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**Whitepaper**

Zero Carbon Commitment Subcommittee

University of Maine Faculty Senate

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

This white paper is meant to help members of the campus community better understand the challenges the university faces in addressing issues arising from the global climate crisis.

Among core questions being asked of the campus administration include:

1. What technological approaches are being explored for achieving the campus net-zero carbon commitment by 2040?
2. Which approaches are most likely to achieve the goal by 2040 and be sustainable over time? What are the benefits and drawbacks of each?
3. What are the predicted costs of each of the potentially successful approaches?
4. What will be the means to finance the approach chosen in order to meet the net-zero carbon commitment by 2040?

This paper addresses some of the same questions through the efforts of volunteer contributions from faculty scientists, researchers, and others. It reviews a range of actions that the university could and/or should take. Feedback from a forthcoming survey of campus community students, faculty, staff, and administrators based on issues discussed in the paper will help the Faculty Senate formulate a set of motions to be forwarded to the campus administration for action.

**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]](#footnote-1)

The University of Maine is a charter signatory to the 2007 American College and University Presidents’ Climate Commitment,[[2]](#footnote-2) now known as the Carbon Commitment, and has developed a Climate Action Plan[[3]](#footnote-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]](#footnote-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 and hydroelectric generation facilities and also encourages the purchase of wind power.

Further, the Faculty Senate supports the University of Maine Energy Project (UMEP) which is a supply-side energy initiative that also includes the evaluation of demand-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 and reservedly supports the use of renewable, sustainable biomass to fuel temporarily the campus steam facilities in order to decrease reliance on fossil fuels for heating.

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[[5]](#footnote-5) would substantially reduce our use of fossil fuels for campus ***heating***, even renewable biofuels 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.[[6]](#footnote-6) Further, the university and its students and staff engage in ***ongoing greenhouse gas emitting activities*** not directly controlled by the university (e.g., commuting and business travel).[[7]](#footnote-7) These latter sources will not decline in carbon intensity until society, as a whole, decarbonizes across all sectors.

All three of these GHG 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***[[8]](#footnote-8) 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 the three GHG emission categories. Further, it should aggressively move well beyond the current planned initiatives for GHG reductions.[[9]](#footnote-9)

**II. Scientific Evidence for Urgent Action**

A core aspiration of the ***2015 Paris agreement****[[10]](#footnote-10)* on climate change was to keep the world within 1.5°C of global warming above pre-industrial levels. At the end of ***COP26 UN Climate Change Conference*** in Glasgow, Scotland in November 2021[[11]](#footnote-11), climate and earth scientists observed that based on the updated provisions agreed to at the conference, the planet will almost certainly miss the 1.5 degrees Celsius warming target. The ***climate clock***[[12]](#footnote-12) for reaching this limit is likely now anywhere from approximately seven to eleven years away depending on the scientific studies cited.[[13]](#footnote-13)

According to the more conservative scientific consensus ***Intergovernmental Panel on Climate Change*** reports, the earth is on track to reach 1.5 degrees C warming within the next 9 to 31 years with high confidence.[[14]](#footnote-14) A global rise of 1.5 degrees C is a best-case scenario. The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (2021) states that:

• Human influence has warmed the climate at a rate that is unprecedented in at least the last 2000 years.

• Averaged over the next 20 years, global temperature is expected to reach or exceed 1.5°C of warming

• Unless deep reductions in CO2 and other greenhouse gas emissions occur in the coming decades, global warming of 1.5°C and even 2°C will be exceeded

For many scientists the goals of both 1.5 and 2 degrees are beginning to look widely out of reach based on the lack of government commitments at Glasgow to stay under these limits.

***Why holding to 1.5°C to 2°C is Important:*** Within 1.5 to 2 degrees of warming, scientists predict that numerous abrupt ecological and climate system disruptions will occur or be put in motion.[[15]](#footnote-15) IPCC Special Reports published in 2018 and 2019 as reported in Nature indicate that tipping points could be exceeded even between 1 and 2 degrees of global warming.[[16]](#footnote-16) Unless deep reductions in greenhouse gases are achieved, a wide range of reported scientific modeling predictions indicate that we are more likely than not to witness a series of looping or tipping point events resulting in a sort of chain reaction accelerating global warming.[[17]](#footnote-17) Because the computer modelling is so complex, there is no scientific consensus in reliably predicting the extent to which and when looping interactions will occur and the conditions under which they will be irreversible for all practical purposes.

