1. Project Title: University of Massachusetts Amherst District Microgrid

2. System Location: Amherst, Massachusetts

3. System Owner: University of Massachusetts Amherst

4. Application Point of Contact: Steve Lemay

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5. Executive Summary

Founded in 1863, UMass Amherst is the flagship campus in the University of Massachusetts System and is the largest public research university in New England. UMass Amherst serves over 32,000 undergraduate and graduate students on a scenic campus in Amherst, Massachusetts. The 1,450-acre campus provides a rich cultural environment in a rural setting and is comprised of approximately 13 million gross square feet of academic, residential, research, athletic and administrative facilities across nearly 300 buildings.

Over the last 15 years, UMass Amherst has transformed its district energy system to significantly reduce the campus' greenhouse gas emissions, to effectively manage energy costs for the University, and to provide reliable, resilient utilities services to the campus. The lynchpin of the district energy system is a unique microgrid, which provides uninterrupted electrical service to meet the rigorous power quality standards required for technical research activities being conducted onsite and enables UMass Amherst to serve as a regional emergency shelter in the event of natural disasters and/or major grid outages.

UMass Amherst's microgrid has a hybrid design that not only provides resiliency for campus operations but also provides a platform for deep decarbonization of the campus' energy systems in the coming years. The microgrid includes a highly efficient cogeneration system, Massachusetts' largest behind-the-meter solar system, and cutting-edge battery storage installations. This unique combination of generation and energy storage technology is configured such that all assets can fully operate in islanding mode during grid outages, and to enable the operations team to dispatch the assets to reduce grid demand during targeted periods coincident peak periods on the grid when the campus is assessed transmission and capacity charges. As UMass Amherst embarks on a phased conversion from district steam towards a new low-carbon district energy system, the microgrid will support the transition while ensuring that campus resiliency is not compromised.

The campus microgrid was created in 2009 when UMass Amherst replaced an 80-year-old coal burning power plant with a new dual-fuel central heating plant. The new facility's combined heat and power system (the "CHP") has a 10-MW combustion turbine with heat recovery steam generator, 2- MW and a 4-MW steam turbine, and four natural gas boilers. The CHP generates roughly 70% of the campus' annual electricity needs and provides 100% of the steam used for heating and cooling buildings across campus. The CHP has received several awards, including the Combined Cycle Journal Pacesetter 2008 Award for the best CHP plant project in the U.S., the Sustainable Campus Leadership Award from the International District Energy Association in 2009, and the Combined Heat and Power Energy Star Award from the U.S. Environmental Protection Agency in 2011.

In 2015, UMass Amherst completed a major overhaul of the campus' electrical infrastructure that is the backbone of the microgrid. This included constructing a new 115-kV substation to provide a direct transmission-level interconnection to the bulk power system, along with continued build out and strengthening of the internal medium voltage electric system. This infrastructure enables the microgrid to support islanded operations during local grid outages utilizing the CHP, onsite solar, and battery storage assets located around campus.

UMass Amherst has installed over 7 MW of onsite solar generation capacity. In 2017, UMass Amherst installed over 15,000 solar panels across the campus totaling 4 MW of rooftop solar and parking canopy arrays. In 2022, UMass Amherst installed another 3 MW of parking canopy arrays. The two phases were developed under an innovative power purchase agreement ("PPA") model with third-party ownership that enabled the campus to maximize the use of federal and state solar incentives. The solar parking canopies have controls that can reliably integrate the intermittent solar generation with the CHP's baseload electric generation.

In conjunction with the build out of solar generation on campus, UMass Amherst has developed an array of electric demand management tools in the microgrid to help manage the campus' grid demand during periods when the local and regional transmission systems experience peak demand. Today, UMass Amherst can quickly shed over 5 MW of grid electricity demand by deploying two behind-the-meter battery storage systems (with over 3 MW of power capacity) and utilizing a building automation system that controls heating, ventilation, and air conditioning operations across more than 200 campus buildings.

