University *of* Massachusetts Amherst

Clean Energy Extension

Mount Ida Campus
Greenhouse Gas, Clean Energy, and Sustainability Planning

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Prepared By
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Key Abbreviations & Acronyms

Abbreviation/Acronym	Meaning
ACEEE	American Council for an Energy-Efficient Economy
ACH	Air Changes per Hour
ASHP	Air-Source Heat Pump
BMS	Building Management System
CEE	Clean Energy Extension
CHP	Central Heating Plant/Combined Heat and Power
COP	Coefficient of Performance
CO_2e	Carbon Dioxide Equivalent
DCAMM	Department of Capital Asset Management and Maintenance
DHW	Domestic Hot Water
DOER	Department of Energy Resources
EIA	U.S. Energy Information Administration
EPPs	Environmentally Preferable Products
ERV	Energy Recovery Ventilator
EUI	Energy Use Intensity
FY	Fiscal Year
GHG	Greenhouse Gas
GSHP	Ground-Source Heat Pump
GWP	Global Warming Potential
HVAC	Heating, Ventilation, and Air Conditioning
kWh	Kilowatt Hour
LBE	Leading By Example
LEED	Leadership in Energy and Environmental Design
MIC	Mount Ida Campus
MOU	Memorandum of Understanding
NG	Natural Gas
PPA	Power Purchase Agreement
PTAC	Packaged Terminal Air Conditioner
RTU	Roof Top Unit

Executive Summary

The burning of fossil fuels is intricately woven into the fabric of our everyday lives, as it is a primary source for electricity, heating, cooling, and transportation. However, humans have become too reliant on these unsustainable fuel sources that threaten to irreversibly damage our world within the next 10 years. Burning these fossil fuels emits carbon dioxide and other harmful greenhouse gases which trap heat in the atmosphere, slowly warming the earth and causing more extreme weather patterns. Staying on our current usage trajectory and reaching a warming of 2°C will not only create global catastrophes like sea level rise, floods, and more intense/frequent storms, but will also have large impacts on the environment and surrounding ecosystems. According to recent findings by the Intergovernmental Panel on Climate Change (IPCC), all the ice within the arctic circle would melt completely once every ten years, undeniably eliminating countless species that rely on that habitat, and less than 1% of all coral reefs will remain. In order to prevent this and halt warming at $1.5 \circ C$, abrupt changes to how we use our environment need to be made today. It would require human caused CO_2 emissions from energy consumption come to a complete stop with a net zero world by 2050. A large scale transition away from fossil fuel use towards renewable energy is necessary, and this report hopes to facilitate this transition at the local level. [1]

This report outlines the work, findings, and recommendations of the UMass Clean Energy Extension (CEE) for the UMass Amherst Mount Ida Campus, regarding essential focus areas for the University's pursuit of energy efficiency and sustainability. Over the course of the spring and summer of 2019 the CEE evaluated the energy use of the Mount Ida Campus to develop energy use reduction strategies and clean energy opportunities. A Greenhouse Gas Inventory was conducted, Energy Use Intensity was calculated, and a Building Atlas was created, which includes specific building statistics. A series of GIS maps were also constructed in order to highlight various characteristics of the campus, such as building meter groupings, generator and heat pump locations, building specific energy use intensities, and so on. By inspecting each building, and analyzing energy usage and emissions, several buildings were targeted as being the most detrimental to the Mount Ida Campus sustainability and clean energy goals. Key recommendations were formulated for individual buildings, overall sustainability, and transportation on campus.

Our team started with an analysis of the largest sector of emissions on campus, buildings, using the first complete year of UMass ownership. **The total energy used by all buildings on the UMass Amherst Mount Ida Campus from May 2018 to April 2019 amounted to approximately 26.9 million kBtu from oil, natural gas, and electricity sources. This energy use resulted in 1,661 metric tons of CO2e emissions, which is equivalent to 1.4% of the total emissions from the UMass Amherst Flagship campus buildings, or the emissions that would be caused by burning 1.8 million pounds of coal.**[2] [3] This data was also split up by building, when viable, and used to find the largest and most inefficient energy users.

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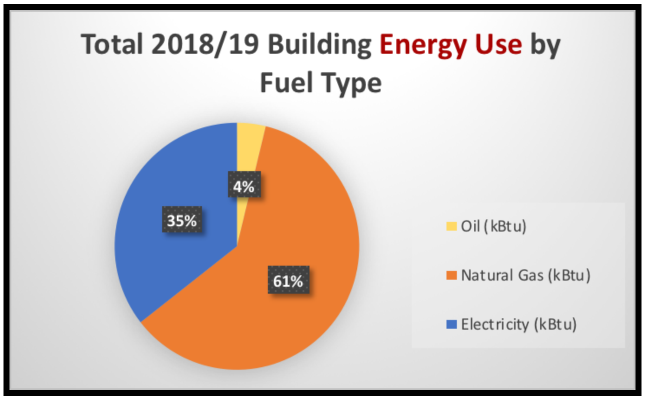
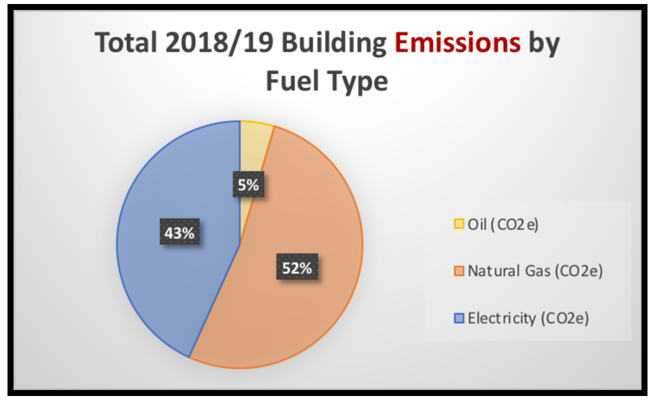
[1] Intergovernmental Panel on Climate Change. "Rapid response needed to limit global warming: Summary for Policymakers of IPCC Special Report on Global Warming of 1.5°C approved by governments." ScienceDaily. ScienceDaily, 8 October 2018. <www.sciencedaily.com/releases/2018/10/181008075147.htm>.

[2] "UMass Amherst 2017 Emissions." *UMass Amherst.* Retrieved from: https://umass.app.box.com/file/408938946910

[3] "Greenhouse Gas Equivalencies Calculator"(2018). *United States Environmental Protection Agency*. Retrieved from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator





ES.1: *The two pie charts above outline the total energy used solely by buildings on the UMass Mount Ida campus between May 2018 and April 2019, and their resulting emissions categorized by fuel type.*

ES.2: *This graphic helps visualize the effects of the Mount Ida Campus emissions from May 2018 to April 2019. For this year, the total emissions are equivalent to those which would result from burning 1.8 million pounds of coal.*[4]

Summary of Key Findings and Outcomes

1. **Metering on Campus:** Not all buildings on the Mount Ida campus have their own meters. Meter account numbers have also changed since the purchase of the campus. Approximately 50% of the buildings on campus have their own electric or natural gas meter. For the rest of the buildings sharing meters, it is difficult to determine energy usage and emissions on a building by building basis.

2. **Campus Energy Use 2018-2019:** As was expected, less energy was used by the Mount Ida campus during the twelve months following the UMass Amherst purchase. Energy use fell 16% from 32,086,085 kBtu during April 2017-March 2018 at the time of full capacity to 26,929,103 kBtu during May 2018-April 2019. Campuswide and individual building Energy Use Intensity, or EUI was then calculated for both historical and recent data.

[4] "Greenhouse Gas Equivalencies Calculator"(2018). *United States Environmental Protection Agency*. Retrieved from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

3. **Campus GHG Inventory:** Similar to EUI, campuswide and individual building emissions were calculated from both historical data (April 2017-March 2018) and recent data (May 2018-April 2019). Campuswide emissions dropped from 2,028 metric tons CO_2e (2017-2018) to 1,661 metric tons (2018-2019). These emission calculations are in agreement with Mount Ida's decreased energy usage since the UMass merger.

4. **Building Atlas:** The Building Atlas is a consolidated spreadsheet of building statistics and information. The Atlas includes building specifics such as thermostat setpoint temperatures, heat pump and generator locations, and heating and cooling systems used. We believe that the Atlas will be a valuable resource for Mount Ida staff and future CEE interns for campus planning efforts.

5. **Target Buildings:** We have identified the following buildings as those that require the most attention in regards to energy efficiency: Chapman Hall, Veterinary Technology Center, and Boulder Farm. We chose Chapman Hall as a model building because of its simple design, available energy data, visibility, and it's projected use as part of the campus occupancy plan. The Vet. Tech. building uses the most energy per square foot of all campus buildings, with an alarming EUI of 200 in the first year Mount Ida became owned by UMass Amherst (May 2018 - April 2019). This is largely because of the ventilation needed to support a lab space, as well as excessive cooling habits. Vet. Tech. accounted for 11% of the total energy use by buildings on the Mount Ida Campus that year, more than any other building we came across, making it an obvious choice for a target building. Lastly, Boulder Farm is one of the five buildings left on campus that still uses oil for heating, and it is the only oil heated building that the University anticipates keeping for the foreseeable future. This is problematic because oil has a worse greenhouse gas impact than natural gas, and therefore disproportionately increases the total campus emissions in comparison to other buildings on campus.

   Many of the buildings on campus share potential areas of improvement. These issues include incorrect set points,a lack of programmable thermostats causing unnecessary HVAC use, and a lack of motion detectors for lighting and appliances use. Some empty buildings were found with A/C units operating at unnecessarily high power, appliances such as fridges running, lights on with no occupancy, and one was even found with the heat on in the middle of June. Many of the buildings on campus also lack individual meters for energy data.

6. **Campus Sustainability:** After careful observation, a few major issues became apparent in terms of general campus sustainability. The first concern has to do with waste management. A large, uncovered road salt pile sits in a corner of campus that borders a Rare Species Habitat as well as a series of vernal pools. Additionally, stormwater is dumped in this area. Both the road salt pile and stormwater disposal pose as serious threats to these vulnerable habitats. The campus also does not have a compost system, resulting in poor management of food and lawn waste. Many exterior lighting fixtures on campus do not currently utilize LED bulbs, and many of these fixtures emit light indiscriminately in all directions, meaning these lights are not energy efficient, and contribute significantly to light pollution in the local ecosystem.

7. **Transportation:** The UMass Amherst Mount Ida Campus currently offers every student access to three free uber rides per day to seven different locations for commuting to work and medical care, running errands, and having fun on the weekends. While this is a helpful amenity, it adds unnecessary GHG emissions to the environment with every ride. Over the course of ten months from September 2018 to June 2019, UMass Amherst Mount Ida provided uber trips to students covering about 8,900 miles, with 95% of the rides taken being private or single-user commutes, as opposed to the less carbon-intensive "UberPool" option. This cost the campus close to \$35,000, and resulted in an estimated 3.27 metric tons of CO_2e emitted.[5] These expenses and emissions could be

[5] Assuming that every car was a gas powered passenger vehicle and model between 2009 and 2019.

avoided by developing a campus-based transportation system for students to utilize, focused on the peak times and locations that passengers tend to be travelling.

Summary of Recommendations

A few major suggestions and plans have been outlined below in order to address the issues highlighted in the key findings section above:

1. **Increase Building Efficiency with Operational/Behavioral Modifications and Retrofits:**

   To minimize the costs and emissions associated with building operation on campus, we recommend:

   - Inefficient buildings that are damaged or do not have a plan for future use (including Malloy and the oil-heated buildings) be decommissioned or demolished in order to avoid the baseline energy consumption associated with keeping these buildings in limbo.
   - If the buildings that are currently heated with oil are to remain a part of the campus, we highly recommend replacing these existing heating systems with air source heat pumps.
   - Switching to electrically powered HVAC systems throughout the University, so that the campus can eventually run entirely off of renewable supplied electricity. These buildings would also benefit from air sealing and insulation upgrades in order to lower the heating demand and the required sizes of heat pumps.
   - Laboratories in particular should be targeted for energy efficiency efforts, as they are typically among the largest sources of energy consumption and emissions on campus. Efforts could include following programs such as UC Irvine's *Smart Labs,* by installing occupancy sensors, air quality sensors, etc. in order to minimize energy loss due to excessive ventilation. If applicable, energy recovery ventilators (ERVs) should also be considered for these systems.
   - Across all campus building operations, effort should be made to reduce unnecessary heating and cooling by modifying thermostat set points and HVAC schedules. This can be achieved by developing HVAC use schedules by monitoring the occupancy for each building to find at what times they are empty.
   - Across campus, all monitoring and data tracking should be improved with the use of individual meters for each building.
   - The campus should establish net zero emissions as a primary goal when constructing new buildings on campus.

2. **Implement Campuswide Sustainability Measures:**

   To protect the nearby environment and promote sustainability, we recommend:

   - Covering or removing the road salt pile in the back corner of campus
   - To stop the disposal of stormwater in this area completely as well, to prevent damage to the nearby protected wildlife area
   - Improve stormwater management across campus using native species of plants and proper planning

- Implement a composting system and signage to educate students and faculty on how to properly compost

- Stimulate education across the entire campus about sustainability, through the implementation of signage about turning off appliances and lights, water conservation, and more

3. **Transform Mount Ida's Transportation Sector:**

   To responsibly maintain the campus fleet, shape commuter habits, and reduce vehicular emissions we recommend:

   - Substituting the existing Uber-based transportation system with a shuttle-based system, potentially utilizing the buses and vans currently in the campus fleet

   - Collaborating with the City of Newton and neighboring businesses in order to establish a "by demand" bussing system

   - Establishing a relationship with LimeBike in order to extend their existing bike drop-off points to the Mount Ida Campus

   - Investigating the feasibility of electrifying the campus fleet, by performing cost-benefit analysis for various electric vehicles such as vans and security cruisers, as well as the implementation of EV charging stations

Table of Contents

1.0 - Introduction

This section outlines the rationale for this project, CEE's main goals, and the history of the Mount Ida campus. It also discusses the reason we focused on the transportation and building sectors, as well as UMass Amherst's commitment to sustainability.

1.1 - Project Overview

The University of Massachusetts Amherst acquired Mount Ida College on May 17, 2018. As the former Mount Ida College became the Mount Ida Campus of UMass Amherst, it also joined in on all of Umass Amherst's goals and requirements. These include Massachusetts's Leading By Example program, the American College and University Presidents' Climate Commitment (ACUPCC), and the University's goal of carbon neutrality. To reach those goals and requirements, this project was created to jump start the energy and overall sustainability efforts at the Mount Ida Campus.

Initiated by the UMass Amherst Clean Energy Extension, this program aims to establish an emissions baseline for the Mount Ida Campus while also pushing the University towards its carbon goals. Our team consists of graduate and undergraduate students from diverse scientific backgrounds with the common goal of developing a sustainable and green future. The CEE created this program to aid UMass Amherst and the Mount Ida Campus, while also incorporating learning, research, and public service aspects.

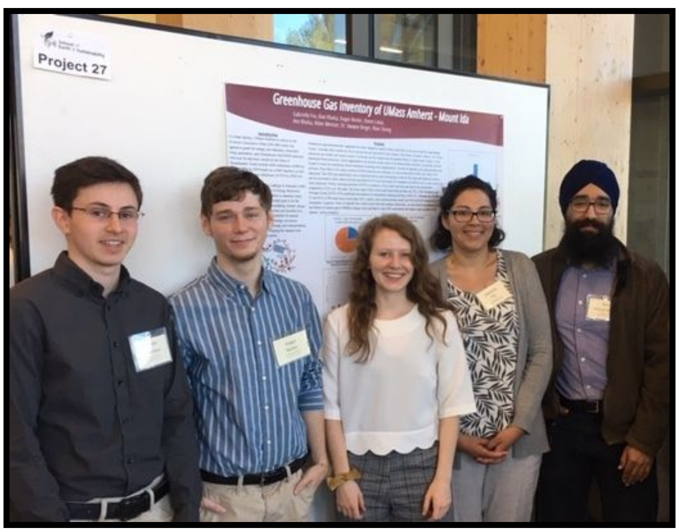


Figure 1.1: *The CEE Intern team at the SES Research Poster Session. Pictured left to right: Alden Mentzer, Dugan Becker, Devon Lukas, Gabriella Fox, Ramcharan Khalsa.*

During the spring semester of 2019, our team began with a course reviewing the logistics of greenhouse gas inventories, case studies, and project planning. We also began to explore some of the initial energy and fuel data from the Mount Ida campus. In June, we continued this project by organizing energy and building data at the UMass Amherst Campus, creating an all in one spreadsheet for building by building data. We also spent time visiting nearby state of the art net zero buildings, Living Buildings, the Umass Amherst CHP, and more. Next, we moved to the Mount Ida Campus where we began exploring the campus and buildings to gather more data and understand what improvements could be made. Throughout this whole project, a few main goals were established and followed:

Goals

1. **Calculate and analyze the campuswide greenhouse gas emissions from current and historical data**

2. **Create a malleable, organized index of data and information or "Atlas" for each building at the Mount Ida Campus that may be used from now on to help track data by building, and to then create a GIS map that visualizes this data**

3. **Identify the buildings that need the most urgent attention in terms of environmental impact, then develop a series of suggestions to improve building efficiency while minimizing investment**

4. **Explore steps for the campus to improve overall sustainability through behavioral and operational changes**

5. **Develop a sustainable and effective transportation plan for future students and faculty**

1.2 - Study Rationale, Background, and Scope

Categorizing Greenhouse Gases

For this project, we primarily focused on Scope 1 and Scope 2 emissions sources. We were able to locate and analyze data for natural gas, oil, and electricity consumption on campus. Other Scope 1 emissions we were unable to find data for include propane and refrigerants, both of which have relatively low use on campus, but would need to be assessed to present a clear picture of total campus emissions. According to the GHG protocol, Scope 1 emissions are direct emissions from owned or controlled sources such as the burning of oil and natural gas for heating. Scope 2 emissions are indirect emissions from the generation of purchased energy such as electricity. Scope 3 emissions are all indirect emissions (not included in Scope 2) that occur in the value chain of the reporting company, including both upstream and downstream emissions. Scope 3 includes commuting, water, waste, and product life cycles.

History of the Mount Ida Campus

Originally established in 1899, Mount Ida has undergone numerous noteworthy transformations over the course of the last 120 years: a shift from an all-girls high school to a co-ed private university, campus relocation, and mergers with other local institutions such as Chamberlayne Junior College, the New England Institute of Funeral Service Education, and Coyne Electrical and Technical School. Mount Ida's latest evolution comes in the form of their establishment as a satellite campus of the University of Massachusetts Amherst. As a newly established public university, Mount Ida will be required to make a number of important changes in order to meet the standards of both UMass, and the Commonwealth as a whole. One essential aspect, and the primary focus of this report, is sustainability on campus. More specifically, this report focuses on the GHG emissions of the newly acquired campus and some potential solutions to reduce and control those emissions.

Figure 1.2: *Shaw Hall, built in 1912.*[6]

With time and resource limitations in mind, CEE decided to start with a review of the energy efficiency for buildings on campus. All the campus buildings are either still using fossil fuels or are in need of repair. These buildings provide the opportunity for the largest jumps in emissions reduction via electrification while at a minimal cost to the University. We also considered the campus's expansion goals as a commuter and internship hub, and how to guide that expansion through the use of more sustainable transportation options.

Status of Energy, Efficiency, and Sustainability in Massachusetts

Due to a range of factors such as frequent inclement weather, dated buildings, and high utility prices, Massachusetts is in a uniquely challenging position when it comes to building efficiency. In recent years, Massachusetts has consistently ranked among the top five states with the highest electricity rates.[7] Similarly, MA tends to face high rates on many heating resources, such as oil and natural gas, as these resources are rarely produced locally. These high utility rates, paired with New England's long winters, create a substantial financial burden for residents and businesses. High utility rates and significant heating demands make it all the more important for organizations based within the Commonwealth to avoid excessive consumption, and emphasize building efficiency. Currently, Massachusetts has the 2nd oldest building stock in America, and these old buildings tend to come up short in terms of efficiency. Draughty windows and doors,

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[6] Phelan, John. "Mount Ida Spent $30M to Upgrade Campus That Will Be Sold to UMass." *Boston Business Journal.* Retrieved from: *https://www.bizjournals.com/boston/news/2018/04/22/mount-ida-spent-30m-to-upgrade-campus-that-will-be.html*

[7] "Average Residential Electricity Price and Expenditures in Selected States, 2016". U.S. Energy Information Administration (EIA), February, 2018. Retrieved from: https://www.eia.gov/todayinenergy/detail.php?id=34932

outdated HVAC and water systems, and insufficient insulation are all common flaws in older buildings which lead to costly utility bills and the release of more harmful GHG emissions.[8]

Despite these obstacles, Massachusetts is an industry leader in the fields of energy efficiency and sustainability. In Fact, Massachusetts has been labeled the “#1 Most Energy Efficient State” by the American Council for an Energy Efficient Economy (ACEEE) for the past 8 consecutive years.[9] As such, it is important for the University of Massachusetts to uphold and represent these values through their everyday operations.

Why Buildings and Transportation?

We chose to focus our efforts primarily on buildings and transportation at Mount Ida, because currently buildings are the primary source of energy consumption on campus, and transportation is where we anticipated seeing some of the largest emissions increases moving forward, due to the campus’s future plans of being a commuter/internship hub. According to the U.S. Energy Information Administration (EIA), ‘In 2018, the residential and commercial sectors… which is mostly building related… accounted for about 40% of total U.S. energy consumption’ and ‘nearly all of energy consumption in U.S. buildings.’[10] As shown in Figure 1.3 below, the Residential and Commercial sectors combined make up 46% of the total fossil fuels used in New England and New York, and almost all of this energy use is due to buildings. Transportation makes up another 44% of this energy use in the northeast. Therefore, targeting building energy use alone can provide major improvements to total emissions reductions.

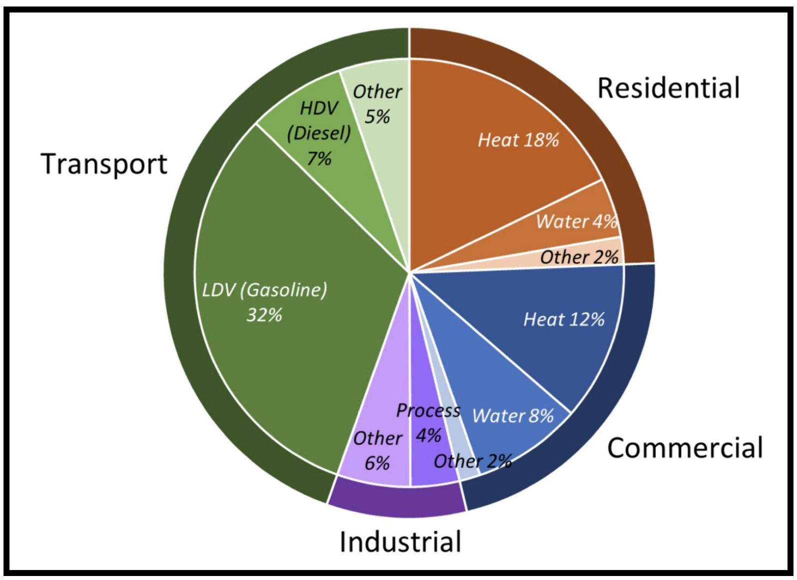

Figure 1.3: *This pie chart breaks down the total fossil fuel use by New England and New York.*[11]

[8] “The Age of Housing Stock by State”. The National Association of Home Builders (NAHB), February, 2014. Sourced from: http://eyeonhousing.org/2014/02/the-age-of-the-housing-stock-by-state/

[9] “2018 State Energy Efficiency Scorecard: Massachusetts”. American Council for an Energy Efficient Economy (ACEEE), 2018. Sourced from: https://aceee.org/sites/default/files/pdf/state-sheet/2018/massachusetts.pdf

[10] “U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.” Factors Affecting Gasoline Prices - Energy Explained, Your Guide To Understanding Energy - Energy Information Administration, 2018, www.eia.gov/tools/faqs/faq.php?id=86&t=1.

[11] “Northeastern Regional Assessment of Strategic Electrification” (2017). *neep.* *https://neep.org/sites/default/files/Strategic%20Electrification%20Regional%20Assessment.pdf*

Reducing the energy requirements of a building through energy efficiency is the cheapest method of decreasing emissions when compared to other sector reductions or energy generation sources. As shown in Figure 1.4, with an 'average of 2.8 cents per kWh, electric utility energy efficiency programs are about one-half to one-third the cost of alternative new electricity resource options.'[12] This means that it costs an average of 2.8 cents per kWh saved for utilities to run energy efficiency programs instead of building new power plants or renewables to meet increasing electric demands.

