Strategy Recommendations to Mitigate Emissions and Support Resilience in Maine Buildings

Report to the Maine Climate Council

Developed by the Buildings, Infrastructure, and Housing Working Group

June 5, 2020

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Executive Summary

In the fall of 2019, the Buildings, Infrastructure, and Housing Working Group was convened and charged with developing, analyzing, and recommending strategies to mitigate emissions and support resilience in Maine buildings. This report is the result of seven months of collective learning, brainstorming, analysis, and refinement from October 2019 through May 2020, and its results are designed to inform the policy and program recommendations of the Maine Climate Council.

The Group placed particular emphasis on identifying the benefits that could be achieved for the people, businesses and institutions of Maine through these strategies. This report of the Group's efforts enumerates a wide range of benefits, such as reducing energy costs, enhancing energy independence, improving health and productivity, making the grid more reliable, keeping businesses competitive in a global marketplace, and fostering jobs and local entrepreneurs. The Group also took care to gather information about costs that would be associated with the recommendations, to discuss ways these costs could be mitigated, and to discuss equity impacts on vulnerable communities. Considerations of costs and benefits became further elevated for the Working Group as, in the midst of this process, the novel coronavirus and COVID-19 ignited an unexpected health and economic crisis in our state. While this report of the Working Group takes an open-minded approach to considering a range of options that might theoretically be pursued to reach carbon reduction targets over the next three decades, the Group is also deeply aware that the Climate Council will need to sort through and balance these options with other pressing concerns of the day.

There are significant opportunities to reduce greenhouse gas emissions in Maine buildings and industry, as illustrated in Figure 1. Given that the State's outdated housing stock[1] and high reliance on fossil fuel heat[2] are major contributors to the building sector's outsized contributions to Maine's total greenhouse gas emissions,[3] the Buildings, Infrastructure, and Housing Working Group (BIH or "the Group") focused on improving building design, construction, and mechanical systems.[4] Our vision for Maine's buildings includes:

- Net-zero, renewable-ready new construction that makes use of Maine-made, low global warming potential building materials and minimizes consumer energy costs;
- Reducing energy needs with clean, cost-effective heating and cooling systems;

[1] 56% of Maine homes were built before 1980. (Maine Housing, "Characteristics of Housing in Maine", January, 2019.)

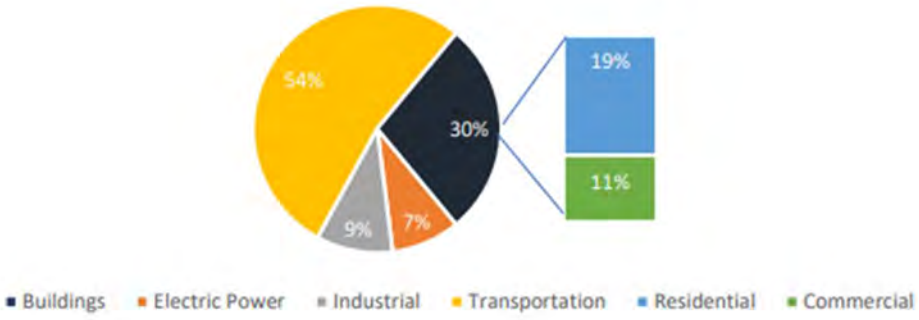
[2] 61% of Maine homes heat with fuel oil, and an additional 19% heat with natural gas or propane.(EIA Maine State Energy Consumption Data, 2017)

[3] Thermal energy use in Maine's buildings accounts for approximately 28% of the state's energy consumption and 39% of the state's total greenhouse gas (GHG) emissions between the residential, commercial, and industrial sectors. The residential sector is the second-most polluting, behind only transportation. (Maine Department of Environmental Protection (DEP). "Eighth Biennial Report on Progress toward Greenhouse Gas Reduction Goals." January 2020. p. 9.)

[4] The BIH Work Scope can be found here.

