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.

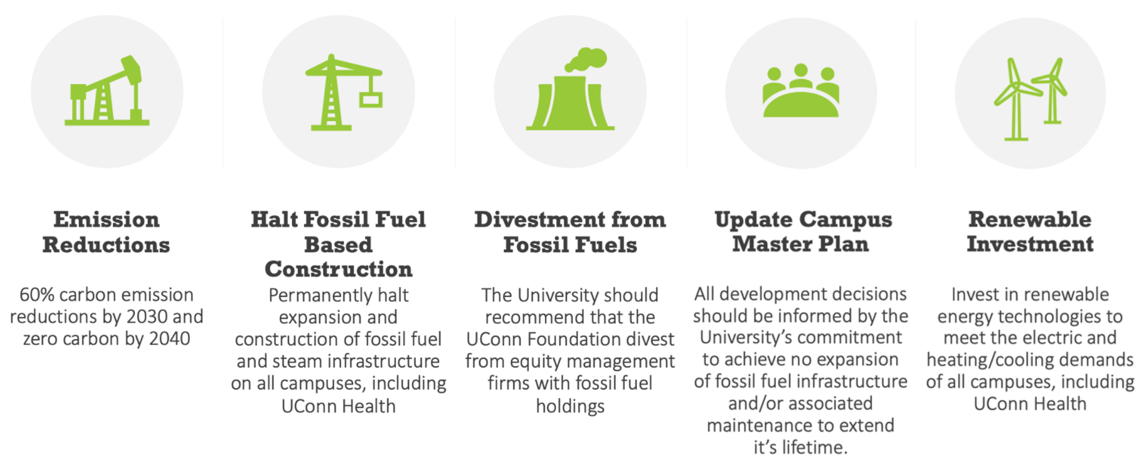


Figure 1: Recommendations from Spring 2020 Report

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.

<u>Emissions Reductions</u>: 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).