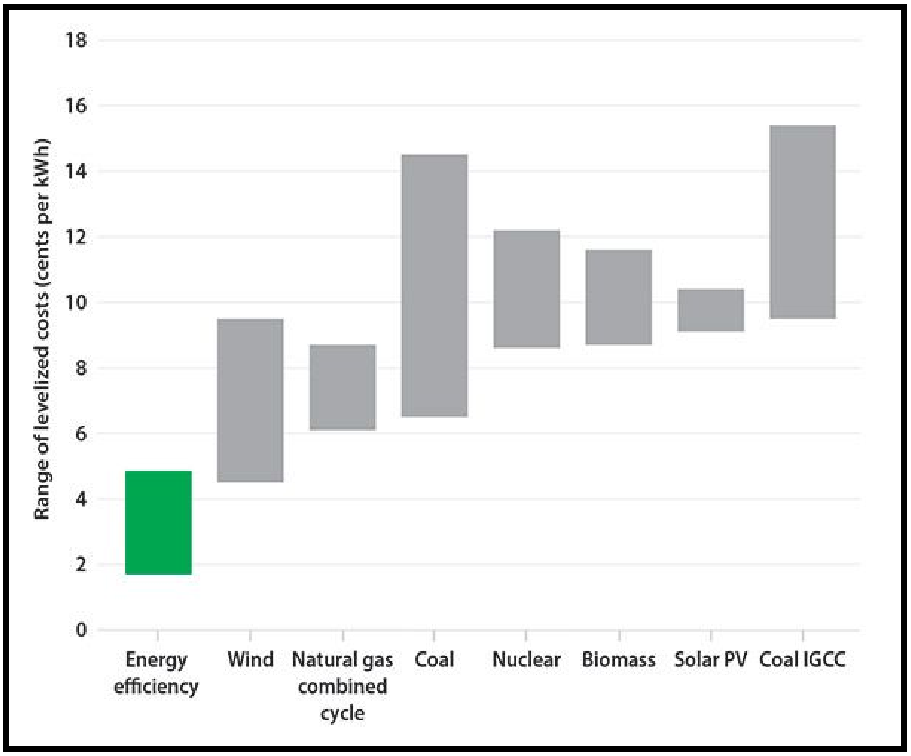

Figure 1.4: Comparison of levelized costs, highlighting energy efficiency as the cheapest option instead of energy generation.[11]

Figure 1.5 visualizes how building efficiency has the greatest potential for emissions reductions, while building efficiency and transportation both have high percentages of their emissions reductions that are classified as low cost. In this graphic, 'Low cost' emission reductions are those less than 20 US dollars per ton of CO_2 equivalent, 'Medium cost' is less than 50 US dollars per ton of CO_2 equivalent, and 'High cost' is less than 100 US dollars per ton of CO_2 equivalent. This highlights the importance of a focus on these sectors when addressing emissions reductions, and being cautious of costs.

[12] Molina, Maggie. "The Best Value for America's Energy Dollar: A National Review of the Cost of Utility Energy Efficiency Programs." *ACEEE*, 23 Apr. 2019, aceee.org/research-report/u1402.

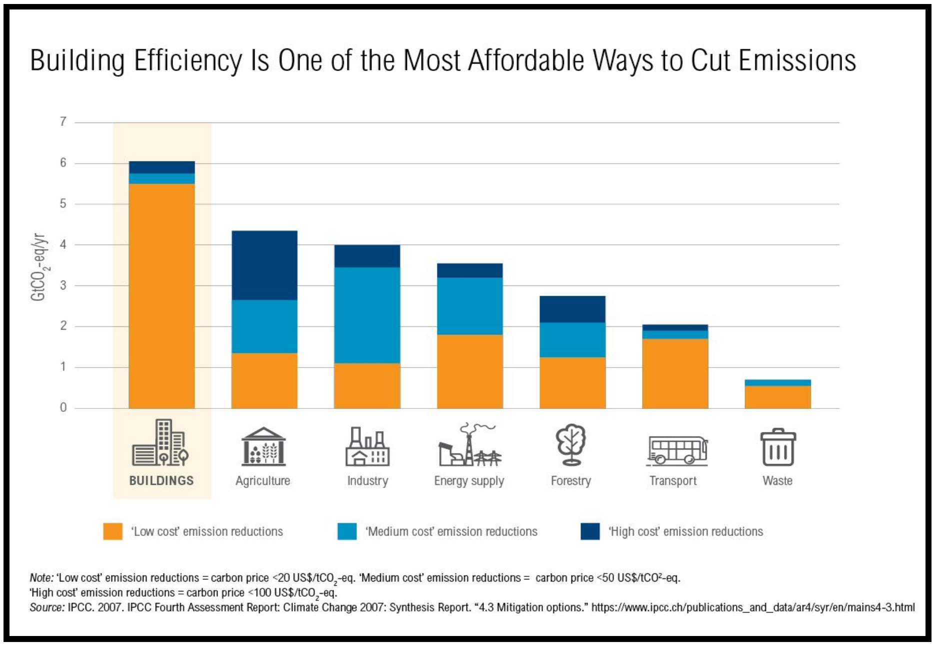

Figure 1.5: Portion of emissions reductions for buildings that are low cost, compared to other sectors.[13]

Targeting transportation is also essential, not only because it is typically the second largest source of GHG emissions, but also because of the proposed plans for the future of the UMass Amherst Mount Ida Campus. UMass Amherst Chancellor Kumble R. Subbaswamy's vision for the UMass Amherst Mount Ida Campus includes to grow "its undergraduate career development programs with expanded access to internships and co-ops in the thriving Greater Boston area."[14] In order to obtain this "expanded access" to the Greater Boston area, UMass Amherst Mount Ida will need a well designed transportation plan. We propose that efficiency and sustainability serve as a primary focus in this plan, to not only prevent emitting harmful GHGs, but to also save the University money in energy, fuel, and maintenance costs.

University Energy Efficiency

As previously stated, one immensely valuable opportunity for emissions reduction comes in the form of targeting building efficiency. That efficiency can be in terms of building systems and function, but also in reference to building operations and maintenance. Upgrades to a building's structure and systems can include improvements to the building envelope such as superinsulation and air sealing, or systems changes like the installation of ERVs, efficient lighting, occupancy sensors, improved heating and cooling systems, smart power strips and more. Operational changes, like increasing the temperature zone between heating and cooling setpoints, and overall reviews of building maintenance can also impact building efficiency. A study from the Lawrence Berkeley National Laboratory found that the full review of operations and maintenance for existing buildings, called existing building commissioning, resulted in '16% median whole-building energy savings in existing buildings … with payback time of 1.1 years'.[15] As time goes on, or even immediately after construction, buildings do not always operate as they were intended to, and that functional stray can lead to major inefficiencies.

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[13] BECQUÉ, RENILDE, et al. "ACCELERATING BUILDING EFFICIENCY Eight Actions for Urban Leaders." *World Resources Institute*, Johnson Controls, publications.wri.org/buildingefficiency/.
[14] Subbaswamy, Kumble R. "Welcome to the Mount Ida Campus of UMass Amherst." *University of Massachusetts Amherst.* 15 November 2018. https://www.umass.edu/mic/news/welcome-mount-ida-campus-umass-amherst.
[15] Mills, Evan. "Building Commissioning A Golden Opportunity for Reducing Energy Costs and Greenhouse Gas Emissions." *Lawrence Berkeley National Laboratory*, 21 July 2009. cx.lbl.gov/documents/2009-assessment/lbnl-cx-cost-benefit.pdf.

Other universities such as American University (AU) and University of California, Irvine (UCI), are prime examples of schools who are targeting building efficiency in order to cut their total GHG emissions. After pledging to reach carbon neutrality, AU committed to ‘construct new buildings to LEED Gold standards and manage existing campus buildings to LEED standards.’ They also used this as an opportunity to test an ‘energy-efficient duct system that is rarely used on the East Coast’, and run a pilot program using data from ‘heating and cooling usage as well as weather forecast data to calculate optimal heating, ventilation, and air conditioning (HVAC) settings.’ With programs like this and more they met their reductions goals two years early, and reduced their campus EUI by 21%. In addition, UCI ‘developed a new “Smart Lab” approach that shows that universities can make their laboratories safer and cut energy use by as much as 60% with measures such as occupancy and air quality sensors.’[16] Laboratories are one of the most critical buildings to target on college campuses, and those reductions can play a major role in reducing overall campus energy use. According to the American Council for an Energy-Efficient Economy (ACEEE), ‘A typical laboratory is three to four times more energy intensive than an average commercial building, and laboratories can account for up to 70% of a campus’s energy footprint.’[17] This inefficiency largely stems from the amount of air changes per hour, or ACH, that laboratories require but frequently mishandle. These kinds of energy efficiency programs at universities allow the campuses to reduce their needs while also placing themselves at the front of the industry.

Why Electrify?

The Mount Ida campus, along with the majority of Massachusetts residents, uses natural gas and fuel oil for heating in the winter. This is not ideal, as fossil fuel use contributes to a significant amount of GHG emissions. From May 2018- April 2019, natural gas and fuel oil #2 contributed 57% of total campuswide emissions. In order to stay in line with the University’s goals to be carbon neutral by 2050, buildings will need to separate from the burning of fossil fuels. Instead of using oil and natural gas in the building sector, electrically powered heat pumps could provide both heating and cooling to the buildings in question. One major reason to support the switch from fossil fuels to electric heat pumps, or electrification, is the fact that the New England electric grid will become more “green” in the coming years as a result of the Commonwealth’s Renewable Portfolio Standard, or RPS. The RPS requires retail electricity suppliers to obtain a percentage of the electricity they serve from renewable sources. Currently, the New England electric grid is made up of 14% renewables, and the RPS is set to increase by 2% each year starting in 2020, then by 1% per year starting in 2029. This means that the New England electric grid will be made up of 55% renewables by 2050. **While fossil fuel combustion will not get more efficient or have lower emissions in the future, the New England electric grid will be adding more and more renewables each year**. In addition, it is likely that heat pumps will get more efficient over time. The COP for a heat pump is approximately 3, which means that for every unit of electricity that is put in, 3 units of thermal energy are produced. This is significantly more efficient than oil, natural gas, and propane.

Air Source Heat Pumps are a form of mechanical heating and cooling technology which can replace conventional fossil fuel sourced systems. ASHPs are highly efficient at heating buildings with electricity. While traditional boiler systems can reach efficiencies of 97% and electric resistance systems provide 100% efficiency, ASHPs can reach efficiencies well over

[16] Selak, Dawn. “American University Just Graduated to Carbon Neutral, Thanks Partly to Energy Efficiency.” *ACEEE*, 14 May 2018, aceee.org/blog/2018/05/american-university-just-graduated.
[17] Koch, Wendy. “Universities Push to Slash Energy Use: Summer Study Speaker Describes How.” *ACEEE*, 27 July 2018, aceee.org/blog/2018/07/universities-push-slash-energy-use.

100% during ideal outdoor temperatures[18]. With average efficiencies of 2.9 for our climate, replacing heating systems with ASHPs can net large energy use reductions.

Electricity is the only energy system with potential to be 100% carbon free. By electrifying our energy use, we can take advantage of renewable energy technologies and move toward net zero energy for our buildings. With seven buildings on campus either fully or partially using ASHPs, this is a proven energy efficiency technology that the University can harness to further emissions goals.

Roughly one third of the buildings on the Mount Ida campus already utilize air-source or water-source heat pumps (See Figure 1.6 below) however, none of these buildings have yet to be fully electrified. It is recommended that Mount Ida pursue full campus electrification, by transitioning the remaining buildings to heat pumps, and eventually cease all natural gas and oil-based heating. Electrification of the Mount Ida campus could be combined with onsite photovoltaics, which would mean that these heat pumps would have zero emissions, and UMass would further progress towards their 2050 net zero aspirations.

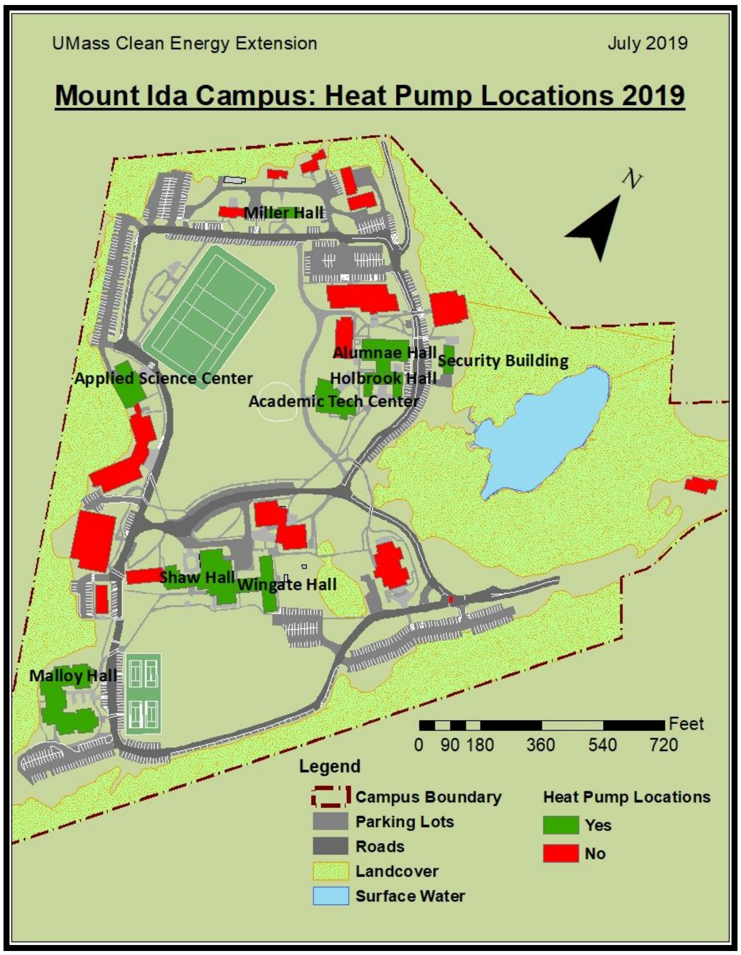

Figure 1.6: *A GIS map depicting which buildings on the Mount Ida Campus currently utilize heat pump systems.*

18 "Heat Pumps vs Gas or Electric Furnaces (Compare Costs & More) - HomeAdvisor." *Home Improvement Tips & Advice from HomeAdvisor*, 29 Apr. 2019, www.homeadvisor.com/r/heat-pump-vs-furnace/.

Executive Order 484: "Leading by Example"

In April 2007, Governor Deval Patrick filed Executive Order 484: *Leading by Example* (LBE). The act established both short-term and long-term goals for State entities to advance energy efficiency and clean energy, as well as reduce greenhouse gas emissions that contribute to climate change. In addition to these goals, the act also established "minimum energy requirements" for new construction, and mandated the "tracking and reporting of energy data to track progress toward these goals."[19] More specifically, Leading by Example establishes the goals of "reducing overall energy consumption at State owned and leased buildings by 35% by 2020" and "reducing greenhouse gas emissions that result from state government operations by 40% by 2020 and 80% by 2050" using FY2004 as the baseline.[20] Now that Mount Ida is a part of UMass Amherst, it must be included in the University's reporting for these LBE mandates. This will increase the total emissions for UMass Amherst, adding a sense of urgency and importance to the pursuit of energy efficiency and sustainability on the Mount Ida campus.

UMass's Commitment to Sustainability

Of the entities currently being tracked by LBE, during FY18, UMass Amherst produced the highest total greenhouse gas emissions of any state owned facility in Massachusetts with 122,960 metric tons. This is 32% of all the emissions produced by state operations. Five of the top ten state facility emitters are UMass affiliated universities, with UMass Medical ranked third. Despite being the largest single emitter in the state, UMass Amherst has worked hard to decrease its emissions. As of 2018, UMass Amherst has decreased its annual GHG emissions by 27% since the LBE baseline year, which is a three year average between FY2002-FY2004. It has also decreased its EUI or Energy Use Intensity, which describes energy use per square foot, by 5% since the baseline year FY2004.[21]

In addition to the state required action UMass Amherst has taken on, the University has also shown its own strive to reduce emissions and become a leader in energy. In 2007, former campus president Jack M. Wilson signed the American College and University Presidents' Climate Commitment (ACUPCC), which required the UMass school system to create a plan for reaching carbon neutrality by 2015. In response to the President's commitment, the "Climate Action Plan 2.0" was created in 2012, which identified strategies to help the campus reach its emission reduction goals. This plan includes recycling efforts, implementing the use of environmentally preferable products (EPPs), reducing water use in labs and residence halls, a bikeshare program, hybrid busses, alternative energy production, and more. The plan has three main goals: to examine new ideas/technologies, to educate students and the surrounding community about sustainability and the environment, and to identify economical ways to decrease UMass's impact on the environment.[22]

Since his appointment as chancellor of UMass Amherst in 2012, Kumble R. Subbaswamy has made sustainability a campus priority. In November 2018, Chancellor Subbaswamy announced the formation of two task forces to advance sustainability efforts on campus. The Climate Resilience Task Force works to develop a mitigation and climate adaptation plan, as well as determine the impacts of climate change on critical infrastructure. The Carbon Mitigation Task Force expands on the 2014 comprehensive campus energy plan by analyzing the energy and emissions impacts of sustainability efforts. A Comprehensive Campus Energy Master Plan was created in 2015, which outlined future energy usage and

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[19] "Leading By Example - Overview and Contacts." *State of Massachusetts*. Sourced from: www.mass.gov/service-details/leading-by-example-overview-and-contacts.
[20] Mass. Exec. Order No. 484, 3 C.F.R. 4 (2007).
[21] "LBE Progress Tracking and 2019 Goals" *Department of Energy Resources* (2019)
[22] Small, Ezra. " Climate Action Plan 2.0" (2012). *Sustainable UMass.* 3. Retrieved from https://scholarworks.umass.edu/csi/3.

highlighted projects that could substantially reduce emissions. This document introduced plans and recommendations for sustainable initiatives at UMass, including alternative energy technologies like the solar parking canopy and ground source heat pumps, how to sustainably manage heating boiler systems and chillers, reducing building loads and increasing cogeneration efficiency, and other long-term environmental improvement programs. The main focus is on transitioning to renewable fuels and more efficient buildings.[23] As the flagship campus, UMass Amherst is expected to lead the effort to reduce GHG emissions as quickly as possible.

As part of the College of Natural Sciences and The Center for Agriculture, Food and the Environment, The Clean Energy Extension (CEE) was formed in 2015, and works to advance communities' adoption of clean energy in Massachusetts. They do so through technical support and assistance when requested, as well as outreach and promotion of clean energy solutions.

UMass' efforts have not gone unnoticed. Last year, UMass Amherst was rated a STARS Gold University by the Association for the Advancement of Sustainability in Higher Education (AASHE). While this rating is an honor and a source of pride for the UMass community, there is still a long way to go. If the campus is to reach its goal of being carbon neutral by 2050, then additional advancements in energy reduction and sustainability are necessary.

[23] Engineering, RMF, "UMass Amherst Comprehensive Campus Energy Master Plan" (2015). Sustainability Reports & Plans.12. Retrieved from https://scholarworks.umass.edu/sustainableumass_reportsplans/12.

2.0 - Data, Methods, and Limitations

To meet the goals outlined above, many different data sources were consulted. Data was collected in sheets, excel, PDFs, GIS, photos, and via research and personal observations. The CEE intern team collected and analyzed these data to calculate GHG emissions, Energy Use Intensity, and develop plans for buildings and sustainability.

2.1 - Data Sources

Campus Energy Use Data

Monthly electricity, natural gas, water, and oil use data from May 2018-May 2019 was acquired through Cathy West of the UMass Amherst Procurement Office with the assistance of Ezra Small, the UMass Amherst Campus Sustainability Manager. Natural gas, electricity, and oil use data was used to calculate recent GHG emissions and EUI, as defined as May 2018-April 2019. The UMass Campus Sustainability Manager also provided CEC with Mount Ida campus square footage data and UMass Amherst FY 2018 EUI data. The square footage data was used to calculate the Mount Ida Campus EUI while the UMass Amherst EUI data served as a comparison to Mount Ida Campus EUI data.

Number 2 fuel oil use from Devaney Energy was obtained from the company and from Amanda Flaherty of Verdolino & Lowey, P.C. The Devaney Invoices covered oil use from February 2017-April 2018. Ms. Flaherty also provided CEE with electricity use from Eversource and natural gas use from National Grid, both of which spanned May 2017-April 2018. Water and sewer invoices covering May 2017-May 2018 from the City of Newton were also provided by Verdolino & Lowey, P.C. Oil use data was extracted from PDFs and was directly used in calculations for GHG emissions and EUI. Missing monthly electricity and natural gas use was sought from the PDFs when it was not available from another source. Water and sewer data was not used to calculate GHG emissions.

Three spreadsheets were shared with CEE by Zac Bloom of Competitive Energy Sources. The first spreadsheet highlighted natural gas account numbers. The second spreadsheet had monthly natural gas and electricity use per building and covered January-December 2017. The data in this document did not fully align with data from procurement so this spreadsheet was not used. The third spreadsheet from Mr. Bloom also included monthly natural gas and electricity usage by building, and covered January 2017- December 2018, with a few months missing for various buildings. This spreadsheet was used to calculate historical GHG emissions and EUI, defined as April 2018-March 2018. Competitive Energy Sources also provided us with 15 minute interval data. Analyzing this interval data would be an excellent research opportunity for the next group of CEE interns.

GIS data was generously shared with the group by Niels La Cour, Doug Beach, and Rylee Wrenner, three UMass affiliates heavily involved in campus planning and GIS technology. The data made available to our team for the purposes of this project included Mount Ida campus basemaps and shapefiles, which proved to be very useful in terms of visualizing our findings about particular buildings.

As mentioned above, the Mount Ida campus provides each student with three free uber rides a day to select locations in the surrounding area. Uber data detailing the cost and distance of rides from September 2018-June 2019 was provided by Steven Reynolds, the Campus Director of the UMass Amherst Mount Ida Campus. Although this information was not included in the GHG inventory because Scope 1 campus vehicle use was incomplete, it was helpful in calculating a rough estimate of campus transportation emissions, and in drafting a transportation plan for the campus.

Campus Building Operation and System Management Records

A list of vehicles used on the Mount Ida campus was provided by Romeo Lopez, the General Manager from Aramark. Building information concerning generators, boiler upgrades, status and use was also provided by Mr. Lopez. This vehicle list helped to inform recommendations in the transportation sector while the information on buildings contributed to the Atlas. Aramark also provided CEE with a Facilities Condition Assessment from 2013, as well as individual Building Level Operating Manuals, both of which were instrumental in the formation of the Building Index or “Atlas”. Additionally, building floor plans were accessed from a campus platform called SharePoint/SPACEShare, with the assistance of Ezra Small. These floor plans were referenced when calculating eui, and were helpful when touring the buildings and locating boilers.

In 2013 Aramark conducted a campus-wide Building Level Operation and Management (BLOM), deferred maintenance, and building system review. Based upon this report, Mount Ida College acted upon recommendations and renovated a number of buildings, replacing heating systems, installing networked building control systems, and improving some envelope issues. These retrofits likely significantly improved these buildings but also made it more difficult to justify mechanical system replacement due to equipment lifecycle.

The replacement heating equipment may be in good condition but still use fossil fuels. **Despite the recent equipment replacement and renovations, we propose that the University disregard traditional equipment lifespans, act upon our recommendations and move forward toward carbon-neutral energy use.**

First-hand Data Collection/Observation

Investigating each building on campus was necessary, not only to compile information for the Campus Building Atlas, but also to formulate an adequate understanding of building operations and uses in order to make specific and valuable recommendations. The boilers, oil tanks, heat pumps, air conditioning systems, water systems, pipes, insulation, walls, windows, and lighting systems were inspected and noted for each building. When possible, we also reached out to regular occupants of the buildings in question, to inquire about any inefficient trends they may have noticed (e.g. keeping the building too hot or too cold, leaving electronics and lights running over night, etc.).

Published Plans at Other Locations

One resource that proved to be extremely helpful was our access to energy and sustainability plans from UMass Amherst, other universities, and towns. Researching UMass Amherst’s Climate Action Plan and Comprehensive Campus Energy Master Plan allowed us to have insight on UMass’s main goals and implementation strategies that our project should focus on. Additionally, reading through the Newton Climate Action Plan enabled us to find programs, initiatives, rebates, and organizations to include in our recommendations for partnerships. Involving the UMass Amherst Mount Ida Campus in the Town of Newton’s initiatives is an extremely important component of this project, and essential to achieving the sustainable goals for the campus that UMass Amherst desires.

While information about UMass Amherst is important, it was also important to research some ideas being implemented on campuses closer to the size of Mount Ida. These provided realistic opportunities while some of the projects at UMass Amherst are simply too large for such a small campus. The sustainability and building plans of Boston University, Amherst College, and Smith College were helpful resources.

2.2 - Research Limitations

This project faced many challenges in terms of data acquisition, situational uncertainty, organization, time, and costs.

Data Acquisition

In terms of data acquisition the team started with data collected during the first few months that UMass Amherst owned the campus. This was provided to us through the sustainability program and UMass procurement services. However, at that point, the Mount Ida Campus had not been owned by UMass Amherst for a full year. This left us with a partial year of data and a limited understanding of how the data was organized and what meters went where. It took us a large portion of time to go through this data and understand it. This theme of incomplete and complicated data sources continued throughout the project. In addition, it often took extended periods of time to wait for data. We had to go through multiple channels and contacts for most data.

Situational Uncertainty

Since the campus changed ownership from a private school to a public institution, it was initially difficult to access data from the previous years, and we only ended up being able to retrieve some. The lack of access to data was a major contributor in deciding which months to use in our two comparison years. We chose the last year of Mount Ida College ownership to be from April 2017 to March 2018 and the first year of UMass Amherst ownership to be from May 2018 to April 2019. We recognize that these years do not span from exactly the same months and do not follow the fiscal year time frame which is not ideal, especially for LBE reporting, but we had to make do with the data that we had. We did not have June or July 2019 data since we completed data analysis in June, and we also found out part of the way through this project that doing a greenhouse gas inventory for official reporting purposes was out of our scope since the campus had already hired an outside consultant for this purpose. Additionally, one important note is that the energy data that we used for May 2018 is not exact because we were missing some data. The natural gas use is from May 2018, but we used electricity and oil usage from May 2019 to substitute in for some of the missing data. Although this causes some uncertainty, May 2019 gives us a good estimate for May 2018. This is described in greater detail in the Appendix.