6. Project Innovation

UMass Amherst is at the forefront of U.S. universities in developing a campus microgrid that balances resiliency needs and decarbonization efforts. While UMass Amherst is proud of this progress on lowering the campus' emissions footprint, it is not sufficient to meet Massachusetts' ambitious emissions reduction goals. In 2021, Massachusetts enacted a mandate to reduce statewide emissions by at least 85% by 2050 and to offset remaining emissions to achieve net zero emissions.

UMass Amherst will need to fundamentally transform the campus' energy infrastructure to meet this goal. The campus must significantly reduce fossil fuel use in the CHP to achieve deep decarbonization, while maintaining reliability and resiliency to serve the campus local communities during emergencies. To this end, UMass Amherst has undertaken a comprehensive strategic planning process over several years to assess and select a pathway to transition the campus' existing district energy production and distribution system to decarbonized energy infrastructure.

A hybrid microgrid will play a critical role in enabling the campus to continue reducing onsite emissions while avoiding having to give up the CHP's significant resiliency benefits. UMass Amherst provides one of the country's best test cases for how distributed renewable generation can be scaled and integrated into resilient microgrids. The microgrid includes 16 MW of cogeneration in the CHP facility and 7 MW of operational behind-the-meter solar as well as 8 MWhs of energy storage. As UMass Amherst has expanded its behind-the-meter solar deployment, the campus faces increasing reliability risks due to integration challenges between the intermittent solar output and baseload cogeneration units. UMass Amherst has successfully addressed these concerns by implementing smart grid capabilities and system design to maintain electrical reliability.

7. Energy Efficiency Improvements

The microgrid has enabled UMass Amherst to reduce its reliance on electricity from the ISO New England grid by 24%, measured in kWh per gross square foot, comparing average consumption in 2018 and 2019 to average consumption in 2022. 2020 and 2021 were omitted due to the COVID-19 pandemic. This reduction has helped to advance UMass Amherst's long-term goal of reducing energy consumption and carbon emissions.

More broadly, UMass Amherst has been able to reduce EUI by 23% over the past 2 decades. Thanks to clean electricity from the CHP and solar systems, the campus' greenhouse gas emissions have declined by nearly 40% over the same time period despite the campus' gross building square footage growing by over 30% and total student enrollment growing by 37%. Increased ability to generate renewable energy locally and store energy enables the university to reduce its reliance on natural gas used to generate both local and grid-purchased electricity.

The microgrid has also helped position UMass Amherst for its planned campus transition to zero carbon heating using ground source heat pumps. The lower the carbon intensity of campus electricity, the more carbon reduction can be accomplished through a transition to heat pumps.