- Improved efficiency, comfort, safety, and cost-savings in existing residential and commercial buildings and affordable housing;
- A long-term transition to lower-carbon fuels used in industrial processes; and
- A modern, resilient electric grid that is right-sized and optimized to accommodate beneficial electrification of heating and transportation and new renewable generation at the "least cost."

Figure 1: Maine Emissions from Fossil Fuel Combustion by Sector for 2017[5]



This vision reflects the contributions of a diverse Working Group, including architects and engineers, community advocates, affordable housing, municipal officials, organized labor, utilities and fuel providers, environmental advocates, industrial energy consumers, Maine youth, the Efficiency Maine Trust, the University of Maine and the Green Campus Consortium, and the Maine State Legislature. Each member volunteered their unique insight and expertise about the current state of Maine buildings and the opportunities for improving their carbon footprint while improving their resilience. The Group fostered a shared knowledge base with monthly meetings on specific topics and frequent presentations from outside experts, including speakers from Maine businesses and institutions, to support this learning.[6] Each learning session was followed by discussion and brainstorming about how these concepts can become actionable recommendations for policies and programs to help meet Maine's long-range carbon reduction objectives.

With that foundation in place, Group members were invited to submit any and all proposals to reduce emissions and enhance resilience in Maine buildings. BIH received more than 40 draft proposals, many reflecting the independent collaboration of multiple Group members. Though not all drafts received consensus support, the Group agreed that all proposals should be included in some form and

[5] Maine Department of Environmental Protection (DEP). "Eighth Biennial Report on Progress toward Greenhouse Gas Reduction Goals." January 2020. p. 9.

[6] Presentations and workshops explored building codes, high performance construction, commercial and industrial operations, distributed energy resources, low-carbon building materials, alternative fuels, and beneficial electrification. Complete agendas and notes can be found here.

acknowledged for their role in advancing the discussion. The full text of all proposals is included in the Appendix of this report.

Beginning in March 2020, the full Group collaborated to organize the straw proposals into categories and to synthesize them into clear, coherent steps that can be incorporated into Maine's Climate Action Plan. We identified six key strategies, each with a number of specific actions, to achieve our collective vision for Maine buildings:

1. **Improve the Design and Construction of New Buildings**
   Building codes set standards for building design, construction, safety, and performance, and are the most powerful tool to advance best practices in new construction. Code compliance protects life safety and offers consumer protections, ensuring that new buildings are comfortable, cost-effective to operate, energy efficient, and resilient in the face of extreme weather. This BIH Report includes recommendations to develop a roadmap to reach net zero emission building codes by 2035 and commit to the training and resources necessary to expand and increase code compliance.

2. **Transition to Cleaner Heating and Cooling Systems**
   New technologies for heating and cooling produce comparatively lower carbon emissions than the current combination of fuels and heating systems. Highly efficient electric heat pumps and heat pump water heaters are already being adopted across the state, and phasing in progressively tighter standards for space- and water-heating systems will support continued beneficial electrification in the future. In addition, modern wood heating presents an opportunity to support Maine's forest products industry while reducing emissions from this sector. This BIH Report includes recommendations to accelerate the transition to low-carbon residential and commercial heating systems and develop mechanical licensing standards to ensure that those systems are installed and serviced with consistent quality control and safety.

3. **Improve the Efficiency and Resiliency of Existing Building Envelopes**
   Maine has successfully implemented weatherization programs to improve the energy efficiency of more than 20,000 market-rate homes since 2010, and many thousands more through the low-income programs of MaineHousing and the Community Action Programs. This BIH Report includes recommendations to expand these existing programs for homeowners of all income levels and commercial property owners, and adopt requirements that commercial buildings disclose their energy usage to support continuous improvement.

4. **Lead-by-Example in Publicly-Funded Buildings**
   With steady progress toward increasingly ambitious building codes, cleaner heating and cooling systems, and expanded access to weatherization programs (Strategies 1-3), all Maine buildings will become more efficient and resilient. The State has an opportunity to accelerate that progress in buildings that are funded by taxpayers. Lead by Example policies can transform affordable housing, state government buildings, and schools at the K-12, community college, and university level—ensuring safety, efficiency, and cost-savings that benefit all taxpayers. This BIH Report includes recommendations to embrace its leadership role by requiring best practices

for building materials, techniques, and systems and expanding awareness of their benefits.

