26 Nov 2021

Whitepaper

Achieving the University of Maine Commitment to Zero Carbon Emissions by 2040

I. Background and Context

The earth is experiencing an environmental crisis that will have negative economic and social consequences in Maine and in the United States that will soon dwarf the negative consequences of any other crisis experienced in modern human history. Governor Janet Mills makes a convincing case that the climate crisis poses a direct and immediate threat to Maine. However, she views the threat also as a major opportunity for developing clean energy sources, expanding and diversifying the Maine workforce with high paying jobs, and moving us toward energy independence while addressing the challenges brought about by climate change.[1]

The University of Maine is a charter signatory to the 2007 American College and University Presidents' Climate Commitment,[2] now known as the Carbon Commitment, and has developed a Climate Action Plan[3] with interim emissions reductions goals (20% by 2015, 40% by 2020, and 67% by 2030) to achieve net-zero greenhouse gas (GHG) emissions by 2040.[4]

Although some progress has been made, the University of Maine has experienced only a 10% overall reduction in carbon emissions between 2008 and 2020. We are far behind in achieving our interim emission reduction goals.

> The Faculty Senate strongly supports the University of Maine commitment to purchase a significant percentage of renewable electricity generated by Maine-based solar energy facilities.
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> Further, the Faculty Senate supports the University of Maine Energy Project (UMEP) which is a supply-side energy initiative that will also include the evaluation of demand-

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[1] https://www.maine.gov/governor/mills/news/speaking-united-nations-governor-mills-announces-maine-will-be-carbon-neutral-2045-2019-09-23

[2] Presidents' Climate Leadership Statement, http://secondnature.org/climate-guidance/the-commitments/#Climate_Leadership_Statement

[3] The University of Maine Climate Action Plan, 2010, http://reporting.secondnature.org/media/uploads/cap/427-cap_1.pdf

[4] Because greenhouse gases consist of several gases, the combination of the specific gases emitted from a facility is typically converted to a "carbon dioxide equivalent (CO_2e)" which is a term for describing different greenhouse gases in a common unit. (e.g., see https://www.era-environmental.com/blog/ghg-emissions-carbon-dioxide-equivalent-co2e)
The terms carbon neutrality, net-zero carbon emissions, net-zero CO_2e emissions, and net-zero greenhouse gas (GHG) emissions may often be used interchangeably in this document. When used in a general sense and for convenience we often use the term **net-zero GHG emissions**.
Under the current energy production environment, even technologies such as solar and wind energy require the expenditure of some GHG emissions in the mining of the materials from which the technologies are created and in manufacturing, transporting, installing and maintaining the capabilities. Thus, to reach net-zero GHG emissions, carbon expended on a project may be neutralized by purchasing equivalent "carbon offsets." The goal of carbon offsets is to counteract the greenhouse gas emissions that one cannot avoid causing. Ideally, carbon offset expenditures should be invested in projects that remove an equivalent amount of existing CO_2e from the atmosphere. Still, the long-term societal goal is to eliminate carbon emissions all together to avoid the need to use carbon offsets. This document sometimes refers to wind, sun, and hydro energy as "near-zero carbon emission sources" for energy generation

side energy projects, an electrical infrastructure study and improvements, and a campus steam system study and improvements.

Although only an interim step forward, the Faculty Senate also potentially supports the use of renewable, sustainable biomass to fuel any new campus steam facilities under consideration in order to decrease reliance on fossil fuels for heating.[5]

These three actions under consideration by the University of Maine administration will further decrease carbon emissions. They are good steps forward.

However, even with the aforementioned actions, not all UMaine ***electrical*** energy will be sourced from near-zero carbon emission energy generation facilities such as solar, wind, and hydro facilities. Further, while the use of biofuels will substantially reduce our use of fossil fuels for campus ***heating***, such fuels continue to emit substantial greenhouse gases into the atmosphere and involve some amount of carbon expenditure in transporting the biofuel to the campus to burn. Further, the university and its students and staff engage in ***further greenhouse gas emitting activities*** not directly controlled by the university (e.g., commuting travel, business travel, food procurement for meals, etc).[6] These latter sources will not decline in carbon intensity until society, as a whole, decarbonizes across all sectors.