In 2013, the Intergovernmental Panel on Climate Change reported that under a worst-case scenario of humans doing nothing to slow climate change, global temperatures may increase by 4 degrees Celsius or more by the year 2100. That is less than eighty years away. "The Earth has not been that warm in millions of years, and such temperature spikes in our planet’s history are connected to mass extinction events that killed off a large percentage of species that existed at the time." “There is a genuine possibility that within the coming century, we will hit temperatures that are deeply incompatible with the continued existence of human life.”[[18]](#footnote-18)

We are already well into the sixth mass global extinction.[[19]](#footnote-19) This one is being caused primarily by humans. Modern homo sapiens has existed on earth for approximately 200,000 years. A mere blink in geologic time. If the accumulating science community projections are correct and humans fail to respond, humanity may be extinct or close to it within the next hundred years. Humans will take a lot of other species with them. Earth will survive but humanity is facing an existential crisis. If even half of the consensus IPCC report findings and the accumulating modeling projections from wide-ranging scientific disciplines are reasonably accurate, these scientifically-based and often conservatively cautious predictions should be taken seriously.

If we listen to the predictions of the scientific community, what might the predictions mean for the future of the campus? Among other things, it probably means that a compulsory carbon market and/or carbon taxes will likely be imposed within years rather than decades. This would make fossil fuel and carbon offset prices very high and volatile. Thus, any major investment in fossil fuel infrastructure on the campus would probably end up being a very poor financial investment in the decades ahead.

Huge challenges create huge opportunities. The U.S. auto industry gets it. It is shifting major segments of its production to electric vehicles capable of being powered by clean solar, wind, and other near-zero carbon emission energy sources. Our current U.S. president gets it. He is proposing bold environmental goals for the nation with a focus on electric power to be supplied by clean energy sources as well as investments in clean energy research and development. Our current Maine governor gets it. Among other actions, she has incentivized rapid substantial growth in solar and wind energy generation in Maine. The University of Maine needs to follow suit.

**III. 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 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***.[[20]](#footnote-20) 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 or decrease it.

A report commissioned by the Maine Climate Council on *Strategy Recommendations to Mitigate Emissions and Support Resilience in Maine Buildings[[21]](#footnote-21)* 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.[[22]](#footnote-22) 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.”[[23]](#footnote-23)

**IV. New Construction on the University of Maine Campus**

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,[[24]](#footnote-24)

(c) the energy supplied for electricity and heating for the expected life of the building should come from near-zero carbon emission energy sources[[25]](#footnote-25) or the costs of sequestering unavoidable CO2e 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.[[26]](#footnote-26) 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” projects that clearly demonstrate the ability to address 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.

Most industrial zero-carbon infrastructure visions for the future envision conversion to electric supply of energy distributed 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 electric ground-source heat pump systems (also known as geothermal heat pumps).[[27]](#footnote-27)

Heat pumps may be deployed on a building-by-building basis but also could be designed to support a heat pump network connecting clusters of buildings or 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 the campus steam plant that burns renewable biofuels. Thus, future conversion to full electric for the building would be built into the design. The best long-term option environmentally to achieve the 2040 commitment would likely be to convert to full electric energy for all new construction and aggressively convert existing buildings to full electric as quickly as possible.

**V. Refurbishing versus Phasing Out the University of Maine Steam Plant**

Currently, burning of fossil fuelsin the University of Maine Central Steam Plant provides heating for most buildings on campus.Numerous technical options exist for achieving net zero carbon emissions for campus heating by 2040. Some of these are listed below:

*Progressive Conversion to All Electrical Power Supplied by Solar and Wind:* Extending from the previous discussion, the first option would be to convert most campus buildings over time to allow them to be heated, cooled and powered by energy supplied by wind and solar farms. All new construction as well would be based on energy needs being met by these or similar future near-zero carbon emission sources. Solar and wind energy systems during their operation do not directly produce air pollutants or greenhouse gases. The GHG emissions produced in the mining, manufacture, transport, installation, operation, and disposal of solar panels and wind systems is a very small fraction of that required for similar production and support operations of fossil fuel energy generation. This proven technology is not without it’s challenges. For example, a geothermal heat pump approach might need a backup heat source for the coldest days of the year. After a period of transition, the all-electric option could negate the continuation of the current steam plant and eliminate the burning of any fuels for heating or electricity on the campus by 2040. In the meantime, the steam plant might continue to burn fossil fuel or be converted to burn renewable biofuel.