Another area of contrasting data was the delivery vs. supply units for natural gas and electricity. Delivery units were used when provided, but when there was missing data, supply units was used.

Another issue we faced was the change in campus operations once UMass Amherst purchased the campus. Some buildings became unoccupied, and in the time UMass has owned the campus, those operations and occupancies have continued to change. With buildings that have systems like window air conditioners, building occupancy can have a large impact on energy use and that change in occupancy can obscure which buildings are the least efficient.

Lastly, the future of the buildings (particularly the smaller ones with oil use and Malloy Hall) is still unknown, which limited us in our specific suggestions for them since we are not sure about what they will be used for.

Data and Campus Organization

One of the most relevant issues we faced in our project was overall organization of data and campus information. After going through some of the data and building lists, we discovered that there are large clumps of buildings that share meters, making it impossible to separate the buildings from each other in terms of energy use. For example, we later discovered that data listed under the Campus Ctr. in our original procurement data from UMass also included a cluster of other buildings not listed. Both natural gas and electricity had large groupings of buildings under single meters. This is why we have a large amount of buildings under the name “Shared Meter Buildings” in our data. For our analysis we then decided to focus on areas where we could understand specific buildings due to their bills or by visual inspection. As our data grew, it presented more difficulties as building names and meter numbers differed between sources. We learned that under Mount Ida College different parts of buildings with different uses were sometimes separated out into their own meters and sometimes they had been built at different times. After reviewing sources of Mount Ida maps we found some buildings also had multiple names and multiple spellings of those names in different places. Some buildings also appeared in some maps but not in the official UMass map. We also discovered that the utility account numbers changed when UMass Amherst purchased the campus. This meant that understanding our data sources and using them to check each other became more difficult.

Time and Costs

This project was under a time limit with an introduction during the spring 2019 semester and 6 weeks during the summer. With this limited time, we were unable to develop deep energy models for our focus buildings. These models help with mechanical system sizing, building envelope upgrade impacts, savings, and pricing. We were able to make general suggestions based off of our knowledge, background, and observations, but energy professionals will be consulted before the University takes action on building energy retrofits in order to obtain exact costs and savings of various efficiency options. This report identifies the key efficiency options and technologies to consider for each building and general cost based on invasiveness and size of proposal.

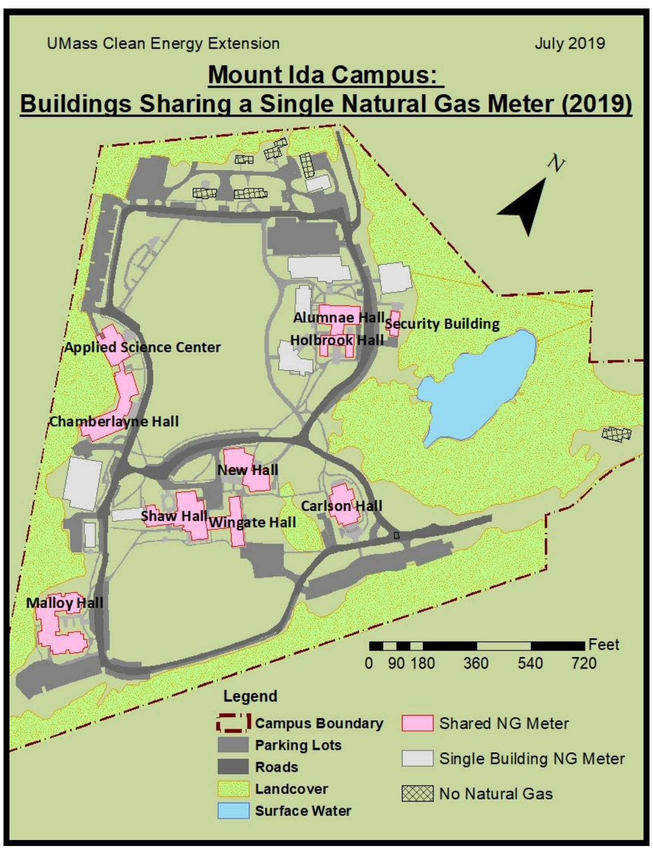
Additionally, we also considered cost as a factor to our recommendations for the campus. As there is currently minimal activity on the campus, there may not be much money available for sustainability projects at least right away. We used this to guide our recommendations toward lower cost efforts or high priority projects. This is especially important as often times there are extra costs or fees involved when a contractor does work on a state facility.

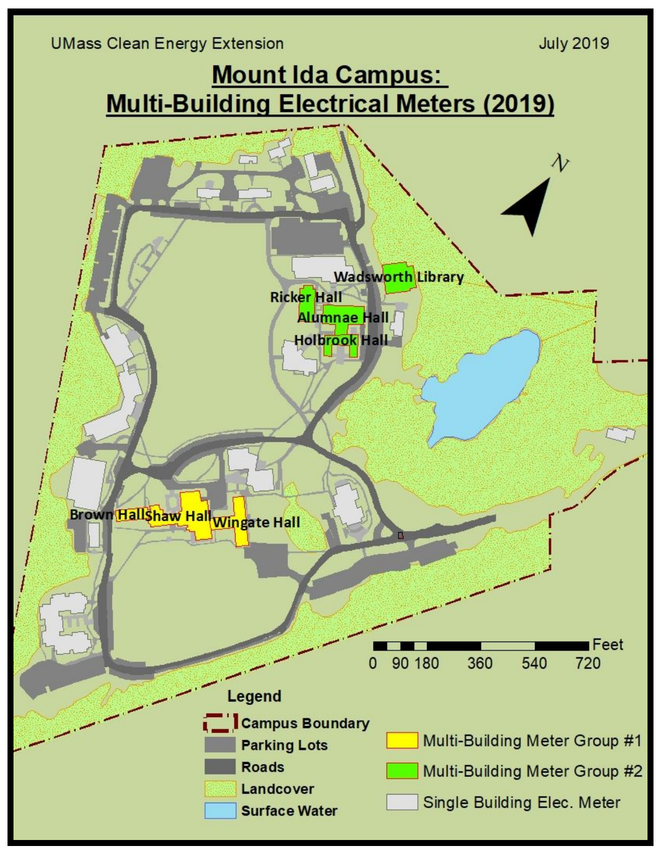
3.0 - Key Findings and Outcomes

Through all of our data collection, we organized our findings into seven main issues outlined below:

3.1 - Metering on Campus

Metering data was compiled by analyzing account numbers from Competitive Energy Services, Procurement Data, and PDF invoices from Verdolino & Lowey, P.C. This proved difficult as some sources had different account numbers, and some utilities account numbers changed after Mount Ida was purchased by UMass Amherst. In addition, some building names have changed throughout the years and several sources have different or multiple building names for the same building. After analyzing the account numbers from various sources, it was concluded that not every building on the Mount Ida campus has its own meter. Ricker, Holbrook/Alumni, and the Wadsworth Library, are on the same electric meter, as are Shaw, Brown, and Wingate Halls (See Figure 3.1 below), while the School of Design, Applied Sciences, Malloy Hall, Shaw Hall, Brown, Wingate, New Hall, the Campus Center, the Police/Security, and Holbrook/Alumni are all on the same natural gas meter (See Figure 3.2 below). The only buildings with their own meters are the Academic Tech Center, Athletic Center, Appleton, Barone/Guest House, Boulder Farm/President's House, Chapman, Halden, Longfellow, Miller, and Vet. Tech.





Figures 3.1 and 3.2: *These two GIS maps depict which buildings share natural gas and electric meters on the Mount Ida Campus. As you can see, the "Shared NG Meter" Group is a group of ten buildings that share a single natural gas meter,*

making assessing individual building consumption virtually impossible. Similarly, seven buildings across two groups share electrical meters, further complicating individual building consumption assessments.

3.2 - Campus Energy Use 2018-2019

In analyzing the energy use by buildings during the first year of UMass Amherst ownership, it became apparent which buildings used the most and had the most inefficiencies. We were able to break down the data and analyze the impact of each individual building, as well as the total campus wide usage. Over the course of the year from May 2018 to April 2019, 26.9 million kBtu of energy was used on campus and is split up by building in Table 3.3 below.

OIL BUILDINGS May 2018 - April 2019				
Building	**Total Electricity Use (kBtu)**	**Total Oil Use (kBtu)**	**Square Footage**	**EUI (kBtu/Sq.Ft.)**
Appleton	79,759	177,868	3,025	85
Barone/Guest House	11,918	91,784	2,803	37
Miller	49,245	254,086	6,955	44
President's House	24,232	267,692	6,469	45
Longfellow	29,527	229,963	4,153	63
NATURAL GAS BUILDINGS May 2018 - April 2019				
Building	**Total Electricity Use (kBtu)**	**Total Nat. Gas Use (kBtu)**	**Square Footage**	**EUI (kBtu/Sq.Ft.)**
Academic Tech. Center	791,079	418,600	22,263	54
Athletic Center	571,865	837,700	35,288	40
Vet Tech + Vet Gen	1,334,092	1,935,600	16,315	200
Chapman	75,934	335,500	8,192	50
Hallden	88,060	236,500	5,558	58
Shared Meter Buildings*	6,518,998	12,569,100	327,284	58

Table 3.3: *This table holds the energy use data for each building over the course of twelve months between 2018 and 2019 when UMass Amherst acquired the campus. *The "Shared Meter Buildings" contains the following buildings due to lumped meters: Carlson Hall/Campus Center, Wingate + WinGen, Shaw, Brown, New Hall + NewGen, Wadsworth, Holbrook/Alumnae Hall + Crl Gen, Ricker, Malloy + MalGen, Public Safety/Police, School of Design/Chamberlayne/School of Applied Sciences.*

In total, the largest contributor to campus energy use was the "Shared Meter Buildings," as expected. Unfortunately, as described in the first Key Finding, splitting up these buildings to analyze their individual energy use was impossible due to lumped metering. Of the buildings that did have their own separate meters, Vet. Tech. had a notable contribution to the energy use pie, taking up 12% of total campus use as shown in Figure 3.4 below. Additionally, the Athletic Center and Academic Tech Center accounted for 5% of energy use each.

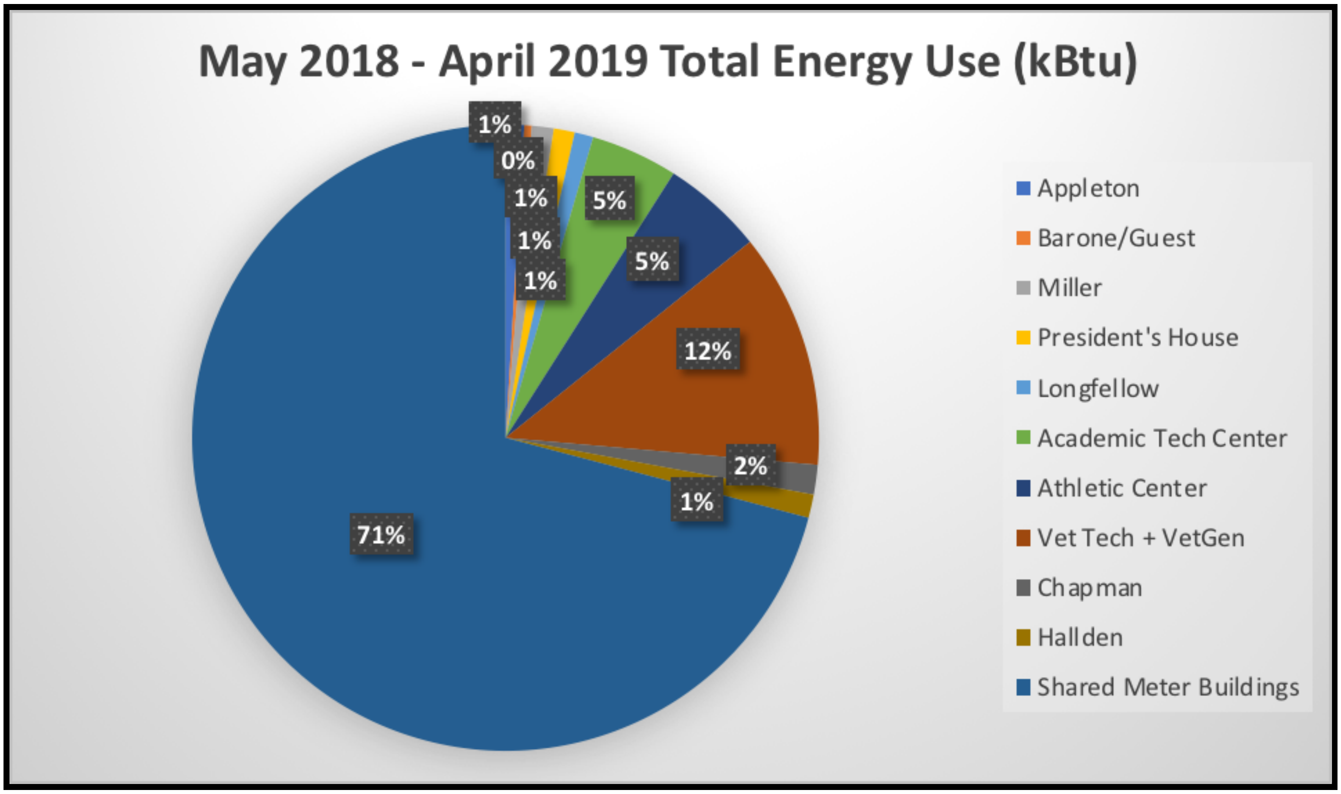


Figure 3.4: *Based off of the information in Table 3.3 above, this pie chart visualizes how much energy out of the total campus use each building contributes. *The "Shared Meter Buildings" contains the following buildings due to lumped meters: Carlson Hall/Campus Center, Wingate + WinGen, Shaw, Brown, New Hall + NewGen, Wadsworth, Holbrook/Alumnae Hall + Crl Gen, Ricker, Malloy + MalGen, Public Safety/Police, School of Design/Chamberlayne/School of Applied Sciences.*

Mount Ida buildings used a considerable amount of energy in the 2018/2019 year, but even more was used during the last year that the campus was under private ownership between 2017 and 2018 because it was more active then, as shown in Figure 3.5 below. The total campus emissions in 2018/2019 reduced to about 84% of the 2017/2018 emissions.

It is important to note that if normalized for weather, the 2017-2018 period did have more heating days (~6% more) and fewer cooling days (~27% less) than 2018-2019 with an estimated total difference of 2.51% between the two time periods.[24] When comparing energy use between these two periods, some of the energy use can be accounted for by weather differences. This will also be reflected in emissions with more heating fuel use in 2017-2018 and more electricity

[24] "Custom Degree Day Data." *Degree Days.net*, 2019, www.degreedays.net/.

use for cooling in 2018-2019. For the purposes of our analysis we did not normalize for weather but for building by building or month to month comparisons weather would need to be accounted for.

Although it is not predicted that the future of the UMass Amherst Mount Ida Campus will ever reach the activity that it had as Mount Ida College, it will likely reach levels in between then and the most recent year of 2018/2019. As shown in Figure 3.6 below, this past year had lower Energy-Use Intensity (EUI) due largely to the transition period as UMass Amherst took control of the campus and certain Mount Ida programs ended. UMass Amherst expects more activity from internships, co-ops, etc. next summer and in the general future as more programs develop. With this plan for growth, emissions may very well increase next year compared to this year but are not expected to exceed the 2017/2018 year, so comparing the past two years gives us a good estimate of the range of emissions that are likely to occur in future years. This allows us to make goals and estimates for reductions based off of what we think will occur regardless of our sustainability efforts suggestions. Figure 3.7 shows energy use by fuel type with fossil fuels for heating taking almost two-thirds of total energy use.

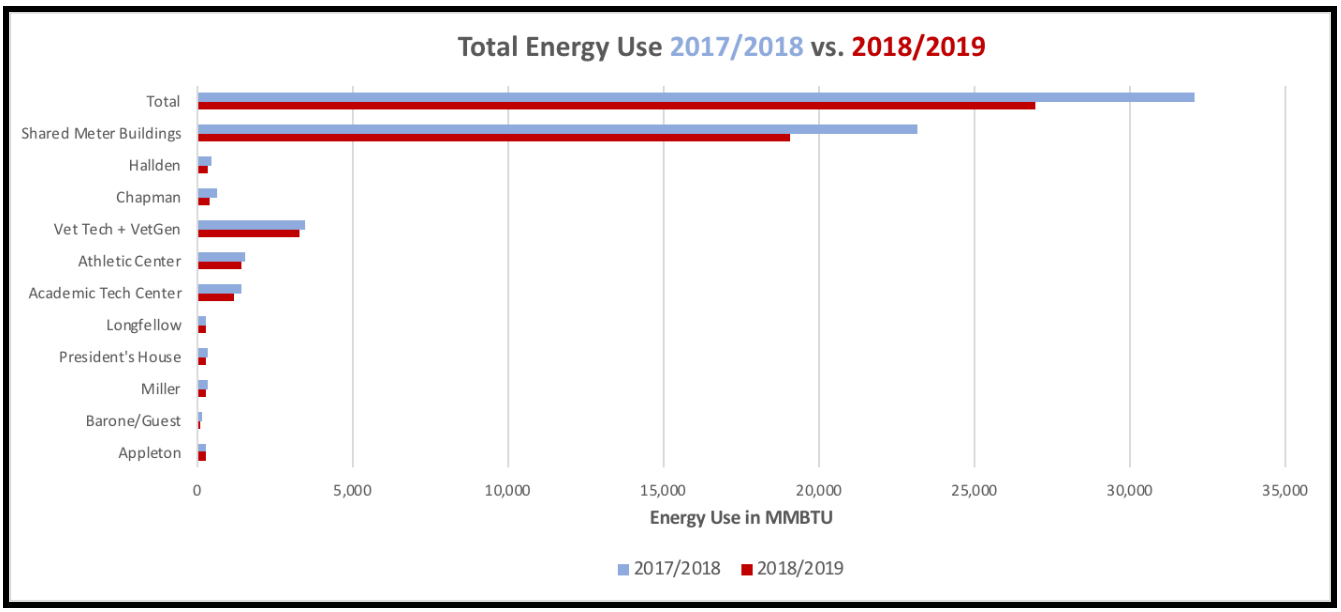


Figure 3.5: *Pictured above is the total energy used to heat, cool, and power the Mount Ida Campus buildings for two consecutive years, 2017/2018 and 2018/2019. *The "Shared Meter Buildings" contains the following buildings due to lumped meters: Carlson Hall/Campus Center, Wingate + WinGen, Shaw, Brown, New Hall + NewGen, Wadsworth, Holbrook/Alumnae Hall + Crl Gen, Ricker, Malloy + MalGen, Public Safety/Police, School of Design/Chamberlayne/School of Applied Sciences.*

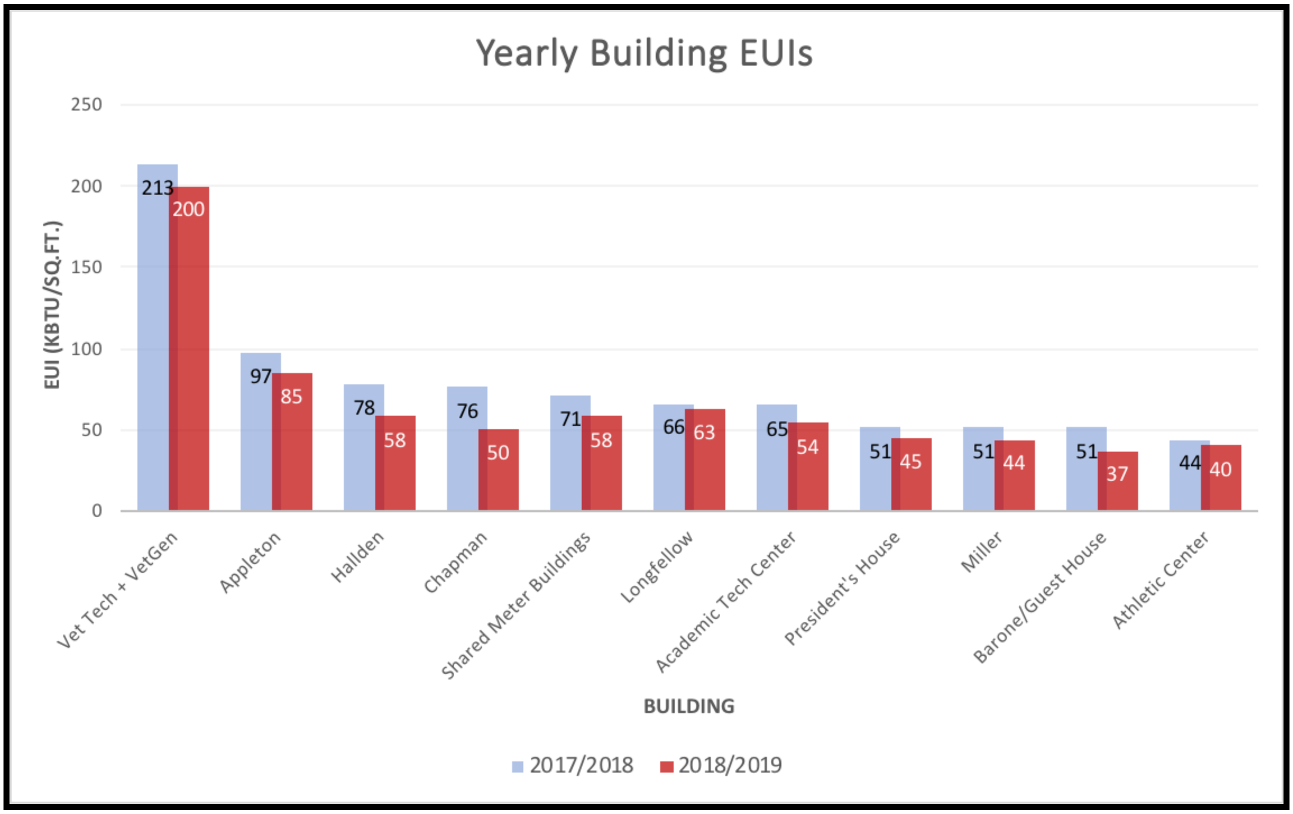


Figure 3.6: *This bar graph compares the EUIs of the buildings during the last school year of Mount Ida College (2017-2018) to the ones of the first year of UMass Mount Ida Campus (2018-2019). *"Shared Meter Buildings" contains the following buildings due to lumped meters: Carlson Hall/Campus Center, Wingate + WinGen, Shaw, Brown, New Hall + NewGen, Wadsworth, Holbrook/Alumnae Hall + Crl Gen, Ricker, Malloy + MalGen, Public Safety/Police, School of Design/Chamberlayne/School of Applied Sciences.*

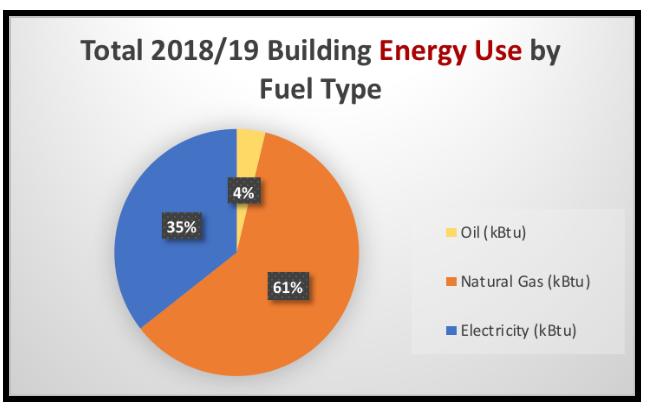


Figure 3.7: *As also shown in the Executive Summary, this pie chart shows the total campus wide energy use by fuel type for May 2018-April 2019.*

3.3 - Campus Greenhouse Gas Inventory

A GHG Inventory was conducted for the Mount Ida campus including campus wide emissions and individual building emissions calculated from both historical energy use (April 2017-March 2018) and recent energy use (May 2018-April 2019) data. Energy sources included in the inventory were oil #2, natural gas, and electricity, which covers scopes one and 2, or direct emissions from Mount Ida. Comprehensive vehicle usage data was not available, therefore emissions from transportation were not included in the inventory. Also not included in the inventory was emissions from refrigerants, as this data was not accessible to the CEE. Historical campus wide emissions reached 2028.9 CO2e before decreasing to 1661.4 CO2e during the first full year after the merger in May 2018. Natural gas used for heating contributed the most GHG emissions from 2018-2019, as shown in Figure 3.8.

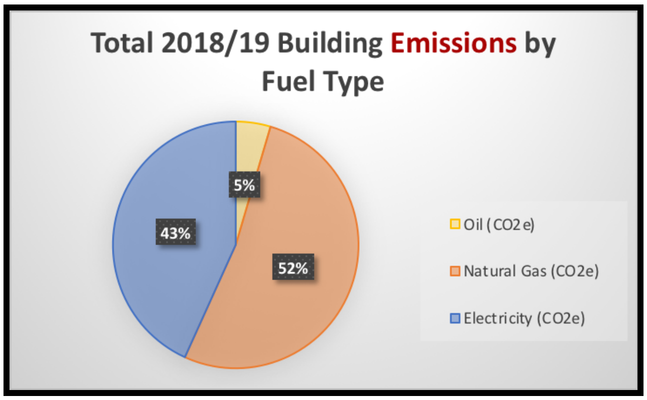


Figure 3.8: *As also portrayed in the Executive Summary, this pie chart shows the total campus wide emissions by fuel type for May 2018-April 2019.*

The building that emitted the most on campus based on historical and recent data was the Vet. Tech. building with 202.8 metric tons of CO2e from May 2018-April 2019. The emissions from the Vet. Tech. building and its generator are equivalent to the emissions from 43.1 passenger vehicles driven for one year.[25] The emissions from Vet. Tech. are most likely due to the large quantity of energy needed to sustain a lab building. Besides Vet. Tech., the largest contributor was the Shared Meter Buildings, which consisted of 12 buildings. These 12 buildings are on a grouped meter, therefore it is impossible to determine the exact emissions for each building. Emissions from the Shared Meter Buildings, along with other buildings on campus can be seen in Table 3.9. and Figure 3.10.

