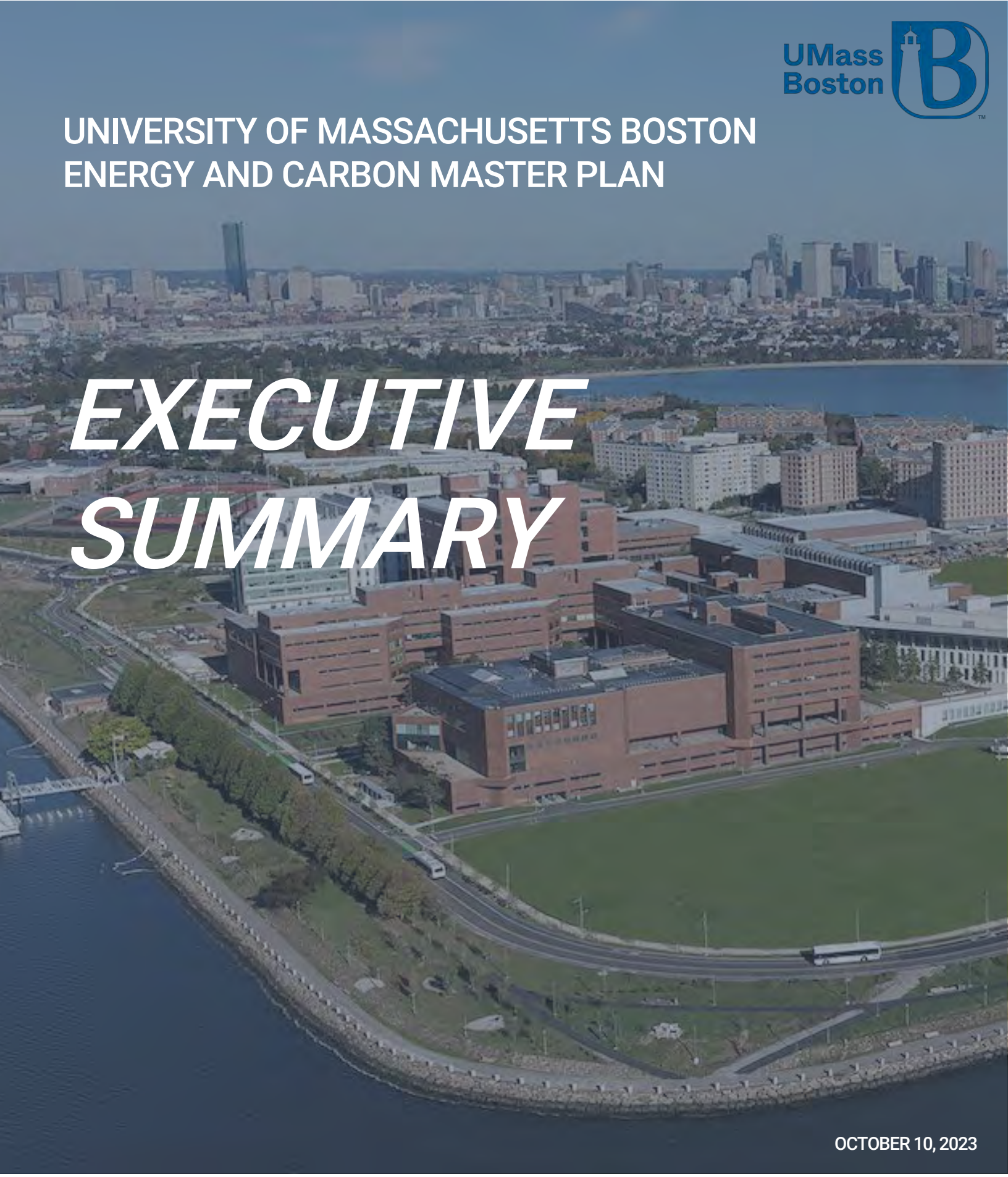
UMass Boston

UNIVERSITY OF MASSACHUSETTS BOSTON ENERGY AND CARBON MASTER PLAN



EXECUTIVE SUMMARY

OCTOBER 10, 2023

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Office of the Chancellor
100 Morrissey Boulevard
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9/29/2023

To the Campus Community:

Following our recent introduction of the new **Campus Master Plan**, I am pleased to introduce a related initiative, UMass Boston's new **Energy & Carbon Master Plan**.

