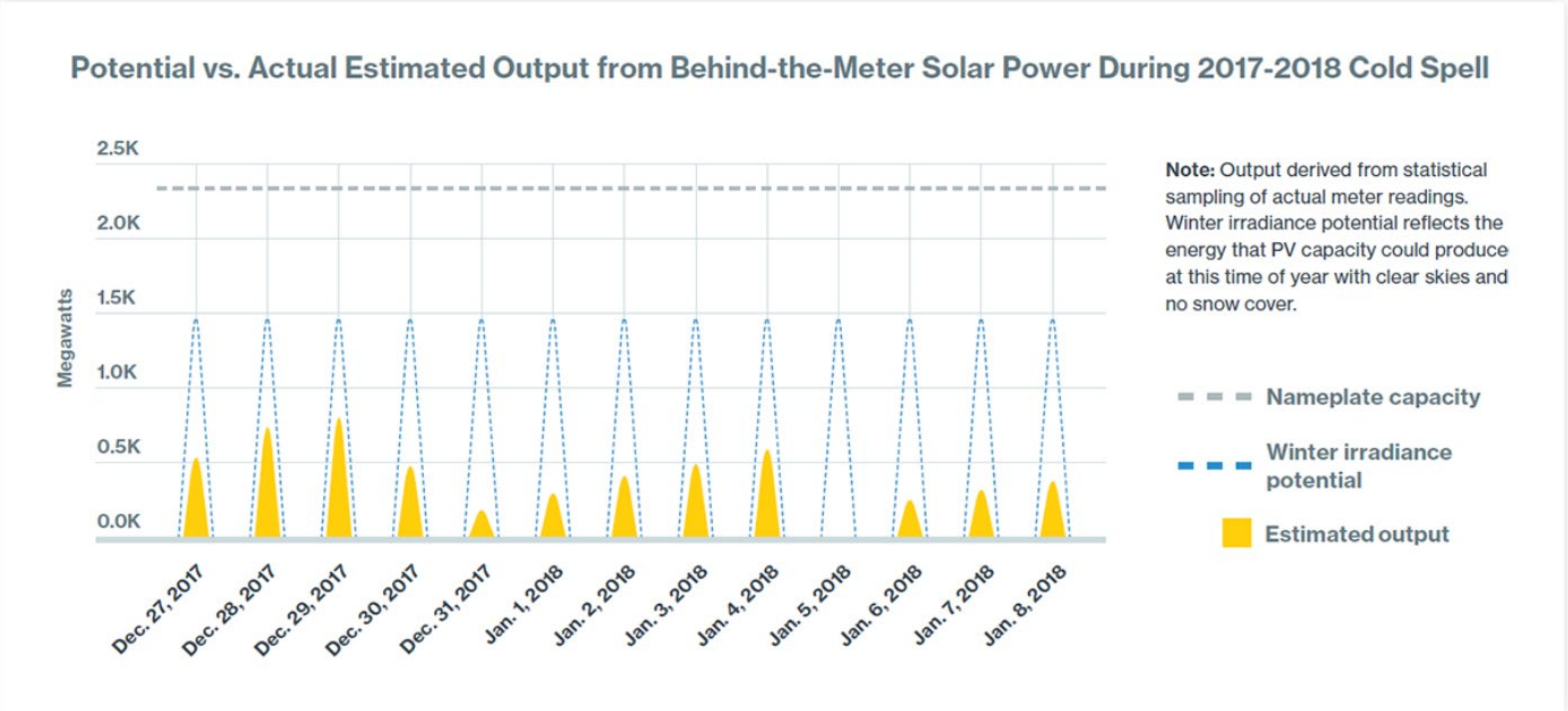


PWGSE Report May 2021 - Appendix C

Item #2: Storrs Load vs. Solar



Item #2: Storrs Load vs. Solar



Item #2: Battery Demonstrations

UMass Amherst – 1.32 MW/4 MWh storage plus solar & CHP
UMass Boston – 0.50 MW/2 MWh solar plus storage
UMass Dartmouth – 0.52 MW/1 MWh storage plus solar/wind
Brandeis University – 0.78 MW/1.5 MWh storage
Acushnet Company – 1.5 MW/3 MWh storage plus CHP

UMASS AMHERST

UMASS BOSTON

UMass Dartmouth

TRUTH EVEN UNTO ITS INNERMOST PARTS Brandeis אמת

ACUSHNET COMPANY

Titleist FootJoy Scotty Cameron Vokey Design Pinnacle

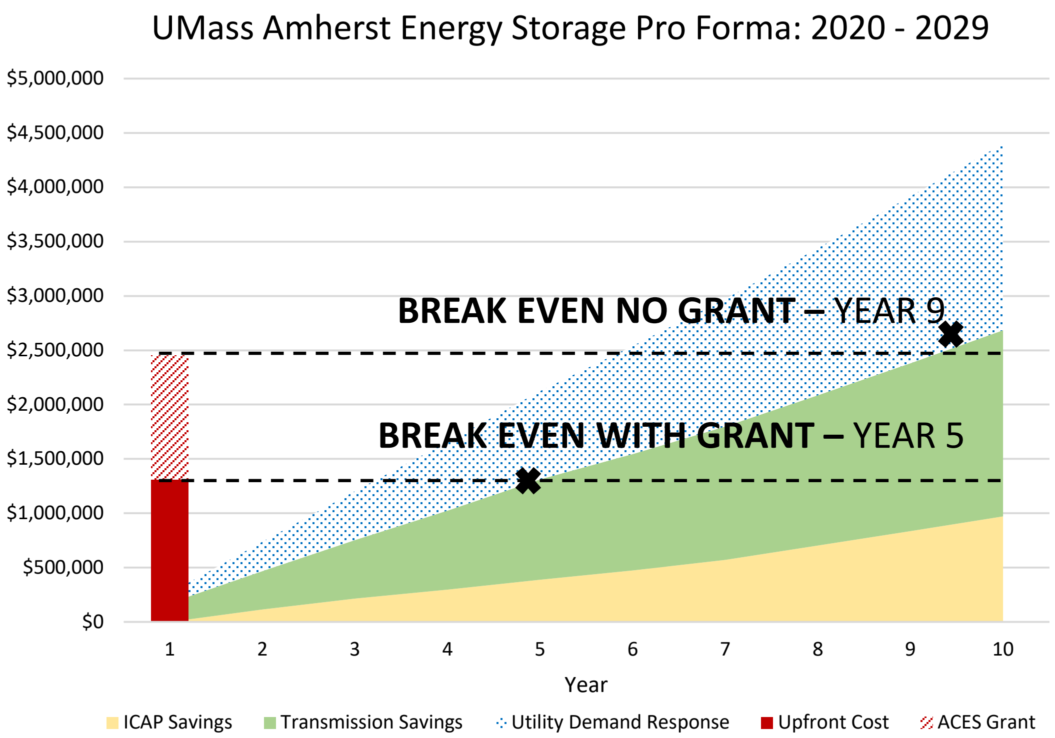
Item #2: Battery Demonstrations

New Energy Storage Technologies Are Coming On Line

- **20 MW** of grid-scale battery storage projects have come on line since late 2015
- Proposals for **more than 1,300 MW** of grid-scale, stand-alone energy storage projects by 2022
- A first: **20 MW** home solar and battery storage cleared FCA #13 for 2022-2023
- Meanwhile, New England has operated two large pumped-storage facilities for 40 years
  - They can supply **1,800 MW** of power in 10 minutes, for up to 7 hours

Item #2: UMass Case Study

- 1.32 MW / 4 MWh lithium ion battery commissioned in July 2019
- $1.1 million state grant covered nearly 50% of installation cost
- Two main goals of operations
  - Shave campus peak demand
  - Help integrate onsite solar
- One operating cycle covers 1% of the campus' average daily load
- UMass Amherst's unique electric rate design and external funding enables a financial payback on the system under 10 years
- Current battery costs and UCONN rate design make a short-term payback challenging for UCONN without external incentives/funding
- Battery operations increase the campus' Scope 2 emissions due to round-trip efficiency losses



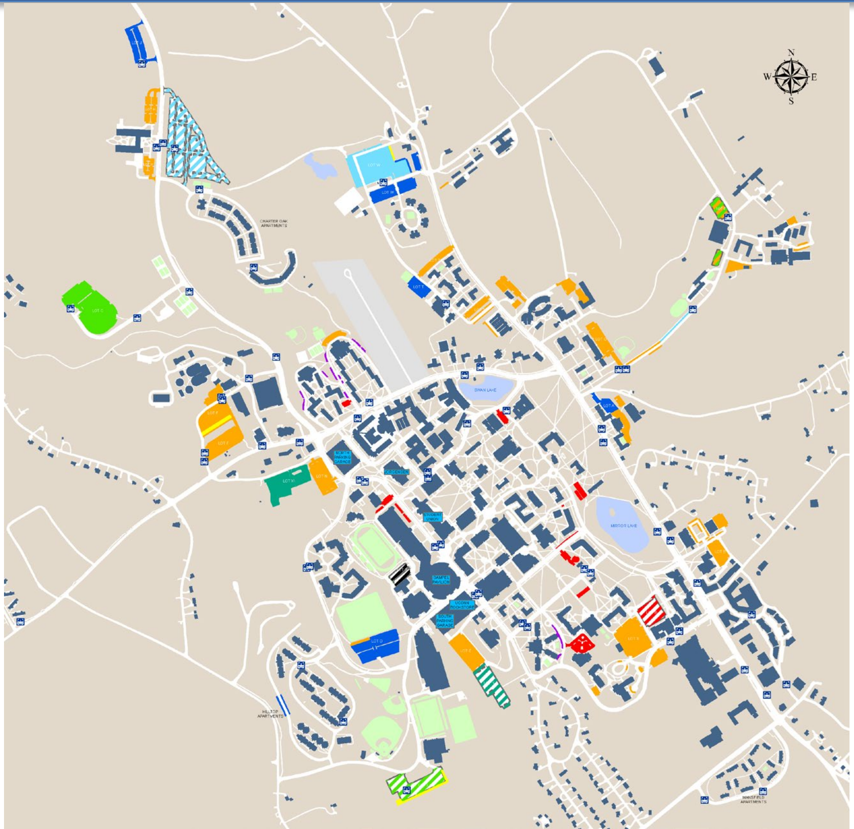
Item #3: Solar Parking Canopies

- In 2016, UMass Amherst installed 4.5 MW of solar parking canopies on campus under a third-party PPA
- UMass Amherst is currently evaluating installing an additional 3 MW of solar parking canopies on campus
- Solar parking canopies designed for Northeast winters may cost $175 - $250 per MWh on a levelized basis due to substantial costs of structural water management requirements
- UMass' projects have been enabled by generous state incentives that provide $150+ per MWh for solar generated by parking canopies

Item #3: Solar Parking Canopies

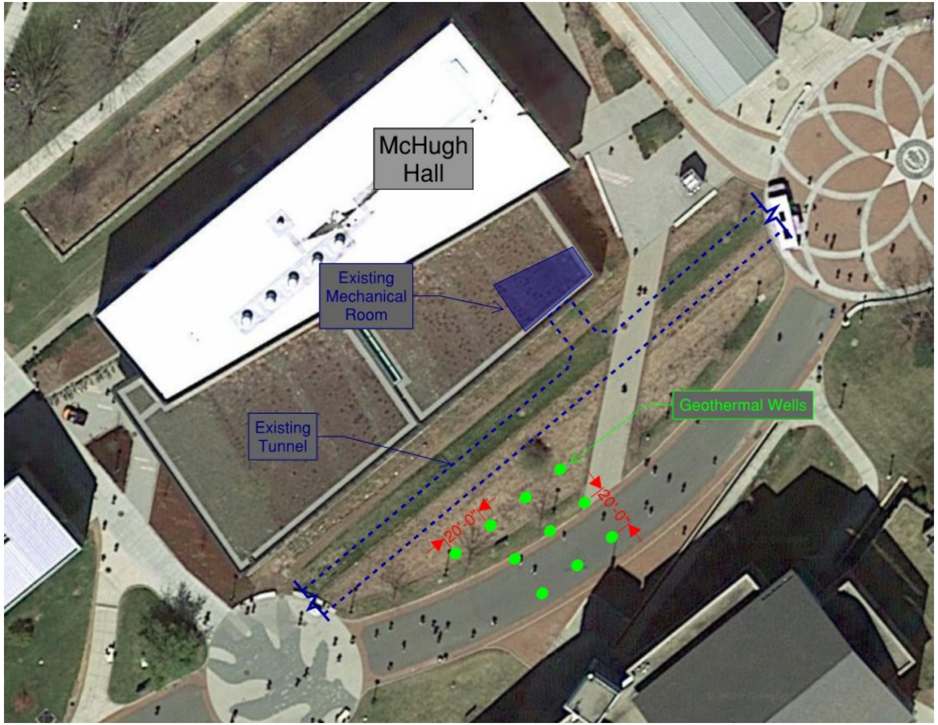
Potential Opportunities

- Charter Oak Apartments and Hilltop Apartments
  - Existing poor pavement conditions
- Lot D (Football Practice/Hilltop)
  - Existing poor pavement conditions
  - Deferred development option for a recreation field
- Lot J (Discovery Drive)
  - Center median sleeved when constructed in 2017
  - No future building proposed
- Lot G (Gampel/Sherman Field)
  - Center median sleeved when constructed in 2018
  - Designed to double when TAB reaches useful life
- Lower T (Towers)
  - Existing poor pavement conditions
  - No future building proposed)
- Lots Y & Z (McMahon)
  - Planned for resurfacing this summer
  - Unutilized option for siting the Student Recreation Center



Item #4: Geothermal Wells (McHugh)

- McHugh estimated to require:
  - 272 tons of cooling
  - 2720 MBH of heating
- 10 Wells
- Capable of offsetting 300 MBH of heating and 30 tons of cooling (approximately 11% reduction in building demand)
- Potential for more than 10 wells, amount dependent on available space in existing mechanical room
- 31 metric tons of carbon reduction estimated



Item #5: Geothermal Wells (Bishop)

- Bishop Center estimated to require:
  - 132 tons of cooling
  - 1320 MBH of heating
- Geothermal heat pump interface to be provided inside existing mechanical room
- 16,500 sq ft. well area is required. 45 wells at 20 feet on center
- 140 metric tons of carbon reduction estimated

Item #5: Geothermal Wells (CESE)

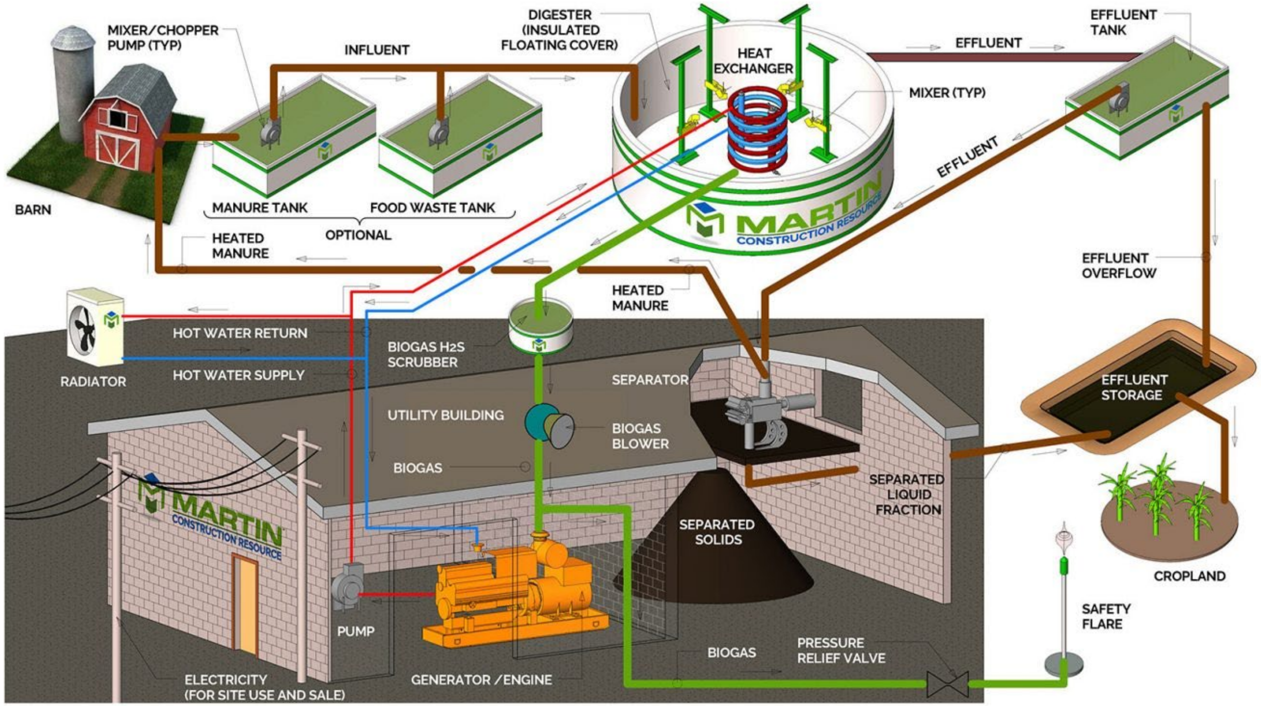
- CESE estimated to require:
  - 184 tons of cooling
  - 1840 MBH of heating
- Geothermal heat pump interface to be provided inside new addition to mechanical room
- 23,000 sq ft. well area is required. 60 wells at 20 feet on center
- PV area of 1.7 acres providing approximately 325 kW will be required
- 414 metric tons of carbon reduction estimated

Item #5: Co-Use PV/Farming (CESE)

- Geothermal wells and PV Solar can overlap
- Integrate farming/agricultural use with solar footprint
- Meet objectives of the East Campus Plan of Conservation and Development

Photos: The 2019 NACD Annual Meeting Presentation

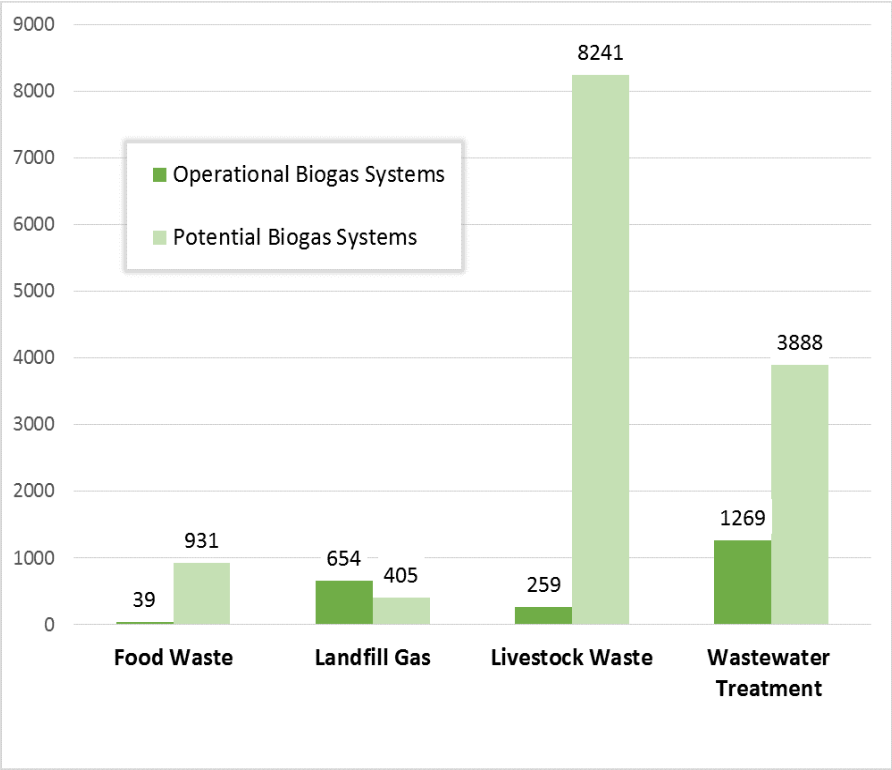
Item #6: Anaerobic Digester



https://martinenergygroup.com/digesters/

Item #6: Anaerobic Digester

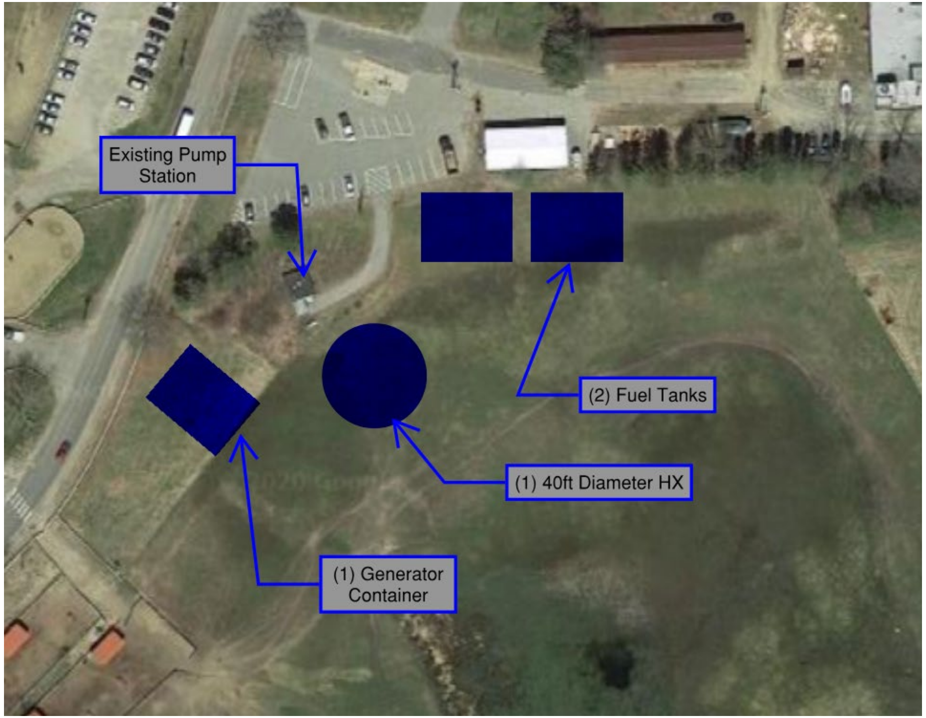
- 1000 lb Cow produces an average of 80 lbs of manure per day
- Wastewater Treatment Plants
- Biogas reduces GHG emissions via Methane Capture
- Biogas combustion is 65% Methane and 35% CO_2



https://doi.org/10.1080/10934529.2018.1459076

Item #6: Anaerobic Digester

- Anaerobic digestion is preferred over aerobic digestion because of decomposition control, odor control and useable fuel byproduct
- The fuel gas (biogas) must be scrubbed to remove hydrogen sulfide before can be effectively used as a reliable and renewable natural gas
- The gas can be burned in a boiler or reciprocating engine generator
- Incorporate PV on roof of generator container
- Methane is a 25x worse GHG than CO^2
- Available campus waste
  - 1000 tons agriculture waste annually
  - 500-700 tons food waste annually



Item #7: Compost Facility

- Reduction in Odor
- Reduction in Volume
- Suppression of plant pathogens
- Reduction of weed seeds in manure
- Reducing emissions of greenhouse gases
- Uses 50% of the 1,000 tons available agriculture waste annually

Carbon Value

- Solar Installations - **Up to 758 Metric Tons (0.6% of 2007 Baseline) for every 1 MW installed**
- CANHR Sequestration - **Up to 3,800 Metric Tons (2.7%) for forest lands**
- Geothermal **(0.4%):**
  - McHugh Hall – **Up to 31 Metric Tons**
  - Bishop Center – **Up to 140 Metric Tons**
  - CESE Building – **Up to 414 Metric Tons**
- Anaerobic Digestion – **Up to 82 Metric Tons (<0.1%)**
- Compost Facility Expansion – **Up to 200 Metric Tons (0.14%)**

Thank you!

integrated
services

APPENDIX B

Zero Carbon Scenario Planning

(Peak Plan)

UCONN
UNIVERSITY OF CONNECTICUT

ZERO CARBON SCENARIO PLANNING (PEAK PLAN)

University of Connecticut
Storrs, Connecticut
Project #300192

September 2020

BVH integrated services

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Contents

1. INTRODUCTION

1.1. BACKGROUND

On June 5, 2020, the President's Working Group on Sustainability and the Environment (PWGS) issued a report entitled *"Planning for a Zero-Carbon Future - Recommendations and Strategies to Align UConn with International Scientific Consensus and the Goals of Climate Justice".* The report was a collaborative effort by faculty, students, and ex officio staff to develop recommendations and strategies to reduce the University's carbon emissions and to respond to Executive Orders issued by Governor Lamont, goals recommended by the Intergovernmental Panel on Climate Change (IPCC), and current UConn sustainability commitments.

The President's charge to the PWGS was to:

> *"Examine UConn's current carbon emissions reduction goals and our progress to achieving them; assess whether or not accelerating these goals is feasible within the context of our budget and available technology; if so, recommend actions UConn can take to achieve that based on facts, data, sound strategies and the best estimates we are able to make."*

As noted in the June report, the initial PWGS efforts were intended to be only the preliminary assessment and further work is necessary to develop a conversion plan to reduce the current carbon footprint to a zero-carbon campus. This current study is therefore a continuation of the work by the PWGS committee with a focus on the goals listed below to convert the campus from fossil fuels to clean, renewable energy.

1.2. GOALS

BVH Integrated Services, P.C. was directed to consider the following goals while developing the conversion plan included within this report:

- Plan for 60% reduction in emissions from 2010 baseline by 2030

  The zero-carbon goal defined in the June report *"applies to Scope 1 (direct on-campus) and Scope 2 (purchased power) carbon dioxide-equivalent emissions from fossil fuels (coal, oil, and natural gas)."* Adjustments to the 2010 baseline are explained further in this report to represent the emissions generated from fossil fuels.

- Plan for zero-carbon from 2010 baseline by 2040

  "All heating and cooling infrastructure should be fully converted to zero-carbon capable systems such as geothermally coupled electric heat pumps, with suitable electrical infrastructure installed by 2040."

  Although the PWGS discussed many potential alternatives, BVH Integrated Services was asked in this study to only focus on a geothermal heating and cooling system solution, with full 100% electrification of the campus by 2040.

- Develop interim target milestones for 2025 and 2035

  Note: The interim target milestone for the 2035 conversion period was determined to be difficult to predict given the uncertainty in campus development and technology that may be available at that time. The conversion period from 2030 to 2040 could assume a steady reduction in emissions as the identified regions (districts) are converted from fossil fuels to clean, renewable energy systems.

- Maintain reliability and resiliency of new infrastructure to level of peer institutions

  "All new infrastructure is designed for a 99.99 percent reliability and sufficient resiliency to protect the $5.3 billion dollars of research assets and provide shelter-in-place capabilities for students in the event of adverse conditions from natural or human initiated event."

1.3. APPROACH

The following approach was followed during the report preparation:

- **Existing Load Analysis** – Identify standalone buildings and buildings on central systems. Develop existing thermal and electrical load matrix.
- **Develop Future Development Plan** – Review future development and incorporate future energy requirements into thermal and electrical load matrix.
- **Ground Source Heat Pump Systems** – Strategy used to convert thermal from fossil fuels to clean renewable energy. Identify potential locations for well fields. Develop districts based on well field locations.
- **Solar Photovoltaic** – Strategy used to develop renewable electrical power. Identify potential locations for solar canopies on campus parking lots, locations for ground-mounted solar (both on campus and offsite), and roof-mounted solar.
- **Electrical Infrastructure Upgrades** – Identify necessary improvements to upgrade the electrical infrastructure systems to support the full electrification of the campus.
- **Facilities Carbon Reduction Projects (ECMs)** – Review the University's ongoing and future carbon reduction projects and integrate into the conversion plan and conversion periods.

- **Emissions Reduction Matrix** – Provide updated emissions reduction matrix illustrating the projected reductions by conversion periods.
- **Renewable Energy Credits** – Review process and need for renewable energy credits (RECs) as part of the conversion plan.
- **Rough Order of Magnitude Capital Cost** – Develop opinion of rough order of magnitude capital cost summary by conversion period.
- **Rough Order of Magnitude Operating Costs** - Include opinion of rough order of magnitude operational and maintenance cost summary by conversion period developed by the University.

1.4. THEORY AND PRACTICE

The work provided with this study needs to be considered a theoretical "desktop" study to meet the PWGS goals noted above. This study has not been tested for practical physical feasibility and execution. The bulleted items below are just a few of the items that need to be reviewed further, and there may be others.

- Funding for both capital costs and on-going operational cost increases.
- Policy changes, Procurement requirements and Regulatory Approvals.
- Assumptions need verification, including the viability of close-looped well fields in multiple locations and in close proximity, as well as, the viability and output from photovoltaic solar panels, both of which require physical testing.
- The conversion plan schedule has not been tested against the availability of contractors to actually conduct the work in a condensed timeline.
- The ability of the University to continue its educational mission and potential operational impacts and losses in revenue due to construction disruption has not been assessed.
- The projected cost included in this study is only a Rough Order of Magnitude (ROM) and requires further design and analysis to verify same.
- In reality, due to the significant amount of design, regulatory and planning work required for a plan of this size, only limited interim carbon reduction milestones at 2025 may be achieved.
- This conversion plan requires a significant capital and infrastructure investment from Eversource to provide electrical capacity to the campus that does not presently exist.

The University has multiple master plans in process which will need to be prioritized and integrated with this plan.

2. EXECUTIVE SUMMARY

BVH Integrated Services, P.C. (BVH) was retained by the University to assist with the development of a more detailed step-by-step conversion plan to transition the campus from fossil fuel generation sources to renewable, clean energy, in accordance with the goals expressed in the PWGS *"Planning for a Zero-Carbon Future - Recommendations and Strategies to Align UConn with International Scientific Consensus and the Goals of Climate Justice" report*. The development of the plan to convert the campus to an electric geothermal heating and cooling system occurred over the summer of 2020 academic break and included involvement with the University Planning, Design and Construction (UPDC) group, Facility Operations (FACOPS), Competitive Energy Services (CES), energy consultants retained by FACOPS, as well as collaboration with a sub-committee of the PWGS, which included staff members, faculty members and student representatives.

The conversion plan includes studying what would be necessary to transform the campus's fossil fuels to clean, renewable sources for the Storrs campus. Currently, the Cogen plant generates approximately 90% of the campus electrical energy and 65% of the thermal energy. Additionally, there are facilities on the perimeter of the main campus and facilities located further from the main campus, such as the Depot Campus, Spring Hill, Spring Manor, Northwood, and Mansfield Apartments that are served directly from the Eversource electrical grid and have standalone heating and cooling.

The list below illustrates the energy sources for the approximately 400 existing buildings reviewed in this study.

- 142 buildings are heated by the Central Utility Plant
- 41 buildings are cooled by either the Central Utility Plant, South Campus Chilled Water Plant, or Gampel Pavilion Chilled Water Plant
- 260 buildings have independent heating and 127 have independent cooling
- 275 buildings are connected to the UConn electrical system

The following provides a summary of the conversion plan and the steps taken to achieve a zero-carbon campus by 2040 as outlined in the preceding "Goals" and "Approach" sections. Additional information is available in the noted appendices.

2.1. CONVERSION PLAN SUMMARY

The goal of the conversion plan was to develop a step-by-step conversion strategy to transition the campus from fossil fuels to clean, renewable energy. The PWGS report recommended a goal of 60% emissions reduction from the 2010 baseline by 2030 and 100% emissions reduction by 2040 with interim targets at 2025 and 2035 to measure progress toward the 2030 and 2040 goals. (Refer to **Section 2.7 Emission Reduction Matrix** for information related to the 2010 baseline and summary of emissions reductions for each conversion period.)

The strategy explored with this study included the conversion of the existing buildings from either centrally distributed heating and cooling or independently heated and cooled to an electric ground source heat pump system supported by an improved electrical distribution system from assumed clean, renewable sources. During the early conversion phases (through 2030), solar photovoltaic is proposed to aid in providing a renewable source of electrical power, but is insufficient to meet the whole demand. In addition to the solar generation, this study includes and assumes Eversource will meet its current statutory commitment to provide 44% of the grid power from clean, renewable sources by 2030, and assumes that Eversource will continue to increase the percentage of electricity from clean, renewable sources to 100% by 2040.

2.2. CONVERSION PERIODS

The conversion periods, which include a variety of carbon emission reduction strategies, are as follows:

- **2021 - 2025:** Includes the continuation of Energy Conservation Measure (ECMs) projects identified by FACOPs, and the installation of on-site photovoltaic solar systems (connected directly to UConn electric distribution).
- **2026 - 2030:** Includes the continuation of additional ECM projects, the conversion of selected districts to ground source heat pumps located on the perimeter of the core campus and remote locations, installation of offsite (connected to utility grid) solar photovoltaic, and installation of selected electrical infrastructure improvements.
- **2031 - 2040*:** Includes the remaining district conversions to ground source heat pumps and additional electrical infrastructure improvements.

* The interim target milestone for the 2035 conversion period was determined to be difficult to predict given the uncertainty in the campus development and technology that may be available at that time and was therefore excluded from this study. The conversion period from 2030 to 2040 assumes a steady reduction in emissions as the identified regions (campus districts) are converted from fossil fuels to clean, renewable energy systems.

Although the 2025 milestone only includes PV and Carbon Reduction projects (ECMs), it is important to understand the district conversion project conception needs to begin as soon as possible to meet the 2030 milestone.

3. CONVERSION PLANS

3.1. EXISTING LOAD ANALYSIS

An inventory of the existing Storrs campus buildings was conducted with information provided by the University's space planning database. (Refer to **Appendix F - Existing Storrs Campus Buildings Matrix** for existing Storrs campus buildings matrix.) This resulted in the compilation of approximately 400 buildings totaling an estimated 10.8 million square feet with the following statistics for the year 2020:

- 142 buildings are heated by the Central Utility Plant
- 41 buildings are cooled by either the Central Utility Plant, South Campus Chilled Water Plant, or Gampel Pavilion Chilled Water Plant
- 260 buildings have independent heating and 127 have independent cooling
- 275 buildings are connected to the UConn electrical system

To determine the existing energy consumption, a typical heating load (BTU/SF) and cooling load (SF/TON) were assigned to the existing facilities based on building type. (Thermal load assumptions are provided in **Appendix B - Thermal Conversion Evaluation**). A summary of the energy consumption by type and source is provided in **Table 3** below.

	Gas Consumption (MMBtu/Yr)	Electrical Consumption (MWhr/Yr)			
		Total Electric Consumption	Non-CUP Sources (Eversource)	PV Generation	CUP
2020	1,700,102	135,304	11,979	40	123,325

Table 3: Existing Energy Consumption

3.2. FUTURE DEVELOPMENT PLAN

The future development plans were reviewed with UPDC through year 2030. Energy consumption loads were calculated in a similar manner to the existing building loads. A summary of the future development is provided in **Table 4** below. Note that some of these projects are in construction but others are in planning only and may not be constructed.

Building Description	Building Address	Type	Gross Building Area (ft2)
New Hockey Arena	523 Jim Calhoun Way	New Construction	**97,700.00**
Stem Research Center Science 1	25 King Hill Road	New Construction	**197,198.00**
38E Substation	King Hill Road	New Construction	**0.00**
Supplemental Utility Plant	King Hill Road	New Construction	**35,753.00**
Greenhouse Replacement	Discovery Drive	New Construction	**26,000.00**
Torrey Life Sciences Building	North Eagleville Road	Demolition	**-147,761.00**
Greenhouses	Auditorium Drive	Demolition	**-15,000.00**
Public Safety Expansion	North Eagleville Road	New Construction	**4,037.00**
Honors Residence Hall	Gilbert Road	New Construction	**210,000.00**
Research and Development Building	Discovery Drive	New Construction	**100,000.00**
Mansfield Apartments	South Eagleville Road	Demolition	**-79,257.00**
Mansfield Apartments	South Eagleville Road	New Construction	**260,000.00**

Table 4: Future Development Plan (2030)
(930,688 New SF / 242,018 SF Demolition = Net 688,670 New SF)

Development past 2030 to 2040 is unknown at this time. Other than Board-approved projects identified in the PWGS June 5th, report listed in Appendix A, Section 3, all new construction including development not identified for the 2030 to 2040 period would need to include "zero-carbon capable systems". These systems need to be supported by the electrical infrastructure upgrades proposed in this report.

3.3. LOAD CONVERSION SUMMARY

The campus load profile projections are noted in **Table 5: Load Profile by Conversion Period** below as a result of converting the Storrs campus from fossil fuel systems to ground source electric heat pump systems supported by an upgraded electrical infrastructure system.

	Gas Consumption (MMBtu/Yr)	Electrical Consumption (MWhr/Yr)			
		Total Electric Consumption	Non-CUP Sources (Eversource)	PV Generation	CUP
2020	1,700,102	135,304	11,979	40	123,325
2025	1,504,202	135,304	4,581	7,398	123,325
2030	743,033	199,536	36,060	44,150	119,325
2040	0	263,168	219,017	44,150	0

Table 5: Load Profile by Conversion Period

- **2020:** CUP providing both maximum electricity and maximum thermal production; small amount of PV generation.

- **2025:** Gas consumption reduced mainly due to carbon reduction projects (ECMs); electrical consumption from Eversource decreased due to addition of PV generation.
- **2030:** Gas consumption reduced by conversion of independent and central heating systems; electrical consumption increases - offset by addition of large scale PV generation and additional “44% "clean" electric from the grid; CUP electrical production is reduced.
- **2040:** Gas consumption is reduced to zero and CUP electrical generation is reduced to zero. Grid power is assumed to be 100% clean.

The following **Charts 1 and 2** indicate a reduction in the use of natural gas on campus and corresponding growth in the use of electricity. **Chart 1** is noted in separate terms of energy for MMBtu and MWHrs.

In the second UConn Consumption Chart **(Chart 2),** the energy consumption terms are reconciled to the same energy units. It is clear that there is a considerable reduction in overall energy consumed as the perimeter of the campus is converted to the efficient ground source thermal system. The change from 2030 to 2040 indicates the conversion of the interior and more dense part of the campus served from the efficient Co-Gen (which technically is Tri-gen) system. This is not as beneficial from an overall energy savings point as the perimeter conversion, but the energy consumption from natural gas used by the turbines to an electrical ground source thermal system will have a large carbon emission reduction.

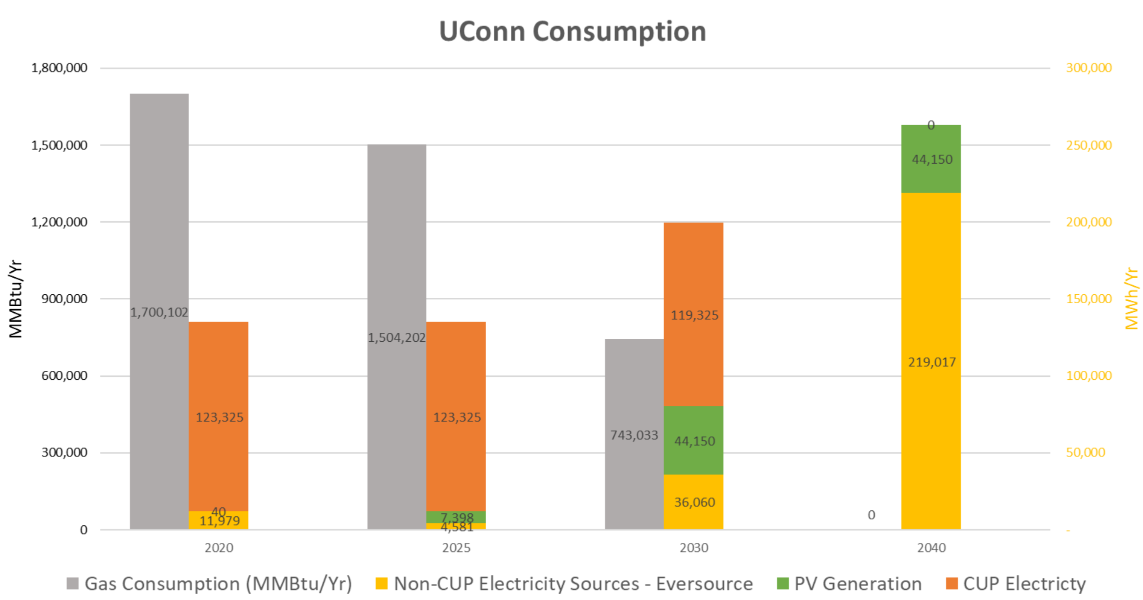


Chart 1: UConn Consumption (MMBtu/year, MWh/year)

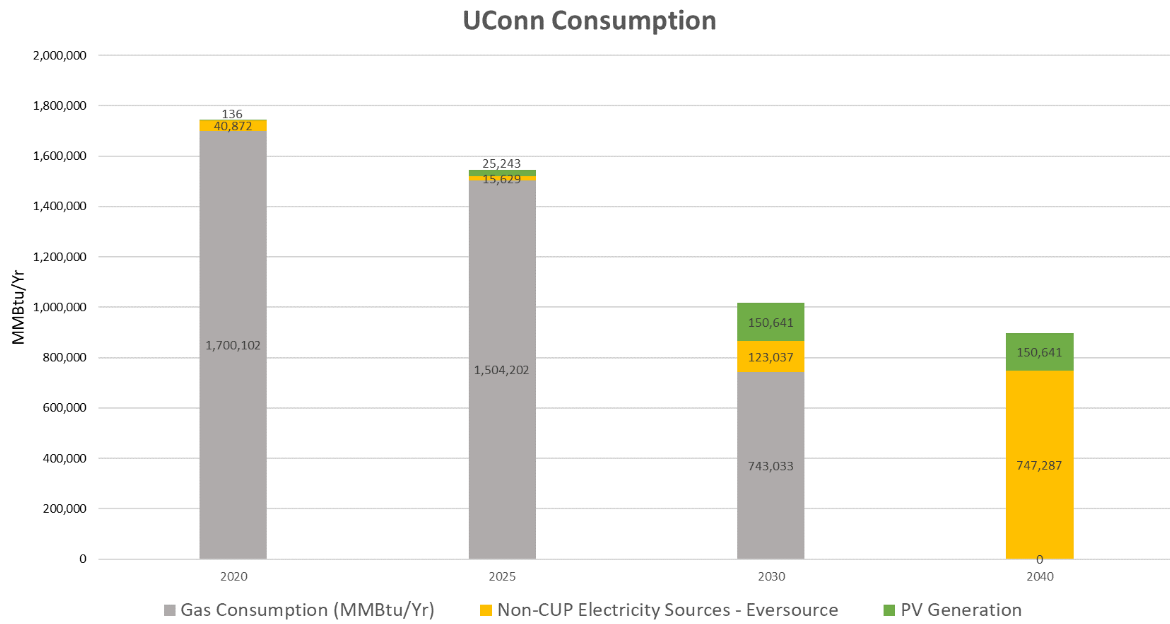


Chart 2: UConn Consumption (MMBtu/year)

3.4. EMISSION REDUCTION MATRIX

The main goal of this study was to develop a conversion plan to reduce carbon emissions 100% from the 2010 baseline by 2040. The emissions considered and used for reduction calculations applied to Scope 1 (direct on-campus) and Scope 2 (purchased power) from **fossil fuels (coal, oil, and natural gas).** Scope 1 emissions studied include fossil fuels burned in the Co-Gen facility to produce electricity and steam, and fossil fuels burned in other on-campus stationary systems (i.e.; boilers). These stationary systems are referred to as "independent systems" within this report. Scope 2 emissions include fossil fuels burned to create energy that is purchased from a utility provider (i.e.; Eversource power). Also included in the Scope 1 emissions is fossil fuels burned by direct transportation (i.e.; vehicles owned by the University). Scope 1 emissions from refrigerants and chemicals or agriculture processes have not been considered in this study nor have, as well as emissions from Scope 3 sources. However they would also need to be eliminated by 2040 to meet the zero-carbon objective.

The June 5th, PWGS report had noted the 2010 baseline was 123,023 metric tons of carbon dioxide (MeTCO2). In order to confirm the conversion plan achieved the reduction goals, a new 2010 baseline was generated to account for the specific Scope 1 and Scope 2 emissions identified above. The 2010 emission baseline used for this study was the sum of the highlighted cells in **Table 6** for a total of 102,778 MeTCO2.

Select Year -->	2010	Energy Consumption	CO_2	CH_4	N_2O	eCO_2
		MMBtu	kg	kg	kg	Metric Tonnes
Scope 1	Co-gen Electricity	643,838.0	34,227,536.6	3,419.2	70.2	34,333.9
	Co-gen Steam	924,131.4	49,128,418.1	4,907.8	100.8	49,281.2
	Other On-Campus Stationary	304,679.0	16,532,868.9	1,705.0	41.9	16,588.0
	Direct Transportation	39,971.7	2,894,750.7	397.1	142.3	2,947.1
	Refrigerants & Chemicals	-	-	-	-	4,402.2
	Agriculture	-	-	50,723.5	1,256.3	1,642.5
Scope 2	Purchased Electricity	35,983.1	3,456,618.6	91.7	98.3	3,488.2

Table 6: UConn 2010 Emissions

The remaining 20,244 metric tons are from Scope 3, and miscellaneous Scope 1 emissions not generated from fossil fuels (refrigerants, chemicals and agriculture).

The 2019/2020 emissions were determined in a similar manner and totaled 98,083 MeTCO2 (sum of highlighted cells in the table below).

Calendar Year	Scope	Source	CO2 (kg)	CO2 (MTCDE)	CH4 (kg)	CH4 (MTCDE)	N2O (kg)	N2O (MTCDE)	GHG MTCDE
2019	1	Co-gen Electricity	31,804,356	31,804.36	3,211	80.29	71	21.04	31,905.68
2019	1	Co-gen Steam	46,853,159	46,853.16	4,731	118.28	104	31	47,002.43
2019	1	Other On-Campus Stationary	21,821,154	21,821.15	2,257	56.43	57	16.89	21,894.48
2019	1	Direct Transportation	2,629,965	2,629.96	371	9.27	132	39.26	2,678.50

Calendar Year	CO2 (kg)	CH4 (kg)	N2O (kg)	Gross MTCDE	Offsets (MTCDE)	Compost (MTCDE	Non-Addition	Biogenic (MTCDE)	Net MTCDE
2019	117,892,658	75,387	3,405	122,654.20	-5398.53	0	0	0	117,256

Table 7: UConn 2019/2020 Emissions

The remaining 19,173 metric tons are from Scope 3 and miscellaneous Scope 1 emissions not generated from fossil fuels (refrigerants, chemicals and agriculture).

Table 8 and **Chart 3** below illustrate the campus estimated emissions and the percent reduction from the 2010 baseline for each interim milestone period and the 2040 zero-carbon goal.

Year	Storrs Scope 1 and Scope 2 Emissions	Emissions Reduction	% Reduction From 2010 Baseline
2010	102,778	-	0%
2020	98,083	4,696	5%
2025	88,194	14,585	14%
2030	40,115	62,664	61%
2040	0	102,778	100%

Table 8: UConn Emissions Reductions Through 2040

(Note: As mentioned previously, the 2035 interim milestone could assume a steady decrease in emission reductions as certain sections of the campus are converted to electric ground source heat pumps, and Eversouce's transition to 100% clean, renewable electricity by 2040.)

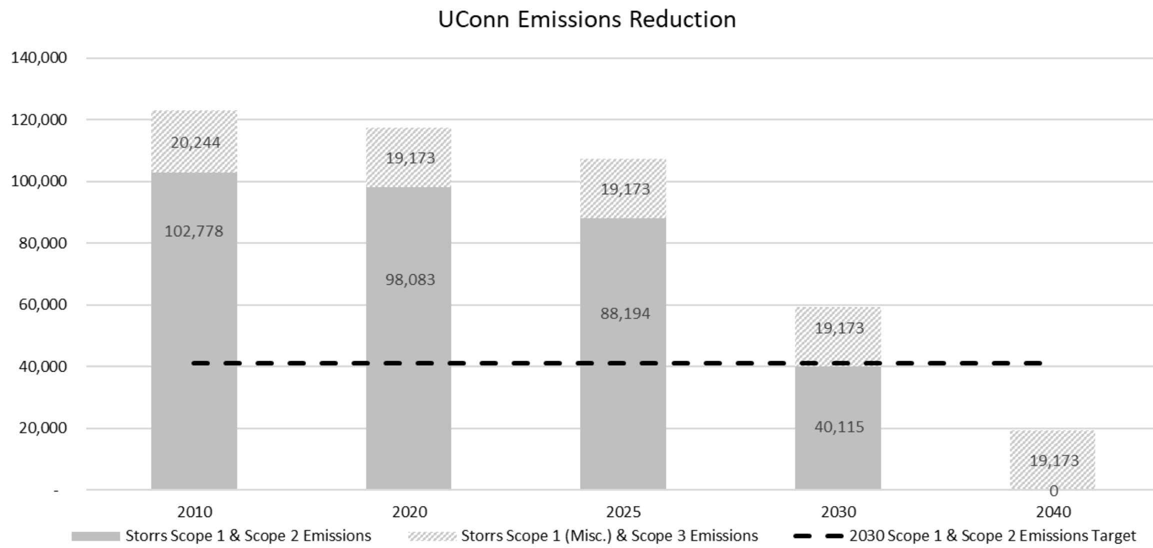


Chart 3: UConn Emission Reductions (MeTCO2)

4. INFRASTRUCTURE IMPROVEMENTS AND CARBON REDUCTION PROJECTS

A number of infrastructure improvements are suggested for the complete conversion from fossil fuels to clean, renewable energy in addition the the University's ongoing and proposed carbon reduction projects necessary to meet interim emission reduction goals.

- The electrical improvements range from increasing the campus electrical infrastructure capacity with new circuits, supplying new electrical services to the proposed district plants, and supply improvements through interconnected electrical substations and multiple connections to the utility grid.
- Thermal conversion improvements include closed looped wells coupled to ground source heat pumps, new district plants, distribution piping and conversion of existing building systems to low temperature HVAC systems.
- Solar photovoltaic includes both on campus systems (solar canopies and roof-mounted) and off campus systems (utility scale solar – Note: Depot campus is considered off campus since it would be connected to the utility grid).
- Carbon reduction projects are various University projects that are on-going and proposed projects. These projects play an important role in the early emission reduction goals.

4.1. ELECTRICAL INFRASTRUCTURE IMPROVEMENTS

To support the conversion from natural gas for thermal loads, upgrades of incoming sources are required to maintain the resiliency required for a flagship research university. The electrical demand is projected to double over the 20-year conversion plan timeline from 30 megawatts to approximately 60 megawatts.

The campus electrical infrastructure includes the following improvements:

- Develop a new "Storrs 38E" Substation and associated distribution improvements adjacent to the future Supplemental Utility Plant.
- Develop a new "SUB 195" Substation and associated distribution improvements in the south campus.
- Install a "High Capacity Feeder" connection to "Storrs 38E" and existing "14G" Trigen bus.
- Install a new transmission circuit from Willimantic to UConn (approximately eight miles).
- Create a load-shedding platform and system.

- Increase campus circuit quantities and switching capability throughout.
- Install approximately 25,000 feet +/- of new electrical ductbank.
- Provide new electrical services to 16 District heat pump plants.
- Upgrade electrical services for standalone / independent heat pump systems.
- Convert IPB from the Eversource to the UConn electrical system.
- Install new controls and sectionalizing automation.
- Add batteries to maintain resiliency with added load (installed next to the Supplemental Utility Plant or SUP).

See **Figure 1** for proposed new Eversource transmission line, and **Figure 2** for proposed electrical infrastructure upgrades. Detailed information related to the electrical system evaluations is included in **Appendix A - Electrical Evaluation**. (Full size map is included in **Appendix G - Supporting Diagrams**)

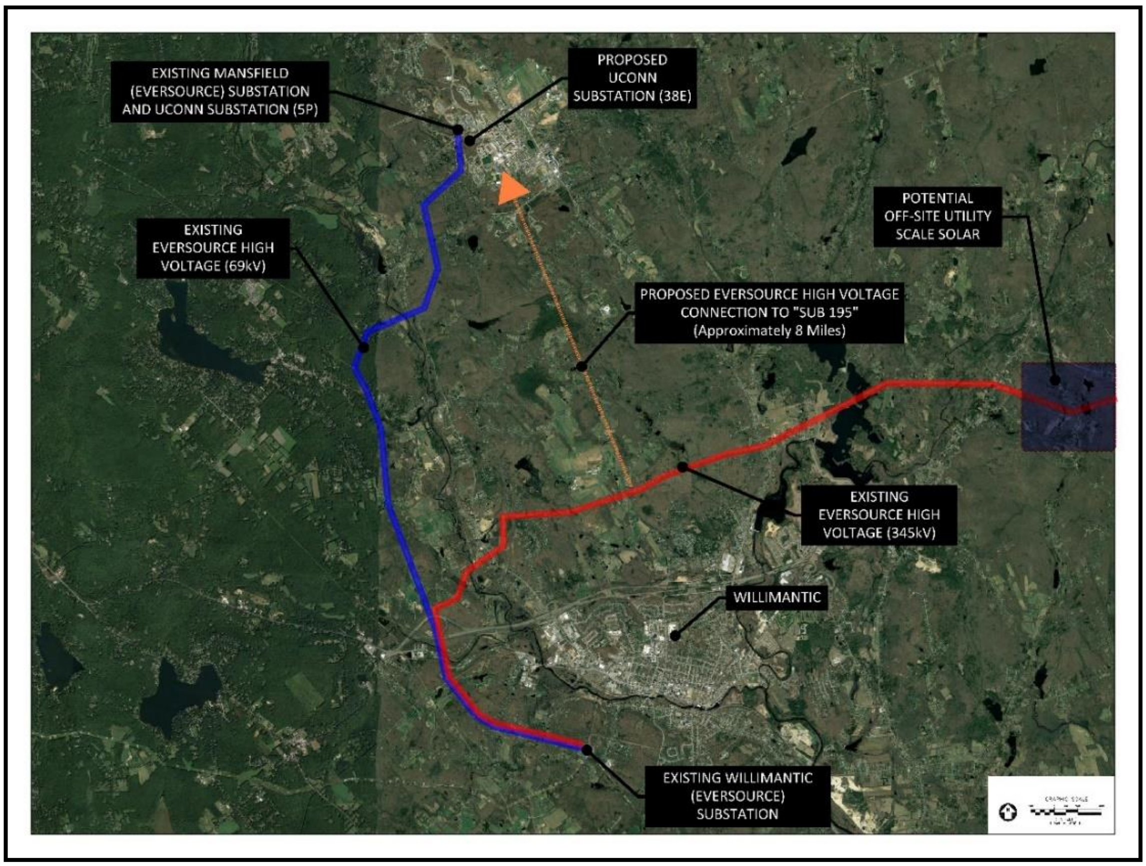


Figure 1: New Eversource Transmission Line

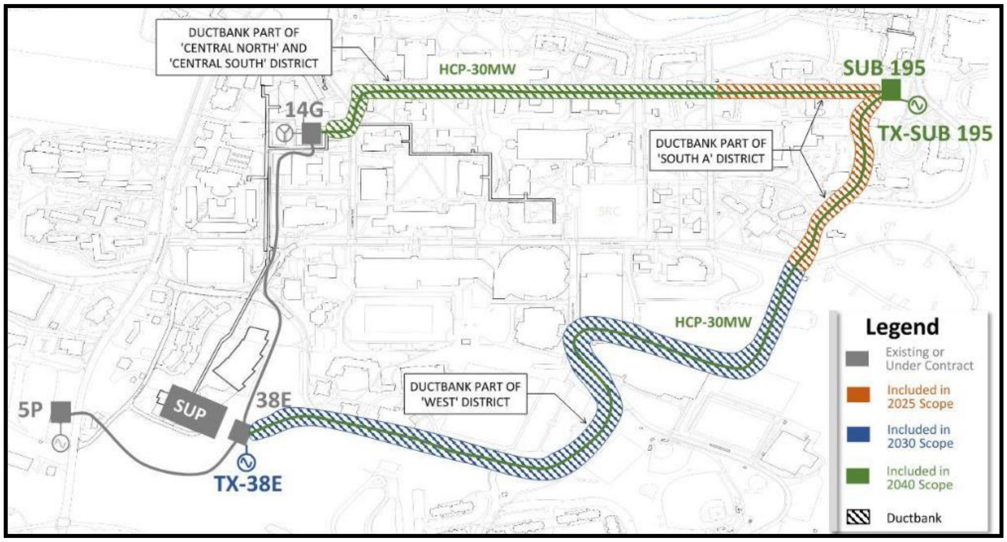


Figure 2: Future Electrical Infrastructure Upgrades

4.2. DISTRICT DEVELOPMENT (THERMAL)

The campus was grouped geographically into districts that utilized available "land" for the installation of closed loop well fields as part of the ground source heat pump system. Each district contains a District Ground Source Heat Pump Plant (District Plant) associated with a specific well field. Well field piping would be routed to the District Plant and connected to the heat pump systems located within the plant. Chilled water and low-temperature hot water distribution piping would be routed from the District Plant to the buildings within that district. As the district mapping was refined, a few of the districts have been identified with sub-districts to minimize distribution pipe lengths and excessive pumping requirements.

The campus thermal conversion includes the following improvements:

- Design and construct 16 District Plants in 14 districts.
- Install approximately 94.5 acres of ground source heat pump (geothermal) wells (10,300 wells).
- Install approximately 155 ground source heat pump units.
- Install approximately 60,000 linear feet of hot water supply and return underground piping.
- Install approximately 58,500 linear feet of chilled water supply and return underground piping.
- Convert 330 buildings to low-temperature hot water heating.
- Disconnect 135 buildings from the existing steam system.

- Disconnect 38 buildings from the existing chilled water system.
- Connect 301 buildings to new district ground source heat pump heating systems.
- Connect 165 buildings to new district ground source heat pump cooling systems.
- Install independent ground source systems for 75 buildings.

See **Figure 3** Campus District Map (full size map is included in **Appendix G - Supporting Diagrams**) for proposed districts. Detailed information related to the ground source heat pump system(s), thermal load calculations, and detailed district summaries is included in **Appendix B - Thermal Conversion Evaluation**.

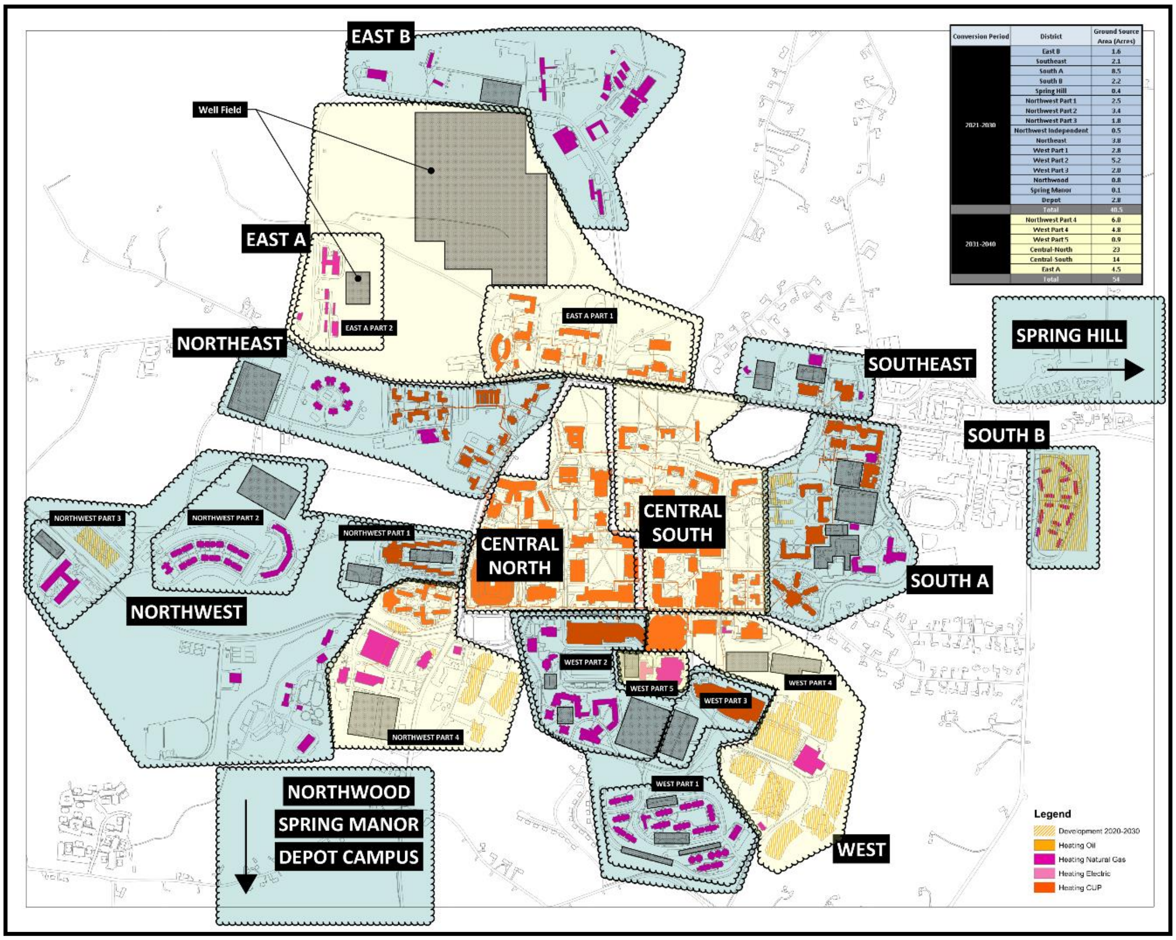


Figure 3: Campus District Map

4.3. SOLAR PHOTOVOLTAIC

Solar photovoltaic (PV) is being recommended in the form of building-mounted, solar canopies, and utility scale ground-mounted. There are two existing solar photovoltaic systems on campus located at the recently constructed Werth Residence Tower and the existing Reclaimed Water Facility which has provided approximately 40 MW hr/yr.

The following summarizes the solar photovoltaic systems currently in construction or proposed for future projects.

Building-Mounted: Anticipated 1 MW installed capacity.

- The new STEM Science 1 facility currently under construction includes the installation of a 400 kW building-mounted PV system.
- The conversion plan assumes any new construction would include building-mounted PV and renovations of potential buildings listed in the Appendix to reach the potential 1 MW of renewable generation capacity.
- Electricity generated from building-mounted systems is assumed to be fed into the University electrical grid (behind the meter).

Parking Lot: Potential 5 MW renewable generation capacity.

- The existing parking areas were assessed for the potential to install solar canopies.
- Reviewing the existing "usable solar canopy area" (actual parking areas not including entrances/exits or circulation drives) resulted in approximately 30 acres of available area. Some of these areas may not be suitable for solar-given orientation, shaded conditions or underlying conditions (i.e., landfills).
- Utilizing a rating system to account for the suitability of the considered areas, a total 5 MW of renewable generation capacity may be expected.
- Similar to the building-mounted systems, the electricity generated from solar canopy systems is assumed to be fed into the University electrical grid (behind the meter).

Utility Scale Solar: Potential 30 MW renewable generation capacity.

- The Depot Campus (including Bergin) was studied during the spring PWGS meetings, and determined approximately 200 of the 264 acres may be available for a utility scale-type solar photovoltaic system. Understanding that a large portion of this area is wooded, a conservative approach would take 50% of the total available acreage and apply a 10 MW/acre conversion factor for a total installed capacity of 10 MW.
- An opportunity exists with a possible third-party to invest in a utility scale solar development located in Brooklyn, Connecticut. This location is attractive due to its close proximity to the existing 345 kV high-voltage line that is being considered as a second source of electrical supply to the campus. Although we believe this solar development will be in excess of 50 MW of renewable generation capacity, we have only accounted for the potential of 20 MW to the Storrs campus.
- The electricity from these two locations is assumed to be fed into the utility company (Eversource) grid and accounted for through virtual net metering.

Detailed information related to the solar photovoltaic systems is included in **Appendix A - Electrical Evaluation**.

4.4. UCONN CARBON REDUCTION PROJECTS

As noted in the June 5th, PWGS report "*UConn is currently in the process of implementing various on-going carbon reduction projects and has proposed several other projects that are needed to meet UConn's Climate Action Plan carbon reduction plans.*"

These projects include various energy conservation measures to reduce energy consumption, thus reducing the overall campus carbon footprint. The list below includes the projects currently on-going or being considered for future implementation. The carbon reductions from these projects are included in meeting the target goals to achieve a zero-carbon campus by 2040.

- Re-lamping campuses to 100% LED (projects currently in progress)
- Vehicle fleet conversion
- Various insulation projects
- Energy Conservation Measures as approved by CT DEEP/PURA
- SLED lighting projects
- Lab Ventilation Management Program Initiative
- Steam/Condensate replacement (10,000 feet of steam line)
- Additional building improvements
- Anaerobic digestion (serving campus waste stream)
- CAHNR sequestration expansion
- Demolition of Torrey Life Science Building

A description of these projects is included in **Appendix C - Carbon Reduction Projects**.

5. IMPLEMENTATION TIMELINE

In order to understand the implementation timeline, a single campus district (South A) was selected and a timeline was developed which included the following tasks:

- Procurement / Design
- Geothermal Wells Development
- Electrical Services Development
- Mechanical Services Development
- Operational Issues

The results revealed a ten-year plus timeline from conception to completion for a single district. Refer to **Appendix D - Implementation – South A District Sample Timeline** for a schedule outline.

6. COST SUMMARY

6.1. CAPITAL COSTS

A Rough Order of Magnitude (ROM) of cost was developed for each conversion period based upon the electrical infrastructure improvements and the campus thermal conversion. Unit costs were developed and confirmed as reasonable by a third party consultant to the University. The range of costs highlights the uncertainty of a theoretical "desktop" study and the need for testing for practical feasibility and execution. For example, if the ancillary building renovation costs resulting from the conversion of all the buildings' heating systems from high temperature to low temperature differs by $100/sf, it changes the cost of the entire project by approximately $1 billion dollars.

A range of costs are summarized below, specific improvements per conversion period are included in **Appendix A and B.**

Conversion Period	Range	
2021-2025	$150,000,000	$220,000,000
2026-2030	$1,900,000,000	$2,700,000,000
2031-2040	$2,200,000,000	$3,100,000,000
Total	$4,250,000,000	$6,020,000,000

Table 1: Cost Range

- The figures presented are in today's dollars (2020) and do not account for construction escalation over time, and should be considered approximate project costs for planning purposes only.
- Unit cost matrix was validated by a third party University consultant (Gibane).

6.2. OPERATIONAL COSTS

The following operational costs have been provided by the University and represent existing Facilities operational and utility budget data.

ENERGY BUDGET	FY 20 (ACTUAL)	FY 30 (ESTIMATED)	FY 40 (ESTIMATED)
STAFF COSTS	$13.8 Million	$16.6 Million	$19.9 Million
CENTRALLY FUNDED UTILITIES (Note 1)			
ELECTRIC	$6.4 Million	$19.3 Million	$117.0 Million
GAS (NATURAL/PROPANE)	$12.5 Million	$11.0 Million	$0.0 Million
OIL	$0.4 Million	$0.3 Million	$0.0 Million
WATER/WASTEWATER	$0.9 Million	$0.9 Million	$0.9 Million
MAINTENANCE	$12.7 Million	$15.2 Million	$18.3 Million
RENEWABLE ENERGY CREDITS (Note 2)	$2.1 Million	$7.2 Million	$0.0 - $29.0 Million
ANNUAL OPERATING COSTS	**$49 Million**	**$70 Million**	**$155 - $185 Million**

Table 2: Operational Costs

Notes:

- All utility values are based on today's rates with no increase or decrease over time.
- For the 2040 REC cost calculation, the low side of the range assumes a 100% clean electric supply and the high side of the range assumes a straight-line increase in renewable energy sources from 2030 - 2040 (resulting in 66% clean energy).
- The figures presented are in today's dollars (2020)

6.3. RENEWABLE ENERGY CREDIT AND CARBON OFFSET PURCHASING OPTIONS

To achieve the 2030 and 2040 emissions reduction goals, UConn will need to purchase and retire Renewable Energy Credits (RECs) from renewable energy generation facilities to offset 100% of Storrs' Scope 2 emissions from grid electricity in 2030 and future years. Competitive Energy Services' memorandum included in **Appendix E - Carbon Offset Purchasing Options** details UConn's options to achieve this requirement. UConn has three options to acquire and retire RECs to offset 100% of Storrs' grid electricity purchases in 2030 and future years - (1) install renewable electricity generation systems on campus and retain the RECs associated with the onsite generation, (2) purchase Renewable Energy Credits from existing renewable generators located off campus through spot purchases or under short-term contracts, as UConn currently does for six of its seven campuses, and/or (3) purchase RECs from new generation projects located off campus under one or more long-term agreements known as Virtual Power Purchase Agreements ("VPPAs"). These purchasing options have varying costs, and additionality[1], geographic and contracting characteristics that will need careful consideration by UConn.

At the low end, the estimated cost for UConn's supplemental REC purchase in 2030 is roughly $50,000 (per year) for 100% Green-e RECs without additionality and without geographic proximity to Storrs. At the high end, REC costs could reach $1.7 million (per year) for RECs from new in-region offshore wind projects under long-term contracts. A key variable affecting this purchasing cost is the increasing percentage obligations under the Connecticut Renewable Portfolio Standard ("RPS") through 2030, which means that an increasing percentage of the costs UConn incurs to offset 100% of its Scope 2 emissions between 2030 and 2040 will be included in the price it pays its retail electricity supplier for grid purchases. To the extent Governor Lamont's recent Executive Order 3 targeting 100% renewable energy generation statewide by 2040 leads to future legislative changes to increase Connecticut's RPS compliance obligations between 2030 and 2040 (the current RPS mandate is 44% of annual retail electric sales by 2030 and continues at that rate through the next decade), UConn's need to purchase supplemental RECs between 2030 and 2040 will decrease as the grid power mix approaches 100% renewable. Under this scenario, UConn's purchasing costs for voluntary supplemental RECs would likely decrease as UConn would acquire and retire a decreasing volume of supplemental RECs between 2030 and 2040. However, UConn's REC costs would not disappear, but rather be increasingly reflected in its delivery and supply charges for grid electricity as the state recovers the costs of supporting an increased RPS from electric ratepayers across Connecticut. (Refer to **Appendix E Carbon Offset Purchasing Options** for additional information.)

[1] Additionality' is defined in the 'Overview of Carbon Offset Options' section of the memo: "Additionality means the emissions avoidance or sequestration would not have occurred without the financial support provided by the ability to sell offset claims."

6.4. CHALLENGES, RISKS, AND NEXT STEPS

The University may expect a number of challenges and risks including, but not limited to, the following:

- Generation of more in-depth detailed feasibility studies for areas within the 2030 timeline
- Generation of more detailed operating/life cycle costs
    - Determination of impacts on occupied buildings and the University's operating budget if buildings and residential housing are unavailable

- Generation of more refined capital costs
  - Determination of scope and impacts on existing buildings to accommodate new HVAC and electrical systems
  - Escalation of construction costs
- Construction Logistics
  - Site logistics for construction on campus and student/staff/faculty safety
  - Availability of trade labor
- Identification of Fund Sources: State, Federal, Grants, Student Fees
- Potential for changes in public policy and regulatory requirements
  - Eversource meeting its 2030 goals for clean energy and an increased commitment to zero carbon by 2040
  - Eversource meeting its delivery goals and increasing it's electric supply capacity
  - Changes in technology
  - Increase in electricity due to public demand for clean, renewable energy

7. CONCLUSION

Although the concept of reaching zero-carbon by 2040 through the conversion to ground source heat pumps and full electrification of the campus is theoretically possible, there are many obstacles, challenges and risks that would ultimately make it extremely difficult to practically implement the conversion plan as outlined in this study.