All three of these emission categories (i.e., Scope 1: Heating, Scope 2: Electrical, Scope 3: University-Related Travel) need to be addressed to reach net-zero greenhouse gas (GHG) emissions by 2040. Reducing emissions from the last category will likely need to depend on acquisition of ***carbon offsets***[7] if society has not resulted in a transition to electric cars and other reduction methods by that time. Meeting the electrical and heating needs of the campus while maintaining net-zero GHG emissions might be achieved through a range or a combination of renewable energy procurement and energy consumption reduction methods

If the university pursues only its current planned actions, it will still remain well short of its commitment to achieve net-zero GHG emissions by 2040. At the very least, the university must commit to NO increase of its carbon footprint in any of these emission source areas. Further, it should aggressively move well beyond the current planned initiatives for GHG reductions.[8]

II. State of Maine Leadership

In 2019, Governor Janet Mills signed LD 1679 into law with strong support from the Maine Legislature to create the ***Maine Climate Council***. The law charged this group with developing a

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[5] Biomass combustion results in net-zero GHG emissions under the condition that new growth carbon sequestering equals or exceeds that emitted during burning. Therefore, when near-zero carbon energy generation is unavailable or economically infeasible in the near term, local biomass for local heating combustion may be an intermediate alternative to near-zero energy sources as part of the mix and progression in replacing fossil fuels.
[6] These Scope 3 carbon emissions for the University of Maine are estimated at a continuing rate of approximately 17,000 metric tons per year.
[7] The current cost of carbon offsets in U.S. commercial offset markets range from $5 to $10 per metric ton. However, these prices are very low due to a range of economic and regulation factors and are not at a current level that reflects a 1:1 ratio in that a 1-ton offset actually results in sequestering of a full ton of CO_2e or avoiding the addition of a full ton of CO_2e emissions into the atmosphere. Future prices may rise rapidly or become highly volatile depending upon government regulations. How Do Carbon Offsets Work? (https://www.washingtonpost.com/climate-solutions/2020/09/23/climate-curious-advice/) Carbon offset prices in Europe are already over $60 per ton.
[8] Until UMaine's scope 1, 2, and 3 emissions are in fact zero, it is the pledged responsibility of the university to offset all emissions in line with UMaine's incremental carbon commitment goals. For definitions of Scope 1, 2, and 3 emissions, see UMaine Climate Action Plan Update Spring 2021.

Maine climate action plan. The Council and six working groups involving more than 200 Maine people with diverse backgrounds carried out a comprehensive scientific and technical assessment about climate change in Maine. That work resulted in the report titled ***Climate Action Plan, Maine Won't Wait***.[9] The report presents numerous recommendations and transformational economic opportunities for Maine. Many of these should be adopted by and for the University of Maine as well as by other UMS campuses. Among the recommendations highly germane to the university's climate commitment include the development and growth of clean energy sources.

A wide array of practices will need to be implemented by the university to achieve net-zero GHG emissions by 2040. However, one of the more critical recommendations is to immediately cease any planned or proposed actions that will significantly expand the campus carbon footprint. The campus needs to immediately convert such actions to initiatives that will have neutral effects on the carbon footprint.

A report commissioned by the Maine Climate Council on *Strategy Recommendations to Mitigate Emissions and Support Resilience in Maine Buildings*[10] recommends that procurement rules be amended for state government, the University of Maine, and Maine Community Colleges to achieve low embodied carbon, zero emissions, zero energy, and resilience in new construction by 2025. ***There is no need to wait until 2025.*** All new construction immediately should be designed to achieve net-zero emissions during construction and during operation.[11] Alternatively, sufficient funds should be earmarked for the procurement of carbon offsets to achieve net-zero *GHG* emissions for the life of the structure. Such practices may and should be adopted immediately and before additional new campus construction proceeds in order to allow us to more realistically meet our 2040 Carbon Commitment.