The best available science tells us that the world needs to cut emissions dramatically by mid-century or sooner to avert the most catastrophic effects of climate change. In large part, this calls on all sectors to accelerate the global transition to low-carbon energy. In Massachusetts, Executive Order 594 – issued in 2021 – establishes milestones for state agencies and operations to reduce greenhouse gas emissions in alignment with the statewide goal of achieving net-zero carbon by 2050.

Transitioning UMass Boston to net-zero carbon emissions is indeed a complex undertaking. It will require re-engineering infrastructure and investment in new technologies. And it will entail operational planning around a core commitment to sustainability. It will also provide benefits of improved building comfort while decreasing energy costs.

The goal of the new Energy & Carbon Master Plan then is to provide a pathway that gets UMass Boston to net-zero and to a more resilient campus by 2050 by:

- Reducing energy consumption and enhancing resiliency in existing buildings.
- Building energy efficient and resilient new buildings.
- Switching fuel sources by electrifying the Central Utilities Plant and expanding sea-water heat pumps.
- And utilizing renewable energy, on and offsite.

These measures will not only enable UMass Boston to be in compliance with the state Executive Order 594. They are, as well, consistent with our mission of teaching, research, and service for the greater good – in this case, a more sustainable future.

And so, UMass Boston will continue taking steps to transform our energy systems and reduce our emissions to ensure that we're doing our share in the fight against climate change.

I look forward to the implementation of the Energy & Carbon Master Plan.

Marcelo Suárez-Orozco
Chancellor, University of Massachusetts Boston

EXECUTIVE SUMMARY

The University of Massachusetts Boston (UMB) is an urban public research university with a commitment to environmental stewardship on campus and sustainability research and education. The goal of the Energy and Carbon Master Plan ("the Plan") is to provide practical, cost-effective energy efficiency, electrification, on-site renewable, and resiliency solutions. The plan also addresses the goals and milestones of Executive Order 594, "Leading By Example: Decarbonizing and Minimizing Environmental Impacts of State Government". This order supports the statewide goal of achieving net zero greenhouse gas (GHG) emissions in 2050 and limits the burning of fossil fuels in buildings and in vehicles. The Leading by Example (LBE) program encourages maximizing the installation of onsite renewable energy. It also supports long-range planning efforts so that the capacity of critical infrastructure and energy systems can withstand growing weather-related impacts associated with climate change. By implementing a range of initiatives and investments, UMB aims to meet environmental mandates, significantly reduce emissions, and create a sustainable campus for the future.

The campus is expected to undergo a variety of changes between now and 2050 to meet the evolving academic community needs and address building asset end of life. The campus is currently comprised of 13 buildings totaling 1,751,900 square feet. Buildings are currently served heating hot water and chilled water from a central plant powered by burning natural gas. Major equipment at the central plant is anticipated to need replacement within the next 5-10 years. Furthermore, the current Campus Master Plan anticipates a 33% growth by 2050. Therefore, upgrades at the central plant will be needed. This is a key opportunity to electrify the central plant and avoid burning more fossil fuels on campus. In addition, a collection of older buildings referred to as the Heritage Buildings are expected to undergo major renovations. This is a key opportunity for projects to reduce loads imposed on the central plant, improve building energy efficiency, and transition to low temperature hot water systems. In addition, current climate models indicate the CUP location could be at risk for flooding by 2050. Lastly, there are operational issues, low-cost energy conservation measures, and deep energy retrofit opportunities that were identified during the plan development. These are key opportunities to reduce loads imposed on the central plant and improve building energy efficiency.

The team evaluated a wide range of energy efficient, electrified alternatives for these anticipated projects. For the central energy plant, a sensitivity analysis was conducted to determine the viability of electrification technologies. The analysis considered UMB specific criteria including emissions, feasibility, cost, operations, and resiliency. This informed a recommendation to carry technologies through to more detailed scoping, energy analysis, and cost estimation. The outputs of this analysis were organized using tools such as life cycle cost and choosing by advantage. This provided a holistic picture such that the key stakeholder team had all required information to make an informed decision about which options to include in the Plan.