Section 3 in the PWGS June 5, report quotes President Katsouleas from his letter dated October 2, 2019. The President wrote that *"… we have an obligation to explore setting more ambitious goals than we already have. But any commitment we make must be real. By that I mean it must be truly achievable and realistic based on data, analysis and the best estimates we are able to make about things like cost, technological capabilities and pace. Promises not backed by facts and strategy are empty, and I would always prefer honesty and realism to the alternative*."

BVH is mindful of the President's charge and although this conversion plan transitions the campus from fossil fuels to clean, renewable energy and zero-carbon by 2040, in our opinion it may not be "truly achievable and realistic" in the time frames considered and in the context of an operating University environment. To align with the President's criteria, we recommend an exploration of alternatives which may be able to meet the University's sustainability goals with less disruption, more flexibility to adapt to developing technologies, and at a lower cost.

BVH integrated services

APPENDIX A

Electrical Evaluation

UNIVERSITY OF CONNECTICUT
Zero-Carbon Peak Plan
Appendix A - Electrical Evaluation

ELECTRIC EVALUATION

1. Campus Power Consumption and Generation

The campus presently generates most of its required power at the Central Utility Plant (CUP) by burning natural gas and limited diesel fuel. The total peak summer capacity is approximately 25 MW, while the campus overall peak is approximately 30 MW, requiring some minor importing of electricity. This system also presently serves the majority of the thermal campus demands efficiently by capturing the waste heat in the form of steam, and distributing the steam directly to buildings in the winter and converting the steam to chilled water in summer. Supplemental steam is also required above the capacity of the turbines which is provided by duct burners, steam boilers, and natural gas chillers.

On the northwest portion of the Storrs campus, there is a existing 20.2 base / 33.6 MVA transformer which can serve the entire campus alone. Regardless of thermal upgrades, this transformer will be shortly undersized to serve the campus, so a new 50 MW base transformer is currently in planning which would be fed form the existing 69 kV Eversource ISO 900 line.

Between the Tri-gen and Eversource, the electrical system has full redundancy most of the year, which for a flagship research university of this size is imperative. Redundancy is important to consider and address as the peak demand increases to serve the thermal conversion electric loads. (See the heating and cooling conversion **Tables E1** and **E2** below.)

District	Gross Building Area (ft2)	Peak		Yearly Consumption	
		Heating Required kW	W/SF	kWh/YR	kWh/YR/SF
Northwest	1,670,469	5,744	3.44	16,772,511	10.04
Central-North	2,294,185	7,629	3.33	22,275,998	9.71
Northeast	481,955	1,538	3.19	4,490,788	9.32
Central-South	1,866,513	5,363	2.87	15,661,237	8.39
Southeast	250,177	811	3.24	2,368,860	9.47
Northwood	83,208	283	3.41	827,345	9.94
Spring Hill	37,016	117	3.17	342,997	9.27
Spring Manor	6,448	18	2.80	52,801	8.19
Depot	399,112	1,116	2.80	3,258,458	8.16
West	3,080,439	6,474	2.10	18,904,541	6.14
East A	575,864	1,852	3.22	5,408,811	9.39
East B	211,242	619	2.93	1,808,753	8.56

District	Gross Building Area (ft2)	Peak		Yearly Consumption	
		Heating Required kW	W/SF	kWh/YR	kWh/YR/SF
South A	1,074,139	3,506	3.26	10,236,153	9.53
South B	260,398	889	3.41	2,595,963	9.97
Grand Total	**12,291,166**	**35,961**	**-**	**105,005,215**	**-**

Table E1: Heating Consumption

District	Gross Building Area (ft2)	Peak		Yearly Consumption	
		Cooling Required kW	W/SF	kWh/YR	kWh/YR/SF
Northwest	1,670,469	3,411	2.04	7,469,486	4.47
Central-North	2,294,185	7,100	3.09	15,549,559	6.78
Northeast	481,955	197	0.41	430,485	0.89
Central-South	1,866,513	4,285	2.30	9,383,851	5.03
Southeast	250,177	60	0.24	131,843	0.53
Northwood	83,208	0	0.00	-	0.00
Spring Hill	37,016	0	0.00	-	0.00
Spring Manor	6,448	12	1.87	26,353	4.09
Depot	399,112	824	2.07	1,805,627	4.52
West	3,080,439	4,325	1.40	9,471,259	3.07
East A	575,864	1,011	1.76	2,213,965	3.84
East B	211,242	48	0.23	104,697	0.50
South A	1,074,139	1,674	1.56	3,666,156	3.41
South B	260,398	457	1.76	1,000,996	3.84
Grand Total	**12,291,166**	**23,404**	**-**	51,254,277	**-**

Table E2: Cooling Consumption

From the tables above, we can see that the peak demand (in kW), and the electrical consumption (in kWH/yr) will increase as a result of the conversion. Present campus peak demand is approximately 33 MW in the late summer when students first return to classes. The added of new cooling demand with the ground source conversion adds approximately 23MW to the peak. 23 MW. This would place the new campus cooling peak demand at approximately 56 MW. The additional heating demand of 36 MW is added only to the lower base winter campus demand, which is currently approximately 22 MW. Thus the campus would have a new campus peak demand in the winter of approximately 58 MW.

Minor adjustments for off campus loads such as the Depot campus, which would not be included for main campus loads, would yield a slightly lower peak adjustment. For planning purposes, simply rounding to whole numbers for system capacity planning, etc., are illustrated in the charts below as the steps to carbon footprint reduction take place. **Chart E1: UConn Electrification** below also indicates the progression of electrical use alongside electrical demand changes. Take note of the units on both the left side and right side of the chart.

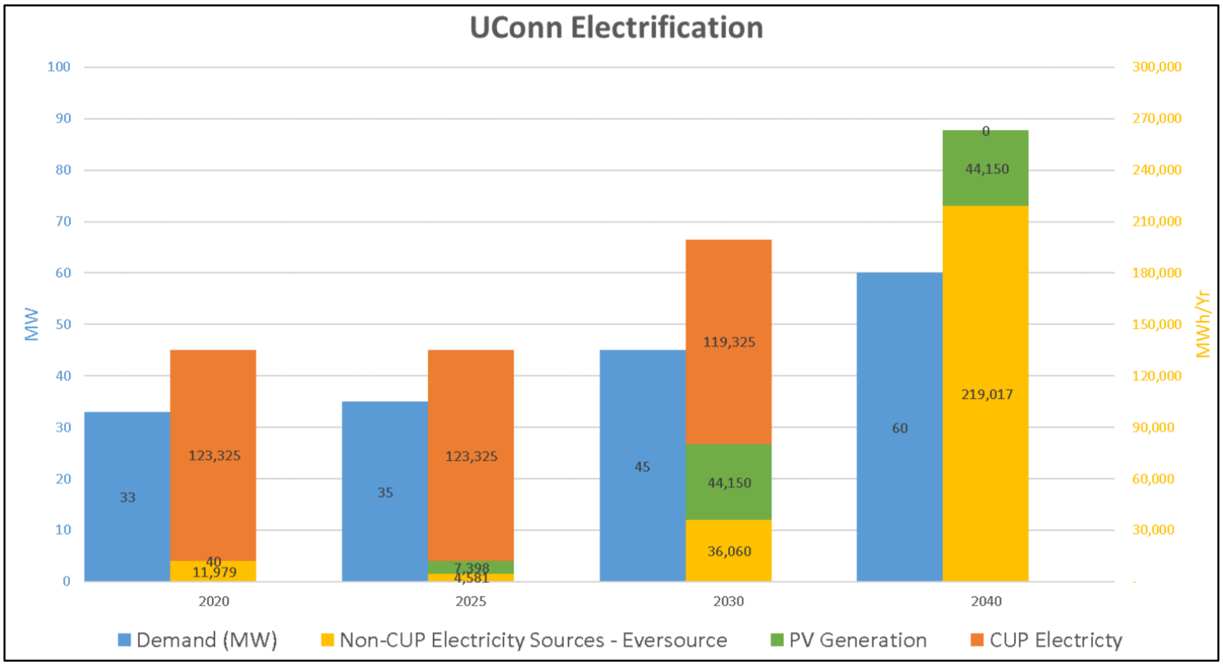


Chart E1: UConn Electrification (MW, MWh/year)

The next two charts indicate the reduction in the use of natural gas on campus (shown in gray) for thermal purposes and the corresponding growth in the use of electricity. These are put in separate terms of energy for MMBtu and MWHrs.

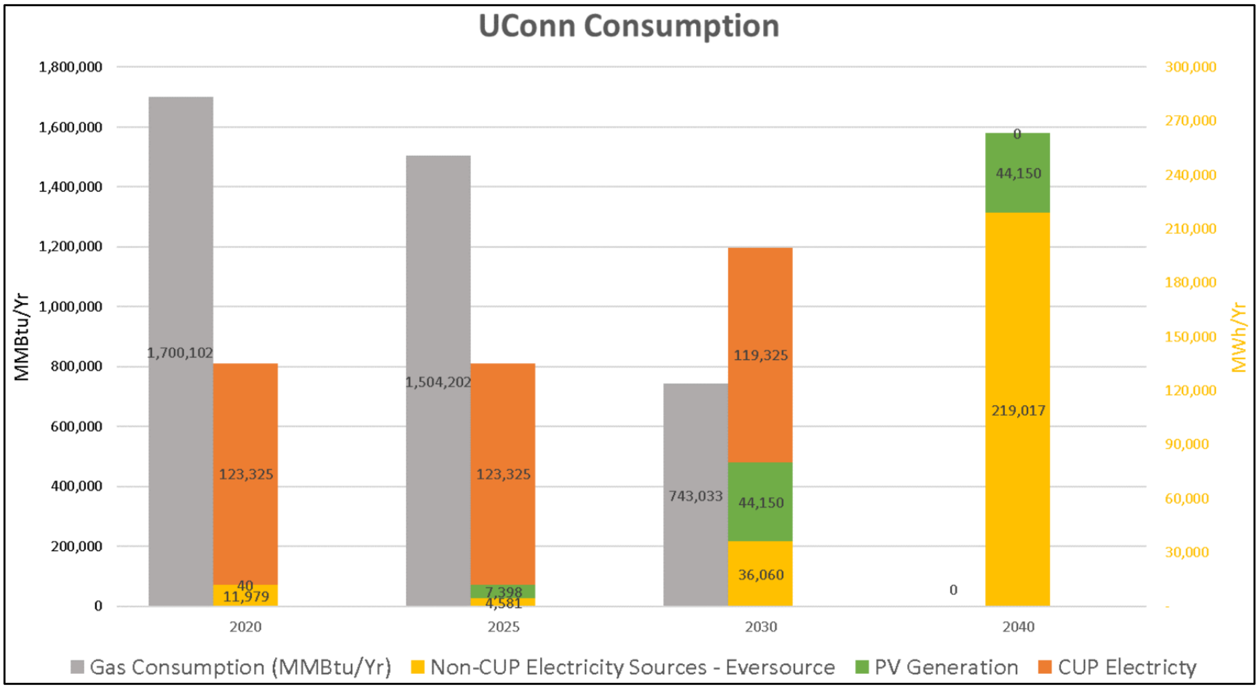


Chart E2: UConn Consumption (MMBtu/year, MWh/year)

In the second UConn Consumption Chart (**Chart E3**) indicated below, the energy consumption terms are reconciled to the same energy units. It is clear that there is a considerable reduction in overall energy consumed as the perimeter of the campus is converted to the efficient ground source thermal system. The change from 2030 to 2040 results from the conversion of the interior and more dense part of the campus served from the efficient Tri-gen system. It can be seen that this is not as beneficial from an overall energy saving point as the perimeter conversion, but the energy consumption from natural gas used for the turbines to an electrical ground source thermal system will have a large carbon emission reduction.

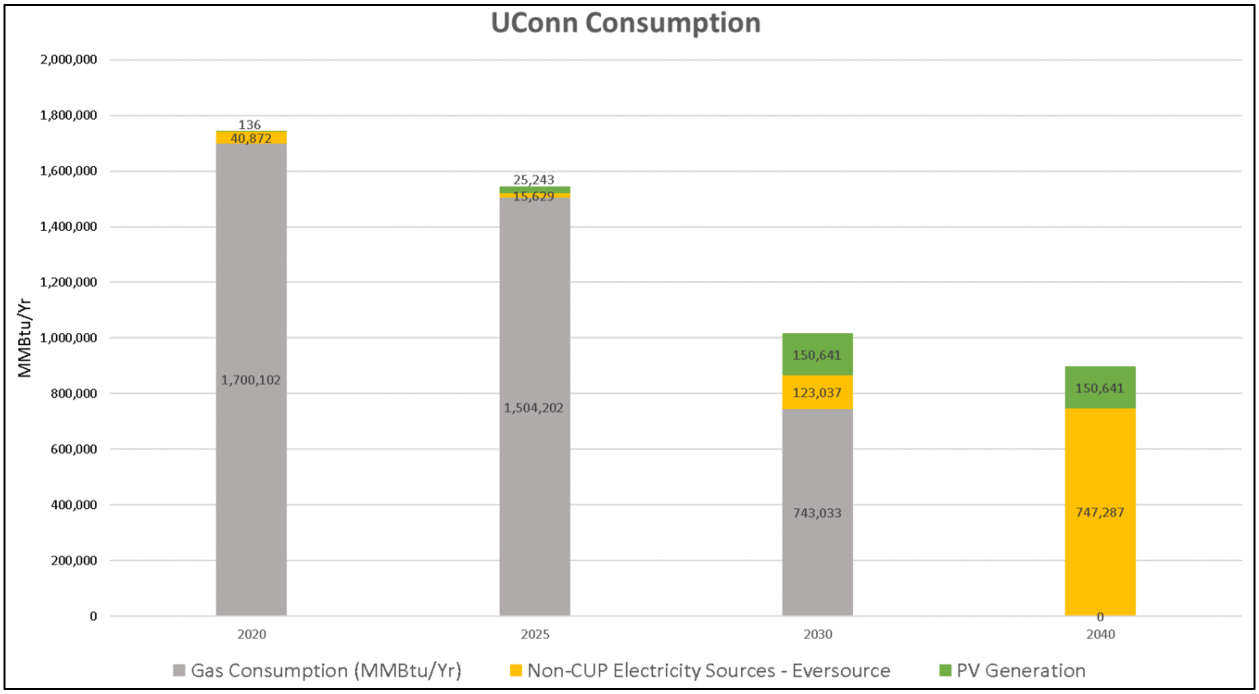


Chart E3: UConn Consumption (MMBtu/year)

In order to convert the campus to electricity as shown in the charts above, the Tri-gen facility will be shut down between the 2030 and 2040 timeframe. With one complete source of energy removed (natural gas), another electrical source will need to be provided to allow campus maintainance, avoid a single point of failure (one large transformer and single transmission line), and maintain resiliency.

It should be noted that comparing the tables to the charts some rounding of values was implemented for simplicity, including smaller factors such as transmission losses, etc., in order to focus on order of magnitude conversion planning. With a final electrical peak demand of approximately 60 MW, and the decommissioning of the Tri-gen facility, a new Eversource line will be required from a separate transmission line source, and we will refer to this pathway and transformer as "SUB 195 in this study. This would be another 50 MVA base or a 60 MVA base station. (See **Diagram E1** below.)

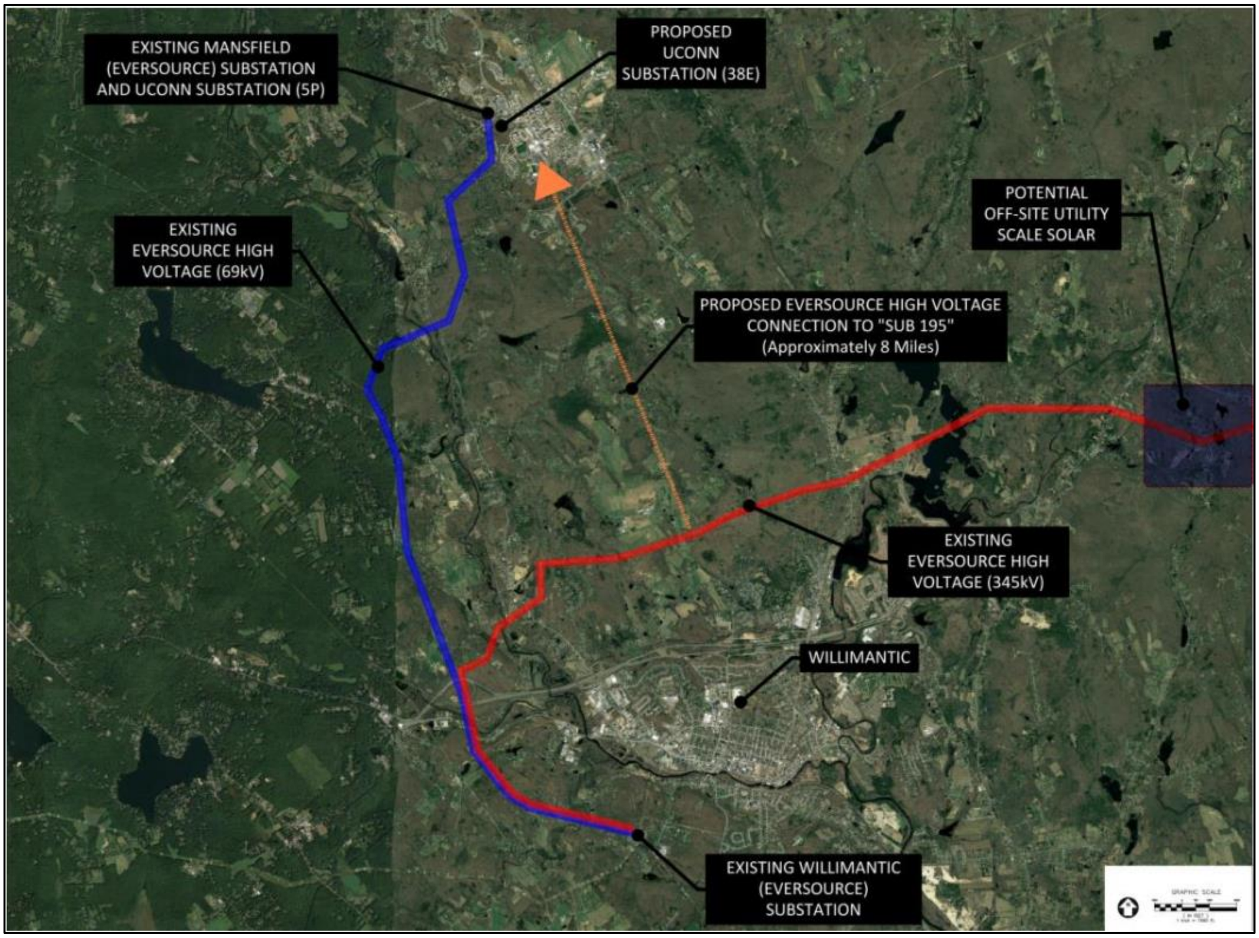


Diagram E1: New Transmission Line

Constructing a new transmission line would allow Eversource to maintain existing transmission lines and UConn to maintain existing transformers without removing power to the entire campus for each service, or be vulnerable to extended outages as a result of a single piece of equipment failing.

To connect the new SUB 195 into the campus power system, an extension of the ring bus developed as a part of the SUP and Science One projects would need to be extended to the new substation. This allows for multiple sources to reach districts across the campus. (See **Diagram E2** below.)

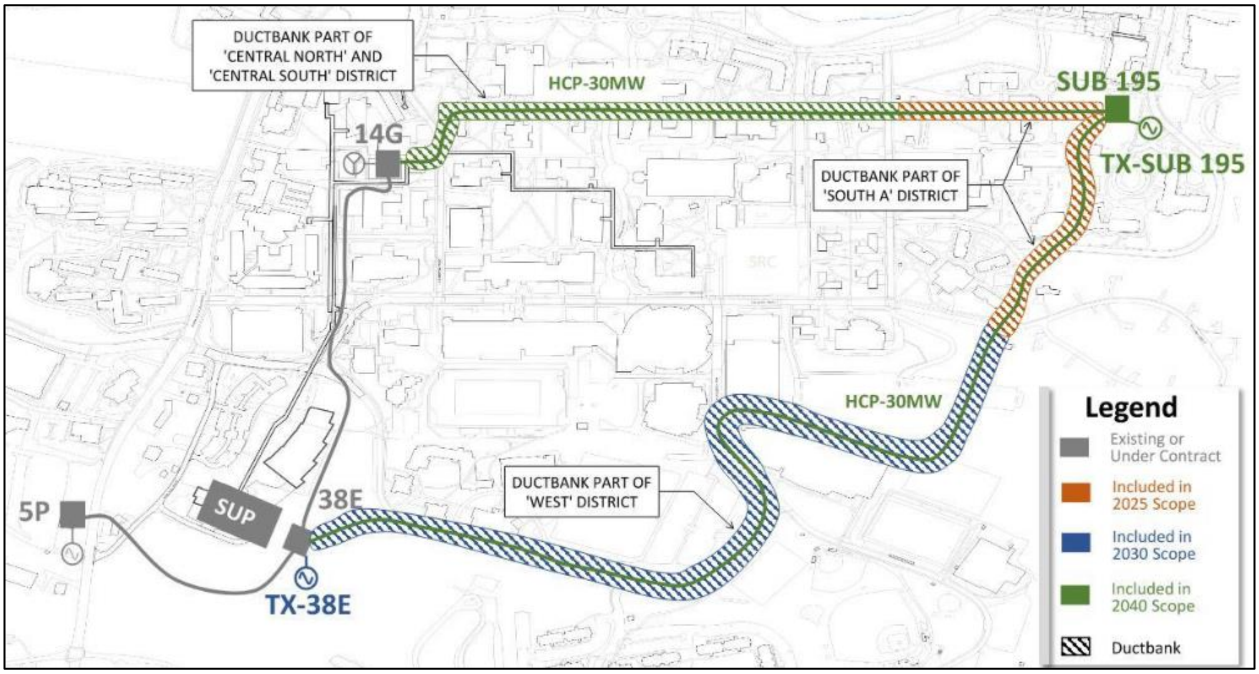


Diagram E2: Electrical Infrastructure

2. Campus Electrical Distribution Evaluation

Electrical power is distributed through the campus via eight (8) existing main circuits, which are roughly indicated in **Diagram E3** below.

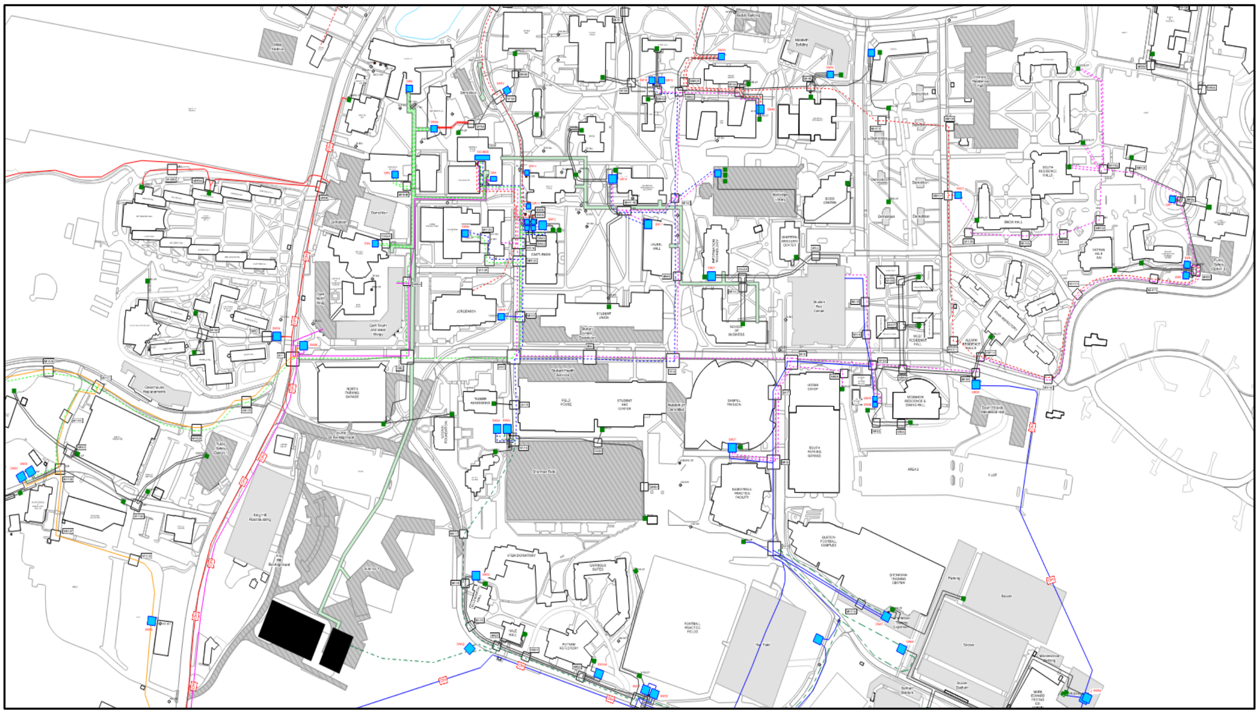


Diagram E3: Campus Electrical Distribution Map

The main distribution will often have to be reconfigured or will get disrupted causing short-term electrical outages. It is important to isolate a circuit to repair, maintain, or reconfigure it in order to keep buildings online. Each circuits' load will frequently require off-loading or switching to other active circuits to allow for repairs, etc. With that in mind, individual circuits should not be loaded above 5 MW so that its load can reasonably be shifted to other circuits in contingency operations such that other circuits only load up to 8 MW in longer operations and short durations to 10 MW. Dividing the new campus 60 MW peak load by 5 MW for individual circuits, yields approximately twelve circuits being required for the full conversion plan, which will need to be distributed to the new loads and plants in each district.

Another consideration in the electrical distribution is to consider providing reliable redundant circuits from separate busses to each new ground source district plant. A strategy of new circuits should be installed with the development and conversion of each of the ground source districts. (Refer to **E4: Campus District Map** below.)

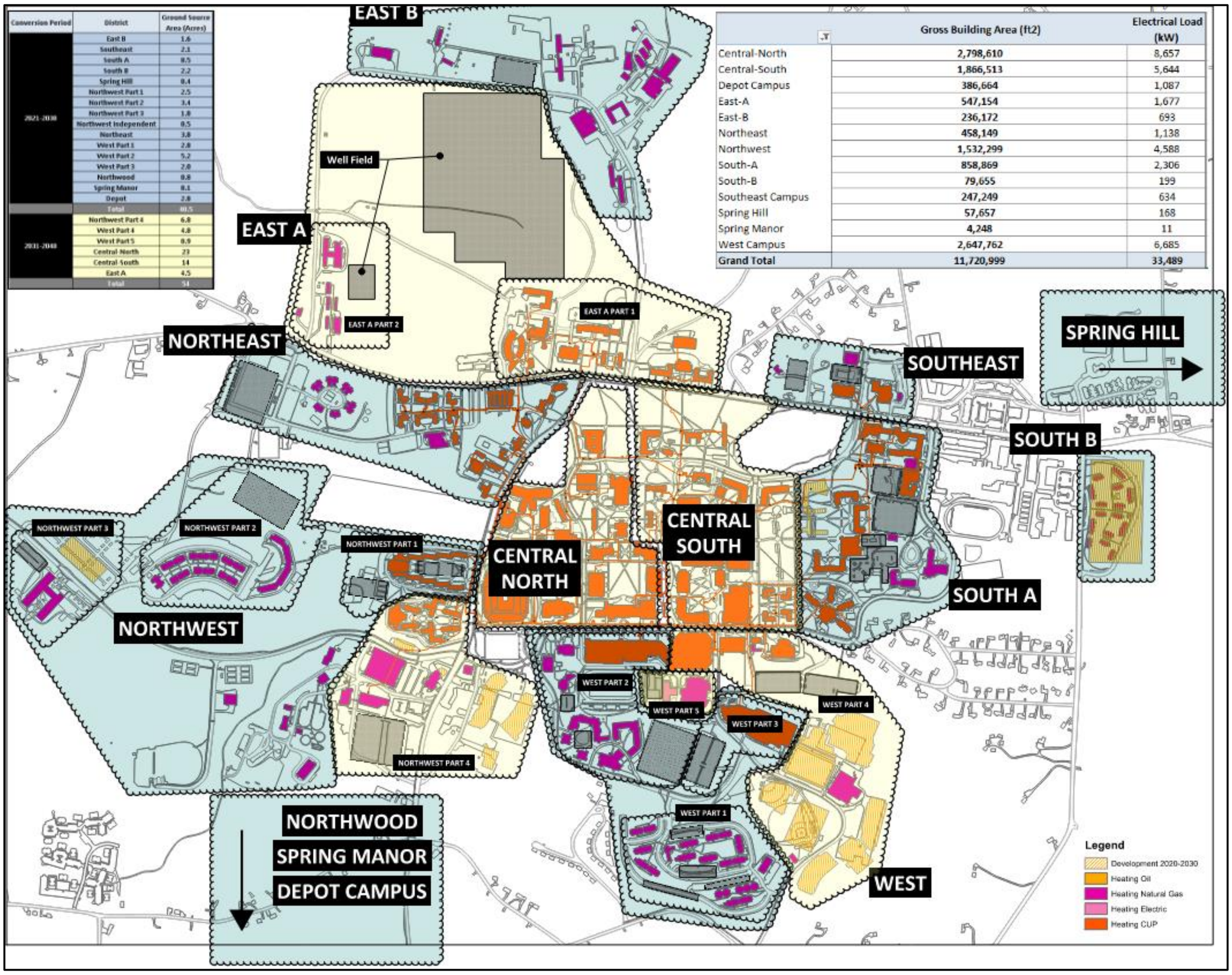


Diagram E4: Campus District Map

As the campus load develops and increases, it will be important to keep in consideration the configuration of each step of the campus. With this development new circuits, a new ring bus, and automated, remote load control with shedding will become a requirement.

3. Conversion Plan

A general concept electrical development plan for the electrical systems to support the thermal conversion to electricity is given below.

Conversion Period 2021 - 2025

1) Develop "Storrs 38E" distribution upgrades that are currently planned as part of the Science 1 development program.
2) Create a load-shedding platform to be expanded in the future.
3) Underground North Eagleville Road and extend Storrs 38E Circuit #3.
4) Develop energy saving measures.
5) PV installations for parking and roofs.

Conversion Period 2026 - 2030

1) Install the new 50-60-70 MVA "Storrs 38E" transformer. Evaluate upgrading of 5P transformer to 50 MVA.
2) Convert IPB.
3) Refeed overhead to Horse Barn Hill, East B District Plant. New Service to East B district plant. Approximately 2,500 ft. of ductbank.
4) Add 9/12 SF6 loop switch pair in Fine Arts district loop to southeast campus. Approximately 2,000 ft. +/- ductbank. New service to district plant.
5) Add 9/12 pair SF6 loop switch to South District Plant. Approximately 1,000 ft. +/- ductbank. New service to District Plant.
6) New service to District Plant at South B from 12J.
7) Add 9/12 SF6 loop switch pair to West District. Extend existing 9/12 pair circuits to new District Plant.
8) New service to new West District Plant. Approximately 500 ft. ductbank.
9) New service to new Northwest District Plant. Approximately 500 ft. ductbank.
10) New service to new Northeast District Plant. Approximately 500 ft. ductbank.
11) Further develop load-shedding control.
12) Add some sectionalizing automation, including the Central districts (Gant, NESB, etc.).
13) Convert buildings to ground source.
14) Begin development for new Eversource SUB 195 transformer. Approximately 5000 ft. ductbank.
15) Batteries to maintain resiliency with added load. Installed at SUP Phase 2 area.

Conversion Period 2031 - 2040

1) Install new south substation transformer in south campus and new Eversource transmission along Route 195 (approximately eight miles).

2) Substation walk-in switchgear, etc.
3) Install new "High Capacity Feeder" connection to "Storrs 38E". 4000 ft. new ductbank and 9,000 LF of feeders 50 MVA capacity.
4) Install four circuit-sectionalizing switches and two node switches.
5) Install new controls.
6) Install new distribution feeders for serving East A, Central North and Central South from east of Route 195.
7) Install new service to East A well field plant that serves three districts. Approximately 2,000 ft. ductbank.
8) Convert buildings to ground source.

Per the conversion plan above, large storage batteries will need to be employed during the 2030 timeframe, mainly due to the lengthy process required to develop the SUB 195 Eversource service. 5P and the new 38E substations do not provide appropriate redundancy since they are served from parallel transmission feeds from Card Street Station. The Tri-gen should stay online until the SUB 195 is installed and during the interim electrical storage in the form of batteries is recommended. The batteries will give time to allow a controlled load shedding process to take place if Eversource or the Tri-gen were to fail, since the peak demand will be exceeding the Tri-gen and 5P substation capacity for many hours during the year. The sizing will need to be the difference between the new campus peak load to the Tri-gen capacity multiplied by the time. This will be approximately 20 MWhrs, which additional capacity would likely be installed at the new SUP building where the future Tri-gen was originally planned for.

4. Utility Company Capacity

Interacting with the utility company and getting a commitment from same will be a leading component of the campus conversion to clean electrical power.

The process to develop the SUB 195 Eversource service will likely take in the 10 to 12-year range for completion. This will require "right-of-ways" which will require public hearings, legal work and approvals. The capacity for the transmission lines will also need to be coordinated as there may be others converting to electricity and impacting the ISO NE electrical delivery system.

5. Utility Company Generation

The charts below indicate the current grid power generation profile.

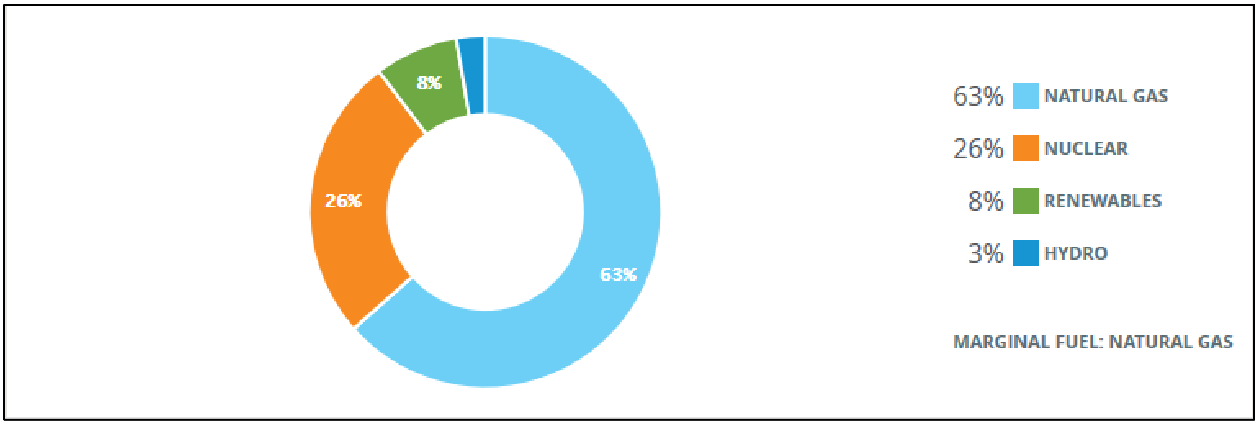


Chart E4: Fuels Used to Generate Electricity
(Source - ISO New England Inc.)

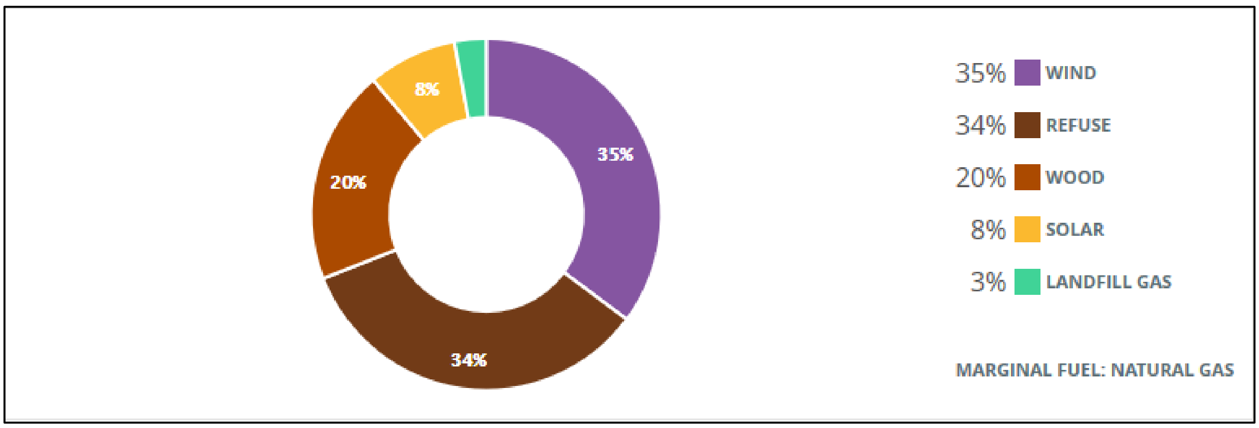


Chart E5: Renewable Sources Used to Generate Electricity
(Source - ISO New England Inc.)

Under current law, by 2030 the generation profile for Connecticut must become at least 44% renewable. Further, the Governor has directed Eversource to develop a plan to be fully renewable by 2040. While this is not yet law, this team has been given direction to assume that by 2040, the utility will be 100% renewable. If Eversource is not providing clean energy by 2040, there would be a potentially large impact on the amount of solar photovoltaic or renewable energy credits (RECs) that would be required to meet the zero-carbon goals.

6. Solar Photovoltaic

There are essentially three major installation strategies for Solar Photovoltaic (PV) - roof-mounted, parking/canopy-mounted, and ground-mounted. The most cost effective installation is ground-mounted from a capacity and cost perspective. With PV power installations, it is important that the listed amount installed in kW is truly the actual capacity, while the kilowatt hours (kWH) of actual generation are a result of the system efficiency. Since it is only light half the day, the efficiency can be no more than 50%, while snow and rain, etc., further limit the actual production. Many installations in place today range in the 11% to 12% efficiency range. The panel efficiencies are increasing, but still have limitslimitations due to conditions, weather, etc. For planning purposes on the amount of PV required to reduce cabon emissions from Eversource, this study utilized a 14% efficiency value.

From the charts listed above, the annual electrical consumption decreases to approximately 265,000 kWH/yr. To produce all power from PV (ignoring storage and load following obstacles) at 14% efficiency, it would require approximately 216,000 kW or 216 MW of total PV installation. For ground-mounted installations, PV panels require 8 to 10 acres per MW. This equates to requiring approximately 2,160 acres for PV installation to carry the full new campus load requirements.

From the law passed for the electric utility stated above, Eversource must generate 44% of their grid electricity from renewable sources by 2030. The PWGS committee directed that we should assume 100% of the grid electricity be from renewable sources by 2040, since that is the goal of the State. The target for PV investment is tied into the 2025 and 2030 timeframe to meet the 60% carbon emission reduction goal via electrification and PV generation.

The costs for purchase power agreements of large PV investment installations are covered in other parts of this study.

The following paragraphs explore each of the the three major installation strategies in further detail.

Roof-Mounted

There is limited PV installed on the campus at this time. There is 40 kW installed on the STEM dorm, 12 kW installed on the water reclaim facility, and 400 kW is planned for the roof of the new Science One Building. Previous feasibility studies have been performed to evaluate other existing roof mounting opportunities for PV. The recommendation was there exists an opportunity for limited roof locations that would total only an additional 40 kW. Weight limitations on roofs and structures were cited as the primary reason for the negative results. There are new thin film technologies which can overcome these concerns; however, they come with some other potential drawbacks. Their typical installation is flat, where snow in New England can cover them and cause either damage or reduced output. Utilizing thin film technologies, there would be a higher amount of PV opportunites on roofs per the chart below.

Roof-Mounted Thin Film Solar Technology	
UConn Building*	Approximate Usable Area of Roof for Thin Film (SF)**
*Taken from Google Maps (2020 Map Data)	**Values take into account to leave approximate room for walking pathways, buffer from edge of buildings, separation from equipment on roof. Only includes buildings with at least 3,000 SF of potential roof space.
Arjona Building	7,000
Dodd Research Center	9,000
Jorgensen Center	11,500
Library	10,000
Music and Dramatic Arts Library and Fine Arts Complex	5,500
Oak Hall	4,000
Student Union	4,700
Wilbur Cross	3,500
Total Approximate Area of Flat Roof for Thin Film:	**55,200.00**
First Solar Series 6 Thin Film Panel Dimensions - *6.59' * 4.04'*. Area (SF)*:*	26.62
Approximate Total Number of First Solar Series 6 Thin Film Panels:	2,073
First Solar Series 6 Thin Film Panel Power Output (98%) (W):	441
Approximate Total Power Capacity (MW):	**0.91**

Table E3: Roof-Mounted Thin Film Solar Technology

While Table E3 indicates approximately 1 MW of potential per square foot of roof area for PV installations, we recommend assuming an additional 500 kW, of this type of PV installation because it is more costly than ground mount installations, and should only be targeted on larger roof areas as major renovations are conducted or new buildings are constructed.

Canopy / Parking-Mounted

Canopy-mounted PV installation is much more expensive than standard ground-mounted due to structural supports and site disruption required; however, it is much more visible as a carbon reduction initiative. Refer to the table below for an analysis of UConn parking lots for potential PV installations.

UConn Parking Lot Solar Canopy Study					
Lot Designation	Total Parking Lot Area (SF)	Usable Solar Canopy Area (SF)	MW	Rating	Rated MW
Lot A - East Residence Hall	57,200	28,750	0.431	3	0.144
Lot B - Bishop Area	67,500	44,000	0.660	3	0.220
Lot C (previous landfill)	193,500	85,000	1.275	5	0.255
Lot D	119,000	69,000	1.035	1	1.035
Lot E	25,500	14,750	0.221	3	0.074
Lot F (previous landfill)	210,200	110,000	1.650	5	0.330
Lot G	28,500	16,400	0.246	1	0.246
Lot H - North and South Lots IPB	53,700	27,700	0.416	2	0.208
Lot J	45,000*	20,000	0.300	1	0.300
Lot K - new lot across from IPB (potential building site)	277,500	104,500	1.568	3	0.523
Lot O - east of Young Building	54,500	27,900	0.419	3	0.140
Lot R - north of Fine Arts	43,500	24,500	0.368	1	0.368
Lot S	131,500	56,000	0.840	1	0.840
Lot T	99,100	53,000	0.795	2	0.398
Lot W	304,500	165,000	2.475	2	1.238
Lot Y	78,000	38,700	0.581	1	0.581
Lot Z	74,500	39,500	0.593	1	0.593
Charter Oak Apartments	245,500	134,000	2.010	2	1.005
Dairy Barn Lot	30,500	13,000	0.195	2	0.098
Dairy Barn Lot	33,200	16,500	0.248	2	0.124
Hilltop Apartments	307,500	172,000	2.580	3	0.860
North Residence Halls	23,000	17,700	0.266	5	0.053
Northwest Residence Halls	12,200	10,700	0.161	5	0.032
Lot b/w NW and Central Warehouse	15,400	12,200	0.183	3	0.061
Field House	23,100	13,000	0.195	4	0.049
Storrs Hall	8,350	4,600	0.069	2	0.035

UConn Parking Lot Solar Canopy Study					
Lot Designation	Total Parking Lot Area (SF)	Usable Solar Canopy Area (SF)	MW	Rating	Rated MW
Admissions	6,200	3,700	0.056	4	0.014
Manchester Hall	13,750	8,000	0.120	2	0.060
Wilbur Cross	16,300	8,300	0.125	5	0.025
Budds	8,500	5,600	0.084	3	0.028
Arjona	12,200	4,900	0.074	4	0.018
Horse Barn Hill Arena	11,300	5,600	0.084	1	0.084
Farm and Events Services	17,000	6,000	0.090	1	0.090
Horse Barn Hill Road	22,500	22,500	0.338	1	0.338
South	7,000	3,600	0.054	1	0.054
Total Installed Capacity (MW):			**20.799**	**Total Rated Capacity (MW):**	**10.515**
Estimated MWh/year:			**30,973.87**		**15,659.09**

Table E4: UConn Parking Lot Solar Canopy Study

The parking lots were evaluated on a one to five scale with one being the most expensive and most shaded lot, while five would be the simplest and most productive lots. Some lots are built on a former landfill and would be very expensive and difficult to disturb the existing environmental cap. The results show a higher number of potential PV installations; however, we utilized a more conservative number of 5 MW to focus on the most cost effective lots.

Ground-Mounted (Utility Scale)

Finding land area for this most cost effective PV installation method can be difficult. It is not recommended to clear trees as that is somewhat counter productive to the greening mission. Open farmland should only be considered where the use is no longer going to take place. The best opportunity for ground-mounted PV is former developed sites, like the Depot Campus that are no longer densily utilized. The Depot Campus site was studied resulting in a recommendation of approximately 10 MW of ground-mountedPV development at that site.

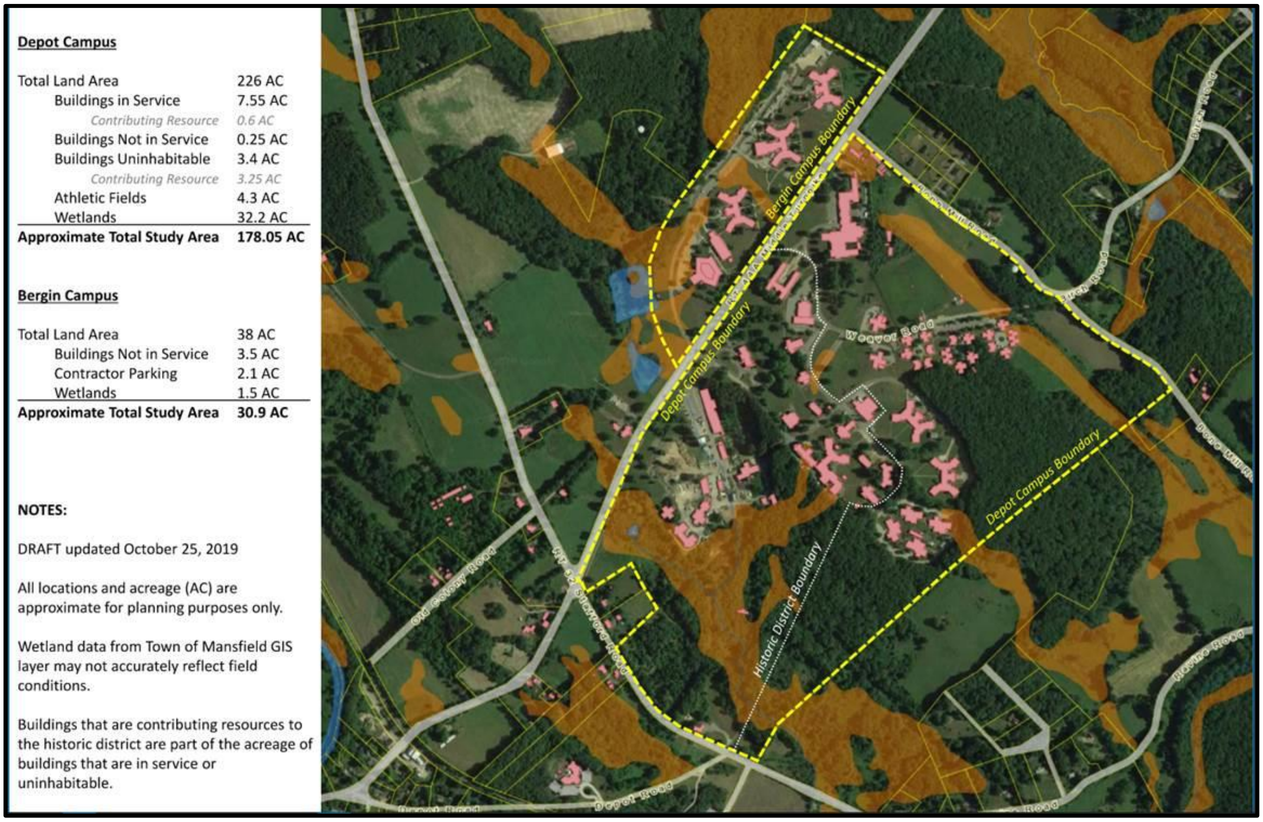


Diagram E5: Depot Campus Potential Development Areas

Another more common method of PV development is working via a power purchase agreement for new local or regional PV installations such as the one identied for a potential 20 MW installation in Brooklyn, Connecticut. Both of these installations would be in a virtual net metering arrangement.

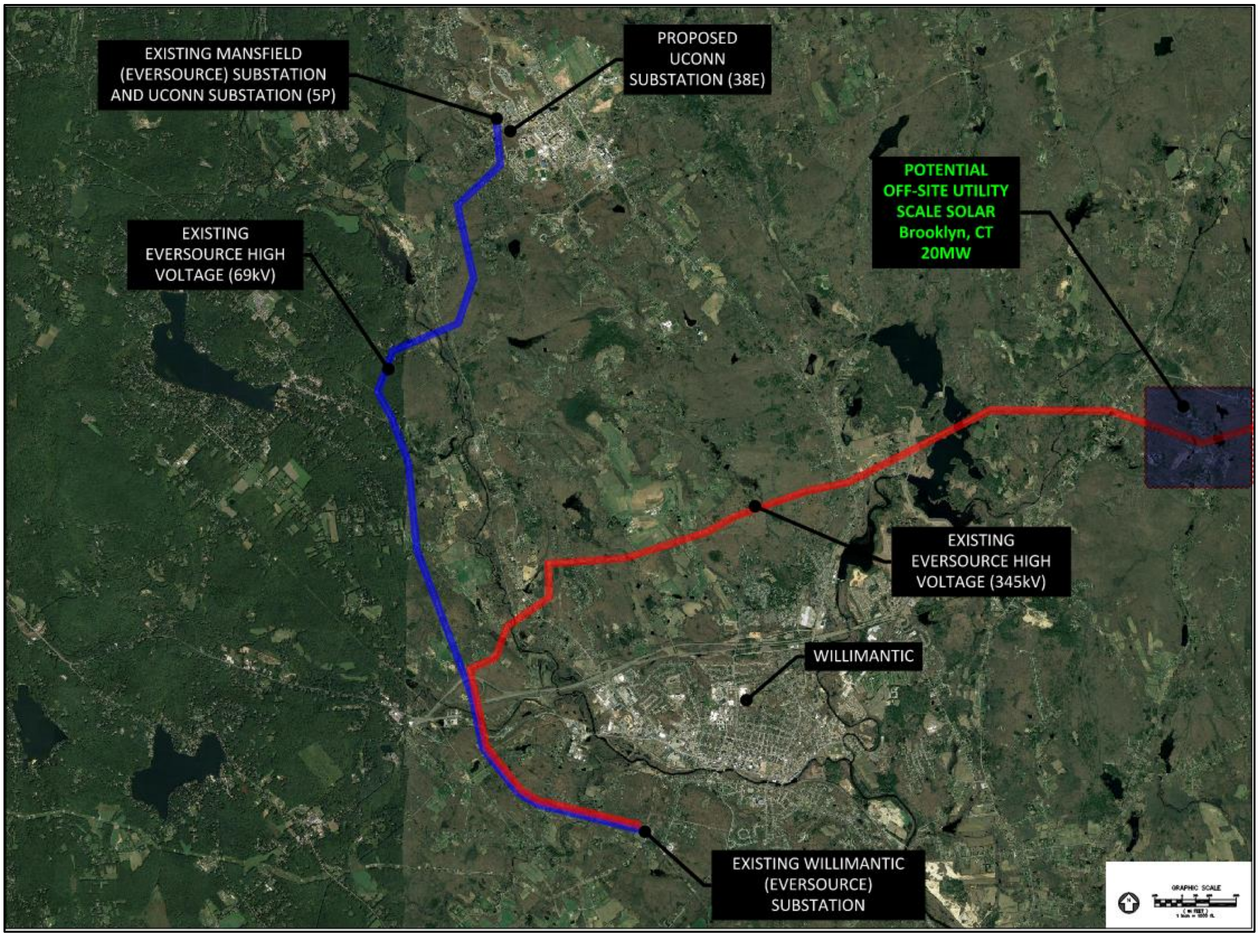


Diagram E6: Potential Utility Scale Solar Development - Brooklyn, Connecticut

BVH integrated services

APPENDIX B

Thermal Conversion Evaluation

UNIVERSITY OF CONNECTICUT
Zero-Carbon Peak Plan
Appendix B - Thermal Conversion Evaluation

THERMAL CONVERSION EVALUATION

1. General Overview of Existing UConn Campus Systems

The core portion of the UConn Storrs campus receives heating and cooling energy from the Central Utility Plant (CUP). The campus heating load is satisfied through the use of cogeneration producing steam with the recovered waste heat through heat recovery steam generators (HRSG) as a byproduct of generating electricity from the natural gas-fired turbines. The CUP also includes duel fuel gas- and oil-fired steam boilers to supplement the production of steam when required. Steam at 65 psig is then distributed throughout the campus to provide heating to the buildings.

Chilled water is created in the Cogeneration Plant (CoGen) through the use of steam-driven chillers using the recovered waste heat from the natural gas-fired turbines, electrical centrifugal chillers, and natural gas engine-driven chillers in the CUP. Chilled water is then pumped throughout the central core of campus to provide cooling to the buildings.

There are additional chilled water plants in Gampel Pavilion consisting of electric centrifugal chillers, at the South Chiller plant consisting of natural gas engine-driven chillers and electric centrifugal chillers, and at the future Supplemental Utility Plant (in 2022) consisting of steam-driven chillers using the recovered waste heat and electric centrifugal chillers. These plants provide chilled water to surrounding buildings.

In addition to the utility plants previously mentioned, there are buildings on the Storrs campus that are not served by the plants and have standalone heating or cooling. These include, but are not limited to, natural gas-fired boilers, oil-fired boilers, and electric heat for heating and water-cooled chillers, air-cooled chillers, packaged direct expansion (DX), and air-to-air heat pumps for cooling.

The individual building HVAC systems vary across the campus. In a significant portion of the buildings served by the CUP steam, there are local steam-to-hot water heat exchangers. These buildings then typically distribute 180 deg. F hot water throughout the building to provide heat. There are some buildings that use direct steam from the CUP throughout the building. The HVAC systems throughout campus include, but are not limited to, central station air-handler units (AHUs) with variable air volume (VAV) boxes with or without reheat coils; distributed terminal equipment such as fan coil units (FCU), unit heaters, valance units, chilled beams, hot water or steam radiation; or air-to-air heat pumps such as variable refrigerant flow (VRF) systems.

See **Appendix G - Supporting Diagrams** for a heating map and cooling map representing the thermal energy source for each of the buildings on the UConn Storrs campus.

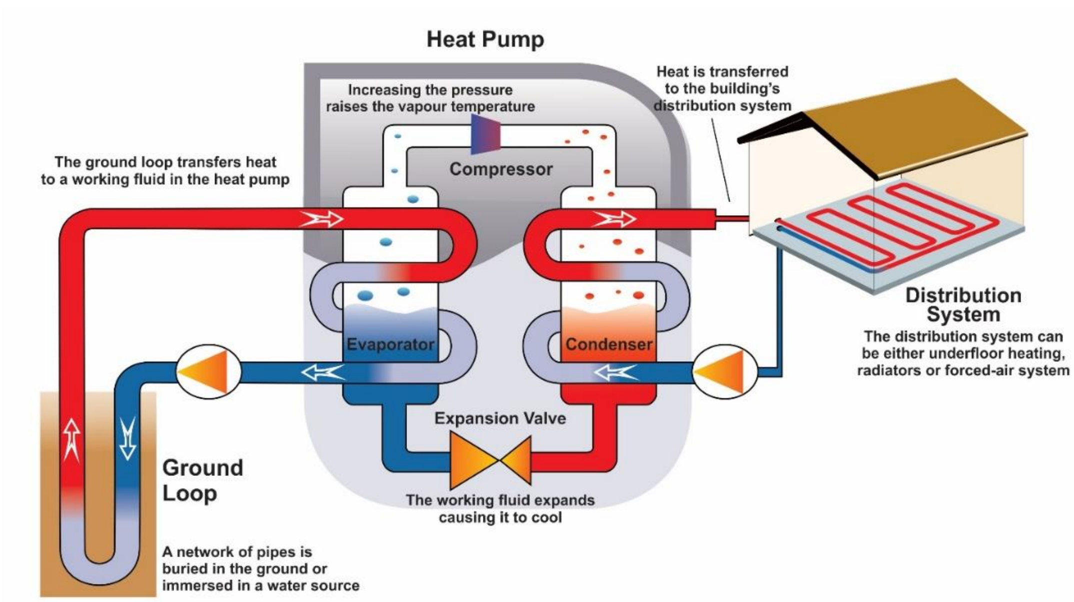
2. Ground Source Heat Pump Heating and Cooling Overview

The basis of this study is around utilizing ground source heat pump technology to convert the UConn campus thermal requirements from fossil fuel to electric-driven systems. There are multiple types of ground source heat pump systems available to be installed; however, for the purpose of this study, it is assumed that all ground source systems will be vertical closed loop type. Further study will need to be conducted to determine if any alternatives would be viable options.

Closed loop ground source systems circulate fluid through a series of vertical boreholes. There are multiple types of borehole designs possible, ranging from 400 to 1,500 feet. This study assumes an approximate depth of 500-foot deep boreholes. The other bore hole designs may be analyzed in a further study or in the design phase.

These systems typically use water or an antifreeze solution such as propylene glycol or ethylene glycol as the heat transfer fluid. Closed loop system fluid never contacts the soil or groundwater. The heat transfer fluid is pumped through the vertical wells transferring thermal energy from the ground. The pipes within the vertical wells are then connected to horizontal pipe headers below the frost line and is then piped to the heat pumps.

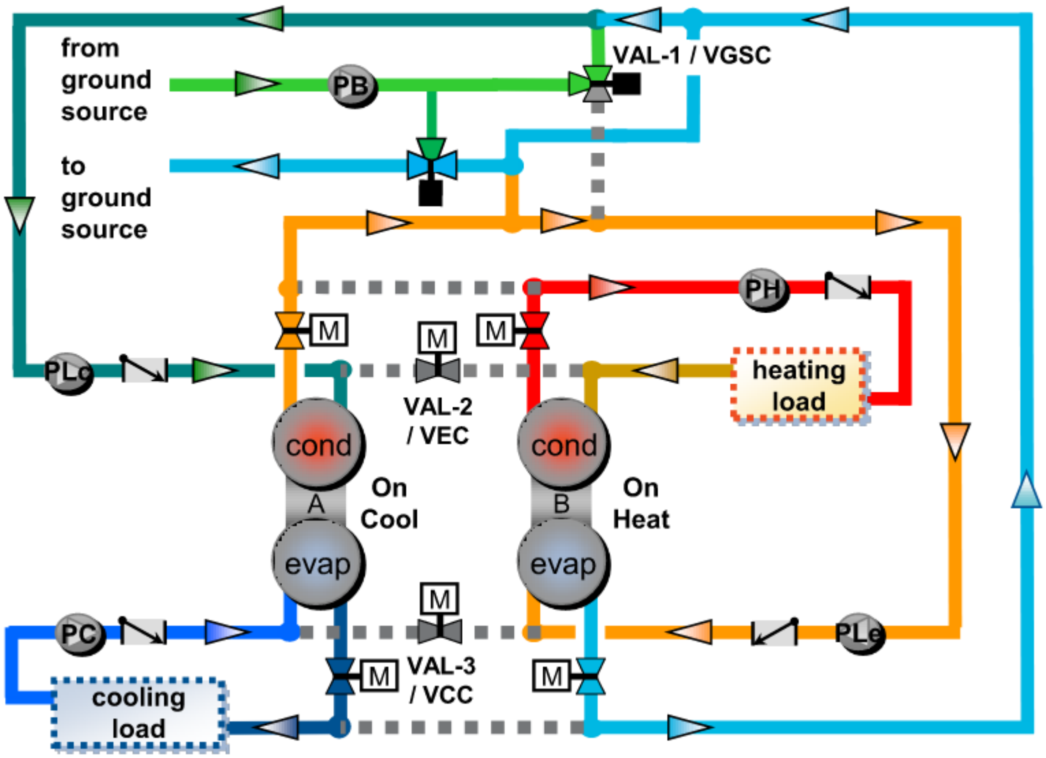
Heat pumps utilize a working fluid, a compressor, expansion valve, and heat exchangers to transfer thermal energy from the ground source loop to a distribution loop to heat and cool buildings. See **Diagram H1** below for a conceptual representation.



[1] Geothermal Heat Pump Association of New Zealand

Diagram H1: Conceptual Heat Pump Diagram

Multiple ground source wells and heat pumps can be paired together to create a central ground source system to serve a distribution system. These systems can provide simultaneous heating and cooling to improve system efficiency. **Diagram H2** shows a simple conceptual central ground source heat pump system serving heating and cooling distribution.



[2] Trane Central Geothermal Systems

Diagram H2: Central Ground Source Heat Pump Chiller Heater Diagram

3. UConn Storrs Campus Thermal Conversion Approach

3.1. District Thermal Plants

The UConn campus was broken up into districts based on campus location and well field location. In select districts, they were further broken up into sub-districts based on well field location and to reduce the amount of required underground piping. See **Diagram H3** for a campus district map and **Appendix G - Supporting Diagrams** for a full size map.

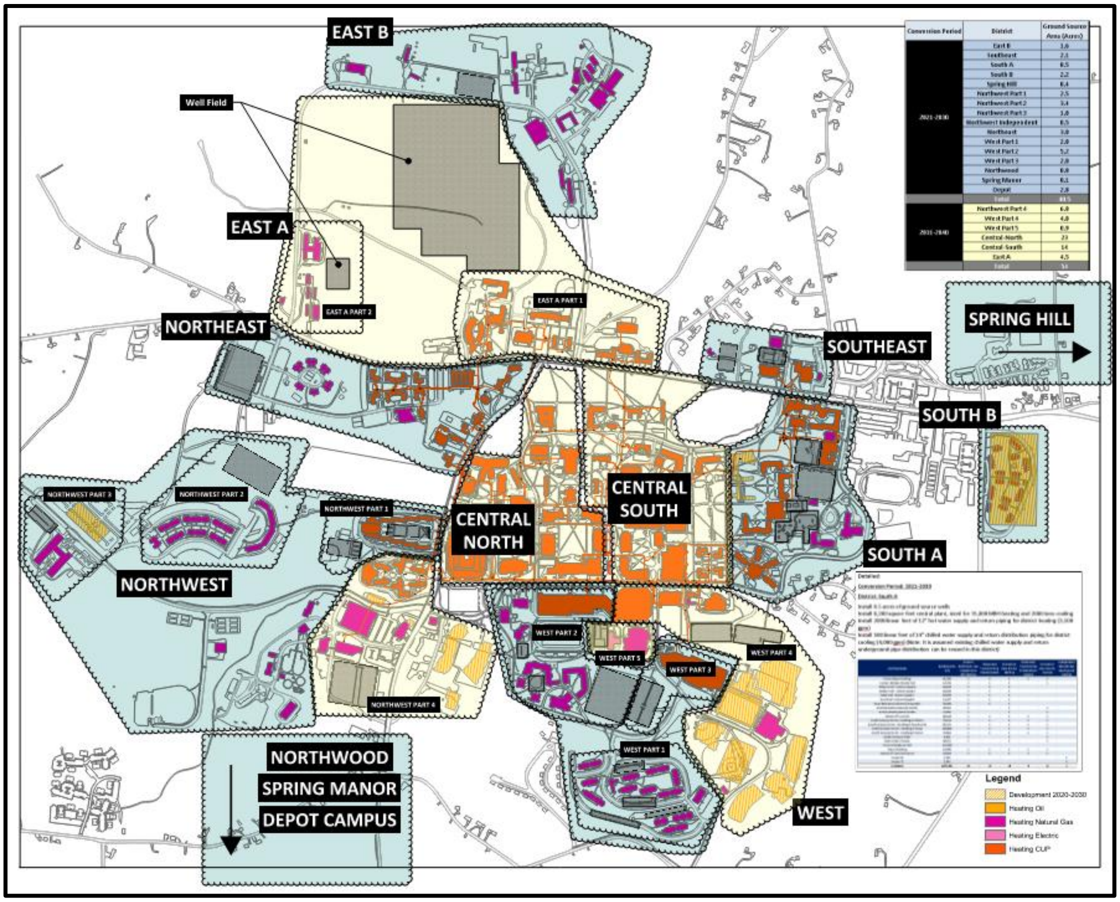


Diagram H3: Campus District Map

Each district and sub-district will have a district plant. The underground pipes from the well fields will enter into each of these district plants. The plants will include heat pump chillers used to create hot water for heating and chilled water for cooling, multiple sets of pumps, piping, valves and hydronic accessories. The plants will also include area to accommodate electrical requirements. The sizes of the plants will be determined based on the thermal load requirements of that district, the mechanical/electrical equipment requirements, and limitations while maintaining required clearances and accessibility. Underground hot water supply and return and chilled water supply and return piping will be distributed throughout the districts to each of the buildings. **Diagram H4** shows a sample layout of major mechanical equipment with approximate sizes in a district plant sized based on the thermal loads of South A District. Actual sizes and layouts will require further study and design.

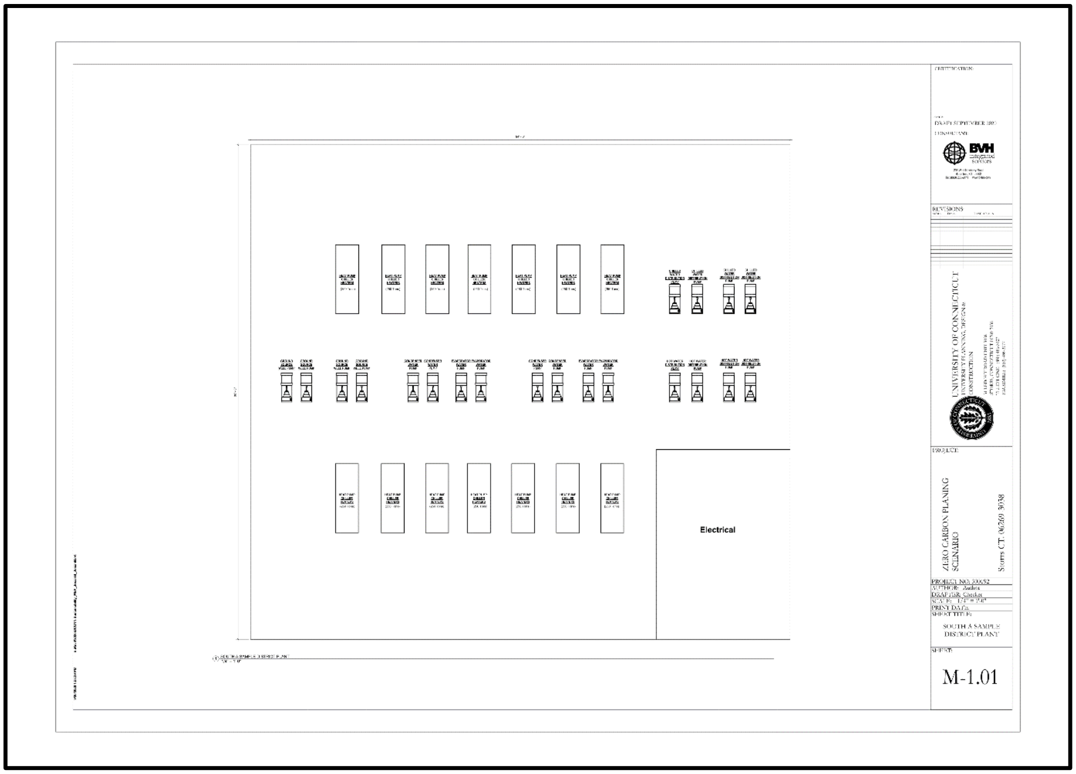


Diagram H4: South A Sample District Plant

Independent Buildings:

For buildings that are a significant distance away from the previously discussed district plants with a relatively small thermal load, a complete ground source system including a well field, well field pumps, heat pumps, and distribution pumps and piping will be installed to serve the individual buildings. The electrification of the independent building systems has been assumed to be closed loop ground source heat pump systems. While other potential options could be pursued such as air-to-air heat pumps using VRF systems, these have not been included as a part of this study but may be viable candidates for some buildings pending further analysis on a case-by-case basis.

Building Conversion Requirements:

As the individual buildings are connected to the district or independent ground source systems, there will need to be modifications and upgrades within each building to accommodate a lower temperature hot water than they are currently designed for. It is assumed the ground source heat pump chiller heaters will provide a maximum of 140 deg. F hot water. A select few buildings currently have direct steam heat and will need to be converted to low-temperature hot water heat. The buildings currently served by chilled water will also need modification for a different chilled water temperature than what is currently supplied. Some buildings will need to be converted from DX cooling to chilled water-cooling. These modifications may include, but are not limited to, changing coils within air-handler units, changing systems distributed throughout the building, including but not limited to FCUS, valance units, chilled beams, perimeter radiation, and VAV boxes. Each building will need to be connected to the underground hot water supply and return and chilled water supply and return underground pipe distribution with valves and other accessories. In buildings currently heated with direct steam heat, hot water pumps will need to be installed at the building entrance. In buildings currently cooled with DX cooling, chilled water pumps will need to be installed at the building entrance. Further study and evaluation of the existing systems will need to be conducted at each individual building to determine the exact scope of work required for the building conversion.

Future Development:

All future identified development in the 2021 - 2030 period is assumed to be designed to connect into the respective district plant and operate with the hot and chilled water temperature provided by the ground source system. The district plants have accounted for the anticipated expansion information provided by UConn.

All future development in the 2031 - 2040 period is assumed to be designed as self-sufficient with zero-carbon capable systems and is not included in any of the district loads discussed in this report.

4. UConn Storrs Campus Thermal Load Calculations

6.1. Existing Thermal Load Analysis:

Table H1 below represents an approximate thermal loading for both heating and cooling for every building, by building type on a square foot basis. See **Appendix F: Existing Storrs Campus Buildings Matrix** for a building list and type. Any structures without any thermal loads, including but not limited to parking, bus shelters, and tunnels are excluded from these calculations.

Building Type	Heating (BTU/SF)	Cooling (SF/Ton)
Academic	30	350
Administrative	25	350
Arts/Culture	30	325
Athletics & Recreation	25	400
Miscellaneous	25	400
Residence	35	500
Dining	35	275
Science	40	250
Labs	50	200
Student Services	30	350
Support/Utility	25	400
Rental	30	30

Table H1: Building Thermal Load by Square Foot

Using the above factors and square footage information provided by the University's space planning database (refer to **Appendix F: Existing Storrs Campus Buildings Matrix** for existing Storrs campus building matrix), the existing thermal heating and cooling loads were calculated. **Table H2** summarizes the peak heating and cooling loads per thermal district.