The Maine Climate Action Plan championed by the governor indicates that publicly funded buildings should ***Lead by Example***. "This will save taxpayers money and show how modern design and construction materials, combined with efficient systems and practices, can reduce both emissions and the operating costs of state and local government buildings, schools, universities, and affordable housing."[12]

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[9] Maine Won't Wait, Climate Action Plan, Maine Climate Council, https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineWontWait_December2020.pdf

[10] Strategy Recommendations to Mitigate Emissions and Support Resilience in Maine Buildings, https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/BuildingsInfraHousingWG_FinalStrategyRecommendations_June2020.pdf

[11] See Advanced Energy Design Guide for Small to Medium Office Buildings: Achieving Zero Energy (2019) by ASHRAE, The American Institute of Architects, Illuminating Engineering Society, U.S. Green Building Council, and U.S. Department of Energy. "Zero energy buildings are designed first to significantly reduce energy consumption and then to meet remaining loads with renewable resources, ideally located on site. These buildings are usually connected to the utility grid to receive energy whenever renewable energy production is insufficient to meet required loads and to return energy to the grid when renewable energy production exceeds the loads." (Page 1)."The cost to obtain zero energy has dropped from over 20% of the project budget in 2009 to less than 4% of the project budget on some recent zero energy projects. This reduction is due to advances in energy conservation technologies, the reduced costs of these technologies, and the reduced costs of renewable generation systems. Meanwhile, estimated building construction costs on the same projects ranged from plus to minus 8% of the projected bid costs. This means that the cost to add zero energy is often within the expected window for bid results." (Page 15 and Fig. 2-2) "As this Guide shows, zero energy office buildings can also have lower maintenance costs. Many energy-efficiency strategies result in less operational time for mechanical and electrical equipment. Reducing the strain on this equipment yields reduced maintenance costs. The most effective systems are simpler and smarter." (Page 4)

[12] Lead by Example Report, 2021, https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/Lead%20By%20Example_2021.pdf. Further, the use of wood-based building materials, such as mass timber and wood fiber insulation, have lower embodied carbon than other more traditional building materials, such as steel and concrete. "Embodied carbon" includes all of the carbon emitted to create the material or product including that emitted

Thus, in constructing any new building or in refurbishing older buildings to serve University of Maine needs:

(a) the unavoidable GHG emissions expended to construct the building should be offset through purchase of carbon offsets, or through the University's own carbon sequestering practices,

(b) the structure should be designed and built using rigorous environmentally responsible best practices such as in selection of climate friendly building materials, provisioning of low energy lighting, heating, and cooling systems, and use of energy efficient construction and weatherization,[13]

(c) the energy supplied for electricity and heating for the expected life of the building should come from near-zero carbon emission energy sources[14] or the costs of sequestering unavoidable CO_2e emissions from energy use over the life of the building should be covered by the initial building construction budget, and

(d) best practices must be rigorously followed in the accounting of carbon emissions and carbon emission offsets.

By following these principles, building projects may require some increased funding for initial construction and energy infrastructure accommodations.[15] Yet often the increase is minimal and may even be less expensive. Even if more expensive initially, in the long-term, energy costs should be much more stable and lower as the negative financial effects of climate change grow. In addition, the governor's office and the legislature may be willing to support state funding or bond initiatives for "showcase" state projects that clearly demonstrate the ability to address

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from energy used to extract and transport raw materials as well as emissions from manufacturing processes. The use of wood-based materials also supports the Maine economy.

[13] **LEED** (Leadership in Energy and Environmental Design) Certification focuses on green construction and green design of a building, but the certification does not have a rating for after the project is complete. It's possible the tenants of a LEED-certified building are using more energy or water than tenants in other buildings, despite design efforts to reduce usage. While LEED certification at the silver level or above should be pursued for each building, the primary focus of this document is on sustainable solutions to reduce the building's long-term carbon footprint.

[14] The campus might supply its own energy plant such as through one or more near-zero carbon emission sources (example: solar or wind energy facilities). However, the university might also contract for long-term electric service from one or many Maine-based businesses to supply near-zero carbon emission electric energy and thus help grow the green energy private business sector in Maine.