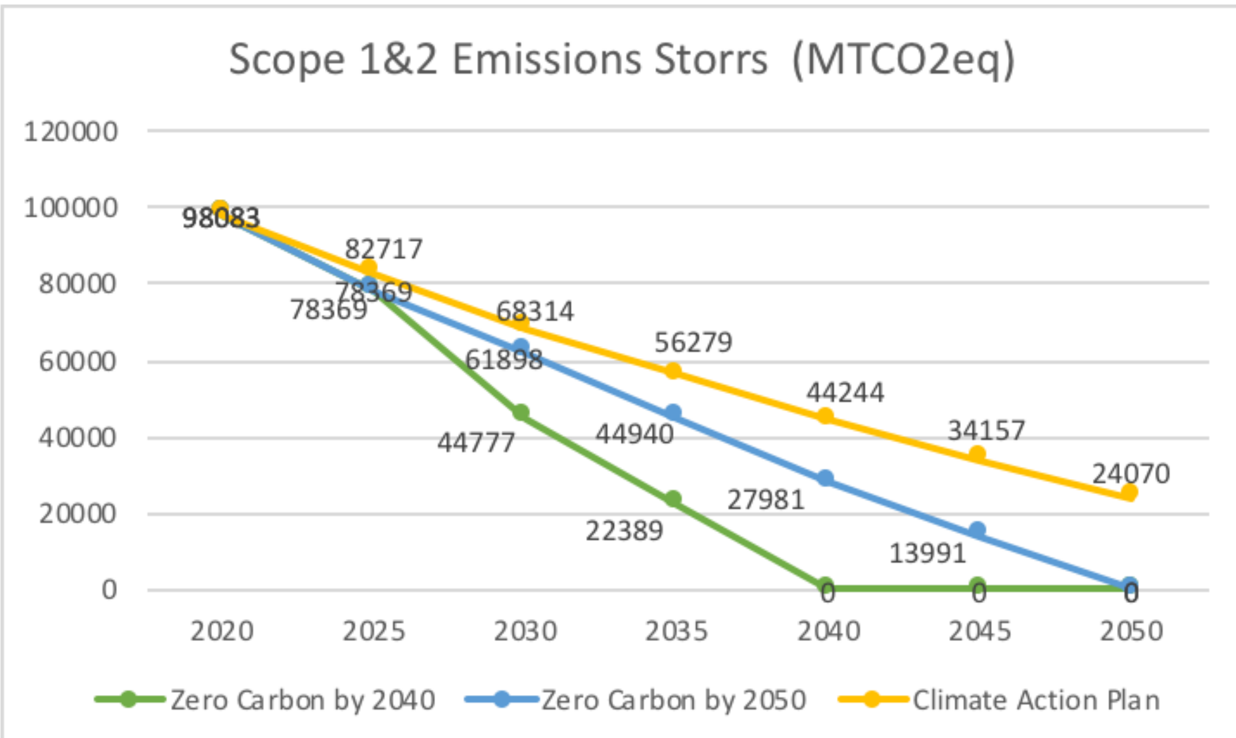
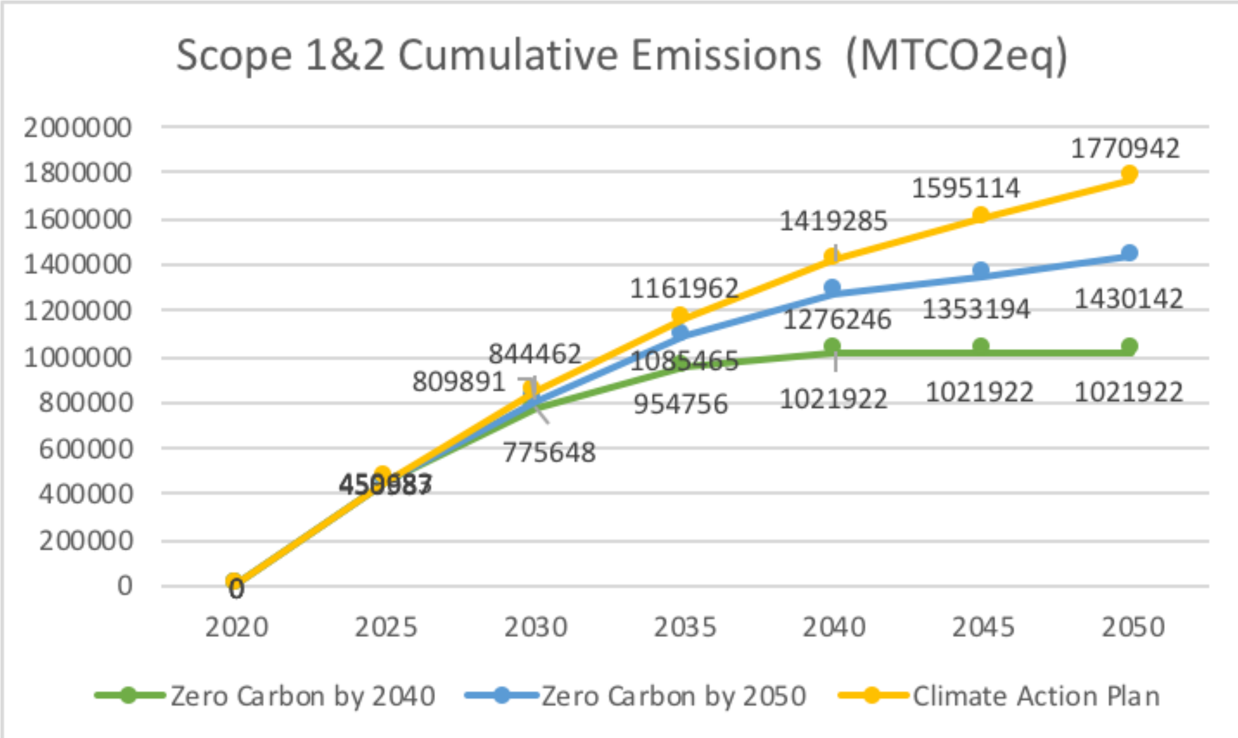


Figure 2. Scope 1 &2 Emissions (MTCO$_2$eq)



<u>Figure 3. Scope 1 & 2 Cumulative Emissions (MTCO$_2$eq)</u>

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.

<u>Total and Incremental Cost Estimates:</u> **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.

<u>Potential Tax Savings:</u> 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).

Potential Negotiated Rate Savings: 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.

Alternative Prioritization of Building Conversions: 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

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

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	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

<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