*Conversion to Renewable Biofuels to meet Most Near-Term Heating Needs****:*** Another option that would eliminate the burning of fossil fuels on campus in the near term would be to convert the current steam plant to burn renewable biofuels. This would eliminate any burning of fossil fuels for heating except perhaps in times of peak demand. Burning wood as a biofuel still creates pollution on the campus and counting it as a renewable energy resource as deployed in practice in other large-scale operations has been highly controversial.[[28]](#footnote-28) This option also raises the question as to whether conversion to renewable biofuel energy production for the campus would be economically worthwhile if the need for such fuels and the need for the steam plant will cease to exist after 2040.

*Conversion to Renewable Biofuels to meet Long-Term Heating Needs****:*** A third optionwould be to convert the steam plant to burn renewable biofuels and count on this as the long-term renewable energy net-zero emission solution for most campus heating. This approach has significant advantages but also potential major disadvantages in meeting the campus zero-carbon emission commitment. The best biofuel solution, if pursued, might be to redesign and reconstruct the heating plant to serve as a showcase example of how a campus-wide system might be converted to use and enforce very high renewable energy and pollution control standards while providing the ability to use the cheapest renewable fuel option (solid, glass, liquid) as biofuel technologies advance over time. Consult Appendix 2 for concerns and arguments on both sides of the issue.

The above three options are among many that might be considered. As mentioned earlier, what would the university’s consulting experts predict as to costs for each of these approaches that have promise in meeting the net-zero carbon commitment by 2040? What would be the potential means to finance each approach?

Direct energy generation from the sun and wind for heating and electrical demands appears to be the best current long-term solution in actually achieving a net zero-carbon commitment for any major institution such as a university. Investment in electric infrastructure is required to support the direct use of sun, wind and tidal energy. Thus, if an interim biomass solution is pursued, any institution set on actually achieving net zero carbon emission goals will also likely need to start a process of constructing new buildings and converting existing buildings to use near-zero carbon energy sources.

**VI. 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 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.

**VII. 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 Carbon Commitment of net-zero GHG 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 CO2e in a recent reporting year rather than decreasing emissions.[[29]](#footnote-29) We have moved in the wrong direction.[[30]](#footnote-30)

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

**VIII. Faculty Senate Motions**

The Faculty Senate hereby approves the following motions:

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

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.[[31]](#footnote-31) It is time for the Faculty Senate to become more actively engaged.

**Appendix 1**

**Computation of Energy Use and CO2e 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 *CO2e emissions.* The following paragraphs very roughly estimate the CO2e 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 CO2e/kwh)

UMaine uses the Iso-New England electrical grid average with a correction factor applied to account for residuals.

**Natural Gas** = 0.053166722 (MT CO2e /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 CO2e /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 CO2e 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 CO2e Emissions Annual Estimate** | **High CO2e Emissions Annual Estimate** |
| Electricity:  3,300,000 kWh/yr x 0.000236929 (MT CO2e/kwh) =  782 MT (metric tons) CO2e per year | Electricity:  11,000,000 kWh/yr x 0.000236929 (MT CO2e/kwh) =  2,606 MT (metric tons) CO2e |
| Heating (assuming natural gas):  8,250,000,000 Btu/year x 0.053166722 (MT CO2e /MMBTU) x (1MMBTU/1,000,000 Btu) =  439 MT (metric tons) CO2e per year | Heating (assuming natural gas):  88,000,000,000 Btu/year x 0.053166722 (MT CO2e /MMBTU) x (1MMBTU/1,000,000 Btu) =  4,678 MT (metric tons) CO2e per year |
| TOTAL = 1,221 MT (metric tons) CO2e per year | TOTAL = 7,284 MT (metric tons) CO2e per year |

The UMaine campus as-a-whole produces approximately 60,000 metric tons per year of CO2e 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) CO2e 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 CO2e 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 CO2e 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 CO2e 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 CO2e, 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 21).

***Appendix 2***

***Benefits and Drawbacks of Using Wood as a Renewable Energy Biofuel on the University of Maine Campus***

The state of Maine has working forests that have been regularly harvested for hundreds of years. To ensure a sustainable supply of wood product source materials, Maine’s working forests are managed for a range of tree species and stand structures, which allows them to provide an ongoing supply of woody biomass in addition to a multitude of additional ecosystem services such as biodiversity, clean water, clean air, and recreation. Such management promotes the healthy composition, density, and growth of natural regeneration.