Most current zero-carbon infrastructure visions for the future envision conversion to electric supply of energy across networks to meet demand using wind, solar, and any additional near-zero carbon emission sources (e.g., hydro, hydrogen, etc.). Electric heating in buildings using filaments is far less energy efficient than electric heating through liquid circulation systems. The high temperatures required for steam heat circulation result in much more energy expenditure as compared to water circulation heating and cooling systems. As a result, one strong option for campus new construction and building refurbishments is to deploy water heating and cooling circulation systems powered by electricity driving ground-source heat pump systems (also known as geothermal heat pumps). See https://www.energy.gov/eere/geothermal/geothermal-heat-pumps.

Heat pumps may be deployed on a building-by-building basis but also be designed to support a more efficient heat pump network connecting all campus buildings over time. All pumps would eventually be powered by near-zero carbon generated electricity. At the very least, even if using carbon offsets for a specific building project to temporarily achieve net-zero carbon emissions, all new facilities should be built to be "zero-carbon ready." By example, a new building might be built with a water heating system utilizing a heat exchanger with steam supplied from a campus steam plant that burns biofuels and/or fossil fuels. Thus, future conversion to full electric for the building would be built into the design. The best long-term option to achieve the 2040 commitment would likely be to convert to full electric energy for all new construction and convert existing buildings to full electric over time.

[15] Appendix 1 provides in illustrative computation of predicted energy use and CO_2e emissions for a building recently constructed on the University of Maine campus. In alignment with the literature cited in footnote 11, the cost to add net-zero energy accommodations would likely have been very minimal when compared to the overall cost of constructing this major new building and within the standard bidding approximation factor of plus or minus 8%.

climate change challenges while growing Maine's work force, stimulating the economy, supporting innovation in arriving at solutions, and providing new opportunities for clean energy businesses in Maine.

III. A University Vision for Future Growth and Sustainability

Proposition: Within 10 years, the University of Maine will be well known as a destination campus for students from across the nation and the globe that want to make a difference. Why? Because the University of Maine and UMS are preparing and engaging students collaboratively across all disciplines in addressing the world's most pressing current and emerging societal challenges. Across and among its many scholarly domains, whether in regard to acquiring education and skills for the workforce of tomorrow, engaging in undergraduate and graduate research experiences, or advancing and critically analyzing new knowledge and innovations, all students are engaged in helping to address the next emerging crises affecting Maine, the nation, and the world. The University of Maine remains up-to-date and always relevant in responding to critical societal needs. Across and among all of its colleges and programs the University of Maine by 2030 has already focused considerable combined energies to comprehensively address the technological, social, economic, and environmental challenges of climate change. It is not only talking the talk, but also walking the walk by being the first land grant university in the nation to achieve net-zero carbon emissions. It has become a magnet for students, researchers, educators, and industry partners that are interested in working collaboratively and from multiple perspectives in helping the nation respond to the climate crisis. Opportunities have expanded for graduates across all of our disciplines as students develop as researchers and leaders in what is becoming the future of all sustainable institutions.

With the current Governor of Maine and President of the United States marshaling and directing resources toward similar visions for the state and nation, the timing is right for action by the University of Maine and the University of Maine System.

Summary

For over a decade, the University of Maine has continued to emit greenhouse gas emissions each and every year well beyond that which would have been emitted if it had been making consistent progress toward its commitment of net-zero carbon emissions by 2040. The university is falling far short. The regularly published national progress report by the University of Maine shows that we have actually increased carbon emissions to back over 60,000 metric tons of CO_2e in the most recent reporting year rather than decreasing emissions.[16] We have moved in the wrong direction.