[25] "Greenhouse Gas Equivalencies Calculator"(2018). *United States Environmental Protection Agency*. Retrieved from https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator

CAMPUS WIDE GHG INVENTORY		
Building	**April 2017-March 2018 Metric Tons CO2e**	**May 2018-April 2019 Metric Tons CO2e**
Shared Meter Buildings *	1452.5	1156.4
Vet Tech and Vet Generator	214.1	202.8
Athletic Center	98.4	87.4
Academic Tech Center	97.2	81.6
Chapman	37.7	23.5
Miller	26.3	22.6
President's House	24.7	21.7
Longfellow	20.3	19.3
Appleton	21.8	19.2
Hallden	25.4	19.2
Barone/Guest House	10.5	7.7
Total	**2028.9**	**1661.4**

Table 3.9: *This table holds the CO2e emissions resulting from the energy used to power and run each building on the Mount Ida Campus from April 2017-March 2018 and May 2018 - April 2019. The CO2e level takes into account the* CO_2, CH_4, *and* N_2O *emissions from the oil, natural gas, and electricity used. *"Shared Meter Buildings" contains the following buildings due to lumped meters: Carlson Hall/Campus Center, Wingate + WinGen, Shaw, Brown, New Hall + NewGen, Wadsworth, Holbrook/Alumnae Hall + Crl Gen, Ricker, Malloy + MalGen, Public Safety/Police, School of Design/Chamberlayne/School of Applied Sciences.*

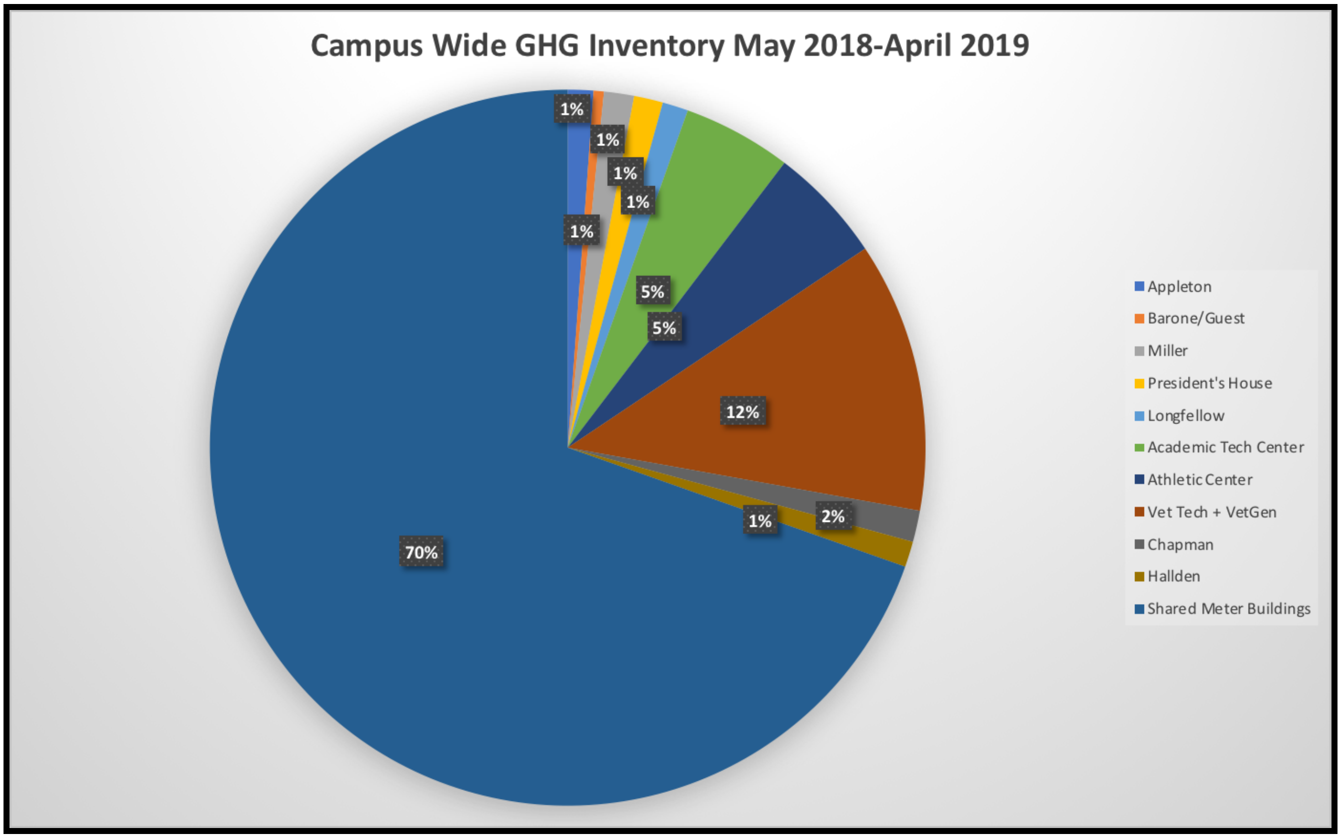


Figure 3.10: *This figure is a visualization of the emissions outlined in the table in Table 3.7 above. As clearly shown, the grouped buildings collectively caused the most emissions, but also notable are the individual contributions from Vet. Tech., Athletic Center, and Academic Tech Center. *"Shared Meter Buildings" contains the following buildings due to lumped meters: Carlson Hall/Campus Center, Wingate + WinGen, Shaw, Brown, New Hall + NewGen, Wadsworth, Holbrook/Alumnae Hall + Crl Gen, Ricker, Malloy + MalGen, Public Safety/Police, School of Design/Chamberlayne/School of Applied Sciences.*

Of the energy sources, natural gas and No. 2 heating oil increased during the cold winter months. Emissions from electricity stayed fairly consistent throughout the year. This can be seen in Figure. 3.11 below.

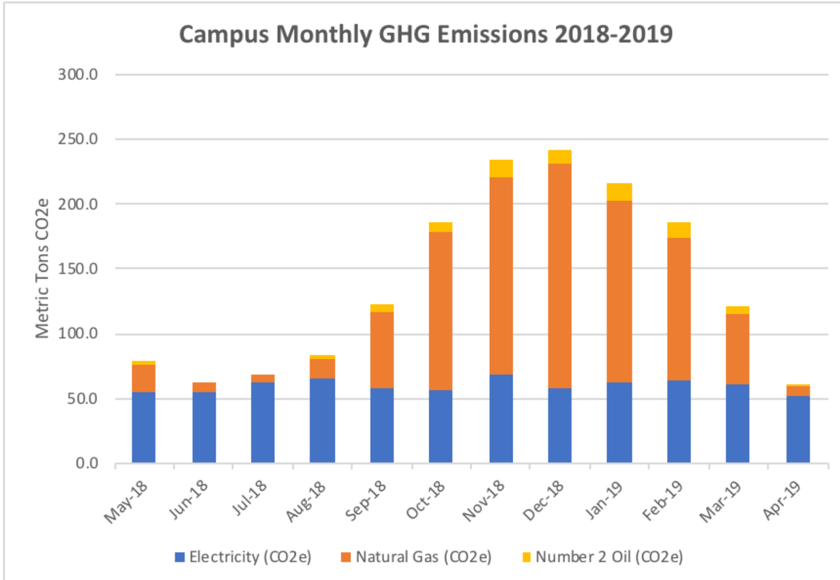


Figure: 3.11: *This graph shows the monthly campus emissions by fuel type during May 2018-April 2019.*

The greenhouse gases that were included in this inventory were Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O). The emissions factors and global warming potential associated with each gas used is shown below in Table 3.12. In order to calculate emissions for each building, the raw energy usage was multiplied by its corresponding emission factor (E.F) and global warming potential (GWP). Final GHG emissions were reported in units of carbon dioxide equivalent (CO_2e). The full GHG Inventory will be provided for review and future use. An example of the GHG calculator that was used can be found in the Appendix.

GHG Inventory Emissions Factors				
Emissions Factor	**Electricity Emissions Factors (lbs/MWh)**	**Natural Gas Emissions Factors (g/mmBtu)**	**#2 Fuel Oil Emissions Factors (g/gallon)**	**Global Warming Potential Multiplier**
CO_2	*558.2*	*53,060*	*10,210*	*1*
CH_4	*0.09*	*1*	*0.41*	*25*
N_2O	*0.012*	*0.1*	*0.08*	*298*

Table 3.12: This table shows the different emissions factors and global warming potentials associated with Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O)

3.4 - Building Atlas

The Atlas is a malleable spreadsheet containing individual building information such as envelope condition, cooling and heating systems, window type, square footage, year built, thermostat setpoints, and whether the building has heat pumps, generators, or boiler upgrades. The Atlas also includes individual building recommendations, the 2019 campus vehicle inventory, and a full energy use dataset. The initial purpose of the Atlas was to provide a way for CEE to familiarize themselves with the Mount Ida campus. It can now act as a resource for Mount Ida staff and future CEE interns working on the Mount Ida campus. The Atlas was created by inspecting each building, analyzing Aramark's 2013 campus-wide Building Level Operation and Management (BLOM), interviewing Mount Ida staff, and gathering raw usage data from Procurement, Devaney Energy, Eversource, National Grid , and via Competitive Energy Services. The building Atlas will be provided to University personnel for review and future use. Examples of this resource are shown below in Figures 3.13 and 3.14.

Full Building List (buildings count as one if they touch)

1	Alumnae (Alumna) Hall + Holbrook Hall
2	Applied Science Center/NEI Professional Building/School of Applied Sciences/Mortuary + School of Design/Chamberlayne (chamberline) Hall
3	Athletic Center + New Gym
4	Barone Hall (House)/Guest House/Dean's House
5	Boulder Farm/President's House
6	Brown Hall (Keith Brown Hall) + Shaw Hall (Admissions,Event Center) + Wingate(Windgate) Hall
7	Carlson Hall Student Center/Campus Center
8	Chapman Hall
9	Guard House/Gate House
10	Hallden Hall
11	Health Center/Health + Counseling Center/Appleton
12	Health Sciences Building/Academic Technology Center/Community Dental Clinic/Dental Education Center
13	Longfellow Hall
14	Maintenance Shed/Garage/Gar Groom/adis dolupta consequo tem acitemp
15	Miller Hall
16	Malloy Hall
17	New Hall
18	Pressbox
19	Ricker Hall
20	Security/Campus Police/Campus Security/Public Safety
21	Vet Tech/Center for Veterinary Technology and Science
22	Wadsworth Library

Key:
Green: Building names refer to the exact same building
Blue: Buildings are different sections but connected
*Note: buildings touching often have split data or incomplete data, and may or may not supply eachother with resources (the building may not be marked in another group that it recieves a resource from)

Figure 3.13: *Shown above is a screenshot of one of the intro pages to the Building Atlas. With a quick glance at the "Key" section, it becomes apparent that there is a metering issue, which will be described in later sections.*

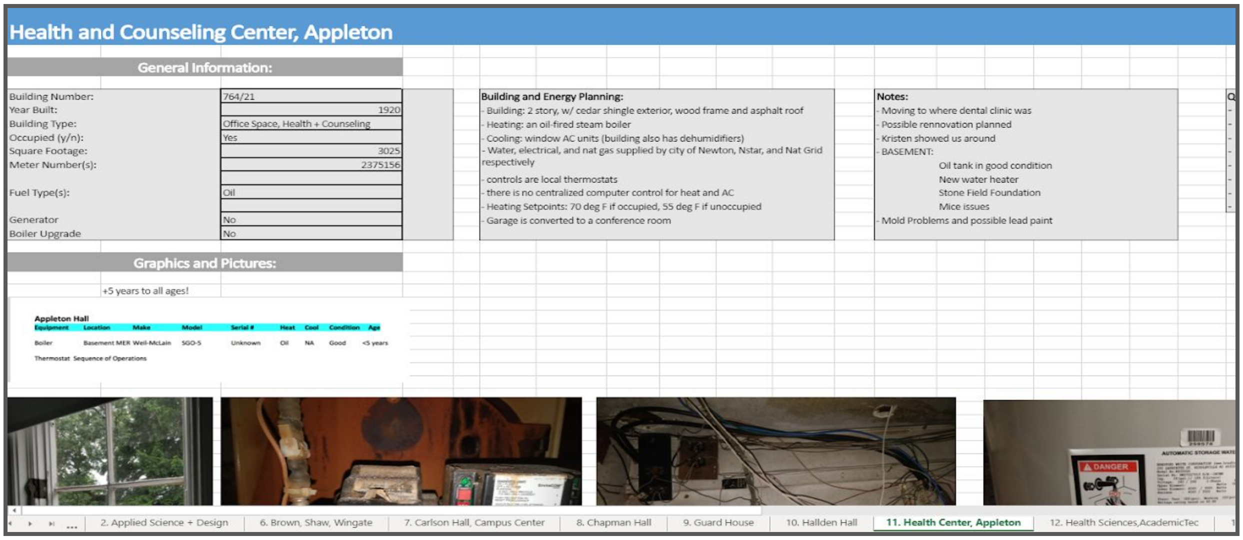


Figure 3.14: *Pictured above is one page of the Building Atlas, specifically for the Appleton Health Center. These pages include information like construction type, fuel use, occupancy, square footage, and more.*

3.5 - Target Buildings

After sifting through energy use data and walking through to observe each building's condition, we were able to identify the "worst" buildings that we wanted to focus on. The three target buildings are, the President's House/Boulder Farm, Chapman Hall, and the Veterinary Technology Center or Vet. Tech. Deciding what made a building "worse" than others depended on EUI, fuel type, general condition, and total emissions.

Boulder Farm

Boulder Farm or the President's House is located along Carlson Ave and the campus main entrance and is used as a full-time residence for the campus administrator. It is a three-story wood beam construction farm house. Built in the early 1700s, this building has significant structural differences from all other buildings and offers unique challenges when considering improvements and net zero. We chose to recommend that the University prioritize retrofit for this building because of its use of fuel-oil for heating, its importance as the campus director's residence, and its visibility as the first building seen as you enter campus.

This house is heated by an oil burning hot water boiler and does not have access to the natural gas pipeline which makes the case for electrification more appealing. Cooking uses a propane fueled stove with a storage tank behind the house. Lighting is non-LED and controls are manual. The heating system uses baseboard radiators located along exterior walls underneath windows and thermostats are conventional with no automatic controls. Floors are wood boards and no apparent insulation was noted in ceilings. Exterior walls are thin stucco and wood siding with thermal bridging from exposed wood beams at regular intervals. Cooling is done with window mounted air conditioners and fans. Garage is used for storage and is heated by an on demand electric resistance blast heater. Some old fiberglass insulation was observed in the attic crawl spaces but looks to be ineffective due to gaps and needs replacement (See Figure 3.15).

Figure 3.15: *Boulder Farm Attic crawlspace*

During our walk around we noted that the wood shingle roof is in poor condition with plant growth and needs immediate replacement. Also, stormwater management systems need improvement as the gutters are not extended away from the house and the splash blocks direct water towards foundation as shown in Figure 3.16. The soil grade around the house does not slope away from the house causing the water to be directed in the wrong direction.

Figure 3.16: *Water downspouts are directed at splash blocks angled toward the house instead of away*

In terms of energy use, the largest percentage of energy used by Boulder Farm is from oil by far, as shown below in Figure 3.17. This relationship is reiterated in Figure 3.18 in monthly increments, showing the clear peaks of use in the winter months. This high oil use makes the building a target and provides a lot of room for reduction.

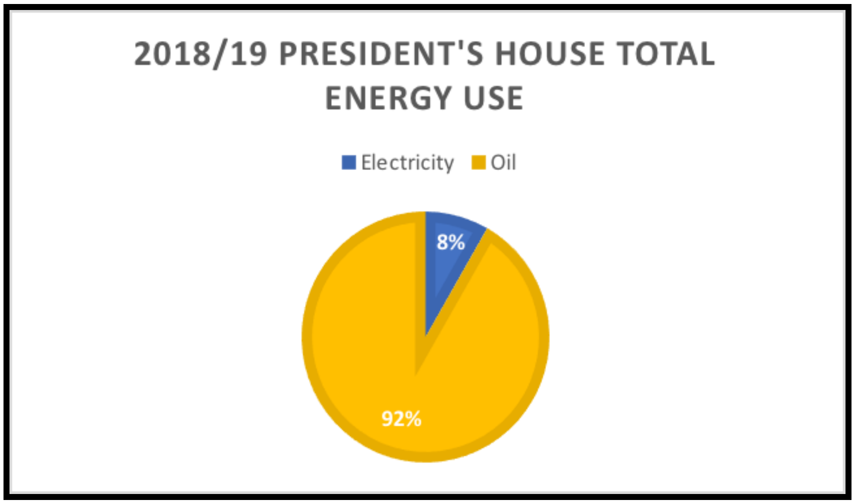


Figure 3.17: *This pie chart helps visualize the percent of energy use in kBtus that comes from oil compared to the percent from electricity.*

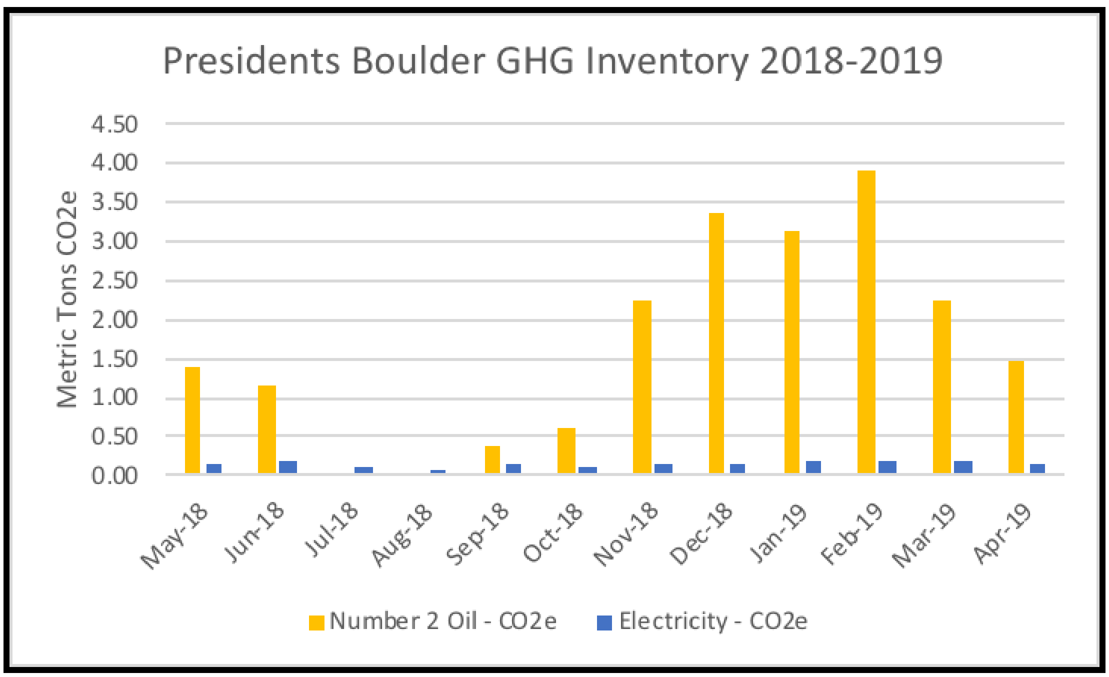


Figure 3.18: *This graph shows the monthly GHG emissions for the President's House or Boulder Farm. Number 2 Oil usage increases in the colder months.*

Chapman

Chapman is a small 2-story, 32 bed dorm with a brick and stucco exterior, wood frame construction and an asphalt roof. It is heated by two NG water boilers, has a large indirect hot water heater and a limited ducted DX cooling system for common areas. Lighting is gas-tube with manual-only control. Envelope condition is good but needs increased insulation.

Chapman represents a typical college dorm and does have an independent NG and electric meter allowing for measurable energy efficiency interventions. We chose Chapman as an actionable net zero building for the University because of its projected continued use, simple design, lack of cooling system, and visibility. Chapman could also be used as a model for retrofits on other larger dormitory buildings. However, it is not one of the largest energy users on campus. Chapman's total energy use for the 2018-2019 year is shown below in Figure 3.19 with natural gas taking up 82%. The month by month emissions in Figure 3.20 shows a steep curve for natural gas use in the winter months, while the electricity seems to spike October and drop off in November. We are unclear as to why this occurred as there is very minimal air conditioning in the building and we do not know of any major events or occupancy changes in Chapman.

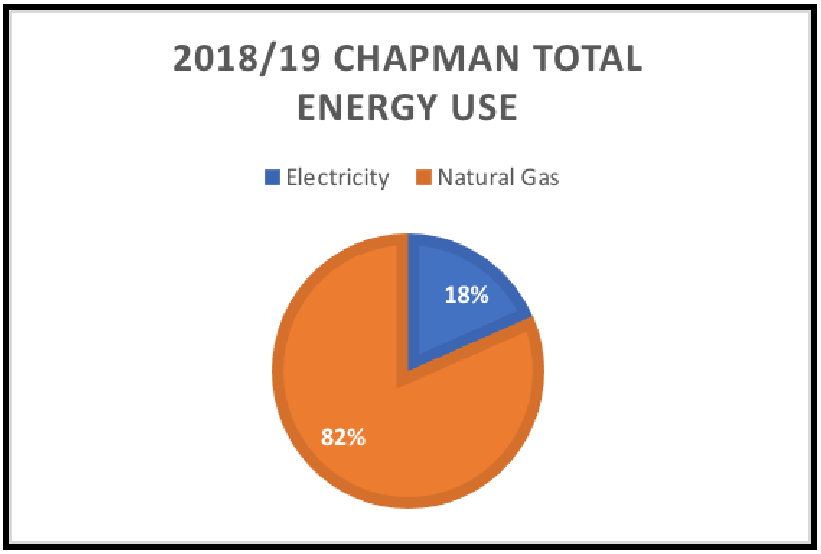


Figure 3.19: *The total energy use in Chapman in the 2018/19 year categorized by source.*

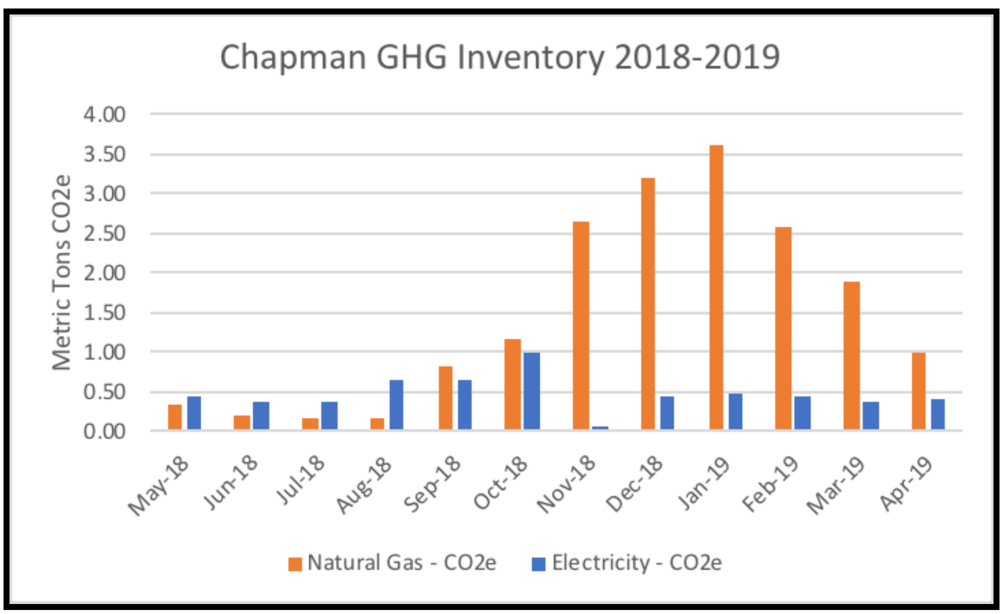


Figure 3.20: Monthly emissions for Chapman can be seen in this graph. Natural gas used for heating spiked during the cold season.

Veterinary Technology Center

As shown in Figure 3.21 below, Vet. Tech. clearly has a large amount of energy use on campus. It is the building with the highest EUI. The Veterinary Technology Center was constructed in 2009 as a state-of-the-art clinical learning laboratory with kennels and classrooms. It is a 2-story building, with a prefab clapboard and metal exterior, steel frame construction and an asphalt and rubber membrane (EDPM) type roof. This building is fairly new, with modern gas-fired boilers and roof-top DX cooling systems. The building uses a bespoke ventilation system which uses 100% fresh air with no recovery system. Lighting is gas-tube and occupancy based, and J&J temperature controls were located in every room.