5. **Accelerate the Decarbonization of Industrial Processes**
   Industrial facilities in Maine have historically shown strong and active participation in energy conservation programs, and there is still more cost-effective opportunity that could be pursued. Achieving deep emissions reductions in this sector will likely require significant shifts away from carbon-intensive fuels to cleaner alternatives. This BIH Report includes recommendations to establish a representative Industrial GHG Task Force to study, propose, and support industrial decarbonization and suggests that pilot projects of industrial fuel switching opportunities in the near term will accelerate their development and deployment in the longer term.

6. **Modernize and Optimize the Electric Grid**
   Many of the emission reduction strategies proposed by BIH and the Transportation Working Group rely on a transition called *beneficial electrification*. Converting from higher carbon-emitting sources, like fossil fuels, to electricity that is increasingly procured from clean, renewable resources will advance Maine's climate goals—and drive the need for significant investments in transmission and distribution (T&D) infrastructure. This BIH Report includes recommendations to approach this transition in a thoughtful, coordinated manner and take steps to modernize, stabilize, and right-size the electric grid.

Many of these strategies intersect with the strategies considered in other Working Groups, and BIH representatives collaborated with multiple other Working Groups. These cross-sector opportunities are referenced throughout our recommendations and include:

- *Overlap with Energy:* BIH primarily considered behind the meter (BTM) strategies to maximize opportunities for end-use customers to benefit from renewable energy resources, including customer-sited distributed energy resources, while Energy considered front of the meter systems such as renewable energy generation, transmission, and distribution.
- *Overlap with Transportation:* BIH primarily considered customer-sited electric vehicle charging infrastructure, while Transportation explored strategies to expand adoption of electric vehicles.
- *Overlap with Transportation **and** Community Resilience, Emergency Planning, and Public Health:* BIH focused on the efficiency and performance of Maine's buildings, while the Community Resilience and Transportation Working Groups focused more on the location of those buildings.

Our collective vision for Maine buildings and the strategies to achieve it reflect the contributions and feedback of a variety of stakeholders with experience and expertise in building design and construction, heating fuels and systems, industrial efficiency and processes, and grid modernization. In addition to the Working Group, these stakeholders include representatives from Maine communities, businesses and industries, advocacy organizations, and professional associations.

B-I-H Strategy Recommendations

Strategy 1: Improve the Design and Construction of New Buildings

1. **Describe the Recommended Strategy and how it addresses Maine's climate resiliency and mitigation goals.**

   This strategy will improve the design and construction of new buildings to promote greater energy efficiency, use of cleaner energy supplies and low-carbon materials, and resilience for individual buildings and the electrical grid. It will regulate the construction of new residential and commercial buildings by adopting progressively tighter building codes over time, training code officers and contractors to improve compliance, and supporting municipalities to improve enforcement.

   The energy used to heat, cool, and light buildings in Maine is responsible for 30% of the state's annual GHG emissions.[7] It also carries a significant cost, and risk of occasional supply interruptions, for Maine's homes, businesses and institutions. In contrast, zero energy buildings (ZEB) combine energy efficiency and renewable energy generation to consume only as much energy as can be produced onsite through renewable resources over a specified time period.[8] Carbon neutral or net zero carbon building also leverage efficiency and renewable energy generation, but allow for that generation to occur offsite to offset the annual carbon emissions associated with operations.[9]

   In addition to this *operational carbon,* the energy associated with the extraction, manufacturing, and transportation of building materials, known as *embodied carbon*, can account for as much as half a building's lifetime carbon footprint. Structural systems account for roughly 80% of embodied carbon in commercial construction, making the selection and life cycle analysis of building materials vitally important.[10] For example, wood and other bio-based materials provide a "double benefit" in construction: they not only have inherently low embodied carbon, they also naturally store carbon and the source wood can be regrown to sequester more.[11] At the other extreme, refrigerants carry a long-term carbon cost which must be planned and accounted for. Because 90% of refrigerant emissions happen at the end of life, effective disposal of those currently in circulation is essential.[12] After being carefully removed and stored, refrigerants can be purified for reuse or transformed into other chemicals that do not cause warming.