District	Gross Building Area (ft2)	Heating MBH	Cooling Tons
Northwest	1,307,097	43890	2388
Central-North	2,456,754	84621	8078
Northeast	481,667	15747	224
Central-South	1,866,321	54916	4875
Southeast	250,177	8306	68
Northwood	83,112	2901	0
Spring Hill	36,082	1203	0
Spring Manor	6,448	185	14
Depot	394,940	11426	938
West	2,151,312	63846	4676
East A	575,699	18966	1150
East B	211,022	6342	54
South A	863,851	28543	1485
South B	79,367	2777	0
Grand Total	**10,763,850**	**343,671**	**23,949**

Table H2: UConn Storrs Existing Campus Peak Thermal Load Summary per District

The identified future development plans through the year 2030 include the addition and demolition of buildings on the UConn Storrs campus. A similar calculation was completed to determine the change in thermal load on the campus during this time period. **Table H3** summarizes the change in thermal loads.

District	Gross Building Area (ft2)	Heating MBH	Cooling Tons
Northwest	362,988	14923	1492
Central-North	-162,761	-6510	0
West	97,700	2443	244
South A	210,000	7350	420
South B	180,743	6326	520
Grand Total	**688,670**	**24,531**	**2,677**

Table H3: UConn Storrs Campus Thermal Load Change Through 2030

The planned developments through 2030 were then included into the existing conditions to develop the overall anticipated thermal loads for each of the districts. **Table H4** summarizes the combined thermal loads of the UConn Storrs campus through 2030.

District	Gross Building Area (ft2)	Heating MBH	Cooling Tons
Northwest	1,670,085	58813	3880
Central-North	2,293,993	78111	8078
Northeast	481,667	15747	224
Central-South	1,866,321	54916	4875
Southeast	250,177	8306	68
Northwood	83,112	2901	0
Spring Hill	36,082	1203	0
Spring Manor	6,448	185	14
Depot	394,940	11426	938
West	2,249,012	66289	4920
East A	575,699	18966	1150
East B	211,022	6342	54
South A	1,073,851	35893	1905
South B	260,110	9103	520
Grand Total	**11,452,520**	**368,202**	**26,626**

Table H4: Overall UConn Storrs Campus Peak Thermal Load through 2030 Per District

The values in **Table H4** were used to determine the number of ground source wells and heat pump units that would be required to transition the campus to electrically-driven thermal energy.

The ground source wells are assumed to provide approximately 39 MBH of heating and 3.25 tons of cooling. The wells are assumed to be drilled 20 feet on center from each other meaning each well requires 400 square feet of ground area per well.

The well performance numbers are assumed to be an average across the Storrs campus and were developed based on a combination of the GZA Northwest Science Quad Geothermal Site Assessment and AHRI Standard 870 Performance Rating Criteria.

Table H5 below summarizes the required well quantity and associated acreage.

District	Gross Building Area (ft2)	Heating (MBH)	Cooling (Tons)	Heating Well Quantity	Cooling Well Quantity	Heating Ground Source Area (Acres)	Cooling Ground Source Area (Acres)
Northwest	1,670,085	58,813	3,880	1,508	1,194	13.8	11.0
Central-North	2,293,993	78,111	8,078	2,003	2,485	18.4	22.8
Northeast	481,667	15,747	224	404	69	3.7	0.6
Central-South	1,866,321	54,916	4,875	1,408	1,500	12.9	13.8
Southeast	250,177	8,306	68	213	21	2.0	0.2
Northwood	83,112	2,901	0	74	0	0.7	0.0
Spring Hill	36,082	1,203	0	31	0	0.3	0.0
Spring Manor	6,448	185	14	5	4	0.0	0.0
Depot	394,940	11,426	938	293	289	2.7	2.7
West	2,249,012	66,289	4,920	1,700	1,514	15.6	13.9
East A	575,699	18,966	1,150	486	354	4.5	3.2
East B	211,022	6,342	54	163	17	1.5	0.2
South A	1,073,851	35,893	1,905	920	586	8.5	5.4
South B	260,110	9,103	520	233	160	2.1	1.5
Grand Total	**11,452,520**	**368,202**	**26,626**	**9,441**	**8,193**	**87**	**75**

Table H5: Required Ground Source Wells to Meet Peak Heating and Cooling Demand

Currently a program is being pursued in which three test wells will be drilled on campus to determine the actual thermal output of ground source wells on campus. Based on the findings of this testing program, the anticipated number of wells, required area, and output of the wells may need to be altered.

The individual district well fields and district plants were sized based on peak demand of that district. In some cases, the cooling thermal requirement is driving the size of the well field and district plant; however, in others, the heating thermal requirement is the driving factor.

In each of these districts, the ground source heat pumps will require electrical power. For the peak heating electrical requirement, a coefficient of performance (COP) of the ground source heat pumps is assumed to be 3.0 for heating and 4.0 for cooling. These efficiency factors are used to calculate the electrical load, in kilowatts, of each of the ground source heat pump systems. **Table H6** summarizes the peak electrical requirement for the ground source heat pumps per district.

District	Gross Building Area (ft2)	Heating (MBH)	Cooling (Tons)	Heating Well Quantity	Cooling Well Quantity	Heating kW	Cooling kW
Northwest	1,670,085	58,813	3,880	1,508	1,194	5,744	3,411
Central-North	2,293,993	78,111	8,078	2,003	2,485	7,629	7,100
Northeast	481,667	15,747	224	404	69	1,538	197
Central-South	1,866,321	54,916	4,875	1,408	1,500	5,363	4,285
Southeast	250,177	8,306	68	213	21	811	60
Northwood	83,112	2,901	0	74	0	283	0
Spring Hill	36,082	1,203	0	31	0	117	0
Spring Manor	6,448	185	14	5	4	18	12
Depot	394,940	11,426	938	293	289	1,116	824
West	2,249,012	66,289	4,920	1,700	1,514	6,474	4,325
East A	575,699	18,966	1,150	486	354	1,852	1,011
East B	211,022	6,342	54	163	17	619	48
South A	1,073,851	35,893	1,905	920	586	3,506	1,674
South B	260,110	9,103	520	233	160	889	457
Grand Total	**11,452,520**	**368,202**	**26,626**	**9,441**	**8,193**	**35,961**	**23,404**

Table H6: Peak Electrical Requirements for Ground Source Heat Pump Conversion

As discussed previously, each of the district plants will have hot water supply and return and chilled water supply and return underground piping to supply thermal energy to each of the buildings on campus. The expected underground pipe sizes are determined based on an assumed 20°ΔT on the hot water and a 12°ΔT on the chilled water.

5. UConn Storrs Campus Thermal Conversion Sequencing

Based on the previously discussed factors, the following is a possible sequence of necessary campus thermal system upgrades required to convert the UConn Storrs campus to ground source heat pump systems.

Conversion Period: 2021 - 2030 Summary Approach

1. Design and construct 10 energy plants in 11 districts.
2. Install approximately 40.5 acres of ground source heat pump (geothermal) wells (4,410 wells).
3. Install approximately 65 ground source heat pump chillers.
4. Install approximately 27,000 linear feet of hot water supply and return underground piping.
5. Install approximately 25,500 linear feet of chilled water supply and return underground piping.
6. Convert 174 buildings to low-temperature hot water heating.
7. Disconnect 54 buildings from existing steam system.
8. Disconnect 11 buildings from existing chilled water system.
9. Connect 174 buildings to new district ground source heat pump heating systems.
10. Connect 84 buildings to new district ground source heat pump cooling systems.

11. Install independent ground source systems for 70 buildings.

Conversion Period: 2031 - 2040 Summary Approach

1. Design and construct six energy plants in five districts.
2. Install approximately 54 acres of ground source heat pump (geothermal) wells (5,881 wells).
3. Install approximately 90 ground source heat pump chillers.
4. Install approximately 33,000 linear feet of hot water supply and return underground piping.
5. Install approximately 33,000 linear feet of chilled water supply and return underground piping.
6. Convert 127 buildings to low-temperature hot water heating.
7. Disconnect 81 buildings from existing steam system.
8. Disconnect 27 buildings from existing chilled water system.
9. Connect 127 buildings to new district ground source heat pump heating systems.
10. Connect 81 buildings to new district ground source heat pump cooling systems.
11. Install independent ground source systems for five buildings.

Conversion Period: 2021 - 2030 Detailed Approach

District: South A:

1. Install 8.5 acres of ground source heat pump (geothermal) wells (926 wells).
2. Install 8,200-SF central plant, sized for 35,000 MBH heating and 2,000 tons cooling.
3. Install 2,000 linear feet of 12-inch hot water supply and return piping for district heating (3,500 gpm).
4. Install 500 linear feet of 14-inch chilled water supply and return distribution piping for district cooling (4,000 gpm). (Note: It is assumed existing chilled water supply and return underground pipe distribution can be reused in this district.)

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Drama Music Building	45,294	X	X	X	X	X	
von der Mehden Recital Hall	14,759	X	X	X		X	
Watson Hall - Alumni Quad 1	50,828	X	X	X			
Belden Hall - Alumni Quad 2	50,839	X	X	X			
Eddy Hall - Alumni Quad 3	50,839	X	X	X			
Brock Hall - Alumni Quad 4	51,307	X	X	X			
Ryan Refectory (Alumni Dining Hall)	36,689	X	X	X			
Communication Sciences Center	28,361	X		X		X	
Human Development Center	31,091	X		X		X	
School of Fine Arts	46,558	X	X	X	X	X	
South Campus Dorms - Building A-Wilson	70,636	X	X	X	X	X	
South Campus Dorms - Building B-Rosebrooks	80,232	X	X	X	X	X	
South Campus Dorms - Building C-Snow	104,885	X	X	X	X	X	
South Campus Dorms - Building D-Rome	70,864	X	X	X	X	X	
South Campus Chiller	4,905	X		X		X	
Nafe Katter Theatre	44,021	X		X		X	
Honors Residence Hall	210,000						
Music Building	41,999	X	X	X	X	X	
School of Fine Arts Atrium	34,569	X	X	X	X	X	
House 20	2,792						X
House 72	2,382						X
Summary	**1,073,851**	**18**	**14**	**18**	**8**	**13**	**2**

Table H7: South A Thermal Conversion Building Requirements

District: South B:

1. Install 2.2 acres of ground source heat pump (geothermal) wells (240 wells).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Mansfield Apartments (New Construction)	260,000						X
Summary	**260,000**	**0**	**0**	**0**	**0**	**0**	**1**

Table H8: South B Thermal Conversion Building Requirements

District: Southeast:

1. Install 2.1 acres of ground source heat pump (geothermal) wells (229 wells).
2. Install 4,000-SF central plant, sized for 8,200 MBH heating and 420 tons cooling.
3. Install 1,800 linear feet of 8-inch hot water supply and return piping for district heating (850 gpm).
4. Install 1,800 linear feet of 8-inch chilled water supply and return distribution piping for district cooling (820 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Bishop Center	36,337	X		X			
Daily Campus Building	6,737	X		X		X	
Shippee Hall & Dining Facility	70,500	X	X	X			
Buckley Hall	105,632	X	X	X			
Barnes and Noble Storrs Center	17,235						X
Mansfield 28 Professional Park Building	9,176	X		X			
House 09	1,316						X
House 07A	1,613						X
Summary	**248,545**	**5**	**2**	**5**	**0**	**1**	**3**

Table H9: Southeast Thermal Conversion Building Requirements

District: Spring Hill:

1. Install 0.4 acres of ground source heat pump (geothermal) wells (44 wells).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Plant Science Res/Farm Main Bldg	6,015						X
Plant Science Res/Farm Greenhouse #2	2,496						X
Plant Science Burr Nursery	537						X
Plant Science Turf Resource Unit	5,000						X
Spring Hill Laboratory	2,979						X
Butler Bldg - Spring Hill	3,039						X
Isolation Barn - Spring Hill	4,545						X
Summary	**24,611**	**0**	**0**	**0**	**0**	**0**	**7**

Table H10: Spring Hill Thermal Conversion Building Requirements

District: East B:

1. Install 1.6 acres of ground source heat pump (geothermal) wells (174 wells).
2. Install 3,250-SF central plant, sized for 6,500 MBH heating and 160 tons cooling.
3. Install 1,000 linear feet of 6-inch hot water supply and return piping for district heating (650 gpm).
4. Install 1,000 linear feet of 6-inch chilled water supply and return distribution piping for district cooling (320 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Water Pumphouse - Fenton River	1,385	X		X			
Horse Barn	8,850						X
A. L. Lorentzen Stable	6,920						X
A. L. Lorentzen Connector	736						X
Environmental Health & Safety Building	8,569	X		X		X	
Polo Arena	35,381	X		X			
Cattle Resource Unit	1,010						X
Modular Waste Storage	588	X		X			
Hoop Barn	3,200						X
Beef-Sheep Barn	19,400						X
Swine Barn	3,227						X
Farm Department Headquarters	15,079	X		X			
Swine Feeding Barn	1,093						X
Shine Shed	3,638						X
Biobehavioral Science Building 5	4,958	X		X		X	
Microchemistry Lab Prefab 2	4,968	X		X			
Canid Research Lab	810	X		X			
Sewage Pumping Station	646	X		X			
Kinesiology Building	22,655	X		X			
Institute of the Environment	23,334	X		X			
Horse Unit #2	2,920						X
Biobehavioral Science Trailer Complex Building 6	4,848	X		X		X	
Mare Shed	1,189	X		X			
Museum Storage	871	X		X			
Museum Annex	3,605	X		X			
Agricultural Biotechnology Lab Annex	661	X		X		X	
Sewage Station 2 - Gurleyville Road	300	X		X			
ASC Warehouse [Addition]	1,867	X		X			
Satellite Farm Shed	96						X
Well House A	136						X
High Shed	1,920	X		X			
Fenton River Well House B	136						X
Fenton River Well House C	136						X
Quonset Hut 1	375						X
Fenton River Well House D	97						X
Agriculture Storage Building	4,030	X		X			
Canid Observation Hut	70						X
Locker & Toilet Building	226						X
Fenton River Generator	407						X
Uconn Swine Feeding Shed	100						X
Green Shed (Near EHS MAA Area)	100						X
House 41 (w/ attached garage)	6,031						X
House 42	3,229						X
House 43	1,788						X
Garage (House 43) - Horsebarn Hill	220						X
Summary	**201,807**	**20**	**0**	**20**	**0**	**4**	**25**

Table H11: East B Thermal Conversion Building Requirements

District: Northeast:

1. Install 3.8 acres of ground source heat pump (geothermal) wells (414 wells).
2. Install 5,500-SF central plant, sized for 15,000 MBH heating and 250 tons cooling.
3. Install 5,000 linear feet of 10-inch hot water supply and return piping for district heating (1,600 gpm).
4. Install 5,000 linear feet of 6-inch chilled water supply and return distribution piping for district cooling (500 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Lakeside Apartments (13)	19,442	X	X	X			
International House	5,027	X		X		X	
Floriculture Building	25,476	X	X	X		X	
Webster Hall - Towers Dorm 1A	14,102	X	X	X			
Sherman Hall - Towers Dorm 1B	16,792	X	X	X			
Jefferson Hall - Towers Dorm 2A	14,109	X	X	X			
Colt Hall - Towers Dorm 2B	14,556	X	X	X			
Trumball Hall - Towers Dorm 3A	14,361	X	X	X			
Sousa Hall - Towers Dorm 3B	14,157	X	X	X			
Lafayette Hall - Towers Dorm 3C	14,053	X	X	X			
Morgan Hall - Towers Dorm 3D	19,719	X	X	X			
Keller Hall - Towers Dorm 4A	14,504	X	X	X			
Fenwick Hall - Towers Dorm 4B	13,317	X	X	X			
Wade Hall - Towers Dorm4C	14,425	X	X	X			
Hamilton Hall - Towers Dorm 4D	19,199	X	X	X			
Vinton Hall - Towers Dorm 5A	14,030	X	X	X			
Beecher Hall - Towers Dorm 5B	17,196	X	X	X			
Allen Hall - Towers Dorm 6A	14,032	X	X	X			
Kingston Hall - Towers Dorm 6B	17,174	X	X	X			
Towers Dormitory Student Center	10,421	X	X	X		X	
Husky Village Building A	17,215	X		X			
Husky Village Building B	17,216	X		X			
Husky Village Building C	17,215	X		X			
Husky Village Building D	17,215	X		X			
Husky Village Building E	10,364	X		X			
Husky Village Building F	10,364	X		X			
Husky Village Director's House - Building G	1,280	X		X			
Towers Dining Hall	22,057	X		X			
Towers Loop Pump Station	2,063	X		X			
Fine Arts Band Tower	100	X		X			
St. Thomas Aquinas Chapel	5,772	X	X	X		X	
St. Thomas Aquinas Rectory	3,256	X	X	X		X	
St. Mark's Chapel	3,525	X	X	X		X	
Storrs Congregational Church	5,427	X	X	X		X	
Bethel Congregation	6,645	X	X	X		X	
Storrs Community Nursery School	8,640	X	X	X		X	
St. Thomas Aquinas Center	9,416	X	X	X		X	
Mink Barn	2,640						X
Mink Shed	776						X
Horticulture Storage	9,600	X	X	X			
Horticulture Garage	4,791	X		X			
Summary	**481,667**	**39**	**27**	**39**	**0**	**10**	**2**

Table H12: Northeast Thermal Conversion Building Requirements

District: Northwest Part 1:

1. Install 2.5 acres of ground source heat pump (geothermal) wells (272 wells).
2. Install 4,700-SF central plant, sized for 11,000 MBH heating.
3. Install 1,000 linear feet of 8-inch hot water supply and return piping for district heating (1,100 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Hartford Hall - NC 1	25,025	X	X	X			
New Haven Hall - NC 2	25,353	X	X	X			
New London Hall - NC 3	24,828	X	X	X			
Fairfield Hall - NC 4	24,933	X	X	X			
Windham Hall - NC 5	24,807	X	X	X			
Litchfield Hall - NC 6	24,933	X	X	X			
Middlesex Hall - NC 7	24,692	X		X			
Tolland Hall - NC 8	24,933	X		X			
Hurley Hall - NC 9	23,707	X		X			
Baldwin Hall - NC 10	23,121	X	X	X			
Summary	**246,332**	**10**	**7**	**10**	**0**	**0**	**0**

Table H13: Northwest Part 1 Thermal Conversion Building Requirements

District: Northwest Part 2:

1. Install 3.4 acres of ground source heat pump (geothermal) wells (370 wells).
2. Install 5,500-SF central plant, sized for 14,000 MBH heating and 800 tons cooling.
3. Install 1,300 linear feet of 10-inch hot water supply and return piping for district heating (1,500 gpm).
4. Install 1,300 linear feet of 10-inch chilled water supply and return distribution piping for district cooling (1,600 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
A. P. Merritt Hall - Charter Oak Apt. 18	25,954	X		X		X	
Chieng-Shiung Wu Hall - Charter Oak Apt. 19	25,614	X		X		X	
C. G. Woodhouse Hall - Charter Oak Apt. 22	25,382	X		X		X	
Foster Hall (Vermont Hall) - Charter Oak Apt. A	31,411	X		X		X	
Hoisington Hall (New Hampshire Hall) - Charter Oak Apt. B	37,104	X		X		X	
Thompson Hall (Maine Hall) - Charter Oak Apt. C	31,379	X		X		X	
Brown Hall (Connecticut Hall) - Charter Oak Apt. D	26,339	X		X		X	
Hubbard Hall (Rhode Island Hall) - Charter Oak Apt. E	26,340	X		X		X	
Hough Hall (Massachusettes Hall) - Charter Oak Apt. F	26,336	X		X		X	
Busby Suites (Charter Oak Suites)	134,229	X		X		X	
Charter Oak Community Center	6,278	X		X		X	
Summary	**396,365**	**11**	**0**	**11**	**0**	**11**	**0**

Table H14: Northwest Part 2 Thermal Conversion Building Requirements

District: Northwest Part 3:

1. Install 1.8 acres of ground source heat pump (geothermal) wells (196 wells).
2. Install 5,500-SF central plant, sized for 10,000 MBH heating and 1,000 tons cooling.
3. Install 300 linear feet of 10-inch hot water supply and return piping for district heating (1,000 gpm).
4. Install 300 linear feet of 12-inch chilled water supply and return distribution piping for district cooling (2,000 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Innovation Partnership Building	122,424	X		X		X	
Research and Development Building	100,000	X		X			
Summary	**222,424**	**2**	**0**	**2**	**0**	**1**	**0**

Table H15: Northwest Part 3 Thermal Conversion Building Requirements

District: Northwest Independent:

1. Install 0.5 acres of ground source heat pump (geothermal) wells (54 wells).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Motor Pool & Vehicle Maintenance Building	9,399						X
Sewage Plant Control Building	8,918						X
Sewage Plant Pump & Chemical Building	4,333						X
Sewage Plant Headworks Building	2,802						X
Sewage Plant - Sludge Holding Tank	805						X
Sewage Plant Sludge Transfer Building	331						X
Sewage Plant Control Building	8,918						X
Main Accumulation Building	8,613						X
COMPOST FACILITY	1,000						X
WELL WATER TREATMENT FACILITY	2,600						X
Water Reclamation Facility	12,132						X
Summary	**59,850**	**0**	**0**	**0**	**0**	**0**	**11**

Table H16: Northwest Independent Thermal Conversion Building Requirements

District: West Part 1:

1. Install 2.8 acres ground source heat pump (geothermal) wells (305 wells).
2. Install 5,500-SF central plant, sized for 11,500 MBH heating and 640 tons cooling.
3. Install 1,800 linear feet of 8-inch hot water supply and return piping for district heating (1,100 gpm).
4. Install 1,800 linear feet of 10-inch chilled water supply and return distribution piping for district cooling (1,300 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
E. Grasso Hall - Hilltop Apt. 10	34,457	X		X		X	
H. B. Stowe Hall - Hilltop Apt. 11	24,886	X		X		X	
A. Novello Hall - Hilltop Apt. 12	34,947	X		X		X	
M. French Hall - Hilltop Apt. 13	24,927	X		X		X	
M. R. Beard Hall - Hilltop Apt. 14	34,457	X		X		X	
S. La Flesche Hall - Hilltop Apt. 15	24,927	X		X		X	
P. Crandall Hall - Hilltop Apt. 16	34,947	X		X		X	
M. M. Bethune Hall - Hilltop Apt. 17	24,927	X		X		X	
M. K. Wheeler Hall - Hilltop Apt. 20	38,293	X		X		X	
S. B. Crawford Hall - Hilltop Apt. 21	34,947	X		X		X	
Hilltop Community Center	5,080	X		X		X	
Hilltop/Capstone Pump House	400	X		X			
Hilltop Pump House	250	X		X			
Summary	**317,445**	**13**	**0**	**13**	**0**	**11**	**0**

Table H17: West Part 1 Thermal Conversion Building Requirements

District: West Part 2:

1. Install 5.2 acres of ground source heat pump (geothermal) wells (566 wells).
2. Install 6,900-SF central plant, sized for 21,000 MBH heating and 1,100 tons cooling.
3. Install 2,500 linear feet of 12-inch hot water supply and return piping for district heating (2,200 gpm).
4. Install 2,500 linear feet of 12-inch chilled water supply and return distribution piping for district cooling (2,100 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Physical Education/Field House	147,354	X	X	X		X	
Hale Hall	65,088	X		X			
Ellsworth Hall	64,556	X		X			
Putnam Refectory	43,023	X		X		X	
Football Equipment Storage	128	X		X			
Football Ticket Booth - North	81	X		X			
Football Ticket Booth - South	81	X		X			
Gampel Pavilion	352,013	X	X	X	X		
Storage Building - Athletic	1,166	X		X			
Admissions (Old Alumni Building)	25,182	X		X		X	
Sports Complex - George J. Sherman	1,166	X		X		X	
Press Box - George J. Sherman Family	251	X		X			
Garrigus Suites (Hilltop Suites)	131,920	X		X		X	
Peter J. Werth Residence Tower (Formerly Next Gen Residence Hall)	215,834	X		X		X	
Alumni Center	29,824	X		X		X	
Uconn Foundation	35,738	X		X		X	
Summary	**1,113,405**	**16**	**2**	**16**	**1**	**8**	**0**

Table H18: West Part 2 Thermal Conversion Building Requirements

District: West Part 3:

1. Install 2.0 acres of ground source heat pump (geothermal) wells (218 wells).
2. Install 4,000-SF central plant, sized for 7,000 MBH heating and 700 tons cooling.
3. Install 300 linear feet of 8-inch hot water supply and return piping for district heating (700 gpm).
4. Install 300 linear feet of 10-inch chilled water supply and return distribution piping for district cooling (1,400 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Burton Football Complex & Shenkman Training Center	96,000	X	X	X	X	X	
Burton Football Complex & Shenkman Training Center	179,874	X	X	X	X	X	
Summary	**275,874**	**2**	**2**	**2**	**2**	**2**	**0**

Table H19: West Part 2 Thermal Conversion Building Requirements

District: Northwood:

1. Install 0.8 acres of ground source heat pump (geothermal) wells (87 wells).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Sewage Station 4 - Northwood Apartments	784						X
Northwood Apartments - Building 1	6,855						X
Northwood Apartments - Building 2	6,856						X
Northwood Apartments - Building 3	6,853						X
Northwood Apartments - Building 4	6,856						X
Northwood Apartments - Building 5	6,856						X
Northwood Apartments - Building 6	6,871						X
Northwood Apartments - Building 7	6,871						X
Northwood Apartments - Building 8	6,856						X
Northwood Apartments - Building 9	6,871						X
Northwood Apartments - Building 10	6,856						X
Northwood Apartments - Building 11	6,856						X
Northwood Apartments - Building 12	6,871						X
Summary	**83,112**	**0**	**0**	**0**	**0**	**0**	**13**

Table 20: Northwood Thermal Conversion Building Requirements

District: Spring Manor:

1. Install 0.1 acres of ground source heat pump (geothermal) wells (11 wells).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Willimantic Well 4 and Pumphouse	576						X
Spring Manor Farm Hoop House	2,200						X
Spring Mnr Farm -Oak Cottage	2,592						X
Willimantic Pumphouse & Well I	303						X
Willimantic Pumphouse & Well II	324						X
Willimantic Pump House & Well III	453						X
Summary	**6,448**	**0**	**0**	**0**	**0**	**0**	**6**

Table H21: Spring Manor Thermal Conversion Building Requirements

District: Depot:

1. Install 2.8 acres of ground source heat pump (geothermal) wells (305 wells).
2. Install 5,500-SF central plant, sized for 11,500 MBH heating and 950 tons cooling.
3. Install 10,000 linear feet of 10-inch hot water supply and return piping for district heating (1,150 gpm).
4. Install 10,000 linear feet of 12-inch chilled water supply and return distribution piping for district cooling (1,900 gpm).

   Note: 60% of buildings are assumed to have cooling; further study is required to determine the exact quantity.

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Longley School - Depot	92,636	X		X			
DEPOT- ASHFORD COTTAGE	2,566	X		X			
DEPOT- BOLTON CTTG (PUPPET ART)	2,566	X		X			
DEPOT- BROWN BUILDING	25,203	X		X			
DEPOT- DEPOT D CT ADV. PAVEMENT LAB	20,444	X		X			
DEPOT- CHAPLIN COTTAGE	11,421	X		X			
DEPOT- COLCHESTER COTTAGE	10,950	X		X			
DEPOT- COLUMBIA COTTAGE	3,520	X		X			
DEPOT- COVENTRY COTTAGE	3,520	X		X			
DEPOT- ELLINGTON COTTAGE	3,520	X		X			
DEPOT- TRI-COUNTY GREENHOUSE	2,693	X		X			
DEPOT- HAMPTON COTTAGE	11,208	X		X			
DEPOT- HEBRON COTTAGE	3,602	X		X			
DEPOT- KENNEDY COTTAGE (DPES)	6,611	X		X			
DEPOT- SURPLUS OPERATIONS (LAUNDRY)	21,135	X		X			
DEPOT- LEBANON COTTAGE	10,864	X		X			
DEPOT- MANSFIELD COTTAGE	3,520	X		X			
DEPOT- MERRITT HALL	34,256	X		X			
DEPOT- NORLING BUILDING	5,666	X		X			
DEPOT- STAFFORD COTTAGE	3,520	X		X			
DEPOT - DEPORT C DRL MAINTENANCE BLDG	27,191	X		X			
DEPOT- THOMSON HALL	33,823	X		X			
DEPOT- TOLLAND COTTAGE	3,606	X		X			
DEPOT- UNION COTTAGE	2,566	X		X			
DEPOT- VERNON COTTAGE	5,495	X		X			
DEPOT- WILLIMANTIC COTTAGE	3,520	X		X			
DEPOT- WILLINGTON COTTAGE	3,520	X		X			
DEPOT- WINDHAM COTTAGE	2,698	X		X			
DEPOT- ATHLETIC FIELD TOILETS	381	X		X			
DEPOT- ATHLETIC FIELD TOILETS	407	X		X			
DEPOT- FUEL CELL INSTITUTE BUILDING	16,512	X		X			
DEPOT- SWG STA, PLAINS ROAD	473	X		X			
DEPOT- SWG STA, BIRCH ROAD	473	X		X			
DEPOT- PLANT SCIENCE GREENHOUSE	2,405	X		X			
Storage Building - Telcom	160	X		X			
Visual Arts Research Complex	8,267	X		X			
Hydraulic Lab	2,153	X		X			
Plant Nutrition Lab	1,869	X		X			
Summary	**394,940**	**38**	**0**	**38**	**0**	**0**	**0**

Table H22: Depot Thermal Conversion Building Requirements

Conversion Period 2030 - 2040 Detailed Approach

District: Northwest Part 4:

1. Install 6.8 acres of ground source heat pump (geothermal) wells (741 wells).
2. Install 8,300-SF central plant, sized for 23,500 MBH heating and 2,100 tons cooling.
3. Install 4,400 linear feet of 12-inch hot water supply and return piping for district heating (2,400 gpm).
4. Install 4,400 linear feet of 16-inch chilled water supply and return distribution piping for district cooling (4,200 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Hanks Hall (A -B) - NW Quad 1	27,913	X	X	X	X	X	
Goodyear (A -B) - NW Quad 2	27,927	X	X	X	X	X	
Russell (A-D) - NW Quad 3	57,118	X	X	X	X	X	
Batterson (A-D) - NW Quad 4	56,986	X	X	X	X	X	
Terry (A -B) - NW Quad 5	27,927	X	X	X	X	X	
Rogers (A -B) - NW Quad 6	27,993	X	X	X	X	X	
Facility Maintenance Storage Bldg (Incinerator)	2,772	X		X		X	
Facilities Trailer	492	X		X			
Police & Fire Complex	24,102	X		X		X	
Facilities University Operations Building	41,629	X		X		X	
Architectural & Engineering Services Building	11,695	X		X		X	
Central Warehouse	89,093	X		X		X	
WHUS/State Police Prefab.	363	X		X		X	
Northwest Quad Dining Hall	31,154	X		X	X	X	
Lodewick Visitors Center	7,707	X		X		X	
Mobile Command Center Garage	2,451	X		X			
Stem Research Center Science 1	197,198	X		X		X	
Supplemental Utility Plant	35,753	X		X		X	
Transportation Office Trailer	672	X		X			
Greenhouse Replacement	26,000	X		X		X	
Public Safety Expansion	4,037	X		X		X	
Summary	**700,982**	**21**	**6**	**21**	**7**	**18**	**0**

Table H23: Northwest Part 4 Thermal Conversion Building Requirements

District: West Part 4:

1. Install 4.8 acres of ground source heat pump (geothermal) wells (523 wells).
2. Install 8,200-SF central plant, sized for 22,000 MBH heating and 1,900 tons cooling.
3. Install 4,600 linear feet of 12-inch hot water supply and return piping for district heating (2,200 gpm).
4. Install 4,600 linear feet of 14-inch chilled water supply and return distribution piping for district cooling (3,800 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Baseball Pressbox	1,220	X		X			
Baseball Dugout 1st Base	1,322	X		X			
Baseball Dugout 3rd Base	1,322	X		X			
Athletic Performance Center	52,351	X		X		X	
Soccer Stadium Ticket Booth A	140	X		X			
Soccer Stadium Ticket Booth B	935	X		X			
Soccer Storage	704	X		X			
Softball Pressbox	1,220	X		X			
Softball Dugout 1st Base	980	X		X			
Softball Dugout 3rd Base	980	X		X			
Softball Public Restroom	191	X		X			
Softball Storage Building	2,488	X		X			
New Hockey Arena	97,700			X			
McMahon Hall & Dining Facility	136,249	X	X	X		X	
Athletics Storage	3,160	X		X			
UConn Co-op	74,797	X	X	X	X	X	
Freitas Ice Arena	49,174	X		X		X	
Art Ceramic Studio	3,300	X		X			
Academic Services Center	4,300	X	X	X		X	
Summary	**432,534**	**18**	**3**	**19**	**1**	**5**	**0**

Table H24: West Part 4 Thermal Conversion Building Requirements

District: West Part 5:

1. Install 0.9 acres of ground source heat pump (geothermal) wells (98 wells).
2. Install 1,600-SF central plant, sized for 2,800 MBH heating and 280 tons cooling.
3. Install 300 linear feet of 4-inch hot water supply and return piping for district heating (280 gpm).
4. Install 300 linear feet of 6-inch chilled water supply and return distribution piping for district cooling (560 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Werth Family Basketball Champions Center	108,518	X		X		X	
Summary	**108,518**	**1**	**0**	**1**	**0**	**1**	**0**

Table H25: West Part 6 Thermal Conversion Building Requirements

District: Central North and Central South:

1. Install 37 acres ground source heat pump (geothermal) wells (4,030 wells).
2. Install 50,000-SF central plant, sized for 143,000 MBH heating and 13,600 tons cooling.
3. Install 20,000 linear feet of 24-inch hot water supply and return piping for district heating (15,000 gpm).
4. Install 20,000 linear feet of 30-inch chilled water supply and return distribution piping for district cooling (27,500 gpm).

Central North:

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Storrs Hall	52,128	X	X	X	X	X	
Benton Musuem of Art	26,827	X	X	X	X	X	
Atwater Lab	44,021	X	X	X		X	
Wilbur Cross Building	115,127	X	X	X	X	X	
Wood Hall	28,475	X	X	X		X	
Castleman Building (Engineering I)	70,959	X	X	X		X	
Heating & Power Plant	42,410	X	X	X		X	
Williams Health Services Building (Infirmary)	27,627	X	X	X		X	
Pathology Lab	13,153	X	X	X			
Student Union	238,336	X	X	X	X	X	
Jorgensen Auditorium & Theatre	98,327	X	X	X		X	
Plantetarium	582	X	X	X		X	
College of Liberal Arts & Sciences Building	126,189	X	X	X	X	X	
Engineering II	58,149	X	X	X		X	
Center for Undergraduate Education	73,615	X	X	X	X	X	
Gentry Building	98,180	X	X	X	X	X	
Bronwell Building	37,707	X	X	X		X	
Gant North (IMS)	86,256	X	X	X		X	
Gant West (Physics)	78,395	X	X	X		X	
Gant South (Math Sciences)	99,900	X	X	X		X	
Gant Plaza	26,413	X	X	X	X	X	
United Technologies Engineering Building	47,813	X	X	X		X	
Biology Physics Building	153,682	X	X	X	X	X	
Chemistry Building	204,815	X	X	X	X	X	
Pharmacy Biology Building	222,222	X	X	X	X	X	
Cogeneration-Chiller Facility	40,669	X	X	X			
Lawrence D. McHugh Hall (Laurel Hall)	70,169	X	X	X	X	X	
Observatory	201	X	X	X			
UITS Modular Building	15,103	X	X	X			
New Engineering and Science Building	120,057	X	X	X	X	X	
Summary	**2,317,506**	**30**	**30**	**30**	**13**	**26**	**0**

Table H26: Central-North Thermal Conversion Building Requirements

Central South:

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Gulley Hall	15,404	X	X	X		X	
Koons Hall	28,648	X	X	X		X	
Hawley Armory	34,426	X	X	X		X	
Hall Building	29,006	X	X	X		X	
Beach Hall	83,171	X	X	X		X	
Manchester Hall	35,688	X	X	X		X	
Family Studies (formerly DRM)	44,542	X	X	X		X	
Budds Building	26,955	X	X	X		X	
Alsop Hall - WC 1A	13,926	X	X	X			
Alsop Hall - WC 1B	14,361	X	X	X			
Hollister Hall - WC 2A	14,316	X	X	X			
Hollister Hall - WC 2B	13,870	X	X	X			
Shakespear Hall - WC 3A	14,358	X	X	X			
Troy Hall - WC 3B	13,820	X	X	X			
Chandler Hall - WC 4A	14,379	X	X	X			
Lancaster Hall - WC 4B	13,921	X	X	X			
Arjona Building	68,695	X	X	X		X	
Monteith Building	68,428	X	X	X		X	
Andre Schenker Lecture Hall	4,981	X	X	X		X	
Whetten Graduate Center	40,114	X	X	X		X	
Psychology Building	121,386	X	X	X	X	X	
Babbidge Library	412,456	X	X	X	X	X	
Thomas J. Dodd Research Center	64,568	X	X	X		X	
Northwest Tunnel	13,200	X	X	X			
School of Business	128,073	X	X	X	X	X	
Information Technology Building	139,894	X	X	X	X	X	
Oak Hall	121,663	X	X	X	X	X	
Student Recreation Center	272,073	X	X	X	X	X	
Summary	**1,866,321**	**28**	**28**	**28**	**6**	**19**	**0**

Table H26: Central-South Thermal Conversion Building Requirements

District: East A Part 1:

1. Install 4.0 acres of ground source heat pump (geothermal) wells (436 wells).
2. Install 4,000-SF central plant, sized for 18,200 MBH heating and 1,150 tons cooling.
3. Install 2,700 linear feet of 10-inch hot water supply and return piping for district heating (1,800 gpm).
4. Install 2,700 linear feet of 10-inch chilled water supply and return distribution piping for district cooling (2,200 gpm).

Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Holcomb Hall	53,015	X	X	X			
Whitney Hall & Cafeteria	39,725	X	X	X		X	
Sprague Hall	43,049	X	X	X			
Young Building	80,390	X	X	X		X	
Hicks Hall	16,964	X	X	X		X	
Grange Hall	16,964	X	X	X		X	
Ratcliffe Hicks Building	32,355	X	X	X		X	
Agricultural Biotechnology	48,501	X	X	X		X	
Advanced Technology Laboratory	22,584	X	X	X		X	
White Building	38,301	X	X	X		X	
Jones Building	25,999	X	X	X		X	
Agricultural Engineering Lab	7,349	X	X	X		X	
Honors Center	5,053	X		X			
Plant Science Greenhouse 4	1,390	X		X			
Commissary Bakery & Warehouse	35,568	X	X	X		X	
Pit Greenhouse	370	X		X			
Kessell Barn	2,160	X		X			
High Head Pumping Station	2,430	X		X			
Agricultural Biotechnology Greenhouse	11,622	X	X	X			
Storrs Barn	11,821	X		X			
Pfizer Modular A	986	X		X			
Pfizer Modular B	1,972	X		X			
Student Commissary Modular	1,865	X		X			X
House 06	2,990						X
Lodewick Residence	9,445						X
House 05 (w/ attached garage)	2,512						X
Offical Residence	8,517						X
Summary	**523,898**	**23**	**14**	**23**	**0**	**11**	**5**

Table H27: South A Thermal Conversion Building Requirements

District: East A Part 2:

1. Install 0.5 acres of ground source heat pump (geothermal) wells (54 wells).
2. Install 1,200-SF central plant, sized for 18,200 MBH heating and 1,150 tons cooling.
3. Install 1,000 linear feet of 4-inch hot water supply and return piping for district heating (180 gpm).
4. Install 1,000 linear feet of 4-inch chilled water supply and return distribution piping for district cooling (150 gpm).

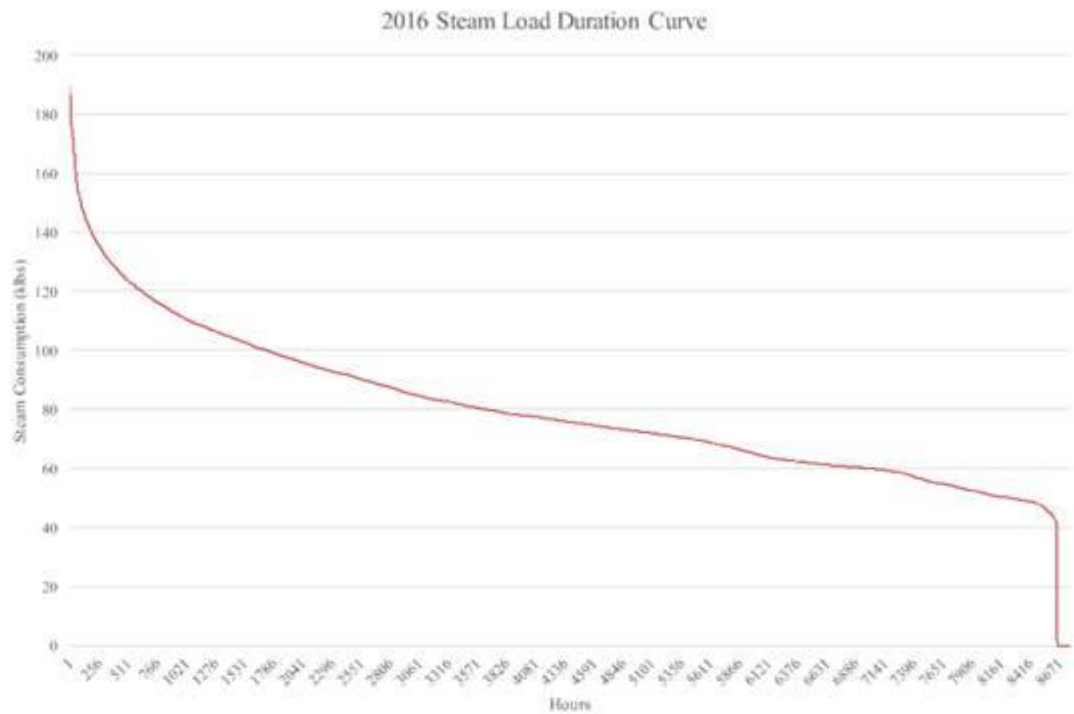
Building Name	Building area (SF)	Convert Building to Low Temperature HW Heating	Disconnect from Exisiting Steam System	Connect to New district Heating	Disconnect from Existing Chilled Water System	Connect to New District Cooling	Independent Geothermal Heating and Cooling
Poultry Commercial House	5,472	X		X			
Poultry Brooder House	2,740	X		X			
Poultry Feed House	3,602	X		X			
High-Tech Poultry Facility	8,680	X		X			
Kellogg Dairy Center	26,413	X		X		X	
Jacobson Barn	4,894	X		X			
Summary	**51,801**	**6**	**0**	**6**	**0**	**1**	**0**

Table H28: South A Thermal Conversion Building Requirements

6. UConn Storrs Campus Thermal Consumption

6.1. Approach

An analysis was conducted based on data provided about the operation of the existing UConn Cogeneration Plant to develop expected thermal heating consumption data for the entire UConn Storrs campus. Chart H1 shows the steam load duration curve of the CUP.

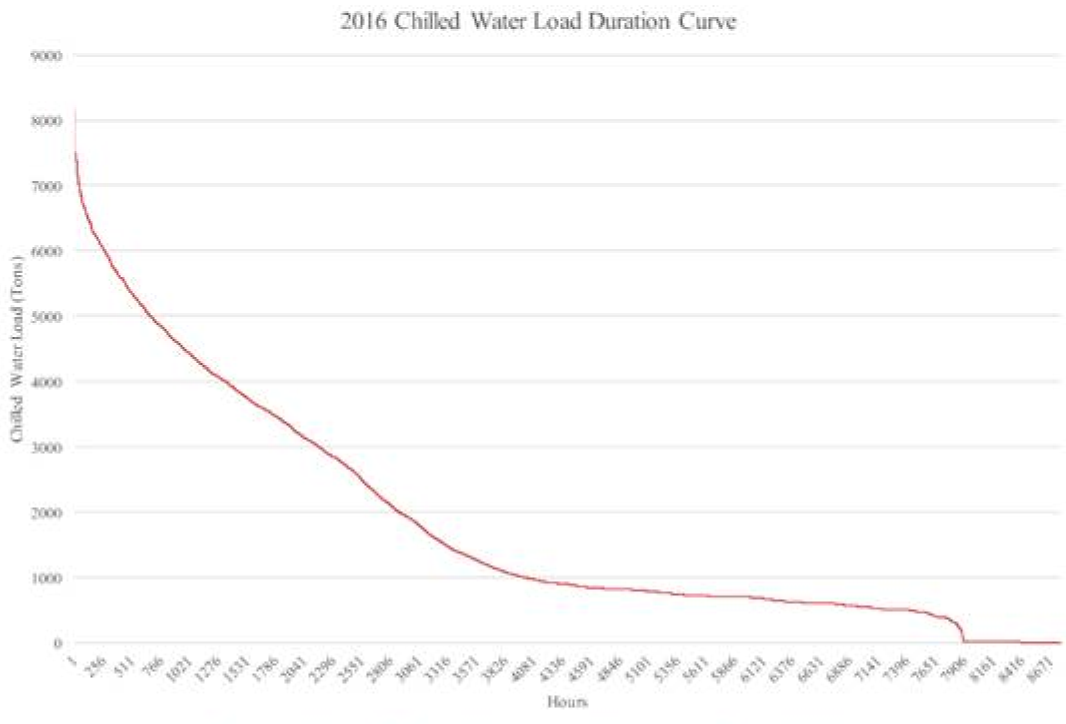


[3] Technical Report for: The University of Connecticut Supplemental Utility Power Plant, Prepared by Waldron Engineering & Construction, Inc.

Chart H1: 2016 CUP Steam Load Duration Curve

In the Technical Report, *The University of Connecticut Supplemental Utility Power Plant*, prepared by Waldron Engineering & Construction, Inc., they report a peak load of approximately 240,000 lb/hr of steam. Based on the load duration curve shown above, the average steam load of the campus averaged over the entire year is approximately 80,000 lb/hr; therefore, is it assumed that the buildings currently served by the CUP consume approximately one-third of the peak load when averaged over the entire year.

A similar analysis was conducted for the cooling thermal consumption data provided about the CUP. Chart H2 shows the chilled water load duration curve of the CUP.



[3] Technical Report for: The University of Connecticut Supplemental Utility Power Plant, Prepared by Waldron Engineering & Construction, Inc.

Chart H2: 2016 CUP Chilled Water Load Duration Curve

In the Technical Report, *The University of Connecticut Supplemental Utility Power Plant*, prepared by Waldron Engineering & Construction, Inc., they report a peak load of approximately 8,000 tons of cooling. Based on the load duration curve shown above, the average cooling load of the campus averaged over the entire year is approximately 2,000 tons; therefore, is it assumed that the buildings currently served by the CUP consume approximately one-quarter of the peak load when averaged over the entire year.

The campus thermal energy consumption required for heating and cooling is not expected to change with the conversion to ground source heat pumps as the energy consumption is tied to the building end use, not the production source. However, the University has planned carbon reduction projects, discussed in **Appendix C - Carbon Reduction Projects**, which will decrease the overall thermal energy consumption. Tables 29 and 30 include the reduction in consumption due to the carbon reduction projects.

It is assumed that the load duration curves of the CUP are representative of the occupancy and use of the entire UConn Storrs campus. The factors discussed previously are therefore used to determine the overall consumption numbers for the entire UConn Storrs campus including the buildings not served by the CUP. The peak thermal loads previously discussed are used in conjunction with the factors discussed above to calculate the total consumption values over the 8,760 hours of the year. As buildings thermally connected to the CUP become reassigned to new districts, the demand is proportionately offloaded from the CUP, both electrically and thermally. The overall performance of the CUP is not substantially affected by the development of the peripheral districts until the Central North and Central South Districts are developed, and thermal loads are displaced during the 2030 to 2040 conversion period.

6.2. Fuel Consumption

The fuel consumption required to provide the heating energy per district is calculated using a weighted average efficiency based on the percentage of buildings served by the Cogeneration Plant and independent boilers. Estimated fuel efficiency of the CUP is 75% and independent boilers is 85%. These fuel consumption numbers are then used to determine the reduction in gas consumption as the districts are converted to electrical ground source heat pump systems.

6.3. Electrical Consumption

The electrical consumption increase due to the thermal conversion to ground source heat pumps is calculated using the same factors as the thermal consumption as they are directly related. The peak electric requirements discussed in **Appendix A - Electrical Evaluation** are used to calculate the consumption.

It is assumed that the heating conversion to ground source heat pumps is a direct addition to the electrical consumption of the campus since the current heating is produced by burning fuels; however, on the cooling side, a portion of campus cooling energy is currently produced using electric chillers, local DX, or other electric cooling. Therefore, only a portion of the cooling conversion to ground source heat pumps is an addition to the campus electrical consumption. Approximately 20% of the electric load from the new districts converted in the 2021 to 2030 time period is included as an addition to the campus electrical consumption. Approximately 75% of the electric load from the new districts converted in the 2031 to 2040 time period is included as an addition to the campus electrical consumption.

6.4. Thermal Consumption Summary Tables

District	Gross Building Area (ft2)	Yearly Heating Consumption					
		MMBTU/YR	kBTU/YR/SF	Weighted Fuel efficiency	:uel Consumption (MMBTU/YR	kWh/YR	kWh/YR/SF
Northwest	1,673,685	172,040	103	80%	215,774	16,802,455	10.0
Central-North	2,293,993	228,084	99	75%	304,112	22,275,998	9.7
Northeast	481,667	45,981	95	78%	59,202	4,490,788	9.3
Central-South	1,866,321	160,355	86	75%	213,807	15,661,237	8.4
Southeast	250,177	24,255	97	78%	31,112	2,368,860	9.5
Northwood	83,112	8,471	102	85%	9,966	827,345	10.0
Spring Hill	36,082	3,512	97	85%	4,132	342,997	9.5
Spring Manor	6,448	541	84	85%	636	52,801	8.2
Depot	394,940	33,363	84	85%	39,251	3,258,458	8.3
West	2,249,012	193,564	86	82%	236,009	18,904,541	8.4
East A	575,699	55,381	96	77%	72,113	5,408,811	9.4
East B	211,022	18,520	88	76%	24,267	1,808,753	8.6
South A	1,073,851	104,808	98	78%	134,536	10,236,153	9.5
South B	260,110	26,580	102	85%	31,271	2,595,963	10.0
Grand Total	**11,452,520**	**104,478,177**	-	-	**1,367,820**	**105,035,159**	-

Table 29: Yearly Heating Consumption

District	Gross Building Area (ft2)	Yearly Cooling Consumption				
		MMBTU/YR	Tons/Yr	kBTU/YR/SF	kWh/YR	kWh/YR/SF
Northwest	1,673,685	101,973	8,497,786	61	7,469,486	4.5
Central-North	2,293,993	212,283	17,690,215	93	15,549,559	6.8
Northeast	481,667	5,877	489,749	12	430,485	0.9
Central-South	1,866,321	128,108	10,675,694	69	9,383,851	5.0
Southeast	250,177	1,800	149,993	7	131,843	0.5
Northwood	83,112	0	0	0	0	0.0
Spring Hill	36,082	0	0	0	0	0.0
Spring Manor	6,448	360	29,981	56	26,353	4.1
Depot	394,940	24,650	2,054,201	62	1,805,627	4.6
West	2,249,012	129,302	10,775,136	57	9,471,259	4.2
East A	575,699	30,225	2,518,754	53	2,213,965	3.8
East B	211,022	1,429	119,110	7	104,697	0.5
South A	1,073,851	50,050	4,170,863	47	3,666,156	3.4
South B	260,110	13,666	1,138,800	53	1,000,996	3.8
Grand Total	**11,452,520**	**699,723**	**58,310,283**	-	**51,254,277**	-

Table 30: Yearly Cooling Consumption

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APPENDIX C

Carbon Reduction Projects

UNIVERSITY OF CONNECTICUT
Zero-Carbon Peak Plan
Appendix C - Carbon Reduction Projects

CARBON REDUCTION PROJECTS

UConn Carbon Reduction Project Descriptions

The following descriptions are from the June 5th, PWGS Report Appendix A.

- **Re-Lamping (Projects not covered under ESCO, SLED or ECSP)**
  Lighting projects to convert existing fixtures to LED. These projects are being completed by UConn Facilities Operations personnel. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource in coordination with UConn's Memorandum of Understanding (MOU) Agreement to reduce energy consumption over a three-year period. If Eversource estimates were not available for certain proposed projects, energy savings factors per square foot were developed using completed lighting projects and the proposed project's building area to be converted to LED.
- **100% Conversion of Light-Duty Vehicles to Hybrid or Electric**
  Greenhouse gas reductions based on the difference in emissions between the gasoline-powered light-duty vehicles in UConn's fleet and replacement hybrid or electric vehicles.
- **Various Insulation Projects**
  The installation of insulation around bare thermal piping and valves in various building locations. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.
- **Other ECMs**
  Other Energy Conservation Measures (ECMs) include the installation of Variable Air Valve (VAV) technology in HVAC systems to allow for variable control of flow, electric chiller replacement at Castleman Hall, and replacement of dining hall cooking ventilation systems to reduce energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.
- **SLED Lighting Projects**
  Storrs LED lighting projects or SLED to convert existing fixtures to LED in approximately 3-million square feet of campus buildings. These projects will be completed by outside lighting contractors. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.
- **Lab Ventilation Management Program Initiative**
  A program to develop, manage, and maintain plans and procedures in consultation with EHS and Facilities Operations to ensure ventilation systems in laboratories and other work areas perform optimally, ensure worker safety, and minimize energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings estimates developed by UConn Facilities Operations Energy Consultant.

- **Steam and Condensate Replacement Projects**
  In order to maintain existing steam infrastructure in the short-term, various repair/replacement projects may be required. Greenhouse gas reduction estimates are based on predicted energy savings for steam and condensate replacement projects consisting of approximately 2,000 to 3,000 linear feet were developed using a similar project completed under the ESCO project by ConEdison. That project resulted in the installation of approximately 2,600 linear feet of steam and condensate piping along Hillside Road.

- **Additional Building Improvements**
  Building improvements can include retro-commissioning, lighting re-lamping projects, HVAC improvements among other identified ECMs. Greenhouse gas reduction estimates are based on predicted energy savings for building improvements developed using a similar project completed under the ESCO project by ConEdison. That project included building improvements for seven energy-intensive science buildings. The project in the 2021 - 2025 timeframe would be similar in process to the ESCO project and would include up to 24 other building types such as administration, instructional, and residential; therefore, energy savings for these buildings was assumed to be half the science building energy savings. For the 2026 - 2030 timeframe, it is assumed that an additional 48 buildings may be identified for improvements based on the results of the proposed Building Assessments and Energy Audits to be completed by Facilities Operations.

- **Anaerobic Digestion**
  A proposed anaerobic digestion facility is assumed to utilize 500 tons of food waste along with manure from 100 cows managed by farm services. The processing of these materials would result in reductions of CO2 and methane emissions. Greenhouse gas emissions reductions were developed by UConn's Framework Consultant, BVH.

- **CAHNR Sequestration Expansion**
  The setting aside of additional UConn forestland that can provide a carbon offset as a result of forest sequestration. Estimated reductions provided by the Sustainability Office.

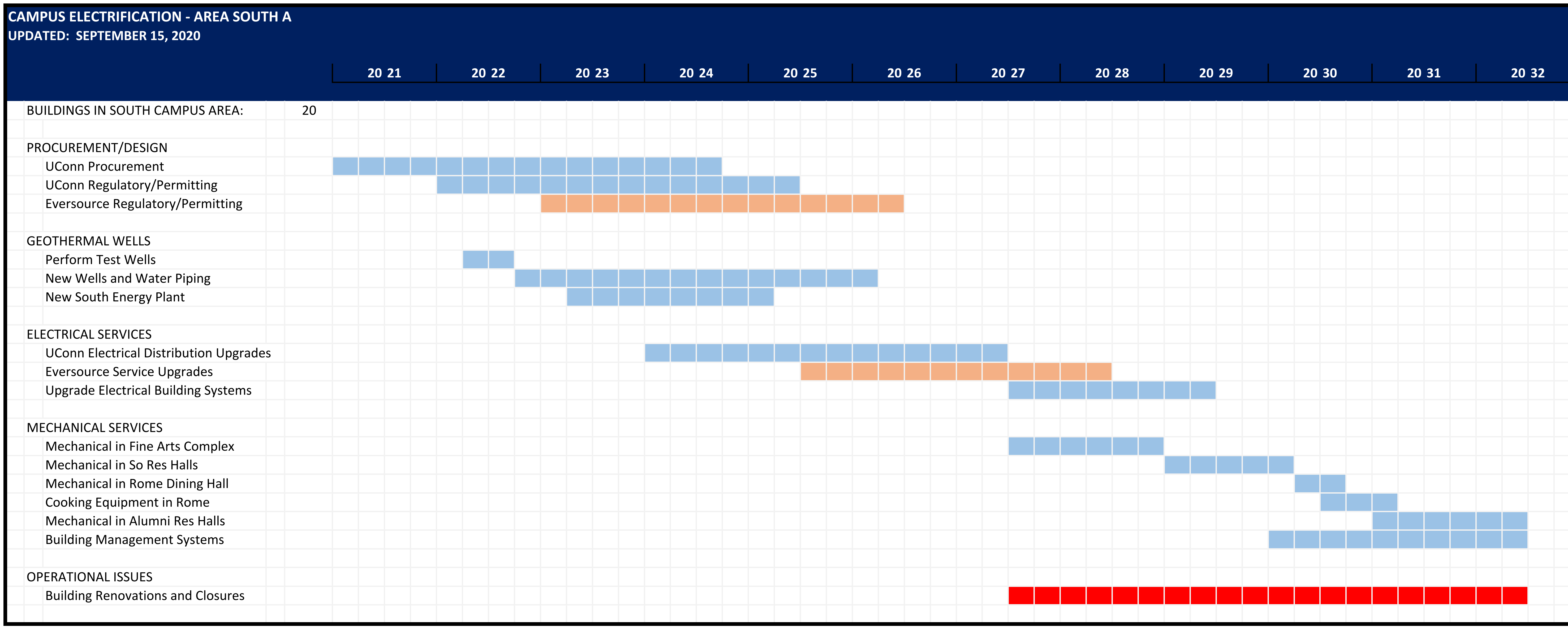
- **Demo of Torrey Life Science**
  Greenhouse gas reduction estimates are based on predicted energy savings from the elimination of energy consumption for this science building.

APPENDIX D

South A District Sample Timeline

Appendix D

South A District
Sample Timeline



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APPENDIX E

Carbon Offset Purchasing Options

COMPETITIVE ENERGY SERVICES

MEMORANDUM

Carbon Mitigation Planning

TO: University of Connecticut

FROM: Competitive Energy Services

DATE: September 30, 2020

Renewable Energy Credit and Carbon Offset Purchasing Options – DRAFT

DRAFT

Executive Summary

Competitive Energy Services ("CES") is supporting the University of Connecticut ("UCONN") and BVH Integrated Services ("BVH") to develop a carbon mitigation plan with strategies for UCONN to decarbonize its campus operations over the next 20 years. The goal of the plan is to identify and evaluate energy procurement and infrastructure investment options for UCONN to achieve a 60% reduction in the Storrs campus' greenhouse gas emissions associated with fossil fuel use by 2030 (using a 2010 baseline) and to achieve zero-carbon campus operations by 2040 while maintaining reliability and resiliency to a level in line with peer institutions. This memorandum identifies and evaluates UCONN's options to acquire and retire Renewable Energy Credits ("RECs") from renewable electricity sources so that UCONN can offset 100% of the emissions associated with electricity purchased from the grid and used by the Storrs campus, so-called Scope 2 emissions, and to acquire and retire carbon offsets from emissions mitigation projects so that UCONN can offset a portion or all of the emissions associated with natural gas and heating oil used on the Storrs campus, so-called Scope 1 emissions.

UCONN cannot achieve its 2030 or 2040 emissions reduction targets in absolute terms without reducing Scope 1 emissions from natural gas consumed in the Storrs Central Utilities Plant ("CUP"), which currently generates 90% of the campus' annual electricity need. To address this need to reduce Scope 1 emissions, BVH is evaluating the costs and technical requirements for UCONN to electrify Storrs' building heating and cooling systems. Campus electrification would shift Storrs' Scope 1 emissions to Scope 2 emissions by significantly increasing the campus' electricity demand and purchases to power ground-source heat pumps and a low-temperature hot water distribution network. In the study, campus electrification reduces the CUP's onsite electric generation over time by phasing out Storrs' high-pressure district steam system by 2040.

BVH estimates the first two phases of the electrification conversion could reduce Storrs' 2030 by approximately 63,000 metric tons carbon dioxide equivalent ("MTCO$_{2e}$") from current levels, which is a 61% reduction below the campus' 2010 baseline of applicable Scope 1 and Scope 2 emissions (102,778 MTCO2e). BVH estimates the third and final electrification phase in the 2030s could reduce Storrs' 2040 emissions by 100% reduction compared to the campus' 2010 baseline of applicable Scope 1 and Scope 2 emissions and a

85% reduction compared to the campus' total 2010 emissions including all Scope 1, Scope 2, and Scope 3 sources (123,022 $MTCO_{2e}$).

While it remains to be seen whether 10 years is enough time for UCONN to complete the first two phases of the proposed electrification conversion, BVH's analysis suggests it is technically possible for Storrs to achieve the 2030 emissions reduction target. This outcome assumes UCONN purchases RECs to offset 100% of Storrs' Scope 2 emissions in 2030 and future years. Due to miscellaneous Scope 1 emissions like refrigerants and Scope 3 emissions such as student and faculty commuting that will be technically difficult and expensive to fully eliminate, UCONN will likely need to purchase carbon offsets in 2040 and future years if the University wants to claim carbon neutrality for Storrs. These carbon offsets would be applied to the roughly 19,000 $MTCO_{2e}$ of remaining Scope 1 and Scope 3 emissions BVH projects for Storrs in 2040 after the completion of the three electrification phases.

UCONN has three options to acquire and retire RECs to offset 100% of Storrs' grid electricity purchases in 2030 and future years – (1) install renewable electricity generation systems on campus and retain the RECs associated with the onsite generation, (2) purchase Renewable Energy Credits from existing renewable generators located off campus through spot purchases or under short-term contracts, as UCONN currently does for six of its seven campuses, and/or (3) purchase RECs from new generation projects located off campus under one or more long-term agreements. These options have varying cost, additionality, geographic, and contracting characteristics that will need careful consideration by UCONN. Based on trends in renewable energy purchasing and state policymaking, UCONN may need to pursue Option 3 for at least a portion of Storrs' REC purchases for students, faculty, and Connecticut policymakers to support the UCONN's Scope 2 mitigation claims for Storrs between 2030 and 2040.

Due to the sharp rise expected in Storrs' electricity usage as the campus' heating and cooling systems are electrified, BVH and CES estimate UCONN will need to acquire and retire approximately 45,000 RECs in 2030 and roughly 147,000 RECs in 2040 to eliminate its Scope 2 emissions. At the low end, the estimated cost for this for 45,000 RECs is currently $45,000 (per year) for 100% Green-e RECs without additionality and without geographic proximity to Storrs. At the high end, REC costs could reach $1.8 million (per year) for 45,000 RECs from new in-region offshore wind projects under long-term contracts. A key variable affecting this purchasing cost is the increasing percentage obligations under the Connecticut Renewable Portfolio Standard ("RPS") through 2030, which means that an increasing percentage of the costs UCONN incurs to offset 100% of its Scope 2 emissions between 2030 and 2040 will be included in the price it pays its retail electricity supplier for grid purchases. To the extent Governor Lamont's recent Executive Order 3 leads to future legislative changes to increase Connecticut's RPS compliance obligations between 2030 and 2040 above the current mandate of 44% of annual retail electric sales, UCONN may need to purchase a smaller volume of supplemental RECs between 2030 and 2040 than discussed herein.

Like REC costs, the cost purchasing of carbon offsets, if UCONN elects to do so, will depend on UCONN's criteria for project type, characteristics, and location. There are numerous providers of carbon offsets serving the voluntary offset market for colleges and universities, so these factors can be evaluated and compared in a competitive solicitation process that requests a wide range of offset options and projects. On the low end of pricing options, offsets can cost as little as $2 to $5 per $MTCO_{2e}$. On the high end, there are a range of offset options ranging between $20 to $100 per $MTCO_{2e}$. CES recommends using $10 per $MTCO_{2e}$ (in 2020 dollars) as a preliminary budget estimate for carbon offset purchases for Storrs if UCONN elects to purchase.

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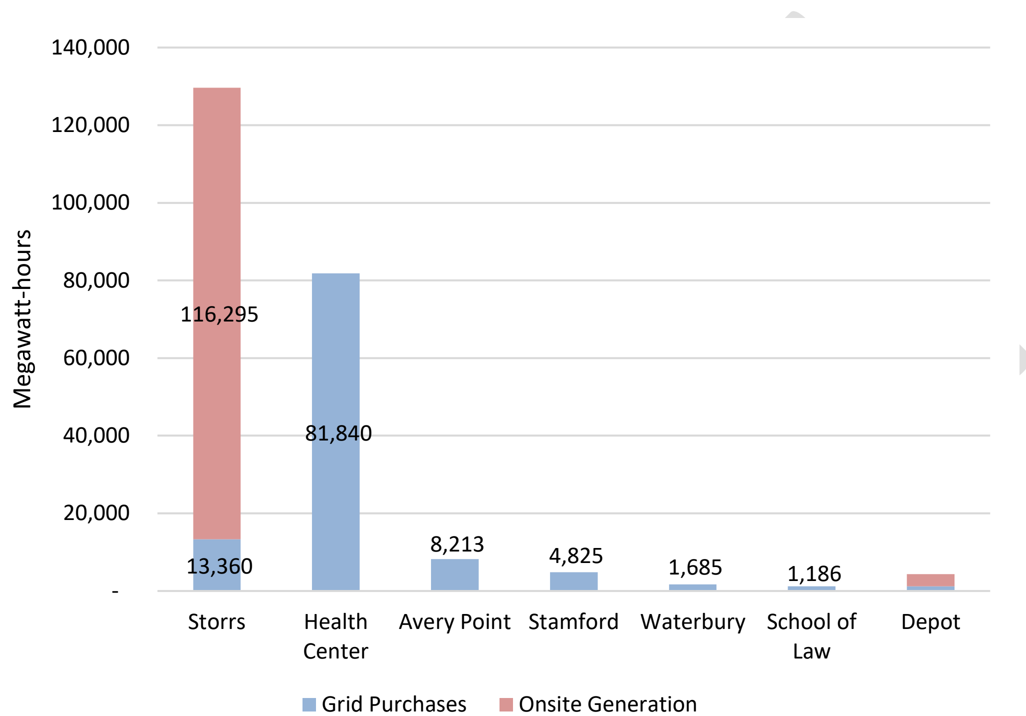
Storrs Electrification Analysis

Today, UCONN purchases approximately 112,000 megawatt-hours ("MWh") of grid electricity per year to serve nearly 400 utility accounts across the University's seven campuses. Figure 1 presents the distribution of UCONN's current grid purchases by campus, which shows the majority of grid electricity is currently consumed at the Farmington Health Center (73%) followed by Storrs (12%), Avery Point (7%), Stamford (4%), Waterbury (1%), School of Law (1%), and Depot (1%).

Figure 1 UCONN Campus Electricity Use: Fiscal Year 2021 Budget



While the Health Center campus currently purchases about six times more MWh of grid electricity per year than the Storrs campus, Storrs' actual electric usage dwarfs that of the Health Center by nearly 60% as shown in Figure 1. Roughly 90% of the Storrs' annual electricity requirement is generated onsite by the CUP; if this onsite generation (net of CUP auxiliary loads) is removed and replaced by grid purchases UCONN's total grid purchases across all campuses would more than double to roughly 230,000 MWh per year.

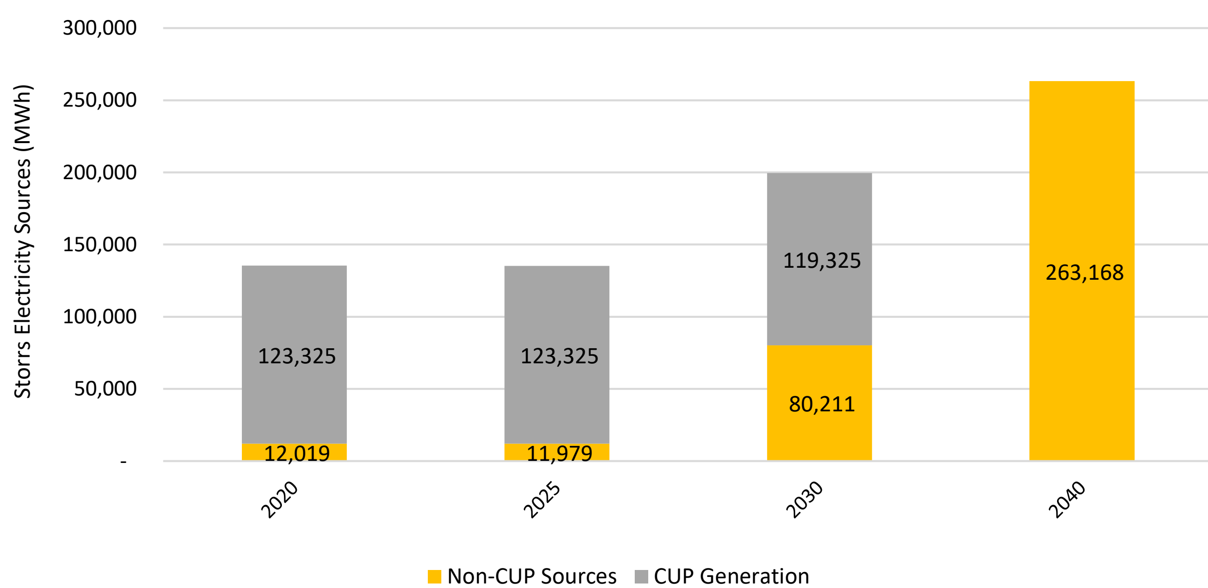
The CUP's steam production and onsite electric generation is the key point of evaluation in UCONN's carbon mitigation strategy. Emissions associated with the operations of the CUP and purchased fuel (natural gas and #2 oil) are considered Scope 1 emissions, and account for nearly 85% of Storrs' current total greenhouse gas emissions. One option to reduce Storrs' Scope 1 emissions is for UCONN to electrify campus heating and cooling across the campus over the next 10 to 20 years, which would shift the campus' Scope 1 emissions to Scope 2 emissions, emissions associated with purchases of electricity off the grid. This electrification conversion would entail transitioning Storrs' district steam system to a low-temperature hot water network served large-scale geothermal wells and ground-source heat pumps. The conversion would cause onsite electric generation from the CUP to be reduced and eventually eliminated as campus steam demand is reduced, while adding electric demand across campus to power the new district system.

BVH has completed a preliminary analysis of how converting Storrs' district steam system to a low-temperature hot water network with ground-source heat pumps could affect Storrs' electricity usage and grid purchases through 2040. BVH has assumed a three-phased electrification implementation at Storrs, with approximately 15% of Storrs' gross building square footage converted to ground-source heat pumps and low-temperature hot water distribution by 2025, 60% of the gross building square feet converted by 2030, and 100% of gross building square feet converted by 2040.