This building offered a unique challenge to the team as it is both too new to need major repairs/retrofits and, being lab-type construction and use. As a veterinary science building housing animals inherently has high energy usage and restrictions via veterinary requirements. When touring the Vet. Tech., we found that the room HVAC controls have a basic manual design with no automatic system zoning control. This has lead to unoccupied spaces to be set at very low temperatures. The building is built conventionally and the envelope uses double-pane gas filled glazing with typical insulation. As the largest energy user on campus, any efficiency strategies employed at the site would have a significant impact on Campus-wide emissions.

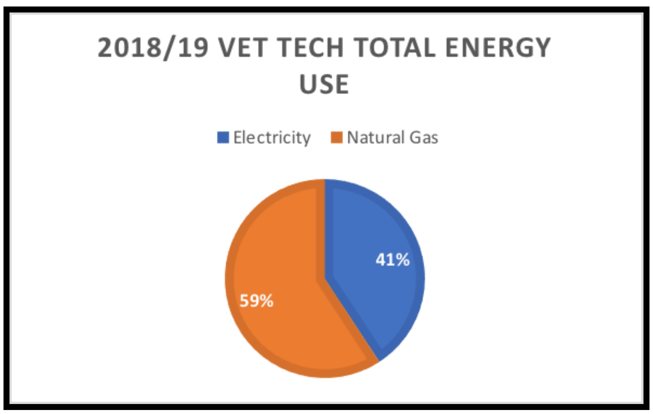


Figure 3.21: *The total energy use by the Vet Tech Building in the 2018/19 year categorized by source.*

Emissions resulting from energy use in the Vet. Tech. followed normal patterns in terms of emissions from natural gas use: it spikes up in the winter and hits a lull in the summer. But, as seen in Figure 3.22 below, the electricity levels are high throughout the whole year. This is due to unmanaged air conditioning and high ventilation rates.

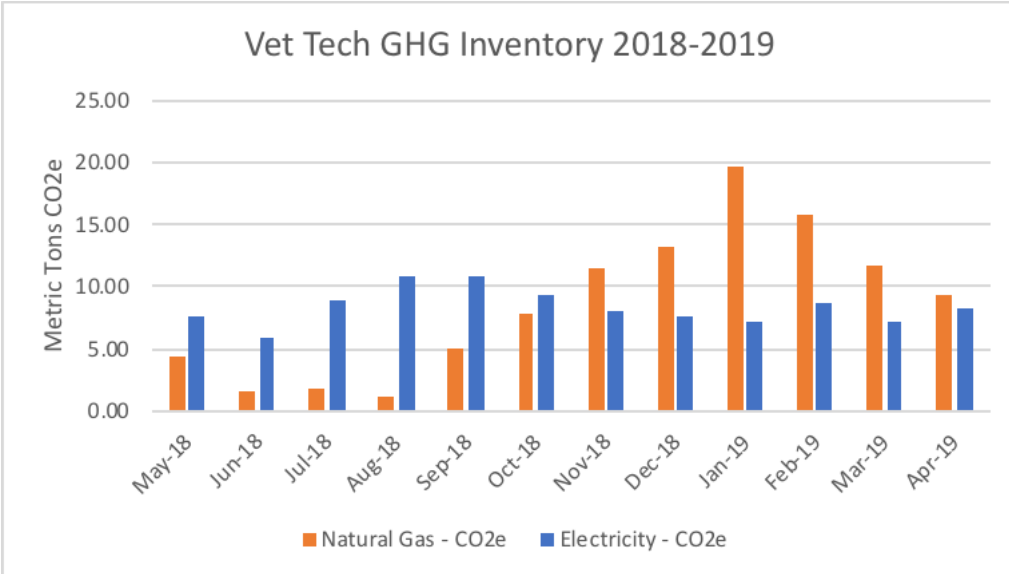


Figure 3.22: *A glimpse at the breakdown of emissions resulting from energy use in the Vet Tech by month. Spikes in natural gas for heating occur during the winter months and electrical use only increases marginally in the summer.*

3.6 - Sustainability Issues

Garbage Area and Protected Land

Upon visiting the campus garbage site located in the back of the Malloy Hall parking lot, we came across concerning practices in terms of storing road salt and waste disposal. The road salt pile, pictured below in Figure 3.23, was uncovered and had been rained on to the point that it has solidified into one large piece. When it rains and the road salt is uncovered, some of that salt is picked up and carried away and is allowed to leach into the nearby soil and forest. The site also has various other trash items that are strewn around and unprotected.

Figure 3.23: *Uncovered road salt piles, rusting paint cans, and other scattered trash*

We also noted that the Clog Busters company contracted to deal with stormwater basins, sewage pumps, etc. on campus dumps their stormwater (that is pumped from catch basins) right next to the garbage area and into the woods. Photographs of this process are presented in Figure 3.24. Although the truck has some ability to clean the waste, which can include pollutants from runoff of vehicles, buildings, and more, the degree of pollutants still left in the water is unclear. They also washed down the area and truck with clean water stored in the truck as the area smelled like sewage. This casts doubts on the cleanliness of this water, along with the fact that they use this same truck for pumping and holding sewage from other systems like septic tanks.

Figure 3.24: *Clogbusters tanker truck dumping their truck contents into the woods directly next to the garbage area behind Malloy Hall*

What makes these findings so troubling is that this site is located on the one corner of campus directly contacting a marked Rare Species Habitat and Vernal Pools. As seen below in Figures 3.25 and 3.26, the South end of campus is right next to the Rare Species Habitat and there are three vernal pools located slightly further back. Although the NHESP map shows the Rare Species Habitat end at the property line, the Newton GIS map clearly shows the Rare Species Habitat come far onto the property and up to the road. The proximity of this area to the garbage area is very close, if not in contact. Based on google maps and other satellite imagery, the garbage area is approximately 150 feet away from the 200 foot protected zone that vernal pools are given under the Massachusetts Wetlands Protection Act. In addition, "take" of protected species is prohibited under the Massachusetts Endangered Species Act (MESA). "Take" is defined, "[i]n reference to animals, [as] to harass, harm, pursue, hunt, shoot, hound, kill, trap, capture, collect, process, disrupt the nesting, breeding, feeding or migratory activity or attempt to engage in any such conduct, or to assist such conduct … Disruption of nesting, breeding, feeding or migratory activity may result from, but is not limited to, the modification, degradation or destruction of Habitat."[26] High chloride concentrations due to road salt can harm native species (including the spotted salamander which use vernal pools as their only breeding ground), kill trees, change stream chemistry, and more.[27] Contaminants from the catch basins can also harm these fragile ecosystems since "stormwater picks up potential pollutants that may include sediment, nutrients (from lawn fertilizers), bacteria (from animal and human waste),

[26] "MA Endangered Species Act (MESA) Overview." *Mass.gov*, www.mass.gov/service-details/ma-endangered-species-act-mesa-overview.

[27] Stromberg, Joseph. "What Happens to All the Salt We Dump On the Roads?" *Smithsonian.com*, Smithsonian Institution, 6 Jan. 2014, www.smithsonianmag.com/science-nature/what-happens-to-all-the-salt-we-dump-on-the-roads-180948079/.

pesticides (from lawn and garden chemicals), metals (from rooftops and roadways), and petroleum by-products (from leaking vehicles)."[28] The severity of the waste area should be investigated as to not harm nearby habitats.

Figure 3.25: *Proximity of garbage area and salt to Rare Species Habitat and Vernal Pools* [29] [30]

[28] "Runoff: Surface and Overland Water Runoff." *Runoff: Surface and Overland Water Runoff*, U.S. Geological Survey, www.usgs.gov/special-topic/water-science-school/science/runoff-surface-and-overland-water-runoff?qt-science_center_objects=0#qt-science_center_objects.
[29] *Google Maps*
[30] "City of Newton Climate Change Vulnerability Assessment and Action Plan" (2018). *Metropolitan Area Planning Council.* Retrieved from http://www.newtonma.gov/civicax/filebank/documents/94675.

Figure 3.26: Map one is of the Natural Heritage & Endangered Species Program (NHESP) Priority Habitats of Rare Species .[31] Map two is from Newton's City of Newton GIS Browser which shows a clearer version of the image in Figure 3.25. The brown dotted area is Rare Species Habitat, the bright green circles are certified vernal pools, the blue areas around the green circles show the extent of the vernal pools, the gray line around them show their protected zones.

Light Pollution and Energy Use

Additionally, light pollution is a frequently overlooked problem that can have devastating effects on local wildlife, human health, and energy budgets. Countless wildlife species rely on Earth's natural day and night light cycles to survive. Nocturnal species in particular are drastically affected by artificial light, negatively impacting their ability to migrate, hunt, and mate.[32] Humans also suffer as a result of light pollution. Research has shown that an abundance of artificial light during nighttime hours can affect our circadian rhythm, in turn hindering hormone production, weakening immune systems, raising cholesterol, and a myriad of other negative side effects.[33] Light pollution largely comes as a result of a phenomenon known as "light trespass," which is defined as when artificial light falls upon areas that it is not intended or needed. As depicted in Figure 3.27 below, many of the exterior lighting fixtures on campus emit light very indiscriminately, rather than focusing their output onto the specific pathways for which they are intended. Light trespass often indicates energy inefficiency as well, as a substantial portion of the total energy consumed by a lighting fixture is wasted on lighting unnecessary areas, with only a fraction of the total light output landing in a useful location.

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[31] "Natural Heritage & Endangered Species Program (NHESP)." *MassGov. Retrieved from* https://www.mass.gov/orgs/masswildlifes-natural-heritage-endangered-species-program and http://massgis.maps.arcgis.com/home/webmap/viewer.html?layers=a953ef7fe0744ef2b2a8fb49118c51c7.

[32] "Light Pollution Effects on Wildlife and Ecosystems." *International Dark-Sky Association*, 12 Sept. 2016, www.darksky.org/light-pollution/wildlife/.

[33] "Human Health." *International Dark-Sky Association*, 17 Nov. 2016, www.darksky.org/light-pollution/human-health/.

Figure 3.27: *These street lights represent one example of indiscriminate outdoor lighting on campus, causing unnecessary light pollution by emitting light in all directions, rather than directing their beams on the intended area below.*

Shaded Solar Compacting Trash Cans and Lack of a Composting System

Many of the solar compacting trash and recycling bins on campus are placed under shade, or even indoors (Figure 3.28). They cannot compact the trash without sunlight, which means maintenance is needed more often and there is a greater chance of bins running out of room. This also means more trips with vehicles to pick up the trash and less trash transported per trip.

Figure 3.28: *Shaded and indoor solar trash and recycling bins*

The campus currently does not have any composting system in place. In Massachusetts, “MassDEP has banned the disposal of commercial organic wastes by businesses and institutions that dispose of one ton or more of these materials per week.”[34] We do not have data for food waste, but as the campus grows there will be more food (and therefore food waste) in the dining halls, and this problem will need to be addressed. The lack of composting also makes the campus miss out on an educational opportunity to allow students and the public to take part in easy sustainability measures.

3.7 - The Current Status of Campus Transportation

As mentioned previously, the current primary method of transport made available to students on the Mount Ida campus is through Uber. Over the course of ten months from September 2018 to June 2019, the UMass Amherst Mount Ida Campus provided Uber trips to students covering about 8,900 miles, costing the campus close to $35,000, and resulting in an estimated 3.27 metric tons of CO2e emissions.[35] As demonstrated in Figure 3.29 below, understandably, the primary ride destination for students was return rides to campus, representing 58% of the total rides called. The following most common destinations were the Newton Centre T stop with 35% of rides, the Newton Highlands T stop with 3%, and the Chestnut Hill T stop with 2% for a combined total of 40% of total rides being called to various stops on the Green Line. These three T stops are consecutive stops along the Green Line, so there is no real need to offer transport to all three, as opposed to only offering rides to the closest stop (Newton Centre).

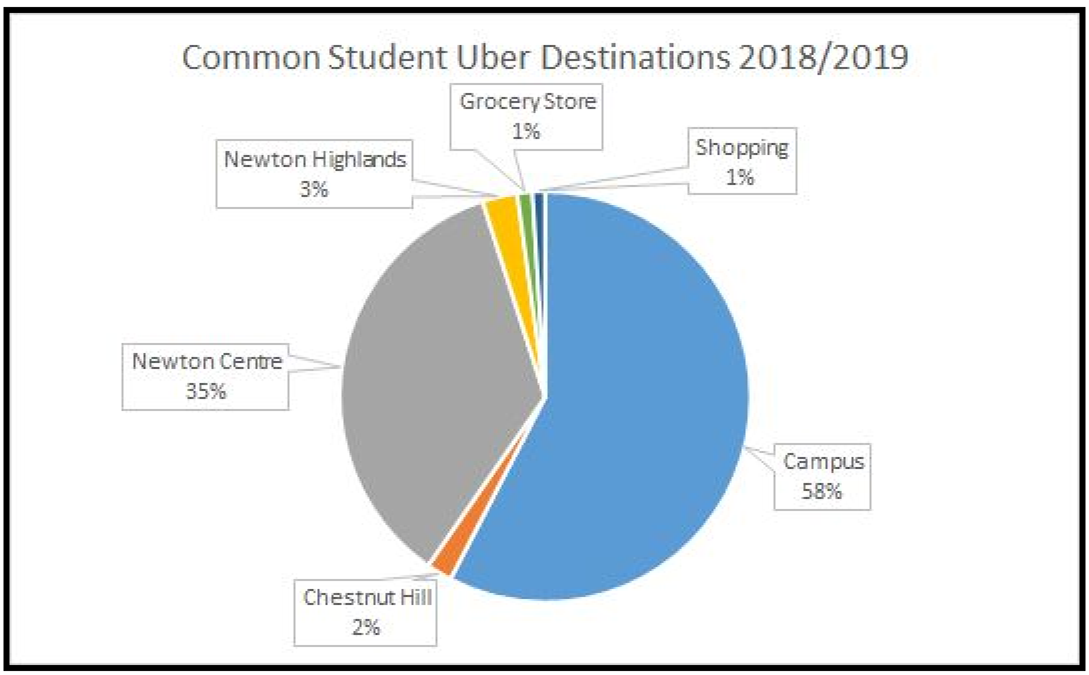

Figure 3.29: *A pie chart depicting the most common destinations for students utilizing the Mount Ida Uber account.*

Also demonstrated through the data is that only 2% of the total rides called were to either grocery stores or shopping centres, and 0% of the rides called were to hospitals or movie theatres, despite these locations being on the list of approved destinations. As such, it could be argued that offering transport to these locations may be unnecessary, and

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[34] Fischer, John. “Commercial Food Material Disposal Ban.” *Mass.gov*, MassDEP, www.mass.gov/guides/commercial-food-material-disposal-ban#-regulations-&-guidance-.
[35] Assuming that every car was a gas powered passenger vehicle and model between 2009 and 2019.

when designing a permanent campus transport plan to replace the current Uber system, removing these locations from the approved destination list would likely be cost effective.

In terms of *when* students are in the greatest need for transportation to and from campus, Figure 3.30 below offers some insight into the matter. The two peak periods for student travel are between 6am-8am and 5pm-7pm, aligning with the traditional "rush hours" associated with the 9-to-5 work day. Between these two peaks, the demand stays relatively constant at 4-7% of total demand, however, between the hours of 7pm and 6am, the demand drops drastically to 0-3%. These demand periods should inform the Mount Ida campus in their future transit planning.

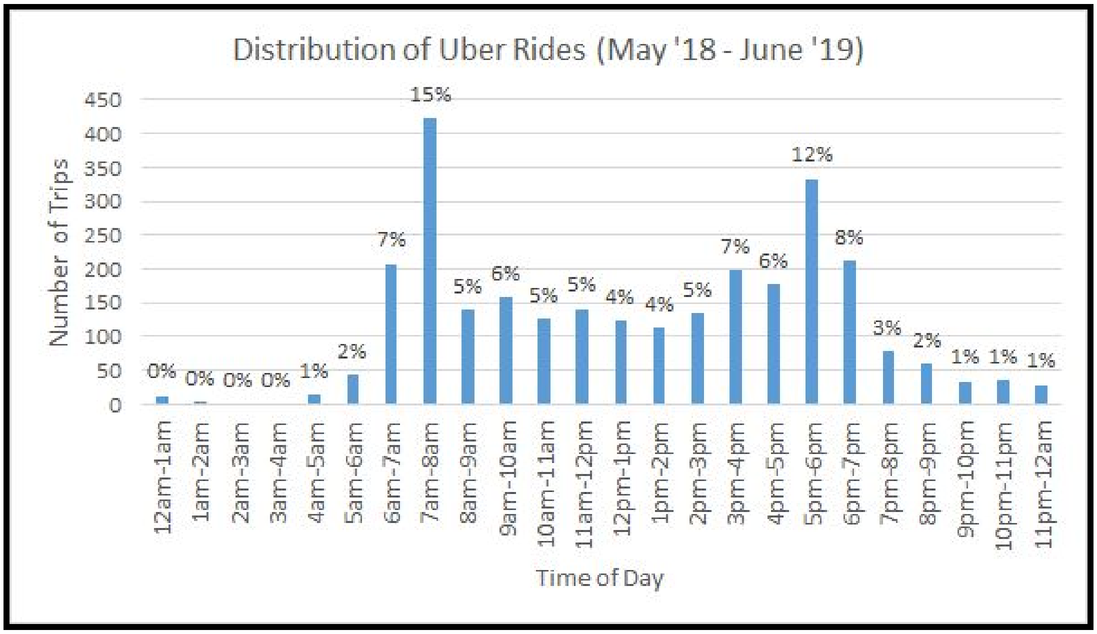


Figure 3.30: *This bar graph depicts the times at which students at Mount Ida tend to call Uber rides throughout the day.*

Lastly, students have no incentive to decrease use with the current Uber System. With rides paid in full by the University, there is no pressure to carpool or use a bike to save money. This does not push students toward sustainable decisions when commuting to work.

4.0 - Analysis and Recommendations

As outlined in the last section, we observed many potential areas in which the UMass Amherst Mount Ida Campus can grow in terms of sustainability. After examining the data and potential solutions, we determined recommendations to help the campus reach its sustainability goals, which are organized into the following three categories:

1. Building Efficiency: Behavioral/Operational Modifications, Retrofits, and Renewable Energy Integration
2. Building a Sustainable and Environmentally Friendly Campus
3. Transportation on Campus: Opportunities for Improved Fleet Composition and Student Commuting

We articulate these recommendations in more detail in **Sections 4.1 – 4.3** below.

4.1 - Building Efficiency: Behavioral/Operational Modifications, Retrofits, and Renewable Energy Integration

For this campus project, we could not conduct an in-depth analysis of every building due to our limited time frame, so we identified three buildings which we feel are the most urgent to be focused on. These buildings were selected for their high energy use, fuel source, and visibility to campus.

Target Building Recommendations

Boulder Farm (President's House)

Our first recommendation for Boulder Farm is to install a roof constructed with locally sourced and environmentally neutral materials. During roof replacement, insulation and air sealing should be prioritized to enhance the thermal envelope. To improve attic insulation, adding blown in dense-pack cellulose can fill those spaces and fill air gaps that can't be reached otherwise. Rain collection should also be addressed during roof replacement. This would include gutter, spout, and soil grading improvements so that the water is all directed down and away from the house. In cases where there is minimal soil area, like pictured in section 3.5, this may include adding a pipe under the soil to move the water away from the house. Rain barrels could also help redirect rainwater and supply landscape watering needs. Reducing water intrusion will also lower dehumidification loads and energy costs for many of the other oil buildings where we saw large numbers of dehumidifiers.

Boulder Farm has been retrofitted with some double-pane windows, but single-pane units still exist in upper floors and the kitchen, which is an envelope weak point and a main source of heat loss. The oil boiler has not been replaced recently and is at the end of its useful life. An electric resistance instant water heater would provide on-demand hot water for showers and hand-washing allowing for boiler decommissioning and ASHP installation. ASHP installation might be difficult with such an old building, but certain rooms could be prioritized for interior unit installation, limiting the need for extensive interior renovations. Efficiency is limited by the thermal wall envelope quality and will be expensive and difficult to improve without losing interior space, but improved insulation and air sealing for the ceiling and floor is possible. With ASHP installation and only two occupants, individual room control should allow for low energy use and operate efficiently despite envelope limitations.

The house has a large traditional central chimney with fireplaces on the first and second floors. The chimney could be repointed and sealed for use with a high efficiency stove insert. This could complement the ASHP and together they could provide all heating needs.

Another option for Boulder Farm is Ground Source Heat Pumps (GSHPs). GSHPs could make use of the existing hydronic heating system to provide low temperature heating to the house. They are highly efficient with higher COPs than air source heat pumps, which justifies the higher installation cost. This is largely due to the fact that soil temperatures stay relatively constant throughout the year, while air temperatures fluctuate. This makes GSHPs also more effective in very hot or very cold weather when compared to ASHPs. Additionally, geothermal systems need less maintenance since the systems can be housed indoors. Using a closed horizontal loop geothermal system is generally the most cost effective for residential properties. The horizontal loops require a larger land area, but there is space around the house for this kind of system. However, these can sometimes be more difficult and expensive in New England due to the rocky soil conditions. We recommend also evaluating vertical loop options.

With the house being the first building seen as one enters campus, installing a cutting edge system will represent reinforcement of the University's commitment to net zero and combating climate change through action. Of the most efficient GSHPs rated for Energy Star's 2019 Criteria, the average manufacturer COP rating is 4.3.[36] We modeled a GSHP system for Boulder Farm for a heating system replacement with a COP of 4, keeping in mind this is a colder climate. In the case of net zero goals, it may be more cost effective to increase the amount of solar to power a system instead of adding the system with the highest possible COP. With a COP of 3.5, a system would still be more operationally cost effective and have much lower emissions than any of the competitor heating mechanisms.[37] The resulting operational savings in energy use and reduced emissions is shown below. This does not include an estimate for installation costs or the emissions associated with the equipment needed for installation or manufacturing emissions.

Table 4.1 below shows a clear reduction in emissions of roughly 75%, however this does not account for the fact that oil fired boilers are less than 100% efficient which would imply the savings could be greater. With a high COP, there are also operational cost savings, but to a much smaller extent. There is also a federal tax credit which includes energy star certified ground source heat pumps. The credit is for 30% through 2019, 26% through 2020, and 22% through 2021.[38]

Estimated Heating Improvements for a Ground Source Heat Pump (COP 4)							
Building	Oil Heating Energy Use (kBtu) (2018-2019)	Estimated Operational Savings (kBtu)	CO2e from Oil (metric tons) (2018-2019)	Estimated CO2e from GSHP Electricity (metric tons)	Estimated CO2e Saved (metric tons)	Estimated Percent CO2e Saved for Heating	Estimated Percent CO2e saved for Total Energy

[36] "ENERGY STAR Most Efficient Geothermal Heat Pumps: ENERGY STAR." *Data.energystar.gov*, 2017, data.energystar.gov/Active-Specifications/ENERGY-STAR-Most-Efficient-Geothermal-Heat-Pumps/4c82-7ysy.

[37] Araujo, Ron. "Heat Pump Technology & Application." *ISO New England*, 2018, www.iso-ne.com/static-assets/documents/2018/09/clg_meeting_araujo_panelist_presentation_september_20_2018_final.pdf.

[38] "2017 Renewable Energy Tax Credits." *About ENERGY STAR | ENERGY STAR*, ENERGY STAR, www.energystar.gov/about/federal_tax_credits/2017_renewable_energy_tax_credits.

Boulder Farm	267,692	200,769	19.94	5.02	14.92	74.8 %	68.8 %

Table 4.1: *Estimated emissions savings by installing a GSHP to provide all of Boulder Farm's heating load.*

Chapman

Chapman is a good candidate for a dense-pack cellulose insulation retrofit via interior wall air gaps, attic air sealing and insulating, and ASHP sizing. ASHPs would increase occupancy capability for the dorm during summer months when normally excessive heat would limit use. The additional benefit of eliminating the boilers for heating and replacing them with ASHPs is that it would decrease direct fossil fuel emissions and fully electrify the building. The current boiler system does not allow for heating control, and only floor level thermostats were observed. ASHPs allow for individual room control of heating and cooling, increasing comfort. Additionally, LED lighting and associated sensors can be installed immediately after assessment to reduce energy while increasing control.

As visualized in Figure 4.2 below, implementing ASHPs in this building would provide a 54% increase in energy savings, and decrease GHG emissions resulting from powering/heating the building by 39%. As the electricity sector includes more renewables in the future, these savings will increase even more.