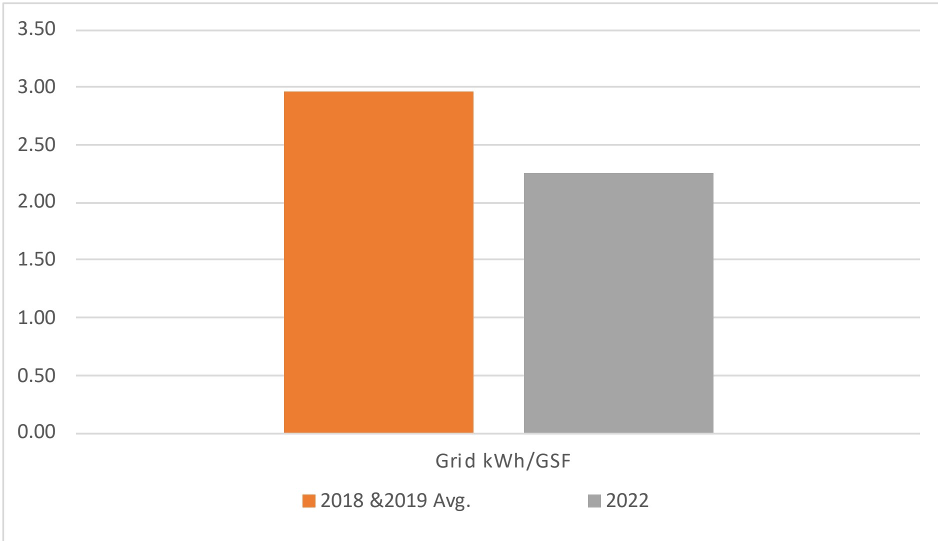

Figure 1. kWh consumed from grid per gross square foot of UMass building space

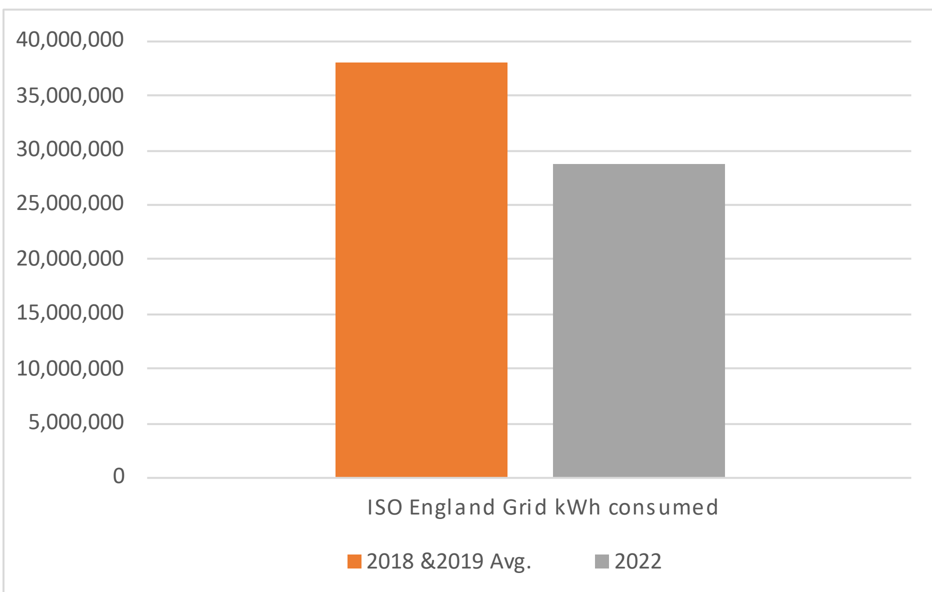

Figure 2. Total kWh consumed from grid

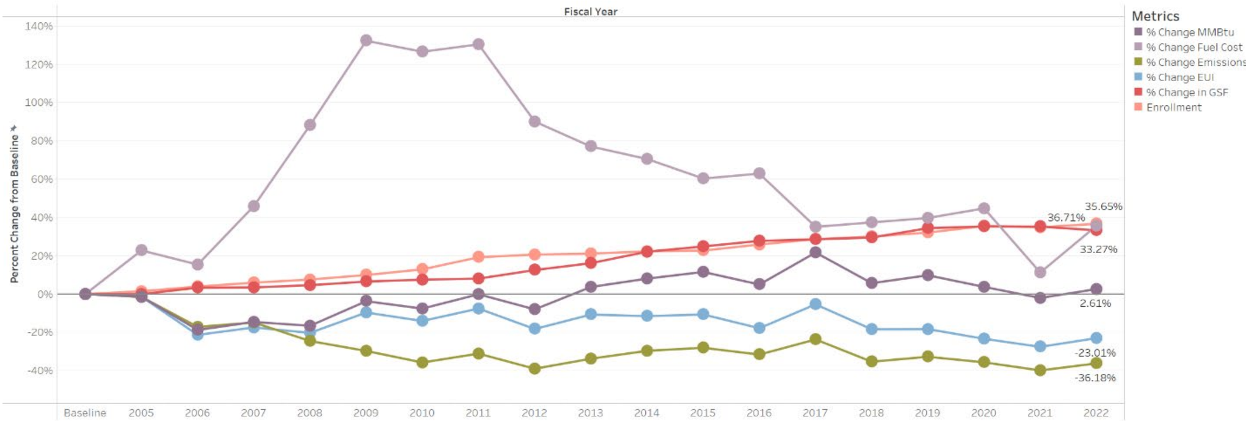

Figure 3. Change in campus EUI and carbon emissions vs. enrollment and gross square footage, 2004-2022