There is more forest biomass today than at any other time in Maine's recent history and this will likely increase due to ongoing sustainable management efforts. Approximately 89% of the state is forested and of that, ~50% is third-party certified by the Forest Stewardship Council (FSC) or the Sustainable Forestry Initiative (SFI).[[32]](#footnote-32) Maine’s working forest biomass is considered renewable over a multi-decadal timeframe (~35 to 80-years, varying with latitude, tree species, and use) providing it is sustainably managed to promote healthy regeneration.

Residual (“waste”) biomass is produced as a by-product of timber harvesting operations for lumber and pulpwood. Driven by consumer demand for sustainable products and various state and federal regulations, many pulp and lumber operations in Maine depend primarily on FSC and SFI certified source material to remain competitive. If the waste biomass to be burned is taken only from sustainably harvested forests, the carbon from each tree will be re-sequestered in a continuing cyclic process. This cyclic process is ongoing as Maine forests have been regularly harvested for hundreds of years. Local surveys have shown that over one million tons of waste biomass are produced on an annual basis within a 50-mile radius of the campus. The collection and use of waste biomass from the forest floor has the additional benefit of reducing fire risk.

Fossil fuels take hundreds of millions of years to re-sequester the carbon released from their burning, so for all intents and purposes they have a permanent negative carbon impact. To remain carbon neutral through the burning of renewable biomass, UMaine would need to commit to burning only waste biomass from sustainably harvested forests. Under sustainable practices, waste from the pulpwood and lumber extraction process is often left to decompose on the forest floor or burned in place. This waste wood could instead be burned in a central steam plant facility and thus would displace ongoing fossil fuel use.

The UMaine campus GHG stack emissions for heating are currently about 35,000 metric tons of fossil CO2e per year. By burning renewable biomass, many more metric tons of renewable CO2e per year would be emitted into the air on campus each year. If computed, planned and enforced appropriately and conservatively, the CO2e emitted per year would be balanced out through new growth. It is also worth noting that the carbon balance from burning sustainably certified renewable biomass is not exactly zero, even after the trees have fully regrown, because energy is used during the harvesting, processing, and transportation of the resource. Studies show that under a typical scenario, it takes ~2.1 gallons of diesel fuel to fell, skid, chip, and transport one green ton of biomass fuel (actual use will vary by harvest type, equipment used, distance to market and other factors).

For air emission reporting purposes to state and federal agencies, UMaine is required to report onsite combustion emissions (also known as stack emissions or burner-tip emissions), not offsite affiliated emissions. As a result, the diesel fuel used to harvest and process renewable biomass would not be counted in UMaine’s official GHG emissions profile. When a Life Cycle Assessment (LCA) of energy systems is conducted, offsite affiliated emissions are included. Studies show that the life-cycle GHG emissions from renewable biomass energy systems are more than an order of magnitude less than those from equivalent fossil natural gas systems.

While in theory, biofuels could be deployed to result in net-zero carbon emissions, the current track record in the use of wood biofuels in practice has been highly controversial.[[33]](#footnote-33) Among the critiques raised include that even though burning wood emits far more CO2e from a smokestack than burning oil or gas, the adverse warming effects of wood burning and its increases in emissions over fossil fuels is not offset until decades later. An increase in facilities burning wood over fossil fuels will increase actual CO2e emissions for decades. Further, there is no binding governmental or industrial oversight that ensures that forests grow back or that the growth will actually offset the carbon load already emitted into the atmosphere. It is common practice to replant hardwood forests with fast-growing pines for biomass production which actually decreases the carbon density of wooded areas. The pellet production industry routinely insists that it uses only the wood bits not used for other purposes (i.e., waste) yet the definition of waste is extremely loose and full logs are often used in the pellet production process. All of this results in a “gaming” of the renewable energy accounting system for biomass. Further, wood biomass is far less energy dense than most fossil fuel alternatives and has high variability in the biomass material. This makes its burning less efficient and often dirtier than fossil fuels. Because it takes so long under current technology to start up, increase, and shut down the burning of wood biomass, a backup source of heat generation is still needed to deal with startup and peak loads. Thus, an ongoing dependency on alternative fuel burning typically continues in such operations.

It should be noted that these drawbacks in current practices are drawn from references critical of the wood pellet industry in an international context. This does not negate the existence of similar concerns that would need to be addressed in the burning of wood waste in a large-scale operation such as might be proposed for the University of Maine.