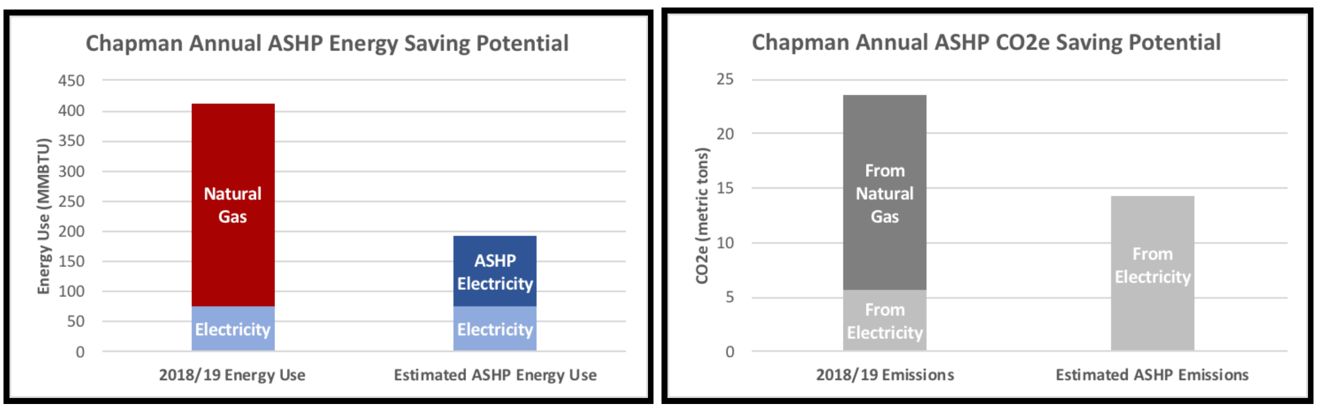


Figure 4.2: *These bar graphs show the estimated potential that installing ASHPs will have in decreasing energy use and GHG emissions by Chapman. These savings are assuming the current grid make up, but will increase when more renewables are incorporated.*

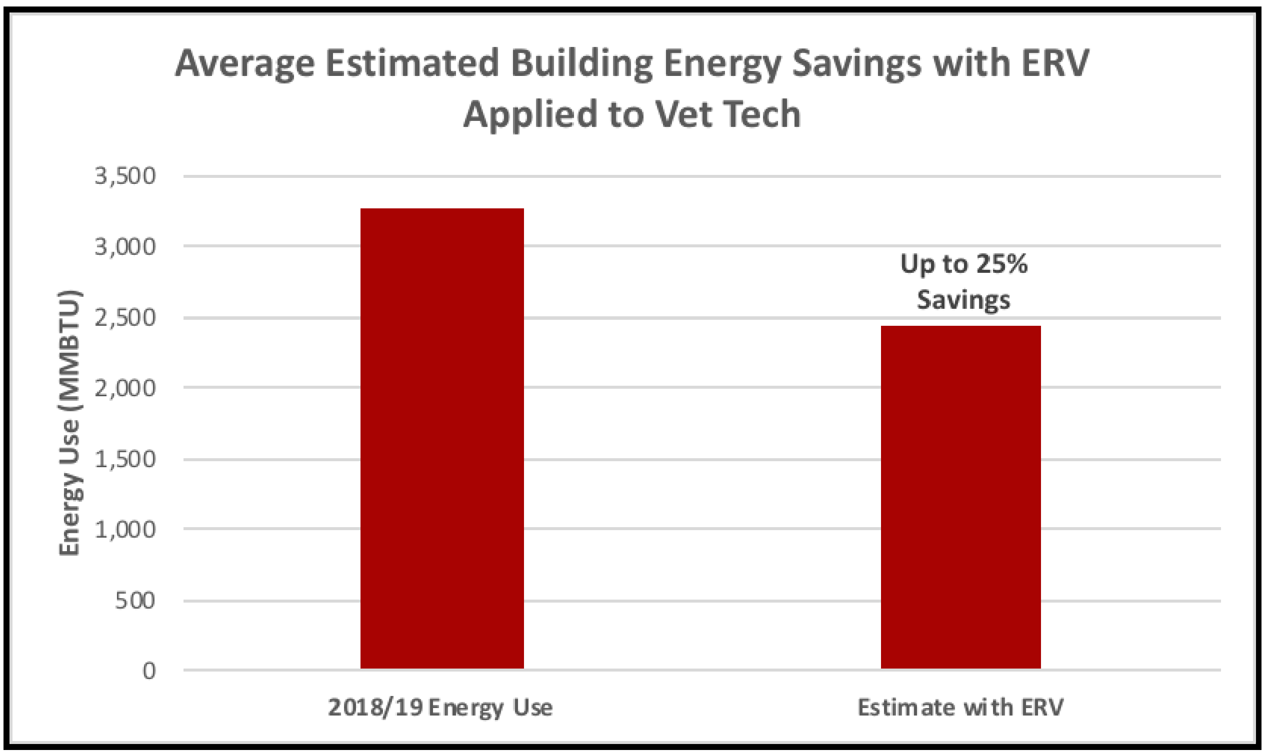
Veterinary Technology Center

The Vet. Tech. building is the highest energy user on campus by a wide margin. Our observed conditions indicate that cooling and ventilation mismanagement are contributing to the high energy use. We observed thermostats set to 62-63 degrees throughout the building when exterior temperatures hit 90 degrees, and high ventilation rates throughout the animal pound and storage areas. Laboratories are inherently high energy users, so it is no surprise that Vet. Tech. is the highest contributor. This building is expected to continue to have high use as the University seeks to continue a veterinary program on the campus, so it is important that this building be addressed.

Informing building staff and occupants about correct ventilation rates and temperatures for proper animal housing could help change occupant habits. Additionally, replacing the RTU with an ASHP with gradual boiler phase-out could prove beneficial, and the large surface-area of the building roof and solar gain makes the building an ideal candidate for roof-top solar.

Another possibility is to measure ventilation rates and exhaust temperatures to determine if an ERV could be installed to reduce ventilation losses. Implementing an ERV in a building can usually result in recovering between 60%-85% of the heating and cooling losses from ventilation.[39] With a 100% fresh air ventilation system like Vet Tech, the HVAC system has to heat, cool, and adjust the humidity of the intake air in order to meet indoor comfort demand. The system then exhausts indoor air to maintain certain air exchanges per hour within the lab space. Adding an ERV would recover most of the energy from the exhaust air and transfer it to the intake, reducing the energy required to condition the fresh air. ERVs use a membrane material that absorbs energy from the air as it passes through and then passes it to the incoming outdoor air. This system would not change the airflow within the building, but would decrease the load on the HVAC system, which in turn would save energy.

As shown below in Figure 4.3, implementing an ERV has the potential to decrease HVAC use and therefore energy use by up to 25%.[40] This could be a very valuable technology to apply to our biggest energy user. Without knowing exact airflow settings and ventilation details of Vet. Tech., we cannot give a more accurate estimate beyond the up to 25%, but system sizing and ventilation loss calculations would be a beneficial future step. Additionally, the Vet. Tech. ventilation system is highly bespoke, which might make it difficult to retrofit with an ERV. But, implementing this technology will undoubtedly have a beneficial impact on energy savings, and we suggest that further analysis be done to determine exact savings and cost benefits.



[39] *Minnesota Sustainable Housing Initiative*, www.mnshi.umn.edu/kb/scale/hrverv.html.

[40] McCullough, Bill. "ERV Products." 2015. PDF file.

Figure 4.3: *The above graph shows how much energy could possibly be saved if an ERV system were to be implemented in the Vet Tech.*

These recommendations coupled with the Green Labs Initiative, which is an energy and water/waste saving lab space certification, could bring the building use down by a lot. The lab will be difficult to become a truly net zero building, and may need the purchase of carbon offsets in order to do so.

Transitioning the campus to full electrification would involve harnessing cutting edge electric thermal efficiency technology like Air-Source Heat Pumps. We calculated the emissions impact a full ASHP retrofit would have on our three target buildings. Taking the total energy use of each building from natural gas, we determined the impact that fuel-switching and the ASHP efficiency increase would have on emissions. The impact assumes that natural gas consumption is 100% efficient, which is not the case and would make the actual savings even greater. Also, we assumed an average ASHP COP of 2.9 for this climate. See Table 4.4 below highlights the potential emissions savings from using this technology.[41]

Potential Carbon Saving Benefits of Air-Source Heat Pumps

Building	2018/19 Total Energy Use from Electricity + NG or Oil (kBtu)	Estimated Total Energy Use from ASHPs and Electricity (kBtu)	2018/19 CO2e (metric tons)	Estimated ASHP CO2e (metric tons)	Estimated CO2e Saved (metric tons)	Estimated Percent CO2e Saved
President's	291,924	115,908	21.8	8.7	13.1	60%
Chapman	411,434	190,831	23.5	14.3	9.2	39%
Vet Tech	3,269,692	1,996,968	202.8	149.7	53.1	26%

Table 4.4: *This table represents the estimated total energy that each building would use if ASHPs are implemented, and compares that to the current use in terms of CO2e emissions. The 2018/19 emissions are from the electricity and either natural gas or oil used that year, and the estimated emissions are from the electricity used for power in the building plus the added electricity use that would result from implementing ASHPs.*

General Building Recommendations

Building Metering, Data Tracking, and Organization

One of our key recommendations for the campus is to improve its metering and data tracking. As we began to tackle this project, we struggled with the organization of data we received in terms of where the energy was going, and how much of it was used. We also came across single meters that are used for large groups of buildings across campus (See Figures 3.1 and 3.2 above). Under the existing metering system, we are unable to analyze individual buildings that are in either the large natural gas or electricity meter groups. **Without meters for individual buildings, it is impossible to have a clear**

[41] Brown, Jordann. "How to Calculate Heat Pump COP - Nordic Heat Pumps." *Maritime Geothermal*, 6 June 2016, www.nordicghp.com/2015/08/how-to-calculate-coefficient-of-performance/.

grasp of what buildings are using the most energy, or how to reduce that energy use in the most effective way. For this project to continue on and the University to reach its energy and carbon goals, metering for individual buildings and then clear tracking of that data should be set up. That tracking can be done in our building index spreadsheet, GIS map, or some other preferred method.

Small Scale Building Recommendations

In addition to the deep retrofit ideas that we discussed for Chapman, Vet. Tech., and Boulder Farm; there are also many smaller, yet significant, changes that can be made to every building in order to start working toward sustainability right away.

With the Mount Ida Campus still at early stages of activity, most, if not all, of campus systems are at low capacity. Many buildings are vacant and have been since the transfer of the property to UMass Amherst. Now that the campus is under new management, steps can be taken to adjust building supply to meet demand. During our time on campus and through our inspections of buildings, we determined that all buildings could benefit from proper energy management. Specifically, oil using buildings highlighted in Figure 4.5 are both vacant and highly emissions intensive, and could be a great focus area.

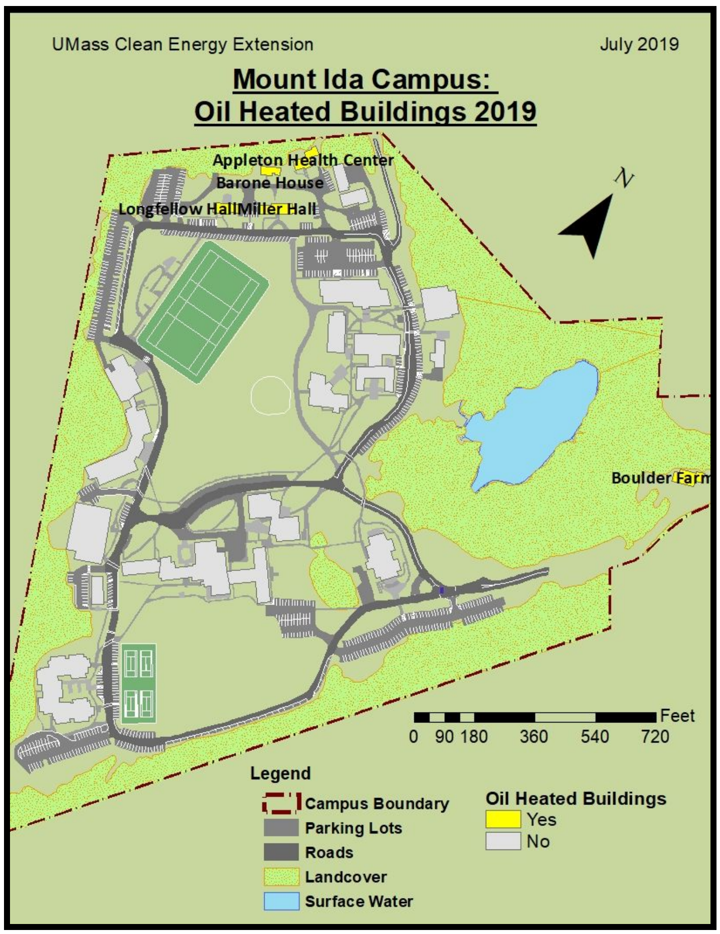


Figure 4.5: *A GIS map depicting the locations of oil-heated buildings on the Mount Ida Campus.*

Simple and low cost behavioral and operational changes can net large energy and emissions reductions when added together. Changes like responsible thermostat setting, closing windows, turning off lights, and powering down electronic appliances can compound to decrease energy use. These changes are possible through a combination of facilities management training and occupant reminders. Other low-cost changes include installing sensors which can determine if a room is occupied or in need of lighting, and adjust systems to accommodate. Some of these sensors like occupancy sensors for lighting, smart plugs for appliances, CO2 sensors for temperature control, daylight sensors, and smart thermostats can add onto existing systems and make their use as efficient as possible.

Many of the unoccupied buildings we visited had thermostats set very low with air conditioning cooling empty rooms, high energy using appliances like refrigerators and computers running in the dark, and lights on in empty classrooms. Installing smart plugs that allow for remote shutdown of these systems can begin to help develop a network of building appliances and scheduling programs for their management. Taking these “low hanging fruit” type recommendations and making them part of foundational facilities operation will help integrate them throughout the campus and inspire staff to develop additional efficiency strategies, further reducing demand.

Throughout our campus inspection and audit, we did not identify any buildings that had been fitted with LED lights. Depending on installed lighting, LEDs can cut electricity use while improving interior lighting quality and occupant comfort. At night, we found that building security and walkway lighting were angled in such a way that caused glare and up-lighting (see Figure 4.6 of Wadsworth’s exterior lighting). While this allows for more coverage area, these lights can affect nocturnal wildlife. These lights could benefit from replacement with LEDs and installation of covers to prevent excessive glare and over lighting of grounds.

Figure 4.6: *Photo of Wadsworth Library exterior lighting and glare*

Demolish, Decommission or Condemn Buildings That Are Not Currently Occupied and/or Have No Plans For Use

As a step toward reducing emissions, removing or condemning buildings is one of the best options when the space is not needed. By condemning a building, and recycling parts of it when possible, all of the emissions for running a building will be cut out of the picture.

There are five residential-style buildings on the Mount Ida campus which still use oil-fired boilers for heating and hot water. Fuel-oil has the highest emissions per BTU, and is the most expensive of all the fuels on campus, and is a natural focus area when looking for reduction opportunities. Since these buildings are of house type construction, they have limited options for educational use and are generally used as residences or offices. Through discussions with administrative staff, we decided to recommend that the University invest in having all oil burning residential-type campus buildings decommission their boiler system (unless otherwise in use) and replace this system with ASHPs to eliminate their impact on emissions. ASHPs have a very high COP (0.85) especially when compared to that of conventional oil boilers (2.9) and could result in high emissions savings. We also suggest that the buildings we analyzed use a blower door test and cavity scanning to locate air leakage sources and seal leaks with low GWP insulating foam and dense-pack cellulose insulation.

After conducting walkthroughs of all of these buildings noting significant issues, we have provided general and specific recommendations below if the building does to continue to function. Each building has unique challenges and opportunities for energy reductions, so we focused on identifying options which we felt would be the most cost effective and impactful on emissions.

<u>Appleton Health Center:</u>

During our building audit of Appleton, we observed that the building needed to be heavily air conditioned with a window unit in every room in order to maintain a comfortable interior temperature during the summer. Additionally, we found that many rooms had dehumidifiers indicating humidity issues. Both of these could contribute to high electricity use. We inspected the mechanical system and found it to be in good operating condition, having been replaced approximately six years ago. This building uses oil to power its boiler rated at an efficiency of approximately 82%.

The building envelope looked to be in poor condition with peeling paint and some damage. The windows are single-pane with water damage from condensation causing peeling interior paint (see Figure 4.7). There is a possibility that the paint is lead-based. This damage indicates high heat loss and poor humidity control. Continued use of the building in a similar manner could cause significant damage to envelope materials requiring increased replacement frequency.

This is one of five residential-type buildings which are part of campus. Four of these buildings are clustered on the North side of campus. Appleton is the oldest of these buildings and was the only one with significant usage during our inspection. For the past few months, Appleton was used as a medical office and counseling center and was occupied by two employees.

Figure 4.7: *Single-pane windows with peeling paint*

We found that Appleton needs significant investment in both mechanical and structural efficiency strategies in order to become carbon-neutral ready. These improvements include window replacement, wall and ceiling insulation, envelope air sealing, and thermal electrification. The existing mechanical system of the oil-fired steam boiler, window AC units, and indirect water heater are inefficient and have high energy use. ASHPs would need to replace current systems which would involve decommissioning of the current system, ducting, electrical upgrades, and interior installation. These retrofits would have a high initial cost, but would eliminate on-site fossil fuel use and enable the building to be carbon-neutral.

Barone House

Barone House is a residential-type oil-burning building located on the North part of campus. This building occasionally serves as a residence for faculty or administrative guests. We found that some retrofit investment has already been done with new windows, a water boiler, and a water-heater within the last six years. The house is cooled via five window air conditioners. The building appears to be in fair condition, but would still require envelope and a mechanical system retrofit in order to move toward carbon neutral energy use. As a short-term residence, installation of occupancy sensors, a central HVAC control system, and smart plugs for appliances would cut waste energy use.

We recommend attic air sealing and insulating along with ASHP installation. With such low usage, we see Barone House as another location where the best action from an emissions standpoint would be to decommission and shut down the building until it can be determined what purpose it could serve for the campus.

Longfellow

Longfellow is another oil-burning residential-type building located on the North part of campus. During our tour of this building, we found that the interior was in poor condition and in need of renovation. The building was most recently used as a childcare center but is now empty. Depending on whether the University decides to make use of the space, the interior condition would provide a good opportunity to renovate and install envelope improvements like insulation, air sealing, and ASHPs to make the building net zero ready. Due to reduced loads in this building and other mixed-use house-type buildings, the new systems would not need to use as much energy to heat and cool the space as the conventional systems would, and would predominantly sit on standby.

Miller

Miller is unique among the residential fuel-oil buildings in that it has undergone the most significant retrofit and renovation. The building has a good condition interior and was used as an office, lounge, and meeting space for faculty and staff, but is now unoccupied. The building uses a traditional oil-fired water boiler and indirect water heater, but also has an ASHP system which provides heat to the basement (see Figure 4.8). The rest of the space uses window air conditioners for cooling, but the ASHP system could easily be expanded to cover the remainder of the space removing the need for the boiler for heating. The boiler would still function to heat domestic hot water, but could gradually be replaced with an instant electric “on demand” water heater. In addition, we found an empty fridge running in the basement with a freezer bursting with ice. We recommend the fridge be turned off and moved outside so the melting ice does not cause water damage.

Figure 4.8: *Air-Source Heat Pump outside Miller Hall.*

<u>Malloy</u>

Malloy is a 3-story building with a prefab clapboard exterior, wood frame construction, and asphalt roof. It is also the largest dorm on campus. This construction style is generally low quality, causing this building to face multiple issues and renovations since construction. These issues include mold, leaks, mice damage, poor insulation installation, and previous condemnation. Currently, it has water damage due to the frozen pipe incident on November 23rd , 2018. The sprinkler system in the attic froze, burst, and flooded lower floors on the North side of the building, causing mold and water damage. To this day, the building continues to leak around 70 cubic feet of water per day from unknown locations. The water heater was identified as a likely cause of some of the loss (see Figure 4.9). The building faces high repair and renovation costs, and according to campus administration, could potentially be put offline, condemned and eventually demolished. We recommend that the building be shut down and decommissioned to eliminate further wasted resources. Demolition of Malloy aligns with a 2018 UMass Department of Landscape Architecture project (see Appendix A, Figure B) suggesting that the Southern part of campus be returned to nature. This accompanies the fact that this corner of campus is where there are both a Rare Species Habitat and numerous vernal pools, as mentioned in section 3.6.

Figure 4.9: *Malloy Water heater in need of replacement*

Malloy was retrofitted in 2013 with new natural gas boilers (see Figure 4.10) supplying baseboard heat to rooms, and ASHPs cooling and heating hallways and common areas. This is unfortunate because the systems are in good condition, but the building is damaged. If the University decides to repair the building, full ASHP or GSHP installation should be considered to fully remove the building from natural gas. GSHPs are capable of heating, cooling and preheating hot water for showers with a high initial investment and a very high COP.

Figure 4.10: *New Lochinvar Boiler in Malloy*

Plans were drawn for renovations to make the building into apartment style rooms but those changes could cost as much as $15 million. In addition, the campus likely does not need that space for housing, seeing as administration plans to utilize other residence buildings as the student population increases.

Recommendations

Based on the future plans of the campus in terms of being a commuter school with limited student presence on campus, we feel that these oil buildings and Malloy are not needed. We suggest that the University condemn or demolish buildings that have no future as a part of the campus and have no plans for use, and do so as soon as possible. **The worst case scenario is that these types of buildings stay running at full capacity while unused.**

If the plan will be to build different buildings in the area that currently houses the campus's oil buildings, then the removal of those buildings will lower total campus emissions and give space for new net zero buildings. Another option to consider if the campus does not need these buildings is to retrofit them in a similar fashion to that of our Boulder Farm plan listed above. Then, these buildings could be used by the City of Newton. This would not only help further integrate the campus into the city, but it would also make the city more likely to include the campus in its sustainable initiatives (such as extending Lime Bikes to reach the campus, as described below in section 4.3).

Yet another idea is that if all of those oil buildings are removed, then that space could be utilized for a ground mounted solar system. Land in Newton is valuable, if the University wishes to generate its renewable energy on site, then this is an excellent opportunity instead of buying PPAs. In a rough sample calculation, using the area that currently houses all of the oil buildings except Boulder Farm, if that space was filled with solar panels it could provide an approximate one million kWh annually. This calculation uses the estimated global horizontal irradiance of 4 kWh/m^2/Day times 365.25 days/year, an area of 6,600 m^2 with an average yield of 15% and a performance ratio of 0.75.[42] These will not be the exact numbers as the true values will depend on a number of other factors, but they represent **the possibility for offsetting roughly a fourth to a third of the University's yearly electrical usage**. This calculation and sizing is outlined below in Figure 4.11. With the removal of oil buildings, Malloy Hall, and the retrofit of other buildings on campus, this solar energy could offset even more of the campus's energy.

[42] Gilroy, Nicholas. "Solar Maps." *NREL.gov*, NREL, 4 Apr. 2017, www.nrel.gov/gis/solar.html.

Calculation of the solar PV energy ouput of a photovoltaic system

Yellow	Yelow cell = enter your own data
Green	Green cell = result (do not change the value)
White	White cell = calculated value (do not change the value)

Global formula : E = A * r * H * PR

E = Energy (kWh)	1084133	kWh/an
A = Total solar panel Area (m²)	6600	m²
r = solar panel yield (%)	15%	
H = Annual average irradiation on tilted panels (shadings not included)*	1461	kWh/m².an
PR = Performance ratio, coefficient for losses (range between 0.9 and 0.5, default value = 0.75)	0.75	
Total power of the system	990.0	kWp

Losses details (depend of site, technology, and sizing of the system)

- Inverter losses (6% to 15 %)	8%
- Température losses (5% to 15%)	8%
- DC cables losses (1 to 3 %)	2%
- AC cables losses (1 to 3 %)	2%
- Shadings 0 % to 40% (depends of site)	3%
- Losses weak irradiation 3% yo 7%	3%
- Losses due to dust, snow... (2%)	2%
- Other Losses	0%

Figure 4.11: *This figure shows the area where the oil buildings and parking areas are located as well as the solar calculations.*

Electrification

There are many benefits to using heat pumps in buildings. Heat pumps provide both heating and cooling in a single, efficient unit without the need for ductwork and with the lowest up-front cost of any clean heating and cooling technology. It is also typically more cost effective to operate heat pumps than traditional cooling/heating systems because the higher equipment and installation costs are offset by long-term energy cost savings. Heat pumps provide individual zonal control for superior comfort and efficiency while having the greatest energy savings and greenhouse gas reductions. Installing this technology is a great option for new construction or replacing existing forced air and hydronic heating systems.

Most of the following buildings use natural gas to power their heating systems. Due to fracking, this fuel source has become very cheap, making electrification economically difficult. The fracking of natural gas is highly damaging to the surrounding environment but allows for cheap heating fuel. This means that it is often less economical for people who currently use natural gas to switch to heat pumps. Natural gas prices are predicted to increase, and the costs of heat pumps will continue to fall. For many of these buildings we have suggested that the heating system be electrified despite the current economics of doing so. We feel that regardless of the costs, climate change is too important of a challenge to be ignored and the University needs to start its transition to net zero and expect temporary losses on its path to reach carbon-neutrality.

These are our notes for specific buildings that can be targeted for electrification, their current systems, and our recommendations:

Hallden

Hallden is an older two story academic building heated by a ducted natural gas furnace and cooled by window air conditioners. This building is currently occupied and temporarily used by 4H staff for office space. The building exterior shows some deterioration and is in need of repair. The building envelope is structurally sound but needs significant insulating and sealing to mitigate heat loss. The first floor has original single-pane windows while the second floor has dual-pane windows installed as part of the 2013 retrofit. The furnace is currently under control by facilities management with no control by occupants. Adding individual controls along with automatic occupancy type systems for both lighting and HVAC could reduce usage without any other improvements. The building could benefit from ASHP installation to eliminate window AC units and replace furnace in the winter. The building envelope looks to have been partially renovated with new windows, additional retrofit with windows, insulation, and air sealing could reduce ASHP sizing and expense.

This building is currently occupied and looks to be part of the campus tentative occupancy plan. We recommend that the University consider our recommendations for the building and apply repair and replacement options to move this building toward net neutrality.