We, the faculty of the University of Maine, as represented by the duly elected members of the Faculty Senate, affirm that we believe in science and the climate science conclusions reached and published by our own faculty and their national and international peers. They inform us that we are already at the beginning of a climate crisis the likes of which humanity has never witnessed. We believe that the University of Maine has much to offer and should take a leadership role in addressing the societal and scientific challenges of tomorrow. A first and important step is to honestly assess our performance toward and step up our progress in meeting our professed climate commitment. As Governor Mills has indicated, the situation presents a golden opportunity for Maine to come out as a leader in addressing the climate crisis while at the same time gaining huge economic, infrastructure, and well-being benefits. The

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[16] University of Maine CO_{2e} Progress Report, https://reporting.secondnature.org/institution/detail!1906##1906

University of Maine can be a shining exemplar in making envisioned benefits happen and provide hope, inspiration, and prosperity for future generations.

IV. Faculty Senate Motions

The Faculty Senate hereby approves the following motions:

- <motions will be developed after receiving campus community feedback>
- TBA
- TBA

Lessons from the Past: Numerous motions have been made in past years by the Faculty Senate and student governments directed to the University of Maine Administration and the UMS Board of Trustees that addressed the need to keep on track in achieving zero carbon emission commitments and to divest from any forms of investment in the fossil fuel industry. For over a decade, those motions have resulted in little to no substantive progress through a succession of administrators.[17] For over a decade, the university has continued to produce greenhouse gas emissions each and every year well beyond that which would have been emitted if it had been making consistent progress toward net-zero carbon emissions by 2040. It is time for the Faculty Senate to become more actively engaged.

[17]See, for instance, approved 2015 Faculty Senate Divestment Resolution. While the UMS Board of Trustees continues to avoid fossil fuel divestment, State of Maine Legislature bill LD99 now bans public investments in fossil fuels. "The bill requires the $17 billion Maine Public Employee Retirement System (PERS) to divest $1.3 billion from fossil fuels within five years, and orders the state Treasury to do the same with all state funds." https://www.ai-cio.com/news/maine-becomes-first-state-to-pass-fossil-fuel-divestment-bill/ See also https://legislature.maine.gov/legis/bills/display_ps.asp?LD=99&snum=130, Enacted, Jun 16, 2021, Governor's Action: Signed, Jun 16, 2021

Appendix 1

Computation of Energy Use and CO_2e Emissions for a University Laboratory Building

Industrial building energy modelers are normally employed to accurately calculate the energy expended to construct a large building and to provide the building with heat, electricity, and maintenance services on a yearly basis over the life of the building. Based on the energy sources to be used, they also compute the expected *CO_2e emissions.* The following paragraphs very roughly estimate the CO_2e emissions for a building recently constructed on the University of Maine campus and the costs to bring it down to net-zero emissions over the life of the building.

1. Building Use: Operational Long-term Energy Consumption and Greenhouse Gas Costs

Very roughly, "Laboratories in the U.S. are energy-intensive facilities that use anywhere from 30 to 100 kilowatt-hours (kWh) of electricity and 75,000 to 800,000 Btu of natural gas per square foot annually. Actual use varies with such factors as the age of the facility, the type of research done there, and the climate zone in which the lab is located. In a typical laboratory, lighting and space heating account for approximately 74% of total energy use." (Reference: https://ouc.bizenergyadvisor.com/article/laboratories).

Thus, for a recent four-floor steel, concrete, and brick university building with 110,000 square feet of floor space, the energy consumption per year might range approximately as follows:

Low Energy Estimate for Building	High Energy Estimate for Building
Electricity: 30 kWh/sf/year x 110,000 sf = 3,300,000 kWh/yr	Electricity: 100 kWh/sf/year x 110,000 sf = 11,000,000 kWh/yr
Heating (assuming natural gas): 75,000 Btu/sf/year x 110,000 sf = 8,250,000,000 Btu/year	Heating (assuming natural gas): 800,000 Btu/sf/year x 110,000 sf = 88,000,000,000 Btu/year

Let's assume these numbers represent the entirety of the annual energy use for the building.

UMaine Energy Use Emissions Factors:
Electricity = 0.000236929 (MT CO_2e/kwh)
UMaine uses the Iso-New England electrical grid average with a correction factor applied to account for residuals.
Natural Gas = 0.053166722 (MT CO_2e /MMBTU)
The Central Steam Plant runs primarily on two Natural Gas Boilers with a third boiler running on #6 Fuel Oil during only the coldest days of winter.
#6 Fuel Oil = 0.474436451 (MT CO_2e /Barrel (42 gallons per Barrel))
The #6 oil-fired boilers are only fired up during the coldest days of winter, the rest of the year the Steam Plant runs on Natural Gas.