Figure 2 presents how BVH expects each phase of the electrification conversion would impact UCONN's annual electricity need and sources. BVH estimates the first phase of the conversion ("Phase 1"), which includes 1.7 million gross building square feet in the Southeast, South A, South B, East B, and Spring Hill districts of campus, will keep annual electricity use essentially level on campus. BVH estimates the second phase of the conversion ("Phase 2"), which includes 5.7 million gross building square feet in the West, Northwest, Northeast, Northwood, Spring Manor, and Depot districts, would increase Storrs' annual electricity use by 64,000 MWh, resulting in a 47% increase from current levels. Finally, BVH estimates the final phase of the conversion ("Phase 3"), which includes 4.9 million gross building square feet in the East A, Central North, and Central South districts, would add another 64,000 MWh of annual electricity use, a 95% increase above current levels.

These load additions are assumed to be served almost entirely by grid electricity. In its study, BVH has assumed 6 MW of onsite solar photovoltaic generation will be installed behind-the-meter across Storrs by 2030, which would generate approximately 9,000 MWh per year once completed and be included as a "Non-CUP Source" as shown in Figure 2. However, as highlighted in Figure 2, this potential new onsite solar generation would be dwarfed by Storrs' total electricity needs and Non-CUP electric purchases, requiring the majority of the campus' electric use to be imported from the grid. BVH estimates the CUP's electric generation will remain essentially flat to current levels until Phase 3, where the CUP's generation assets will be decommissioned as the steam system is retired.

Figure 2 Storrs Electricity Needs with Phased Campus Electrification: 2020 – 2040



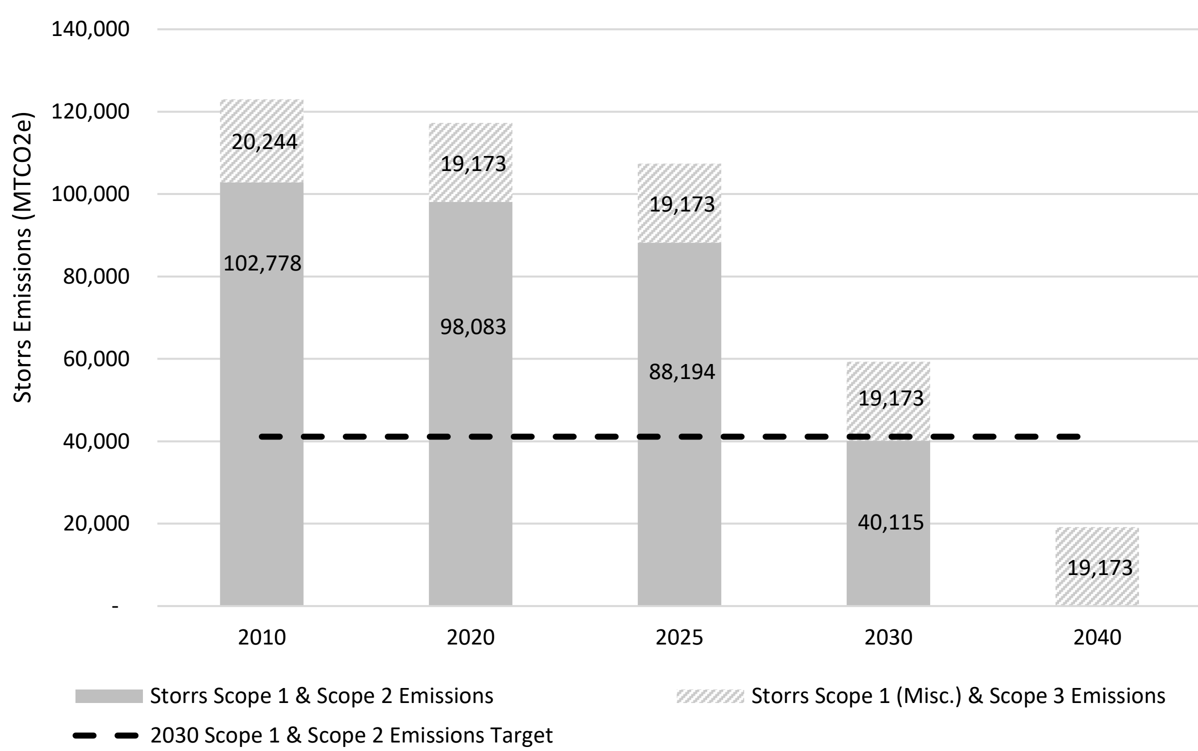
As shown in Table 1, BVH estimates Phase 1 and Phase 2 of the electrification conversion and a portfolio of energy efficiency investments on campus over the next decade could reduce Storrs' emissions in 2030 by approximately 63,000 $MTCO_{2e}$ compared to the 2010 baseline of 102,778 $MTCO_{2e}$, producing a 61% reduction that surpasses the 2030 reduction target of 60%. This outcome assumes UCONN acquires and retires RECs in 2030 and future years equaling 100% of its grid electricity purchases and any onsite solar generation.

Table 1 Estimated Impact of Campus Electrification on Storrs Emissions: 2020 – 2040

Year	Storrs Gas Usage (MMBtu)	Cumulative Emissions Reduction vs. 2010 Baseline (MMBtu)	Cumulative Emissions Reduction vs. 2010 Baseline (%)
2020	1,700,102	4,696	5%
2025 (Phase 1)	1,504,202	14,585	14%
2030 (Phase 2)	743,033	62,664	61%
2040 (Phase 3)	0	102,778	100%

As shown in Figure 3, the 2010 baseline only accounts for Scope 1 and Scope 2 emissions related to fossil fuel use on campus and excludes certain Scope 1 and Scope 3 emissions that total approximately 19,000 $MTCO_{2e}$ and are expected to remain level through 2040. As a result, UCONN is not projected to be able to achieve "zero-carbon" campus operations in 2040 in absolute terms, but rather could elect to purchase carbon offsets for these remaining emissions to claim "carbon neutrality" for the campus' emissions footprint. The following sections discuss UCONN's options to acquire and retire RECs and carbon offsets.

Figure 3 Storrs Greenhouse Gas Emissions: 2020 – 2040



Overview of Carbon Offset Options

Carbon offsets, also referred to as Verified Emissions Reductions ("VERs"), represent a unit of carbon dioxide-equivalent that is reduced, avoided, or sequestered and claimed to mitigate increases in global greenhouse gas emissions by offsetting Scope 1 and/or Scope 3 emissions being generated elsewhere. The concept of carbon offsets is based on the notion that reducing greenhouse gas emissions by financially supporting an offset project has an equivalent global emissions outcome as reducing an entity's own emissions footprint through direct changes in operations and energy consumption.

Entities purchase carbon offsets to be able to claim "carbon neutrality", which implies the purchased offsets' avoided emissions equal the purchaser's own Scope 1 and Scope 3 emissions (plus REC purchases to offset Scope 2 emissions) for a defined period, typically by year. Carbon offset projects span a broad variety of actions that can be taken to avoid or sequester carbon emissions, including landfill gas capture and destruction, organic waste composting, coal methane capture, agricultural methane capture, ozone depleting substance capture, and tree planting, to name but a few examples. For purchasers of carbon offsets an important component in selecting offset projects is the notion of additionality. Additionality means the emissions avoidance or sequestration would not have occurred without the financial support provided by the ability to sell offset claims; all credible third-party verification sources for carbon offsets qualify projects on this basis. Other important traits of carbon offsets are that they are real, verified, enforceable, and permanent.

Various registries and standards have been developed to verify greenhouse gas emissions avoidance or sequestration from carbon offset projects. These registries and standards aim to address purchasers' concerns that the emissions impact claimed for an offset project can be verified and is not being double counted through project claims being sold to multiple purchasers. Depending on an institution's emissions reduction goals and the requirements of a given emissions protocol, it is important to investigate the registries and standards a proposed project meets. Examples of these registries and standards are listed below.
A carbon offset project may seek qualification under multiple standards and/or listing on multiple registries. The number of different standards and registries can create confusion for those looking to develop and implement a strategy for the purchase of carbon offsets. Buyers need to consider many options when considering a carbon offset purchase including geographic location, project type, vintage year, the listing registry and price. In many cases it is appropriate to issue a request for bids, seeking pricing and project details from a wide variety of project sponsors. It is also possible for buyers to invest in projects that are not yet developed, although this can introduce uncertainty in the number and cost of associated credits.

- Clean Development Mechanism (CDM): this international standard was defined in the 2007 Kyoto Protocol to facilitate additional clean development projects in developing countries through the financial support of other nations. CDM host countries are required to confirm that projects contribute to their own national development. The standard requires proof of additionality, as well as third-party verification of baseline emissions and project reductions. Carbon offsets generated under the CDM standard may also be referred to as Certified Emissions Reductions ("CERs").

- Climate Action Reserve (CAR): The program was originally developed as the California Climate Action Registry by the State of California in 2001. CAR now serves as one of the major standards in North America. Each project is verified to ensure that they are real, additional, permanent, and enforceable. The program also lists tertiary goals aimed to ensure registered projects are not harmful socially or economically to the subject community. Carbon offsets generated under the Climate Action Reserve may also be referred to as Climate Reserve Tonnes ("CRTs").

- Verified Carbon Standard (VCS): VCS (also called Verra) is a non-profit NGO, founded in 2005, that now maintains one of the leading global voluntary GHG reduction programs. Projects are classified into categories, which must pass through conservative quality assurance principles defined by VCS in an aim to reduce overstatement concerns expressed by critics. Projects are verified and approved by a validation body to confirm that they are: additional, real, measurable, conservative, and permanent. Carbon offsets generated under the VCS may also be referred to as Verified Carbon Units ("VCUs").

- The Gold Standard: Established in 2003 by the World Wildlife Foundation, the Gold Standard has a focus on mitigation as well as the substantial co-benefits that can be derived from successful implementation. Although the standard focuses on the core carbon offsetting items—additional, real, and verifiable—their advertised differentiator is a defined focus on economic, health, welfare, and environmental impacts on the community hosting the project.

- American Carbon Registry (ACR): ACR was founded in 1996 as the first private voluntary carbon offset program by Winrock International—a non-profit organization. The standard focuses on projects meeting the conditions of additionality, permanence, measurability, and conservatism. Projects are also independently verified.

The cost of carbon offset purchases for Storrs in 2040 will depend on UCONN's criteria for project type, characteristics, and location, and whether the federal government implements a control regime on carbon emissions. On the low end of pricing options, offsets currently cost as little as \$2 to \$5 per $MTCO_{2e}$. Landfill gas capture and destruction and reforestation projects typically fall into this lowest-cost category of offset projects. In contrast, there are a range of offsets options with much higher pricing, ranging between \$20 to \$100 per $MTCO_{2e}$. Like pricing, purchasing terms for carbon offsets vary depending on the project. Certain offset projects require long-term contractual commitments, whereas certain offsets can be purchased on short-term or year-to-year contracts. There are numerous providers of carbon offsets serving the voluntary offset market for colleges and universities, so these factors can be evaluated and compared in a competitive solicitation process that requests a wide range of offset options and projects.

If UCONN elects to pursue carbon neutrality in 2040 and future years, CES recommends using \$10 per $MTCO_{2e}$ (in 2020 dollars) as a preliminary budget estimate for carbon offset purchases for Storrs, which reflects a mid-point price observed in the current voluntary offset market. Based on BVH's estimate of a 2040 offset purchase requirement of up to 20,000 $MTCO_{2e}$ for UCONN to declare carbon neutrality, this budget estimate produces an annual cost of approximately \$300,000 in 2040. As noted above, this cost could change depending on the final project(s) selected by UCONN and future legislation.

Scope 2 Emissions Accounting & REC Purchasing Overview

Our focus for the remainder of the memorandum is on Storrs' Scope 2 emissions, those emissions associated with purchases of electricity off the electric grid. To achieve the carbon mitigation plan's 2030 and 2040 emissions targets UCONN will need to purchase and retire RECs for 100% of Storrs' grid electricity purchases between 2030 and 2040.

A REC is a tradeable certificate that represents the environmental attributes of one MWh of electricity generated by a renewable energy source.[1] One REC is produced for each MWh of renewable electricity generated. Scope 2 emissions are offset one-for-one – that is, a REC must be acquired and retired for each MWh of electricity UCONN purchases. While a REC must be purchased, the actual purchaser does not have to be UCONN, and in fact, a large share of the RECs that will need to be acquired by or on behalf of UCONN over the next twenty years will be acquired by UCONN's retail electricity supplier pursuant to the supplier's obligations under the RPS law and regulations in Connecticut. This law requires that all suppliers serving retail load in Connecticut must meet their supply obligations by purchasing a certain percentage of electricity from renewable energy generators. Retail electricity suppliers do this by purchasing and retiring RECs from renewable generators in exactly the same way that UCONN would do, but for the actions of the supplier. We refer to these RECs as compliance RECs.

Compliance RECs purchased by the supplier pursuant to this RPS obligation are not cheap. We estimate that UCONN is paying roughly $900,000 a year to its supplier to satisfy the RPS associated with electric load at UCONN's seven campuses. This cost does not include the Green-e RECs UCONN currently purchases on a voluntary basis for 100% of its grid purchases, which equate to approximately $110,000 in annual cost. We refer to these RECs as voluntary RECs and discuss these further below. Based on the design of the bulk power grid and regional electricity markets, the voluntary REC currently purchased by UCONN do not count towards UCONN satisfying its RPS compliance obligations because the wind generators from which the RECs are sourced are located outside of the New England power grid.

In 2020, Connecticut's RPS percentage for renewable energy sources is 25%[2]; however, as shown in Figure 4 below, this percentage is scheduled to increase by two percentage points a year until it reaches 44% in 2030 where it will remain level through 2040. A future increase to the RPS obligations for 2030 to 2040 is likely based on recent executive action. In September 2019, Governor Lamont issued Executive Order 3, which

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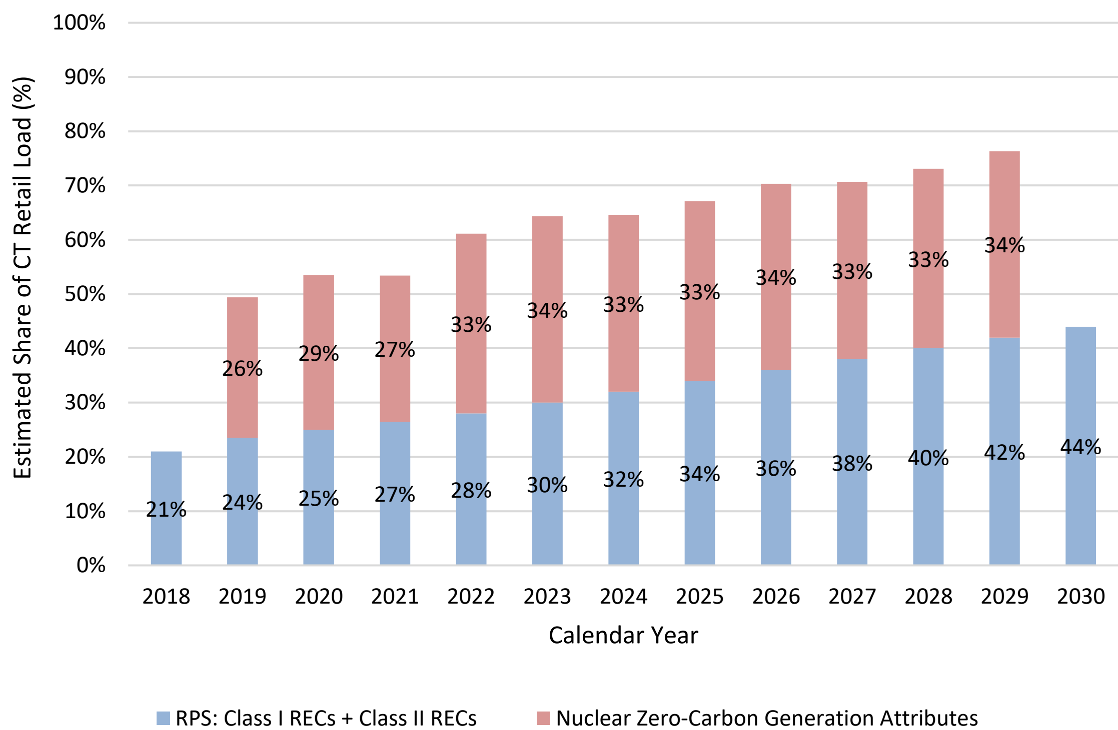
[1] It is important to note that UCONN's purchase of RECs, both for the University's current purchase of Green-e RECs and potential future purchase of RECs from new solar or wind generation projects, provides no physical delivery to UCONN of the electricity generated associated with those RECs. Therefore, REC purchases have no impact on its decisions regarding how UCONN chooses to procure its electricity supply.

[2] While the Connecticut RPS includes three categories of generation sources that may participate in the program – Class I, Class II, and Class III sources – only Class I and Class II sources are defined as renewable energy sources under state law. Class I renewable energy sources include electricity derived from solar power, wind power, fuel cells, geothermal, landfill methane gas, anaerobic digestion or other biogas derived from biological sources, ocean thermal, wave or tidal power, low emission advanced renewable energy conversion technologies, certain run-of-river hydropower facilities, and certain biomass facilities that use fuel cultivated and harvested in a sustainable manner. Class II renewable energy sources include electricity derived from qualified trash-to-energy facilities. Class III sources include electricity output from qualified combined heat and power systems operating at commercial and industrial facilities in the state, certain waste heat recovery systems, and electricity savings from certain conservation and load management measures. The CUP is qualified as a Class III source.

called for state regulators to develop a roadmap to enable Connecticut to transition its electricity mix to 100% zero-carbon sources by 2040. Once this roadmap is developed, CES expects the legislature to review how the RPS may be adjusted for 2030 to 2040 to reflect a higher RPS target than the flat 44% obligation currently in effect.

Figure 4 Connecticut State-Sponsored Zero-Emission Electricity Generation: 2018 – 2030



In addition to presenting the annual RPS obligations for Connecticut through 2030, Figure 4 presents nuclear zero-carbon generation attributes as a share of statewide retail electric load. These generation attributes relate to recent action Connecticut has taken outside of the RPS program to support nuclear power generation in the state's electricity mix. In 2019, the Connecticut Public Utilities Regulatory Authority ("PURA") directed the state's two investor-owned electric utilities, Eversource and United Illuminating, to purchase electricity and environmental attributes generated by Millstone Station and Seabrook Station, New England's two remaining nuclear power plants. The two facilities are the largest zero-emission electricity generation sources in New England, meeting about 25% of the region's total electric load each year and producing more electricity than all in-region wind, solar, and hydro facilities combined.

The purchasing agreements include energy and environmental attributes for approximately 40% of Millstone's total generation from 2019 through 2029 and 15% of Seabrook's generation from 2022 through 2029. As shown in Figure 4, the environmental attributes being purchased with the contracted energy account for a large share of Connecticut's total retail load, on par with the state's total RPS target through the early 2020s. Based on the contracted purchase prices, the agreements will likely produce above-market costs in each contract year through 2029 that Eversource and United Illuminating will need to recover from Connecticut ratepayers through electric delivery charges. For fiscal year 2021, CES estimates these above-market costs to UCONN across the six campuses served by Eversource will total $700,000, nearly as much as the $900,000 UCONN is expected to pay its electricity supplier for RPS compliance.

If UCONN includes the environmental attributes of the state's out-of-market nuclear purchasing agreements into its REC procurement strategy, the volume of supplemental RECs that UCONN needs to purchase to fully offset its Scope 2 emissions decreases substantially through 2029. However, the two agreements expire on December 31, 2029, so if UCONN wants to fully offset its Scope 2 emissions in 2030 to count towards a 60% emissions reduction goal in that year its supplemental REC volume would not be affected by either agreement as currently structured.

Because the RPS percentage will be less than 100% in 2030, UCONN must act directly to purchase and retire RECs for that portion of its electricity grid purchases not covered by the actions of its supplier if UCONN wants to offset 100% of Storrs' Scope 2 emissions between 2030 and 2040. The fact that the RPS associated with UCONN electricity purchases of grid delivered electricity is met by the supplier through its purchase and retirement of RECs does not disassociate the actions from UCONN campus electricity use and its Scope 2 emissions. The REC purchases made by the supplier are made on behalf of UCONN and provide the same degree of Scope 2 emissions offset as would be the case if UCONN acted as its own retail supplier and made the compliance REC purchases and retirements itself.[3]

Figure 5 presents the estimated supplemental RECs UCONN will need to acquire and retire for Storrs in 2030 and 2040, roughly 44,000 and 148,000 respectively, based on BVH's analysis of Storrs' phased campus electrification. As previously discussed, BVH estimates campus electrification could increase Storrs' total annual electricity needs from roughly 135,000 MWh in 2020 to 199,000 MWh in 2030 and 263,000 MWh in 2040. Compared to Storrs' current annual grid purchases of approximately 12,000 MWh, which includes 10,000 MWh to serve the CUP account and roughly 2,000 MWh to serve roughly 150 distributed buildings not connected to the CUP, BVH estimates annual grid electricity purchases could increase from current levels by up to 64,000 MWh in 2030 following Phase 1 and Phase 2 of the conversion and by up to 128,000 MWh in 2040 following Phase 3 of the conversion. These estimates will be reduced to the extent UCONN installs onsite solar generation at Storrs. Based on the RPS compliance obligation of 44% for 2030 through 2040, we have estimated supplemental REC requirements as 56% of BVH's estimated 2030 and 2040 Storrs electricity use not served by the CUP, resulting in the estimated supplemental REC requirement of roughly 45,000 in 2030 and 147,000 in 2040.

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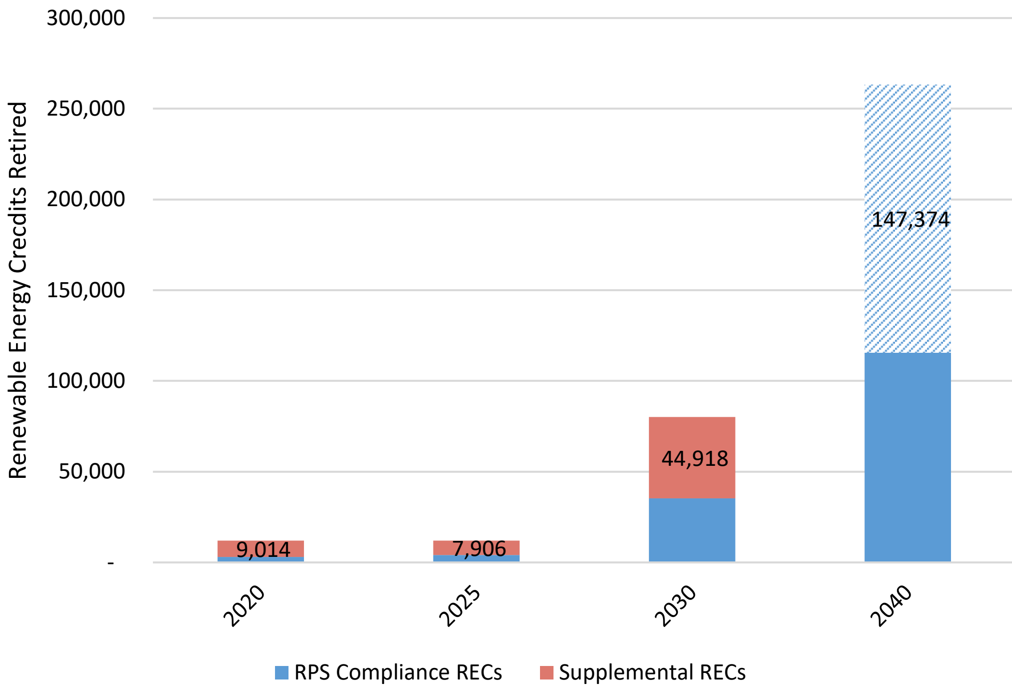
[3] We note that they also provide the same degree of emissions offset as would be the case where UCONN retires RECs from a renewable energy project it owns that is located behind the UCONN meter. Any distinction drawn between these three cases – (a) non-compliance RECs from renewable generation located behind the UCONN meter, (b) compliance RECs purchased by UCONN acting as its own retail electricity supplier and (c) compliance RECs purchased by UCONN's retail electricity supplier are artificial. They are not based on differences in emission consequences of the three cases, because there are no differences.

Buying supplemental RECs for only the volume of grid electricity that is not otherwise covered by RECs provided by third party suppliers due to their RPS obligations requires certain GHG inventory methodologies. Taking emissions credit for the quantity of compliance RECs being purchased by third-party retail electricity suppliers requires the so-called "residual mix" for electricity purchases that are not offset with supplemental RECs. To the extent that compliance RECs provided by third party suppliers under their RPS obligations are already reflected in regional emissions rates, using average grid emissions factors could lead to a double counting. As UCONN approaches the point at which 100% of its Scope 2 emissions are offset by compliance and supplemental RECs, this distinction gets less important.

Figure 5 Estimated REC Purchasing Requirements to Offset Storrs Scope 2 Emissions



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Based on current annual capacity factors of utility-scale solar and wind generators in New England, an annual purchase of 44,918 RECs could be met by 25 MW of ground-mounted solar, 12.5 MW of onshore wind generation, or 10 MW of offshore wind generation. An annual purchase of 147,374 RECs could be met by a 84 MW of ground-mounted solar, 42 MW of onshore wind generation, or 34 MW of offshore wind generation. These generation sizes change if RECs are purchased from out-of-region generators, with Midwest and Southwest wind and onshore solar able to realize higher capacity factors than generation facilities in New England.

The difference between supplemental REC requirements in Figure 5 is striking. If Phase 3 is implemented and the CUP is decommissioned, UCONN may need to purchase over 100,000 more RECs in 2040 compared to 2030 levels to maintain full offsets of Storrs' Scope 2 emissions. That being said, Governor Lamont has called for state regulators to develop a roadmap to enable Connecticut to transition its electricity mix to 100% zero-carbon sources by 2040. One other state, New York, currently has an RPS in effect mandating 100% zero-emissions electricity generation by 2040.[4] If Connecticut revises its RPS to 100% by 2040, UCONN's supplemental REC purchasing would be eliminated, represented by the blue shaded bar in 2040 in Figure 5, since suppliers would need to purchase RECs for 100% of UCONN's load. However, we caution against assuming this will be the default case. If end users throughout Connecticut electrify building heating and cooling systems and the state's transportation fleet to achieve deep cuts in Scope 1 emissions, as UCONN is contemplating in the carbon mitigation plan, the state's power grid and renewable generation fleet will need an unprecedented overhaul and expansion. This transition may be achieved but requires an unprecedented infrastructure buildout of the existing power grid and would likely take decades to complete.

[4] The New York Legislature passed the Climate Leadership and Community Protection Act ("CLCPA") in June 2019.

Options for Purchasing and Retiring RECs

The first option for UCONN to acquire RECs is from renewable generation located on campus. This type of renewable generation meets two important criteria – additionality and geographic proximity. To the extent that UCONN elects to install behind-the-meter solar on campus in the coming years, which could include ground-mounted solar, rooftop solar and/or solar parking canopies that deliver electricity directly to the campus electrical system, UCONN can choose whether to retain the associated RECs and retire them as offsets to its Scope 2 emissions.

The challenge with this option is that the actual or implied costs of these RECs are quite high today. Installation costs for behind-the-meter solar are higher than installation costs for utility-scale ground-mounted solar that can be developed remotely from UCONN's campuses due to higher relative soft costs, module costs, and interconnection costs. While behind-the-meter solar can help UCONN avoid certain retail electricity charges that utility-scale solar interconnected remotely cannot monetize, UCONN's grid electricity rate design limits the value of behind-the-meter solar by assessing demand-based charges that cannot be reliability reduced by intermittent solar generation.

The second option is for UCONN to purchase and retire RECs from existing renewable generators located off campus. UCONN currently uses this option, purchasing RECs from large-scale wind projects located outside of New England for 100% of grid purchases at six of the seven campuses. Alternatively, UCONN could purchase RECs from existing large-scale or smaller, community-scale wind, solar, or hydro projects located in New England. As with the first option, UCONN can claim offsets to its Scope 2 emissions by purchasing and retiring RECs from any of these generation facilities. This option offers very low costs but sacrifices additionality and may sacrifice geographic proximity. We refer to this option as the Green-e option.

The third option is for UCONN to execute a long-term virtual power purchase agreement ("VPPA") with a project developer to construct a new renewable generator located off campus in Connecticut or out of state.[5] There are several examples of UCONN's peers executing VPPAs in recent years, including the Massachusetts Institute of Technology executing a VPPA with a new utility-scale solar project in North Carolina and various colleges in New England executing a VPPA with a new utility-scale solar project in Maine.[6] This option provides additionality and perhaps geographic proximity but is likely to cost significantly more.

UCONN's peers that have taken this approach have elected to contract with a private developer to finance, own, operate, and maintain the generator. Under this approach the developer acquires the land where the generator is sited, provides funding for the project, and is responsible for all aspects of system development and operations. This contracting structure enables a public offtaker like UCONN to realize lower purchase pricing due to federal tax credits for solar and wind generation that are only available to project owners with tax liability. Furthermore, if the offtaker does not dictate where the generator needs to be sited, i.e. on property owned by the offtaker, developers can site generators where energy production (and economies of scale in development) can be maximized and interconnection costs can be minimized.

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[5] This contract could be structured in two ways: for physical delivery of contracted energy and RECs to UCONN if the generator is located in New England or as a virtual settlement whereby UCONN only acquires RECs from the project. A virtual settlement can be done regardless of whether the generator is located in New England or outside the region.

[6] More information on Amherst, Hampshire, and Smith Colleges' VPPA can be found at https://www.competitive-energy.com/news/2019/10/24/five-leading-liberal-arts-college-partner-to-create-new-solar-energy-facility-in-maine.

Green-e RECs

A common way colleges and universities acquire and retire RECs to claim offsets in their Scope 2 emissions is by purchasing RECs from existing generators in voluntary markets. Voluntary markets refer to REC sales where an end user acquires and retires RECs on a voluntary basis; that is, the purchase and the retirement of those RECs does not help an end user satisfy compliance obligations under a state renewable portfolio standard, regional greenhouse gas trading program, or other mandated program.

There are numerous sellers and marketers of RECs serving the voluntary market. UCONN can conduct a competitive solicitation process to select a provider of such RECs. If UCONN were to conduct a solicitation for RECs, the campus would need to decide which certification and verification program to utilize for contracted RECs. There are several different programs that REC sellers and buyers operating in the voluntary REC market can use to certify and verify that purchased RECs are credibly sourced from renewable generation and are not being counted towards other institutions' emissions inventories. CES recommends acquiring only "Green-e" RECs.

Green-e Energy is the leading independent certification and verification program for voluntary REC purchasing in the U.S. The Green-e certification program is administered by the Center for Resource Solutions, a nonprofit organization based in San Francisco, California. To be certified as offering a Green-e product a REC seller is required to disclose the quantity, type and geographic source of each REC certified. There are four primary criteria for Green-e certification. First, electricity must come from eligible generation sources, which include wind, solar, geothermal, and certain biomass and low-impact hydropower plants. Second, only renewable generators built within the last 15 years of a sale date are certified under the Green-e label. For Green-e RECs sold in 2020 eligible generators had to have begun operations or been repowered after 2006. Third, Green-e RECs cannot be used by a party to satisfy a state-mandated renewable energy program. Lastly, Green-e RECs sold in a given calendar year must be generated within the 12 months of that calendar year, the six months before the calendar year began, or the three months after the calendar year has ended. This creates a 21-month window of eligible generation dates from which renewable energy generation can be used toward Green-e certified sales in any given year.

The most attractive aspects of Green-e RECs are their low cost and short contract terms. The current price of Green-e RECs is approximately $1 per MWh, inclusive of transaction fees. As discussed elsewhere, the price is a fraction of the cost CES estimates UCONN will pay its electricity supplier for 2020 compliance with Connecticut' mandated renewable energy programs, or of the potential cost UCONN may pay for RECs from new in-region wind or solar generators today. Further, UCONN would not have to commit to 10- to 20-year contract terms like it would for a new renewable generator through a VPPA. Unbundled RECs can be purchased through one-time transactions in the spot market or through short term contracts running between one and five years, providing buyers flexibility to modify contracted volumes or purchasing strategies over time.

While purchasing RECs from existing generators provides a low cost, flexible means for UCONN to claim Scope 2 emissions offsets, this approach is increasingly being viewed critically by students, communities, and policymakers. Criticism is based in the contention that many existing renewable generators that produce Green-e RECs would likely be operating without the REC sales revenue, and therefore the purchase of RECs

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does not have an incremental impact in reducing global emissions from electricity generation – that is, the project lack additionality.[7]

CES believes that Green-e RECs can provide a useful tool to meet some of UCONN's REC purchase and retirement requirements if the campus has budgetary restrictions in the coming years, or if the campus is uncertain on the final timeline of potential infrastructure changes on campus coming out of the carbon mitigation plan. While purchasing trends around the country clearly show a preference among higher education institutions to shift away from Green-e RECs from existing generators and to more highly favor projects that provide additionality, CES is finding that most institutions with carbon reduction objectives are continuing to utilize this tool, for at least a portion of their Scope 2 related emissions offsets, and are likely to do so for some time to come.

Virtual Power Purchase Agreements

A contract for differences ("CFD"), or virtual power purchase agreement ("VPPA") as it is known in the electric generation industry, is a contract that fixes the future price of a commodity or other good or service. CFDs are widely used in the U.S. economy for long-term business arrangements. Among the more common uses of CFDs are in finance, where a CFD is referred to as an interest rate fixed for floating swap, and in transactions involving foreign currencies.

This same concept works for long-term electricity contracts. A VPPA allows UCONN to enter into a long-term contract with a new, large-scale wind or solar generator located remotely from UCONN's campus. The generator could be located in Connecticut, in other New England states, or outside the region. For project developers a VPPA with a credit-worthy counterparty like UCONN provides a financeable contract to construct a generation project. For UCONN, a VPPA provides a means to leverage the pricing advantages of large-scale offsite renewable energy development and to demonstrate additionality in its REC purchases. Importantly, a VPPA does not require physical delivery of energy generated by the project, so UCONN would have the option to continue purchasing electricity supply for use on campus from the competitive market or from the local utility's default service.[8]

Under a VPPA, UCONN would agree to pay a fixed price to the generator for electric energy and RECs generated at its facility. Let's say that price for energy and RECs is fixed at $50 per MWh for a term of 20 years. For every MWh of electricity that the generator produces and delivers to the grid UCONN, would pay the generator $50. That same output would then be sold by the generator into the local spot market at a variable wholesale price. The generator would pay UCONN the variable price corresponding to the period in which the MWh is delivered to the grid. If the variable market price for a MWh is $40 at the time the generation was delivered to the grid, the net cost to UCONN would be $10. If the variable price for a MWh is $60, its net cost would be minus $10, and UCONN would receive $10 in payment from the generator.

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[7] A related argument among critics of unbundled Green-e RECs is that investment in new wind generation, the largest source of unbundled Green-e RECs in the country, has been largely driven by federal incentives for renewable energy and not by project owners' expectations of REC revenue as a primary value stream. This, however, is not as significant a source of criticism as the additionality issue.

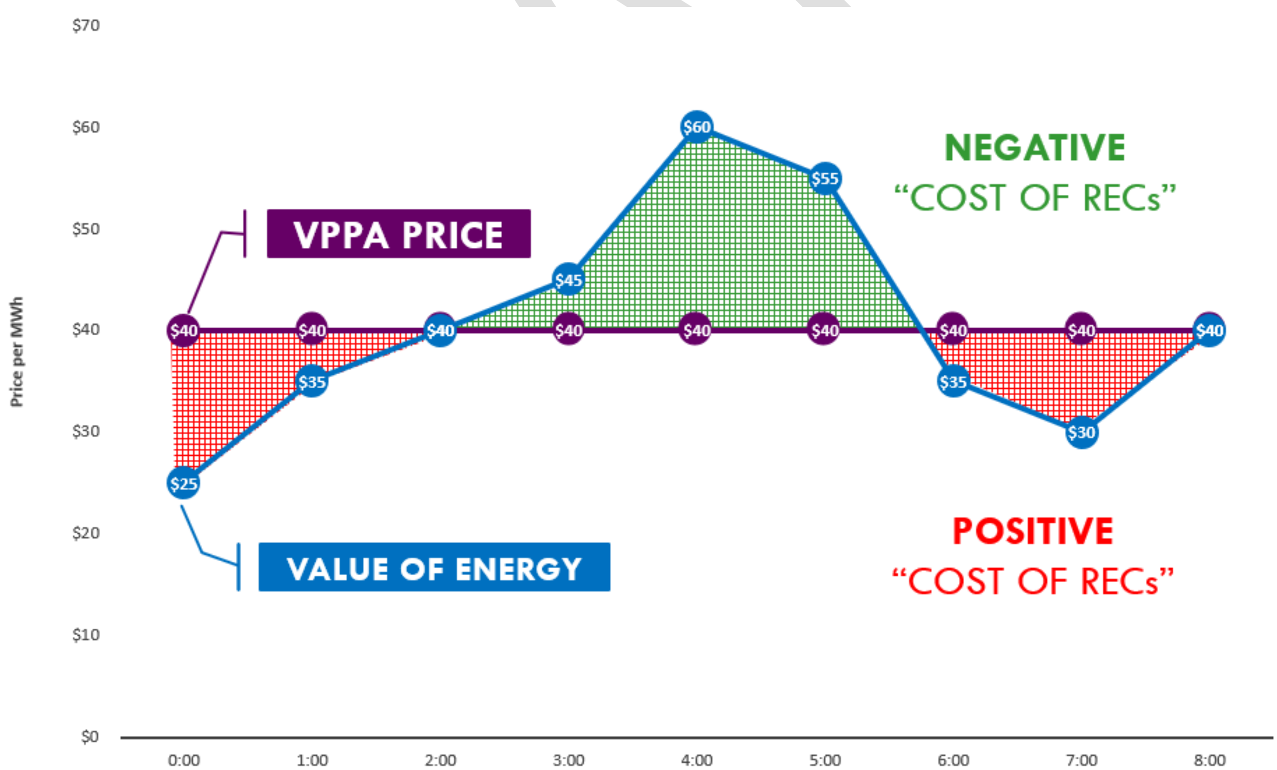
[8] While there is never "physical" delivery under a VPPA in the common-sense notion of the term, geographic proximity between the generator and UCONN contracted using a virtual settlement can convey similar benefits as a physical contract for delivery of energy and RECs in certain cases.

This hourly settlement process is shown below in Table 2 and illustrated in Figure 6. At the end of each month, UCONN would receive an hourly reconciliation of generation and corresponding variable market prices from the generator and either a payment or an invoice. This net settlement value is referred to as the "implied REC cost". If the net settlement requires UCONN to make a payment to the generator, the implied REC cost is a positive value. If the net settlement amount is negative and UCONN receives a payment from the generator, the implied REC cost is negative.

Table 2 Hourly VPPA Settlement Process - Example

Hour Ending 1	
$50 per MWh	Fixed price UCONN guarantees generator
-$40 per MWh	Energy price generator receives from local spot market
$10 per MWh	Implied REC cost (positive value indicates UCONN owes generator)
Hour Ending 2	
$50 per MWh	Fixed price UCONN guarantees generator
-$60 per MWh	Energy price generator receives from local spot market
-$10 per MWh	Implied REC cost (negative value indicates generator owes UCONN)

Figure 6 VPPA Hourly Settlement Example



Indicative VPPA Pricing & Implied REC Costs

Table 3 presents a range of indicative prices for different renewable generator project types based on recent competitive VPPA solicitations CES has administered for other colleges, universities, and private companies. The indicative prices shown are fixed for contract terms between 10 and 20 years, depending on the project location, and are for electric energy (to be sold and netted as described above) and RECs. These RFPs have requested project pricing for new renewable generators throughout New England and across other U.S. regions. Responses have included wind projects throughout the Midwest, Texas, the Mid-Atlantic, and Maine and solar projects throughout the Southwest, Texas, the Mid-Atlantic, and New England. CES can provide indicative pricing for other states or regions as requested by UCONN.

Table 3 Indicative VPPA Pricing Range by Generation Type and Project Location

Generation Type	Low End ($ per MWh)	High End ($ per MWh)	Mid-Point ($ per MWh)
Connecticut Utility-Scale Solar	$50	$60	$55
Maine Onshore Wind	$65	$75	$70
Nebraska Wind	$15	$25	$20
Texas Solar	$20	$30	$25

It should be emphasized these indicative prices are indicative only. The timing of a competitive solicitation issued by UCONN will ultimately dictate project pricing received. Over the next decade there are several factors that could raise or lower pricing from new renewable generation. Key federal incentives for wind and solar systems are set to phase down in the coming years. All other things being equal, we would expect the phasing out of these tax advantages to raise pricing for new projects. On the other hand, the wind and solar industries are projecting continued cost declines that could help counteract declining external incentives and could produce lower project pricing for VPPAs executed later this decade.

To take advantage of new technologies and falling unit costs for wind and solar and to allow flexibility to respond to changing conditions in U.S. electricity markets and policy over time, CES recommends organizing long-term REC purchases into tranches that are implemented in phases. Based on the timeline being considered in the carbon mitigation plan, UCONN could consider soliciting long-term REC proposals in multiple tranches over the next 10 years. Because new renewable generation projects often require 2-3 year lead times to come on-line, RECs would not become available until the mid-2020s under a solicitation started today. Because VPPAs have contract terms between 10 and 20 years, the resulting contracts would expire before 2040. UCONN would need to complete a follow up solicitation to acquire additional RECs to meet the campus' emissions goals for 2040 and future years.

Comparing the mid-point indicative prices for each generation type and location – $55 per MWh for New England solar, $70 per MWh for Maine wind, $20 per MWh for Nebraska wind, and $25 per MWh for Texas solar – with the value of energy in those respective markets, there are clear pricing advantages for out-of-region renewables. The better economies of scale and production factors for wind generation in the Midwest and solar generation in Texas or the Southwest generally produce lower pricing for RECs that offer additionality than from new solar or onshore wind facilities in New England. In recent RFPs CES has seen the implied REC prices for out-of-region wind and solar between 40% and 70% lower than implied REC pricing for projects located in New England.

To estimate the REC costs for UCONN, CES has applied the mid-point indicative prices in Table 3 against local spot market prices in a project's corresponding location. This calculated value of energy, presented in Table 4, represents the average value a renewable generator would have achieved in 2017, 2018, and 2019 based on the expected hourly generation profile of each generator. New England's higher wholesale electricity costs are driven by constrained natural gas pipeline capacity into the region that increases the cost of the marginal fuel (gas) used in the ISO New England generation fleet for most hours of the year.

Table 4 Value of Energy by Generation Type and Project Location: 2017 – 2019

Generation Type	2017 ($ per MWh)	2018 ($ per MWh)	2019 ($ per MWh)	3-Year Average ($ per MWh)
Connecticut Utility-Scale Solar	$32.54	$42.01	$29.88	$34.81
Maine Onshore Wind	$33.26	$44.64	$32.63	$36.84
Nebraska Wind	$22.09	$21.88	$24.04	$22.67
Texas Solar	$26.70	$35.03	$25.26	$29.00

Table 5 completes the implied REC cost calculation by subtracting the three-year value of energy in each project location from the corresponding indicative mid-point purchase price. Table 5 assumes an annual purchase of 45,000 RECs (generated offsite) per year by UCONN based on the estimated 2030 supplemental REC requirement discussed previously. As noted above, the implied REC costs for projects in the Midwest and the Southwest are lower than for those in New England. In fact, over the past three years, Nebraska wind and Texas solar would have had negative implied REC cost, meaning the offtaker would have received a net payment over the three years instead of paying for the RECs assuming the prices shown.[9]

Table 5 Implied REC Cost Estimates: Annual Purchase of 45,000 RECs through a VPPA

Generation Type	Mid-Point Price ($ per MWh)	Value of Energy ($ per MWh)	Implied REC Cost ($)	Annual Cost ($)
Connecticut Utility-Scale Solar	$55.00	$34.81	$20.19	$908,550
Maine Onshore Wind	$70.00	$36.84	$33.16	$1,492,200
Nebraska Wind	$20.00	$22.67	($2.67)	($120,150)
Texas Solar	$25.00	$29.00	($4.00)	($180,000)

While reviewing local wholesale prices retrospectively is a helpful tool to measure potential financial performance of a VPPA, the annual cost of RECs purchased through a VPPA will vary year to year depending on future conditions in the electricity market(s) where contracted project(s) are located and interconnected. First, with natural gas serving as the marginal generation fuel in markets around the U.S., the future price of gas and the efficiency of marginal generators will be a key factor in determining future spot electricity prices. Trends in both factors indicate continued downward pressure on market clearing prices for electricity. Second, the penetration of renewable generation in a project's area and local transmission access are key, because wind and solar generation suppress spot pricing especially where congestion arises due to limited transmission capacity to move renewably generated electricity to major metropolitan load centers. In

[9] We would not expect negative prices to continue. These implied negative REC prices will attract more renewable energy project development, which will tend to reduce market clearing prices.

those areas that are seeing large increases in renewable generation development, spot energy prices tend to be lower. CES reviews these factors, among others, as part of its cost analysis and risk evaluation for all REC RFPs it issues.

Conclusion

The increasing percentage obligations under the Connecticut RPS through 2030 means that an increasing percentage of the costs UCONN incurs to offset 100% of its Scope 2 emissions will be included in the price it pays its retail electricity supplier for grid purchases. To the extent Governor Lamont's Executive Order 3 leads to legislative changes in the coming years to increase Connecticut's RPS compliance obligations for 2030 through 2040 above the current mandate of 44% of annual load, UCONN will need to purchase a smaller volume of supplemental RECs starting in 2030 to fully offset Storrs' Scope 2 emissions through 2040.

Due to the scale of REC requirements and renewable generation sizing needed if UCONN pursues campus electrification at Storrs, UCONN will need to purchase RECs from offsite renewable generators. Due to the economies of scale and siting advantages of utility-scale renewable energy development, CES projects purchasing RECs from offsite generators will provide UCONN the most cost effective option to acquire and retire RECs to meet the carbon mitigation plan's 2030 and 2040 goals. This is not to say that UCONN should avoid installing behind-the-meter solar; CES recommends UCONN evaluates rooftop hosting capacity on campus and designs new building rooftops or renovations to be "solar-ready". However, under this approach onsite solar is used on a targeted basis to reduce onsite electric demand at the building level where system installation costs can be optimized and limited, rather than pursuing large-scale behind-the-meter solar deployment for the sake of maximizing REC production.

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Based on BVH's analysis of Storrs' phased campus electrification, UCONN can expect to need to acquire and retire a total of approximately 45,000 RECs in 2030, increasing to 147,000 RECs by 2040 to offset 100% of Storrs' Scope 2 emissions. Figure 7 presents a range of costs UCONN could expect to pay in the coming years at these REC volumes for illustrative purposes, assuming UCONN purchases all RECs from off campus sources. At the low end, the costs for 45,000 RECs are in the $45,000 (per year) range for 100% Green-e RECs *without additionality and without geographic proximity*. At the high end, the costs are in the $1.8 million (per year) range for RECs from new in-region offshore wind projects under 20-year PPAs.

Figure 7 Offsite REC Options and Indicative Costs

REC Option	Price $/REC	45,000	Quantity of RECs →	147,000
Green-e Certified	$1.00	$45,000	Increasing Cost	$147,000
Midwest Wind	$3.00	$135,000		$441,000
Southwest Solar	$5.00	$225,000		$735,000
N.E. Solar	$25.00	$1,125,000		$3,675,000
N.E. Offshore Wind	$40.00	$1,800,000		$5,880,000

The higher purchase volume of 147,000 RECs is shown in Figure 7 for reference only. The cost range at this volume does not represent what UCONN can expect to pay for supplemental RECs in 2040, as the installed cost of renewable generation and market value of energy will change over the next 20 years. Since this volume requirement is contingent on Phase 3 of the electrification conversion being implemented and may change based on future changes to Connecticut's RPS, CES recommends this volume requirement is revisited by UCONN once Phase 3 of the electrification conversion is approved for implementation.

The wide range of potential REC purchasing costs begs the question of how UCONN should reflect its various REC purchasing options in the carbon mitigation plan's cost analysis. CES recommends UCONN defines three REC purchasing strategies, presented below as 100% Green-e RECs, 100% Additionality, and Mixed Purchases, into the plan's cost analysis to demonstrate the expected low end and high end costs of potential REC purchases.

1. <u>100% Unbundled RECs</u>. UCONN prioritizes low-cost REC acquisition and purchases 100% Green-e national certified RECs through spot-market purchases and under short-term contracts.

2. <u>100% Additionality</u>. UCONN prioritizes additionality in its REC acquisition and purchases only RECs from new renewable generator projects. This may include multiple generation technologies and a mix of purchases from in-region and out-of-region generators.

3. <u>Mixed Purchases</u>. UCONN purchases a mix of Green-e national unbundled RECs and RECs from new generators that offer additionality. This approach aims to balance cost and additionality objectives and could potentially be achieved by purchasing RECs in lower-volume tranches and/or through REC arbitrage (i.e., selling a portion or all in-region RECs into local compliance markets depending on annual budget targets and outcomes). Under this approach UCONN may choose to purchase a portion of its REC requirement from new in-region or out-of-region generators under long-term agreements and to purchase Green-e RECs in the spot market.

CES recommends all three strategies be identified and included in the carbon mitigation plan as potential means for UCONN to purchase and retire the quantity of RECs required to meet its targeted Scope 2 emissions offsets by 2030 and beyond. CES recommends any formal solicitation for RECs be structured to reflect the four considerations noted below.

- <u>Procurement Timeline</u>. Because new renewable generators can take several years to be financed, permitted, and constructed, any REC solicitation process needs to consider development lead-times when developing a target timeline for purchases. To take advantage of falling costs of wind and solar generation and to allow flexibility to respond to changing conditions in U.S. electricity markets and policies, CES recommends organizing REC purchases into tranches that are implemented over time.

- <u>Volume Targets.</u> To determine the volume of RECs to solicit in each purchasing tranche UCONN will need to determine whether it will be issuing a solicitation for Storrs' REC requirements or if all UCONN campuses' REC needs will be included in the procurement. UCONN's purchasing power for all seven campuses may help improve project pricing being offered by developers and may allow for greater flexibility in establishing purchasing tranches. To address uncertainty in future campus electricity usage, UCONN could utilize short-term Green-e REC purchases to fill REC shortfalls.

- Project Characteristics. An RFP can be crafted to solicit proposals for a variety of renewable generation technologies, including in-region and out-of-region (geographic proximity) purchasing options and existing or new (additionality) generators. By allowing a mix of proposal submissions, UCONN can evaluate the full range of project options and pricing available.

- Electricity Supply Procurement. UCONN should structure all REC purchasing options presented in this memo as an overlay to its existing retail electric supply purchasing. By doing so, the REC acquisition process will have no impact on energy procurement.

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BVH integrated services

APPENDIX F

Existing Storrs Campus Buildings Matrix

APPENDIX F - EXISTING STORRS CAMPUS BUILDINGS MATRIX

Building Number	Building Description	District	Building Address	Gross Building Area (ft2)	Status	Building Type (B)	Year Built
0304A	Baseball Pressbox	West	515 Jim Calhoun Road	1,220.00	In Service	Athletics & Recreation	
0304B	Baseball Dugout 1st Base	West	515 Jim Calhoun Road	1,322.00	In Service	Athletics & Recreation	
0304C	Baseball Dugout 3rd Base	West	515 Jim Calhoun Road	1322	In Service	Athletics & Recreation	
0305	Athletic Performance Center	West	507A Jim Calhoun Road	52351	In Service	Athletics & Recreation	
0306A	Soccer Stadium Ticket Booth A	West	507 Jim Calhoun Road	140.00	In Service	Athletics & Recreation	
0306B	Soccer Stadium Ticket Booth B	West	507 Jim Calhoun Road	935.07	In Service	Athletics & Recreation	
	Soccer Storage	West		704.00	In Service	Athletics & Recreation	
0307A	Softball Pressbox	West	508 Jim Calhoun Road	1,220.00	In Service	Athletics & Recreation	
0307B	Softball Dugout 1st Base	West	508 Jim Calhoun Road	980.00	In Service	Athletics & Recreation	
0307C	Softball Dugout 3rd Base	West	508 Jim Calhoun Road	980.00	In Service	Athletics & Recreation	
0307D	Softball Public Restroom	West	508 Jim Calhoun Road	191.38	In Service	Athletics & Recreation	
0307E	Softball Storage Building	West	508 Jim Calhoun Road	2,488.00	In Service	Athletics & Recreation	
1125	Longley School - Depot	Depot	270 Middle Turnpike	92,635.76	In Service	Academic	1952
2101	DEPOT- ASHFORD COTTAGE	Depot	9 BOURN PLACE	2,566.02	IN SERVICE	Academic	
2105	DEPOT- BOLTON CTTG (PUPPET ART)	Depot	8 BOURN PLACE	2,566.04	IN SERVICE	Academic	
2106	DEPOT- BROWN BUILDING	Depot	9 WALTERS AVENUE	25,203.00	IN SERVICE	Administrative	
2107	DEPOT- DEPOT D CT ADV. PAVEMENT LAB	Depot	71 ROMANO ROAD	20,444.00	IN SERVICE	Academic	
2108	DEPOT- CHAPLIN COTTAGE	Depot	69 AHERN LANE	11,420.88	IN SERVICE	Administrative	
2110	DEPOT- COLCHESTER COTTAGE	Depot	79 AHERN LANE	10,950.33	IN SERVICE	Academic	
2111	DEPOT- COLUMBIA COTTAGE	Depot	5 SHERMAN PLACE	3,520.26	IN SERVICE	Administrative	
2112	DEPOT- COVENTRY COTTAGE	Depot	11 SHERMAN PLACE	3,520.26	IN SERVICE	Academic	
2114	DEPOT- ELLINGTON COTTAGE	Depot	14 SHERMAN PLACE	3,519.74	IN SERVICE	Student Services	
2121	DEPOT- TRI-COUNTY GREENHOUSE	Depot	290 MIDDLE TURNPIKE	2,693.00	In Service	Academic	
2124	DEPOT- HAMPTON COTTAGE	Depot	105 AHERN LANE	11,208.00	IN SERVICE	Science	
2125	DEPOT- HEBRON COTTAGE	Depot	12 WITRYOL PLACE	3,601.85	IN SERVICE	Support/Utility	
2131	DEPOT- KENNEDY COTTAGE (DPES)	Depot	47 WEAVER ROAD	6,611.00	IN SERVICE	Administrative	
2134	DEPOT- SURPLUS OPERATIONS (LAUNDRY)	Depot	6 AHERN LANE	21,135.42	IN SERVICE	Support/Utility	
2135	DEPOT- LEBANON COTTAGE	Depot	95 AHERN LANE	10,864.20	IN SERVICE	Academic	
2138	DEPOT- MANSFIELD COTTAGE	Depot	2 BOURN PLACE	3,519.74	IN SERVICE	Academic	
2141	DEPOT- MERRITT HALL	Depot	54 AHERN LANE	34,255.94	IN SERVICE	Support/Utility	
2142	DEPOT- NORLING BUILDING	Depot	79 ROMANO ROAD	5,665.50	IN SERVICE	Support/Utility	
2160	DEPOT- STAFFORD COTTAGE	Depot	1 BOURN PLACE	3,520.26	IN SERVICE	Academic	
2163	DEPOT - DEPORT C DRL MAINTENANCE BLDG	Depot	17 ROMANO ROAD	27,191.00	IN SERVICE	Support/Utility	
2166	DEPOT- THOMSON HALL	Depot	30 AHERN ROAD	33,823.30	IN SERVICE	Academic	
2167	DEPOT- TOLLAND COTTAGE	Depot	3 WITRYOL PLACE	3,606.47	IN SERVICE	Administrative	
2169	DEPOT- UNION COTTAGE	Depot	6 SHERMAN PLACE	2,566.00	IN SERVICE	Science	
2170	DEPOT- VERNON COTTAGE	Depot	11 WITRYOL PLACE	5,494.86	IN SERVICE	Administrative	
2174	DEPOT- WILLIMANTIC COTTAGE	Depot	6 BOURN PLACE	3,520.26	IN SERVICE	Academic	
2175	DEPOT- WILLINGTON COTTAGE	Depot	6 WITRYOL PLACE	3,520.26	IN SERVICE	Academic	
2177	DEPOT- WINDHAM COTTAGE	Depot	10 WITRYOL PLACE	2,698.33	IN SERVICE	Support/Utility	
2179	DEPOT- ATHLETIC FIELD TOILETS	Depot	WEAVER ROAD	381.00	IN SERVICE	Athletics & Recreation	
2180	DEPOT- ATHLETIC FIELD TOILETS	Depot	WEAVER ROAD	407.00	IN SERVICE	Athletics & Recreation	
2198	DEPOT- FUEL CELL INSTITUTE BUILDING	Depot	44 WEAVER ROAD	16,512.00	IN SERVICE	Science	
2199	DEPOT- SWG STA, PLAINS ROAD	Depot	30 PLAINS ROAD	472.50	IN SERVICE	Support/Utility	
2200	DEPOT- SWG STA, BIRCH ROAD	Depot	196 BIRCH ROAD	472.50	IN SERVICE	Support/Utility	
2201	DEPOT- PLANT SCIENCE GREENHOUSE	Depot	AHERN LANE	2,405.00	IN SERVICE	Science	
0069	Holcomb Hall	East A	1346 Storrs Road	53,015.00	In Service	Residence	1922
0127	Whitney Hall & Cafeteria	East A	1346 Storrs Road	39,724.85	In Service	Residence	1939
0139	Sprague Hall	East A	1346 Storrs Road	43,049.00	In Service	Residence	1942
0175	Young Building	East A	1376 Storrs Road	80,390.17	In Service	Academic	1953
0176	Hicks Hall	East A	1346 Storrs Road	16,964.00	In Service	Academic	1950
0177	Grange Hall	East A	1346 Storrs Road	16,964.00	In Service	Residence	1950
0212	Ratcliffe Hicks Building	East A	1380 Storrs Road	32,354.55	In Service	Academic	1951
0219	House 06	East A	10 Willowbrook Road	2,990.00	In Service	(Rental)	1917
0421A	Agricultural Biotechnology	East A	1390 Storrs Road	48,501.00	In Service	Science	2000
0421B	Advanced Technology Laboratory	East A	1392 Storrs Road	22,584.00	In Service	Science	2002
7018	Lodewick Residence	East A		9,445.00	In Service	(Rental)	
1001	Water Pumphouse - Fenton River	East B	Near 223 Gurleyville Road	1,385.00	In Service	Support/Utility	1914
0055	House 41 (w/ attached garage)	East B	Horsebarn Hill Road Extension	6,031.15	In Service	(Rental)	1920
0056	House 42	East B	Horsebarn Hill Road	3,229.39	In Service	(Rental)	1890
0134	Poultry Commercial House	East A	3112 Horsebarn Hill Road	5,472.00	In Service	Academic	1943
0135	Poultry Brooder House	East A	3212 Horsebarn Hill Road	2,740.00	In Service	Academic	1943
0170	Horse Barn	East B	3099 Horsebarn Hill Road	8,850.11	In Service	Academic	1949
0170A	A. L. Lorentzen Stable	East B	3099 Horsebarn Hill Road	6,920.25	In Service	Academic	1992
0170B	A. L. Lorentzen Connector	East B	3099 Horsebarn Hill Road	736.40	In Service	Academic	1992
0222	White Building	East A	3636 Horsebarn Hill Road Extension	38,301.41	In Service	Academic	1955
0240	Jones Building	East A	3624 Horsebarn Hill Road Extension	25,999.00	In Service	Academic	1959
0242	Poultry Feed House	East A	3626 Horsebarn Hill Road Extension	3,602.25	In Service	Academic	1960
0373	Environmental Health & Safety Building	East B	Horsebarn Hill Road	8,569.00	In Service	Administrative	1988
0419	Polo Arena	East B	4034 Horsebarn Hill Road	35,381.00	In Service	Academic	2001
0420	Cattle Resource Unit	East B	4030 Horsebarn Hill Road	1,010.17	In Service	Academic	1999
0479	High-Tech Poultry Facility	East A	3200 Horsebarn Hill Road	8,680.00	In Service	Science	2004
0481	Modular Waste Storage	East B	Horsebarn Hill Road	588.00	In Service	Support/Utility	2004
0490	Hoop Barn	East B	Off Horsebarn Hill Road	3,200.00	In Service	Academic	
1009	House 43	East B	Horsebarn Hill	1,788.00	In Service	(Rental)	1850
1023	Beef-Sheep Barn	East B	3123 Horsebarn Hill Road	19,400.40	In Service	Support/Utility	1951
1025	Swine Barn	East B	3137 Horsebarn Hill Road	3,227.33	In Service	Academic	1951
1052	Farm Department Headquarters	East B	3099 Horsebarn Hill Road	15,078.51	In Service	Academic	1959
1064	Swine Feeding Barn	East B	Horsebarn Hill Road	1,093.34	In Service	Academic	1951
1065	Shine Shed	East B	Horsebarn Hill Road	3,638.44	In Service	Support/Utility	1951
1067	Biobehavioral Science Building 5	East B	3107 Horsebarn Hill Road	4,958.00	In Service	Academic	1965
1081	Microchemistry Lab Prefab 2	East B	3113 Horsebarn Hill Road	4,967.83	In Service	Science	1968
1082	Canid Research Lab	East B	Horsebarn Hill Road	810.00	In Service	Support/Utility	1968
1087	Sewage Pumping Station	East B	Horsebarn Hill Road	646.34	In Service	Support/Utility	1968
1101A	Kinesiology Building	East B	3107 Horsebarn Hill Road	22,655.00	In Service	Academic	1972
1101B	Institute of the Environment	East B	3107 Horsebarn Hill Road	23,334.00	In Service	Science	1994
1103	Horse Unit #2	East B	3115 Horsebarn Hill Road	2,920.00	In Service	Support/Utility	1968
1106	Biobehavioral Science Trailer Complex Building 6	East B	3107 Horsebarn Hill Road	4,847.60	In Service	Academic	1974
1109	Mare Shed	East B	3129 Horsebarn Hill Road	1,189.15	In Service	Support/Utility	1974
1123	Museum Storage	East B	Horsebarn Hill Road	870.76	In Service	Academic	1990
1124	Museum Annex	East B	3107 Horsebarn Hill Road	3,605.00	In Service	Academic	1991
1126	Kellogg Dairy Center	East A	3218 Horsebarn Hill Road Extension	26,413.00	In Service	Academic	1991
1134	Agricultural Biotechnology Lab Annex	East B	Horsebarn Hill Road	661.32	In Service	Academic	1998
0001	Storrs Hall	Central-North	231 Glenbrook Road	52,128.00	In Service	Academic	1906
0002	Gulley Hall	Central-South	352 Mansfield Road	15,404.00	In Service	Administrative	1908
0004	Koons Hall	Central-South	358 Fairfield Road	28,648.00	In Service	Academic	1913
0006	Hawley Armory	Central-South	359 Mansfield Road	34,426.00	In Service	Academic	1915
0007	Agricultural Engineering Lab	East A	1380 Storrs Road	7,348.85	In Service	Academic	1915
0029	Benton Musuem of Art	Central-North	245 Glenbrook Road	26,827.46	In Service	Academic	1920
0030	Horticulture Storage	Northeast	2019 Hillside Road	9,600.00	In Service	Administrative	1922
0037	Hall Building	Central-South	362 Fairfield Road	29,005.62	In Service	Academic	1940
0038	Beach Hall	Central-South	354 Fairfield Road	83,171.00	In Service	Academic	1929
0040	Atwater Lab	Central-North	61 North Eagleville Road	44,021.00	In Service	Academic	1930
0042	Honors Center	East A	1332 Storrs Road	5,053.00	In Service	Student Services	1820
0043	Lakeside Apartments (13)	Northeast	1 North Eagleville Road	19,442.00	In Service	Administrative	1931
0044	International House	Northeast	1315 Storrs Road	5,027.00	In Service	Student Services	1769
0045	House 05 (w/ attached garage)	East A	1310 Storrs Road	2,512.37	In Service	(Rental)	1769
0054	Jacobson Barn	East A	Storrs Road	4,894.00	In Service	Academic	1819
0060	Horticulture Garage	Northeast	2021 Hillside Road	4,790.82	In Service	Academic	1944
0126	Wilbur Cross Building	Central-North	233 Glenbrook Road	115,127.00	In Service	Student Services	1939
0130	Manchester Hall	Central-South	344 Mansfield Road	35,688.00	In Service	Academic	1940
0131	Wood Hall	Central-North	241 Glenbrook Road	28,475.00	In Service	Academic	1940
0132	Offical Residence	East A	9 Oak Hill Road	8,517.08	In Service	(Rental)	1940