The Plan details a path towards a carbon neutral and more resilient campus. The framework of the Plan incorporates energy efficiency, electrification, on-site renewable, and resiliency solutions. The campus will focus on significantly reducing energy consumption. This allows the "right-sizing" of the new central plant for the new electrification strategies. UMB will also advance recommended onsite renewable energy options. In addition, to meet commitments to net-zero greenhouse gas emissions, UMB will pursue offsite renewable electricity purchases. The campus will continue to look at ways to mitigate emissions associated with fleet vehicles, commuting, and other sources, but that was not the focus of this plan. The Climate Hazards assessment indicated likely future vulnerabilities to flooding and heat; therefore, the campus will move forward with the proposed climate resiliency actions for current and future buildings.

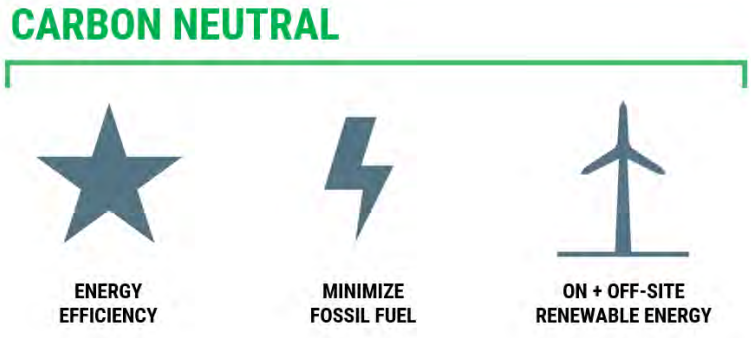

Figure 1: Overall carbon neutral strategy

Plan Framework

Energy Efficiency: Reducing energy reduces emissions. Energy reduction is planned through major renovation and comprehensive energy projects. Highest emitters are prioritized to have a cost-effective, significant impact. Major renovations are the best opportunities to reduce energy consumption. This is a holistic approach to building system renewal. Comprehensive energy projects focus on proper building operation, low-cost energy conservation measures, and deep energy retrofits. A key focus is on regular third-party testing of energy systems ("retrocommissioning") to ensure ongoing proper operation.

Electrification: The shift from traditional fossil fuel burning heating equipment to electric alternatives contributes to reducing emissions and promoting sustainability. The new central plant incorporates electrified technologies such as high-temperature heat pumps, seawater heat pumps, air-to-water heat pumps, and geothermal heat pumps. Air source heat pumps are identified as the primary means of electrification. New construction and major renovations will connect to the central plant so that they're fully electrified, eliminating the need for additional gas capacity. The MA Clean Energy Standard requires in 2023 that 26% of electricity be provided from renewable sources, increasing to 80% by 2050.

Asset End of Life: Energy efficiency and electrification projects are aligned with the estimated end of life of equipment. This improves the cost effectiveness of projects. It also prevents the need to retire equipment early.

Phased Approach: A phased approach enables the gradual implementation of upgrades and improvements. The plan suggests phasing in central plant capacity and equipment to proactively electrify ahead of new construction and major renovations. This allows for UMB to make significant progress towards carbon neutrality while also being able to take advantage of future technologies.

Low Temperature Hot Water: A low temperature hot water system is the most cost-effective alternative. Campus systems are currently designed for high temperature hot water. In the short term following the boiler upgrades, buildings should be stressed tested to understand the maximum temperature required. Buildings systems such as air handling units, fan coil units, and variable air volume terminal units incorporate low temperature coils so that the plant can transition to low temperature hot water in the future.

Coordination and Budgeting: Close coordination during capital planning is recommended to ensure that project budgets encompass both the building costs of individual projects and the central plant upgrades. This integrated approach avoids budgetary limitations and optimizes the allocation of resources.

Maintenance and Staffing: Given that the recommended equipment is not currently present on campus, maintenance and staffing requirements require special consideration. It is important to assess the skill sets and expertise needed to operate and maintain the new systems effectively.