8. Financial Advantages of the Project

UMass Amherst has realized significant financial savings from the campus' hybrid microgrid. UMass has been a vocal advocate for electric rate design that incentivizes large customers to reduce grid demand during peak periods on the local and regional transmission systems. As a result, the campus' electricity supply and delivery rate design include demand charges that are targeted during New England's annual peak demand hour and during Eversource's monthly peak demand hour on its transmission system. UMass Amherst has developed a demand management plan utilizing the microgrid's assets to maximize savings opportunities under this rate structure.

The first phase of onsite solar development, completed in 2017, has produced net savings of nearly $2 million for UMass Amherst. This figure is based on a review of electricity supply and delivery costs that the campus would have incurred without the solar generation offsetting grid purchases. Nearly 75% of these net savings are avoided transmission and capacity demand charges.

In 2019, UMass Amherst completed the installation of its first lithium-ion battery storage system. This system is one of 26 battery storage projects awarded state grant funding under Massachusetts' Advancing Commonwealth Energy Storage ("ACES") demonstration program administered by the Massachusetts Clean Energy Center. The battery is strategically discharged to reduce the campus' grid demand during periods when the local and regional transmission systems experience peak demands. The campus achieved a payback on the battery in just over two years and has generated over $2 million in total savings during the first 3.5 years of operation.

9. Implementation Challenges

The primary challenge in developing and operating the hybrid microgrid has been enabling the continued addition of solar generation on campus. The intermittency of the campus' 7 MW behind-the-meter solar has required detailed analysis and thoughtful system design to ensure that the baseload electrical generation from the CHP can operate in harmony with the solar generation under all operating conditions throughout the year.

UMass Amherst has tackled this challenge in multiple ways. First, protection schemes have been implemented for the 5.8 MW of solar parking canopies, which are installed across four different sites on campus. The protection scheme, designed by UMass Amherst's Physical Plant team in collaboration with CHA Consulting, deploys automatic, targeted solar curtailment if excess generation conditions across the solar assets and the CHP are detected. This design allows individual inverter strings to be temporarily shed, rather than an entire solar system being taken offline. Second, UMass Amherst installed a new ductbank to relieve transfer constraints between the campus electrical system's eastside and westside networks. Third, the two battery systems on campus are configured to be able to charge from the onsite solar generation to help relieve excess generation risks. The new 2 MW/4 MWh battery system installed in 2022 is co-located and DC-coupled with the new 2 MW solar parking canopy located on Lots 21/22 and can only be charged by the solar generation.

This approach has enabled broad stakeholder buy-in from campus operators and planners, and sets the stage for new solar additions in the future.