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0133	Castleman Building (Engineering I)	Central-North	261 Glenbrook Road	**70,959.00**	In Service	Academic	1941
0138	Family Studies (formerly DRM)	Central-South	348 Mansfield Road	**44,542.00**	In Service	Academic	1942
0141	Heating & Power Plant	Central-North	242 Glenbrook Road	**42,410.00**	In Service	Support/Utility	1938
0143	Sewage Station 2 - Gurleyville Road	East B	Gurleyville Road	**300.00**	In Service	Support/Utility	1951
0148	Physical Education/Field House	West	2111 Hillside Road	**147,354.00**	In Service	Athletics & Recreation	1950
0149	Hartford Hall - NC 1	Northwest	82 North Eagleville Road	**25,024.76**	In Service	Residence	1950
0150	New Haven Hall - NC 2	Northwest	82 North Eagleville Road	**25,353.08**	In Service	Residence	1950
0151	New London Hall - NC 3	Northwest	82 North Eagleville Road	**24,827.70**	In Service	Residence	1950
0152	Fairfield Hall - NC 4	Northwest	82 North Eagleville Road	**24,933.34**	In Service	Residence	1950
0153	Windham Hall - NC 5	Northwest	82 North Eagleville Road	**24,807.11**	In Service	Residence	1950
0154	Litchfield Hall - NC 6	Northwest	82 North Eagleville Road	**24,932.68**	In Service	Residence	1950
0155	Middlesex Hall - NC 7	Northwest	82 North Eagleville Road	**24,691.78**	In Service	Residence	1950
0156	Tolland Hall - NC 8	Northwest	82 North Eagleville Road	**24,933.34**	In Service	Residence	1950
0157	Hurley Hall - NC 9	Northwest	82 North Eagleville Road	**23,706.97**	In Service	Residence	1950
0158	Baldwin Hall - NC 10	Northwest	82 North Eagleville Road	**23,121.00**	In Service	Residence	1950
0159	McConaughy Hall - NC 11	Northwest	82 North Eagleville Road	**56,649.00**	In Service	Residence	1950
0163	Hanks Hall (A -B) - NW Quad 1	Northwest	110 North Eagleville Road	**27,913.11**	In Service	Residence	1950
0164	Goodyear (A -B) - NW Quad 2	Northwest	110 North Eagleville Road	**27,927.00**	In Service	Residence	1950
0165	Russell (A-D) - NW Quad 3	Northwest	110 North Eagleville Road	**57,118.00**	In Service	Residence	1950
0166	Batterson (A-D) - NW Quad 4	Northwest	110 North Eagleville Road	**56,986.00**	In Service	Residence	1950
0167	Terry (A -B) - NW Quad 5	Northwest	110 North Eagleville Road	**27,926.75**	In Service	Residence	1950
0168	Rogers (A -B) - NW Quad 6	Northwest	110 North Eagleville Road	**27,993.00**	In Service	Residence	1950
0171	Williams Health Services Building (Infirmary)	Central-North	234 Glenbrook Road	**27,627.00**	In Service	Student Services	1950
0172	Budds Building	Central-South	343 Mansfield Road	**26,954.67**	In Service	Administrative	1951
0174	Pathology Lab	Central-North	61 North Eagleville Road	**13,153.22**	In Service	Science	1950
0204	Plant Science Greenhouse 4	East A	Gillette Farm	**1,390.00**	In Service	Academic	1967
0213	Student Union	Central-North	2110 Hillside Road	**238,336.00**	In Service	Student Services	1953
0214	Floriculture Building	Northeast	1395 Storrs Road	**25,476.44**	In Service	Academic	1953
0221	Jorgensen Auditorium & Theatre	Central-North	2132 Hillside Road	**98,326.59**	In Service	Academic	1956
0223A	Alsop Hall - WC 1A	Central-South	450 Whitney Road	**13,926.00**	In Service	Residence	1955
0223B	Alsop Hall - WC 1B	Central-South	450 Whitney Road	**14,361.00**	In Service	Residence	1955
0224A	Hollister Hall - WC 2A	Central-South	2016 Hillside Road	**14,316.00**	In Service	Residence	1955
0224B	Hollister Hall - WC 2B	Central-South	2016 Hillside Road	**13,870.00**	In Service	Residence	1955
0225A	Shakespear Hall - WC 3A	Central-South	625 Gilbert Road	**14,358.00**	In Service	Residence	1955
0225B	Troy Hall - WC 3B	Central-South	625 Gilbert Road	**13,820.00**	In Service	Residence	1955
0226A	Chandler Hall - WC 4A	Central-South	635 Gilbert Road	**14,379.00**	In Service	Residence	1955
0226B	Lancaster Hall - WC 4B	Central-South	635 Gilbert Road	**13,921.00**	In Service	Residence	1955
0227	House 47	West	14 Eastwood Road	**1,236.00**	In Service	(Rental)	1955
0232	Plantetarium	Central-North	55 North Eagleville Road	**581.56**	In Service	Academic	1959
0233	Drama Music Building	South A	802 Bolton Road	**45,294.49**	In Service	Academic	1959
0235	Arjona Building	Central-South	337 Mansfield Road	**68,694.83**	In Service	Academic	1959
0236	Monteith Building	Central-South	341 Mansfield Road	**68,427.55**	In Service	Academic	1959
0237	Andre Schenker Lecture Hall	Central-South	341 Mansfield Road	**4,981.17**	In Service	Academic	1959
0238	College of Liberal Arts & Sciences Building	Central-North	215 Glenbrook Road	**126,189.00**	In Service	Academic	1959
0239	Engineering II	Central-North	191 Auditorium Road	**58,149.00**	In Service	Academic	1959
0243	House 55	Southeast	75 Willowbrook Road	**1,632.00**	In Service	(Rental)	1890
0244	Commissary Bakery & Warehouse	East A	30 Gurleyville Road	**35,568.45**	In Service	Student Services	1959
0245	von der Mehden Recital Hall	South A	875 Coventry Road	**14,759.38**	In Service	Academic	1960
0246	Center for Undergraduate Education	Central-North	368 Fairfield Road	**73,615.00**	In Service	Academic	1960
0247	Gentry Building	Central-North	249 Glenbrook Road	**98,180.00**	In Service	Academic	1960
0252	Torrey Life Sciences Building	Central-North	75 North Eagleville Road	**139,248.09**	In Service	Academic	1961
0253A	Webster Hall - Towers Dorm 1A	Northeast	3384 Towers Loop Road	**14,102.00**	In Service	Residence	1961
0253B	Sherman Hall - Towers Dorm 1B	Northeast	3384 Towers Loop Road	**16,791.89**	In Service	Residence	1961
0254A	Jefferson Hall - Towers Dorm 2A	Northeast	3384 Towers Loop Road	**14,109.00**	In Service	Residence	1961
0254B	Colt Hall - Towers Dorm 2B	Northeast	3384 Towers Loop Road	**14,556.00**	In Service	Residence	1961
0255A	Trumball Hall - Towers Dorm 3A	Northeast	3384 Towers Loop Road	**14,361.00**	In Service	Residence	1961
0255B	Sousa Hall - Towers Dorm 3B	Northeast	3384 Towers Loop Road	**14,157.00**	In Service	Residence	1961
0255C	Lafayette Hall - Towers Dorm 3C	Northeast	3384 Towers Loop Road	**14,053.00**	In Service	Residence	1961
0255D	Morgan Hall - Towers Dorm 3D	Northeast	3384 Towers Loop Road	**19,718.67**	In Service	Residence	1961
0256A	Keller Hall - Towers Dorm 4A	Northeast	3384 Towers Loop Road	**14,504.00**	In Service	Residence	1961
0256B	Fenwick Hall - Towers Dorm 4B	Northeast	3384 Towers Loop Road	**13,317.00**	In Service	Residence	1961
0256C	Wade Hall - Towers Dorm4C	Northeast	3384 Towers Loop Road	**14,425.00**	In Service	Residence	1961
0256D	Hamilton Hall - Towers Dorm 4D	Northeast	3384 Towers Loop Road	**19,198.67**	In Service	Residence	1961
0257A	Vinton Hall - Towers Dorm 5A	Northeast	3384 Towers Loop Road	**14,030.00**	In Service	Residence	1961
0257B	Beecher Hall - Towers Dorm 5B	Northeast	3384 Towers Loop Road	**17,195.56**	In Service	Residence	1961
0258A	Allen Hall - Towers Dorm 6A	Northeast	3384 Towers Loop Road	**14,032.00**	In Service	Residence	1961
0258B	Kingston Hall - Towers Dorm 6B	Northeast	3384 Towers Loop Road	**17,174.00**	In Service	Residence	1961
0262	Facility Maintenance Storage Bldg (Incinerator)	Northwest	LeDoyt Road	**2,772.00**	In Service	Support/Utility	1961
0263	McMahon Hall & Dining Facility	West	2011 Hillside Road	**136,249.00**	In Service	Residence	1964
0272	Pit Greenhouse	East A	Storrs Road	**369.75**	In Service	Academic	1953
0292B	ASC Warehouse [Addition]	East B	Gurleyville Road	**1,867.13**	In Service	Support/Utility	1991
0299	Kessell Barn	East A	4 Moulton Road	**2,160.00**	In Service	Academic	1967
0303	House 09	Southeast	28 Oak Hill Road	**1,316.00**	In Service	(Rental)	1931
0314	House 20	South A	1 Hillside Road	**2,792.00**	In Service	(Rental)	1941
0315	House 07A	Southeast	16 Oak Hill Road	**1,612.89**	In Service	(Rental)	1933
0317	Motor Pool & Vehicle Maintenance Building	Northwest	9 North Hillside Road	**9,399.00**	In Service	Support/Utility	1968
0318	Bronwell Building	Central-North	260 Glenbrook Road	**37,706.83**	In Service	Academic	1968
0324	Whetten Graduate Center	Central-South	438 Whitney Road Extension	**40,114.07**	In Service	Academic	1970
0325	Watson Hall - Alumni Quad 1	South A	630 Gilbert Road	**50,828.00**	In Service	Residence	1966
0326	Belden Hall - Alumni Quad 2	South A	632 Gilbert Road	**50,839.00**	In Service	Residence	1966
0327	Eddy Hall - Alumni Quad 3	South A	634 Gilbert Road	**50,839.00**	In Service	Residence	1966
0328	Brock Hall - Alumni Quad 4	South A	2000 Hillside Road	**51,307.00**	In Service	Residence	1966
0329	Ryan Refectory (Alumni Dining Hall)	South A	2006 Hillside Road	**36,689.00**	In Service	Academic	1967
0330	Communication Sciences Center	South A	850 Bolton Road	**28,361.06**	In Service	Academic	1970
0331A	Gant North (IMS)	Central-North	97 North Eagleville Road	**86,255.54**	In Service	Academic	1970
0331B	Gant West (Physics)	Central-North	202 Auditorium Road Ext	**78,395.00**	Renovation	Academic	1971
0331C	Gant South (Math Sciences)	Central-North	196 Auditorium Road	**99,900.00**	In Service	Academic	1974
0331D	Gant Plaza	Central-North	97 North Eagleville Road	**26,413.00**	In Service	Academic	2002
0339	Towers Dormitory Student Center	Northeast	3384 Towers Loop Road	**10,421.00**	In Service	Student Services	1971
0341	Human Development Center	South A	6 Alethia Drive	**31,090.67**	In Service	Academic	1971
0342	Bishop Center	Southeast	1 Bishop Circle	**36,336.71**	In Service	Academic	1971
0344	Hale Hall	West	2372 Alumni Drive	**65,088.00**	In Service	Residence	1971
0345	Ellsworth Hall	West	2376 Alumni Drive	**64,556.00**	In Service	Residence	1971
0346	Putnam Refectory	West	2358 Alumni Drive	**43,023.00**	In Service	Student Services	1971
0349	Psychology Building	Central-South	406 Babbidge Road	**121,385.69**	In Service	Academic	1974
0362	High Head Pumping Station	East A	Route 195	**2,430.00**	In Service	Support/Utility	1975
0364	Babbidge Library	Central-South	369 Fairfield Road	**412,456.00**	In Service	Academic	1978
0365	School of Fine Arts	South A	875 Coventry Road	**46,558.12**	In Service	Academic	1980
0368	Football Equipment Storage	West	505 Jim Calhoun Way	**127.67**	In Service	Athletics & Recreation	
0369	United Technologies Engineering Building	Central-North	191 Auditorium Road	**47,813.20**	In Service	Academic	1987
0370	Facilities Trailer	Northwest	(Waste Treatment Facilities)	**492.00**	In Service	Support/Utility	1986
0371	Football Ticket Booth - North	West	Jim Calhoun Way	**81.16**	In Service	Athletics & Recreation	1986
0372	Football Ticket Booth - South	West	Jim Calhoun Way	**81.36**	In Service	Athletics & Recreation	1986
0374	Gampel Pavilion	West	2095 Hillside Road	**352,013.00**	In Service	Athletics & Recreation	1990
0375	Storage Building - Athletic	West	2111 Hillside Road	**1,166.00**	In Service	Athletics & Recreation	1989
0376	Storage Building - Telcom	Depot	Weaver Road	**160.00**	In Service	Support/Utility	1989
0379	Daily Campus Building	Southeast	11 Dog Lane	**6,736.51**	In Service	Administrative	1992
0380	Police & Fire Complex	Northwest	126 North Eagleville Road	**24,102.00**	In Service	Administrative	1992
0381	Facilities University Operations Building	Northwest	25 LeDoyt Road	**41,629.00**	In Service	Administrative	1995
0382	Admissions (Old Alumni Building)	West	2131 Hillside Road	**25,182.00**	In Service	Academic	1993
0383	Thomas J. Dodd Research Center	Central-South	405 Babbidge Road	**64,567.95**	In Service	Academic	1995
0384	Biology Physics Building	Central-North	91 North Eagleville Road	**153,682.00**	In Service	Science	2003
0384A	Northwest Tunnel	Central-South	91 North Eagleville Road	**13,200.00**	In Service	Support/Utility	
0385	Sports Complex - George J. Sherman	West	Jim Calhoun Way	**1,165.78**	In Service	Athletics & Recreation	1995
0386	Press Box - George J. Sherman Family	West	2111 Hillside Road	**251.17**	In Service	Athletics & Recreation	1995
0387	Architectural & Engineering Services Building	Northwest	31 LeDoyt Road	**11,695.00**	In Service	Administrative	1995

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0388	Sewage Plant Control Building	Northwest	40 LeDoyt Road	**8,917.64**	In Service	Support/Utility	1995
0389	Sewage Plant Pump & Chemical Building	Northwest	41 LeDoyt Road	**4,333.02**	In Service	Support/Utility	1995
0390	Sewage Plant Headworks Building	Northwest	38 LeDoyt Road	**2,802.01**	In Service	Support/Utility	1995
0391	Sewage Plant - Sludge Holding Tank	Northwest	32 LeDoyt Road	**804.59**	In Service	Support/Utility	1979
0392	Sewage Plant Sludge Transfer Building	Northwest	39 LeDoyt Road	**331.43**	In Service	Support/Utility	1995
0406	Athletics Storage	West	512 Jim Calhoun Way	**3,160.11**	In Service	Athletics & Recreation	1996
0409	Chemistry Building	Central-North	55 North Eagleville Road	**204,815.00**	In Service	Labs	1998
0410	Central Warehouse	Northwest	3 Discovery Drive	**89,093.00**	In Service	Administrative	2000
0414	School of Business	Central-South	2100 Hillside Road	**128,073.34**	In Service	Academic	2001
0415	Pharmacy Biology Building	Central-North	69 North Eagleville Road	**222,222.00**	In Service	Labs	2005
0418	UConn Co-op	West	2075 Hillside Road	**74,797.00**	In Service	Student Services	2002
0421C	Agricultural Biotechnology Greenhouse	East A	1392 Storrs Road	**11,622.00**	In Service	Science	2002
0423	WHUS/State Police Prefab.	Northwest	126 North Eagleville Road	**363.00**	In Service	Support/Utility	1995
0424	House 72	South A	25 Hillside Circle	**2,382.00**	In Service	(Rental)	1942
0425	South Campus Dorms - Building A-Wilson	South A	300 Mansfield Road	**70,636.00**	In Service	Residence	1998
0426	South Campus Dorms - Building B-Rosebrooks	South A	626 Gilbert Road Extension	**80,232.00**	In Service	Residence	1998
0427	South Campus Dorms - Building C-Snow	South A	626 Gilbert Road Extension	**104,885.00**	In Service	Residence	1998
0428	South Campus Dorms - Building D-Rome	South A	626 Gilbert Road Extension	**70,864.02**	In Service	Residence	1998
0429	South Campus Chiller	South A	860 Bolton Road	**4,905.00**	In Service	Support/Utility	1998
0432	Satellite Farm Shed	East B		**96.00**	In Service	Support/Utility	1991
0433	Freitas Ice Arena	West	509 Jim Calhoun Way	**49,174.00**	In Service	Athletics & Recreation	1998
0434	Information Technology Building	Central-South	371 Fairfield Road	**139,894.42**	In Service	Academic	2003
0435	Lodewick Visitors Center	Northwest	115 North Eagleville Road	**7,707.00**	In Service	Administrative	2000
0436	Northwest Quad Dining Hall	Northwest	110 North Eagleville Road	**31,154.00**	In Service	Student Services	2000
0442	Garrigus Suites (Hilltop Suites)	West	2373 Alumni Drive	**131,920.00**	In Service	Residence	2001
0443	E. Grasso Hall - Hilltop Apt. 10	West	10 Husky Circle	**34,457.00**	In Service	Residence	2001
0444	H. B. Stowe Hall - Hilltop Apt. 11	West	11 Husky Circle	**24,886.00**	In Service	Residence	2001
0445	A. Novello Hall - Hilltop Apt. 12	West	12 Husky Circle	**34,947.00**	In Service	Residence	2001
0446	M. French Hall - Hilltop Apt. 13	West	13 Husky Circle	**24,927.00**	In Service	Residence	2001
0447	M. R. Beard Hall - Hilltop Apt. 14	West	14 Husky Circle	**34,457.00**	In Service	Residence	2001
0448	S. La Flesche Hall - Hilltop Apt. 15	West	15 Husky Circle	**24,927.00**	In Service	Residence	2001
0449	P. Crandall Hall - Hilltop Apt. 16	West	16 Jonathan Way	**34,947.00**	In Service	Residence	2001
0450	M. M. Bethune Hall - Hilltop Apt. 17	West	17 Jonathan Way	**24,927.00**	In Service	Residence	2001
0451	A. P. Merritt Hall - Charter Oak Apt. 18	Northwest	18 Jonathan Way	**25,954.00**	In Service	Residence	2001
0452	Chieng-Shiung Wu Hall - Charter Oak Apt. 19	Northwest	19 Husky Circle	**25,614.00**	In Service	Residence	2001
0453	M. K. Wheeler Hall - Hilltop Apt. 20	West	20 Husky Circle	**38,293.00**	In Service	Residence	2001
0454	S. B. Crawford Hall - Hilltop Apt. 21	West	21 Husky Circle	**34,947.00**	In Service	Residence	2001
0455	C. G. Woodhouse Hall - Charter Oak Apt. 22	Northwest	22 Husky Circle	**25,382.00**	In Service	Residence	2001
0456	Hilltop Community Center	West	30 Jonathan Way	**5,080.00**	In Service	Residence	2001
0459	Hilltop/Capstone Pump House	West	2353 Alumni Drive	**400.00**	In Service	Support/Utility	2001
0461	Foster Hall (Vermont Hall) - Charter Oak Apt. A	Northwest	916 Towers Court	**31,410.76**	In Service	Residence	2003
0462	Hoisington Hall (New Hampshire Hall) - Charter Oak Apt. B	Northwest	916 Towers Court	**37,104.05**	In Service	Residence	2003
0463	Thompson Hall (Maine Hall) - Charter Oak Apt. C	Northwest	916 Towers Court	**31,378.92**	In Service	Residence	2003
0464	Brown Hall (Connecticut Hall) - Charter Oak Apt. D	Northwest	916 Towers Court	**26,339.04**	In Service	Residence	2003
0465	Hubbard Hall (Rhode Island Hall) - Charter Oak Apt. E	Northwest	916 Towers Court	**26,339.60**	In Service	Residence	2003
0466	Hough Hall (Massachusettes Hall) - Charter Oak Apt. F	Northwest	916 Towers Court	**26,335.90**	In Service	Residence	2003
0467	Busby Suites (Charter Oak Suites)	Northwest	917 Towers Court	**134,229.00**	In Service	Residence	2003
0468	Charter Oak Community Center	Northwest	916 Towers Court	**6,278.00**	In Service	Student Services	2003
0469	Husky Village Building A	Northeast	10 & 15 Laurel Way	**17,214.71**	In Service	Residence	2003
0470	Husky Village Building B	Northeast	20 & 25 Laurel Way	**17,216.00**	In Service	Residence	2003
0471	Husky Village Building C	Northeast	30 & 35 Laurel Way	**17,215.00**	In Service	Residence	2003
0472	Husky Village Building D	Northeast	40 & 45 Laurel Way	**17,215.02**	In Service	Residence	2003
0473	Husky Village Building E	Northeast	50 & 55 Laurel Way	**10,363.89**	In Service	Residence	2003
0474	Husky Village Building F	Northeast	60 & 65 Laurel Way	**10,363.57**	In Service	Residence	2003
0475	Husky Village Director's House - Building G	Northeast	70 Laurel Way	**1,280.00**	In Service	Residence	2003
0476	Towers Dining Hall	Northeast	3388 Towers Loop Road	**22,057.00**	In Service	Student Services	2003
0477	Towers Loop Pump Station	Northeast	Towers Loop Road	**2,062.67**	In Service	Support/Utility	2003
0478	Nafe Katter Theatre	South A	802 Bolton Road	**44,021.00**	In Service	Academic	2004
0480	Burton Football Complex & Shenkman Training Center	West	505 Jim Calhoun Way	**96000**	In Service	Athletics & Recreation	2006
0480	Burton Football Complex & Shenkman Training Center	West	505 Jim Calhoun Way	**179874**	In Service	Athletics & Recreation	2006
0483	Cogeneration-Chiller Facility	Central-North	244 Glenbrook Road	**40669**	In Service	Support/Utility	2006
0485	Mobile Command Center Garage	Northwest	126 North Eagleville Road	**2451**	In Service	Support/Utility	
0486	Oak Hall	Central-South	365 Fairfield Way	**121,663.00**	In Service	Academic	2013
0487	Lawrence D. McHugh Hall (Laurel Hall)	Central-North	372 Fairfield Way	**70,169.00**	In Service	Academic	2013
0489	Water Reclamation Facility	Northwest	48 Ledoyt Road Ext	**12,132.00**	In Service	Support/Utility	
0500	Werth Family Basketball Champions Center	West	2158 Jim Calhoun Way	**108,518.00**	In Service	Athletics & Recreation	
0501	Hilltop Pump House	West	Husky Circle	**250.00**	In Service	Support/Utility	
0502	Innovation Partnership Building	Northwest	159 Discovery Drive	**122,424.00**	In Service	Science	
0503	New Engineering and Science Building	Central-North	67 North Eagleville Road	**120,057.00**	In Service	Science	2016
0504	Main Accumulation Building	Northwest	21 Avalonia Way	**8,613.00**	In Service	Support/Utility	
0505	Peter J. Werth Residence Tower (Formerly Next Gen Residence Hall)	West	2378 Alumni Drive	**215,834.00**	In Service	Residence	
0506	Fine Arts Band Tower	Northeast	Towers Loop Road	**100.00**	In Service	Student Services	
0508	Student Recreation Center	Central-South	2060 Hillside Road	**272,073.00**	In Service	Athletics & Recreation	Future
1002	Well House A	East B	Near 223 Gurleyville Road	**136.00**	In Service	Support/Utility	1926
1005	High Shed	East B	(farm area)	**1,920.00**	In Service	Support/Utility	1951
1010	Garage (House 43) - Horsebarn Hill	East B	98 Manter Road	**220.00**	In Service	(Rental)	1900
1013	Sears Barn	East B	Route 195/Spring Hill	**8,184.13**	In Service	Support/Utility	1920
1018	Hydraulic Lab	Depot	Pink Ravine	**2,152.65**	In Service	Science	1948
1019	Fenton River Well House B	East B	Near 223 Gurleyville Road	**136.00**	In Service	Support/Utility	1949
1020	Fenton River Well House C	East B	Near 223 Gurleyville Road	**136.00**	In Service	Support/Utility	1949
1021	Quonset Hut 1	East B		**375.00**	In Service	Support/Utility	1950
1029	Farm Machinery Metal Shed 3			**2,574.58**	In Service	Support/Utility	1953
1035	Sewage Station 4 - Northwood Apartments	Northwood	Northwood Road	**784.00**	In Service	Support/Utility	1955
1036	Northwood Apartments - Building 1	Northwood	Northwood Road	**6,855.00**	In Service	Residence	1955
1037	Northwood Apartments - Building 2	Northwood	Northwood Road	**6,856.27**	In Service	Residence	1955
1038	Northwood Apartments - Building 3	Northwood	Northwood Road	**6,853.00**	In Service	Residence	1955
1039	Northwood Apartments - Building 4	Northwood	Northwood Road	**6,856.00**	In Service	Residence	1955
1040	Northwood Apartments - Building 5	Northwood	Northwood Road	**6,856.00**	In Service	Residence	1955
1041	Northwood Apartments - Building 6	Northwood	Northwood Road	**6,871.00**	In Service	Residence	1955
1042	Northwood Apartments - Building 7	Northwood	Northwood Road	**6,871.00**	In Service	Residence	1955
1043	Northwood Apartments - Building 8	Northwood	Northwood Road	**6,856.00**	In Service	Residence	1955
1044	Northwood Apartments - Building 9	Northwood	Northwood Road	**6,871.00**	In Service	Residence	1955
1045	Northwood Apartments - Building 10	Northwood	Northwood Road	**6,856.00**	In Service	Residence	1955
1046	Northwood Apartments - Building 11	Northwood	Northwood Road	**6,856.00**	In Service	Residence	1955
1047	Northwood Apartments - Building 12	Northwood	Northwood Road	**6,871.00**	In Service	Residence	1955
1051	Kirkpatrick Barn/Garage			**704.00**	In Service	Academic	1970
1060	Fenton River Well House D	East B	Near 223 Gurleyville Road	**97.00**	In Service	Support/Utility	1958
1063	Plant Nutrition Lab	Depot		**1,868.71**	In Service	Support/Utility	1962
1066	Storrs Barn	East A	Storrs Road	**11,821.20**	In Service	Academic	1869
1068	Agronomy Prefab Storage Building			**8,286.61**	In Service	Support/Utility	1965
1095	Agriculture Storage Building	East B	(farm area)	**4,030.04**	In Service	Academic	1970
1113	Gas Shed	East B	Spring Hill Road	**64.00**	In Service	Support/Utility	1970
1114	Canid Observation Hut	East B	Gurleyville Road	**70.00**	In Service	Academic	1974
1119	Observatory	Central-North	Spring Hill Road	**200.76**	In Service	Academic	1980
1120	Hay Storage Shed	East B	Spring Hill Road	**967.09**	In Service	Support/Utility	1981
1121	Transportation Office Trailer	Northwest	3 Discovery Drive	**672.00**	In Service	Administrative	1987
1128	Locker & Toilet Building	East B	(farm area)	**225.50**	In Service	Support/Utility	1989
1132	Fenton River Generator	East B	Near 223 Gurleyville Road	**407.00**	In Service	Support/Utility	1994
1135	Pfizer Modular A	East A	Spring Hill Road	**986.00**	In Service	Science	1998

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1136	Pfizer Modular B	East A	Spring Hill Road	**1,972.00**	In Service	Science	1998
7000	UITS Modular Building	Central-North		**15,103.00**	In Service	Administrative	
7012	Alumni Center	West		**29,824.00**	In Service	Administrative	
7015	Uconn Foundation	West		**35,738.00**	In Service	Administrative	
7017	St. Thomas Aquinas Chapel	Northeast		**5,772.00**	In Service	Miscellaneous	
N/A	St. Thomas Aquinas Rectory	Northeast	North Eagleville Road	**3,256.00**	In Service	Miscellaneous	
N/A	St. Mark's Chapel	Northeast	North Eagleville Road	**3,525.00**	In Service	Miscellaneous	
N/A	Storrs Congregational Church	Northeast	North Eagleville Road	**5,427.00**	In Service	Miscellaneous	
N/A	Bethel Congregation	Northeast	North Eagleville Road	**6,645.00**	In Service	Miscellaneous	
N/A	Storrs Community Nursery School	Northeast	North Eagleville Road	**8,640.00**	In Service	Miscellaneous	
N/A	St. Thomas Aquinas Center	Northeast	North Eagleville Road	**9,416.00**	In Service	Miscellaneous	
0179	Mansfield Apartments - Building 02 (4 Units)	South B	1 South Eagleville Road	**4,522.00**	In Service	Residence	1951
0180	Mansfield Apartments - Building 03 (6 Units)	South B	1 South Eagleville Road	**6,808.00**	In Service	Residence	1951
0181	Mansfield Apartments - Building 04 (4 Units)	South B	1 South Eagleville Road	**4,522.00**	In Service	Residence	1951
0182	Mansfield Apartments - Building 05 (4 Units)	South B	1 South Eagleville Road	**4,522.00**	In Service	Residence	1951
0183	Mansfield Apartments - Building 06 (6 Units)	South B	1 South Eagleville Road	**6,808.00**	In Service	Residence	1951
0184	Mansfield Apartments - Building 07 (4 Units)	South B	1 South Eagleville Road	**4,522.00**	In Service	Residence	1951
0185	Mansfield Apartments - Building 09 (4 Units)	South B	1 South Eagleville Road	**4,522.00**	In Service	Residence	1951
0186	Mansfield Apartments - Building 10 (4 Units)	South B	1 South Eagleville Road	**4,521.50**	In Service	Residence	1951
0187	Mansfield Apartments - Building 11 (4 Units)	South B	1 South Eagleville Road	**4,522.00**	In Service	Residence	1951
0188	Mansfield Apartments - Building 12 (6 Units)	South B	1 South Eagleville Road	**6,808.00**	In Service	Residence	1951
0189	Mansfield Apartments - Building 13 (4 Units)	South B	1 South Eagleville Road	**4,521.00**	In Service	Residence	1951
0190	Mansfield Apartments - Building 14 (4 Units)	South B	1 South Eagleville Road	**4,521.00**	In Service	Residence	1951
0191	Mansfield Apartments - Building 15 (6 Units)	South B	1 South Eagleville Road	**6,808.43**	In Service	Residence	1951
0192	Mansfield Apartments - Building 16 (4 Units)	South B	1 South Eagleville Road	**4,521.00**	In Service	Residence	1951
0193	Mansfield Apartments - Building 17 (6 Units)	South B	1 South Eagleville Road	**6,808.43**	In Service	Residence	1951
0194	Sewage Station 3 - Mansfield Apartments	South B	1 South Eagleville Road	**70.00**	In Service	Support/Utility	1951
0028	Mink Barn	Northeast	1503 Storrs Road	**2,640.21**	In Service	Support/Utility	1920
0273	Mink Shed	Northeast	1501 Storrs Road	**776.37**	In Service	Support/Utility	1920
1098	House 69	Spring Hill	1595 Storrs Road	**1,830.00**	In Service	(Rental)	1970
1115	House 71	Spring Hill	1561 Storrs Road	**1,451.00**	In Service	(Rental)	1976
1014	Plant Science Res/Farm Main Bldg	Spring Hill	Agronomy Road	**6,015.00**	In Service	Science	1922
1104	Plant Science Res/Farm Greenhouse #2	Spring Hill	Agronomy Road	**2,496.00**	In Service	Science	1997
1133	Plant Science Burr Nursery	Spring Hill	Agronomy Road	**537.00**	In Service	Science	1995
1140	Plant Science Turf Resource Unit	Spring Hill	66 Agronomy Road	**5,000.00**	In Service	Academic	2004
0234	Music Building	South A	1295 Storrs Road	**41,998.78**	In Service	Academic	1959
0412	School of Fine Arts Atrium	South A	1295 Storrs Road	**34,569.00**	In Service	Academic	1999
0280	Pump Station - (below ground)	South B	South Eagleville Road	**40.00**	In Service	Support/Utility	1948
0261	Shippee Hall & Dining Facility	Southeast	1288 Storrs Road	**70,500.33**	In Service	Residence	1962
0295	Buckley Hall	Southeast	1276 Storrs Road	**105,632.00**	In Service	Residence	1969
1011	House 46	Spring Hill	950 Storrs Road	**2,901.60**	In Service	(Rental)	1930
1012	Garage (House 46)	Spring Hill	950 Storrs Road	**740.00**	In Service	(Rental)	1964
1031	Spring Hill Laboratory	Spring Hill	950 Storrs Road	**2,979.00**	In Service	Science	1953
1032	Butler Bldg - Spring Hill	Spring Hill	950 Storrs Road	**3,039.00**	In Service	Academic	1957
1034	Isolation Barn - Spring Hill	Spring Hill	950 Storrs Road	**4,545.00**	In Service	Academic	1955
1050	House 49	Spring Hill	986 Storrs Road	**2,694.15**	In Service	(Rental)	1820
1088	House 52	Spring Hill	968 Storrs Road	**1,854.00**	In Service	(Rental)	1969
1139	Willimantic Well 4 and Pumphouse	Spring Manor	Near 440 Spring Manor Lane	**576.00**	In Service	Support/Utility	
7104	Spring Manor Farm Hoop House	Spring Manor	104 Spring Manor Lane	**2,200.00**	In Service	Academic	
7121	Spring Mnorr Farm -Oak Cottage	Spring Manor	104 Spring Manor Lane	**2,591.54**	In Service	Academic	
7022	Barnes and Noble Storrs Center	Southeast	1 Royce Circle	**17,235.00**	In Service	Student Services	
7023	Mansfield 28 Professional Park Building	Southeast	28 Professional Park Road	**9,176.00**	In Service	Administrative	
1117	Willimantic Pumphouse & Well I	Spring Manor	Near 440 Spring Manor Lane	**303.00**	In Service	Support/Utility	1976
1118	Willimantic Pumphouse & Well II	Spring Manor	Near 440 Spring Manor Lane	**324.00**	In Service	Support/Utility	1976
1127	Willimantic Pump House & Well III	Spring Manor	Near 440 Spring Manor Lane	**453.00**	In Service	Support/Utility	1989
0244A	Student Commissary Modular	East A	59 Gurleyville Road	**1,865.00**	In Service	Student Services	
1064A	Uconn Swine Feeding Shed	East B		**100.00**	In Service	Support/Utility	
1083	Green Shed (Near EHS MAA Area)	East B	3107 Horsebarn Hill Road (Path)	**100.00**	In Service	Support/Utility	
2218	COMPOST FACILITY	Northwest		**1,000.00**	IN SERVICE	Science	
2219	WELL WATER TREATMENT FACILITY	Northwest		**2,600.00**	IN SERVICE	Support/Utility	
7001	Visual Arts Research Complex	Depot	114 Mansfield Hollow Road (Kirby Mills)	**8,267.00**	IN SERVICE	Academic	
	Art Ceramic Studio	West		**3,300.00**	In Service	Academic	
	Academic Services Center	West		**4,300.00**	In Service	Academic	

BVH integrated services

APPENDIX G

Supporting Diagrams

Ground Source Thermal Conversion District Mapping

Heating System Map - Main Campus

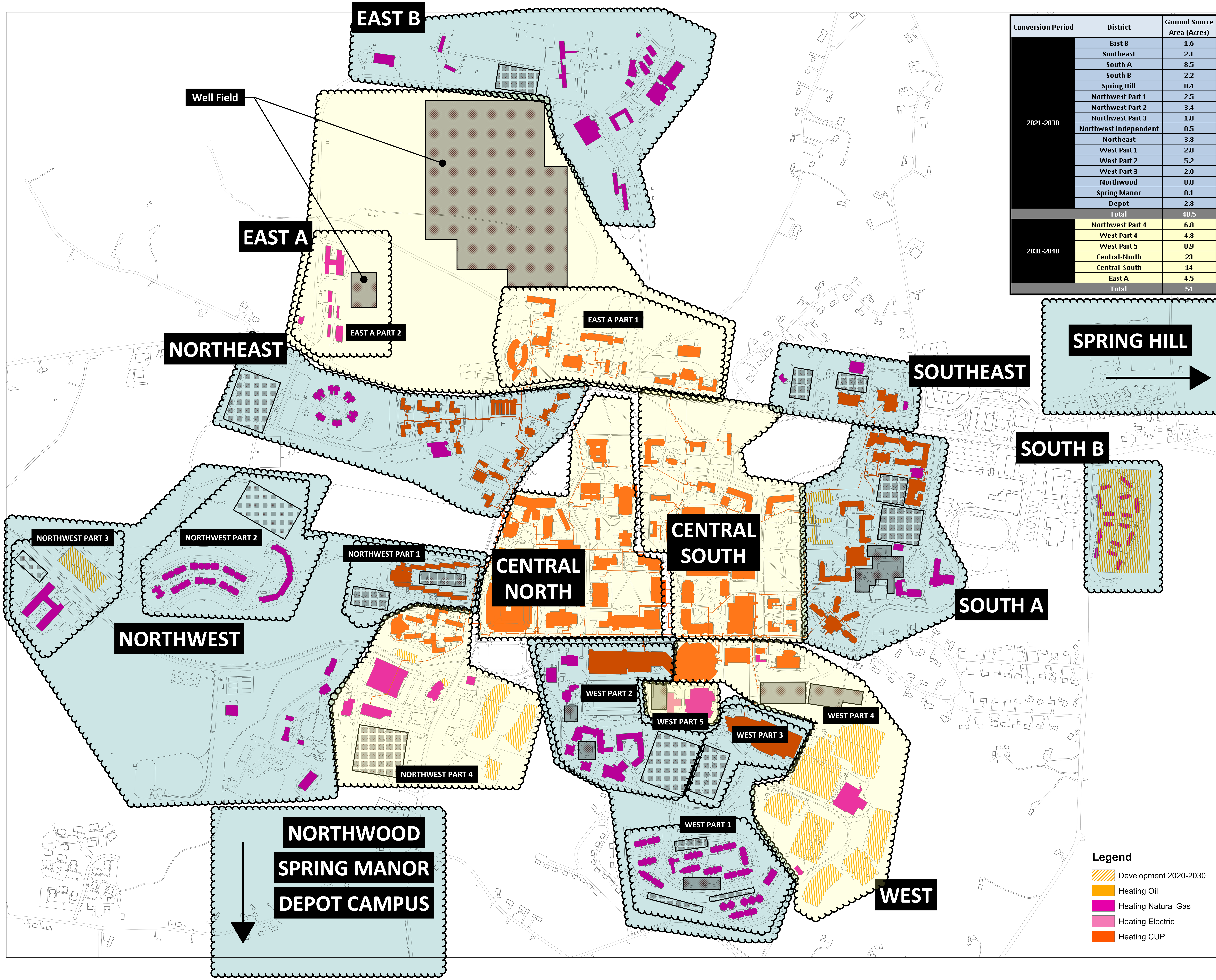
Cooling System Map - Main Campus

District Plant South A Sample

Electrical System Map - Main Campus

Electrical System Map – Transmission Line

Solar Canopies Parking Lot - Main Campus



Conversion Period	District	Ground Source Area (Acres)
2021-2030	East B	1.6
	Southeast	2.1
	South A	8.5
	South B	2.2
	Spring Hill	0.4
	Northwest Part 1	2.5
	Northwest Part 2	3.4
	Northwest Part 3	1.8
	Northwest Independent	0.5
	Northeast	3.8
	West Part 1	2.8
	West Part 2	5.2
	West Part 3	2.0
	Northwood	0.8
	Spring Manor	0.1
	Depot	2.8
	Total	40.5
2031-2040	Northwest Part 4	6.8
	West Part 4	4.8
	West Part 5	0.9
	Central-North	23
	Central-South	14
	East A	4.5
	Total	54

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STORRS, CT 06340

PROJECT NO: 902040
WORK ORDER NO:
FILE NAME: 2115093 - UConn Utility Framework
AUTHOR: ALP
CHECKER: SPW
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SHEET TITLE:

GROUND SOURCE HEAT PUMP DISTRICT MAPPING

N

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STORRS, CT 06340

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FILE NAME: 2115093 - UConn Utility Framework
AUTHOR: ALP
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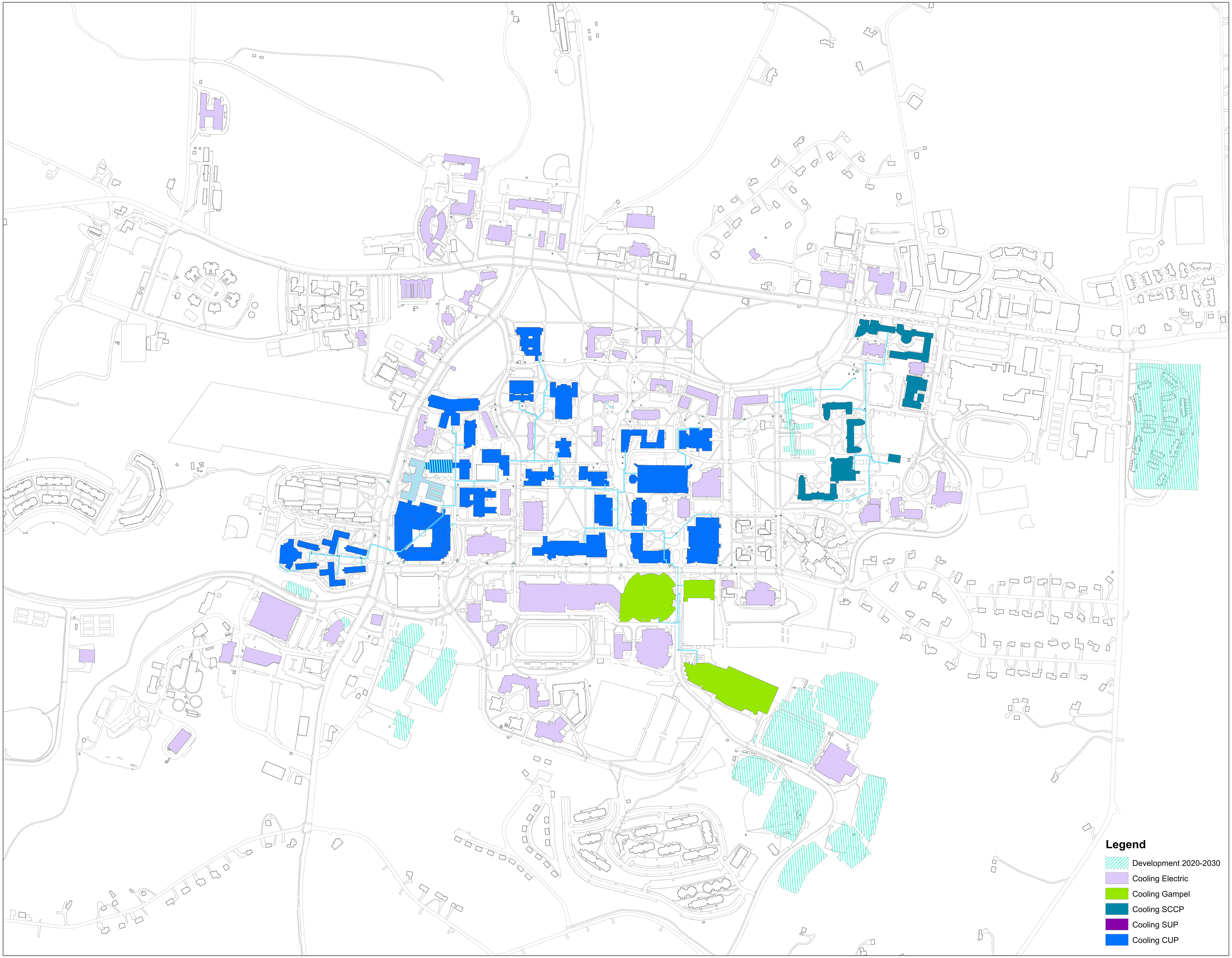
SHEET TITLE:

HEATING SYSTEM



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FILE NAME:
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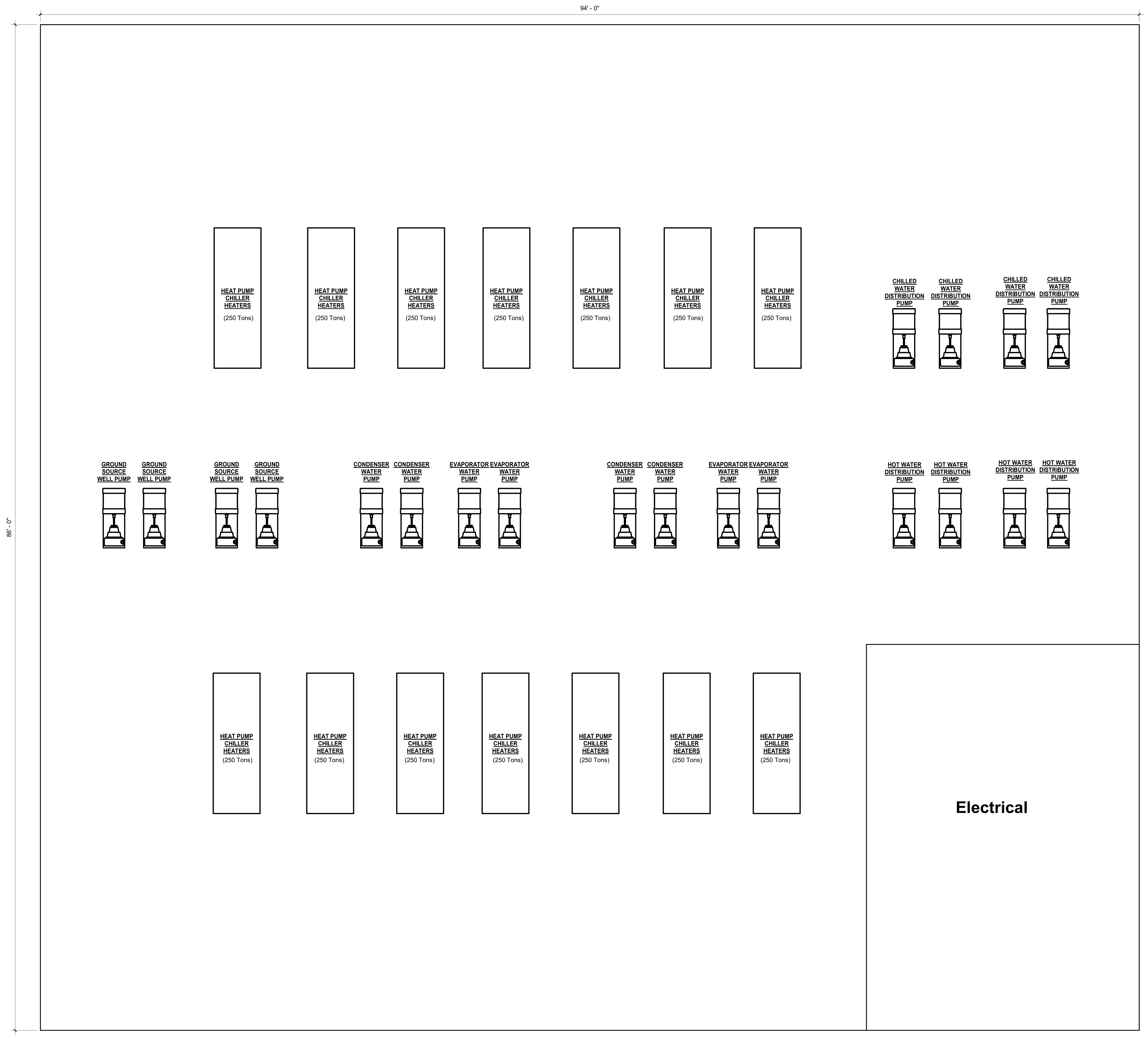
COOLING SYSTEM



1 SOUTH A SAMPLE DISTRICT PLANT
1/4" = 1'-0"

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9/30/2020 1:58:39 PM

CERTIFICATION:

STATUS:
DRAFT SEPTEMBER 2020

CONSULTANT:

BVH integrated services
206 West Newberry Road
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PROJECT:

ZERO CARBON PLANING SCENARIO
Storrs CT. 06269-3038

PROJECT NO: 300192
AUTHOR: Author
DRAFTER: Checker
SCALE: 1/4" = 1'-0"
PRINT DATE: -
SHEET TITLE:

SOUTH A SAMPLE DISTRICT PLANT

SHEET:

M-1.01

SHEET INDEX

STRM-1	STRM-2	STRM-3
STRM-4	STRM-5	STRM-6
STRM-7	STRM-8	STRM-9

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BUILDING SERVICES

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PROJECT NO: 902040
WORK ORDER NO:
FILE NAME:
2115093 - UConn Utility Framework
AUTHOR: J.D.O'N.
CHECKER: S.P.W.
SCALE: AS NOTED
PRINT DATE:
SHEET TITLE:

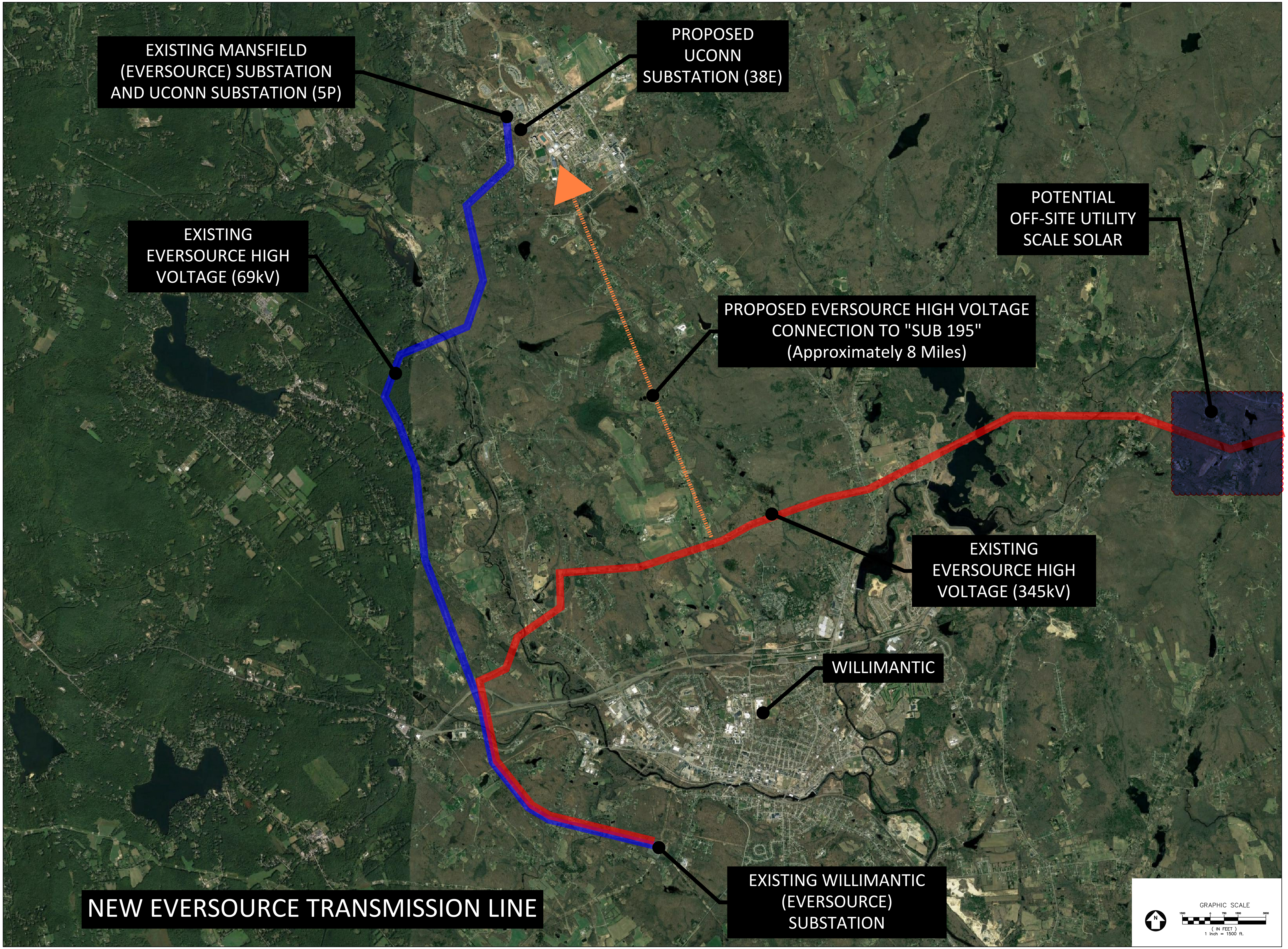
ELECTRIC
SYSTEM

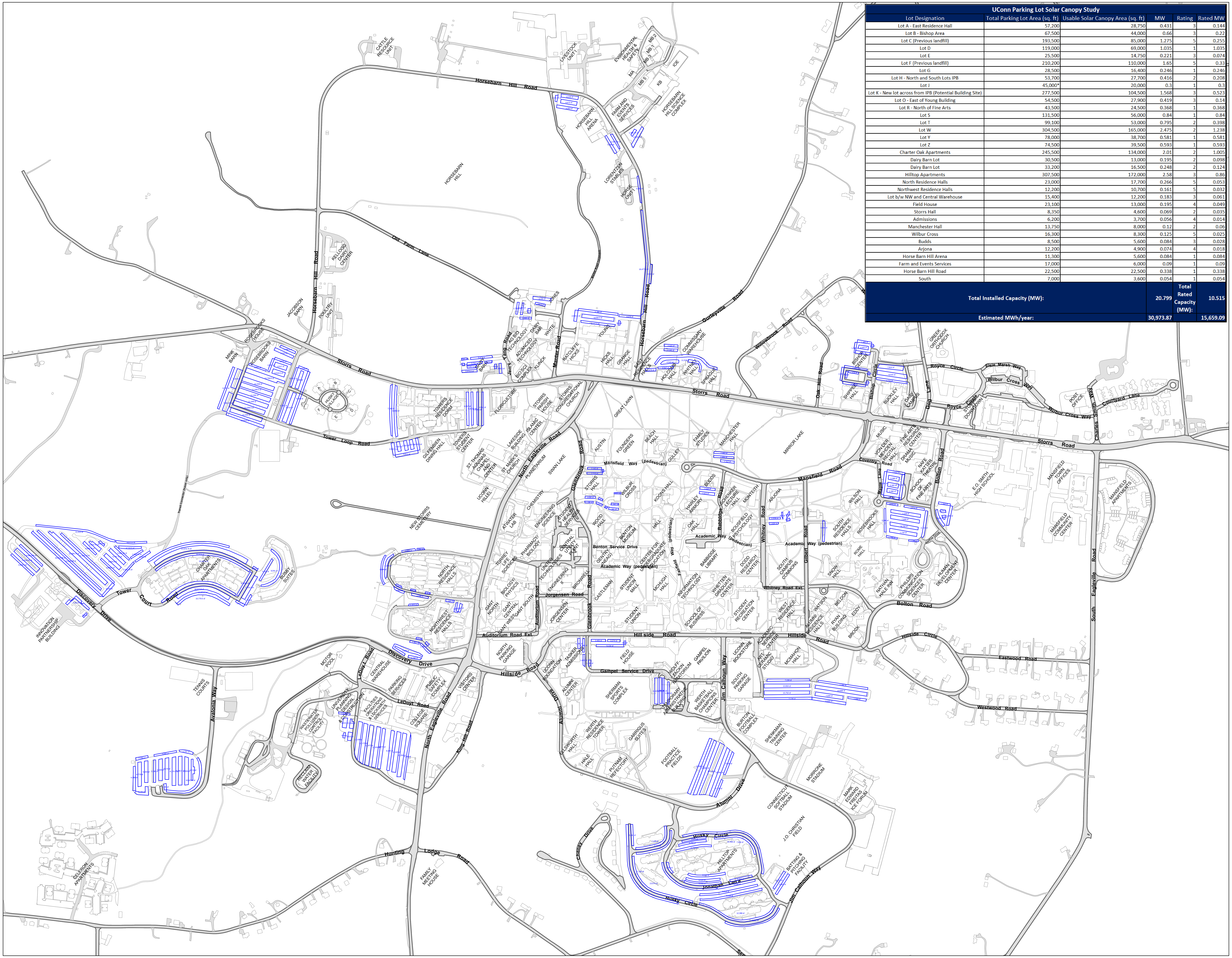
SHEET:
SHEET
INDEX

N

0 300 600
Feet

SCALE: 1"=300'


EXISTING MANSFIELD (EVERSOURCE) SUBSTATION AND UCONN SUBSTATION (5P)
PROPOSED UCONN SUBSTATION (38E)
POTENTIAL OFF-SITE UTILITY SCALE SOLAR
EXISTING EVERSOURCE HIGH VOLTAGE (69kV)
PROPOSED EVERSOURCE HIGH VOLTAGE CONNECTION TO "SUB 195" (Approximately 8 Miles)
EXISTING EVERSOURCE HIGH VOLTAGE (345kV)
WILLIMANTIC
EXISTING WILLIMANTIC (EVERSOURCE) SUBSTATION
NEW EVERSOURCE TRANSMISSION LINE
GRAPHIC SCALE
(IN FEET)
1 inch = 1500 ft.



UConn Parking Lot Solar Canopy Study

Lot Designation	Total Parking Lot Area (sq. ft)	Usable Solar Canopy Area (sq. ft)	MW	Rating	Rated MW
Lot A - East Residence Hall	57,200	28,750	0.431	3	0.144
Lot B - Bishop Area	67,500	44,000	0.66	3	0.22
Lot C (Previous landfill)	193,500	85,000	1.275	5	0.255
Lot D	119,000	69,000	1.035	1	1.035
Lot E	25,500	14,750	0.221	3	0.074
Lot F (Previous landfill)	210,200	110,000	1.65	5	0.33
Lot G	28,500	16,400	0.246	1	0.246
Lot H - North and South Lots IPB	53,700	27,700	0.416	2	0.208
Lot J	45,000*	20,000	0.3	1	0.3
Lot K - New lot across from IPB (Potential Building Site)	277,500	104,500	1.568	3	0.523
Lot O - East of Young Building	54,500	27,900	0.419	3	0.14
Lot R - North of Fine Arts	43,500	24,500	0.368	1	0.368
Lot S	131,500	56,000	0.84	1	0.84
Lot T	99,100	53,000	0.795	2	0.398
Lot W	304,500	165,000	2.475	2	1.238
Lot Y	78,000	38,700	0.581	1	0.581
Lot Z	74,500	39,500	0.593	1	0.593
Charter Oak Apartments	245,500	134,000	2.01	2	1.005
Dairy Barn Lot	30,500	13,000	0.195	2	0.098
Dairy Barn Lot	33,200	16,500	0.248	2	0.124
Hilltop Apartments	307,500	172,000	2.58	3	0.86
North Residence Halls	23,000	17,700	0.266	5	0.053
Northwest Residence Halls	12,200	10,700	0.161	5	0.032
Lot b/w NW and Central Warehouse	15,400	12,200	0.183	3	0.061
Field House	23,100	13,000	0.195	4	0.049
Storrs Hall	8,350	4,600	0.069	2	0.035
Admissions	6,200	3,700	0.056	4	0.014
Manchester Hall	13,750	8,000	0.12	2	0.06
Wilbur Cross	16,300	8,300	0.125	5	0.025
Budds	8,500	5,600	0.084	3	0.028
Arjona	12,200	4,900	0.074	4	0.018
Horse Barn Hill Arena	11,300	5,600	0.084	1	0.084
Farm and Events Services	17,000	6,000	0.09	1	0.09
Horse Barn Hill Road	22,500	22,500	0.338	1	0.338
South	7,000	3,600	0.054	1	0.054
Total Installed Capacity (MW):			20.799	Total Rated Capacity (MW):	10.515
Estimated MWh/year:			30,973.87		15,659.09

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PROJECT NO: 902040
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FILE NAME: 2115093 - UConn Utility Framework
AUTHOR: ALP
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SOLAR CANOPIES PARKING LOT MAPPING

N

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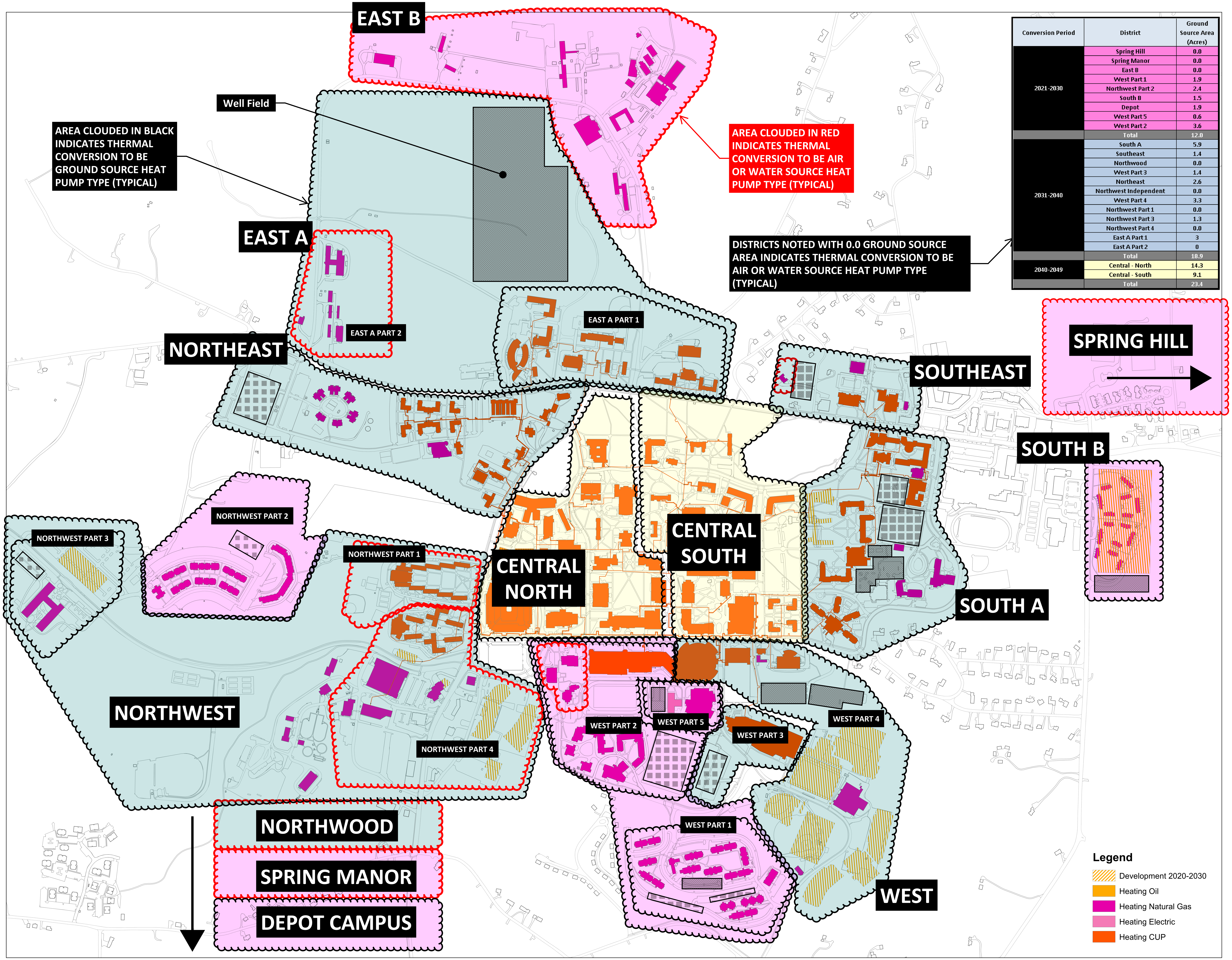
APPENDIX C

District Mapping



Conversion Period	District	Ground Source Area (Acres)
2021-2030	Spring Hill	0.0
	Spring Manor	0.0
	East B	0.0
	West Part 1	1.9
	Northwest Part 2	2.4
	South B	1.5
	Depot	1.9
	West Part 5	0.6
	West Part 2	3.6
	Total	12.0
2031-2040	South A	5.9
	Southeast	1.4
	Northwood	0.0
	West Part 3	1.4
	Northeast	2.6
	Northwest Independent	0.0
	West Part 4	3.3
	Northwest Part 1	0.0
	Northwest Part 3	1.3
	Northwest Part 4	0.0
	East A Part 1	3
	East A Part 2	0
	Total	18.9
2040-2049	Central - North	14.3
	Central - South	9.1
	Total	23.4

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FILE NAME: 2115093 - UConn Utility Framework
AUTHOR: ALP
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PRINT DATE:
SHEET TITLE:

DISTRICT MAPPING

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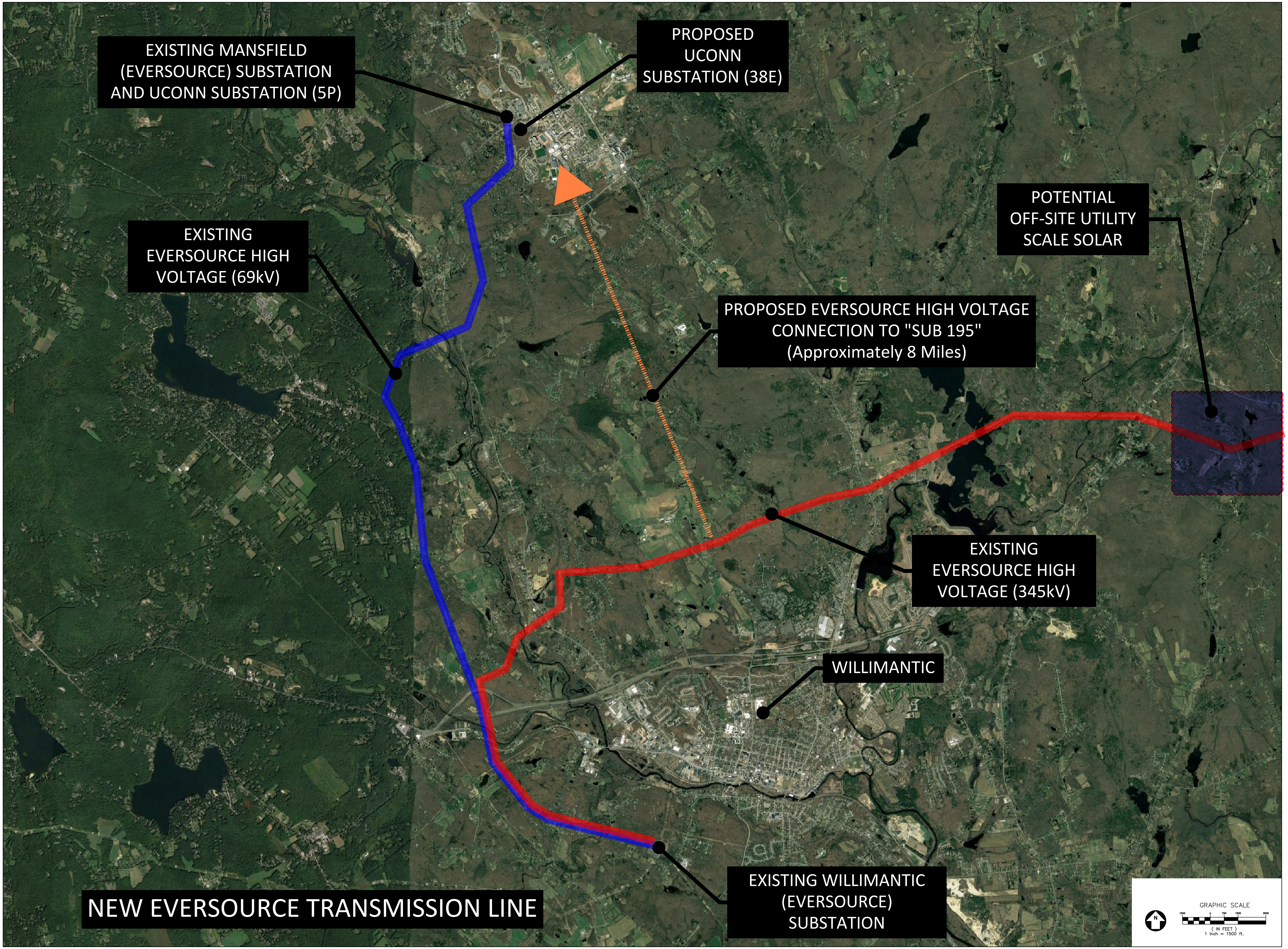
APPENDIX D

New Eversource Transmission Line Diagram


EXISTING MANSFIELD (EVERSOURCE) SUBSTATION AND UCONN SUBSTATION (5P)
PROPOSED UCONN SUBSTATION (38E)
EXISTING EVERSOURCE HIGH VOLTAGE (69kV)
POTENTIAL OFF-SITE UTILITY SCALE SOLAR
PROPOSED EVERSOURCE HIGH VOLTAGE CONNECTION TO "SUB 195" (Approximately 8 Miles)
EXISTING EVERSOURCE HIGH VOLTAGE (345kV)
WILLIMANTIC
EXISTING WILLIMANTIC (EVERSOURCE) SUBSTATION
NEW EVERSOURCE TRANSMISSION LINE
GRAPHIC SCALE
(IN FEET)
1 inch = 1500 ft.

BVH integrated services

APPENDIX E

Carbon Reduction Project (ECMs)

UNIVERSITY OF CONNECTICUT
Zero-Carbon Scenario Planning
Appendix C - Carbon Reduction Projects

CARBON REDUCTION PROJECTS

UConn Carbon Reduction Project Descriptions

The following descriptions are from the June 5th, PWGS Report Appendix A.

- **Re-Lamping (Projects not covered under ESCO, SLED or ECSP)**
  Lighting projects to convert existing fixtures to LED. These projects are being completed by UConn Facilities Operations personnel. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource in coordination with UConn's Memorandum of Understanding (MOU) Agreement to reduce energy consumption over a three-year period. If Eversource estimates were not available for certain proposed projects, energy savings factors per square foot were developed using completed lighting projects and the proposed project's building area to be converted to LED.
- **100% Conversion of Light-Duty Vehicles to Hybrid or Electric**
  Greenhouse gas reductions based on the difference in emissions between the gasoline-powered light-duty vehicles in UConn's fleet and replacement hybrid or electric vehicles.
- **Various Insulation Projects**
  The installation of insulation around bare thermal piping and valves in various building locations. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.
- **Other ECMs**
  Other Energy Conservation Measures (ECMs) include the installation of Variable Air Valve (VAV) technology in HVAC systems to allow for variable control of flow, electric chiller replacement at Castleman Hall, and replacement of dining hall cooking ventilation systems to reduce energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.
- **SLED Lighting Projects**
  Storrs LED lighting projects or SLED to convert existing fixtures to LED in approximately 3-million square feet of campus buildings. These projects will be completed by outside lighting contractors. Greenhouse gas reduction estimates are based on predicted energy savings developed by Eversource.
- **Lab Ventilation Management Program Initiative**
  A program to develop, manage, and maintain plans and procedures in consultation with EHS and Facilities Operations to ensure ventilation systems in laboratories and other work areas perform optimally, ensure worker safety, and minimize energy consumption. Greenhouse gas reduction estimates are based on predicted energy savings estimates developed by UConn Facilities Operations Energy Consultant.

Steam and Condensate Replacement Projects are to be considered part of the campus operational maintenance plan during the conversion to renewable sources.

Steam and Condensate Replacement Projects
In order to maintain existing steam infrastructure in the short-term, various repair/replacement projects may be required. Greenhouse gas reduction estimates are based on predicted energy savings for steam and condensate replacement projects consisting of approximately 2,000 to 3,000 linear feet were developed using a similar project completed under the ESCO project by ConEdison. That project resulted in the installation of approximately 2,600 linear feet of steam and condensate piping along Hillside Road.

- **Additional Building Improvements**
  Building improvements can include retro-commissioning, lighting re-lamping projects, HVAC improvements among other identified ECMs. Greenhouse gas reduction estimates are based on predicted energy savings for building improvements developed using a similar project completed under the ESCO project by ConEdison. That project included building improvements for seven energy-intensive science buildings. The project in the 2021 - 2025 timeframe would be similar in process to the ESCO project and would include up to 24 other building types such as administration, instructional, and residential; therefore, energy savings for these buildings was assumed to be half the science building energy savings. For the 2026 - 2030 timeframe, it is assumed that an additional 48 buildings may be identified for improvements based on the results of the proposed Building Assessments and Energy Audits to be completed by Facilities Operations.

- **Anaerobic Digestion**
  A proposed anaerobic digestion facility is assumed to utilize 500 tons of food waste along with manure from 100 cows managed by farm services. The processing of these materials would result in reductions of CO2 and methane emissions. Greenhouse gas emissions reductions were developed by UConn’s Framework Consultant, BVH.

- **CAHNR Sequestration Expansion**
  The setting aside of additional UConn forestland that can provide a carbon offset as a result of forest sequestration. Estimated reductions provided by the Sustainability Office.

- **Demo of Torrey Life Science**
  Greenhouse gas reduction estimates are based on predicted energy savings from the elimination of energy consumption for this science building.

DRAFT

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APPENDIX F

Geothermal Test Well Study Report

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WATER
CONSTRUCTION MANAGEMENT

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December 22, 2020
GZA File No. 05.0046697.00

Mr. Scott Waitkus, P.E.
BVH Integrated Services
206 West Newberry Road
Bloomfield, Connecticut 06002

RE: Results of Geothermal Test Well Study
University of Connecticut
Storrs, Connecticut

Dear Mr. Waitkus:

GZA GeoEnvironmental Inc. (GZA) appreciates the opportunity to have conducted three geothermal test wells on the Storrs campus of the University of Connecticut (UConn). GZA has summarized the geothermal installation, testing results, and transmitted this information to BVH Integrated Services (BVH) to be incorporated into their energy assessment. This report is subject to the Limitations attached as **Appendix A**.

BACKGROUND

GZA understands that BVH is evaluating the application of ground source heat pumps (GSHP) into UConn's heating/cooling sustainability program, and to reduce UConn's carbon footprint. To evaluate the geothermal loading potential, GZA was contracted to install three 500-foot-deep geothermal boreholes, install two types of geothermal loops (a single and double loop configuration) and to conduct thermal conductivity tests at these three locations. Boreholes were completed at:

1) TW-1 – located in the S Lot;
2) TW-2 – located along Horse Barn Hill Road off the parking spaces; and
3) TW-3 – located in the open field near W Lot and the Cell Tower.

SCOPE OF SERVICES

GZA performed the following geothermal services:

- Developed subcontract agreement with driller.
- Obtained the required Call-Before-You-Dig clearances.
- Prepared Health and Safety plan for GZA's staff.
- Coordinated with the client to locate and stake the proposed borehole in the field.
- Prepared site conditions prior to drilling.
- Drilled and logged three bedrock borehole to a depth of approximately 500 feet.
- Installed single and double loop geothermal tubing with a factory sealed U-Loop.
- Installed Single Loop design at TW-2.
- Installed Double Loop design at TW-1 and TW-3.

- Grouted the boreholes using a thermally enhanced cement/bentonite grout.
- Allowed the grouted borehole to stabilize (due to exothermal reaction with grout) for 5-days.
- Conducted three independent 48-hour thermal conductivity tests, and
- Prepared this summary report.

TEST WELL INSTALLATION

Test Well Locations

The proposed geothermal test wells were staked in the field by the client representative and GZA on October 26, 2020. These locations were selected based on known utility locations and drill rig accessibility. On November 9, 2020, GZA contracted Underground Surveying, LLC to conduct a ground penetration radar (GPR) study, to confirm the presence/absence of utilities in the selected test well locations and pit locations, at the staked locations. These locations were defined as follows:

- TW-1 – located in the S Lot (**Figure 2A**)
- TW-2 – located along Horse Barn Hill Road off the parking spaces (**Figure 2B**)
- TW-3 – located in the open field near W Lot and the Cell Tower (**Figure 2C**).

Fluid & Cuttings Pit Excavation

On November 17, 2020, GZA contracted Cisco Geotechnical, LLC (Cisco) to excavate shallow pits to retain drill cuttings and formation water. These pits were located adjacent to the proposed test well locations. The pits were approximately 12-feet square approximately 6-feet deep, except at TW-1 where a storm pipe and asphalt curbing restricted the size of the pit. Upon completion, orange construction fence was secured around each pit and a secondary security barrier comprised of cones and yellow chain was placed around the proposed work zone.

Geothermal Borehole Installation

Prior to drilling, Connecticut Wells Inc. (CWI), installed silt fence and hay bales around the pits for additional drilling fluids and cutting containment. Once control measures were in place, CWI advanced a 6-inch diameter core-bit to drill the borehole using an air rotary drill rig. Initially, drilling was to advance through the overburden soil and into competent bedrock to set casing. A summary of casing advancement, at each test well, is provided on **Table 1.0**.

Table 1.0

Test Well	Thickness of Overburden (ftbg)	Top of Weathered Bedrock (ftbg)	Top of Competent Bedrock (ftbg)	Depth of Casing (ftbg)
TW-1	20	20	26	39
TW-2	80	80	110	119
TW-3	52	52	65	79

ftbg = feet below grade

Water bearing fractures were encountered while drilling TW-3, at multiple intervals. The amount of water exceeded the containment pit with a final estimated flow rate of 75 gallons per minute (gpm). GZA discussed with Mr. Michael Lombardi (UConn) the possibility of pumping the water from the pit overland through the woods, north of the drill rig, after being retained by an additional silt fence. This process was approved. The discharge water, while cloudy, flowed through the wood and infiltrated prior to reaching a small stream further downgradient of the discharge.

After casing installation, the boreholes were advanced to 500 feet below grade (see driller's "well drilling completion report" in **Appendix B** and GZAs boring logs in **Appendix C**). GZA timed the rate of penetration through the bedrock which was generally consistent between boreholes at a rate of 1 foot per minute.