Regardless of its potential drawbacks, if a wood burning interim solution is pursued for the University of Maine steam plant to decrease near-term net-zero carbon emissions for the campus, the critiques of the use of wood as a renewable resource should be addressed by any campus implementation. Stringently drafted contracts with high penalties for violation should restrict wood suppliers to use only waste wood not suitable for other primary purposes (e.g., pulp and lumber), the waste must be acquired from only FSC Certified sustainable wood parcels or cast-off waste from lumber mills that saw wood primarily from certified sustainable growers, and the carbon sequestering through new growth each year must verifiably offset the carbon emitted that year from the steam plant. If land from which biofuel has been obtained is no longer used as *working forest* in the future such as through land use change, then contractually enforceable penalties should be payable to the university in an amount sufficient to purchase carbon offsets to achieve carbon neutrality for the land in question for the remainder of the 50 years. Further, the trucking of wood waste to the campus for burning (i.e., many large truckloads each and every day) and removal of ash must be included in the CO2e emission computations. Truck deliveries should occur other than at times when classes are in session and enforced by contract. In addition to CO2e emissions, smoke from the burning of wood contains particulate matter and other pollutants that should be stringently controlled and/or recaptured through appropriate design, regular testing, and maintenance requirements.

Use of near-zero carbon emission energy sources such as solar or wind do not raise this plethora of concerns. Solar and wind energy systems during their operation do not directly produce air pollutants and greenhouse gases nor do they require the continued transport operations, data tracking, and enforcement burdens that biomass burning involves. As such, wood burning and biomass burning in general is not a substantial nor viable generalizable solution for addressing carbon emissions for the nation. However, wood burning might be assessed for consideration in a state such as Maine where waste wood is abundant, nearby, and perhaps could be economically viable in meeting some short-term fossil fuel reduction goals. A better biofuel option might be to redesign the steam plant to be able to use a range of biofuel options (solid, gas, liquid) so that when biofuel technologies advance over time the university may switch to cleaner, cheaper and easier to transport net-zero GHG emission biofuels as needed.

The question remains whether the campus should invest limited campus financial resources first and foremost in incremental achievement of the long-term zero-carbon commitment goal of 2040 by advancing electrification and near-zero carbon emission energy infrastructure. Or should the campus instead invest financial resources to achieve some interim net reduction goals in the next decade through wood burning in order to provide breathing space for achieving the long-term commitment? Several detailed financial analyses incorporating many predictions about future costs would better position decision-making. Yet the need for a decision in moving forward is great even in the face of many uncertainties.