   Construction offers the most cost-effective moment to reducing the operational and embodied carbon of buildings, thanks to many new weatherization materials, construction techniques, and

[7] Maine Department of Environmental Protection (DEP). "Eighth Biennial Report on Progress toward Greenhouse Gas Reduction Goals." January 2020. p. 9.

[8] Prepared for the U.S. Department of Energy by The National Institute of Building Sciences. "A Common Definition for Zero Energy Buildings." September 2015.

[9] Canada Green Building Council. "Zero Carbon Building Standard." May 2017.

[10] Urban Land Institute. "Embodied Carbon in Building Materials for Real Estate." November 2019.

[11] Wood structures have been proven to be structurally adequate, durable, and fire-safe, and have been evaluated and approved by the International Code Council for structural use in buildings up to 18 stories high. Code changes are underway in many states and municipalities making mass timber an allowable building structure alternative.

[12] Project Drawdown. "Refrigerant Management." Accessed February 10, 2020.

heating and cooling technologies that can significantly reduce buildings' GHG emissions and energy costs. However, when these GHG-reducing materials, systems, and techniques are not installed at the time a building is first designed and built, it is considered a "lost opportunity." The orientation and shape of the building cannot easily be altered after it is designed.[13] Low carbon materials cannot be retroactively selected. The width of walls cannot easily be expanded after they have been framed in, and insulation cannot easily be added once the foundation has been backfilled and the walls and ceilings closed in and painted. And once the cost of installing the distribution system for a particular type of heating, cooling and ventilation is sunk, it is much more expensive and difficult to convert. Commonly, the cost and disruption of retrofitting the building envelope or the heating/cooling systems are so significant that decades will pass before the property owner next faces an economic opportunity to upgrade.

True to the axiom that "an ounce of prevention is worth a pound of cure," implementing progressively stringent and uniform building codes and enhancing mechanisms to ensure code compliance and enforcement will benefit Maine's economy and building operators for generations to come.[14]

2. **What is your measurable outcome for this strategy, assuming all recommended actions to implement the strategy are achieved?** [Pending modeling results]

    a. For mitigation strategies:
        i. What is the estimated CO2e savings (metric tons) by 2025, 2030, 2050?

        ii. What is the cost effectiveness of those reductions (cost per ton of CO2e reduced) and the total cost?
        New construction of single-family homes designed to a high performance standard similar to "net zero" was found to be net cost-effective for regions near Portland and Bangor (both in Climate Zone 6) with the dollar per pound of CO2 saved -$0.04 and -$0.08, respectively. Modeling of the same build in Caribou (Climate Zone 7) suggests that it would have an incremental cost of $855 and result in a net cost of $0.07 per pound of CO2 saved compared to a IECC 2009-compliance baseline home.[15]

    b. Are outcomes measurable with current monitoring systems?

[13] The Portland Society of Architects (PSA) believes the orientation of new buildings should be integral to every community's planning board process. See http://www.2030palette.org/ for examples.

[14] Given the lifespan and evolving uses of most buildings, this is true even for homes initially occupied on a seasonal basis.

[15] Calculations assumed baseline home designed to IECC 2009 standards, the MUBEC standards in effect at the time this report was written. Recent legislation requires MUBEC to update the IECC to at least 2015 standards, which would render slightly different results. Analysis prepared by Energy Resources Group (ERG), based on the National Renewable Energy Lab's (NREL) "Building Energy Optimization Tool" (BeOpt) and RMI (2018) "The Economics of Zero Energy Homes." May 2020. See Appendix p. 9 for full analysis results.