Bedrock Geology

Prior to drilling, GZA reviewed the Connecticut Environmental Conditions Online (CT ECO) data base for regional overburden soil classifications and bedrock descriptions. CT ECO's database uses the "*Bedrock Geological Map of Connecticut", complied by John Rodgers, 1985* as its source. **Figure 3** presents the mapped overburden soil classification and **Figure 4** presents the mapped bedrock formations. TW-1 was located in the Hebron Gneiss and TW-2 and TW-3 are located in the Lower Member of the Bigelow Brook Formation (a schist). GZA notes, a fault line running east to west separates the two bedrock formations. Both schist and gneiss are metamorphic rocks with similar physical properties. A summary of our review is presented on **Table 2.0**.

Table 2.0

Well ID	Mapped Overburden	Mapped Bedrock
TW-1	Glacial Till	Hebron Gneiss - Interlayered dark-gray, medium- to coarse-grained schist, composed of andesine, quartz, biotite, and local K-feldspar, and greenish-gray, fine- to medium-grained calc-silicate rock, composed of labradorite, quartz, biotite, actinolite, hornblende, and diopside, and locally scapolite. Local lenses of graphitic two-mica schist
TW-2	Glacial Till	Lower Member of Bigelow Brook Formation - gray medium grained Granofel/Schist (see Note 1).
TW-3	Glacial Till	Lower Member of Bigelow Brook Formation - gray medium grained Granofel/Schist (see Note 1)

1. *Schist is medium grade metamorphic rock, formed by the metamorphosis of mudstone / shale, or some types of igneous rock.*

As the borehole was advanced, GZA collected drill cuttings to describe changes in the bedrock. These observations are provided on boring logs in **Appendix C**. These conditions reflect the drilling conditions at the borehole and may differ in a larger field of geothermal wells. However, based upon the geology discussed above, the bedrock was generally consistent with the type of bedrock reported by CT ECO.

The geologic lithologies of the bedrock formations were logged through visual observation of the drill cuttings as the borehole was advanced. The subsurface conditions and strata changes observed were estimated based on

GZA's observations of changes in drilling effort and soil cuttings. The actual geothermal well field subsurface conditions may be different from borehole to borehole. A summary of the geology encountered is summarized on **Table 3.0**.

Table 3.0

Test Well	Overburden	Bedrock
TW-1	Glacial Till to 20 ftbg	• Weathered Gray, mica schist (20 to 26 ftbg) • Gray, Mica Schist (26-200 ftbg) with a Quartz seam at (193 to 194 ftbg) • White Quartzite (200-270 ftbg) • Gray, mica schist (270-500 ftbg)
TW-2	Glacial Till to 80 ftbg	• Highly Weathered Gray, Granofel (80 to 110 ftbg) • Gray, Granofel (110 to 500 ftbg)
TW-3	Glacial Till to 52 ftbg	• Weathered Gray, Granofel (52 to 65 ftbg) • Gray, Granofel (65 to 500 ftbg)

ftbg = feet below grade

The bedrock encountered during drilling was consistent with the mapping by USGS (see **Figure 4** - Bedrock Geology Map), except at TW-1 where a quartzite unit was encountered from 200 fbgs to approximately 270 fbgs. Both schist and gneiss are metamorphic rocks with similar physical properties. They are difficult to discriminate from one another based on drill cutting observations alone.

As drilling advanced, the amount of water was estimated from fractures encountered within the formations. **Table 4.0** summarizes the estimated yield from water bearing fractures.

Table 4.0

Test Well	Fracture Zones	Estimated Yield
TW-1	64 ftbg 160 ftbg 170 ftbg 225 ftbg	Trace water ~ 2 gpm No additional water No additional water
TW-2	200 to 220 ftbg 352 ftbg 410 ftbg	No distinct fracture - ~1 gpm No additional water No additional water
TW-3	76 ftbg 95 ftbg 145 ftbg 205 ftbg 225 ftbg 300 ftbg 310 ftbg 355 ftbg	~ 2 gpm ~ 3 gpm – total well yield ~ 5gpm No additional water No additional water ~ 15 gpm – total well yield ~ 20 gpm ~ 55 gpm – total well yield ~ 75 gpm No additional water No additional water

At the completion of the boreholes, the driller's estimated the water yield from each well as being approximately <2 gallon per minute from wells TW-1 and TW-2 and approximately 75 gallons per minute from well TW-3, based on a bucket test. A significant water bearing fracture zone was encountered at TW-3 between 225 and 300 ftbg.

Geothermal "geo-loop" Installation

Part of the overall study was to assess 1) thermal capacity of the two different bedrock formations and 2) to evaluate different loading capacities between a single and double geothermal loop configuration. The tests included:

A single and a double geothermal loop were installed in the Lower Member of Bigelow Brook Formation (TW-2 and TW-3) and a single loop was installed in the Hebron Gneiss (TW-1). Factory sealed High Density Polyethylene (HDPE) geothermal loops with a fuse-jointed U-bend were installed in the boreholes. The purpose of the U-bend permits water to be circulated downward through one of the geothermal borehole pipes and the water is then returned up the other pipe connected to the U-bend. This process permits either heating and/or cooling water entering the geothermal borehole to be circulated through the borehole which acts as a heat exchanger. Prior to installation, clean water was added to the geo-loops, to counteract the buoyancy effect of the pipe. The test wells were constructed as follows:

1. The single loop was comprised of two 1.25-inch diameter "geo-loop" pipes that were unreeled off the factory spool into the 500-foot deep borehole. At the bottom of the two-pipe system was a single fuse-jointed U-bend.
2. The double loop was comprised of four 1.00-inch diameter "geo-loop" pipes that were unreeled off the factory spool into the 500-foot deep borehole. At the bottom of the four-pipe system were two single fuse-jointed U-bends. Due to the number of pipes in the 6-inch borehole, spacers were connected to the four pipes every 20-feet to permit each pipe to become in contact with the grout.

Following installation at each well, CT Wells grouted the borehole with the "geo-loop" piping using a thermally enhanced grout. The mixture was pumped via a piston drive grout pump through a tremie pipe from the base of the borehole to the surface (bottom to top). The grout mixture is summarized on **Table 5.0**. Variations in the grout volume reflect the number of pipes in the boreholes and accounts for fracture zones that would use more grout and the borehole is sealed.

Table 5.0

Test Well	Water (gallons)	Thermal Grout Lite (2-50-pound bags/batch)	PowerTEC Graphite (1-32-pound bags per batch)	Batches per well	Total Grout Volume (gallons)
TW-1	672	42	21	21	802.2
TW-2	768	48	24	24	916.8
TW-3	52	56	28	28	1,069.6

Copies of the grout manufacturing and specifications are included in **Appendix D**.

Pit Restoration

Drill cuttings and fluids directed to the pits, during drilling, were excavated and removed on November 24 and 25, 2020 by our subcontractor. After removal, the pits were backfilled and compacted with the previously excavated soils. Due the low permeability of glacial till, the pits retained. To clear the pits, the water was discharged onto the ground surface, contained within silt fencing and allowed to infiltrate into the ground or flow across the fencing then infiltrated.

After water was removed from the pit, a slurry from the rock cuttings remained in the pit which could not fully be removed. Dry soils from the stockpile were added to the slurry prior to compaction. Compaction of the backfilled soils was limited to bucket compaction.

After the pits were backfilled, they were topped with topsoil along with other disturbed areas. These areas were seeded and hayed to stabilize the soils.

Thermal Conductivity Testing

Between November 25 and December 4, 2020 (a minimum of 5 days after grout installation) GZA and CT Wells remobilized to the Site to initiate independent 48-hour thermal conductivity tests. A field generator (enclosed within an insulated trailer) was used to provide the required power to conduct the test. Instrumentation was connected to the “geo-loop” through an exterior connector (see photographs in **Appendix E**) to measure the performance of the test.

The tests were conducted by circulating heated water at a constant rate and temperature through the HDPE pipe loop installed in the borehole. Insulating sleeves and reflective blankets were placed around the above-ground portions of the polyethylene loop to limit the influence of ambient air on the water temperature.

To establish the undisturbed bedrock formation temperature, un-heated water was circulated through the “geo-loop” piping for 45 minutes and recorded by the instrument. Once the baseline formation temperatures were established, the heat was turned on. Heated water was circulated and the temperature at the inlet and outlet locations of the geo-loop was monitored using an automatic data logger for 48 hours. The following parameters were recorded during the 48-hour test:

1. Thermal conductivity - the rate of heat transfer across a unit thickness of the material when there is a unit temperature gradient across two surfaces of the material. It is a measure of the ability of a material to transfer heat.
2. Thermal diffusivity - the ratio of thermal conductivity to specific heat capacity and indicates the rate with time that substances equilibrate thermally with their surroundings. To estimate thermal diffusivity, it is necessary to estimate the specific heat capacity for the separate formation strata. A weighted average of these values is then used to develop an average heat capacity for the formation.
3. Hear Input Rate – the rate that heated water is circulated through the geo-loop.

Table 6.0 summarizes the thermal conductivity test parameters and results for the three wells.

Table 6.0

Well ID	TW-1	TW-2	TW-3
Loop Configuration (single or double loop)	Double	Single	Double
Undisturbed Bedrock Formation Temp (°F)	53.9-54.8	52.2-53	50.4-51.2
Flow Rate (gpm)	8.8	9	9.7
Heat input rate (BTU/hr)	33,985	34,019	34,661
Heat input rate per foot (BTU/hr)	68	69	69.3
Formation Thermal Diffusivity (ft^2/day)	1.16	1.28	1.35
Formation Thermal Conductivity (Btu/hr-ft-°F)	1.85	1.95	2.06

After completion of each of the three tests, the equipment was turned off and disconnected. The HDPE geo-loop pipe and casing were cut slightly below grade and sealed. The area around the well was raked, seeded and hayed after the trailer used to conduct the thermal conductivity test had been removed from the Site.

Upon completion of the thermal conductivity test, the recorded data was forwarded to Geothermal Resources Technologies, Inc. (GRTI) for analyses. The results of the test and an explanation of the reported parameters are provided in GRTI's Report which is included in **Appendix F**.

CONCLUSIONS AND RECOMMENDATIONS

GZA understands that BVH will use these thermal conductivity test results to estimate the number of boreholes required to design a geothermal heating/cooling system using heat pumps. The data collected is consistent with previous desktop reviews completed for UCONN and it is GZA's opinion that the subsurface conditions are suitable for a closed loop geothermal system. The final design will require that the thermal well field be modeled to estimate optimum separation between wells.

The side by side comparison between the single and double loop geo-loops indicated:

- The single and double geo-loops installed in the Lower Member of Bigelow Brook Formation (TW-2 (single) and TW-3 (double) reported an approximately 6% increase in formation thermal conductivity at TW-3. This may be a direct contribution from the double loop system or that TW-3 had a greater yield of water from bedrock fractures.

- The second double loop was installed at TW-1 within the Hebron Gneiss. In comparing the double loops (TW-1 versus TW-3) the formation thermal conductivity results at TW-3 was approximately 11% greater.

- The reported results between the single loop at TW-2 (Lower Member of Bigelow Brook Formation) and the double loop at TW-1 (Hebron Gneiss) indicates that there was a 5% increase of formation thermal conductivity at TW-2, the single loop well.

These data suggest that the Lower Member of Bigelow Brook Formation provides a greater formation thermal conductivity, perhaps due to the inclusion of graphite that may be present in this formation. However, based upon these test results, in all cases the Hebron Gneiss appears to have a lower formation thermal conductivity. This will not preclude development of a geothermal well field in the Hebron Gneiss just that there will be the need for additional boreholes.

The greatest concern noted during drilling, that may influence construction costs, was the excess water encountered at TW-3. Should a large geothermal field be designed in this area, either a water management plan or change in drilling methods should be considered. At other the other locations, water may also be an issue but was not encountered during the advancement of the test wells.

We hope this report satisfies your current requirements. GZA looks forward to continuing our involvement on this project. If you have any question regarding this analysis or want to discuss these finding, please do not hesitate to contact us.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Benjamin D. Rach
Project Manager

David Barstow, P.E.
Consultant Reviewer

Richard J. Desrosiers, P.G., LEP
Associate Principal

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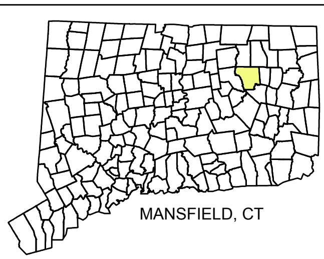
Attachments:

Figure 1 – Site Locus Map
Figure 2A – Geothermal Test Well Location TW-1
Figure 2B – Geothermal Test Well Location TW-2
Figure 2C - Geothermal Test Well Location TW-3
Figure 3 – Soil Classification Map
Figure 4 – Bedrock Geology Map

Appendix A – Limitations
Appendix B – Well Drilling Completion Report
Appendix C – GZA Well Logs
Appendix D – Grout and Sand Specifications
Appendix E – Photographs
Appendix F – Geothermal Test Results

FIGURES



SOURCE:GOOGLE EARTH PROFESSIONAL AERIAL IMAGE CAPTURED APRIL 2018

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SCALE IN FEET

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PROJ MGR: BDR
DESIGNED BY: BDR
REVIEWED BY: RJD
DRAWN BY: MJT

DATE: 12-15-2020

LOCUS MAP

UNIVERSITY OF CONNECTICUT
STORRS, CT

PROJECT NO.: 05.0046697.00

FIGURE NO. 1

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NOTES:

1. 2019 AERIAL PHOTO OBTAINED FROM CT ECO ONLINE DATABASE

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SCALE IN FEET

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UNIVERSITY OF CONNECTICUT
STORRS, CT

SITE PLAN SHOWING TW-1 LOCATION

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: BVH INTEGRATED SERVICES	
PROJ MGR: BDR	REVIEWED BY: RJD	CHECKED BY: BDR	FIGURE 2A
DESIGNED BY: BDR	DRAWN BY: MJT	SCALE: AS SHOWN	
DATE: 12-15-2020	PROJECT NO. 05.0046697.00	REVISION NO.	SHEET NO. 1 OF 1

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NOTES:

1. 2019 AERIAL PHOTO OBTAINED FROM CT ECO ONLINE DATABASE

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0 20 40 80

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UNIVERSITY OF CONNECTICUT
STORRS, CT

SITE PLAN SHOWING TW-2 LOCATION

PREPARED BY:	PREPARED FOR:
GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com	BVH INTEGRATED SERVICES

PROJ MGR: BDR	REVIEWED BY: RJD	CHECKED BY: BDR	FIGURE
DESIGNED BY: BDR	DRAWN BY: MJT	SCALE: AS SHOWN	2B
DATE: 12-15-2020	PROJECT NO. 05.0046697.00	REVISION NO.	SHEET NO. 1 OF 1

NOTES:

1. 2019 AERIAL PHOTO OBTAINED FROM CT ECO ONLINE DATABASE

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UNIVERSITY OF CONNECTICUT
STORRS, CT

SITE PLAN SHOWING TW-3 LOCATION

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com

PREPARED FOR: BVH INTEGRATED SERVICES

PROJ MGR: BDR	REVIEWED BY: RJD	CHECKED BY: BDR	FIGURE 2C
DESIGNED BY: BDR	DRAWN BY: MJT	SCALE: AS SHOWN	
DATE: 12-15-2020	PROJECT NO. 05.0046697.00	REVISION NO.	SHEET NO. 1 OF 1

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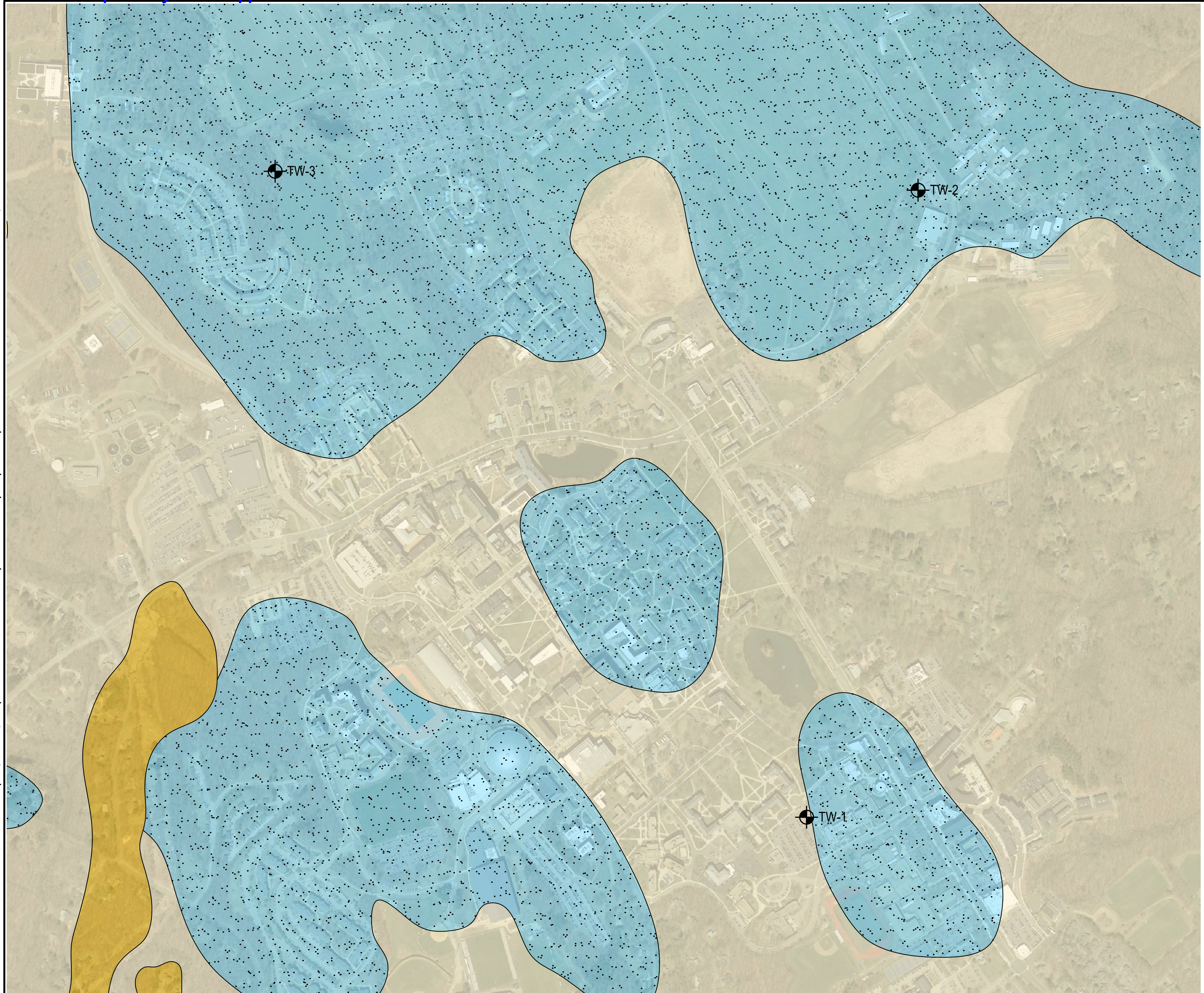


NOTES:

1. BASE MAP: SURFICIAL MATERIALS MAP OF CONNECTICUT OBTAINED FROM CT ECO ONLINE WEB MAPPING SERVICE.

NO.	ISSUE/DESCRIPTION	BY	DATE

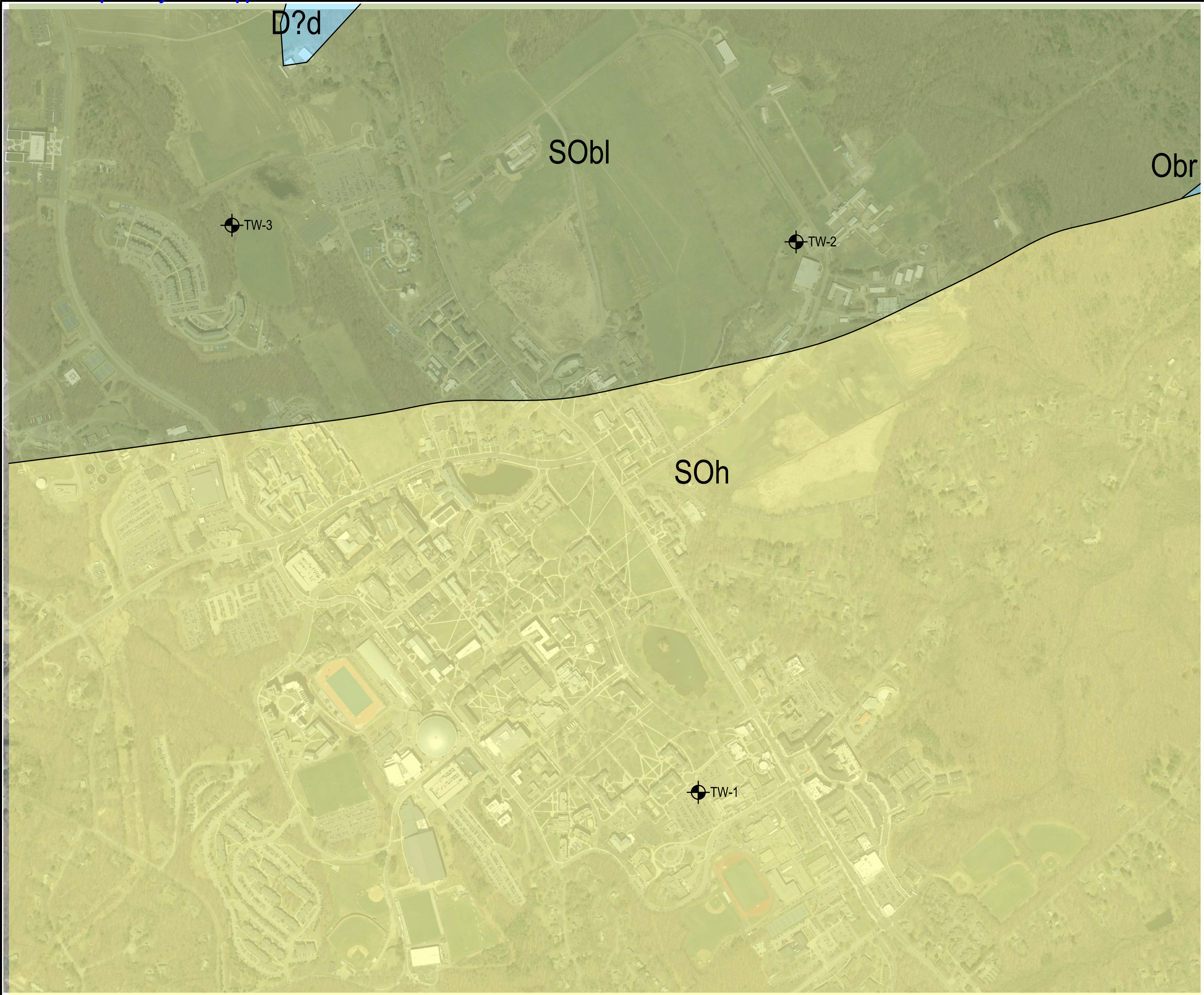
UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR ALTERED IN ANY MANNER FOR USE AT ANY OTHER LOCATION OR FOR ANY OTHER PURPOSE WITHOUT THE PRIOR WRITTEN CONSENT OF GZA. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING BY THE CLIENT OR OTHERS, WITHOUT THE PRIOR WRITTEN EXPRESS CONSENT OF GZA, WILL BE AT THE USER'S SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

UNIVERSITY OF CONNECTICUT
STORRS, CT

SOIL CLASSIFICATION MAP

PREPARED BY: GZA GeoEnvironmental, Inc. Engineers and Scientists www.gza.com		PREPARED FOR: BVH INTEGRATED SERVICES	
PROJ MGR: BDR	REVIEWED BY: RJD	CHECKED BY: BDR	FIGURE 3
DESIGNED BY: BDR	DRAWN BY: MJT	SCALE: AS SHOWN	
DATE: 12-15-2020	PROJECT NO. 05.0046697.00	REVISION NO.	SHEET NO. 1 OF 1

©2018 – GZA GeoEnvironmental, Inc. GZA-J:_46,500-46,999\46697.H97 BVH INTEGRATED\46697-00.RJD\CAD\FIGURES\B-FIG-GEOTHERM.DWG F3 11X17 DECEMBER 17, 2020 MICHAEL TUMOLO



LEGEND

SOh	HEBRON GNEISS
SObl	LOWER MEMBER OF BIGELOW BROOK FORMATION
OBr?	BRIMFIELD SCHIST
D?D	FOLIATED QUARTZ DIORIATE

NOTES:

1. BASE MAP: BEDROCK GEOLOGY MAP OF CONNECTICUT OBTAINED FROM CT ECO ONLINE WEB MAPPING SERVICE.

N

0 400 800 1600

SCALE IN FEET

NO.	ISSUE/DESCRIPTION	BY	DATE

UNLESS SPECIFICALLY STATED BY WRITTEN AGREEMENT, THIS DRAWING IS THE SOLE PROPERTY OF GZA GEOENVIRONMENTAL, INC. (GZA). THE INFORMATION SHOWN ON THE DRAWING IS SOLELY FOR USE BY GZA'S CLIENT OR THE CLIENT'S DESIGNATED REPRESENTATIVE FOR THE SPECIFIC PROJECT AND LOCATION IDENTIFIED ON THE DRAWING. THE DRAWING SHALL NOT BE TRANSFERRED, REUSED, COPIED, OR ALTERED IN ANY MANNER FOR USE AT ANY OTHER LOCATION OR FOR ANY OTHER PURPOSE WITHOUT THE PRIOR WRITTEN CONSENT OF GZA. ANY TRANSFER, REUSE, OR MODIFICATION TO THE DRAWING BY THE CLIENT OR OTHERS, WITHOUT THE PRIOR WRITTEN EXPRESS CONSENT OF GZA, WILL BE AT THE USER'S SOLE RISK AND WITHOUT ANY RISK OR LIABILITY TO GZA.

UNIVERSITY OF CONNECTICUT
STORRS, CT

BEDROCK GEOGRAPHIC MAP

PREPARED BY:
GZA GeoEnvironmental, Inc.
Engineers and Scientists
www.gza.com

PREPARED FOR:
BVH INTEGRATED SERVICES

PROJ MGR: BDR	REVIEWED BY: RJD	CHECKED BY: BDR	FIGURE
DESIGNED BY: BDR	DRAWN BY: MJT	SCALE: AS SHOWN	4
DATE: 12-15-2020	PROJECT NO. 05.0046697.00	REVISION NO.	SHEET NO. 1 OF 1

©2018 – GZA GeoEnvironmental, Inc. GZA-J:_46,500-46,999\46697.H97 BVH INTEGRATED\46697-00.RJD\CAD\FIGURES\B-FIG-GEOTHERM.DWG F4 11X17 DECEMBER 17, 2020 MICHAEL TUMOLO

APPENDIX A
LIMITATIONS

USE OF REPORT

1. GZA GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of our Client for the stated purpose(s) and location(s) identified in the Proposal for Services and/or Report. Use of this report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions; and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not expressly identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

STANDARD OF CARE

2. GZA's findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Proposal for Services and/or Report and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).

3. GZA's services were performed using the degree of skill and care ordinarily exercised by qualified professionals performing the same type of services, at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made. Specifically, GZA does not and cannot represent that the Site contains no hazardous material, oil, or other latent condition beyond that observed by GZA during its study. Additionally, GZA makes no warranty that any response action or recommended action will achieve all of its objectives or that the findings of this study will be upheld by a local, state or federal agency.

4. In conducting our work, GZA relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Inconsistencies in this information which we have noted, if any, are discussed in the Report.

SUBSURFACE CONDITIONS

5. The generalized soil profile(s) provided in our Report are based on widely-spaced subsurface explorations and are intended only to convey trends in subsurface conditions. The boundaries between strata are approximate and idealized, and were based on our assessment of subsurface conditions. The composition of strata, and the transitions between strata, may be more variable and more complex than indicated. For more specific information on soil conditions at a specific location refer to the exploration logs. The nature and extent of variations between these explorations may not become evident until further exploration or construction. If variations or other latent conditions then become evident, it will be necessary to reevaluate the conclusions and recommendations of this report.

6. Water level readings have been made, as described in this Report, in and monitoring wells at the specified times and under the stated conditions. These data have been reviewed and interpretations have been made in this report. Fluctuations in the level of the groundwater however occur due to temporal or spatial variations in areal recharge rates, soil heterogeneities, the presence of subsurface utilities, and/or natural or artificially induced perturbations. The observed water table may be other than indicated in the Report.

COMPLIANCE WITH CODES AND REGULATIONS

7. We used reasonable care in identifying and interpreting applicable codes and regulations necessary to execute our scope of work. These codes and regulations are subject to various, and possibly contradictory, interpretations. Interpretations and compliance with codes and regulations by other parties is beyond our control.

SCREENING AND ANALYTICAL TESTING

8. GZA collected environmental samples at the locations identified in the Report. These samples were analyzed for the specific parameters identified in the report. Additional constituents, for which analyses were not conducted, may be present in soil, groundwater, surface water, sediment and/or air. Future Site activities and uses may result in a requirement for additional testing.

9. Our interpretation of field screening and laboratory data is presented in the Report. Unless otherwise noted, we relied upon the laboratory's QA/QC program to validate these data.

10. Variations in the types and concentrations of contaminants observed at a given location or time may occur due to release mechanisms, disposal practices, changes in flow paths, and/or the influence of various physical, chemical, biological or radiological processes. Subsequently observed concentrations may be other than indicated in the Report.

INTERPRETATION OF DATA

11. Our opinions are based on available information as described in the Report, and on our professional judgment. Additional observations made over time, and/or space, may not support the opinions provided in the Report.

ADDITIONAL INFORMATION

12. In the event that the Client or others authorized to use this report obtain additional information on environmental or hazardous waste issues at the Site not contained in this report, such information shall be brought to GZA's attention forthwith. GZA will evaluate such information and, on the basis of this evaluation, may modify the conclusions stated in this report.

ADDITIONAL SERVICES

13. GZA recommends that we be retained to provide services during any future investigations, design, implementation activities, construction, and/or property development/ redevelopment at the Site. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

APPENDIX B
WELL DRILLING COMPLETION REPORT

PWGSE Report May 2021 - Appendix C

STATE OF CONNECTICUT
DEPARTMENT OF CONSUMER PROTECTION
REAL ESTATE & PROFESSIONAL TRADES DIVISION
WELL DRILLLING COMPLETION REPORT
165 Capitol Avenue, Hartford, Connecticut 06106

DO NOT fill in
STATE WELL NO.
OTHER NO.

OWNER	NAME: GZA ATTN: RICH DESROSIERS	ADDRESS: 95 GLASTONBURY BLVD 3RD FLOOR GLASTONBURY
LOCATION OF WELL	(No & Street) MAPLE LANE (Town) STORRS-MANSFIELD	(Lot Number)

PROPOSED USE OF WELL	☐ DOMESTIC	☐ BUSINESS ESTABLISHMENT	☐ FARM	☒ TEST (GEOTHERMAL) WELL
	☐ PUBLIC SUPPLY	☐ INDUSTRIAL	☐ AIR CONDITIONING	☐ OTHER
DRILLING EQUIPMENT	☐ ROTARY	☒ COMPRESSED AIR PERCUSSION	☐ .	☐ OTHER (Specify)

CASING DETAILS	LENGTH (feet)	DIAMETER (inches)	WEIGHT PER FOOT	THREADED	WELDED	DRIVE SHOE	WAS CASING GROUTED?
	27	6	17	☒	☐	☒ YES ☐ NO	☒ YES ☐ NO

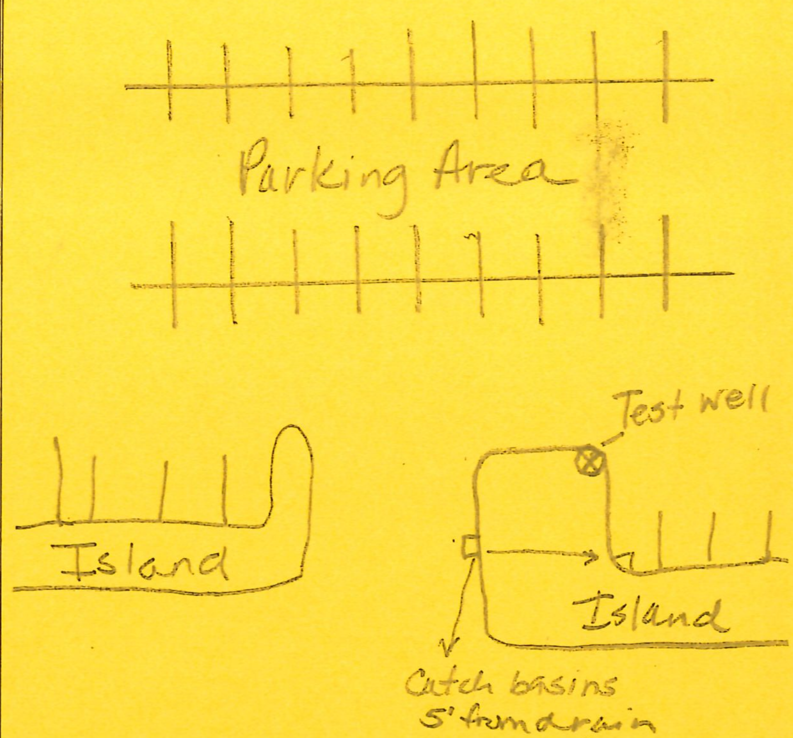
YIELD TEST	☐ BAILED	☐ PUMPED	☒ COMPRESSED AIR	HOURS: 4	YIELD(GPM): 1

WATER LEVEL	MEASURE FROM LAND SURFACE – STATIC (Specify feet)	DURING YIELD TEST (feet)	Depth of Completed Well in feet
	25	495	500

SCREEN DETAILS	MAKE					LENGTH OPEN TO AQUIFER (feet)	
	SLOT SIZE	DIAMETER (inches)	IF GRAVEL PACKED	Diameter of well including gravel pack (inches)	GRAVEL SIZE (inches)	FROM (feet)	TO (feet)

DEPTH FROM LAND TO SURFACE FEET TO FEET		FORMATION DESCRIPTION
0	23	SAND AND GRAVEL
23	26	SOFT BEDROCK
26	500	BEDROCK

Sketch exact location of well with distances to at least two permanent landmarks



If yield was tested at different depths during drilling, list below

FEET	GALLONS PER MINUTE
200	1

DATE WELL COMPLETED	PERMIT NO	REGISTRATION NO	DATE OF REPORT	WELL DRILLER (Signature)
11/19/20	270936	4	12/8/20	

Owner · Contractor · Dept of Consumer Protection · Dept of Environmental Protection - Water Resources · Local Director of Public Health

Form provided by Forms On-A-Disk, Inc. · Dallas, Texas · (214) 340-9429

STATE OF CONNECTICUT
DEPARTMENT OF CONSUMER PROTECTION
REAL ESTATE & PROFESSIONAL TRADES DIVISION

WELL DRILLLING COMPLETION REPORT

165 Capitol Avenue, Hartford, Connecticut 06106

DO NOT fill in
STATE WELL NO.
OTHER NO.

OWNER	NAME: GZA ATTN: RICH DESROSIERS	ADDRESS: 95 GLASTONBURY BLVD 3RD FLOOR GLASTONBURY
LOCATION OF WELL	(No & Street) 3212 HORSEBARN HILL ROAD (Town) STORRS-MANSFIELD	(Lot Number)

PROPOSED USE OF WELL	DOMESTIC	☐ BUSINESS ESTABLISHMENT	☐ FARM	☒ TEST (GEOTHERMAL) WELL
	☐ PUBLIC SUPPLY	☐ INDUSTRIAL	☐ AIR CONDITIONING	☐ OTHER
DRILLING EQUIPMENT	☐ ROTARY	☒ COMPRESSED AIR PERCUSSION	☐	☐ OTHER (Specify)

CASING DETAILS	LENGTH (feet)	DIAMETER (inches)	WEIGHT PER FOOT			DRIVE SHOE	WAS CASING GROUTED?
	120	6	17	☒ THREADED	☐ WELDED	☒ YES ☐ NO	☒ YES ☐ NO

YIELD TEST				HOURS	YIELD(GPM)
	☐ BAILED	☐ PUMPED	☒ COMPRESSED AIR	4	2

WATER LEVEL	MEASURE FROM LAND SURFACE – STATIC (Specify feet)	DURING YIELD TEST (feet)	Depth of Completed Well in feet
	25	495	500

SCREEN DETAILS	MAKE					LENGTH OPEN TO AQUIFER (feet)	
	SLOT SIZE	DIAMETER (inches)	IF GRAVEL PACKED	Diameter of well including gravel pack (inches)	GRAVEL SIZE (inches)	FROM (feet)	TO (feet)

DEPTH FROM LAND TO SURFACE FEET TO FEET		FORMATION DESCRIPTION
0	15	SAND
15	80	TILL W/GRAVEL
80	110	SOFT BEDROCK
110	500	BEDROCK

Sketch exact location of well with distances to at least two permanent landmarks

If yield was tested at different depths during drilling, list below

FEET	GALLONS PER MINUTE
175	1
425	2

DATE WELL COMPLETED	PERMIT NO	REGISTRATION NO	DATE OF REPORT	WELL DRILLER (Signature)
11/20/20	270937	4	12/8/20	

Owner · Contractor · Dept of Consumer Protection · Dept of Environmental Protection - Water Resources · Local Director of Public Health

Form provided by Forms On-A-Disk, Inc. · Dallas, Texas · (214) 340-9429

STATE OF CONNECTICUT
DEPARTMENT OF CONSUMER PROTECTION
REAL ESTATE & PROFESSIONAL TRADES DIVISION

WELL DRILLLING COMPLETION REPORT

165 Capitol Avenue, Hartford, Connecticut 06106

DO NOT fill in
STATE WELL NO.
OTHER NO.

OWNER	NAME: GZA ATTN: RICH DESROSIERS	ADDRESS: 95 GLASTONBURY BLVD 3RD FLOOR GLASTONBURY
LOCATION OF WELL	(No & Street) LAUREL WAY (Town) STORRS-MANSFIELD	(Lot Number)
PROPOSED USE OF WELL	DOMESTIC; [ ] PUBLIC SUPPLY; [ ] BUSINESS ESTABLISHMENT; [ ] INDUSTRIAL	[ ] FARM; [ ] AIR CONDITIONING; [X] TEST (GEOTHERMAL) WELL; [ ] OTHER
DRILLING EQUIPMENT	[ ] ROTARY; [X] COMPRESSED AIR PERCUSSION	[ ] ; [ ] OTHER (Specify)

CASING DETAILS	LENGTH (feet)	DIAMETER (inches)	WEIGHT PER FOOT	THREADED	WELDED	DRIVE SHOE	WAS CASING GROUTED?
	80	6	17	[X]	[ ]	[X] YES [ ] NO	[X] YES [ ] NO

YIELD TEST		HOURS	YIELD (GPM)
	[ ] BAILED [ ] PUMPED [X] COMPRESSED AIR	4	80

WATER LEVEL	MEASURE FROM LAND SURFACE – STATIC (Specify feet)	DURING YIELD TEST (feet)	Depth of Completed Well in feet
	25	495	500

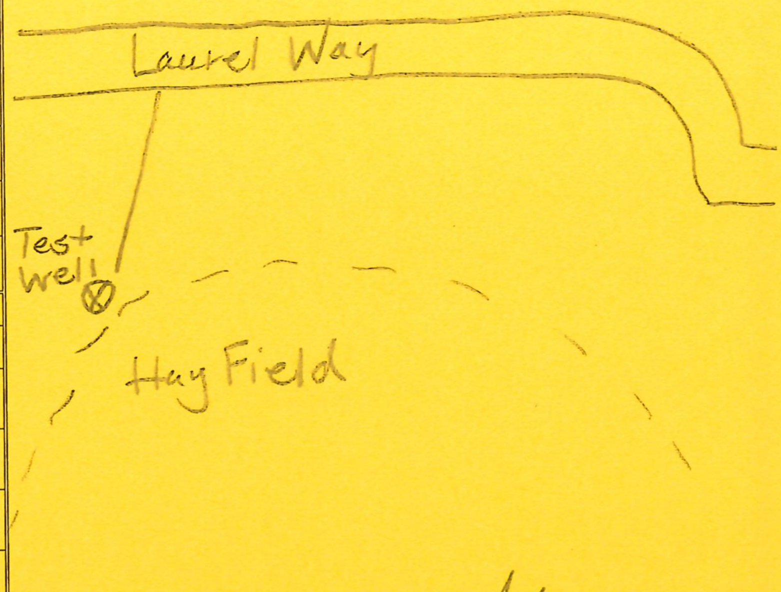
SCREEN DETAILS	MAKE					LENGTH OPEN TO AQUIFER (feet)	
	SLOT SIZE	DIAMETER (inches)	IF GRAVEL PACKED	Diameter of well including gravel pack (inches)	GRAVEL SIZE (inches)	FROM (feet)	TO (feet)

DEPTH FROM LAND TO SURFACE FEET TO FEET		FORMATION DESCRIPTION
0	10	SAND
10	62	TILL W/GRAVEL
62	80	WEATHERED ROCK
80	500	BEDROCK

If yield was tested at different depths during drilling, list below

FEET	GALLONS PER MINUTE
20	225
80	300

Sketch exact location of well with distances to at least two permanent landmarks



DATE WELL COMPLETED	PERMIT NO	REGISTRATION NO	DATE OF REPORT	WELL DRILLER (Signature)
11/18/20	270938	4	12/8/20	[signature]

Owner · Contractor · Dept of Consumer Protection · Dept of Environmental Protection - Water Resources · Local Director of Public Health

Form provided by Forms On-A-Disk, Inc. · Dallas, Texas · (214) 340-9429

APPENDIX C
GZA WELL LOGS

GEOPROBE LOG

GZA
GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #1
SHEET: 1 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/19/2020 - 11/20/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	**Time**	**Water Depth**	**Stab. Time**

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Stratum Description (Elev. (ft.) / Depth (ft.))	Equipment Installed
10								TILL	
							1		
20		20-30				Grey Mica Schist	2	20 WEATHERED ROCK	
30		30-40			ND	Grey Mica Schist	3	26	
40									
50									
60		60-70			ND	Grey Mica Schist			
70							4		
80		80-100				No Sample			
90					ND				
100		100-120				Grey Mica Schist			
110					ND				
120		120-140				Grey Mica Schist			
130									
140									
150									

REMARKS

1 - Casing installed to 40'.
2 - Depth to weathered bedrock = 20'
3 - Competent bedrock - 26'
4 - Fracture - trace water @ 64'

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #1

GZADEPTH.GDT; GZA TEMPLATE GEOPROBE W/EQUIP; 12/18/2020; 2:56:40 PM

GEOPROBE LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #1
SHEET: 2 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/19/2020 - 11/20/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	Time	Water Depth	Stab. Time

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) Stratum Description Depth (ft.)	Equipment Installed
		150-160			ND	Interlayered, dark grey SCHIST, trace Quartz			
160		160-180				Dark grey, SCHIST, trace Quartz	5		
170					ND		6		
180		180-200			ND	Interlayered, Grey SCHIST, trace Quarts White Quartz vein, trace Mica at 193'			
190									
200		200-220			ND	White Quartzite, trace Garnet, trace Mica			
210									
220		220-240			ND	White Quartzite, trace Garnet, trace Mica			
230									
240		240-260				White Quartzite and dark grey Gneiss			
250					ND		7		1-inch Double Geo-Loop (0.5-500')
260		260-280				No Sample			
270									
280		280-300			ND	Grey Mica Schist, trace Quartz			
290					ND				
300									

REMARKS

5 - Fracture @ 160' . Total Estimated Well Yield - 2 gpm.
6 - Fracture @ 170'. Total Estimated Well Yield - 2 gpm.
7 - Fracture @ 255' - no additional water

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #1

GEOPROBE LOG

GZA GeoEnvironmental, Inc. *Engineers and Scientists*	**University of Connecticut** **Storrs, Connecticut**	**EXPLORATION NO.:** Test Well #1 **SHEET:** 3 of 4 **PROJECT NO:** 05.0046697.00 **REVIEWED BY:**

Logged By: B Rach **Drilling Co.:** Connecticut Wells **Foreman:** Aaron Weick	**Geoprobe Location:** See Plan **Ground Surface Elev. (ft.):** **Final Geoprobe Depth (ft.):** 500 **Date Start - Finish:** 11/19/2020 - 11/20/2020	**H. Datum:** **V. Datum:**

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	**Time**	**Water Depth**	**Stab. Time**

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) Stratum Description Depth (ft.)	Equipment Installed
		300-320				Dark grey, Mica Schist, trace Quartz			
310					ND				
320		320-340				Grey, Mica Schist, trace Quartz			
330					ND				
340		340-360				Grey, Mica Schist, trace Quartz			
350					ND				
360		360-380				Grey, Mica Schist, trace Quartz			
370					ND				
380		380-400				Grey, Mica Schist, trace Quartz			
390					ND				
400		400-420				Grey, Mica Schist, trace Quartz			
410					ND				
420		420-440				Grey, Mica Schist, trace larger Mica flakes, trace Quartz			
430					ND				
440									
450									

REMARKS

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #1

GEOPROBE LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #1
SHEET: 4 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/19/2020 - 11/20/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	**Time**	**Water Depth**	**Stab. Time**

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) Stratum Description Depth (ft.)	Equipment Installed
		450-460			ND	Grey, Mica Schist, trace Quartz			
460		460-480				Grey, Mica Schist, trace Quartz			
470					ND				
480		480-500				Grey, Mica Schist, larger Mica flakes, trace Garnet, trace Quartz			
490					ND		8 9 10		
500						End of Exploration at 500 feet.			
510									
520									
530									
540									
550									
560									
570									
580									
590									
600									

REMARKS

8 - Installed spacers every 20'.
9 - Grout Batch = 32 gallons water, 1 - 32 lb bag Power TEL Graphite, 2 - 50 lb bgs of TGLite thermal grout. 21 total batches.
10 - 500-feet of 1-inch double geo-loop installed from 0.5 to 500 feet below ground surface with a fused u-connection at the bottom. Thermal grout installed from 0.5 to 500 feet below ground surface.

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #1

GZADEPTH.GDT; GZA TEMPLATE GEOPROBE W/EQUIP; 12/18/2020; 2:56:40 PM

GEOPROBE LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #2
SHEET: 1 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/20/2020 - 11/20/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	**Time**	**Water Depth**	**Stab. Time**

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.)	Stratum Description	Depth (ft.)	Equipment Installed
0		0-80				Grey-brown, fine to medium SAND and SILT, trace Gravel			TILL		
80		80-100			ND	100' highly weathered ROCK, Granofel			WEATHERED BEDROCK	80	
100		100-120			ND	Dark grey, fine-grained Granofel, trace Quartz & Garnet					
110									BEDROCK	110	
120		120-140				No sample collected	1				
140		140-150				Dark grey, fine grained Granofel, trace Quartz & Garnet					

REMARKS

1 - Casing set 1t 120', 10 feet into competent rock.

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #2

GZADEPTH.GDT; GZA TEMPLATE GEOPROBE W/EQUIP; 12/18/2020; 2:43:37 PM

GEOPROBE LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #2
SHEET: 2 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/20/2020 - 11/20/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	Time	Water Depth	Stab. Time

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) / Stratum Description / Depth (ft.)	Equipment Installed
		150-160			ND	Dark grey, fine grained Granofel, trace Quartz			
160		160-180			ND	Dark grey, medium grained Granofel, little Quartz			
170									
180		180-200			ND	Dark grey, medium grained Granofel, little Quartz			
190									
200		200-220			ND	Grey, medium grained Granofel, little Quartz, trace Garnet Quartz vein 1 ft thick at 215'	2		
210									
220		220-240			ND	Grey, medium grained Granofel, trace Quartz			
230									
240		240-260			ND	Grey, medium grained Granofel, little Quartz, trace Potassium Feldspar			
250									1.25-inch Single Geo-Loop (0.5-500')
260		260-280				Grey, medium grained Granofel, little Quartz			
270									
280		280-300				No sample			
290									
300									

REMARKS

2 - No distinct fracture. Total Estimated Well Yield - ~1 gpm/

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #2

GEOPROBE LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #2
SHEET: 3 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/20/2020 - 11/20/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	**Time**	**Water Depth**	**Stab. Time**

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) Stratum Description Depth (ft.)	Equipment Installed
		300-320			ND	Grey, medium grained Granofel, little Quartz			
310									
320		320-340				No sample			
330									
340		340-360				Dark grey, medium grained Granofel, little Quartz			
350					ND		3		
360		360-380				No sample			
370									
380		380-400				Grey, medium grained Granofel, little Quartz, trace Garnet			
390					ND				
400		400-420				Grey, medium grained Granofel, little Quartz, trace Garnet			
410					ND		4		
420		420-440			ND	Grey, fine to medium grained Granofel, trace Mica flakes, trace Quartz			
430									
440									
450									

REMARKS

3 - Fracture @ 352'. no water
4 - Fracture @ 410', no water

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #2

GZADEPTH.GDT; GZA TEMPLATE GEOPROBE W/EQUIP; 12/18/2020; 2:43:37 PM

GEOPROBE LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #2
SHEET: 4 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/20/2020 - 11/20/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	Time	Water Depth	Stab. Time

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) Stratum Description Depth (ft.)	Equipment Installed
		450-460				Grey, medium grained Granofel, trace Garnet, little Quartz			
460		460-480				Grey, medium grained Granofel, little Quartz			
470									
480		480-500				Light brown, medium grained Granofel, some Quartz			
490							5		
500							6 7		
						End of Exploration at 500 feet.			
510									
520									
530									
540									
550									
560									
570									
580									
590									
600									

REMARKS

5 - Grout Batch = 32 gallons water, 1 - 32 lb bag Power TEL Graphite, 2 - 50 lb bags of TGLite thermal grout. 24 total batches.
6 - Bucket test at end ~2 gpm
7 - 500-feet of 1-inch double geo-loop installed from 0.5 to 500 feet below ground surface with a fused u-connection at the bottom. Thermal grout installed from 0.5 to 500 feet below ground surface.

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #2

GEOPROBE LOG

GZA GeoEnvironmental, Inc.
Engineers and Scientists

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #3
SHEET: 1 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/18/2020 - 11/19/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	Time	Water Depth	Stab. Time

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Stratum Description (Depth ft.)
0		0-10				Dark brown, fine SAND and SILT, little Gravel		TILL
10		10-20				Dark brown, fine SAND and SILT, little Gravel		
20		20-30			ND	Dark brown, fine SAND and SILT, little Gravel		
30		30-40			ND	Dark brown, fine to medium SAND and SILT, little Gravel		
40		40-50			ND	Dark brown, fine to medium SAND and SILT, little Gravel		
50		50-52			ND	Dark brown, fine to medium SAND and SILT, little Gravel		52
		52-65			ND ND	Grey, weathered, medium grained Granofel		WEATHERED BEDROCK
60		65-80			ND	Grey, medium grained Granofel		65 BEDROCK
80		80-100				Grey, medium grained Granofel	1 2	
90					ND		3	
100		100-120				Grey, medium grained Granofel		
120		120-140			ND	Grey, medium grained Granofel, trace Quartz		
140		140-150				Grey, medium grained Granofel, trace Quartz	4	
150								

Equipment Installed

REMARKS

1 - Water bearing fracture at 76'. Total Estimated Well Yield - 2 gpm
2 - Casing to 80'.
3 - Fracture at 95'. Total Estimated Well Yield - 5 gpm.
4 - Fracture at 145', no additional water.

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #3

GZADEPTH.GDT; GZA TEMPLATE GEOPROBE W/EQUIP; 12/22/2020; 2:49:40 PM

GEOPROBE LOG

GZA GeoEnvironmental, Inc. *Engineers and Scientists*	**University of Connecticut** **Storrs, Connecticut**	**EXPLORATION NO.:** Test Well #3 **SHEET:** 2 of 4 **PROJECT NO:** 05.0046697.00 **REVIEWED BY:**

Logged By: B Rach **Drilling Co.:** Connecticut Wells **Foreman:** Aaron Weick	**Geoprobe Location:** See Plan **Ground Surface Elev. (ft.):** **Final Geoprobe Depth (ft.):** 500 **Date Start - Finish:** 11/18/2020 - 11/19/2020	**H. Datum:** **V. Datum:**

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	Time	Water Depth	Stab. Time

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) Stratum Description Depth (ft.)	Equipment Installed
		150-160			ND	Grey, medium grained Granofel, trace Quartz, trace Mica			
160		160-180			ND	Grey, medium grained Granofel			
170									
180		180-200			ND	Grey, medium grained Granofel			
190									
200		200-220				Grey, medium grained Granofel	5		
210									
220		220-240				No Sample	6		
230									
240		240-260				Grey, medium grained Granofel, little Quartz, trace banding			
250									1-inch Double Geo-Loop (0.5-500')
260		260-300				No Sample			
270									
280									
290									
300									

REMARKS

5 - Fracture @ 205', no additional water.
6 - Fracture @ 225'. Total Estimated Well Yield - 20 gpm
7 - Fracture @ 300'. Total Estimated Well Yield - 75 gpm

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #3

GEOPROBE LOG

GZA GeoEnvironmental, Inc. *Engineers and Scientists*

University of Connecticut
Storrs, Connecticut

EXPLORATION NO.: Test Well #3
SHEET: 3 of 4
PROJECT NO: 05.0046697.00
REVIEWED BY:

Logged By: B Rach
Drilling Co.: Connecticut Wells
Foreman: Aaron Weick

Geoprobe Location: See Plan
Ground Surface Elev. (ft.):
Final Geoprobe Depth (ft.): 500
Date Start - Finish: 11/18/2020 - 11/19/2020

H. Datum:
V. Datum:

Type of Rig: Reich Drill
Rig Model: Leggard 6
Drilling Method:

Sampler Type:
Sampler O.D. (in.):
Sampler Length (in.):
Rock Core Size:

Groundwater Depth (ft.)			
Date	**Time**	**Water Depth**	**Stab. Time**

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.) Stratum Description Depth (ft.)	Equipment Installed
		300-320				Grey, medium grained Granofel, trace Quartz, trace Pyrite	7		
310							8		
320		320-340				No Sample			
330									
340		340-360				Grey/white, medium grained Granofel, some Quartz, trace garnet, trace Olivine			
350									
360		360-380				Grey/white, medium grained Granofel, some Quartz, travel Garnet	9		
370									
380		380-400				Grey/white, medium grained, Granofel, trace Garnet			
390									
400		400-420			ND	No Sample			
410					ND		10		
420		420-440				Grey/white, medium grained Granofel, some Quartz, trace Garnet			
430									
440									
450									

REMARKS

8 - Fracture @ 310', no additional water
9 - Fracture @ 355', no additional water
10 - Screened water at 410 with PID. Results = Non Detect.

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #3

GZADEPTH.GDT; GZA TEMPLATE GEOPROBE W/EQUIP; 12/22/2020; 2:49:40 PM

GEOPROBE LOG

GZA GeoEnvironmental, Inc. *Engineers and Scientists*	University of Connecticut Storrs, Connecticut	**EXPLORATION NO.:** Test Well #3 **SHEET:** 4 of 4 **PROJECT NO:** 05.0046697.00 **REVIEWED BY:**
Logged By: B Rach **Drilling Co.:** Connecticut Wells **Foreman:** Aaron Weick	**Geoprobe Location:** See Plan **Ground Surface Elev. (ft.):** **Final Geoprobe Depth (ft.):** 500 **Date Start - Finish:** 11/18/2020 - 11/19/2020	**H. Datum:** **V. Datum:**
Type of Rig: Reich Drill **Rig Model:** Leggard 6 **Drilling Method:**	**Sampler Type:** **Sampler O.D. (in.):** **Sampler Length (in.):** **Rock Core Size:**	

Groundwater Depth (ft.)

Date	Time	Water Depth	Stab. Time

Depth (ft)	Sample No.	Sample Depth (ft.)	Pen. (in)	Rec. (in)	PID (ppm)	Sample Description Modified Burmister	Remark	Elev. (ft.)	Stratum Description	Depth (ft.)	Equipment Installed
		450-460				Grey/white, medium grained Granofel, some Quartz, trace Garnet					
460		460-480			ND	Grey/white, medium grained Granofel, some Quartz, trace Garnet					
470											
480		480-500				Grey/white, medium grained Granofel, some Quartz, trace Garnet					
490					ND		11				
500							12				
						End of Exploration at 500 feet.	13				
510											
520											
530											
540											
550											
560											
570											
580											
590											
600											

REMARKS

11 - Bucket test and end of drilling - 75 gpm.
12 - Grout Batch = 32 gallons water, 1 - 32 lb bag Power TEL Graphite, 2 - 50 lb bags of TGLITE thermal grout. 28 total batches.
13 - 500-feet of 1-inch double geo-loop installed from 0.5 to 500 feet below ground surface with a fused u-connection at the bottom. Thermal grout installed from 0.5 to 500 feet below ground surface.

Stratification lines represent approximate boundaries between soil types. Actual transitions may be gradual. Water level readings have been made at the times and under the conditions stated. Fluctuations of groundwater may occur due to other factors than those present at the times the measurements were made.

Test Well #3

GZADEPTH.GDT; GZA TEMPLATE GEOPROBE W/EQUIP; 12/22/2020; 2:49:40 PM

APPENDIX D
GROUT AND SAND SPECIFICATIONS

GeoPro, Inc.

POWERTEC

MIX DETAILS

Grouting Product	TG Lite
Thermal Enhancement Compound (TEC)	PowerTEC
Target Thermal Conductivity	1.00 Btu/hr-ft-°F
Density	10.4 lb/gal (US)
Percent Solids	32.41 %
Percent Active Solids	26.65 %
Permeability	$<1\text{x}10^{-7}$ cm/s

BATCH RECIPE

TG Lite	2 bags
PowerTEC	1 bags
Mix Water	33.0 gal (US)
Yield	39.2 gal (US)

DOCUMENTS

SUBMITTAL

SPECIFICATION

TG LITE SDS

POWERTEC SDS

PERMEABILITY https://goo.gl/OX272D

ALL MIXES

32LB BAG FIELD MIX CARD

16LB BAG FIELD MIX CARD

POWERTEC

PowerTEC is an engineered graphite alternative to silica sand. It is specifically formulated for use with TG Lite or TG Select to achieve thermal conductivities ranging from 0.79 to

1.60 Btu/hr-ft-°F.

PowerTEC is well suited for any thermally-enhanced grouting application and offers increased thermal conductivity ranges when compared to traditional silica sand recipes. It is field proven to be easier to handle, mix and pump while also reducing formation losses as well as costs for labor and freight.

Geothermal heat pump projects of any size can benefit from the decreased dry material requirements and improved handling characteristics of our PowerTEC mixes.

BENEFITS

When compared to silica sand, PowerTEC:

- Extends the range of possible thermal conductivity values to 1.60 Btu/hr-ft-°F.
- Eliminates the need for silica sand on the jobsite.
- Extends the life of grouting equipment due to low-viscosity & self-lubricating nature.
- Reduces the amount of dry material required on the jobsite by 60% to 70% (depending on target thermal conductivity value), which reduces total freight costs and the amount of staging area needed.
- Makes deeper bores possible by reducing total grout weight by 20% to 30% when compared to sand mixes.
- Decreases formation losses in fractured and porous formations.
- Is silica free, eliminating health concerns and OSHA safety compliance costs and requirements.
- Complies with NSF/ANSI Standard 60 requirements for purity and suitability for contact with drinking water.

PowerTEC is packaged in 32 lb bags with 75 bags per heat shrunk pallet. Properties and associated certifications are independently verified by a third party laboratory. Copies of independent test reports are available upon request.

Certifications and support apply only when PowerTEC is mixed with TG Lite or TG Select.

GeoPro, Inc.

THERMAL GROUT LITE

GROUT PROPERTIES

Grouting Product	TG Lite
Thermal Enhancement Compound (TEC)	PowerTEC
Target Thermal Conductivity	1.00 Btu/hr-ft-°F
Density	10.4 lb/gal (US)
Percent Solids	32.41 %
Percent Active Solids	26.65 %
Permeability	$<1x10^{-7}$ cm/s

BATCH RECIPE

TG Lite	2 bags
PowerTEC	1 bags
Mix Water	33.0 gal (US)
Yield	39.2 gal (US)

DOCUMENTS

SUBMITTAL

SPECIFICATION

TG LITE SDS

POWERTEC SDS

PERMEABILITY https://goo.gl/OX272D

ALL MIXES

THERMAL GROUT LITE

TG Lite is GeoPro's original bentonite grouting product for use in thermally-enhanced applications. It can be used to achieve thermal conductivity values up to 1.20 Btu/hr-ft-°F with PowerTEC (or up to 1.0 Btu/hr-ft-°F with silica sand).

TG Lite is the benchmark for quality, consistency and pumpability within the thermal grout market. When compared to TG Select, TG Lite is the most cost-effective way to reach the thermal conductivity values in the range provided. The majority of ground heat exchanger designs call for thermal conductivity values below 1.20 Btu/hr-ft-°F, making TG Lite the most predominant grouting product in the geothermal heat pump industry today.

As with all of GeoPro's grouting products, TG Lite provides superior groundwater protection and environmental sealing capabilities.

BENEFITS

When mixed according to our specifications, TG Lite:

- Does not flash hydrate.
- Does not require thorough testing of mix water chemistry prior to use.
- Does not require the use of polymers, soda ash or other chemicals for proper handling.
- Provides more working time in the field compared to the leading alternative, which leads to less frequent problems with system plugging and shutdown.
- Complies with IGSHPAs Closed-Loop Design and Installation Standards.
- Provides an environmental seal with a measured permeability values less than $1x10^{-7}$ cm/s (tested according to ASTM D-5084).
- Provides a wide range of thermal conductivity values to choose from (tested according to ASTM D-5334).
- Complies with NSF/ANSI Standard 60 requirements for purity and suitability for contact with drinking water.

TG Lite is packaged in 50 lb bags with 54 bags per heat shrunk pallet. Properties and associated certifications are independently verified by a third party laboratory. Copies of independent test reports are available upon request.

QUALITY ASSURANCE

Grout sample thermal conductivity testing is an important component of thermal grout commissioning and quality assurance efforts for every installation. GeoPro, Inc. provides free thermal conductivity testing for any customer who chooses to take advantage of the service.

APPENDIX E
PHOTOGRAPHS

Photographic Log

Client Name: BVH Integrated Services	**Site Location:** University of Connecticut Storrs, CT	**Project No.** 05.0046697.00

Photo No. 1 &2	**Date:** 11/19/20
Test Well ID TW-1	
Description: TW-1 (S Lot) well drilling and geo-loop installation	

Photo No. 3	**Date:** 12/2/20
Test Well ID: TW-1	
Description: Area restored, hayed and seeded. Thermal Conductivity Running	

Photographic Log

Client Name: BVH Integrated Services	**Site Location:** University of Connecticut Storrs, CT	**Project No.** 05.0046697.00

Photo No. 4&5	**Date:** 11/20/20
Test Well ID: TW-2	
Description: TW-2 (Horsebarn Hill) well drilling and geo-loop installation	

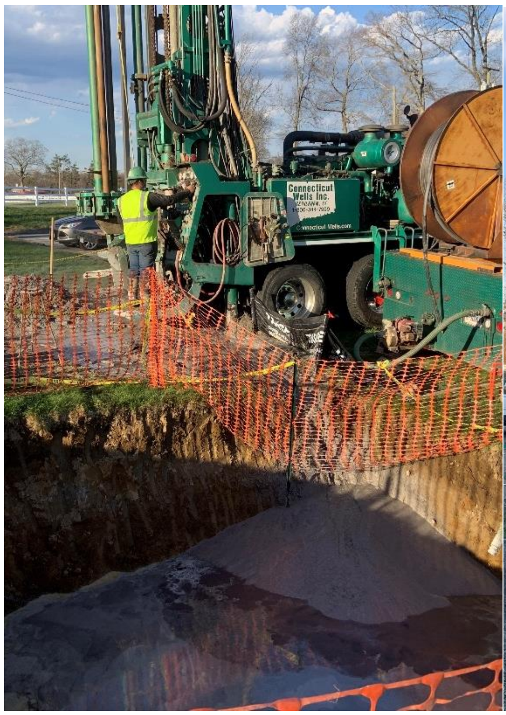


Photo No. 6	**Date:** 12/4/20
Test Well ID: TW-2	
Description: Area restored, hayed and seeded. Thermal Conductivity Running	

Photographic Log

Client Name: BVH Integrated Services	Site Location: University of Connecticut Storrs, CT	Project No. 05.0046697.00

Photo No.	Date:
7&8	11/18/20

Test Well ID: TW-3

Description: TW-3 (Cell Tower) well drilling and geo-loop installation

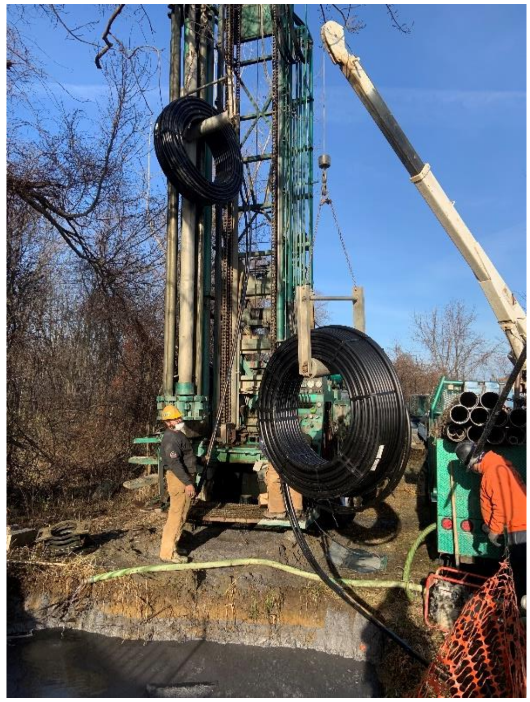


Photo No.	Date:
9	11/27/20

Test Well ID: TW-3

Description: Area restored, hayed and seeded. Thermal Conductivity Running

APPENDIX F
GEOTHERMAL TEST RESULTS

GRTI

Formation Thermal Conductivity
Test & Data Analysis

Test location **UConn-Storrs, TW-3**
Storrs, CT

Test Date November 25-27, 2020

Analysis For Connecticut Wells Inc.
49 Hard Hill Road North
Bethlehem, CT 06751
Phone: (203) 266-5272

Test Performed By Connecticut Wells Inc.

EXECUTIVE SUMMARY

A formation thermal conductivity test was performed on geothermal test bore TW-3 at a GPS location of N 41.81665º (latitude), W 72.26032º (longitude) at the University of Connecticut-Storrs campus. The vertical bore was completed on November 18, 2020 by Connecticut Wells Inc. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on the morning of November 25, 2020.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

Formation Thermal Conductivity = 2.06 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

Formation Thermal Diffusivity ≈ 1.35 ft^2/day

Bore thermal resistance calculations were made on the test data using the method outlined in the Gehlin Doctoral Thesis[1]. Since the average value listed below was empirically determined from the test data it may not directly correlate with values found in loopfield design programs.

Bore Thermal Resistance = 0.135 hr-ft-°F/Btu

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

Undisturbed Formation Temperature ≈ 50.4-51.2°F

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to commercially available loop-field design software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at www.grti.com.

[1] Signhild Gehlin. "Thermal Response Test - Method Development and Evaluation," (Doctoral Thesis, Lulea University of Technology, 2002).

TEST PROCEDURES

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

Grouting Procedure for Test Loops – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

Time Between Loop Installation and Testing – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

Undisturbed Formation Temperature Measurement – The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

Required Test Duration – A minimum test duration of 36 hours is recommended, with a preference toward 48 hours**.**

Data Acquisition Frequency - Test data is recorded at five minute intervals.

Equipment Calibration/Accuracy – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than ±2%. Temperature sensor accuracy is periodically checked via ice water bath.

Power Quality – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

Input Heat Rate – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

Insulation – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

Retesting in the Event of Failure – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

DATA ANALYSIS

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. Applying the line source method to a u-bend grouted in a borehole, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In the analysis of the data from the formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger was plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients were calculated that produce a line that fit the data. This procedure was repeated for various time intervals to ensure that variations in the power or other effects did not produce inaccurate results.

Bore thermal resistance was determined using the formula outlined in Gehlin's Doctoral Thesis[2]. A serial development was used to approximate the exponential integral. The calculated bore resistance applies only to the test conditions, a bore in an operating loopfield could have a significantly different resistance due to changes in the loop fluid temperature, flow rate and presence of antifreeze.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

CONTACT: Chad Martin
Regional Managing Engineer
Asheville, NC
(828) 225-9166
cmartin@grti.com

[2]Gehlin, 12-13

TEST BORE DETAILS
(AS PROVIDED BY CONNECTICUT WELLS INC.)

Site Name	TW-3, University of Connecticut-Storrs
Location	Storrs, CT
Driller	Connecticut Wells Inc.
Installed Date	November 18, 2020
Borehole Diameter	8 3/4 inches, 0-80 ft 6 inches, 80-500 ft
Casing	Permanent 6 inch steel casing to 80 ft
U-Bend Size	1 inch DR-11 HDPE Double U-Bend
U-Bend Depth Below Grade	500 ft
Grout Type	GeoPro TG Lite/PowerTEC 1.2
Grout Mixture	100 lb TG Lite, 32 lb PowerTEC, 30 gal water
Grouted Portion	Entire bore

DRILL LOG

FORMATION DESCRIPTION	DEPTH (FT)
Dirt fill	0'-10'
Till	10'-62'
Weathered rock	62'-80'
Bedrock	80'-500'

Note: Bore produced 20 gpm water from 225-300 ft; 80 gpm from 300-500 ft.