Let's also roughly assume that UMaine annual CO_2e emissions for the energy needs of the new 110,000 sq ft laboratory building are generated only by electricity drawn from the New England electric grid and only natural gas burned in the UMaine steam plant.

Low CO_2e Emissions Annual Estimate	High CO_2e Emissions Annual Estimate
Electricity: 3,300,000 kWh/yr x 0.000236929 (MT CO_2e/kwh) = 782 MT (metric tons) CO_2e per year	Electricity: 11,000,000 kWh/yr x 0.000236929 (MT CO_2e/kwh) = 2,606 MT (metric tons) CO_2e
Heating (assuming natural gas):	Heating (assuming natural gas):

8,250,000,000 Btu/year x 0.053166722 (MT CO_2e /MMBTU) x (1MMBTU/1,000,000 Btu) = 439 MT (metric tons) CO_2e per year	88,000,000,000 Btu/year x 0.053166722 (MT CO_2e /MMBTU) x (1MMBTU/1,000,000 Btu) = 4,678 MT (metric tons) CO_2e per year
TOTAL = 1,221 MT (metric tons) CO_2e per year	TOTAL = 7,284 MT (metric tons) CO_2e per year

The UMaine campus as-a-whole produces approximately 60,000 metric tons per year of CO_2e so this recent single building alone is likely increasing the yearly emissions of the campus somewhere between 2% and 12%. We would guess it to be on the higher end of this scale. However, a professional building energy modeler would need to be employed to make a much more concise estimate.

Let us assume that this new building produces 5,000 MT (metric tons) CO_2e per year. Let us also assume the carbon offset investment costs over a life span for this building for say 50 years will be at a predicted annual average price of say $10 per MT. Using these assumptions (5000 MT/yr x 50 yr x 10 $/MT) the initial cost to fund the building should be increased by about $2.5 million dollars. This amount would of course cover only the annual CO_2e offset costs and not the yearly energy costs. All of these numbers are highly speculative and subject to wide variations depending on the specific building, the specific fuels used, the volatility of the carbon offset market, the cost to actually sequester the CO_2e amount versus the market price for offsets, time value of money, and a host of additional factors that could be best approximated by a specialist.

2. Construction: Embodied Short-term Energy Consumption and Greenhouse Gas Costs

Operational carbon is that released over the life of a building whereas embodied carbon is released during the year the building is constructed. Embodied carbon includes the energy to create the building materials as well as the energy expended in the construction process. Using a very simplistic calculator for embodied carbon for a 110,000 sf building with 4 stories above grade, a landscape disturbance no greater than the first story floor plan, and averaging between steel versus concrete building construction, the computed embodied CO_2e for this project based on estimates from previous projects is probably between 3,231 metric tons and 4,881 metric tons (http://www.buildcarbonneutral.org/). Thus, the embodied carbon released to construct the project might be about 4,000 MT (metric tons). In the initial construction year let us assume a $10 per MT cost of sequestering unavoidable CO_2e, the initial cost to fund the building should be increased by another $40,000 dollars. Again, such a number is highly speculative and could best be approximated by a building energy modeler.

3. Total Carbon Offset Costs for a Single University Building

The goal of making some rough computations here is to indicate through an example for a single building the likely costs (plus or minus perhaps a factor of 5) to achieve net-zero carbon emissions for a single building project. The construction budget for the university building described above was about $75 million dollars.

As indicated above, the carbon offset costs incurred to initially construct a university lab/classroom/office building of this size might be about $40,000**.** The costs to handle the offsets over the life of the building would be approximately $2.5 million. Together these costs would raise the fundraising goal for the building by somewhat over $2.5 million dollars. Although our rough estimates are speculative, this is less than 3.3% of the $75 million cost of the building. Anything under 5% would certainly appear to be a very reasonable onus for building advocates to bear. (See footnote 15).