Wadsworth

The Wadsworth Library is a unique building. The building used to be a horse barn in the past and was retrofitted into a library when needs changed. We see this building seeing high usage as the campus ramps up occupancy and more students begin studying and living on campus. This building uses NG boilers for heating and DX in ceiling units for cooling. After inspecting the building and interviewing occupants, the building seems to be over cooled and installing individual room and automatic control systems would help manage temperature and increase comfort. **Occupants regularly open windows and exterior doors during hot days to regulate temperature as it is too cold inside.** The interior lighting involves four different systems and sky lighting making for an unnecessarily complex and inefficient system. Installing daylight sensors and LEDs could help better control lighting and reduce energy use. Replacement of the NG boilers with ASHPs would significantly reduce energy use by allowing for room-level temperature control so that when occupancy is low, rooms can be shut down. The cooling system ducting could be used for ASHP installation reducing costs.

Holbrook and Alumnae

Alumnae Hall is a one-floor multi-function gymnasium building which also houses the server room for campus. It is currently unoccupied and is being used for storage. Holbrook is a two story office and meeting room type building which is unoccupied. These two buildings share meters and are physically connected. Holbrook mainly uses water boilers for heating through room PTAC systems which also have individual AC units. Alumnae Hall uses a NG furnace to heat the large open gym and ASHPs to cool the server room. Holbrook also uses extensive ASHPs to heat and cool basement rooms, some offices, and media labs.

According to campus administration, these buildings do not have any planned use or occupancy in the near future. With both buildings having limited ASHPs installations, adding additional systems to remaining spaces would allow for decommissioning of NG powered systems. We recommend increasing insulation in Alumni Hall roof and walls before ASHP sizing and determine occupancy to select areas with high use. Further benefits of ASHPs are that low use does not lead to freezing pipes since the system does not use a hydronic loop in most cases. However, with no planned use, decommissioning and shutting down all unnecessary systems would be most impactful to campus emissions.

Security

This building is a small trailer-type building with typically two occupants. The building has NG use via a generator which did have high use based on our energy data. The building is heated and cooled by an ASHP system. We recommend that the generator be complemented with a battery storage system and that ASHP use be carefully controlled to ensure efficient use.

Campus Center

Figure 4.12: *The Campus Center*

This building is central and important to campus and is used as a dining hall, associated kitchens, theater, and office space. It is a 3-story building, with a brick and stucco exterior, steel frame and wood beam construction, and mixed slate and EPDM rubberized roof (see Figure 4.12). The heating system has natural gas-fired hot water boilers and the cooling system is a roof mounted air cooled chiller. Ventilation is provided by 3 industrial exhaust cooking hoods in the kitchen and an intake rooftop ventilation unit.

With the multi-use and ramping up of campus activities and services, the energy demand in the Campus Center is likely to increase. We found that with the 2013 renovation, the building received new boilers, envelope improvements, possibly an upgraded chiller with VFD, some occupancy lighting, and a new DHW water heater (see Figure 4.13 and 4.14). We noted that this building has lighting issues with lack of control and confirmed with administration that the lighting systems would be retrofitted with LEDs and rewired in the near future. On the first floor, **an empty kitchen with no activity had approximately 13 mostly empty refrigerators and an exhaust hood running**. Thermostat controls are located in common areas and are likely networked into a BMS system but **many individual areas were set to 62 while unoccupied**. **The theater room had powerful stage lights running while unoccupied and occupancy sensors were not functioning.**

Figure 4.13 and 4.14: *Campus Center boilers and VFD*

For this building, the highest energy use is coming from the kitchen and the conditioned air being ventilated from the exhaust hoods. When we inspected the kitchen, we found that the hoods were constantly running even when no cooking was being done. The hoods only have on/off controls making for an always on condition during operating hours. This amount of ventilation can be taxing on the heating and cooling systems with the need for air in the occupied spaces as well as the high fan use in the hoods. This cycle could be better controlled with better training of kitchen staff to learn to turn off hoods when not in use and by installing variable drive motors to the hoods so different speeds can be selected depending on need.

<u>New Hall</u>

New Hall is one of the newest campus buildings and currently sees high use as a dorm. It is a 4-story building, with panels and glass exterior, steel frame construction and white rubber membrane roof. Heating is hydronic with two NG fired boilers. Cooling is done via chilled water supplied by a rooftop air cooled chiller serving vertical fan coil units in each room. Ventilation is provided by two 100% fresh air units with heat recovery (HRV). Domestic hot water is supplied by two 8-panel solar-thermal arrays and supplemented by the boilers. Thermostats are advanced units with individual room control and automatic settings. Lighting is conventional gas-tube with mostly manual on/off control and occupancy sensors in bathrooms. Envelope construction is conventional commercial with a high glazing percentage.

During our walk-through, we identified a number of potential operational improvements. We observed that even at night, all common areas and hallways are fully illumined and do not have occupancy sensors or any controls.

Conversion to LED lighting with electrical upgrades is being considered by the University. The ventilation system does have an HRV installed but does not recycle any interior air leading to some loss. **A major issue we found when interviewing occupants was the solar glare and heat gain in the common areas and South facing offices and rooms. Even during the winter months, overheating was noted in these areas.** Adding an exterior shading device would cut these solar gains and help keep the building at a comfortable temperature. Another possible issue is individual heating control. It is likely that with a hydronic looped system, individual control is not possible and overheating in certain rooms is inevitable. The solar-thermal hot water system appears to be functioning but is in need of repair with cracked insulation on piping (see Figure 4.15). Keeping this system in good condition and educating management staff on its use will ensure its continued effectiveness.

Figure 4.15: *New Hall solar thermal system and damage*

The School of Design

The School of Design building is a large academic building used for classes. The building is already being used for classes and as a meeting space and administrative staff envision usage to increase. The building is two-stories with a brick, stucco and metal exterior, steel frame construction and a rubber membrane (EDPM) type roof. Most of the interior is in good condition with a recent renovation but there are other areas currently under renovation. The building is heated with recently installed NG fueled hot water boilers and cooled by seven ducted DX AC units of unknown age. Some of the art rooms have ERV systems with filtration to improve air quality and reduce thermal energy loss from ventilation (see Figure 4.16). The building does have enTouch networked controls installed allowing for operational control of building level systems. Individual room temperature controls are inconsistent but do have automatic settings. Occupancy sensors are installed in each room for lighting but LED lighting was not observed. **Computers throughout the building were found to be on and running at all times** (see Figure 4.17).

Figure 4.16: *Ceiling-mounted ERV in School of Design classrooms*

Figure 4.17: *Computer lab with computers running at night*

With the projected use of this building, we think that gradually improving roof, wall and floor insulation when renovations are occurring should be part of the long-term plan. Also, replacing DX AC systems at end-of-life or during renovations with ASHPs will allow for gradual boiler load reductions and additional temperature control. Eventually, the boilers can be decommissioned as the building transitions to 100% Heat Pump heating. During LED lighting retrofit, daylight sensors should also be considered to take advantage of natural light. Computer systems can be connected to smart plugs or on a scheduled shut down.

<u>Applied Science Building</u>

The Applied Science building is attached to the School of Design building with a hallway and is used for labs, lectures and classrooms. It uses a series of four ducted Roof-Top Units or RTUs to both cool and heat the spaces. RTUs are packaged units which use NG to heat air and use a refrigerant coil to cool air which is then blown through ducts into the building. The building also has one ASHP which heats and cools hallways. The advantage of having ducted heating and cooling systems is that it allows for easy ASHP integration. The building has enTouch controls for HVAC, some automatic thermostats, and occupancy lighting sensors in classrooms.

Since this building was recently renovated, a minimally intrusive ASHP system could gradually be installed one unit at a time, replacing RTUs. The flat black EDPM roof of this building absorbs a high level of solar gain which is transferred to the interior requiring the HVAC system to work harder to cool the building. Painting the roof a lighter color would reflect more of the energy and help keep the roof cool.

In the interior, the labs and mortuary have high flow ventilation systems which when not used correctly can excessively ventilate and waste conditioned interior air. Installing variable controls would offer users options for flow rate and even automatic systems would provide the required Air Exchanges per Hour (ACH) for laboratory work. **Mortuary freezers are another source of energy waste as they are currently running, and with the future of the program in question, freezers should be shut down until a decision is made** (see Figure 4.18).

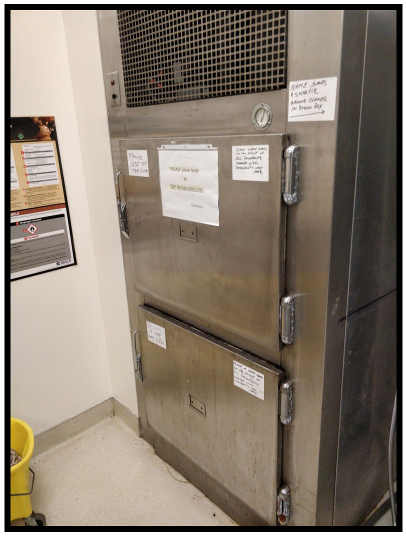


Figure 4.18: *Mortuary freezers*

In addition, the parking lot next to the Applied Sciences building has **lights that are left on all the time**. These lights waste electricity during the day time and should be turned off while it is still bright outside (see Figure 4.19).

Figure 4.19: *Commuter lot lights running*

Athletic Center

The Athletic Center is an important and constantly used campus building. As a high energy user that will continue to see use well into the future, reviewing and implementing efficiency strategies take on a high priority. The building is 1-story, with a brick, stucco and metal exterior, steel frame construction, and rubber membrane roof. An addition was constructed in 2014, called New Gym, adding new gym space and locker rooms. The building is heated and cooled with seven NG and electricity powered RTUs and domestic hot water is provided by a 130+ gallon direct NG water heater. Court lighting is conventional t-8 gas-tube with on/off control only (see Figure 4.20). New addition has occupancy lighting and also uses t-8s. Temperature control is limited however the new addition has integrated enTouch system. Additional locker rooms in the original building have additional NG direct hot water heaters.

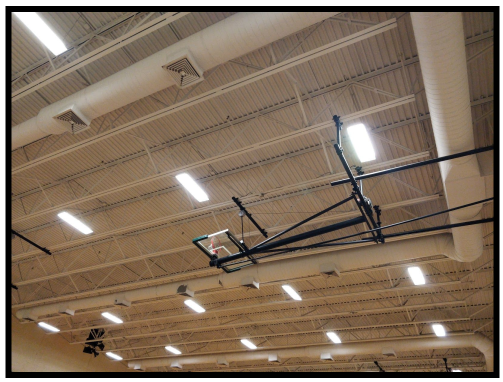


Figure 4.20: *Court lighting*

During inspection the building appears to be in good condition but has limited envelope insulation allowing for heat loss. Improving insulation would reduce mechanical load and could even allow for decommissioning of one or more RTUs. The building sees high internal loads from activity and is often over cooled to compensate. Installation of CO2 sensors could help the system respond to occupancy levels and increase control. Sensors can be connected to enTouch and increase centralization of building management. An RTU system provides both heating and cooling just like an ASHP which would allow for direct replacement. As RTUs require replacement the University can commit to replacing these systems with ASHPs and gradually eliminate all NG use. ASHPs allow for better room by room control reducing or eliminating “hot spots” or “cold spots”. Lighting systems are dire need for upgrade, with hundreds of inefficient lights illuminating the courts every day. Retrofit with LEDs and increased control systems are a simple efficiency measure. Tracking of locker room and shower use will help with decision-making about whether to replace these systems with instant electric options.

We believe the data and calculations for the Athletic Center might be incorrect. The EUI of 40 is unexpectedly low and this is most likely because part of the buildings electricity is counted somewhere else. In our data, the natural gas is listed under “Athletic Center” while the electricity data is under a title called “New Gym.” The Athletic Center was originally built in 1999, but the New Gym is a newer addition to it. Therefore, we think that the Athletic Center must have had electricity before the New Gym was added but there is no data for the Athletic Center’s electricity. Most likely, the New Gym was attached to the Athletic Center’s natural gas line, and had its own electricity meter implemented. In this case, the main part of the building (the Athletic Center) continued to use its previous source of electricity, which is likely coming from a different group or building. This is something that we ran out of time to look into but another group can look into this in the future.

Academic Tech Center

The Academic Tech Center or ATC is a primarily medical and dental type center designed for classrooms, dental center, media center and computer labs. It is a 3-story building, with a brick and pane exterior, steel frame construction and an asphalt roof. The building is heated by a NG water boiler and cooled by Water-Source Heat Pumps (WSHPs) with an evaporative condenser. Lighting systems look to be manual only T-8s and medical level lighting systems. ATC has a central BMS system but facilities currently does not have access.

The building could benefit from automatic temperature controls with CO2 sensors for occupancy, LED office lights with sensors, and WSHP retrofit to add heating capability. Adding heating capability would drastically reduce the need for the boiler to fire other than heating DHW. Even DWH could be preheated with the return WSHP loop. These improvements would reduce demand and fully transition the building to electricity. As a medical lab, high energy use from equipment is typical but can be monitored and controlled with smart plugs eliminating parasitic loads. Reducing HVAC system load helps compensate for the typical high energy use of a medical lab.

Wingate Hall and Brown Hall

Wingate Hall is a residence hall with a dorm rooms, a bookstore, function room, and mail room. It is a 4-story building, with a brick exterior, steel frame construction, and a rubber membrane roof. It is heated by baseboard supplied hot water via two NG water boilers installed in 2013 and cooled by 4 ducted RTUs DX above the dining hall building and two ductless ASHP units in the residence hall. DHW is supplied by six 119-gallon indirect DHW tanks. Lighting is manual in the dorm rooms, motion sensing in common areas, and always on with no visible control in hallways. Envelope is typical 1960s design with poor insulation throughout but looks to be in fair condition. No thermostats were visible, there is likely floor by floor zoning with no individual room control. No cooling is available in dorm rooms and ASHPs only serve classrooms on the third and fourth floors. No central networked BMS system was observed. First floor bookstore and common area is cooled via RTU and bathroom vents appear to be running constantly. **In the low-rise section of Wingate, the unused kitchen, several empty refrigerators were found running and the event center was being actively cooled to a set-point of 65 degrees while unoccupied.**

Brown Hall is a similar residence hall with dorm rooms, offices, and athletic locker rooms. It is a 4-story building, with a brick and stucco exterior, wood frame construction and an asphalt roof. Heating is supplied by NG hot water boilers upgraded in 2012. There is no cooling system. Domestic hot water is supplied by two indirect water heaters. Brown has received some upgraded T-8 lighting with motion sensing. Limited thermostats were observed; all were manual with no automatic control. The University sees this building as having high usage in the near future.

The campus administration has stated that both of these buildings will be important in the future and will eventually be used for housing after New Hall reaches capacity. I**n anticipation of use, we recommend that these building undergo a series of retrofits aimed at efficiency and electrification that both reduce emissions and improve comfort and usability.** Our suggestions for envelope improvement are limited but involve **identifying envelope air gaps and other open spaces and adding in insulation and air sealing. For mechanical heating and cooling, existing ASHP units on Wingate can be expanded into dorm rooms increasing control and adding a cooling option.** ASHP management is important to maximize efficiency benefits and cooling unoccupied rooms when outdoor temps at over 90 degrees nullifies their effectiveness. RTUs on the low-rise can be swapped for ASHPs at end-of-life. For Brown, ASHP integration is a good option for heating as it is minimally invasive and highly effective. Both buildings' NG boilers can slowly be reduced to DHW heating and very cold temperature support only and then eventually decommissioned and replaced with instant water heating. **Both buildings receive plenty of sunlight and offer large footprints for potential solar PV and/or solar thermal installations.** LED lighting retrofits with better room, occupancy, and daylight controls is a simple, highly visible and effective efficiency measure. These buildings will see high occupancy, and retrofitting measures will be highly visible to students, reinforcing the University's commitment to sustainability.

Shaw

Shaw is an old residential mansion that has been converted into an administrative building. It is a 3-story building, with a brick and stucco exterior, wood frame construction and a slate roof. The building used to be heated by hot water and air from two gas-fired boilers in Wingate Hall but is now fully retrofitted with ASHPs which supply heating and cooling to individual rooms. The original steam heating system still exists and was changed to hydronic but looks to have been decommissioned. The building envelope looks to be well insulated but a few single-pane windows still exist. Lighting controls are not motion sensing and could benefit from LED retrofit and daylight sensors. Thermostats and ASHP remotes are accessible from each room and a CO2 occupancy sensor could greatly assist the system from over conditioning unoccupied space. Being built in 1912, retrofitting with ASHPs is very challenging but in this case has been managed well and integrated such that there is no compromise to the charm of the building. Shaw is a model for what is possible with heat pump technology integration.

Maintenance Garage

The Garage building is in poor condition with significant damage to building envelope, insulation and air sealing elements. Heating system looks to be electrical resistance but an oil tank was identified in the rear of the building. If this building is occupied and not just used for storage of landscaping equipment and needs to be mechanically conditioned, we recommend that the envelope be drastically improved. Improvement might not be possible in this case and depending on needs might be better of torn down and a new storage building constructed in the same space.

Renewable Energy

As the UMass Amherst Mount Ida Campus grows, renewable options should be considered for future construction and retrofits. The Mount Ida Campus administration and sustainability management has been working with Zac Bloom and Competitive Energy Services to design and size a small rooftop and parking lot solar PV system. Going beyond solar, we recommend that the campus consider horizontal and vertical loop geothermal under open fields sized to serve multiple buildings, thermal storage systems to harness lower cost off-peak electricity or heating, and battery storage to collect excess solar production. Due to time constraints we did not conduct analysis into renewable energy system sizing. This is a potential future project that the University can direct towards CEE or energy consulting firms.

Improve Efficiency Through Building Temperature Control

In general, current unoccupied buildings temperatures are set at 55 °F to 60 °F for heating in the winter and air conditioning is off in the summer. Occupied buildings are set to 68 °F to 72 °F for heating in the winter and 68 °F to 70 °F for cooling in the summer. These set temperatures for occupied buildings are a good range for heating but excessively cold for summer comfort. Comfort is not just reliant on temperature, and by using a tool like a Psychrometric Chart shown below in Figure 4.21, it can be seen that the summer comfort/cooling range is much higher than the current setting. The summer Comfort Zone starts at 72/73 °F and goes up to 79/81 °F, depending on other factors like relative humidity. By moving the set points for summer cooling up, the University could save emissions and money, while improving comfort.

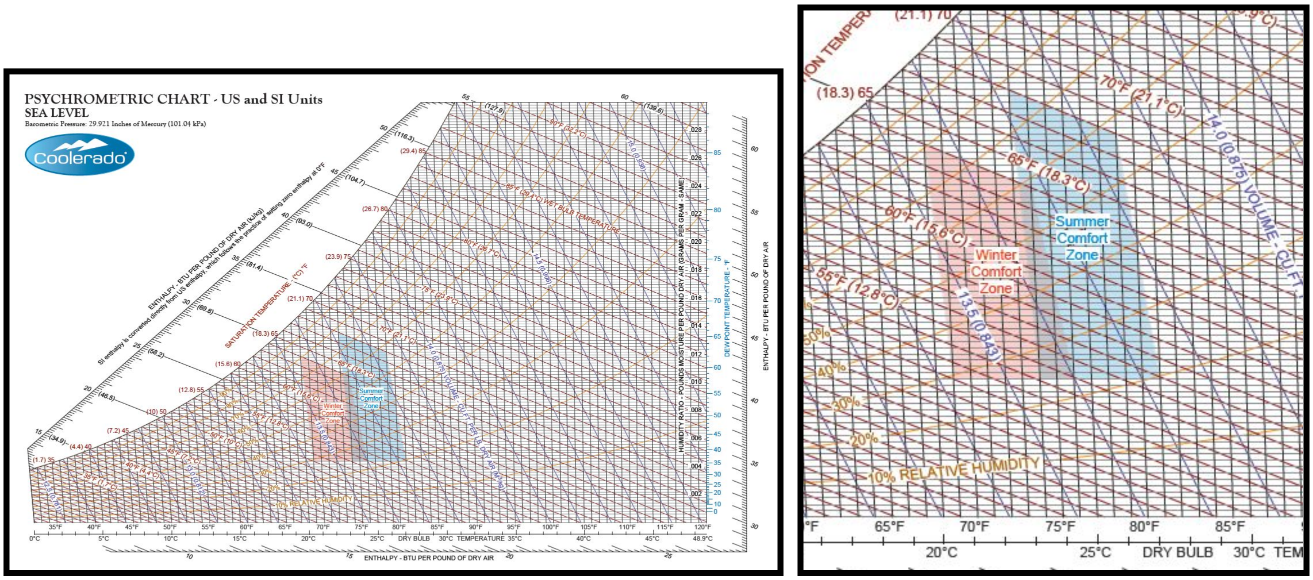


Figure 4.21: *Psychrometric Chart with Winter and Summer Comfort Zones*

We found many buildings like the Campus Center, Vet Tech, The School of Design, and more to be over-cooled during the summer. In addition, the buildings do not run on temperature schedules based on occupancy which means they try to reach their comfort goals even if no one is inside. To increase overall building efficiency and avoid unnecessary fuel/electrical waste, a temperature schedule should also be developed for each occupied building after analyzing the times that they are in use. This will allow each building to reduce energy use by turning off or minimizing the AC or heating when it is not needed. The buildings will always stay at the correct temperature to keep systems working, but will not need to be at a comfortable temperature at night when no one is present. This may also include the required installation of programmable thermostats.

Future Building Standards Commitment

The University is currently committed to LEED Silver plus ratings for any new design buildings or major renovations under its 2010 Green Building Guidelines.[43] However, many of the buildings on the Amherst Campus that are Leed Certified, like the Hampshire Dining Commons which has an EUI from FY18 of 309.26, are not energy leading buildings.

If the University wishes to reach its carbon and sustainability goals it should commit to net zero or Passive House standard new buildings. By far, the majority of buildings will not be rebuilt by 2050 and will need retrofit to increase their efficiency. **When a new building is planned, there is an opportunity to choose a path for that building that will last far**

[43] "Green Buildings." *UMass Amherst*, www.umass.edu/sustainability/buildings-infrastructure/green-buildings.

beyond the carbon neutral goal year of 2050. **A clear commitment to net zero energy use for all future buildings that are built or used by UMass Amherst Mount Ida Campus will be the first step towards achieving the University's goals.**

In addition to a commitment to higher building energy standards, the University should also focus on the sustainable sourcing of building materials, the health aspects for people that will inhabit those buildings, and other features that consider more than what LEED requires. These areas are discussed in detail in the UMass Amherst Green Building Guidelines. https://blogs.umass.edu/campusplanning/files/2016/01/GBG-for-draft-review-1_26_16noblankpages2.pdf

4.2 - Building a Sustainable and Environmentally Friendly Campus

Relocate Garbage Area + Possible Remediation

Based on the issues of the garbage disposal and waste location, we recommend that the road salt pile be covered or removed as soon as possible and that the water from Clog Busters is not dumped in this corner of campus. In addition, the school should investigate the possible legal implications, if any, of maintaining this site. For the long term, the University should consider moving this entire garbage area to a different location on campus, away from the protected wildlife areas. Depending on if there is current damage to the area, which could be assessed by a consultant, there may also be the option for remediation and future protection in this area.

Reduce Unnecessary Light Pollution and Energy Use

While sufficient outdoor lighting is a necessity for campus safety and functionality, the locations and types of lighting fixtures selected make all the difference when attempting to minimize the harmful effects of light pollution. When it comes to environmentally friendly outdoor lighting, the International Dark Sky Association (IDA, Inc.) is undoubtedly one of the leaders of expertise in the area. The IDA maintains a database of "Dark Sky Friendly Lighting Fixtures", through which they connect users with various approved retailers, however, they also assert that virtually any existing lighting fixture can be modified to be "dark sky friendly" by using proper shielding to direct the light beams at the intended area.[44]

In conclusion, the harmful effects of light pollution can be minimized by:

1. Only using exterior lights when necessary
2. Only illuminating areas that need to be lit
3. Minimizing the brightness of exterior bulbs
4. Minimizing "blue light emissions" by using warm colored light bulbs
5. Utilizing fully shielded (downward pointing) exterior lights as shown in Figure 4.22

We highly recommend referencing the International Dark Sky Association's website for further guidance.[45]

[44] "Find Dark Sky Friendly Lighting." *International Dark Sky Association.* Retrieved from: https://www.darksky.org/our-work/lighting/lighting-for-industry/fsa/fsa-products/

[45] International Dark Sky Association (https://www.darksky.org/)

Figure 4.22: *An illustration depicting what types of streetlights create the most light pollution.*[46]

Use Prime Locations for Solar Compacting Trash Cans and Add a Composting System

In order to use the solar compacting trash cans effectively and lower maintenance these should either be relocated into the sun, moved outdoors, or have the trees trimmed above them.

A composting system could also be added to these outdoor bins and dining halls. The campus waste vendor does accept compost and this could be added to the dining hall since all the waste sorting is done by dining hall staff. Indoor composting in residence halls can present odor and pest problems, but is possible. As a start, if the University does not wish to try indoor compost, BigBelly also produces composting bins which are sealed from large animal access and could be placed outdoors next to the current trash and recycling bins.[47]

Working With Newton

Following the example of notable climate leaders in the state such as the Cities of Boston and Cambridge, the City of Newton is in the process of establishing their very own *Green Ribbon Commission*. The Commission, comprised of some of the largest and most influential property owners throughout the city, will act as a body of local leaders, doing their part to reduce GHG emissions, operate sustainably, and set a good example for the community as a whole. Together, these Commission members, the City of Newton, and local utilities, will work together to set ambitious emission reduction targets, measure their progress, share best practices and technical support, and challenge one another to do better.[48] Local utilities will assist in formulating an individual Memorandum of Understanding (MOU) with each participant, and help to identify energy reduction goals, while the City will keep track of partnerships and the progress made by each commission member. Our team strongly suggests that Mount Ida join onto the Newton Green Ribbon Commission, to solidify UMass as a responsible community leader, and further advance UMass's commitment to sustainability.