THERMAL CONDUCTIVITY TEST DATA

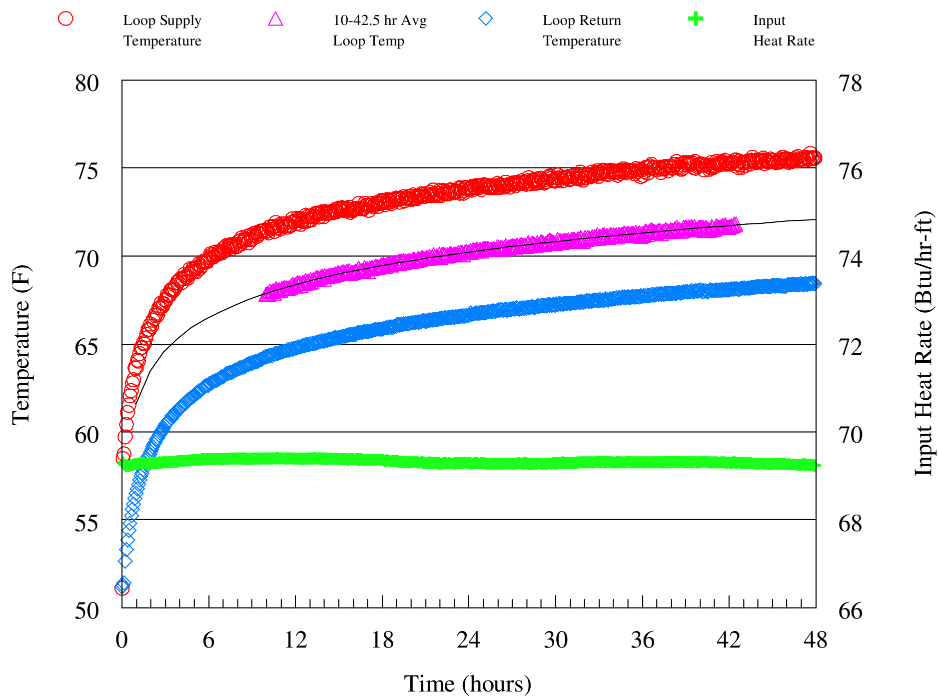


FIG. 1: TEMPERATURE & HEAT RATE DATA VS TIME

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

SUMMARY TEST STATISTICS

Test Date	November 25-27, 2020
Undisturbed Formation Temperature	Approx. 50.4-51.2°F
Duration	48.0 hr
Average Voltage	239.0 V
Average Heat Input Rate	34,661 Btu/hr (10,156 W)
Avg Heat Input Rate per Foot of Bore	69.3 Btu/hr-ft (20.3 W/ft)
Circulator Flow Rate	9.7 gpm
Standard Deviation of Power	0.06%
Maximum Variation in Power	0.13%

LINE SOURCE DATA ANALYSIS

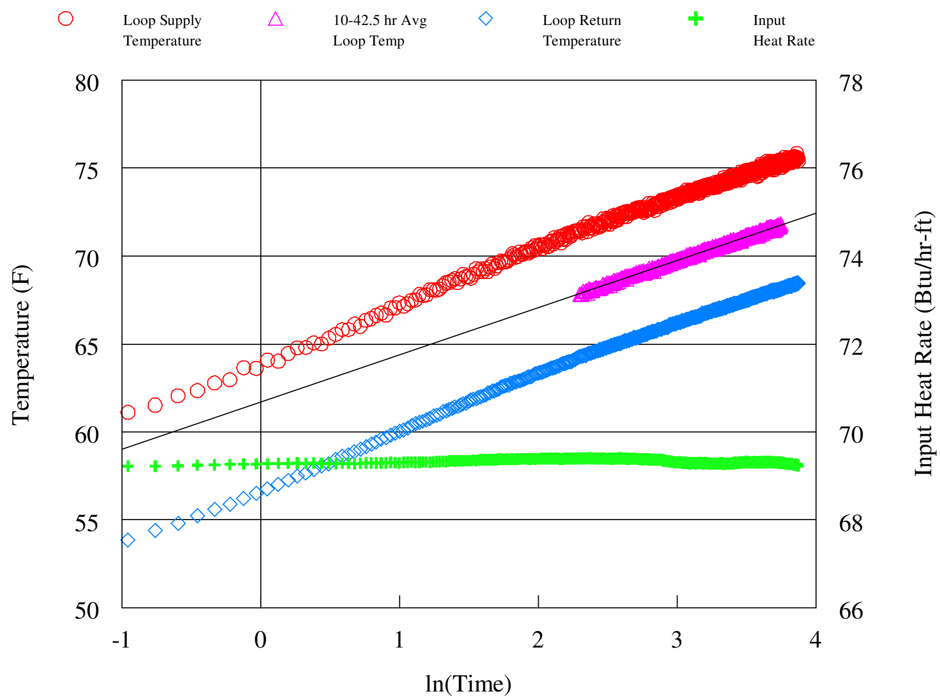


FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 42.5 hours. The slope of the curve fit was found to be 2.68. The resulting thermal conductivity was found to be **2.06 Btu/hr-ft-°F**.

THERMAL DIFFUSIVITY

The reported drilling log for this test borehole indicated that the formation consisted of dirt fill, glacial till, and bedrock. USGS identifies the formation at this location to be metamorphic rock including granofels and schist. A heat capacity value for the formation was calculated from specific heat and density values listed by Kavanaugh and Rafferty[1]. A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 36.6 Btu/ft^3-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be **1.35 ft^2/day**.

[1]Stephen P. Kavanaugh and Kevin Rafferty, Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (Atlanta: ASHRAE, 2014), 75.

BORE THERMAL RESISTANCE

Resistance to heat transfer from a geothermal bore can be viewed as consisting of two components, bore resistance and ground resistance. This relationship is diagrammed in Figure 3, where t_f is the loop fluid temperature, t_b is the bore wall temperature and t_g is the ground temperature. The ground resistance is dependent upon the formation thermal conductivity and diffusivity. Factors that affect bore thermal resistance include the resistance of the pipe material, diameter of the heat exchanger, position of the heat exchanger in the bore, the bore diameter, casing length and type, and the thermal conductivity of the grout/backfill in the bore annulus. A detailed examination of bore resistance is discussed by Kavanaugh and Rafferty[4].

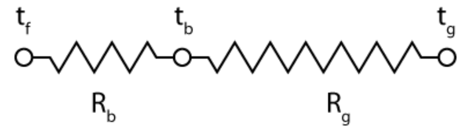


FIG. 3: RESISTANCE DIAGRAM FOR A GEOTHERMAL BORE

Bore thermal resistance calculations were made on the test data according to the formula below as outlined in the Gehlin Doctoral Thesis[5]. The calculated formation thermal conductivity and thermal diffusivity from the Line Source Analysis were used in the formula. The average undisturbed formation temperature of 50.8°F was used as the undisturbed temperature, and the average bore thermal resistance from 10-42.5 hrs was found to be **0.135 hr-ft-°F/Btu** .

The calculated bore resistances apply only to the test conditions, and a bore in an operating loopfield could have a significantly different resistance due to changes in the loop fluid temperature, flow rate, and presence of antifreeze. Additional information on bore resistance may be found in the study by Oklahoma State University and Oklahoma Gas & Electric where various vertical bore heat exchanger configurations were tested[6].

$$R_b = \frac{H}{Q} * \left\{T(t) - T_g - \frac{Q}{4\pi\lambda_g H} * \left[Ei\left(\frac{r_b^2}{4\alpha_g t}\right)\right]\right\}$$

Where:	R_b	Borehole thermal resistance (hr-ft-°F/Btu)
	H	Active U-bend depth (ft)
	Q	Average heat injected (Btu/hr)
	$T(t)$	Temperature dependent on time t (°F)
	T_g	Undisturbed ground temperature
	λ_g	Formation thermal conductivity (Btu/hr-ft-°F)
	r_b	Average borehole radius (in)
	α_g	Formation thermal diffusivity (ft^2/hr)

[4]Stephen P. Kavanaugh and Kevin Rafferty, Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (Atlanta: ASHRAE, 2014), pages 58-67.
[5]Gehlin, 12-13.
[6]Beier, R. and Ewbank, G. (2012, August). *In-Situ Test Thermal Response Tests Interpretations, OG&E Ground Source Heat Exchange Study*. Retrieved from http://ghpok.org/

CERTIFICATE OF CALIBRATION

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

FTC Unit 214

DA Unit 65

Primary Equipment		
Component	**Calibration Date**	**Calibration Due Date**
Datalogger	9/24/2018	9/24/2021
Current Transducer	9/26/2018	9/26/2021
Voltage Transducer	9/26/2018	9/26/2021

GRTI periodically verifies the combined temperature sensor/datalogger accuracy via a water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

Date	4/23/2020	10/3/2018	1/10/2018	
Thermocouple 1 (°F)	42.4 42.6 42.6	32.0 31.9 31.8	80.0 80.0 80.1	
Thermocouple 2 (°F)	42.5 42.6 42.7	32.0 31.9 31.8	80.0 80.1 80.1	
Thermocouple 3 (°F)	42.3 42.4 42.5	32.0 31.9 31.9	79.9 80.0 80.0	
Thermocouple 4 (°F)	42.3 42.4 42.5	32.0 32.0 31.9	79.9 80.0 80.0	
Digital Thermometer (°F)	42.3 42.4 42.5	32.1 32.1 32.0	79.8 79.9 79.9	

GRTI

FORMATION THERMAL CONDUCTIVITY

TEST & DATA ANALYSIS

TEST LOCATION **UConn-Storrs, TW-1**
Storrs, CT

TEST DATE November 30-December 2, 2020

ANALYSIS FOR Connecticut Wells Inc.
49 Hard Hill Road North
Bethlehem, CT 06751
Phone: (203) 266-5272

TEST PERFORMED BY Connecticut Wells Inc.

WESTERN OFFICE
PO Box 256, Elkton, SD 57026
P: 866-991-4784 F: 605-542-5391

SOUTHERN OFFICE
PO Box 150, Bowie, TX 76230
P: 940-872-2222

EASTERN OFFICE
6 William Warren Dr, Asheville, NC 28806
P: 828-275-7113

EXECUTIVE SUMMARY

A formation thermal conductivity test was performed on geothermal test bore TW-1 at a GPS location of N 41.80398º (latitude), W 72.24655º (longitude) at the University of Connecticut-Storrs campus. The vertical bore was completed on November 19, 2020 by Connecticut Wells Inc. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on the morning of November 30, 2020.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

Formation Thermal Conductivity = 1.85 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

Formation Thermal Diffusivity ≈ 1.16 ft^2/day

Bore thermal resistance calculations were made on the test data using the method outlined in the Gehlin Doctoral Thesis[1]. Since the average value listed below was empirically determined from the test data it may not directly correlate with values found in loopfield design programs.

Bore Thermal Resistance = 0.121 hr-ft-°F/Btu

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

Undisturbed Formation Temperature ≈ 53.9-54.8°F

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to commercially available loop-field design software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at www.grti.com.

[1] Signhild Gehlin. "Thermal Response Test - Method Development and Evaluation," (Doctoral Thesis, Lulea University of Technology, 2002).

TEST PROCEDURES

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

Grouting Procedure for Test Loops – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

Time Between Loop Installation and Testing – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

Undisturbed Formation Temperature Measurement – The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

Required Test Duration – A minimum test duration of 36 hours is recommended, with a preference toward 48 hours**.**

Data Acquisition Frequency - Test data is recorded at five minute intervals.

Equipment Calibration/Accuracy – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than ±2%. Temperature sensor accuracy is periodically checked via ice water bath.

Power Quality – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

Input Heat Rate – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

Insulation – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

Retesting in the Event of Failure – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

DATA ANALYSIS

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. Applying the line source method to a u-bend grouted in a borehole, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In the analysis of the data from the formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger was plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients were calculated that produce a line that fit the data. This procedure was repeated for various time intervals to ensure that variations in the power or other effects did not produce inaccurate results.

Bore thermal resistance was determined using the formula outlined in Gehlin's Doctoral Thesis[2]. A serial development was used to approximate the exponential integral. The calculated bore resistance applies only to the test conditions, a bore in an operating loopfield could have a significantly different resistance due to changes in the loop fluid temperature, flow rate and presence of antifreeze.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

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Asheville, NC
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cmartin@grti.com

[2]Gehlin, 12-13

Test Bore Details
(As Provided by Connecticut Wells Inc.)

Site Name	TW-1, University of Connecticut-Storrs
Location	Storrs, CT
Driller	Connecticut Wells Inc.
Installed Date	November 19, 2020
Borehole Diameter	8 3/4 inches, 0-27 ft 6 inches, 27-500 ft
Casing	Permanent 6 inch steel casing to 27 ft
U-Bend Size	1 inch DR-11 HDPE Double U-Bend
U-Bend Depth Below Grade	500 ft
Grout Type	GeoPro TG Lite/PowerTEC 1.2
Grout Mixture	100 lb TG Lite, 32 lb PowerTEC, 30 gal water
Grouted Portion	Entire bore

Drill Log

Formation Description	Depth (ft)
Sand and gravel with water	0'-23'
Soft rock	23'-26'
Bedrock	26'-500'

Note: Bore produced 1 gpm water from 200-500 ft.

THERMAL CONDUCTIVITY TEST DATA

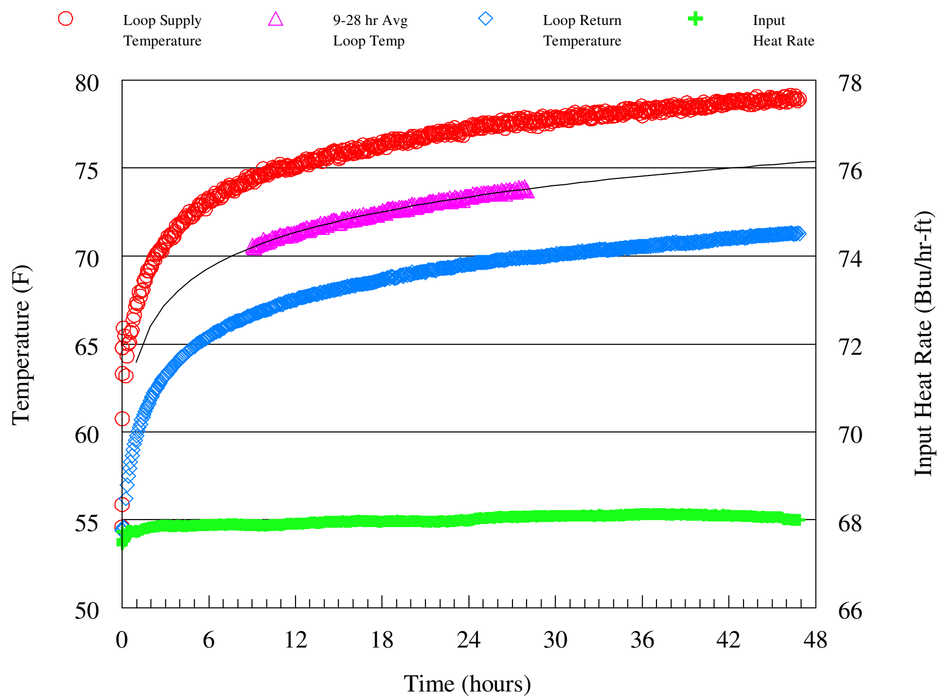

FIG. 1: TEMPERATURE & HEAT RATE DATA VS TIME

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

SUMMARY TEST STATISTICS

Test Date	November 30-December 2, 2020
Undisturbed Formation Temperature	Approx. 53.9-54.8°F
Duration	46.9 hr
Average Voltage	237.3 V
Average Heat Input Rate	33,985 Btu/hr (9,958 W)
Avg Heat Input Rate per Foot of Bore	68.0 Btu/hr-ft (19.9 W/ft)
Circulator Flow Rate	8.8 gpm
Standard Deviation of Power	0.08%
Maximum Variation in Power	0.17%

LINE SOURCE DATA ANALYSIS

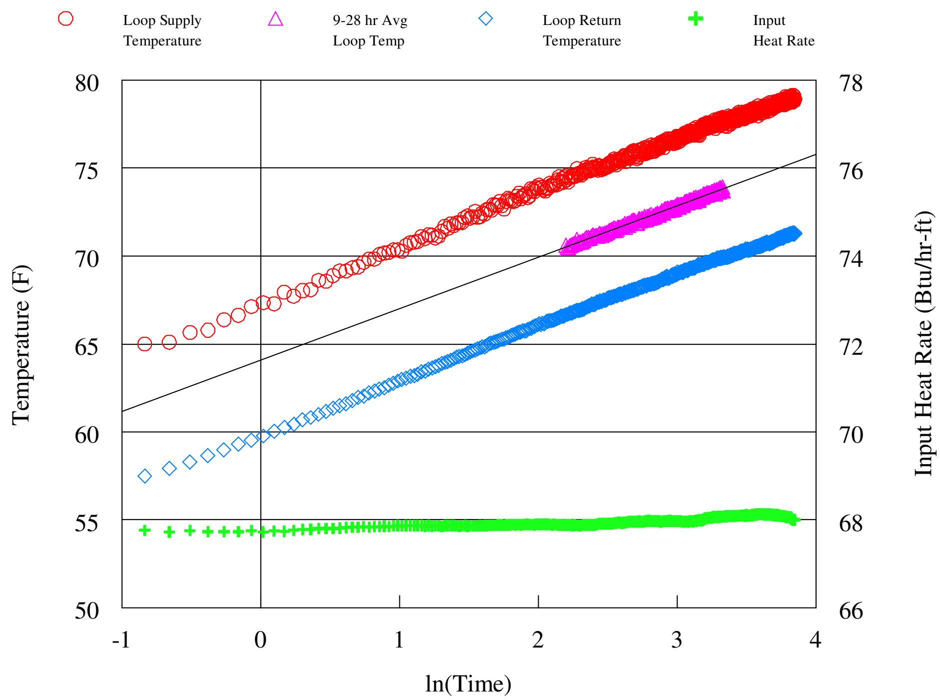

FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 9 and 28.0 hours. The slope of the curve fit was found to be 2.92. The resulting thermal conductivity was found to be **1.85 Btu/hr-ft-°F**.

THERMAL DIFFUSIVITY

The reported drilling log for this test borehole indicated that the formation consisted of sand, gravel, and bedrock. USGS identifies the formation at this location to be primarily composed of schist. A heat capacity value for the formation was calculated from specific heat and density values listed by Kavanaugh and Rafferty[1]. A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 38.5 Btu/ft^3-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be **1.16 ft^2/day**.

[1]Stephen P. Kavanaugh and Kevin Rafferty, Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (Atlanta: ASHRAE, 2014), 75.

BORE THERMAL RESISTANCE

Resistance to heat transfer from a geothermal bore can be viewed as consisting of two components, bore resistance and ground resistance. This relationship is diagrammed in Figure 3, where t_f is the loop fluid temperature, t_b is the bore wall temperature and t_g is the ground temperature. The ground resistance is dependent upon the formation thermal conductivity and diffusivity. Factors that affect bore thermal resistance include the resistance of the pipe material, diameter of the heat exchanger, position of the heat exchanger in the bore, the bore diameter, casing length and type, and the thermal conductivity of the grout/backfill in the bore annulus. A detailed examination of bore resistance is discussed by Kavanaugh and Rafferty[4].

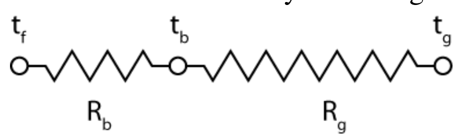

FIG. 3: RESISTANCE DIAGRAM FOR A GEOTHERMAL BORE

Bore thermal resistance calculations were made on the test data according to the formula below as outlined in the Gehlin Doctoral Thesis[5]. The calculated formation thermal conductivity and thermal diffusivity from the Line Source Analysis were used in the formula. The average undisturbed formation temperature of 54.4°F was used as the undisturbed temperature, and the average bore thermal resistance from 9-28.0 hrs was found to be **0.121 hr-ft-°F/Btu** .

The calculated bore resistances apply only to the test conditions, and a bore in an operating loopfield could have a significantly different resistance due to changes in the loop fluid temperature, flow rate, and presence of antifreeze. Additional information on bore resistance may be found in the study by Oklahoma State University and Oklahoma Gas & Electric where various vertical bore heat exchanger configurations were tested[6].

$$R_b = \frac{H}{Q} * \left\{ T(t) - T_g - \frac{Q}{4\pi\lambda_g H} * \left[Ei\left(\frac{r_b^2}{4\alpha_g t} \right) \right] \right\}$$

Where:	R_b	Borehole thermal resistance (hr-ft-°F/Btu)
	H	Active U-bend depth (ft)
	Q	Average heat injected (Btu/hr)
	$T(t)$	Temperature dependent on time t (°F)
	T_g	Undisturbed ground temperature
	λ_g	Formation thermal conductivity (Btu/hr-ft-°F)
	r_b	Average borehole radius (in)
	α_g	Formation thermal diffusivity (ft^2/hr)

[4]Stephen P. Kavanaugh and Kevin Rafferty, Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (Atlanta: ASHRAE, 2014), pages 58-67.
[5]Gehlin, 12-13.
[6]Beier, R. and Ewbank, G. (2012, August). *In-Situ Test Thermal Response Tests Interpretations, OG&E Ground Source Heat Exchange Study*. Retrieved from http://ghpok.org/

GRTI
Geothermal Resource Technologies, Inc.
www.grti.com

CERTIFICATE OF CALIBRATION

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

FTC Unit 214

DA Unit 65

Primary Equipment		
Component	Calibration Date	Calibration Due Date
Datalogger	9/24/2018	9/24/2021
Current Transducer	9/26/2018	9/26/2021
Voltage Transducer	9/26/2018	9/26/2021

GRTI periodically verifies the combined temperature sensor/datalogger accuracy via a water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

Date	4/23/2020	10/3/2018	1/10/2018	
Thermocouple 1 (°F)	42.4 42.6 42.6	32.0 31.9 31.8	80.0 80.0 80.1	
Thermocouple 2 (°F)	42.5 42.6 42.7	32.0 31.9 31.8	80.0 80.1 80.1	
Thermocouple 3 (°F)	42.3 42.4 42.5	32.0 31.9 31.9	79.9 80.0 80.0	
Thermocouple 4 (°F)	42.3 42.4 42.5	32.0 32.0 31.9	79.9 80.0 80.0	
Digital Thermometer (°F)	42.3 42.4 42.5	32.1 32.1 32.0	79.8 79.9 79.9	

WESTERN OFFICE
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P: 866-991-4784 F: 605-542-5391

SOUTHERN OFFICE
PO Box 150, Bowie, TX 76230
P: 940-872-2222

EASTERN OFFICE
6 William Warren Dr, Asheville, NC 28806
P: 828-275-7113

GRTI

FORMATION THERMAL CONDUCTIVITY

TEST & DATA ANALYSIS

TEST LOCATION **UConn-Storrs, TW-2**
Storrs, CT

TEST DATE December 2-4, 2020

ANALYSIS FOR Connecticut Wells Inc.
49 Hard Hill Road North
Bethlehem, CT 06751
Phone: (203) 266-5272

TEST PERFORMED BY Connecticut Wells Inc.

WESTERN OFFICE
PO Box 256, Elkton, SD 57026
P: 866-991-4784 F: 605-542-5391

SOUTHERN OFFICE
PO Box 150, Bowie, TX 76230
P: 940-872-2222

EASTERN OFFICE
6 William Warren Dr, Asheville, NC 28806
P: 828-275-7113

EXECUTIVE SUMMARY

A formation thermal conductivity test was performed on geothermal test bore TW-2 at a GPS location of N 41.81627º (latitude), W 72.24353º (longitude) at the University of Connecticut-Storrs campus. The vertical bore was completed on November 20, 2020 by Connecticut Wells Inc. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on the afternoon of December 2, 2020.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

Formation Thermal Conductivity = 1.95 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

Formation Thermal Diffusivity ≈ 1.28 ft^2/day

Bore thermal resistance calculations were made on the test data using the method outlined in the Gehlin Doctoral Thesis[1]. Since the average value listed below was empirically determined from the test data it may not directly correlate with values found in loopfield design programs.

Bore Thermal Resistance = 0.194 hr-ft-°F/Btu

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

Undisturbed Formation Temperature ≈ 52.2-53.0°F

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to commercially available loop-field design software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at www.grti.com.

[1] Signhild Gehlin. "Thermal Response Test - Method Development and Evaluation," (Doctoral Thesis, Lulea University of Technology, 2002).

TEST PROCEDURES

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

Grouting Procedure for Test Loops – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

Time Between Loop Installation and Testing – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

Undisturbed Formation Temperature Measurement – The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

Required Test Duration – A minimum test duration of 36 hours is recommended, with a preference toward 48 hours**.**

Data Acquisition Frequency - Test data is recorded at five minute intervals.

Equipment Calibration/Accuracy – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than ±2%. Temperature sensor accuracy is periodically checked via ice water bath.

Power Quality – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

Input Heat Rate – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

Insulation – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

Retesting in the Event of Failure – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

DATA ANALYSIS

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. Applying the line source method to a u-bend grouted in a borehole, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In the analysis of the data from the formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger was plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients were calculated that produce a line that fit the data. This procedure was repeated for various time intervals to ensure that variations in the power or other effects did not produce inaccurate results.

Bore thermal resistance was determined using the formula outlined in Gehlin's Doctoral Thesis[2]. A serial development was used to approximate the exponential integral. The calculated bore resistance applies only to the test conditions, a bore in an operating loopfield could have a significantly different resistance due to changes in the loop fluid temperature, flow rate and presence of antifreeze.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

CONTACT: Chad Martin
Regional Managing Engineer
Asheville, NC
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[2]Gehlin, 12-13

TEST BORE DETAILS
(AS PROVIDED BY CONNECTICUT WELLS INC.)

Site Name	TW-2, University of Connecticut-Storrs
Location	Storrs, CT
Driller	Connecticut Wells Inc.
Installed Date	November 20, 2020
Borehole Diameter	8 3/4 inches, 0-120 ft 6 inches, 120-500 ft
Casing	Permanent 6 inch steel casing to 120 ft
U-Bend Size	1 1/4 inch DR-11 HDPE U-Bend
U-Bend Depth Below Grade	500 ft
Grout Type	GeoPro TG Lite/PowerTEC 1.2
Grout Mixture	100 lb TG Lite, 32 lb PowerTEC, 30 gal water
Grouted Portion	Entire bore

DRILL LOG

FORMATION DESCRIPTION	DEPTH (FT)
Sand and fill with water	0'-15'
Till with gravel	15'-80'
Top of rock - 20 gpm water	80'
Soft rock	80'-110'
Firm bedrock	110'-500'

Note: Bore produced 1 gpm water from 175-425 ft; 2 gpm from 425-500 ft.

THERMAL CONDUCTIVITY TEST DATA

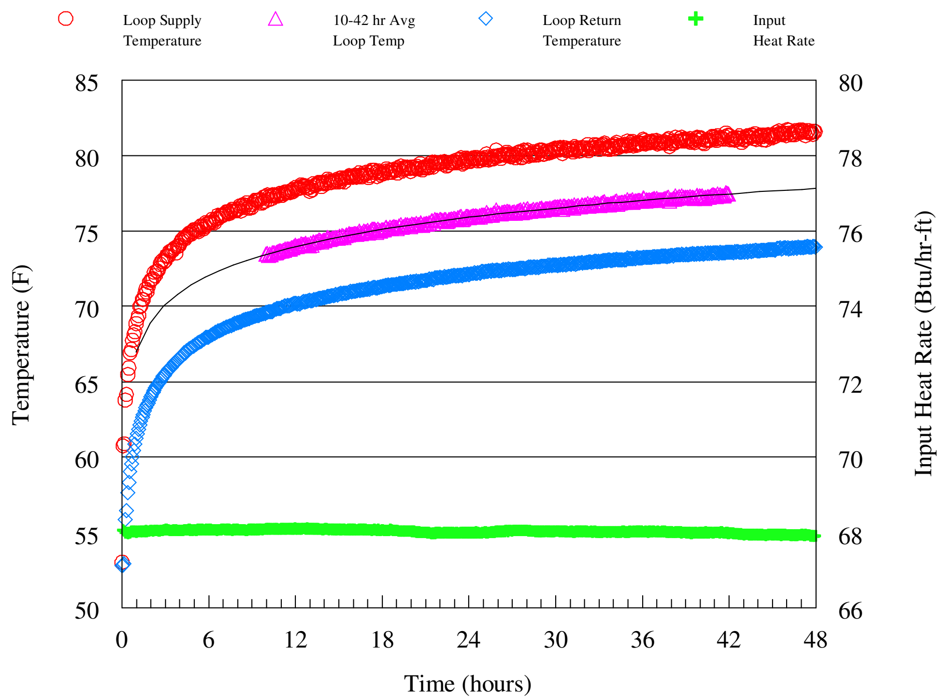


FIG. 1: TEMPERATURE & HEAT RATE DATA VS TIME

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

SUMMARY TEST STATISTICS

Test Date	December 2-4, 2020
Undisturbed Formation Temperature	Approx. 52.2-53.0°F
Duration	48.5 hr
Average Voltage	237.7 V
Average Heat Input Rate	34,019 Btu/hr (9,967 W)
Avg Heat Input Rate per Foot of Bore	68.0 Btu/hr-ft (19.9 W/ft)
Circulator Flow Rate	9.0 gpm
Standard Deviation of Power	0.05%
Maximum Variation in Power	0.12%

LINE SOURCE DATA ANALYSIS

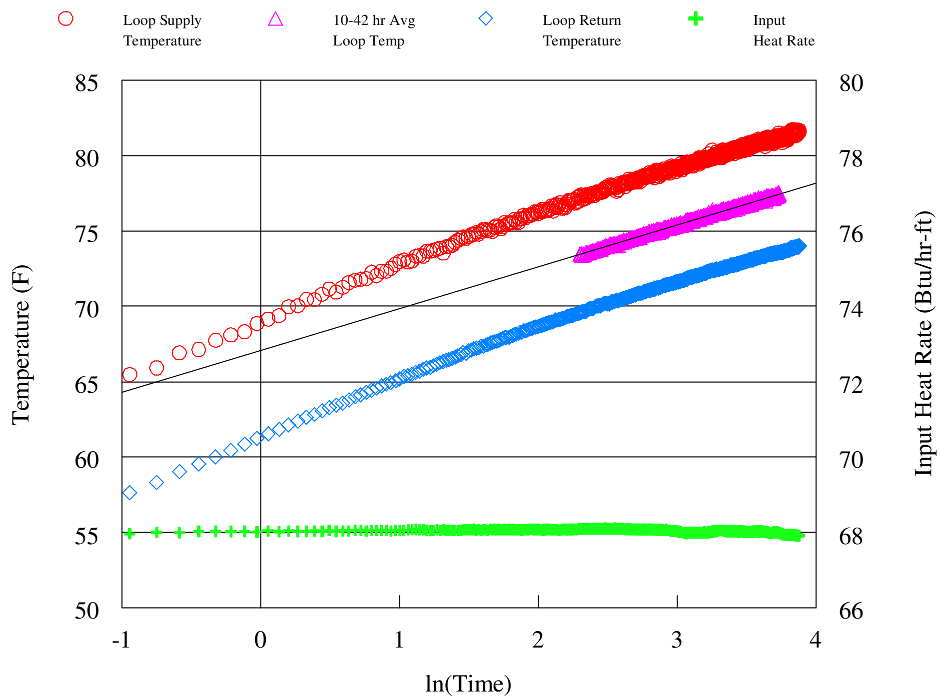


FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 42.0 hours. The slope of the curve fit was found to be 2.78. The resulting thermal conductivity was found to be **1.95 Btu/hr-ft-°F**.

Thermal Diffusivity

The reported drilling log for this test borehole indicated that the formation consisted of sand, fill, gravel, glacial till, and bedrock. USGS identifies the formation at this location to be metamorphic rock including granofels and schist. A heat capacity value for the formation was calculated from specific heat and density values listed by Kavanaugh and Rafferty[1]. A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 36.5 Btu/ft^3-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be **1.28 ft^2/day**.

[1]Stephen P. Kavanaugh and Kevin Rafferty, Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (Atlanta: ASHRAE, 2014), 75.

BORE THERMAL RESISTANCE

Resistance to heat transfer from a geothermal bore can be viewed as consisting of two components, bore resistance and ground resistance. This relationship is diagrammed in Figure 3, where t_f is the loop fluid temperature, t_b is the bore wall temperature and t_g is the ground temperature. The ground resistance is dependent upon the formation thermal conductivity and diffusivity. Factors that affect bore thermal resistance include the resistance of the pipe material, diameter of the heat exchanger, position of the heat exchanger in the bore, the bore diameter, casing length and type, and the thermal conductivity of the grout/backfill in the bore annulus. A detailed examination of bore resistance is discussed by Kavanaugh and Rafferty[4].

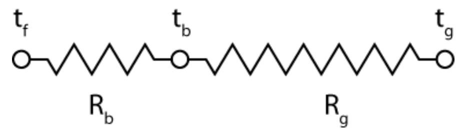


FIG. 3: RESISTANCE DIAGRAM FOR A GEOTHERMAL BORE

Bore thermal resistance calculations were made on the test data according to the formula below as outlined in the Gehlin Doctoral Thesis[5]. The calculated formation thermal conductivity and thermal diffusivity from the Line Source Analysis were used in the formula. The average undisturbed formation temperature of 52.6°F was used as the undisturbed temperature, and the average bore thermal resistance from 10-42.0 hrs was found to be **0.194 hr-ft-°F/Btu** .

The calculated bore resistances apply only to the test conditions, and a bore in an operating loopfield could have a significantly different resistance due to changes in the loop fluid temperature, flow rate, and presence of antifreeze. Additional information on bore resistance may be found in the study by Oklahoma State University and Oklahoma Gas & Electric where various vertical bore heat exchanger configurations were tested[6].

$$R_b = \frac{H}{Q} * \left\{ T(t) - T_g - \frac{Q}{4\pi\lambda_g H} * \left[Ei\left(\frac{r_b^2}{4\alpha_g t}\right)\right]\right\}$$

Where:	R_b	Borehole thermal resistance (hr-ft-°F/Btu)
	H	Active U-bend depth (ft)
	Q	Average heat injected (Btu/hr)
	$T(t)$	Temperature dependent on time t (°F)
	T_g	Undisturbed ground temperature
	λ_g	Formation thermal conductivity (Btu/hr-ft-°F)
	r_b	Average borehole radius (in)
	α_g	Formation thermal diffusivity (ft^2/hr)

[4]Stephen P. Kavanaugh and Kevin Rafferty, Geothermal Heating and Cooling: Design of Ground-Source Heat Pump Systems (Atlanta: ASHRAE, 2014), pages 58-67.
[5]Gehlin, 12-13.
[6]Beier, R. and Ewbank, G. (2012, August). *In-Situ Test Thermal Response Tests Interpretations, OG&E Ground Source Heat Exchange Study*. Retrieved from http://ghpok.org/

GRTI
Geothermal Resource Technologies, Inc.

www.grti.com

CERTIFICATE OF CALIBRATION

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

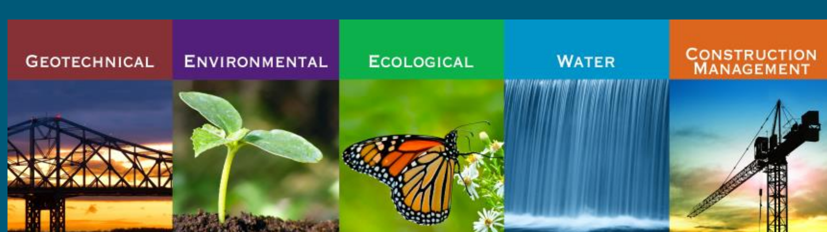
FTC Unit 214

DA Unit 65

Primary Equipment		
Component	Calibration Date	Calibration Due Date
Datalogger	9/24/2018	9/24/2021
Current Transducer	9/26/2018	9/26/2021
Voltage Transducer	9/26/2018	9/26/2021

GRTI periodically verifies the combined temperature sensor/datalogger accuracy via a water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

Date	4/23/2020	10/3/2018	1/10/2018	
Thermocouple 1 (°F)	42.4 42.6 42.6	32.0 31.9 31.8	80.0 80.0 80.1	
Thermocouple 2 (°F)	42.5 42.6 42.7	32.0 31.9 31.8	80.0 80.1 80.1	
Thermocouple 3 (°F)	42.3 42.4 42.5	32.0 31.9 31.9	79.9 80.0 80.0	
Thermocouple 4 (°F)	42.3 42.4 42.5	32.0 32.0 31.9	79.9 80.0 80.0	
Digital Thermometer (°F)	42.3 42.4 42.5	32.1 32.1 32.0	79.8 79.9 79.9	



GZA GeoEnvironmental, Inc.

APPENDIX G

Carbon Mitigation Planning

COMPETITIVE ENERGY SERVICES

MEMORANDUM

Carbon Mitigation Planning

Carbon Reduction Options

The previous section focuses on solutions to transition Storrs' energy infrastructure to new systems that reduce fossil fuel use on campus. In order to claim that these new systems are decarbonizing campus operations, UCONN will need to structure its energy purchases in a manner such that the University can claim that the energy sources used to operate Storrs are not producing a net increase in global greenhouse gas emissions. The following section discusses UCONN's options to purchase renewable energy credits ("RECs") and carbon offsets so that the University can make this claim.

UCONN can achieve "net zero" emissions for Storrs' campus operations through two procurement actions:

- Acquire and retire enough renewable energy credits ("RECs") from renewable electricity generators to offset 100% of the emissions associated with Storrs' electricity purchases (Scope 2 emissions), an action that UCONN currently takes on a voluntary basis.
- Acquire and retire enough carbon offsets from emissions mitigation projects to offset 100% of Storrs' remaining emissions produced by fossil fuel combustion on campus (Scope 1 emissions).

To achieve this target for Storrs, UCONN would continue acquiring and retiring enough RECs each year to eliminate Storrs' Scope 2 emissions and by 2040 would start acquiring and retiring carbon offsets each year in a quantity equal to Storrs' Scope 1 emissions. UCONN has a variety of options to do this. The cost for UCONN to achieve and maintain net zero campus operations for Storrs will vary depending on 1) UCONN's selection criteria for emissions mitigation projects and renewable energy generation projects from which carbon offsets and voluntary RECs are acquired, 2) future legislative changes to Connecticut's Renewable Portfolio Standard ("RPS") that may increase renewable energy requirements for retail electric suppliers, and 3) the implementation schedule achieved for Storrs' campus electrification. Table 1 presents indicative cost estimates for Storrs's main campus[1] to achieve net zero campus operations in 2020, 2030, and 2040 based on these factors.

Table 1 Indicative Voluntary REC and Carbon Offset Cost Estimates

Year	Total RPS Target (%)	Annual Cost – Low Estimate		Annual Cost – High Estimate	
		Voluntary RECs	Carbon Offsets	Voluntary RECs	Carbon Offsets
2020	25%	$7,484	$980,830	$224,520	$4,904,150
2030	44%	$26,522	$754,533	$795,660	$4,581,208
2040 – current RPS law	44%	$107,652	$407,630	$3,229,560	$2,947,587
2040 – change in RPS	80%	$38,447	$407,630	$1,153,410	$2,947,587
2040 – change in RPS	100%	$0	$407,630	$0	$2,947,587

[1] By this we mean the campus' footprint served by the Central Utilities Plant and main Eversource electric account. As we reference "Storrs" throughput the memorandum we refer to this footprint that excludes distributed utility accounts.

Renewable Energy Credits

A REC is a tradeable certificate that represents the environmental attributes of one MWh of electricity generated by a renewable energy source. One REC is produced for each MWh of renewable electricity generated. Storrs' Scope 2 emissions can be offset one-for-one with RECs. In other words, a REC must be acquired and retired by UCONN for each MWh of electricity purchased for Storrs, be it from the power grid or from an onsite renewable generation source interconnected directly to the campus' electrical system.

While a REC must be acquired and retired to offset Storrs' Scope 2 emissions, the actual purchaser does not have to be UCONN. In fact, a large share of the RECs that will need to be retired for UCONN to eliminate Storrs' Scope 2 emissions in the coming years and decades will be acquired and retired by UCONN's retail electricity supplier pursuant to the supplier's obligations under Connecticut's RPS regulations. Connecticut's RPS requires that all suppliers serving retail electric load in the state must meet their supply obligations by purchasing a certain percentage of electricity from renewable energy generators including wind, solar, and hydro facilities. Retail electricity suppliers do this by purchasing and retiring RECs from renewable generators in the same way that UCONN would, but for the actions of the supplier. We refer to these RECs as "compliance" RECs.[2]

Compliance RECs are not cheap. We estimate that UCONN is currently paying over $90,000 per year to its electricity supplier to satisfy the RPS obligations associated with Storrs' grid electricity purchases.[3] This cost does not include the RECs that UCONN voluntarily purchases for Storrs, which cost approximately $10,000 per year. Based on the design of the bulk power grid and regional electricity markets, the voluntary RECs currently purchased by UCONN do not count towards UCONN satisfying its RPS compliance obligations because the wind generators from which the RECs are sourced are located outside of the New England grid.

In 2020, Connecticut's RPS percentage for renewable energy sources is 25%. As shown in the solid blue bars in Figure 1, this percentage is scheduled to increase by two percentage points per year until it reaches 44% in 2030 where it will remain level through 2040. A change in law to increase Connecticut's RPS targets between 2030 and 2040 appears likely. In September 2019, Governor Lamont issued Executive Order 3, which called for state regulators to develop a roadmap to transition Connecticut's electricity mix to 100% zero-carbon sources by 2040. Once this roadmap is developed, we expect the legislature to review how RPS obligations may be adjusted for 2030 to 2040 to target a higher compliance total than the flat 44% obligation currently in effect through 2040. The shaded blue bars in Figure 1 show one potential path of increasing RPS compliance obligations beyond 2030 to reach 100% in 2040.

Executive Order 3 is not a guarantee that the legislature will increase Connecticut's RPS obligation to 100% by 2040. Achieving a 100% zero-carbon electricity mix by 2040 would require substantial build out of the state and regional electric transmission systems and would require a massive scaling up of utility-scale renewable generation and energy storage capacity above currently planned levels. The lead time to complete these initiatives requires the legislature to update RPS targets as soon as possible if this goal is to be achieved.

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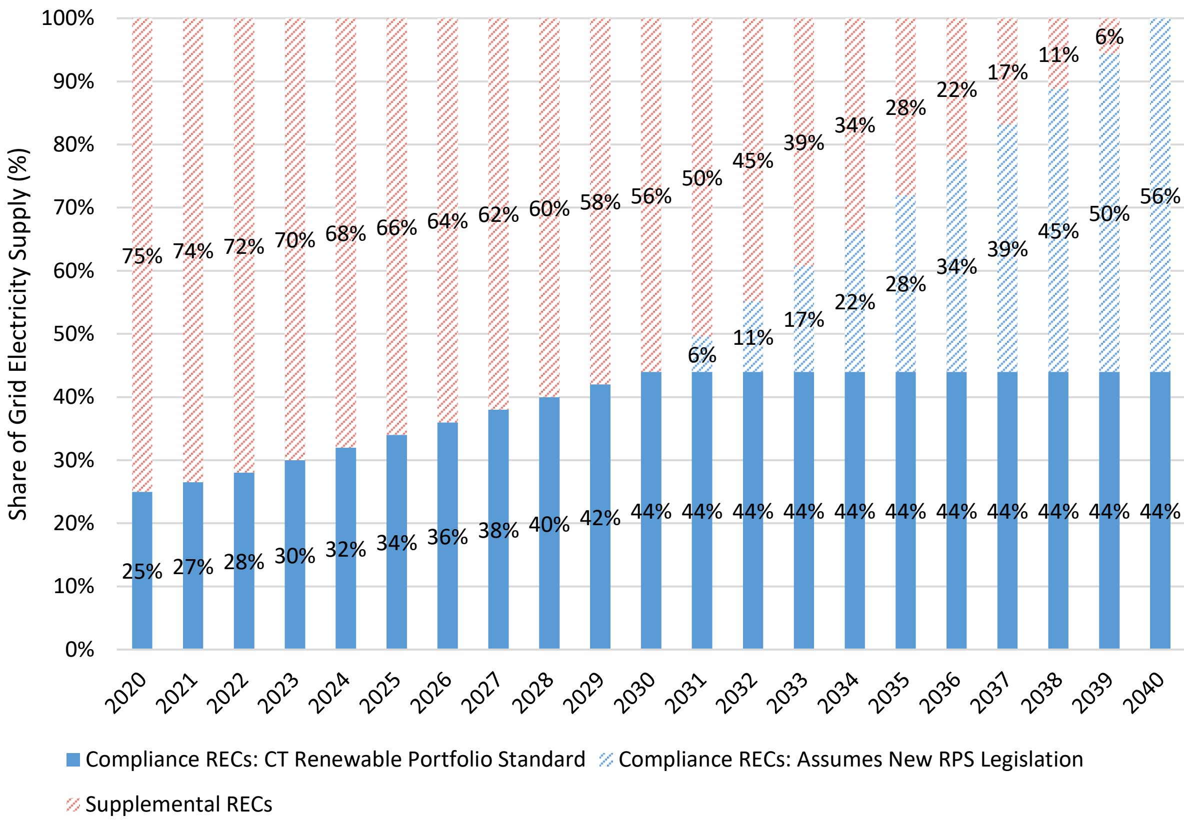
[2] The REC purchases made by the supplier on behalf of UCONN provide the same degree of Scope 2 emissions offset as would be the case if UCONN acted as its own retail supplier and made the compliance REC purchases and retirements itself or if UCONN retired voluntary RECs.

[3] UCONN is currently paying an estimated $900,000 to its supplier to satisfy the RPS obligations for grid electricity purchases at Storrs, Health Center, Law School, Stamford, Waterbury, and County Extension.

Figure 1 UCONN REC Sources to Eliminate Storrs Scope 2 Emissions: 2020 – 2040



Because the RPS percentage will be less than 100% until at least 2040, UCONN must continue purchasing voluntary RECs for that portion of its electricity grid purchases not covered by the actions of its supplier if UCONN wants to continue offsetting 100% of Storrs' Scope 2 emissions. This voluntary REC need is shown in the shaded red bars in Figure 1, assuming a future change in law to the RPS. Storrs' voluntary REC requirements are also shown in Table 2, which highlights the substantial growth in Storrs' electricity purchases as campus heating systems are electrified and the Central Utilities Plant ("CUP") generates less power as steam demands are reduced in the conversion. UCONN expects to need to purchase more than 26,000 voluntary RECs in 2030, and, depending on future legislative changes to Connecticut's RPS, anywhere between 0 (100% RPS obligation) and 108,000 (current 44% RPS obligation) voluntary RECs in 2040.

Table 2 Estimated REC Requirements for Storrs to Eliminate Scope 2 Emissions: 2020 – 2040

Year	Total Storrs Electricity Use (MWh)	Electricity Need Not Met by CUP (MWh)	Total RPS Compliance (%)	Compliance RECs	Voluntary RECs
2020	135,304	9,979	25%	2,495	7,484
2030 – current law	172,685	47,360	44%	20,838	26,522
2040 – current law	247,446	192,235	44%	84,583	107,652
2040 – change in law	247,446	192,235	80%	153,788	38,447
2040 – change in law	247,446	192,235	100%	192,235	0

On Campus vs. Off Campus Renewables

UCONN has three options to acquire and retire voluntary RECs in order to continue offsetting 100% of Storrs' electricity purchases – (1) install renewable electricity generation systems on campus and retain and retire the RECs generated by the systems, (2) purchase RECs from existing renewable generators located off campus through spot purchases or under short-term contracts, as UCONN currently does through its retail electricity supply arrangement, and/or (3) purchase RECs from new generation projects located off campus under one or more long-term agreements. These options have varying cost, additionality, geographic, and contracting characteristics that will need careful consideration by UCONN.

The first option for UCONN to acquire voluntary RECs is from renewable generation located on campus. This type of renewable generation meets two important criteria – additionality and geographic proximity – and offers visible demonstration of UCONN's efforts to campus stakeholders. To the extent that UCONN elects to install behind-the-meter solar generation on campus in the coming years, which could include ground-mounted arrays, rooftop systems and/or parking canopies, UCONN can choose whether to retain and retire the associated RECs or sell the RECs in order to reduce project costs. If UCONN sells the RECs, UCONN would need to purchase replacement RECs in order to maintain the claim of "green power" for generation from the system(s). The challenge with developing behind-the-meter renewable generation on campus is that the actual or implied costs of the associated RECs are quite high today. Due to economies of scale, installation costs for behind-the-meter solar, especially parking canopies, are higher than installation costs for utility-scale ground-mounted solar developed remotely from UCONN's campuses. While behind-the-meter solar can help UCONN avoid certain retail electricity charges that remotely-sited generation cannot, UCONN's grid electricity rate design limits the value of behind-the-meter solar by assessing demand-based charges that cannot be reliability reduced by intermittent solar generation.

The second option is for UCONN to purchase and retire RECs from existing renewable generators located off campus. UCONN currently uses this option, purchasing low-cost Green-e RECs from utility-scale wind projects located in the U.S. Midwest for 100% of grid purchases at six of the University's seven campuses. The option to use out-of-region RECs from existing generators offers very low costs but sacrifices additionality and geographic proximity. UCONN could similarly purchase unbundled RECs from existing utility-scale or community-scale wind, solar, or hydro projects located in New England, as contemplated in recent updates to Connecticut's voluntary Clean Energy Options Program. This in-region option comes with a significant cost premium compared to the Green-e option.

The third option is for UCONN to execute a long-term virtual power purchase agreement ("VPPA") with a project developer to construct a new renewable generator located off campus in Connecticut or out of state.[4] There are numerous examples of private companies executing VPPAs in recent years, and several examples of UCONN's peers including the Massachusetts Institute of Technology executing a VPPA with a new utility-scale solar project in North Carolina and various colleges in New England executing a VPPA with a new

[4] This contract could be structured in two ways: for physical delivery of contracted energy and RECs to UCONN if the generator is in New England or as a virtual settlement whereby UCONN only acquires RECs from the project. A virtual settlement can be done regardless of whether the generator is in New England or outside the region.

utility-scale solar project in Maine.[5] This option provides additionality and perhaps geographic proximity but is likely to cost significantly more than the lowest cost unbundled REC option.

UCONN's peers that have taken this approach have elected to contract with a private developer to finance, own, operate, and maintain the generator. Under this approach the developer acquires the land where the generator is sited, provides funding for the project, and is responsible for all aspects of system development and operations. This contracting structure enables a public offtaker like UCONN to realize lower purchase pricing due to federal tax credits for solar and wind generation that are only available to project owners with tax liability. Furthermore, if the offtaker does not dictate where the generator needs to be sited, i.e., on property owned by the offtaker, developers can site generators where energy production (and economies of scale in development) can be maximized and interconnection costs can be minimized.

Voluntary REC Procurement

The future cost of acquiring and retiring voluntary RECs may ultimately be an operating expense or a capital expense for UCONN. The University could purchase RECs from a third party that finances, owns, operates and maintains a project, in which case the cost would be an operating expense. This arrangement is known as a power purchase agreement ("PPA"). Conversely, UCONN could choose to directly finance a renewable energy generation facility (or an emissions mitigation project in the case of carbon offsets), in which case the cost would be treated as a capital expense. Each approach has benefits and risks that UCONN will need to consider. For the purposes of cost estimation and comparison of the investment cases studied in this report, RECs and offsets are treated as operating expenses.

The wide range of purchasing options for voluntary RECs from offsite renewable generation projects begs the question of how UCONN should compare its purchasing opportunities. UCONN can explore three purchasing strategies for voluntary RECs sourced from off campus generators:

1. <u>100% Unbundled RECs</u>. UCONN purchases 100% of its voluntary REC needs from existing generators through spot-market purchases or under short-term contracts. UCONN can pursue a low-cost option of sourcing RECs from out-of-region generators or a higher-cost option of sourcing RECs from in-region generators.

2. <u>100% Additionality</u>. UCONN prioritizes additionality in its REC acquisition and purchases only RECs from new renewable generator projects. This may include multiple generation technologies and a mix of purchases from in-region and out-of-region generators.

3. <u>Mixed Purchases</u>. UCONN purchases a mix of unbundled RECs from existing generators and RECs from new generators that offer additionality. This approach aims to balance cost and additionality objectives and could potentially be achieved by purchasing RECs in lower-volume tranches and/or through REC arbitrage (i.e., selling a portion or all in-region RECs into local compliance markets depending on annual budget targets and outcomes). Under this approach UCONN may choose to purchase a portion of its REC requirement from new in-region or out-of-region generators under long-term agreements and to purchase unbundled RECs in the spot market.

[5] More information on Amherst, Hampshire, and Smith Colleges' VPPA can be found at https://www.competitive-energy.com/news/2019/10/24/five-leading-liberal-arts-college-partner-to-create-new-solar-energy-facility-in-maine.

The voluntary REC cost estimates presented herein assume UCONN pursues the Mixed Purchases option, with the majority of RECs acquired from new utility-scale solar generation projects under long-term offtake agreements. These RECs are estimated to cost $30 per MWh on average through 2040; actual costs will vary depending on electricity market conditions and the final purchase price contracted with awarded project developers. Low-cost Green-e REC are estimated to cost $1 per MWh.

Carbon Offsets

Carbon offsets represent a unit of carbon dioxide-equivalent that can be avoided or sequestered to offset emissions being generated onsite at Storrs. The concept of carbon offsets is that if UCONN financially supports an offset project the University can achieve an equivalent global emissions outcome (i.e., no net increase in cumulative global emissions) as reducing Storrs' emissions through changes in campus operations and energy use. Carbon offset projects span a broad variety of actions that can be taken to avoid or sequester carbon emissions, including landfill gas capture and destruction, organic waste composting, agricultural methane capture, ozone depleting substance capture, and tree planting, to name but a few examples.

There are two types of emissions against which carbon offsets can be applied: Scope 1 and Scope 3. Scope 1 includes emissions generated by fossil fuel combustion in the CUP and building-level heating systems in distributed campus facilities. Scope 3 includes emissions generated by indirect sources associated with campus operations such as student and faculty air and ground travel, commuting, and campus waste disposal. If an entity claims that it has achieved carbon neutrality or net zero emissions, this implies the entity has acquired and retired carbon offsets equal the purchaser's own Scope 1 and Scope 3 emissions (plus REC purchases and retirement to offset Scope 2 emissions) for a defined period, typically by year. The PWGS has elected to not incorporate Storrs' Scope 3 emissions into the University's current mitigation strategy, so the 2040 net zero target discussed herein only applies to Storrs' Scope 1 and Scope 2 emissions.

For purchasers of carbon offsets an important criterion in selecting emissions mitigation projects is additionality. Additionality means the emissions avoidance or sequestration would not have occurred without the financial support provided by the ability to sell offset claims. All credible third-party verification sources for carbon offsets qualify projects on this basis. Other important traits of carbon offsets are that they are real, verified, enforceable, and permanent. Various registries and standards have been developed to verify greenhouse gas emissions avoidance or sequestration from carbon offset projects. These registries and standards aim to address purchasers' concerns that the emissions impact claimed for an offset project can be verified and is not being double counted through project claims being sold to multiple purchasers.

In developing an offset purchasing strategy, UCONN will need to consider a number of factors such as registry characteristics, project location and type, vintage year, and price. There are numerous providers of carbon offsets serving the voluntary offset market for colleges and universities, so these factors can be evaluated and compared in a competitive solicitation process that requests a wide range of offset options and projects. It is also possible UCONN to directly invest in emissions mitigation projects that are not yet developed, although this can introduce uncertainty in the number and cost of associated offsets.

The cost of acquiring and retiring carbon offsets will vary depending on UCONN's selection criteria. Offsets currently cost as little as $2 to $5 per $MTCO_{2e}$. Landfill gas capture/destruction and reforestation initiatives typically fall into this lowest-cost category of projects. There is also a range of offsets options with much higher purchase pricing between \$20 and \$100 per $MTCO_{2e}$. Like pricing, contracting terms for carbon offsets vary depending on the project. Certain offset sellers require long-term contractual commitments, whereas other offsets can be purchased on short-term or year-to-year contracts.

Based on current pricing in the voluntary offset market and offset selections by other universities and colleges located in the Northeast U.S. and have declared carbon neutrality, we have assumed a low-end offset cost of \$10 per $MTCO_{2e}$ in 2021, increasing by 2% per year to \$14.57 per $MTCO_{2e}$ in 2040. If UCONN elects to purchase "premium" carbon offsets to fulfill certain educational goals, purchasing costs will depend on the project selected. As an indicative estimate for premium offsets we have assumed pricing of \$50 per $MTCO_{2e}$ in 2021, increasing by 4% per year to \$105.34 per $MTCO_{2e}$ in 2040.

APPENDIX H

Carbon Reduction Strategies

1.0 CARBON REDUCTION STRATEGIES

Heating/Cooling Options

Various types of thermal heat pump technologies have been evaluated to convert the UConn campus thermal requirements from fossil fuel to electric powered systems. There are multiple types of heat pump systems available to be installed, including ground source, water source, and air source. Additionally, electric boilers and chillers have also been evaluated. The most practical technology for each district or sub-district has been considered for the Alternative Carbon Zero Plan as existing conditions may merit.

Ground Source Heat Pumps

Closed loop ground source systems circulate fluid through a series of vertical boreholes. There are multiple types of borehole designs possible, ranging from 400 to 1,500 feet. This study assumes closed loop type with boreholes at an approximate depth of 500 feet. The other bore hole designs may be analyzed in a further study or in the design phase.

These systems typically use water or an antifreeze solution such as propylene glycol or ethylene glycol as the heat transfer fluid. Closed loop system fluid never contacts the soil or groundwater. The heat transfer fluid is pumped through the vertical wells transferring thermal energy from the ground. The pipes within the vertical wells are then connected to horizontal pipe headers below the frost line and is then piped to the heat pumps.

Heat pumps utilize a working fluid, a compressor, expansion valve, and heat exchangers to transfer thermal energy from the ground source loop to a distribution loop to heat and cool buildings. **Figure 1.0** below provides a conceptual representation in heating mode.

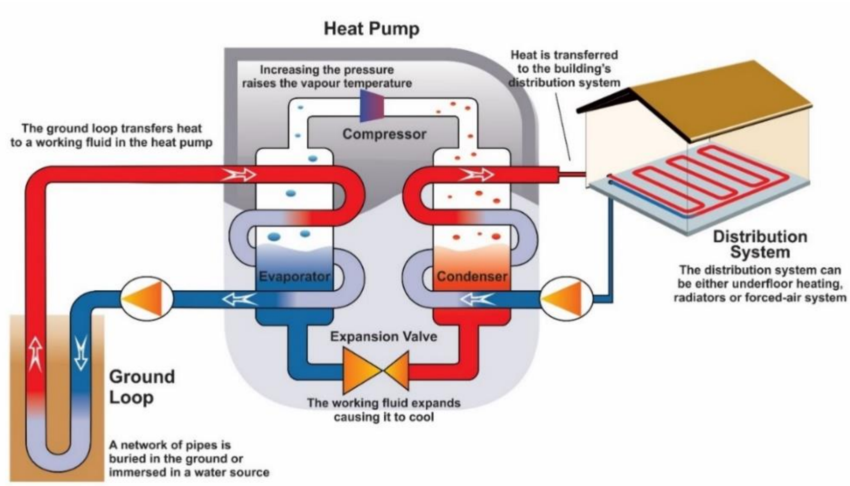


Figure 1.0: Ground Source Heat Pump Diagram in Heating Mode

Multiple ground source wells and heat pumps can be paired together to create a central ground source system to serve a distribution system. These systems can provide simultaneous heating and cooling to improve system efficiency. **Figure 1.1** shows a conceptual central ground source heat pump system in combination heating and cooling mode.

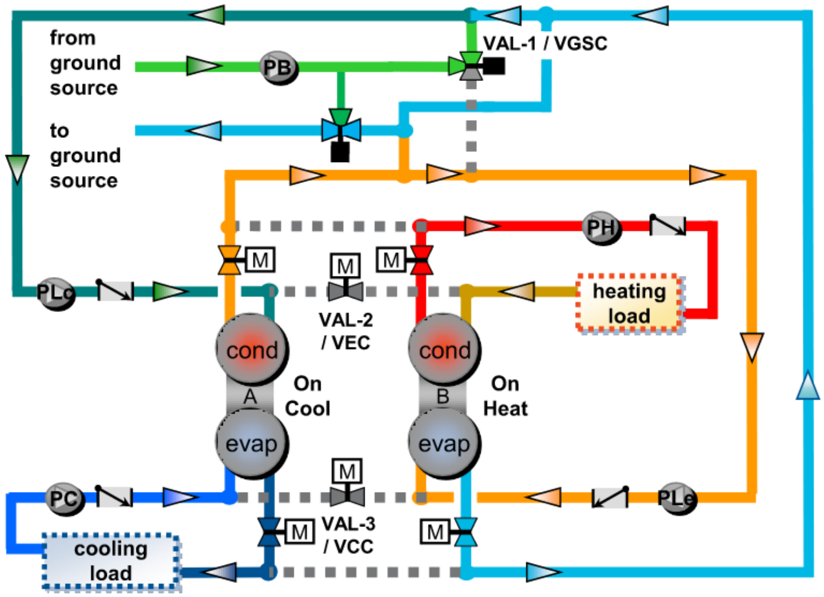


Figure 1.1: Central Ground Source Heat Pump Diagram in Heating and Cooling Mode

Some of the advantages and disadvantages of ground source heat pumps are the following:

Advantages:

- Centralized equipment
- Highest Efficiency
- Can get “Free” heating/cooling depending on load balance
- High COPs during simultaneous heating/cooling (shoulder seasons)

Disadvantages:

- Significant site work including drilling and piping
- Highest first cost

Water Source Heat Pumps

Water source heat pumps operate very similarly to ground source heat pumps previously discussed. The major difference is that rather than the thermal source/sink being provided by a ground source well field, it is provided by a cooling tower/fluid cooler and a hot water boiler. For the purpose of this study, it is assumed all boilers are electric type.

Similar to the central ground source systems, water source heat pumps can be used in a centralized system to produce hot and chilled water to be distributed throughout the building to meet the thermal load. **Figure 1.2** shows a conceptual diagram of an electric chiller with open circuit cooling tower to cool condenser water but with heat recovery using condenser water heat for reheat coils in an air handler. The chiller evaporator water is used for cooling to the chilled water coil in the air handler.

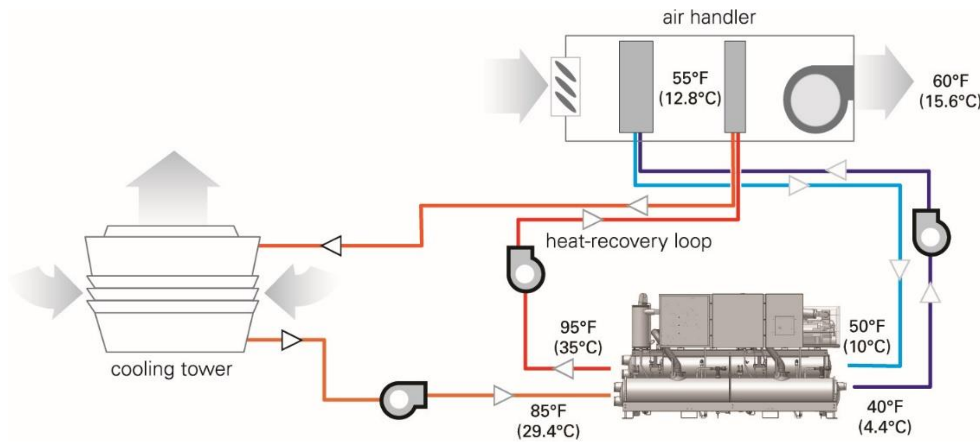


Figure 1.2: Electric Chiller Diagram in Cooling Mode with Heat Recovery for Reheat

Figure 1.3 shows a chiller heater utilizing a cooling tower and an auxiliary heat source (boiler) to satisfy as simultaneous heating and cooling load.

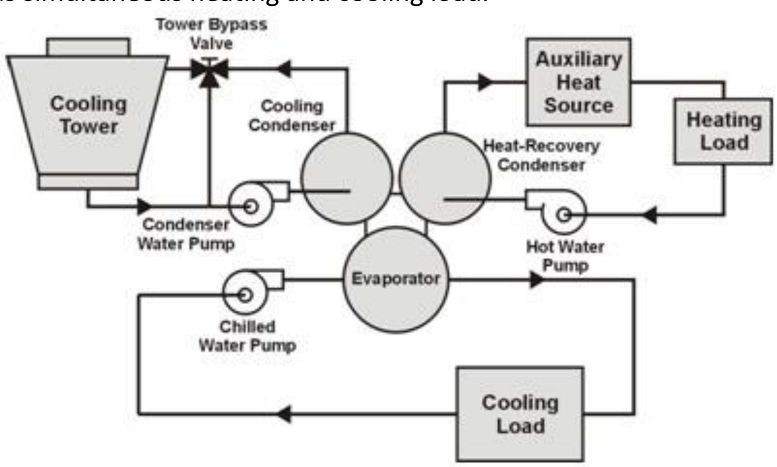


Figure 1.3: Central Chiller Heater Diagram in Heating and Cooling Mode with Heat Booster

Water source heat pumps can also be implemented in a distributed system rather than a centralized system. These systems involve circulating the source/sink fluid throughout the building and the distributed heat pumps produce the heating and cooling for the building. Heat pumps provide cooling to rooms in the south side of a building and reject heat to a hot water loop for hot water heating on the north side of the building. Supplemental heating is available from boilers. A closed circuit fluid cooler is used to release heat to atmosphere if a building is in full cooling mode. These systems are generally referred to as water to air heat pumps.

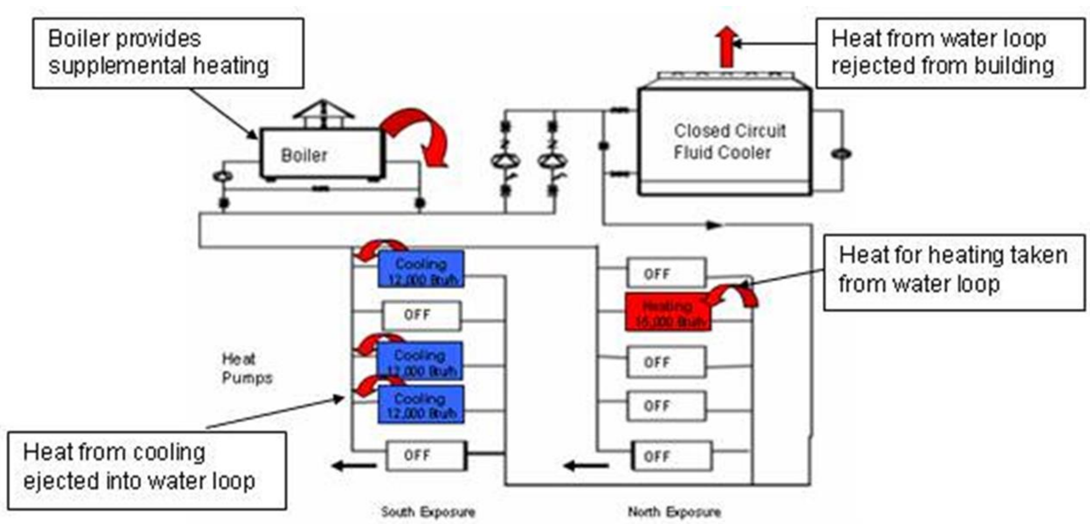


Figure 1.4: Decentralized Water-to-Air Heat Pump Diagram with Supplemental Boiler

Some of the advantages and disadvantages of water source heat pumps (distributed or larger central heat pump chillers with cooling towers/fluid coolers) are the following:

Advantages:

- Minimal Site work required
- Small distributed electric boiler load
- No Well Drilling
- Can get "Free" heating/cooling depending on load balance
- Very high COPs during simultaneous heating/cooling (shoulder seasons)
- System can be designed based on actual load profile of building

Disadvantages:

- Distributed equipment means more maintenance
- Less ability to account for campus load diversity
- Will need building conversions based on system type
- Need a roof/ground area for cooling tower/fluid coolers

Air Source Heat Pumps

Air source heat pumps function with the same fundamentals as a water source system with refrigerant as the working fluid, a compressor, expansion valve, and heat exchangers to transfer thermal energy. The major difference in these systems is that the thermal source/sink is the ambient air, rather than a water mixture.

These systems function using an indoor evaporator and an outdoor condensing unit. Refrigerant from the heat pump is circulated to release heat inside a building and absorb heat to vaporize the refrigerant outside a building when in heating mode. A reversing valve is utilized to switch the direction of the flow to allow the unit to operate in cooling mode. Refrigerant from the heat pump is circulated to absorb heat inside a building, therefore cooling the space and rejecting heat to vaporize the refrigerant outside a building when in cooling mode. **Figure 1.5** shows a conceptual diagram of a standalone air source heat pump system.

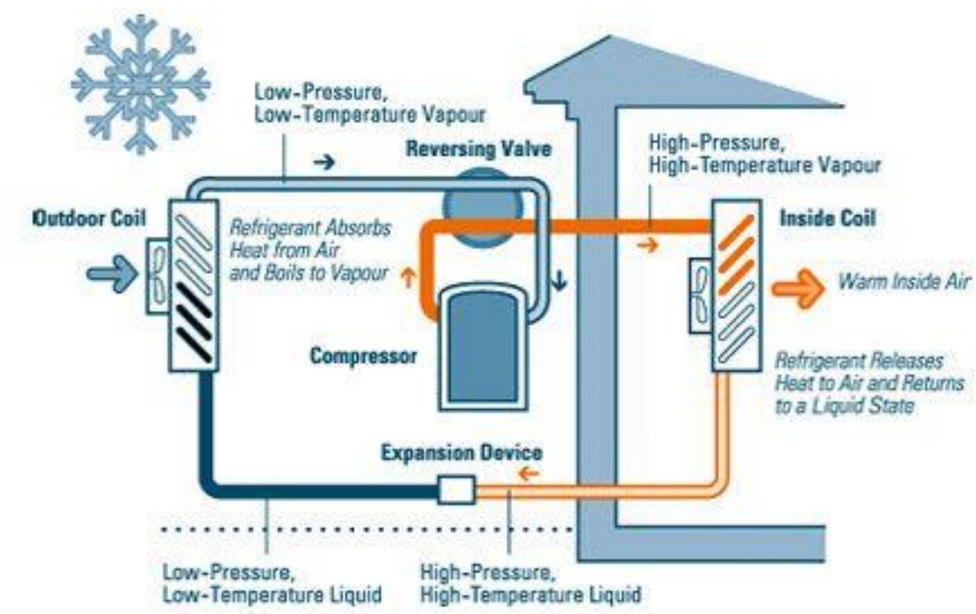


Figure 1.5: Air-to-Air Heat Pump Diagram in Heating Mode

Variable Refrigerant Flow (VRF)

On a larger scale, air source heat pump technology can be implemented using a variable refrigerant flow system. Refrigerant is circulated similarly as discussed in the Air Source Heat Pump section but both refrigerant gas and liquid are circulated so rooms may be individually heated or cooled, depending on occupancy requirements. These systems include a distribution of refrigerant to many terminal units throughout a building. Complex controls allow a varying amount of refrigerant to be circulated to each individual unit based on the heating or cooling load in that space and therefore increasing the efficiency of the overall system. **Figure 1.6** shows a conceptual diagram of a VRF distribution system throughout a building.