Resilient Buildings: Enhancing the resiliency of campus operations is a crucial consideration. Relocating the central plant to a more resilient location/elevation is proposed to ensure the critical operation remains functional during potential disruptions and natural disasters. Future improvements on the UMB campus should incorporate resiliency and adhere to the City of Boston's Climate Resilient Design Guidelines and the Resilient Massachusetts Action Team's Climate Resilience Design Standards and Tool. This ensures that all projects align with industry best practices and withstand the potential impacts of climate change.

The key stakeholder team agreed on a new central plant in a new location to address the potential flood risk associated with the current central plant location. The basis of design for the new central plant is 100% electrification by 2050 with natural gas reserved for back-up heating. The new central plant incorporates electrified technologies such as high-temperature heat pumps, seawater heat pumps, air-to-water heat pumps, geothermal heat pumps, and natural gas boilers for backup purposes as detailed in the conceptual diagram below.

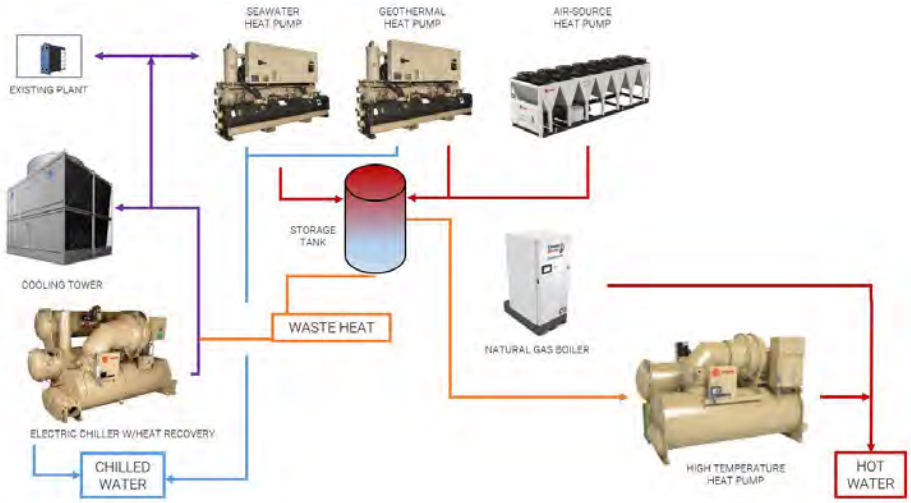

Figure 2: Central Energy Plant Conceptual Diagram

The existing buildings on the campus require high-temperature heating hot water at 180°F. However, current heat pump technology is unable to meet the entire heating demand of the campus with a single machine type particularly given the lack of consistent heat source. To address this issue, the Plan specifies the use of high-temperature heat pumps. These heat pumps are designed to provide high-temperature heating hot water meeting the specific requirements of the existing buildings. Additionally, the Plan outlines a strategy for renovating the buildings with low-temperature hot water systems. As these renovations occur the high-temperature heat pumps can be retired. A low-temperature hot water system is the most cost-effective option over the entire life cycle, indicating that it offers significant benefits in terms of system efficiency and operational costs.

The current UMB seawater pump house is only used for heat rejection. The Plan expands this function to also extract heat from Savin Hill Cove for a waste heat loop to serve the high-temperature heat pumps. The stakeholder team agreed on this strategy to align with the current seawater pump house overhaul project. In addition, the seawater heat pump option was the second most life cycle cost-effective option. A key challenge with this strategy is the permitting process, with attention to the discharge temp allowed and its interaction with tidal cycles. Therefore, it is a limited heat source, and other technologies are required to achieve the full campus heat capacity. If the existing permit cannot be expanded to incorporate these performance requirements, then additional air-source heat pumps will be required.

A finite area for geothermal wells is anticipated given the urban environment and campus growth. A geothermal field consisting of 525 boreholes is scoped between University Dr E and the HarborWalk. This area was closely coordinated with the Campus Master Plan team to avoid conflicts with campus growth. A geothermal test well is recommended prior to work to confirm performance criteria assumptions. If the test well results prove favorable, then the geothermal scope may be moved up in the implementation timeline.