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[46] Astrophotography Telescope. "How to Reduce Light Pollution with 4 Easy Tricks ?" *Astrophotography Telescope*, 9 Dec. 2017, astrophotography-telescope.com/how-to-reduce-light-pollution-with-4-easy-tricks/.

[47] "Smart Solutions for Cities // World Leader in Smart Waste." *Bigbelly*, bigbelly.com/.

[48] Newton Citizens Climate Action Plan p. 58/59 - http://www.newtonma.gov/civicax/filebank/documents/96838

Our team had the opportunity to meet with the Director of Sustainability for the City of Newton, Ann Berwick, to discuss UMass's efforts to achieve energy efficiency and sustainability on the Mount Ida Campus. Ann had the following to say about the potential for future collaboration between UMass and The City of Newton:

> "The City of Newton is excited about the opportunities for the Mt. Ida Campus to reduce its greenhouse gas emissions, and for Mt. Ida to serve as a leader in Newton's anticipated Green Ribbon Commission. We expect that many of Mt. Ida's "leading by example" initiatives will contribute momentum to the City's climate programs."
>
> - Ann Berwick, Director of Sustainability for the City of Newton, Jun 29, 2019

If this campus became a member of the Newton Green Ribbon Commission, it would receive valuable support from the city and local utilities, aiding in achieving UMass's various emissions reduction goals. We believe that these partnerships would be mutually beneficial, and serve as a great opportunity to set a good example for those all throughout the Commonwealth.

One of the other ways the Mount Ida Campus can work to reduce its emissions is through Newton's Municipal Aggregation program called Newton Power Choice. Under Massachusetts state law, cities and towns are allowed to purchase their own electricity to be distributed by the utilities, instead of the utilities both buying and distributing the electricity. This allows cities and towns to choose where their energy comes from and therefore to choose a higher percentage of renewable energy than state law requires. In Newton's case they buy renewable energy to cover 60% of the City's use. This program is also an opt-out program, where residents are automatically paying for the 60% renewable energy mix and must opt out if they want to reduce this percentage to the state minimum or use basic service. In addition, residents can also opt up to 100% renewable energy. Newton's electricity contracts last for 22 months and rates stay the same during that time, while Eversource rates last for 6 months. Prices cannot be guaranteed due to this timing discrepancy but in general municipal aggregation programs allow towns and cities more freedom to negotiate for better pricing.[49] **The Mount Ida Campus could work with the City of Newton to investigate the option of joining Newton's Power Choice program and increasing their renewable energy mix to 60% or even 100%.**

4.3 - Transportation on Campus: Opportunities for Improved Fleet Composition and Student Commuting

Implement a Shuttle Bus System and Encourage the Use of Public Transit

As previously noted, it is obvious that the current Uber-based transportation system on campus is unsustainable for both environmental and monetary reasons. As such, it will be important for the campus to elect a more permanent solution. Based on conversations with Mount Ida Campus Director, Stephen Reynolds, the University is actively exploring potential

[49] "Newton Power Choice." *MassPowerChoice.com*, Peregrine Energy Group and Bay State Consultants, masspowerchoice.com/newton.

alternatives to the current transportation system, including a proposed “bussing on demand” system in collaboration with local businesses.

In order to assist the University in their transportation planning efforts, we recommend that they consider our findings from section 3.7: The Current Status of Campus Transportation, specifically the findings represented through Figures 3.25 and 3.26 (recreated below as Figures 4.23 and 4.24 for convenience sake). As previously noted, apart from return trips to the campus, the top three most common destinations for students were Newton Centre (35%), Newton Highlands (3%), and Chestnut Hill (2%). These top three destinations are consecutive stops along the Green Line, so we recommend limiting the approved destinations for both the current transportation system as well as any future transportation systems to solely Newton Center, or any single stop, for T-based destinations. This will simplify the system as a whole, reduce the carbon emissions associated with driving to the farther T stops, and minimize the fueling/driver-based expenses of these longer rides. Similarly, the current system includes locations such as shopping centers and movie theatres as approved destinations, but very few rides have been taken to these locations since UMass Amherst acquired the campus, so we recommend that the University consider removing these locations from the approved list for the sake of simplifying their future transportation routes.

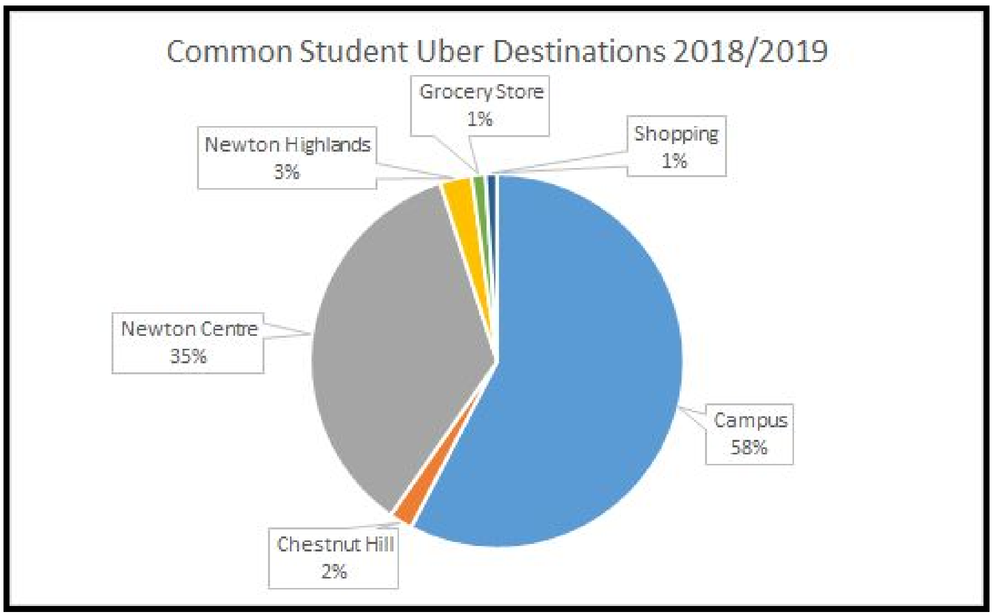

Figure 4.23: *A pie chart depicting the most common destinations for students utilizing the Mount Ida Uber account.*

Shown below, Figure 4.24 depicts the times at which Mount Ida Campus students frequently call Uber rides. This can be interpreted as also demonstrating the common times at which students are in need of campus-based transportation. As you can see, the peak periods closely mirror the typical 9-5 work day, so it is essential for the campus to offer transportation options during these time periods in particular, especially if the University hopes to encourage Mount Ida’s status as an internship hub. Figure 4.24 also demonstrates how transportation demand drops off quite rapidly after 7pm-8pm. This should be kept in mind when planning the future of campus transportation, in an effort to minimize the necessary hours of shuttle operation. These statistics may change during the year when students are commuting for classes, not just internships.

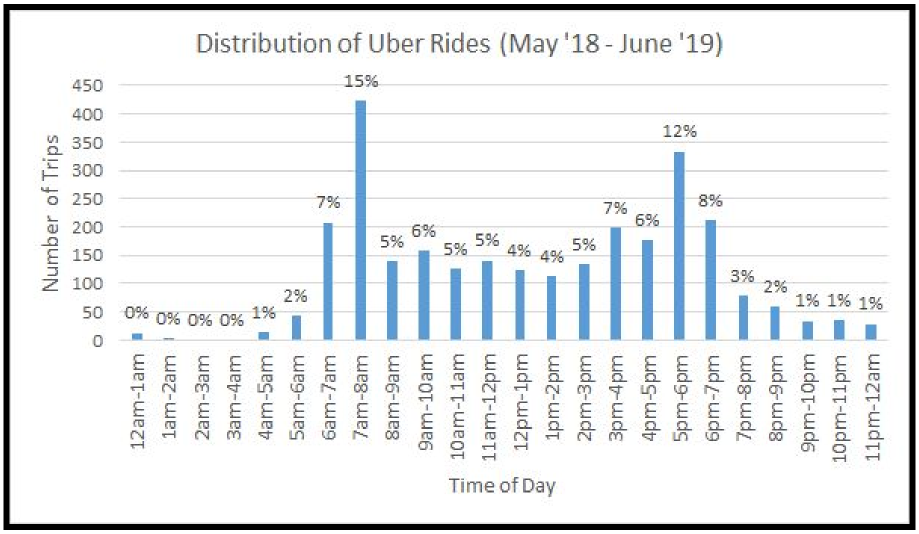

Figure 4.24: *This bar graph shows the times at which students at Mount Ida call Uber rides throughout the day.*

In addition to utilizing our Uber findings, we recommend that the University consider the following actions during their future campus transportation planning:

- **Utilize the vans currently in the campus fleet to transport student interns to the T during peak hours** (See Figures 4.25 and 4.26 below): Even making just two trips per day (one around 7-8am, and one around 6-7pm) to the Newton Centre T stop could consolidate many student rides that would otherwise be taken separately. Even if the proposed "bussing on demand" system is implemented, the campus would run into similar issues as they currently experience with Uber, as students would frequently be picked up individually (seeing as there is no significant incentive to orchestrate carpooling with other students), rather than organizing a singular pick up for many students. Even more so, these proposed buses likely have worse fuel economy than the current campus vans, as well as the passenger cars commonly utilized by Uber, so total campus transportation emissions could rise. The economical effectiveness of using the on campus buses will increase with more students commuting to internships in future years.

- **Consider electrifying existing campus vans:** Converting the existing campus vehicles to hybrid electric, potentially utilizing a company such as Massachusetts based XL Hybrids, could save the University a significant sum of money in terms of reduced fueling and maintenance costs, while also significantly decreasing the campus's total transportation-based emissions. Similarly, purchasing new hybrid vans should also be considered if the campus plans to run its own transportation system.

- **Encourage students to utilize the existing Newton bus system:** MBTA Bus #52 stops near the entrance to campus on Carlson Ave, and is a great option for commuting from campus, seeing as the bus route stops at over 60 popular locations. The campus could incentivize students to take the bus by offering free or reduced price bus passes, while also potentially attaching a larger, less enticing, price tag to the less eco-friendly "bussing by demand" option.

Figures 4.25 and 4.26: *The two unused vans parked in the back of campus.*

Expand Lime Bikes and Add Sidewalk

Newton Bike Share program has dockless bikes that can be used all around Newton and any of the 15 participating communities for $1 every 30 minutes, and with additional discounts for students.[50] As shown in Figure 4.27, the current LimeBike routes do not often extend toward the Mount Ida Campus. The University could work with these companies to increase the use of these bikes to and from campus. This could be through adding bikes or creating a bike drop off somewhere on campus. This should also be coupled with the addition of a sidewalk down the main road to campus. Since the Campus is set back from the main road, where the MBTA bus stops, it is a barrier to those who want to walk or bike off campus. Often the people who do not have their own bikes are the ones renting bikes, and will also be more comfortable biking on a sidewalk than in the road. This could be a great addition to Boston's efforts to become more bikeable included in Boston's Climate Action Plan and Mayor Menino's Boston Bikes program. [51]

[50] Green Newton. "Bike Share Has Come to Newton!" *Green Newton*, Green Newton, 31 July 2018, www.greennewton.org/bike-share-has-come-to-newton/.
[51] City of Boston. "A Climate of Progress." *City of Boston*, Apr. 2011, www.cityofboston.gov/Images_Documents/A%20Climate%20of%20Progress%20-%20CAP%20Update%202011_tcm3-25020.pdf.

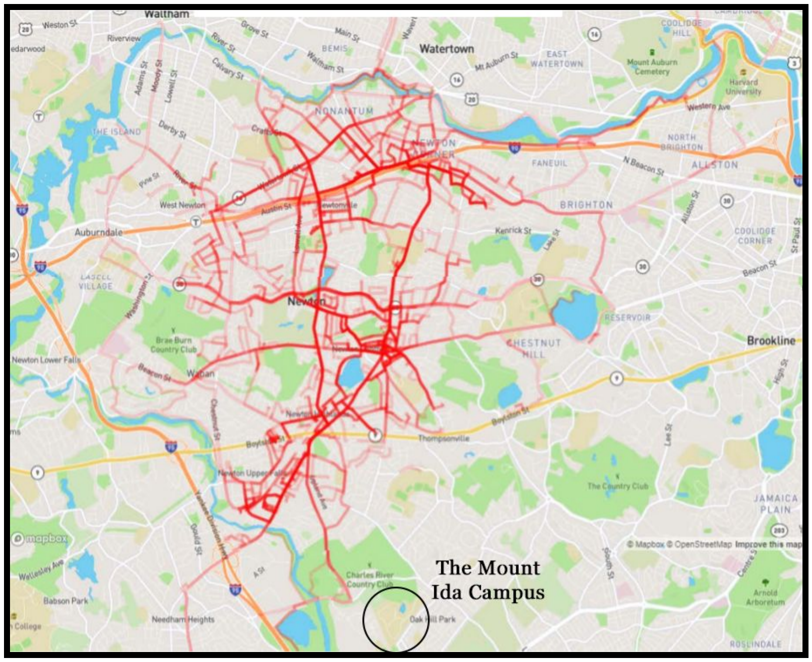

Figure 4.27: *Map of LimeBike Routes (Updated Jan 2019) and Mount Ida.*[52]

Convert On Campus Vehicles to Electric Models

For campus vehicles that go off campus or in the case of the already existing vans, it makes more economical and emissions sense to start out with what is already produced and paid for. However, vehicles that are used daily on campus, whether for patrols or maintenance, can be replaced more rapidly and with more sensible options. **Sometimes waiting till a machine breaks before replacing it can be a barrier to purchasing electric, less abundant products, therefore often a replacement plan with pre selected products and predicted equipment lifespans can help.** Some possible areas to look at include:

- The current campus golf carts and gator golf carts run off gasoline, which is not only inefficient and bad for people around them, but they are also something that does not need a long range. The golf carts are primarily used around campus and could be changed out for electric models that have enough range to get all around campus and the minimal energy use associated with small vehicles. They do not pollute the air around them and can be powered by renewables. These could also be used instead of the full size cars that are often used around campus for transit.

- The campus security patrol cars and smaller maintenance cars can similarly be replaced with smaller and electric vehicles. Larger maintenance cars can be transitioned as technology and the options for electric vehicles advance.

- Other combustion equipment can also be switched out for electric equipment. The campus owns three ride on lawn mowers, one push mower, four trimmers which could all be transitioned to electric equipment. If fully electric equipment is not an option, newer equipment still has much mo6re efficient

[52] "Newton." *Newton, MA - Bike Share*, www.newtonma.gov/gov/planning/bike_share.asp.

engines due to tightened regulations by the EPA that became fully in effect in 2015.[53] Ride on lawn mowers also produce large amounts of emissions and "the Environmental Protection Agency estimates that a gasoline powered lawn mower emits air pollution equivalent to a single car driven for 45 miles for each hour of operation."[54] There are fully electric lawn mowers, like MeanGreenMowers, for example.

EV Chargers and Cars On Campus

Electric car chargers make up an important piece of promoting electric cars and reduced emissions. By building up the framework for people to reliably travel with an electric car, EV sales and use will continue to rise. The Eversource Make Ready program will install all of the infrastructure for EV charging stations free of charge, which covers a substantial portion of the cost. The charging unit itself will not be provided. Level 2 chargers can cost between $400 and $6,500 depending on quality and available features, with installations cost for pedestal units averaging $3,209.[55] These charging stations can also be financed through other means, like Greenspot (discussed below in 5.2) as the City of Newton has done. For example, Newton worked with Eversource and Greenspot to build 2 charging stations in one of their parking lots. One is used by the company for its car share and one is for public use. A system like this could help with charger costs and also bring an EV car share to campus.

One of the other methods Newton uses to encourage EV use is preferential parking. **Not only are charging stations positioned to give EVs closer spots, but they also can give EVs preferential parking without chargers.** This is a minimal investment option that can easily be changed if the parking lot has an uncertain future. Once there is more certainty in the future of the parking lot then EV chargers can be added to those spots.

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[53] "US: Nonroad: Emissions." *Transport Policy*, International Council on Clean Transportation and DieselNet, www.transportpolicy.net/standard/us-nonroad-emissions/.
[54] Nealon, Sean. "Lawn Mower Emission Reduction Device Wins National Award." *University of California*, University of California, 14 Oct. 2015, www.universityofcalifornia.edu/news/lawn-mower-emission-reduction-device-wins-national-award.
[55] Smith, Margaret, and Jonathan Castellano. "Costs Associated With Non-Residential Electric Vehicle Supply Equipment." *U.S. Department of Energy*, New West Technologies, LLC and the U.S. Department of Energy Vehicle Technologies Office, Nov. 2015, afdc.energy.gov/files/u/publication/evse_cost_report_2015.pdf.

5.0 - Conclusion

The biggest take away from project is something that cannot be stressed enough: **change needs to be made now.** The choices and changes that we make today will have immense effects on the future of climate change. Our only hope at preventing the irreversible effects of climate destruction relies on your power to make change. **Not only is it a critical time across the globe, but it is a rare opportunity for the University to make major changes during a transition time.** Once campus life increases, many of these changes will increase in complexity and possibly cost.

5.1 - Next Steps: The Future of the UMass Amherst Mount Ida Campus

We suggest that the UMass Amherst Mount Ida Campus's first step is to assess our first key finding: metering. Each building should have its own individual meter, which would make tracking data such as energy use and emissions more manageable. Almost no accurate assessments and retrofits of the 12 lumped buildings can be done until their individual usage can be analyzed. Next, we suggest following our major recommendations in the building, transportation, and sustainability sectors as soon as possible. By decommissioning buildings such as Malloy and the oil-heated buildings that are damaged or have no plans for future use, money and energy will be saved. Replacing natural gas heating with heat pumps will decrease the campus carbon footprint. This impact will be more pronounced in the coming years as the grid is powered by an increasing amount of renewables. Installing occupancy sensors and modifying thermostat setpoints will also decrease unnecessary heating and cooling. If new buildings are to be built in the future, then they should be net zero.

To improve the transportation sector, implement a shuttle bus system that is based on peak times of demand. Expanding the City of Newton's already existing LimeBike program to include Mount Ida campus with a drop-off point on campus will help to promote one of the healthiest modes of transportation. Electrifying the campus fleet and installing EV charging stations will also help the campus move towards their energy reduction goals.

To increase sustainability, cover or remove the road salt pile behind Malloy Hall and discontinue the disposal of stormwater in this area. Although campus population is low and food waste may be minimal, a composting system should be implemented, as this returns nutrients back to the soil or can even be used to create energy through anaerobic digestion.

Although these suggestions vary in cost and ease of implementation, all would increase the overall sustainability of the campus and/or decrease its carbon footprint.

5.2 - Project Continuation: Suggestions For Future Interns

The goals and focus of this project changed and grew many times as we continued to immerse ourselves in the data, research, and observations. New information and opportunities were always coming up, making the nature of this project very flexible and constantly changing. As we navigated through completing this recommendation plan, new ideas came up that we did not have a chance to investigate. Sustainability at UMass Amherst Mount Ida is an ongoing project that has only just begun this year, and will constantly need attention and motivation. This problem could never be solved in one summer, and the work of future interns on this issue will be extremely valuable. Below we outline some steps for next year's interns to pick back up where we left off:

1. Using our 2017/2018 and 2018/2019 emissions/energy use data as guides for a range of possible campus emissions, and find an estimate for what the emissions will be for future years. Then, set an emissions goal based off of if sustainable plans/retrofits are implemented.
2. Examine interval energy use data to develop a detailed plan for building HVAC schedules.
3. Look deeper into solar and geothermal opportunities for specific buildings and areas on campus.
4. After looking into renewables, do a deep cost analysis for retrofits/renewables (look into gaining a team member in the economics field).
5. Investigate sustainability measures specifically for labs (smart labs, etc.) to potentially use with Vet. Tech. and future buildings. Develop a possible ERV retrofit.
6. Further develop the Building Atlas and GIS maps and continue to add information to them. Add pictures, and update the data sheets with information from PDFs.
7. Analyse the fuel and vehicle usage of vehicles on campus and used by campus staff.
8. Look at energy storage options on campus to decrease use at peak times.
9. Keep not only this internship going, but develop other internships/programs in sustainability at the Mount Ida campus.

Appendix A – References and Selected Sources

- For 2018-2019 EUI and GHG calculations, May 2018-April 2019 data was used. This data was not always available however. When this data was not available for buildings that used natural gas for heating, May 2018 data was used for natural gas, while May 2019 data was used for electricity. For buildings that heated with oil, May 2019 data was used for both oil and electricity.

- For 2017-2018 EUI and GHG calculations, April 2017- March 2018 data was used. When this data was not available for both natural gas and oil using buildings, January, February, and March 2017 data was used.

- **Figure A:** *Greenhouse Gas Calculator created for campus emissions*

GHG Calculator

OIL

Gallons of #2 Oil	CO2 (metric tons)	CO2e (from CH4)	CO2e (from N2O)	Total CO2e (metric tons)
10	0.1024346	0.000103875	0.000247638	0.102786113

NG

Therms Nat Gas	CO2 (metric tons)	CO2e (from CH4)	CO2e (from N2O)	Total CO2e (metric tons)
10	0.053047319	2.4994E-05	2.97929E-05	0.053102106

ELEC

kWh Electricity	CO2 (metric tons)	CO2e (from CH4)	CO2e (from N2O)	Total CO2e (metric tons)
10	0.002531032	1.02058E-05	1.62204E-05	0.002557458

Total Emissions from Building: 0.158445677

Table of Multipliers	
Gallons #2 Oil to MMBTU	0.1385
kg CO2 per mmBtu Oil	73.96
g CH4 per mmBtu Oil	3
g N2O per mmBtu Oil	0.6
Therms NG to MMBTU	0.0999761
kg CO2 per mmBtu NG	53.06
g CH4 per mmBtu NG	1
g N2O per mmBtu NG	0.1
kWh to MWh	0.001
lbs CO2 per MWh	558
lbs CH4 per MWh	0.09
lbs N2O per MWh	0.012
kg to metric ton	0.001
g to metric ton	0.000001
lbs to metric ton	0.00045359
CH4 GWP	25
N2O GWP	298

- **Figure B:** *UMass Amherst LARP Future of Mt Ida Project*

Appendix B - Incentives and Rebates

This section highlights some of the possible sources for incentives and rebates based on the recommended energy and sustainability measures. Some funding sources can only be used if the systems are owned by a third party since the University does not qualify for some incentives due to its status as a state entity.

General

Leading by Example Grants:

- Funding specifically for state entities
- "Feasibility Studies Grant Program for State Entities, Solar (Canopies & Other) and Innovative Solar Grant Program for State Entities"
- Source: https://www.mass.gov/service-details/leading-by-example-grants

Federal Tax Credits for Renewable Energy:

- This can only be used if a third party owns the system
- Geothermal Heat Pumps, Solar Energy Systems, Small Wind Turbines and Fuel Cells
- 30% if in service by 2020, 26% if in service after 2019 and before 2021, 22% if in service after 2020 and before 2022
- Source: https://www.energystar.gov/about/federal_tax_credits/2017_renewable_energy_tax_credits

Massachusetts Clean Energy Center

- Air-Source Heat Pumps, Ground-Source Heat Pumps, Solar Hot Water
- Source: https://www.masscec.com/government-non-profit/clean-heating-and-cooling

Department of Energy

- Lists additional resources, tools, programs, initiatives, and technical assistance sources
- Source: https://www.energy.gov/eere/services/states-and-local-communities

Mass Save

- Mass Save offers site assessments, rebates, and other incentives for efficient technology and efficiency improvements
- Source: https://www.masssave.com/

Database of State Incentives for Renewables and Efficiency (DSIRE)

- Lists state and country incentives for renewables and efficiency
- Source: https://programs.dsireusa.org/system/program?state=MA

DeployMass

- Assessed technologies with deployment funding
- Source: https://www.masscec.com/deploymass
- Technologies: https://www.masscec.com/deploy-mass-commercially-ready-technologies-list

Transportation

Eversource - EV Make Ready Program:

- Eversource pays for all infrastructure costs for new EV charging stations, the cost for charging stations must be paid for separately
- Source: https://www.eversource.com/content/ema-c/residential/save-money-energy/explore-alternatives/electric-vehicles
- Application: https://www.eversource.com/content/docs/default-source/save-money-energy/electric-vehicle-make-ready-application.pdf

Greenspot Car Share

- Will pay for charging stations and the car sharing is open to the public
- Newton worked with Eversource and Greenspot to build 2 charging stations, one used by the company and one for public use
- Source: http://joingreenspot.com/

The Massachusetts Electric Vehicle Incentive Program (MassEVIP)

- APPLICATION PERIOD HAS ENDED but there is a mailing list for updates on future similar opportunities: massevip.massdep@mass.gov
- “Helps property owners with publicly accessible parking acquire electric vehicle (EV) charging stations.”
- Source: https://www.mass.gov/how-to/apply-for-massevip-public-access-charging-incentives

Massachusetts Offers Rebates for Electric Vehicles (MOR-EV)

- Rebates for electric vehicle drivers up to $1,500
- Available for EV purchases through September 30th, 2019
- Source: https://mor-ev.org/

Clean Cities Coalition and Alternative Transportation/Massachusetts Clean Cities Coalition (MCCC)

- Promotes the move away from petroleum for vehicles
- Source: https://www.mass.gov/massachusetts-clean-cities-alternative-transportation