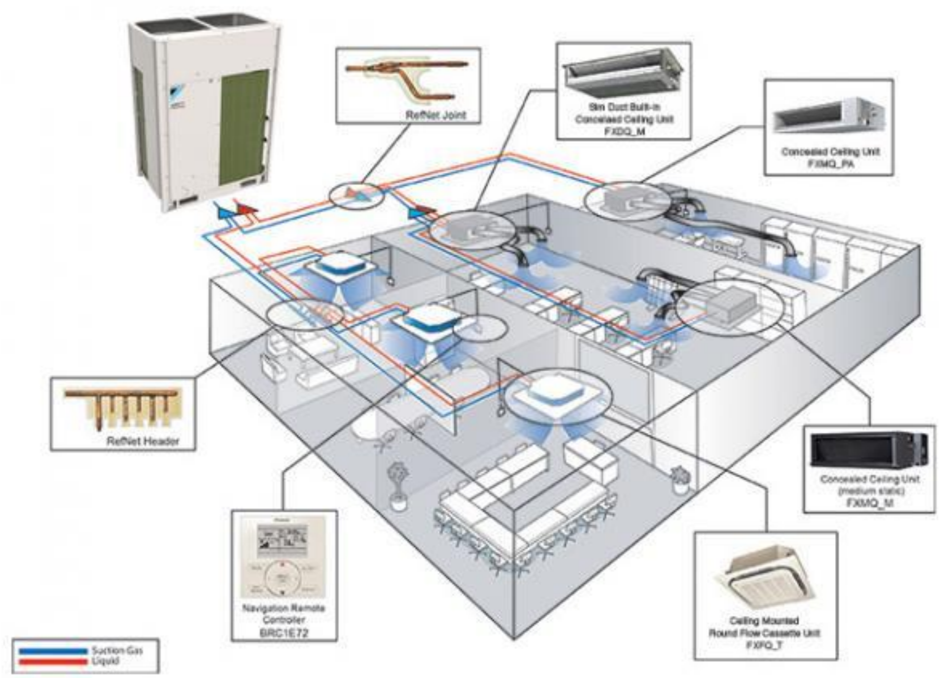


Figure 1.6: Variable Refrigerant Flow (VRF) Diagram in Heating and Cooling Mode

Some of the advantages and disadvantages of air source heat pumps (air-to-air and variable refrigerant flow) are the following:

Advantages:

- No Site work required
- No electric boiler load
- No Well Drilling
- Good COP
- System can be designed based on actual load profile of building
- Relatively low space impact

- Can be retrofitted into buildings fairly easily (although aesthetics of mini splits may not be desired)

Disadvantages:

- Distributed equipment means more maintenance
- Building renovations to accommodate/retrofit depending on current systems
- Need local space outdoors (roof/ground) to place condensing units

Hybrid Ground Source System

Hybrid type ground source heat pump systems use a smaller well field and a supplemental heat source/sink to provide the required thermal capacity. The additional heat sink comes from either a cooling tower or fluid cooler. Additional required heat is provided through the use of an electric boiler. **Figure 1.7** shows a simple conceptual hybrid central ground source heat pump system with an additional cooling tower serving heating and cooling distribution.

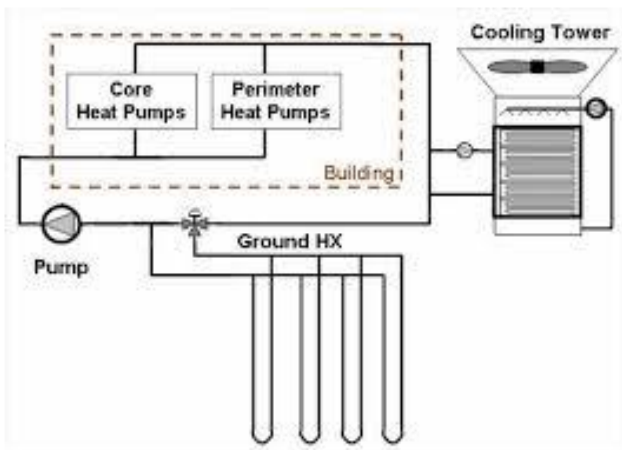


Figure 1.7: Ground Source Heat Pump Diagram with Supplemental Cooling Tower

Another technology that may be used with the ground source well field is a water source variable refrigerant flow (VRF) system. These systems utilize distributed terminal units throughout the building to provide heating and cooling throughout the spaces. The major difference in these types of systems is that rather than running distributed hot water and chilled water, smaller refrigerant piping is run throughout the building to the terminal units. The ground source wells are used as the heating/cooling source/sink to provide the needed. **Figure 1.8** shows a simple conceptual ground source VRF system with heating and cooling terminal units.

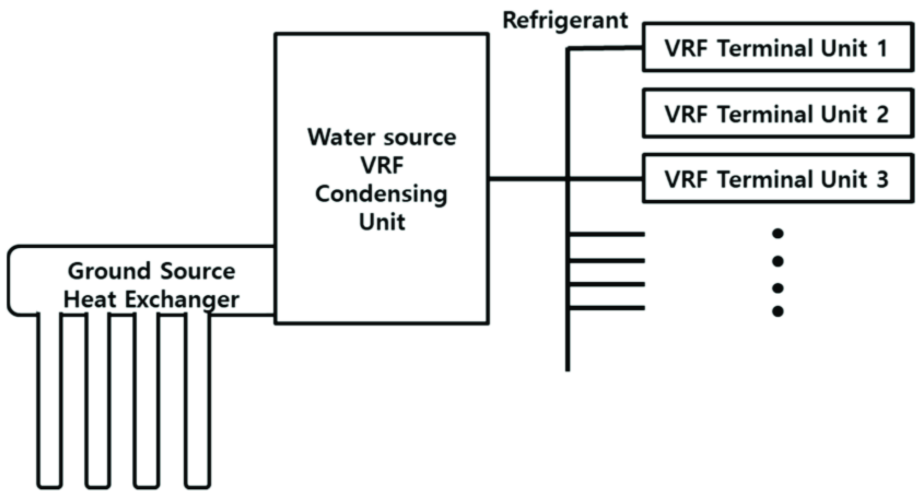


Figure 1.8: Variable Refrigerant Flow Diagram with Ground Source Heat Exchanger

Water source variable refrigerant flow may also be used with a cooling tower/fluid cooler and a hot water boiler. These systems function identically to the ground source VRF discussed previously; however rather than the well field providing the source/sink, heat transfer is done with a cooling tower/fluid cooler and a boiler.

Figure 1.9 shows a conceptual water source VRF system with heating and cooling terminal units.

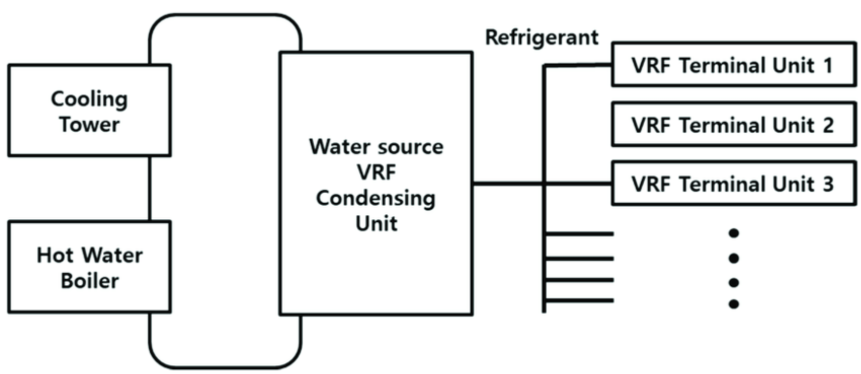


Figure 1.9: Variable Refrigerant Flow Diagram with Cooling Tower

Electric Boilers

Electric boilers may be used to provide booster heating for the various technologies previously described or can directly replace existing fossil fuel boilers. Electric boilers function by having water pass over an electric resistive heating element or direct contact with electrode plates to produce either steam or hot water for local building use or campus distribution. **Figure 1.10** shows an image of an industrial high voltage electrode steam boiler.

Figure 1.10: Industrial Electric Steam Boiler

There are two options to convert the campus core to a zero carbon system using the technologies mentioned in this section, each with their advantages and disadvantages.

Replace Central Utility Plant with Chiller Heaters, Booster Hot Water Boilers and Fluid Coolers

Advantages:

- Less site work required
- Smaller electric boiler load
- No well drilling
- Can get "free" heating/cooling depending on load balance
- High COPs during simultaneous heating/cooling
- Centralized system with fewer pieces of equipment (can be up to 2,500 tons per chiller), approximately 4.4 kW/ton
- Not all buildings will need to be converted (can push up to 165 deg. LWT if needed)

Disadvantages:

- Steam infrastructure will need to be converted to hot water
- Some buildings will require hot water conversion

Replace the Central Utility Plant with Electric Steam Boilers, Chillers and Cooling Towers

Advantages:

- Least amount of site work required
- No building conversions necessary
- No Well Drilling

Disadvantages:

- Even more significant electrical upgrades necessary (For reference, CUP would be pushing a peak of 70 MW alone)
- Highest Operating Costs
- Highest Energy use
- Worst COP

Two other possibilities to convert the campus include maintaining the existing Cogeneration Facility as carbon capture technologies develop, while another may be to convert to a carbon free fuel, such as hydrogen, as the infrastructure becomes available.

BVH integrated services

APPENDIX I

Cost and Scope Matrix

COST AND SCOPE MATRIX

ZERO CARBON WORK/COST MATRIX THROUGH 2030 - FEBRUARY 8, 2021				
		Climate Action Plan	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
ECMS	Relamping and LED Light Fixture Replacement	X	X	X
	Anaerobic Digestion Facility	X	X	X
	CAHNR Sequestration Expansion	X	X	X
	Demo Torrey Life Science Building	X	X	X
	Lab Ventilation Replacement	X	X	X
	Other Energy Conservation Measures	X	X	X
	Pipe and Valve Insulation	X	X	X
	Cost Range	**$60M - $90M**	**$60M - $90M**	**$60M - $90M**
Initial Projects	Progam Planning and Concept Designs	X	X	X
	Spring Manor - Air or Water Source	X	X	X
	South B - Ground Source	X	X	X
	East B - Air or Water Source		X	X
	Northwest Part 2 - Ground Source		X	X
	Spring Hill - Air or Water Source		X	X
	West Part 1 -Ground Source		X	X
	Cost Range	**$30M - $50M**	**$250M - $320M**	**$250M - $320M**
Campus Electrical Infastructure/PV	1 MW Solar Array - On Campus Parking	X	X	X
	5 MW Solar Array - Depot		X	X
	30 MW Off Campus PPA		X	X
	Load shedding platform for future expansion		X	X
	Complete North Eagleville Undergrounding		X	X
	Extend Storrs 38E Circuit #3		X	X
	Install new 50 MVA base "Storrs 38E" transformer		X	X
	Ductbank for Substation 195 high capacity connection		X	X
	Install batteries to maintain campus resiliency		X	X
	New Electric Distribution/Energy Plant at West Sections		X	X
	New Electric Distribution/Energy Plant at East Sections			X
	New Electric Distribution/Energy Plant at North Sections			X
	New Electric Distribution/Energy Plant at South Sections			X
	Commece new Main Feeder from Willamantic			X
	Cost Range	**$10M - $20M**	**$250M - $320M**	**$300M - $370M**
Perimeter Thermal Conversions	Depot		X	X
	West Part 2		X	X
	West Part 5		X	X
	East A		X	X
	Northeast			X
	Northwest Independent			X
	Northwood			X
	South A			X
	Southeast			X
	West Part 3			X
	West Part 4			X
	Northwest Part 1			
	Northwest Part 3			
	Northwest Part 4			
	Cost Range	**$0**	**$290M - $350M**	**$390M - $490M**
Central Core	Central North - Part 1			X
	Central North - Part 2			
	Central South - Part 1			
	Central South - Part 2			
	Cost Range	**$0**	**$0**	**$140M - $250M**
Totals				
	Total Capital Cost From 2021-2030	**$100M - $160M**	**$850M - $1080M**	**$1140M - $1520M**
	Total Operating Cost From 2021-2030	**$540M - $550M**	**$550M - $570M**	**$560M - $580M**
	TOTAL CAPITAL AND OPERATING COST 2021-2030	**$640M - $710M**	**$1.4B - $1.65B**	**$1.7B - $2.1B**

Appendix D

Supplemental Report After Peer Institution Review (Mar 2021)

PWGSE Report May 2021 - Appendix D

UCONN
UNIVERSITY OF CONNECTICUT

TO: President's Working Group on Sustainability (PWGS)

FROM: Laura Cruickshank
Robert Corbett

CC: Scott Jordan

DATE: March 17, 2021

RE: **Supplemental Report on Carbon Plan Alternatives**
Based on Review of Peer Institution Sustainability Plans

This Memorandum shall serve to supplement the BVH Integrated Services dated January 2021 titled *Zero Carbon Scenario Planning for the University of Connecticut - Project Number 300192* (BVH Report). The BVH Report compared three (3) alternative plans related to the University's goal of reducing and/or eliminating greenhouse gas carbon emissions from the use of fossil fuels. The Climate Action Plan, which was adopted by the University in 2012, committed to a linear 2% annual reduction in carbon emissions, but at its completion in2050 continues to operate the Central Utility Plant on fossil fuels and purchases carbon off-sets to meet a "net zero carbon" goal. The Zero Carbon by 2050 Plan accelerates the emissions reductions, sequentially addressing the buildings on the perimeter of the campus that burn fossil fuels first, followed by conversion of the Central Utility Plant between 2040 and 2050 when additional conversion technology may become available. The Zero Carbon by 2040 Plan accelerates emissions reductions even further, addressing perimeter buildings and buildings on the Central Utility Plant concurrently, but would be much more disruptive to the operations of the University.

As of 2019, UConn's Scope 1 and 2 carbon emissions are approximately 98,080 metric tons (MT) per year, which is already a 20% reduction below a 2007 baseline. From today's emissions level, the Carbon Action Plan would additionally reduce emissions by 30% by 2030, 55% by 2040, and 75% by 2050. As stated above, the Carbon Action Plan is a "net zero" carbon reduction plan, therefore the purchase of carbon off-sets addresses the remaining 25% emissions after 2050. The Zero Carbon by 2050 Plan projects a reduction of 37% of the current Scope 1 and 2 emissions by 2030, an approximately 70% reduction by 2040, and a 100% reduction by 2050. Since work is conducted in more areas of the campus simultaneously in the Zero Carbon by 2040 Plan, the projected reduction in current carbon emissions is 60% by 2030 and 100% by 2040, which is consistent with the PWGS goals outlined in their June 2020 report.

Upon completion of the draft BVH Report, an investigation and comparison of UConn and peer institution plans and costs was undertaken.

PEER INSTITUTION REVIEW

UPDC contacted three (3) Universities that are undertaking large-scale carbon emissions reduction plans, and a summary and comparison to the UConn Zero Carbon by 2040 Plan is attached in Exhibit A. An overview summary of these peer institution carbon emission reduction plans is as follows:

Stanford University: Between 2007 and 2015, Stanford University reduced their carbon emissions by approximately 65% through removal of their central cooling and heating plant and replaced it with five (5) new regional energy/electric plants and a new hot/cold water loop. In 2021 dollars, their capital expense for this program was approximately $600 Million. This capital cost includes construction of the energy plants, new distribution piping and 155 steam-to-hot-water conversion locations but excludes electrical distribution costs and internal building mechanical system conversions to fully utilize the low temperature hot water heat systems. Their central heating/cooling plant was at the end of its useful life and a large capital expense was already anticipated by Stanford to address same.

Stanford's utility expenses roughly doubled after completion of their new hot water supply and distribution system, and are anticipated to be approximately $1.0B over the next 30 years. However, due to reductions in projected fees from current and anticipated California carbon emission taxes, and lower electric rates attained through a 60 MW off-campus solar power purchase agreement, Stanford believes implementation of their plan may ultimately be less costly than continuing to operate their fossil fuel system. Some of the reasons that Stanford's plan may not be directly comparable to UConn plans include the fact that the heating and cooling peak loads in California are significantly lower than Connecticut, Stanford utilized fully electric equipment versus the predominately geothermal exchange systems proposed in the BVH Report, and electric costs are less expensive in California versus Connecticut. Additionally, resiliency is not an issue for Stanford University as their main campus is powered from two (2) separate electric grid feeds.

University of California – Davis: UC Davis is in the preliminary stages of implementing a 15-year carbon emissions reduction plan, which has taken approximately seven years to plan and design. UC Davis's capital budget for this sustainability project is capped at just under $300 Million. UC Davis hopes to construct two new electric energy plants and distribute new hot water piping to approximately 250 of its 1,200 buildings on campus, which would result in a 30% reduction in its carbon emissions. UC Davis anticipates the large-scale purchasing of carbon off-sets after 2035 to meet its net zero carbon goals.

UC Davis is projecting that its operating costs will rise over the next 15 years due to the increased electrical usage, but a portion of the expenses will be off-set by reduced O&M costs from replacement of its old steam infrastructure and construction of a new 14 MW on-campus solar photo-voltaic farm. Some of the reasons that UC Davis' plan may not be directly comparable to UConn plans include the fact that the heating and cooling peak loads in California are lower than Connecticut, UC Davis utilized fully electric equipment versus the predominately geothermal exchange systems proposed in the BVH Report, and UC Davis' modest carbon reduction goals versus UConn's goal of attaining zero carbon. Resiliency at UC Davis is provided by three (3) separate electric grid feeds.

Princeton University: Princeton University is in their sixth year of a thirty year plan to reduce their carbon emissions by 75% by 2046. Their current capital cost projection is approximately $875 Million, which is almost double their original 2016 budget for the project. Approximately 80% of its campus buildings are served by its existing fossil fuel central utility plant, and their plan includes incrementally building new energy plants and hot/cold water distribution systems on a regionalized basis, eventually resulting in the decommissioning of their 1996 central plant. The new energy plants will get their heating and cooling from between 35 and 50 acres of geoexchange wells. Princeton's original plan to reduce their emissions even further, including conversion of their approximately 40 buildings not on their central plant to biofuel systems, has been reconsidered, and the current plan is to purchase carbon off-sets for any remaining fossil fuel emissions after 2046. Their capital cost budget for this project excludes costs associated with electrical upgrades and electric distribution, and excludes the costs associated with modifications to internal building mechanical systems, which will be addressed as part of a larger $5.5B building new construction and renovation program.

Princeton's analysis in 2016 concluded that operating and maintaining their existing mid-life steam system would have been less expensive than operating the new geoexchange wells and hot water system, however they believe the environmental benefits from carbon reduction likely off-set the additional expenses. Princeton currently self-assesses a "shadow" or "social" cost of $45/Metric Ton of carbon emissions as a financial off-set when considering rising operational expenses. Additionally, Princeton constructed a 16.5 MW solar array on campus and sold the environmental RECs, which lowered their average electric rate and reduced utility expenses. Princeton originally planned to construct up to a total of 76 MW of solar capacity but has decided not to pursue any additional purchase power agreements because they believe the electric grid in New Jersey will use 100% renewable energy sources by 2046.

Princeton's plan is more similar to UConn's alternatives than the plans of Stanford and UC Davis. Princeton is utilizing geoexchange wells for heating and cooling, has peak seasonal loads for heating and cooling similar to UConn, and is transitioning incrementally over a construction period of 25 years. However, Princeton has fewer buildings that have stand-alone systems (40 at Princeton versus 160 at UConn) and the cost of building mechanical system conversions is not included in their current project budget. Additionally, other differences include Princeton having significant existing electric capacity on-campus to allow electrification from three (3) separate grid feeds, Princeton having advanced controls systems in place for a transition to low temperature systems, and New Jersey having lower costs of electricity than Connecticut.

CAPITAL COST REVISION

The following summary of the alternative plans was included in the BVH Report as Table 4.4:

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TABLE 4.4

	Climate Action Plan		Zero Carbon by 2050		Zero Carbon by 2040	
Conversion Period	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	$60-$80M	$50M	$150-$220M	$50M	$150-$220M	$50M
2026-2030	$40-65M	$64M	$700-$850M	$65M	$1,000-$1,300M	$70M
2031-2040	$700-$825M	$105-$115M	$800-$1,100M	$115-$125M	$1,250-$1,700M	$150-$160M
2041-2050	$700-$825M	$160-$170M	$750-$1,050M	$200-$220M		$200-$220M
TOTAL	**$1,500-$1,800M**	**$2,850-$3,000M**	**$2,400-$3,220M**	**$3,175-$3,375M**	**$2,400-$3,220M**	**$3,575-$3,775M**

To fully quantify the potential costs of conversion to low temperature systems, the costs to connect and convert mechanical systems within buildings was included in the UConn Plans' cost estimates. If campus-wide building management control systems can be implemented to delay the mechanical system work similar to other Universities until the end of the useful life of the equipment in each building, then regular annual and deferred maintenance budgets may be able to address the capital needs of the conversions, thereby reducing the need to include these capital costs in the Zero Carbon Plans. Table 4.4 in the BVH Report would be revised to the following if the mechanical system work in the buildings was excluded from the capital cost estimate:

TABLE 4.4.R1

	Climate Action Plan		Zero Carbon by 2050		Zero Carbon by 2040	
Conversion Period	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	$60-$80M	$50M	$150-$220M	$50M	$150-$220M	$50M
2026-2030	$40-65M	$63M	$550-$700M	$65M	$700-$900M	$70M
2031-2040	$500-$625M	$105-$115M	$600-$780M	$115-$125M	$950-$1,280M	$150-$160M
2041-2050	$500-$630M	$160-$170M	$500-$700M	$200-$220M		$200-$220M
TOTAL	**$1,100-$1,400M**	**$2,850-$3,000M**	**$1,800-$2,400M**	**$3,175-$3,375M**	**$1,800-$2,400M**	**$3,575-$3,775M**

INCREMENTAL COSTS (CAPITAL AND OPERATING):

As BVH was tasked, Table 4.4 provides both the estimated gross capital cost and the estimated gross annual operating costs for each timeframe for each UConn Plan. When comparing costs of plans that vary over time as done by other peer institutions, the net present value (NPV) of projected operating cost is generally utilized in the analysis. Additionally, a certain level of investment in existing infrastructure and buildings can be anticipated over time and baseline operating costs will be incurred for the existing heating and cooling systems regardless of the undertaking of a zero carbon plan. To compare the net cost of the UConn carbon emissions reduction plans to peer institutions, these customary expenses could be deducted to determine the incremental cost of the plans as follows:

TABLE ICE.1.0

INCREMENTAL COST EVALUATION	CLIMATE ACTION PLAN	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
EMISSIONS AVOIDED BY 2050	1,171,548	1,512,349	1,920,569
CUMULATIVE CAPITAL COST TO 2050 ANTICIPATED MINIMUM CAPITAL COST *	$1.1B - $1.4B $800M - $900M	$1.8B - $2.4B $800M - $900M	$1.8B - $2.4B $800M - $900M
NET ADDITIONAL CAPITAL COST *MID-RANGE NET CAPITAL COST/TON AVOIDED*	$300M - $500M *$350*	$1.0B - $1.5B *$800*	$1.0B - $1.5B *$650*
NPV OPERATING COST TO 2050 NPV MINIMUM OPERATING COST	$1.2B - $1.5B $1.0B - $1.1B	$1.7B - $2.0B $1.0B - $1.1B	$1.9B - $2.2B $1.0B - $1.1B
NET ADDITIONAL OPERATING COST *MID-RANGE NET OPERATING COST/TON AVOIDED*	$200M - $400M *$250*	$700M - $900M *$550*	$900M - $1.1B *$500*
CARBON PLAN NPV CAPITAL + OPERATING COST *MID-RANGE TOTAL COST/TON AVOIDED*	**$500M - $900M** *$600*	**$1.7B - $2.4B** *$1,350*	**$1.9B - $2.6B** *$1,150*

** Full Deferred Maintenance Cost less ECMs and Electrical Upgrades that are required regardless of which Zero Carbon Plan is pursued*

UCONN ALTERNATE #1: FIXED CARBON TAX

Unlike California, Connecticut has not instituted a tax on carbon emissions to incentivize the use of, and conversion to, renewable energy. Princeton, as noted above, chose to self-impose a tax in its carbon emissions reduction plan for the purposes of evaluating its potential additional expenses and off-sets. If UConn chose to assess, or was ultimately required to pay, a fee or tax on carbon emissions it would marginally affect the estimated operating costs for the three alternative plans. Table 4.4.1 and the incremental cost Table ICE 1.1 (with changes in red from the adjusted baseline) show the potential effects of a $45/Metric Ton of carbon emissions fixed fee tax being implemented. Under this scenario, the estimated net present value (NPV) of the operating costs increase by approximately $50 Million for the Climate Action Plan, because this plan is subject to higher carbon taxes for longer periods of time. There is no monetary effect on the Zero Carbon by 2050 Plan because early years of paying the carbon tax are effectively equivalent to the tax avoidance in later years. The Zero Carbon by 2040 Plan net

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operating costs are reduced by approximately $50 Million since the early reductions in emissions lead to longer periods of tax avoidance.

TABLE 4.4.1

	Climate Action Plan		Zero Carbon by 2050		Zero Carbon by 2040	
Conversion Period	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	$60-$80M	$50M	$150-$220M	$50M	$150-$220M	$50M
2026-2030	$40-65M	$68M	$550-$700M	$69M	$700-$900M	$72M
2031-2040	$500-$625M	$110-$120M	$600-$780M	$120-$130M	$950-$1,280M	$150-$160M
2041-2050	$500-$630M	$165-$175M	$500-$700M	$200-$220M		$200-$220M
TOTAL	**$1,100-$1,400M**	**$2,950-$3,150M**	**$1,800-$2,400M**	**$3,250-$3,475M**	**$1,800-$2,400M**	**$3,600-$3,800M**

TABLE ICE.1.1

INCREMENTAL COST EVALUATION	CLIMATE ACTION PLAN	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
EMISSIONS AVOIDED BY 2050	1,171,548	1,512,349	1,920,569
CUMULATIVE CAPITAL COST TO 2050 ANTICIPATED MINIMUM CAPITAL COST *	$1.1B - $1.4B $800M - $900M	$1.8B - $2.4B $800M - $900M	$1.8B - $2.4B $800M - $900M
NET ADDITIONAL CAPITAL COST *MID-RANGE NET CAPITAL COST/TON AVOIDED*	$300M - $500M *$350*	$1.0B - $1.5B *$800*	$1.0B - $1.5B *$650*
NPV OPERATING COST TO 2050 NPV MINIMUM OPERATING COST	$1.25B - $1.55B $1.0B - $1.1B	$1.75B - $2.05B $1.05B - $1.15B	$1.95B - $2.25B $1.1B - $1.2B
NET ADDITIONAL OPERATING COST *MID-RANGE NET OPERATING COST/TON AVOIDED*	$250M - $450M *$300*	$700M - $900M *$550*	$850M - $1.05B *$450*
CARBON PLAN NPV CAPITAL + OPERATING COST	**$550M - $950M**	**$1.7B - $2.4B**	**$1.85B - $2.55B**
CHANGE FROM BASELINE	$50M	$0	($50M)
MID-RANGE TOTAL COST/TON AVOIDED	*$650*	*$1,350*	*$1,100*

** Full Deferred Maintenance Cost less ECMs and Electrical Upgrades that are required regardless of which Zero Carbon Plan is pursued*

UCONN ALTERNATE #2: GRADUATED CARBON TAX

Peer institutions believe that once carbon taxes are implemented, they will increase over time to continue to incentivize conversion to renewable energy sources. If a policy or implementation of a carbon tax was on an ever-increasing rate, starting at $45/MT and increasing to $200/MT annually over 30 years, the effect of a carbon tax on the operating costs would be greater. As shown in the updated tables below (Table 4.4.2 and Table ICE 1.2), with changes from the adjusted baseline in red, the NPV of the Climate Action Plan operating costs remain unchanged because the rate of carbon reduction is approximately equal to the rate of increase in the carbon tax. The net operating cost of the Zero Carbon by 2050 Plan is reduced by approximately $50 Million and the tax avoidance of the Zero Carbon by 2040 Plan doubles to result in approximately $100 Million less operating cost.

TABLE 4.4.2

	Climate Action Plan		Zero Carbon by 2050		Zero Carbon by 2040	
Conversion Period	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	$60-$80M	$50M	$150-$220M	$50M	$150-$220M	$50M
2026-2030	$40-65M	$70M	$550-$700M	$71M	$700-$900M	$73M
2031-2040	$500-$625M	$115-$125M	$600-$780M	$120-$130M	$950-$1,280M	$150-$160M
2041-2050	$500-$630M	$170-$180M	$500-$700M	$200-$220M		$200-$220M
TOTAL	**$1,100-$1,400M**	**$3,050-$3,200M**	**$1,800-$2,400M**	**$3,300-$3,500M**	**$1,800-$2,400M**	**$3,600-$3,800M**

TABLE ICE 1.2

INCREMENTAL COST EVALUATION	CLIMATE ACTION PLAN	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
EMISSIONS AVOIDED BY 2050	1,171,548	1,512,349	1,920,569
CUMULATIVE CAPITAL COST TO 2050 ANTICIPATED MINIMUM CAPITAL COST *	\$1.1B - \$1.4B \$800M - \$900M	\$1.8B - \$2.4B \$800M - \$900M	\$1.8B - \$2.4B \$800M - \$900M
NET ADDITIONAL CAPITAL COST *MID-RANGE NET CAPITAL COST/TON AVOIDED*	\$300M - \$500M *\$350*	\$1.0B - \$1.5B *\$800*	\$1.0B - \$1.5B *\$650*
NPV OPERATING COST TO 2050 NPV MINIMUM OPERATING COST	\$1.25B - \$1.55B \$1.05B - \$1.15B	\$1.75B - \$2.05B \$1.1B - \$1.2B	\$1.95B - \$2.25B \$1.15B - \$1.25B
NET ADDITIONAL OPERATING COST *MID-RANGE NET OPERATING COST/TON AVOIDED*	\$200M - \$400M *\$250*	\$650M - \$850M *\$500*	\$800M - \$1.0B *\$400*
CARBON PLAN NPV CAPITAL + OPERATING COST	**\$500M - \$900M**	**\$1.65B - \$2.35B**	**\$1.8B - \$2.5B**
CHANGE FROM BASELINE	\$0M	(\$50M)	(\$100M)
MID-RANGE TOTAL COST/TON AVOIDED	*\$600*	*\$1,300*	*\$1,050*

** Full Deferred Maintenance Cost less ECMs and Electrical Upgrades that are required regardless of which Zero Carbon Plan is pursued*

UCONN ALTERNATE #3: PURCHASE POWER AGREEMENTS

In order to keep the variables in the BVH Report to a minimum, the operating costs utilized the current generation rates for electricity in Connecticut, which are approximately \$0.08/kwh, for both electric service from the grid (Eversource) and solar power purchase agreements (PPA). Since UConn produces approximately 90% of its electricity through the Central Utility Plant (CUP) currently, the effective cost of electricity today for the University is approximately \$0.04/kwh. When the CUP is eventually replaced in both the Zero Carbon by 2050 Plan and the Zero Carbon by 2040 Plan, in addition to a large volume increase in electricity usage, the operating cost estimates assume the cost of electricity would return to market values.

The Zero Carbon by 2050 Plan and the Zero Carbon by 2040 Plan both include 6MW of on-campus solar photo-voltaic generation (PV) and 30MW of off-campus solar PPA. The Climate Action Plan is not specific on its PV use, but it can be assumed that at least the on-campus portion of the renewable electric energy generation would be implemented. On-campus installations would include solar canopies in large parking lots and roof-top installations on large buildings. Since these types of installations tend to be more expensive than installations on grade, the use of the current \$0.08/kwh generation cost for the 6MW on campus PV is likely a good assumption and is consistent with recent

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installations in Connecticut. Central Connecticut State College executed a PPA in 2017 at a rate of \$0.08/kwh for two locations on rooftops totaling 1.5MW PV and Southern Connecticut State College executed a PPA in 2017 at a rate of \$0.083/kwh for three locations in parking areas on their campus totaling approximately 2MW PV. Both these Universities locked in the fixed electric rate from these solar arrays for at least a 20 year period.

The current and future rates for large-scale PPAs in Connecticut are unknown. As indicated in the BVH Report, given the large quantities of electrical usage during and after completion of conversion to primarily electric-based heating and cooling, small increases or decreases in the electric rate can have large effects on operating costs. Princeton and Stanford Universities were able to get slightly below market electric generation rates for 16.5MW and 60MW PPAs respectively, plus they include rate stability since the rates are fixed for at least 20 years. Table 4.4.3 and the incremental cost Table ICE 1.3, with changes to the adjusted baseline in red, show the potential effects of the proposed 30MW PPA if the rate was locked in at \$0.07/kwh as opposed to the current market rate of \$0.08/kwh. This scenario did not affect the Climate Action Plan operating cost estimate since it is unknown whether the plan would include a large solar PPA. With a lower electric fixed rate from a PPA, the Zero Carbon by 2050 Plan has an estimated reduction in the NPV of its operating costs of \$50 Million and the Zero Carbon by 2040 Plan has a reduction in the NPV of its operating cost estimate of \$100 Million. Note that these estimated savings would be doubled if the PPA electric generation rate was attained at \$0.06/kwh or if a 60MW solar PV installation was constructed.

TABLE 4.4.3

	Climate Action Plan		Zero Carbon by 2050		Zero Carbon by 2040	
Conversion Period	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	\$60-\$80M	\$50M	\$150-\$220M	\$50M	\$150-\$220M	\$50M
2026-2030	\$40-65M	\$63M	\$550-\$700M	\$64M	\$700-\$900M	\$66M
2031-2040	\$500-\$625M	\$105-\$115M	\$600-\$780M	\$110-\$120M	\$950-\$1,280M	\$145-\$155M
2041-2050	\$500-\$630M	\$160-\$170M	\$500-\$700M	\$190-\$210M		\$190-\$210M
TOTAL	**\$1,100-\$1,400M**	**\$2,850-\$3,000M**	**\$1,800-\$2,400M**	**\$3,050-\$3,250M**	**\$1,800-\$2,400M**	**\$3,450-\$3,650M**

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TABLE ICE 1.3

INCREMENTAL COST EVALUATION	CLIMATE ACTION PLAN	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
EMISSIONS AVOIDED BY 2050	1,171,548	1,512,349	1,920,569
CUMULATIVE CAPITAL COST TO 2050 ANTICIPATED MINIMUM CAPITAL COST *	$1.1B - $1.4B $800M - $900M	$1.8B - $2.4B $800M - $900M	$1.8B - $2.4B $800M - $900M
NET ADDITIONAL CAPITAL COST *MID-RANGE NET CAPITAL COST/TON AVOIDED*	$300M - $500M *$350*	$1.0B - $1.5B *$800*	$1.0B - $1.5B *$650*
NPV OPERATING COST TO 2050 NPV MINIMUM OPERATING COST	$1.2B - $1.5B $1.0B - $1.1B	$1.65B - $1.95B $1.0B - $1.1B	$1.8B - $2.1B $1.0B - $1.1B
NET ADDITIONAL OPERATING COST *MID-RANGE NET OPERATING COST/TON AVOIDED*	$200M - $400M *$250*	$650M - $850M *$500*	$800M - $1.0B *$450*
CARBON PLAN NPV CAPITAL + OPERATING COST	**$500M - $900M**	**$1.65B - $2.35B**	**$1.8B - $2.5B**
CHANGE FROM BASELINE	$0	($50M)	($100M)
MID-RANGE TOTAL COST/TON AVOIDED	*$600*	*$1,300*	*$1,100*

** Full Deferred Maintenance Cost less ECMs and Electrical Upgrades that are required regardless of which Zero Carbon Plan is pursued*

ALTERNATE #4: COMBINED CARBON TAX AND PPA

Individually, a graduated carbon tax and a purchase power agreement for renewable energy were shown to positively impact the Zero Carbon by 2050 Plan and the Zero Carbon by 2040 Plan. To maximize potential operating cost reductions, the combination of both would result in the largest potential savings. Table 4.4.4 and incremental cost Table ICE 1.4 have been updated below, with changes from the baseline tables in red, to show the potential effects of the implementation of a graduated carbon tax starting at $45/MT in 2021 and increasing to $200/MT in 2050, plus implementation of a 60 MW solar power purchase agreement (PPA) at $0.07/kwh. There is no effect on the Climate Action Plan net operating cost because the graduated carbon tax fee and fee avoidance are effectively equal over time, and the Climate Action Plan presently does not include a PPA. The effects on the Zero Carbon by 2050 Plan and the Zero Carbon by 2040 Plan are triple the values of the graduated carbon tax or 30MW PPA alone, totaling a reduction of $150 Million and $300 Million respectively, since the PPA is twice the size of the one in Alternate #3 and the Plans get the additional benefits of carbon tax avoidance through early emissions reductions.

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TABLE 4.4.4

	Climate Action Plan		Zero Carbon by 2050		Zero Carbon by 2040	
Conversion Period	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range	Capital Cost Range	Annual Operating Cost Range
2021-2025	\$60-\$80M	\$50M	\$150-\$220M	\$50M	\$150-\$220M	\$50M
2026-2030	\$40-65M	\$70M	\$550-\$700M	\$68M	\$700-\$900M	\$66M
2031-2040	\$500-\$625M	\$115-\$125M	\$600-\$780M	\$110-\$120M	\$950-\$1,280M	\$140-\$150M
2041-2050	\$500-\$630M	\$170-\$180M	\$500-\$700M	\$180-\$200M		\$180-\$200M
TOTAL	**\$1,100-\$1,400M**	**\$3,050-\$3,200M**	**\$1,800-\$2,400M**	**\$3,050-\$3,200M**	**\$1,800-\$2,400M**	**\$3,300-\$3,500M**

TABLE ICE 1.4

INCREMENTAL COST EVALUATION	CLIMATE ACTION PLAN	ZERO CARBON BY 2050 PLAN	ZERO CARBON BY 2040 PLAN
EMISSIONS AVOIDED BY 2050	1,171,548	1,512,349	1,920,569
CUMULATIVE CAPITAL COST TO 2050	\$1.1B - \$1.4B	\$1.8B - \$2.4B	\$1.8B - \$2.4B
ANTICIPATED MINIMUM CAPITAL COST *	\$800M - \$900M	\$800M - \$900M	\$800M - \$900M
NET ADDITIONAL CAPITAL COST	\$300M - \$500M	\$1.0B - \$1.5B	\$1.0B - \$1.5B
MID-RANGE NET CAPITAL COST/TON AVOIDED	*\$350*	*\$800*	*\$650*
NPV OPERATING COST TO 2050	\$1.25B - \$1.55B	\$1.65B - \$1.95B	\$1.75B - \$2.05B
NPV MINIMUM OPERATING COST	\$1.05B - \$1.15B	\$1.1B - \$1.2B	\$1.15B - \$1.25B
NET ADDITIONAL OPERATING COST	\$200M - \$400M	\$550M - \$750M	\$600M - \$900M
MID-RANGE NET OPERATING COST/TON AVOIDED	*\$250*	*\$400*	*\$350*
CARBON PLAN NPV CAPITAL + OPERATING COST	**\$500M - \$900M**	**\$1.55B - \$2.25B**	**\$1.6B - \$2.3B**
CHANGE FROM BASELINE	\$0M	(\$150M)	(\$300M)
MID-RANGE TOTAL COST/TON AVOIDED	*\$600*	*\$1,200*	*\$1,000*

** Full Deferred Maintenance Cost less ECMs and Electrical Upgrades that are required regardless of which Zero Carbon Plan is pursued*

RISKS AND CHALLENGES

The Risks and Challenges identified in the BVH Report also apply to this Supplemental Report. Please make particular note of the following:

- **Costs are shown in 2020 dollars and cost escalation is not included in the estimates and can significantly affect the final costs of implementation**
- Increases or decreases in utility rates are not included in the estimates (except the PPA Alternate) and may significantly affect future operating costs
- Construction and site logistics may have a significant impact on the operations of the University
- This analysis assumes Eversource can meet its 2030 clean energy goals and receives an increased commitment to reach zero carbon by 2040
- All carbon emissions reduction plans assume Eversource can increase regional line and transmission capacity to meet the new electric demand and deliver additional capacity timely
- **This analysis excludes major mechanical work in the approximately 340 buildings to accept low temperature heating and cooling and assumes adequate funding in the future for necessary and complementary building modifications. Buildings may experience temporary under-heating or under-cooling conditions during conversions.**
- Timing of funding for both capital and operating expenses needs to be confirmed
- Availability of trade labor to execute the Plans is a risk
- Back-up electric generation and life safety systems currently operate on fossil fuels and new technology is required to eliminate these sources in the future to ultimately reach zero carbon

COMPARISON OF OVERALL COSTS

CAPITAL COSTS:

As stated previously, Princeton University's sustainability plan is more comparable to UConn's plans than the plans of Stanford University or UC Davis due to the fact that Princeton is using the same technical solution (geoexchange wells) and has similar peak heating and cooling loads. Princeton expects to expend approximately $875 Million in capital cost over a 30 year period to attain a 75% reduction in carbon emissions. The BVH Report (adjusted herein to more closely align with peer institutions by reflecting NPV operating costs and removing building conversion costs) estimates the gross unescalated capital costs of the Zero Carbon by 2050 Plan and the Zero Carbon by 2040 Plan at between $1.8 Billion - $2.4 Billion.

There are three primary items that account for the adjusted capital cost estimate differences between Princeton and UConn. First, Princeton already has on-campus 100 MW of electrical capacity and distribution, while UConn needs to increase electrical capacity and needs to distribute new electrical service throughout campus. The estimate for the additional electrical capacity and distribution capital cost is estimated at approximately $300 - $400 Million.

Second, Princeton's central plant serves 180 buildings and UConn's central utility plant serves 190 buildings. UConn's capital cost estimate to replace the central utility plant and distribute hot water to the 190 core buildings is $750 Million - $1.0 Billion, effectively equal to Princeton's current cost projection. However, Princeton has 40 additional buildings that are not being addressed, which results in only a 75% carbon emissions reduction. UConn's goal is to attain zero carbon emissions, and hence, the Zero Carbon by 2050 Plan and the Zero Carbon by 2040 Plan add new energy plants and heating/cooling distribution to an additional 150 buildings on the perimeter of the campus. The estimated additional capital cost in the BVH Report for these buildings on the perimeter of the campus is between $750 Million - $1.0 Billion.

Lastly, market conditions at UConn make projects more expensive than at Princeton. Being a private institution, Princeton does not have to utilize prevailing wage labor, does not have to meet compliance goals, and does not have the other statutory obligations of UConn. Additionally, Princeton is in the metro-Philadelphia and metro-New York construction markets, while UConn is in the metro-Hartford construction market, which is considered much smaller, much more volatile and subject to local inflationary pressures from large projects.

INCREMENTAL COSTS (CAPITAL AND OPERATING):

Stanford University reported that the net present value of their combined capital and operating cost of completing their sustainability plan was approximately $1.3 Billion to attain a 65% reduction in carbon emissions. When adjusting for recent capital cost increases, Princeton University estimates the net present value of their combined capital and operating cost to be approximately $1.45 Billion to attain 75% reduction in carbon emissions. UConn's Zero Carbon by 2050 Plan has an estimated range for net present value of combined capital and operating costs of $1.7 Billion - $2.4 Billion ($2.0 Billion midpoint) and UConn's Zero Carbon by 2040 Plan has an estimated range for net present value of combined capital and operating costs of $1.9 Billion - $2.6 Billion ($2.25 Billion midpoint). Stanford University and Princeton University are more compact, with only five (5) added energy plants required for both, while UConn has a larger campus area and estimates that nineteen (19) new energy plants are likely required. Additionally, the fact that UConn's goal is to reach zero carbon emissions, while the Stanford and Princeton plans do not attain zero carbon emissions further explains the differences of the plans and the higher projected net additional costs for UConn.

EXHIBIT A: UCONN AND PEER INSTITUTIONS COMPARISON TABLE

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PWGSE Report May 2021 - Appendix D

PEER INSTITUTION REVIEW ON CARBON PLANS

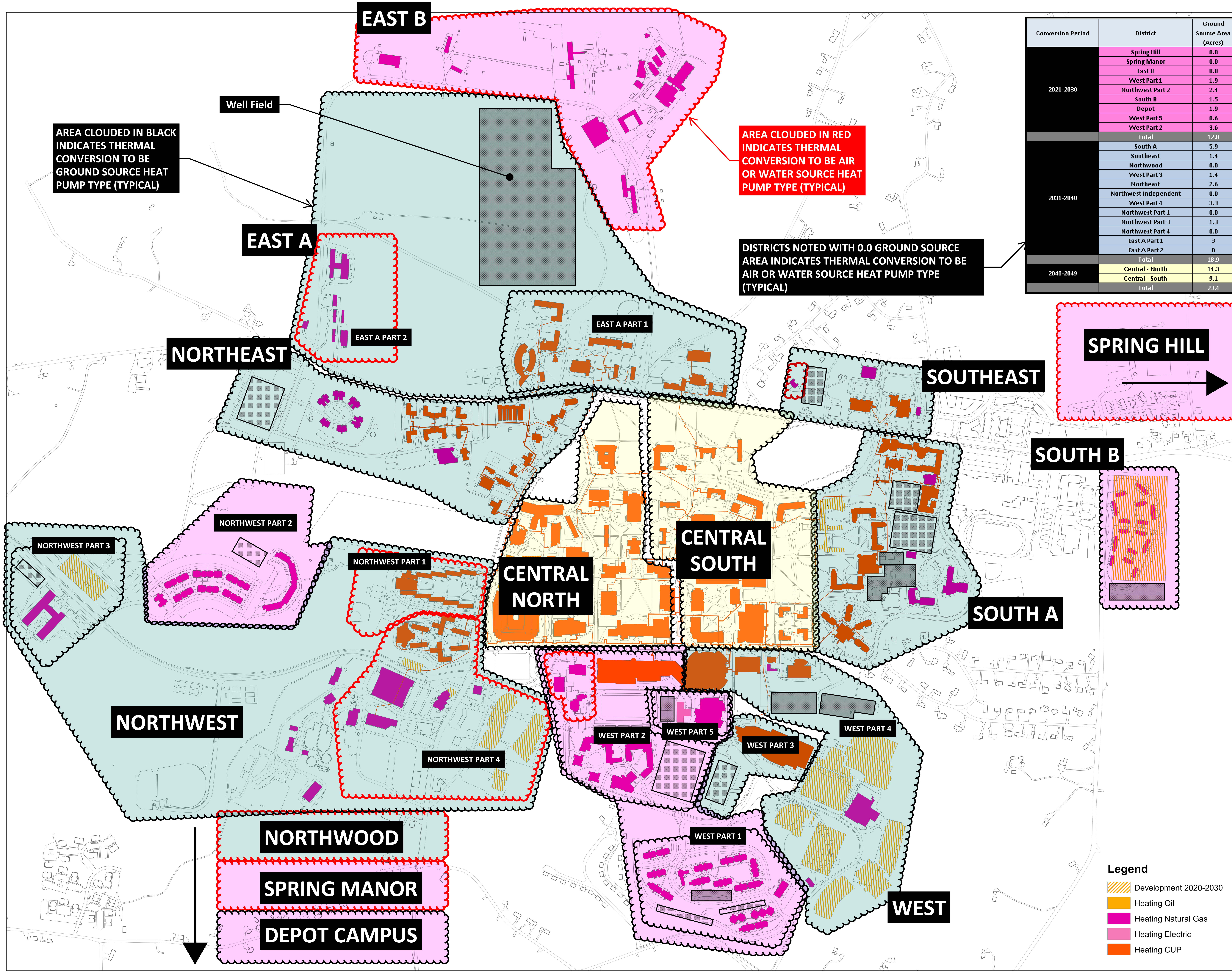
UPDATE: March 17, 2023

DRAFT FOR REVIEW

	UCONN - ZERO CARBON BY 2040	UCONN - CORE PORTION ONLY	STANFORD UNIVERSITY - CUP ONLY	UC DAVIS - BIG SHIFT PLAN	PRINCETON - NET NEUTRALITY BY 2046
SIZE OF CAMPUS					
NUMBER OF SQUARE FEET	10.9M Square Feet	6.5M Square Feet (Est.)	7.4M Square Feet	4.0M Square Feet	9.0M Square Feet
NUMBER OF BUILDINGS	340 Buildings	190 Buildings	300 Buildings	250 Buildings	180 Buildings
CENTRAL LAND AREA	800 Acres	440 Acres	350 Acres	400 Acres (Est)	500 Acres
SCOPE OF WORK					
PLANNING TIMELINE	2021 - 2024	2021 - 2024	2007 - 2010	2012 - 2019	2016 - 2018
CONSTRUCTION TIMELINE	2025 - 2040	2025 - 2040	2011 - 2015	2020 - 2035	2019 - 2046
CAPITAL COSTS	$2.4B - $3.2B (includes CUP, Perimeter, Electrical, ECMs and Building Conversions)	$900M - $1.3B (CUP and Bldg Conversion Only, excluding Electrical and ECMs)	$485 Million ($600M in 2021 $s)	$296M	$875M Estimate (Phase 1 original budget = $238 vs actual $442M), excluding PV and Electric upgrades
SIMULTANEOUS CAMPUS CLOSURES	30% - 50%	30% - 50%	Approximately 30%	"Outrageously" disruptive with many building and road closures simultaneously	Very disruptive - "Looked like a bomb went off" when we dug all the recent pipe trenches on the main campus
GENERAL SCOPE	PERIMETER AND CUP	CUP ONLY	100% of Campus on CUP	CUP and five close District conversions (excludes 700 perimeter buildings)	100% of Central Campus on CUP
EXISTING PLANT CONDITION	Existing Natural Gas Energy Heating/Cooling Plant with Steam Distribution with 30 - 35 Year Life Remaining	Existing Natural Gas Energy Heating/Cooling Plant with Steam Distribution with 30 - 35 Year Life Remaining	Existing Natural Gas Energy Heating/Cooling Plant with Steam Distribution at the end of its Useful Life	Existing Natural Gas Steam Plant (accounts for 32% of CO2 emissions from the campus)	Existing Natural Gas Energy Heating/Cooling Plant built in 1996 with Steam Distribution
CUP REPLACEMENT	New Central Heating Plants with 55 - 60 Acres of Geothermal Wells	New Central Heating Plants with 25 - 30 Acres of Geothermal Wells	New Primarily Cooling Plant with Waste Heat Utilized for Hot Water Heating. Electric Boilers and Chiller with Natural Gas boosters.	No Cooling or Chiller Costs included	New Central Heating Plant with Hot Water Circulation utilizing 35 - 50 Acres of Geoexchange Wells
PIPING INFRASTRUCTURE	16 Miles of Geothermal Piping	8 Miles (Est) of Geothermal Piping	22 Miles of new Direct-Bury Hot Water	7 miles of new hot water piping	Unknown Miles of hot water and chilled water piping
HEATING/COOLING STORAGE	None	None	Hot and Cold Water Storage Tanks Included (10M gallons CW and 2.5M gallons HW)	Hot Water Massing Well Included to reduce equipment for peak heating load	Storage charging in cold weather for hot water (and vica versa) - Effectively a 2 pipe system going forward
ELECTRICAL INFRASTRUCTURE	60MW Added Transformer Farm, plus 5 miles of Primary Distribution Lines	35MW Added Transformer Farm, plus 5 miles of Primary Distribution Lines	5 New 20MW Transformers and Distribution to 5 Energy Plants, plus Battery Storage Capacity to Level Peaks	None Included in this Project (previously spent $65M in electric upgrades)	Electric costs not included and being done through separate projects
ELECTRIC CAPACITY UPGRADES	50MW Additional Electrical Capacity	20MW (Est) Additional Electrical Capacity	None Required because Capacity was available locally (2 feeds)	None Required because Capacity was available locally (3 feeds)	2 Feeds available and 3rd being installed now. 20MW back-up power to remain on fossil fuels.
TOTAL ELECTRICAL PEAK CAPACITY	80MW	50MW (Est)	100MW capacity (80MW peak heating season and 43MW peak cooling)	50MW	100MW
ENERGY PLANTS	19 New Regional Energy Plants	4 New Regional Energy Plants	5 New Regional Energy Plants, plus renovation of CUP	2 new Heat Exchange Plants	2 New Hot Water Plants
BUILDINGS CONVERTED	190 Buildings on CUP and 150 Perimeter Stand-Alone Systems	190 Buildings on CUP only (Perimeter Excluded)	All 300 buildings on steam from the CUP at the start. Hot water distributed to 155 buildings and connected to the remaining buildings from there to assist phasing.	250 of 1,200 Buildings on new Heating System	180 Buildings Converted over 30 Years
CARBON EMISSIONS					
PHASE OF CARBON REDUCTION PROGRAM		PRELIMINARY	ADVANCED	PRELIMINARY	PRELIMINARY
ANNUAL CARBON AT START	98,000	98,000	251,500	239,000	108,000
ANNUAL CARBON AT END	0	59,000	88,500	167,000	26,000
PERCENT CARBON REDUCTION	100%	40%	65%	30%	75%
CARBON AVOIDENCE GOALS:	Zero Carbon by 2040	Zero Carbon by 2040	100% Reduction by 2030 when added 69MW solar farm is complete	Net Zero Carbon by 2035 (with purchase of carbon off-sets)	Net Zero Carbon by 2046 (Assume grid will eventually be zero carbon, but will buy off-sets until then)
OPERATING COSTS					
ANNUAL UTILITY COSTS	$70M - $80M	$35M - $40M (Est)	$28M - $30M	$21.5M Electric Cost Currently	$12.5M Electric Cost Currently
OPERATIONAL COSTS/SAVINGS	$3.0B Gross Added Cost over 30 Years	$1.5B Gross Added Cost over 30 Years	Actual Cost approximately $1B, which is a projected $420M Savings over 30 Years (60% of savings is CA Carbon Cap & Trade Tax Avoidance)	NPV of Electrical Costs approximately $500M, but projecting a $158M Savings in O&M over 20 years	NPV for a Steam distribution system would have been cheaper, but the environmental benefits off-set added costs ($45/MT "shadow cost" now, but considering higher)
RENEWABLE ENERGY					
ON-CAMPUS PV	6MW	6MW	4.5MW	14MW (No battery storage, so utilized only in the daytime)	16.5MW (No battery storage currently)
OFF-CAMPUS PPA	30MW	30MW	60MW	NONE	NONE
PREVIOUS COST OF ELECTRICITY	$0.04/KWH	$0.04/KWH	$0.07/KWH	$0.07/KWH	$0.05/KWH
FUTURE COST OF ELECTRICITY	$0.08/KWH	$0.08/KWH	$0.05/KWH	Unknown	$0.03/KWH (but sold environmental RECs to developer)
		PRIMARY DIFFERENCES TO UCONN PROPOSED ZERO CARBON PLAN:	1. Heating plant versus cooling plant (with free heating) at Stanford	1. Peak loads for heating much lower at UC Davis	1. Electric upgrades and building conversion costs excluded from project by Princeton (2017 - 2030 Cycle = $5.5B)
			2. Peak loads for heating/cooling much lower at Stanford	2. No Cooling or Electrical Costs included at UC Davis	2. Effectively a 2 pipe main distribution system (either cooling or heating - not both)
			3. Geothermal wells versus electric boilers/chillers at Stanford	3. Geothermal wells versus electric boilers/chillers at UC Davis	3. Not trying to reach zero carbon in the short-term and waiting for the utility market to catch up
			4. Additional electric capacity was available at Stanford	4. Additional electric capacity was available at UC Davis	4. No perimeter buildings and all buildings already on the CUP at Princeton
			5. Larger PPA at Stanford lowered electric cost versus California grid costs	5. Net Zero Carbon Plan at UC Davis versus Zero Carbon Plan	5. Additional electric capacity is available at Princeton
				6. Did not change hydronics of buildings at UC Davis	6. Very good controls system now, so modifying hydronics can wait for future building renovations
				7. Social cost of carbon of $60/MT included as an off-set in the lifecycle cost analysis	7. "Shadow Price" of carbon of $45/MT included as an off-set in lifecycle cost analysis

Appendix E

Map of UConn Storrs Districts for Transition to Renewable Thermal Technologies



Conversion Period	District	Ground Source Area (Acres)
2021-2030	Spring Hill	0.0
	Spring Manor	0.0
	East B	0.0
	West Part 1	1.9
	Northwest Part 2	2.4
	South B	1.5
	Depot	1.9
	West Part 5	0.6
	West Part 2	3.6
	Total	12.0
2031-2040	South A	5.9
	Southeast	1.4
	Northwood	0.0
	West Part 3	1.4
	Northeast	2.6
	Northwest Independent	0.0
	West Part 4	3.3
	Northwest Part 1	0.0
	Northwest Part 3	1.3
	Northwest Part 4	0.0
	East A Part 1	3
	East A Part 2	0
	Total	18.9
2040-2049	Central - North	14.3
	Central - South	9.1
	Total	23.4

BVH integrated services
50 Griffin Road South
Bloomfield, CT 06002

REVISIONS:

No.	Date	Description

UNIVERSITY OF CONNECTICUT
UNIVERSITY PLANNING, DESIGN & CONSTRUCTION

31 LEDOYT ROAD UNIT 3038
STORRS, CONNECTICUT 06269-3038
TELEPHONE: (860) 486-3127
FACSIMILE: (860) 486-3177

UNIVERSITY OF CONNECTICUT 1881

STORRS CAMPUS
STORRS, CT 06340

PROJECT NO: 902040
WORK ORDER NO:
FILE NAME: 2115093 - UConn Utility Framework
AUTHOR: ALP
CHECKER: SPW
SCALE: 1:3600
PRINT DATE:
SHEET TITLE:

DISTRICT MAPPING

Appendix F

Tables for Carbon Emissions by Area

TABLES FOR CARBON EMISSIONS BY AREA (NON-COLORED)
MARCH 17, 2021

COST OF CARBON EMISSIONS AVOIDENCE BY CAMPUS AREA
ZERO CARBON BY 2040 PLAN

CAMPUS AREA	PERCENT OF THE AREA ON THE CUP	EMISSIONS AVOIDED IN METRIC TONS (MT)	MID-POINT CAPITAL COST ESTIMATE PER AREA	COST/MT EMISSIONS AVOIDED
2021 - 2024 Projects				
Campus Electric	**N/A**		$128,000,000	$0
ECMs - Campuswide	**N/A**	466,029	$146,100,000	$310
2025-2029 Projects				
Depot	0%	41,434	$114,200,000	$2,760
East B	0%	25,612	$45,000,000	$1,760
Northwest - Part 2	0%	43,920	$50,200,000	$1,140
South B	0%	32,994	$72,900,000	$2,210
Spring Hill	0%	4,367	$4,500,000	$1,030
Spring Manor	0%	666	$1,200,000	$1,800
West - Part 1	0%	44,410	$55,600,000	$1,250
West - Part 2	60%	82,495	$105,400,000	$1,280
West - Part 5	0%	14,275	$19,800,000	$1,390
2030 - 2035 Projects				
Central - North	100%	357,041	$384,000,000	$1,080
Northeast	80%	31,741	$94,200,000	$2,970
Northwest - Ind	0%	6,462	$16,500,000	$2,550
Northwood	0%	10,515	$20,500,000	$1,950
South A	90%	141,982	$107,400,000	$760
Southeast	80%	32,837	$49,700,000	$1,510
West - Part 3	100%	62,483	$47,000,000	$750
2035 - 2040 Projects				
Central - South	100%	225,652	$289,200,000	$1,280
East A - Part 1	100%	60,889	$59,500,000	$980
East A - Part 2	0%	15,222	$17,700,000	$1,160
Northwest - Part 1	100%	32,289	$40,400,000	$1,250
Northwest - Part 3	0%	23,262	$33,100,000	$1,420
Northwest - Part 4	70%	87,841	$98,300,000	$1,120
West - Part 4	90%	76,151	$99,600,000	$1,310
TOTALS		1,920,569	$2,100,000,000	$1,090

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CARBON EMISSIONS BY AREA (LOWEST TO HIGHEST COST/MT)

		Cost/MT
LOWEST UNIT COST	ECMs - Campuswide	$310
	West - Part 3	$750
	South A	$760
	East A - Part 1	$980
	Spring Hill	$1,030
	Central - North	$1,080
	Northwest - Part 4	$1,120
	Northwest - Part 2	$1,140
	East A - Part 2	$1,160
	Northwest - Part 1	$1,250
	West - Part 1	$1,250
	Central - South	$1,280
	West - Part 2	$1,280
	West - Part 4	$1,310
	West - Part 5	$1,390
	Northwest - Part 3	$1,420
	Southeast	$1,510
	East B	$1,760
	Spring Manor	$1,800
	Northwood	$1,950
	South B	$2,210
	Northwest - Ind	$2,550
	Depot	$2,760
HIGHEST UNIT COST	Northeast	$2,970

CARBON EMISSIONS BY AREA (HIGHEST TO LOWEST BY AREA)

		Emissions
HIGHEST EMISSIONS	ECMs - Campuswide	466,029
BY AREA	Central - North	357,041
	Central - South	225,652
	South A	141,982
	Northwest - Part 4	87,841
	West - Part 2	82,495
	West - Part 4	76,151
	West - Part 3	62,483
	East A - Part 1	60,889
	West - Part 1	44,410
	Northwest - Part 2	43,920
	Depot	41,434
	South B	32,994
	Southeast	32,837
	Northwest - Part 1	32,289
	Northeast	31,741
	East B	25,612
	Northwest - Part 3	23,262
	East A - Part 2	15,222
	West - Part 5	14,275
	Northwood	10,515
	Northwest - Ind	6,462
LOWEST EMISSIONS	Spring Hill	4,367
BY AREA	Spring Manor	666

CARBON EMISSIONS FOR THE CUP AREAS ONLY
(BASED ON THERMAL HEAT LOAD)

		% on CUP	CUP Emissions
HIGHEST EMISSIONS	Central - North	100%	357,041
BY AREA	Central - South	100%	225,652
	South A	90%	127,784
	West - Part 4	90%	68,536
	West - Part 3	100%	62,483
	East A - Part 1	100%	60,889
	Northwest - Part 4	70%	61,488
	West - Part 2	60%	49,497
	Northwest - Part 1	100%	32,289
	Southeast	80%	26,270
	Northeast	80%	25,393
	Depot	0%	0
	East A - Part 2	0%	0
	East B	0%	0
	Northwest - Ind	0%	0
	Northwest - Part 2	0%	0
	Northwest - Part 3	0%	0
	Northwood	0%	0
	South B	0%	0
	Spring Hill	0%	0
	Spring Manor	0%	0
LOWEST EMISSIONS	West - Part 1	0%	0
BY AREA	West - Part 5	0%	0

TABLES FOR CARBON EMISSIONS BY AREA (COLORED VERSION)
MARCH 17, 2021

COST OF CARBON EMISSIONS AVOIDENCE BY CAMPUS AREA
ZERO CARBON BY 2040 PLAN

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East B	0%	25,612	$45,000,000	$1,760
Northwest - Part 2	0%	43,920	$50,200,000	$1,140
South B	0%	32,994	$72,900,000	$2,210
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Spring Manor	0%	666	$1,200,000	$1,800
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Southeast	80%	32,837	$49,700,000	$1,510
West - Part 3	100%	62,483	$47,000,000	$750
2035 - 2040 Projects				
Central - South	100%	225,652	$289,200,000	$1,280
East A - Part 1	100%	60,889	$59,500,000	$980
East A - Part 2	0%	15,222	$17,700,000	$1,160
Northwest - Part 1	100%	32,289	$40,400,000	$1,250
Northwest - Part 3	0%	23,262	$33,100,000	$1,420
Northwest - Part 4	70%	87,841	$98,300,000	$1,120
West - Part 4	90%	76,151	$99,600,000	$1,310
TOTALS		1,920,569	$2,100,000,000	$1,090

AREAS THAT ARE 100% ON THE CENTRAL UTILITY PLANT

AREAS THAT ARE PARTIALLY ON THE CENTRAL UTILITY PLANT AND PARTIALLY ON STAND-ALONE HEATING/COOLING SYSTEMS

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CARBON EMISSIONS BY AREA (LOWEST TO HIGHEST COST/MT)

	Area	Cost/MT
LOWEST UNIT COST	ECMs - Campuswide	$310
	West - Part 3	$750
	South A	$760
	East A - Part 1	$980
	Spring Hill	$1,030
	Central - North	$1,080
	Northwest - Part 4	$1,120
	Northwest - Part 2	$1,140
	East A - Part 2	$1,160
	Northwest - Part 1	$1,250
	West - Part 1	$1,250
	Central - South	$1,280
	West - Part 2	$1,280
	West - Part 4	$1,310
	West - Part 5	$1,390
	Northwest - Part 3	$1,420
	Southeast	$1,510
	East B	$1,760
	Spring Manor	$1,800
	Northwood	$1,950
	South B	$2,210
	Northwest - Ind	$2,550
	Depot	$2,760
HIGHEST UNIT COST	Northeast	$2,970

CARBON EMISSIONS BY AREA (HIGHEST TO LOWEST BY AREA)

	Area	Emissions
HIGHEST EMISSIONS	ECMs - Campuswide	466,029
BY AREA	Central - North	357,041
	Central - South	225,652
	South A	141,982
	Northwest - Part 4	87,841
	West - Part 2	82,495
	West - Part 4	76,151
	West - Part 3	62,483
	East A - Part 1	60,889
	West - Part 1	44,410
	Northwest - Part 2	43,920
	Depot	41,434
	South B	32,994
	Southeast	32,837
	Northwest - Part 1	32,289
	Northeast	31,741
	East B	25,612
	Northwest - Part 3	23,262
	East A - Part 2	15,222
	West - Part 5	14,275
	Northwood	10,515
	Northwest - Ind	6,462
LOWEST EMISSIONS	Spring Hill	4,367
BY AREA	Spring Manor	666

AREAS THAT ARE 100% ON THE CENTRAL UTILITY PLANT

AREAS THAT ARE PARTIALLY ON THE CENTRAL UTILITY PLANT AND PARTIALLY ON STAND-ALONE HEATING/COOLING SYSTEMS

CARBON EMISSIONS FOR THE CUP AREAS ONLY
(BASED ON THERMAL HEAT LOAD)

	Area	% on CUP	CUP Emissions
HIGHEST EMISSIONS	Central - North	100%	357,041
BY AREA	Central - South	100%	225,652
	South A	90%	127,784
	West - Part 4	90%	68,536
	West - Part 3	100%	62,483
	East A - Part 1	100%	60,889
	Northwest - Part 4	70%	61,488
	West - Part 2	60%	49,497
	Northwest - Part 1	100%	32,289
	Southeast	80%	26,270
	Northeast	80%	25,393
	Depot	0%	0
	East A - Part 2	0%	0
	East B	0%	0
	Northwest - Ind	0%	0
	Northwest - Part 2	0%	0
	Northwest - Part 3	0%	0
	Northwood	0%	0
	South B	0%	0
	Spring Hill	0%	0
	Spring Manor	0%	0
LOWEST EMISSIONS	West - Part 1	0%	0
BY AREA	West - Part 5	0%	0

AREAS THAT ARE 100% ON THE CENTRAL UTILITY PLANT

AREAS THAT ARE PARTIALLY ON THE CENTRAL UTILITY PLANT AND PARTIALLY ON STAND-ALONE HEATING/COOLING SYSTEMS

Appendix G

ZC40-ZC50 Energy Consumption Graphs

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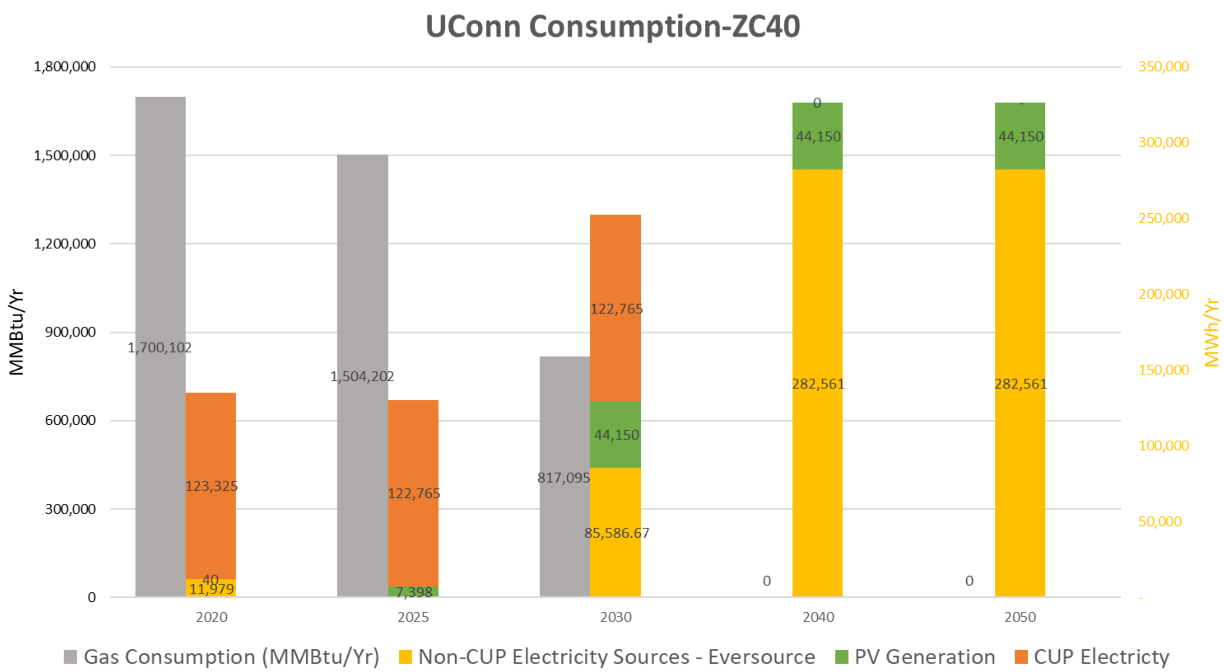

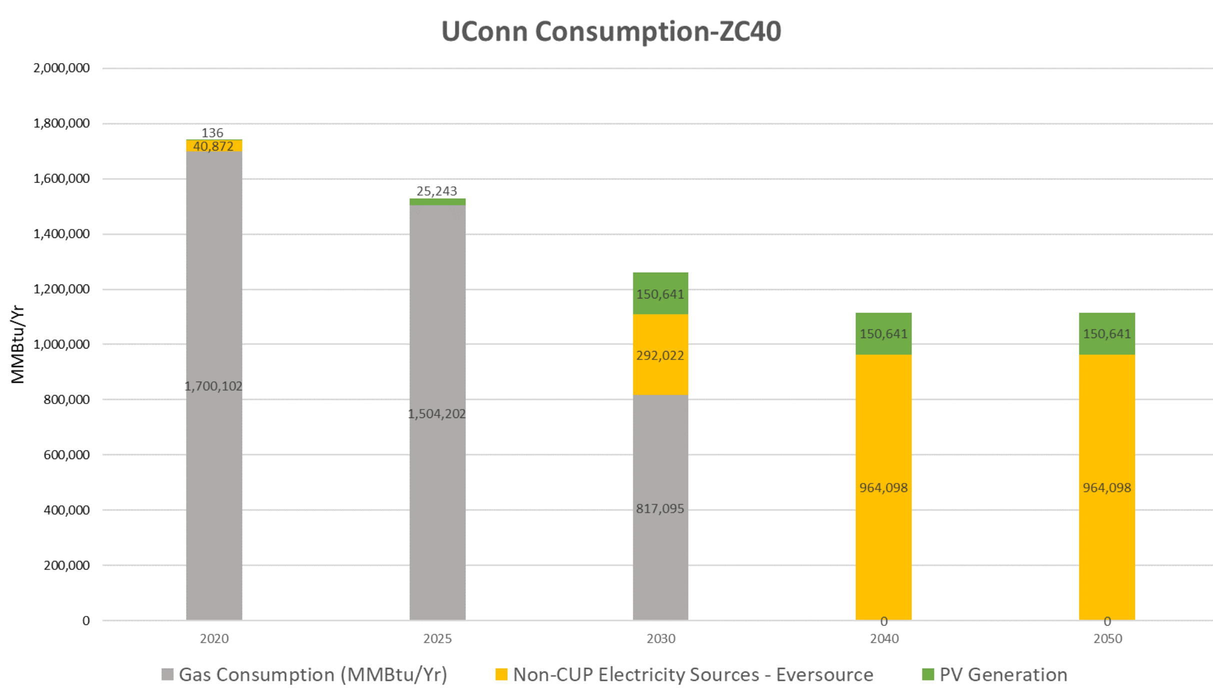

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