2020-2021 Massachusetts Public Campus Decarbonization Studies Summary

Throughout 2020 and 2021, four public institutes of higher education across the Commonwealth (Salem State University, UMass Amherst, UMass Dartmouth, and UMass Lowell) launched studies to chart pathways to campus net-zero carbon emissions by 2050 or earlier. The studies, three of which were funded in part or in full by the Leading by Example Program, resulted in high-level roadmaps that are helping each campus plan for future growth while continuing to achieve ambitious GHG reduction goals. These studies were the first of their kind for MA state government as these entities work to meet the goals of Executive Order 594 and statewide emissions reduction goals as outlined in the 2050 Roadmap and 2025/2030 Clean Energy and Climate Plan.

This document is intended to provide an overview of the studies' recommended strategies that these campuses are now considering as part of a comprehensive strategy to decarbonize. Given the rapidly changing policy, funding and technology landscapes, these plans should be considered works in progress.

Background and Context

The four campuses are partially or fully heated via central power plants (powered by natural gas) and steam distribution systems. The studies focused on identifying available strategies and technologies that could transition these district systems away from fossil fuels, while still meeting the projected campus thermal demands. In cases where some buildings were not connected to the district system, building-level solutions were also proposed. Although the four campuses vary in size and complexity, and each study was tasked with meeting somewhat different targets, each campus was ultimately presented with an array of recommendations that could potentially help them eliminate use of onsite fossil fuels for heating and cooling by 2050 or sooner (see Figure 1).

Figure 1: Campus Decarbonization Study Logistics

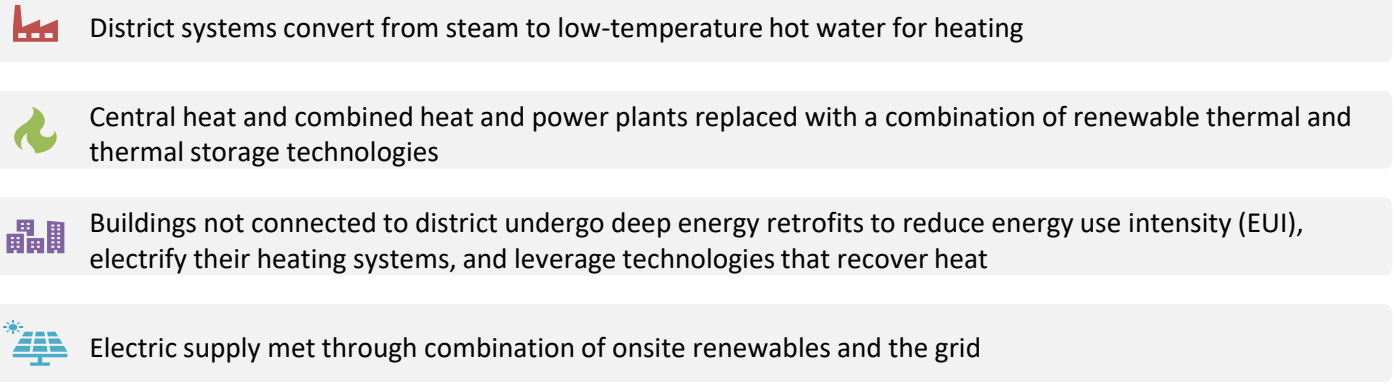
	UMA	UMD	UML	SSU North Campus
Impacted Area	280 buildings, 12.8m sq ft	71 buildings, 2.5m sq ft	50 buildings, 3.4m sq ft	10 buildings, 690k sq ft
Study Timeframe	Jan 2020-Feb 2021	Jan-Dec 2020	Oct 2020-July 2021	Oct 2020-Aug 2021
Goals/Targets	100% renewable electricity, heating, cooling by 2032	Carbon neutrality by 2040	Carbon neutrality by 2050	Fossil fuel-free heating/cooling for North Campus
Study cost	~250,000	~$200,000	$97,000	$100,000
LBE Grant[1]	n/a	$100,000	$97,000	$100,000
Consultant	MEP Associates, Brailsford & Dunlavey, CES, Greener U	Ramboll	BR+A	MEP Associates

Proposed Strategies

Each study identified several possible pathways to achieve net zero emissions, with at least one pathway being highlighted as a "preferred" scenario based on estimated costs, emissions reduction benefits, and/or overall feasibility. While the scale and specific details of each preferred pathway varied across the campuses, there were common technologies and strategies across all studies (Figure 2) -- namely transitioning from steam-based distribution systems to low temperature hot water and leveraging a combination of several renewable thermal systems to heat and cool campus district systems.

[1] The LBE Feasibility Studies Grant Program supports state entity efforts to identify and study potential clean energy technologies that could be deployed at state facilities to reduce energy use, greenhouse gas emissions and/or energy costs.

Figure 2: Common Technologies and Strategies to Achieve Campus Decarbonization



Proposed Renewable Thermal Technologies

Thermal demand for each campus is proposed to be met by a combination of renewable thermal technologies. These technologies fall into one of three categories based on the degree to which they will serve the campus.