Air-to-water heat pumps are scoped to meet most of the campus heating needs. This technology is ideal in an urban environment with spatial limitations given the technology's heat capacity density. Air-to-water heat pumps will be located on the roof of the new central plant.

Natural gas boilers are scoped as a back-up heating source for low temperature conditions and power outages. Fuel diversity is a key resiliency strategy of the Plan. This is the best solution at this time given the alternative of backing up heat pumps would require an extensive investment of generators, fuel storage, and switchgear. A phased approach will allow UMB to incorporate the most efficient technology at the time of implementation inclusive of new technologies that may eliminate the need for natural gas for back-up.

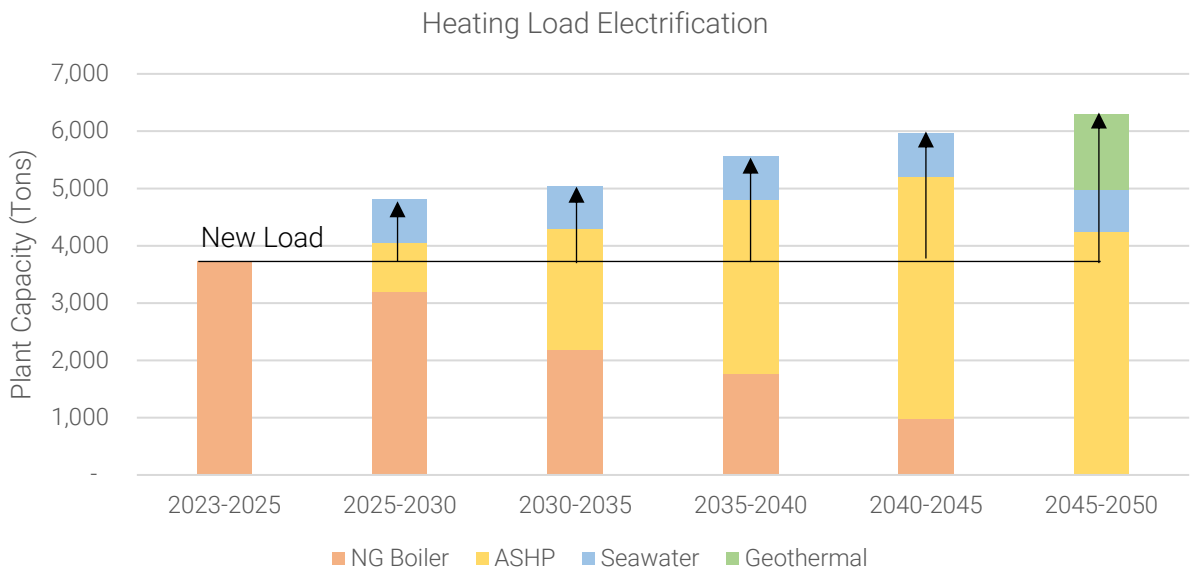

Figure 3: Heating Load Breakdown by Electrification Strategy

Figure 4: Projected 2050 Campus Map

Conformance with the Plan is estimated to result in the following outcomes:

- 34% energy usage reduction.
- 86% fossil fuel emissions reduction (100% excluding P3 and process natural gas)
- 20% reduction in operating costs (70% increase including growth and escalation)
- 7% increase in total capital spending between 2023 and 2050 ($345M increase above the $4.1B baseline costs)

Through the implementation of the Plan, the campus is predicted to comply with EO 594's fossil fuel emissions reduction goal by demonstrating more than 60% reduction in onsite emissions by 2040 and 95% by 2050. Electrifying the central plant utilizing electricity and renewable resources will achieve an 85% reduction in onsite emissions. It is estimated that natural gas use in commercial kitchens in the resident halls could contribute 12% to emissions. However, it is predicted that by 2050, electric equipment will be the gold standard and possibly a requirement for commercial kitchens. The remaining amount 2% of greenhouse gases are used by labs for research. While there are initiatives to reduce these pollutants with research alternatives, their continued use would comfortably be under the 5% allowed in 2050.

To read the full document
visit the
Energy & Carbon Master Plan
Website