3. **What specific actions would be required to implement the strategy, including but not limited to legislation or regulation?**

    a. **Building codes: Phase-in building codes for new residential and commercial construction to improve resilience and reach net zero emissions by 2035.**

        i. Establish a target for Maine building energy codes that would require new buildings to be net zero carbon by 2035 and a plan to reach that target by adopting incremental improvements every three years to the Maine Uniform Building and Energy Code (MUBEC). Many jurisdictions offer instructive models[16] which can be tailored to Maine by MUBEC's Technical Advisory Group[17] or other representative stakeholder process. Maine's zero carbon code roadmap should include analysis and recommendations for phasing in specific standards, including:
            1. Requirements for new buildings to be **EV-ready and PV-ready**, meaning they include features such as dedicated electrical circuits and conduit to facilitate the addition of electrical vehicle charging and appropriate building orientation and design to facilitate and optimize rooftop solar;
            2. Progressively tighter **GHG emissions standards for heating systems** in new construction/major renovations;
            3. Progressively **tighter standards for the global warming potential (GWP)** of building materials including, but not limited to, insulation products, structural materials, and heating/cooling system refrigerants;[18] and
            4. Provisions to support the adoption of **mass timber construction**,[19] including the use of wood structural systems for Low (1-5 story) and Mid-rise (6-12 story) commercial buildings.

        ii. Authorize legislative and rulemaking changes to support this Plan.
            1. Amend statute (10 MRSA Chapter 1103) to establish legislative target for 2035 of net zero carbon building code adoption, as a complement to existing requirement for code updates according to model code cycles
            2. Authorize MUBEC board to adopt building codes stronger than IECC model code, starting in 2027, if doing so is necessary to achieve target date in a timely, incremental manner.

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[16] See, for example, ZERO Code, which provides code-adaptable language that defines the energy efficiency measures and on-site renewable energy production and/or off-site renewable energy procurement for zero-net-carbon new buildings; and Boston's 2020 guidebook for Zero Emissions Buildings.

[17] Technical Advisory Groups (TAGs) are groups of experts that provide the MUBEC Technical Codes and Standards Board with detailed information and recommendations on amendments to the MUBEC. Membership is open to stakeholders, by application.

[18] GWP provides a common unit of measure to compare the relative global warming impacts of different gases. It measures how much energy the emissions of one ton of a gas will absorb over a period of time relative to the emissions of one ton of carbon dioxide; the larger the GWP, the more that gas warms the Earth compared to CO2. (Source: EPA, "Understanding Global Warming Potentials.") Wood fiber insulation is made from wood byproducts ground into wool-like fibers to create a highly-efficient insulation product.

[19] "Mass timber" describes a family of building materials including Cross Laminated Timber (CLT), which is made up of layers of stacked timbers oriented perpendicular to each other and is strong relative to its cross section. CLT is likely to become a "disruptive sustainable material" because it has the potential to replace concrete and steel as the primary load-bearing structure in buildings up to 18 stories.

b. Building Code Compliance: Establish mechanisms to expand and increase code compliance across the state.

i. **Applicability**[20] -- Direct a study on suitability of existing exceptions or exemptions to building codes, with consideration of the impacts of non-uniform applicability on statewide commerce, consumer protection, equity, and achieving statewide carbon reduction targets.

ii. **Training** -- Enhance training and expand availability of certifications for:
   1. Code Enforcement Officers (CEOs), Third-Party Inspectors (TPIs) and Municipal Officials;[21]
   2. Contractors / builders;
   3. Building Inspectors; and
   4. Realtors.

iii. **Insurance** -- Require proof of code compliance (e.g., certificate of occupancy) prior to insuring new properties.

iv. **Disclosure** -- Amend MUBEC as necessary to require that contractors disclose and post at the electrical panel certain performance characteristics of new buildings:
   1. For all buildings, performance characteristics include but are not limited to blower-door tested air leakage, insulation type and R-value by zone, and HVAC system efficiencies.
   2. For commercial properties, the disclosure should include Energy Use Intensity (EUI) performance.
   3. Further require the Efficiency Maine Trust to establish a public repository to report performance disclosures for new residential and commercial buildings and require Multiple Listing Service (MLS) to publish performance disclosures where available from the Trust's repository.

v. **Financial incentives**[22] -- Authorize Efficiency Maine to include energy savings beyond baseline compliance levels (including savings from stretch code) in its calculation of Maximum Achievable Cost-Effective savings.