Figure 3: Proposed Technologies for Campus District Decarbonization

Base *(majority of thermal demand)*	• Ground-source heat pumps provide heat in the winter and cooling in the summer. • Heat recovery chillers, paired with ground-source heat pumps, allow for simultaneous heating and cooling, improving overall system efficiency. • Other sources and sinks for heat (e.g., cold– and warm-water storage tanks and wastewater heat recovery systems) were considered to supplant or amend geothermal wells. Feasibility of other sources will need to be further investigated by each campus before they can be pursued.
Intermediate *(used for part of the year)*	• Air-source heat pumps can heat and cool the water in the district systems when ground-source systems are not enough. • Buildings may be heated and cooled with standalone air-source heat pumps where needed (e.g., if a building is not connected to the district).
Peak *(used for coldest days)*	• Onsite fuel combustion provides supplemental heat during the coldest days of the year. • While these peak systems may need to run on fossil fuels in the near-term, each study proposed transitioning to renewable fuels in the future when feasible and cost-effective.

Energy Conservation Measures

The studies varied in their level of concentration on energy conservation measures (ECMs), but all recognized that improving building efficiency, namely by reducing building thermal demand, would help ensure the efficacy of the proposed transition to low-temperature hot water heating systems. In addition, ECMs can effectively drive down thermal demand and reduce the size and cost of the new energy infrastructure. Proposed ECMs included improving roof and wall insulation, replacing windows, improving building controls, and upgrading air-handling units. For most campuses, ECMs were not proposed building-by building; rather, the studies recommended reducing energy use intensity (EUI - energy used per square foot) by a given percentage and provided examples of how that reduction can be achieved. In the case of UMass Lowell, each building was given a list of proposed ECMs based on existing conditions. This was done for both those connected to central heating systems and standalone buildings. In the case of the latter, ECMs are particularly important to reduce the increased costs of energy typically associated with switching from fossil fuels to electric heating systems.

Implementation Investments Required

Each study provided high-level estimates of the investment needed to transition to the proposed decarbonized solutions, though these estimates were based on engineering estimates and were limited to estimated construction costs, not including design, overhead, contingency, escalation, and other factors. Based on these early valuations, the capital investments required to decarbonize each campus varies from $30 to $350 per square foot, which can be better understood by dividing the work into two categories:

Building Upgrades	Energy conservation measures and transitioning from steam to hot water or stand-alone heat pumps	$4.50-$160/sq ft
Energy Supply	New power plant, geofield, centralized heat pumps, heat recovery chillers, utility piping, etc	$15-$100/sq ft

These wide ranges are due to the various building types and conditions of each building and campus. Older buildings with poor envelopes, for example, will need larger investments than newer buildings with modern systems.

These upfront costs are high, but account for a complete transformation of each campus's energy systems, including replacement of steam pipes with low temperature hot water pipes, construction of geothermal wells, enhancing insulation in existing buildings, and more. Each study recommended implementation of proposed solutions in a series of phases, allowing the campuses to integrate the recommendations of these roadmaps into existing plans and equipment replacement schedules. In addition, each report compared these new energy systems with business-as-usual scenarios over the lifetimes of each system. The results showed that when ongoing maintenance, management, and fuel costs are considered, the total cost of ownership of the decarbonized solutions are, in many cases, offset. Further study will be needed, however, to give each campus a clearer view of the capital and ongoing investments needed.

Key Lessons Learned

The campus decarbonization study teams met regularly throughout their study periods to share best practices and learn from each other's experiences. Listed below are high-level recommendations for entities looking to conduct similar studies. This list is not comprehensive; for further information and guidance, please contact MA Leading by Example staff.

- ✓ Secure early support and buy-in from senior staff and key departments to ensure the study results will lead to appropriate changes in how near and long-term planning is conducted
- ✓ Detailed energy use data on the thermal and electric use and demands of each campus building, and projected changes to these buildings and overall campus over time, can streamline the study process, giving consultants a better understanding of current and projected energy needs.
- ✓ Consider avoiding analysis of strategies/technologies that have been consistently rejected in other studies and consider starting with solutions proposed in completed studies, or implemented at other campuses
- ✓ The capital costs required to implement extensive decarbonization measures should be seen as *investments* to improve campus-wide energy infrastructure. Such improvements add value, including providing additional heating and cooling to new buildings and modernizing equipment nearing their natural end of life.
- ✓ While implementation of these roadmaps will take decades, they allow public entities to understand the transformative actions and investments required to achieve their climate goals. Completion of such studies helps entities prioritize future studies and projects, seek appropriate funding, and integrate recommendations into existing plans and processes.

Additional Information

MA Leading by Example Program
UMass Amherst Carbon Zero
UMass Dartmouth Campus Sustainability
UMass Lowell Institute for Sustainability & Energy
Salem State University Sustainability