10. Project Images & Diagrams

Figure 4. UMass Amherst Central Heating Plant

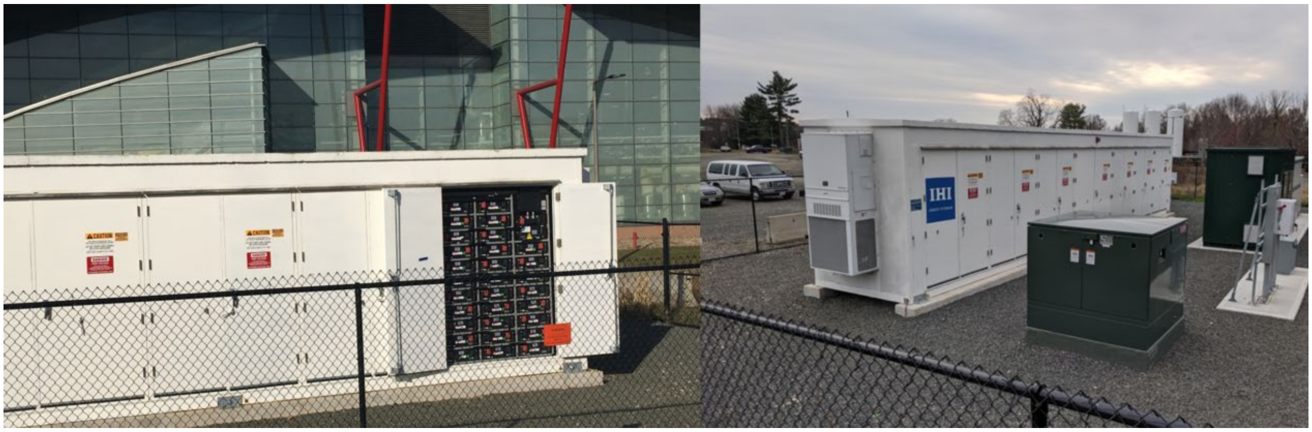

Figure 5. Battery Energy Storage System (BESS)

Figure 6. Lot 22 solar panels

Figure 7. Tillson Substation (115 kV)

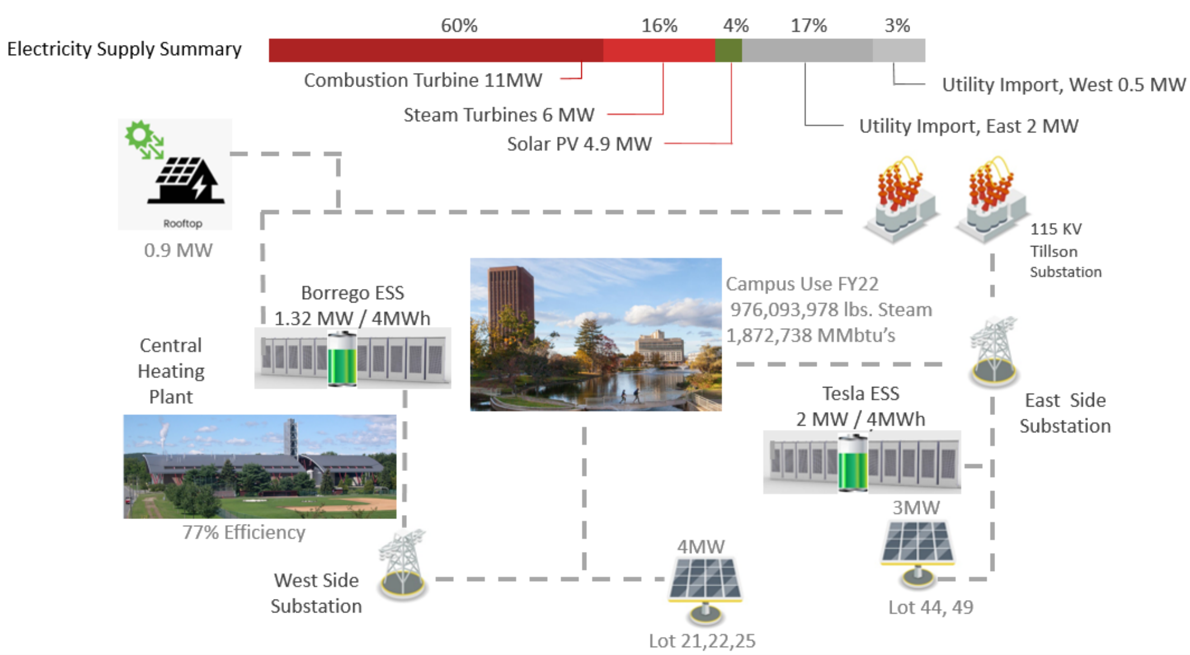

Figure 8. Microgrid system diagram