1. <https://www.maine.gov/governor/mills/news/speaking-united-nations-governor-mills-announces-maine-will-be-carbon-neutral-2045-2019-09-23> [↑](#footnote-ref-1)
2. Presidents' Climate Leadership Statement, <http://secondnature.org/climate-guidance/the-commitments/#Climate_Leadership_Statement> [↑](#footnote-ref-2)
3. The University of Maine Climate Action Plan, 2010, <http://reporting.secondnature.org/media/uploads/cap/427-cap_1.pdf> [↑](#footnote-ref-3)
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 (CO2e)” 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 CO2e 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 GHG emissions that one cannot avoid causing. Ideally, carbon offset expenditures should be invested in projects that remove an equivalent amount of existing CO2e 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 [↑](#footnote-ref-4)
5. Primary biofuels refer to organic materials used primarily for heating purposes and electricity production. Examples include wood chips and pellets typically left in their natural state and burned. Secondary biofuels include processed biomass usually resulting in liquid fuel such as ethanol or biodiesel that are also burned. Extensive research into development of crops and methods for extraction of combustible biofuels that might produce energy more efficiently is ongoing. See <https://biofuels-news.com/news/future-trends-in-biofuel/> [↑](#footnote-ref-5)
6. Biomass combustion results in net-zero GHG emissions under the condition that the carbon sequestered by new growth equals or exceeds that emitted during burning. Therefore, when near-zero carbon energy generation is unavailable or economically infeasible in the near term, local renewable biomass for campus heating may be an intermediate alternative to near-zero energy sources as part of the mix and progression in replacing fossil fuels. The burning of the renewable biofuel ethanol in vehicles results in substantial CO2e emissions but is used as an interim partial solution in the transportation sector for reducing fossil fuel emissions until such time as electric vehicles running off of solar, wind, and other near zero-carbon emission sources are widely available and supported by electric vehicle charging infrastructure. In a similar manner, wood may be burned for heating under stringent engineering and contract conditions to temporarily replace fossil fuels during the transition to near zero carbon emission electric heating sources when such an interim investment might make economic sense to achieve the campus net-zero carbon emission goal by 2040. Appendix 2 raises major concerns in the use of renewable biomass as a step along the way in achieving net zero carbon emissions [↑](#footnote-ref-6)
7. These Scope 3 carbon emissions for the University of Maine are estimated at a continuing rate of approximately 17,000 metric tons per year. [↑](#footnote-ref-7)
8. 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 CO2e or avoiding the addition of a full ton of CO2e 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. [↑](#footnote-ref-8)
9. 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](https://umainesystem-my.sharepoint.com/:b:/g/personal/harlan_onsrud_maine_edu/EcN8SrwHV95Gm5NVIL12hZEBXnStr13AB5GLXHFyHjy50Q?e=RKKcoS). [↑](#footnote-ref-9)
10. <https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement> [↑](#footnote-ref-10)
11. <https://www.un.org/en/climatechange/cop26> [↑](#footnote-ref-11)
12. <https://climateclock.world/science#deadline> [↑](#footnote-ref-12)
13. There’s Still Time to Fix Climate – About 11 Years, Scientific American, Oct 21, 2021, <https://www.scientificamerican.com/article/theres-still-time-to-fix-climate-about-11-years/> [↑](#footnote-ref-13)
14. IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., et.al. (eds.)]. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg1/> [↑](#footnote-ref-14)
15. The impacts of climate change at 1.5C, 2C and beyond, <https://interactive.carbonbrief.org/impacts-climate-change-one-point-five-degrees-two-degrees/?utm_source=web&utm_campaign=Redirect> [↑](#footnote-ref-15)
16. Climate tipping points – too risky to bet against. Nature, 27 November 2019, <https://www.nature.com/articles/d41586-019-03595-0> [↑](#footnote-ref-16)
17. For a dramatization and lay person’s explanation of tipping points and their potential cascading further warming effects or climate looping phenomena, see Earth Emergency, <https://www.pbs.org/video/earth-emergency-6njifx/> [↑](#footnote-ref-17)
18. <https://climate.mit.edu/ask-mit/why-do-some-people-call-climate-change-existential-threat> citing Intergovernmental Panel on Climate Change. "Long-Term Climate Change: Projections, Commitments and Irreversibility." In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. 2013. The figures cited reflect projections for the RCP 8.5 emissions pathway, sometimes called a "high emissions" or "business-as-usual" pathway. [↑](#footnote-ref-18)
19. Elizabeth Kolbert, The Sixth Extinction: An Unnatural History (2015) [↑](#footnote-ref-19)
20. 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> [↑](#footnote-ref-20)
21. 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> [↑](#footnote-ref-21)
22. 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) [↑](#footnote-ref-22)
23. 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 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. [↑](#footnote-ref-23)
24. **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. [↑](#footnote-ref-24)
25. The campus might supply its own clean 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. [↑](#footnote-ref-25)
26. Appendix 1 provides in illustrative computation of predicted energy use and CO2e emissions for a building recently constructed on the University of Maine campus. In alignment with the literature cited in footnote 21, 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%. [↑](#footnote-ref-26)
27. See <https://www.energy.gov/eere/geothermal/geothermal-heat-pumps>. [↑](#footnote-ref-27)
28. See Appendix 2. [↑](#footnote-ref-28)
29. University of Maine CO2e Progress Report, [https://reporting.secondnature.org/institution/detail!1906##1906](https://reporting.secondnature.org/institution/detail!1906) [↑](#footnote-ref-29)
30. There was indeed a decrease for 2021 but this was due primarily to the move to online teaching as a result of the pandemic. [↑](#footnote-ref-30)
31. See, for instance, approved [2015 Faculty Senate Divestment Resolution](https://umaine.edu/facultysenate/wp-content/uploads/sites/218/2015/04/Divestment-Resolution_Senate_Coghlan_29April2015.pdf). 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. Multiple Faculty Senate zero-carbon emission motions have also been passed. [↑](#footnote-ref-31)
32. Example certification standards include those issued and supported by the Forest Stewardship Council (FSC) (<https://us.fsc.org/en-us/certification>) and the Sustainable Forest Initiative (SFI) (<https://www.forests.org/>) [↑](#footnote-ref-32)
33. See: The Millions of Tons of Carbon Emissions that Don’t Officially Exist (<https://www.newyorker.com/news/annals-of-a-warming-planet/the-millions-of-tons-of-carbon-emissions-that-dont-officially-exist>) and How Burning Wood Pellets in Europe is Harming the U.S. South (<https://climate.to/ten-years-to-1-5c-how-climate-anxiety-is-affecting-young-people-around-the-world-podcast/>) [↑](#footnote-ref-33)