4. What is the timeframe for this strategy?

	Short-term (2022)	Mid-term (2030)	Long-term (2050)	2070 -2100
To implement	Starts immediately with baseline code	Authorize MUBEC board to adopt	By 2035, all new construction meets	

[20] The Maine Uniform Building and Energy Code (MUBEC) applies statewide, but enforcement is required only in municipalities with populations greater than 4000.

[21] The Maine Municipal Association (MMA) strongly supports the need for increased emphasis on state-led training for code enforcement officers in order to achieve the goals of this roadmap to net zero carbon building codes. They urge that comprehensive training must be accessible across all regions of the state before enhanced building codes are required.

[22] MMA supports the use of incentives rather than government mandates.

	compliance study, setting benchmarks for compliance. Training will be needed in 2020 around the 2015 update. Encourage Efficiency Maine and Code Bureau to increase outreach and form partnerships with training entities (e.g., community colleges, trade schools.) Anticipating the adoption of the 2021 code in 2022, this framework could be integrated into the next Efficiency Maine Triennial plan (2022).	building code stronger than model code, starting in 2027, if doing so is necessary to achieve target date in a timely, incremental manner. Direct MUBEC board to adopt a "stretch code" that meets net zero carbon by 2027. Direct EMT & Code Bureau/Board to begin incorporating elements in code that require lower embodied carbon, starting no later than 2027 Require all state-financed buildings to use the stretch code.	the "net zero carbon" standard.	
To realize outcomes			Directs 70% net energy reduction by 2030 compared to (a) IECC 2009 for res. Or (b) IECC 2015 for commercial codes; all new construction to be net zero by 2035. Build robust EMT list of net zero-certified contractors	

5. Please analyze the Recommended Strategy against the following criteria.

Workforce -

Building industry professionals -- including architects and engineers, builders, insulation and HVAC installers, code enforcement officers, and building inspectors -- all have important roles to play in improving the design and construction of new buildings. Workforce training will support a more uniform application of the building energy code across municipal boundaries, reducing costs and confusion and enhancing transparency and protections for building occupants. Recommendations include:

- Model on-site compliance training for residential construction on successful commercial practices to ensure that builders are aware of the code requirements;
- Work with workforce training programs to promote and deliver resources that support code-compliant construction, including but not limited to the Maine Community College system, Maine Building & Construction Trades Council, Sanford Technical Center and other technical schools, Loring Job Corps, Brunswick Landing, E2 Tech, businesses such as Hancock Lumber and Eldredge Lumber that train employees, and private contractors;
- Mobilize architects and electricians to become familiar with EV charging systems and make it easy for consumers to find qualified professionals;[23] and
- Increase recruitment of and training for code enforcement officers and third-party inspectors, especially in more rural communities where these resources are limited.[24]

Benefits (non-workforce) -

Improved building design and construction, coupled with increased transparency and real-world data about building performance offers a host of immediate co-benefits for building occupants and broader savings for taxpayers, including:

- Lower energy costs for households and businesses;[25]
- Improved indoor air quality and safety of new buildings, with associated gains in occupant health;
- Increased energy efficiency, with associated reductions in peak demand on the grid and enhancements in grid reliability and resilience;
- Increased consumer access to resources for net-zero standards, including through Efficiency Maine, and real-world information about the energy efficiency of new construction;
- Consumer protections and assurances that new construction is safe and efficient; and
- Reduced burdens on social systems, from emergency room visits to fire response to LIHEAP subsidies, due to increased building health, safety, and affordability.

[23] For example, Efficiency Maine already includes Level 2 Charger Installations as a service on its Qualified Partners list.

[24] PSA submits that code enforcement officers are in short supply and that those in the field are overworked. To meet higher code compliance mandates, communities will need state funding to hire more CEO employees.

[25] Today's new homes are the 15-year-old homes of 2035, so over time building codes directly benefit a larger and larger segment of the population.

A clear roadmap to net zero building codes, coupled with compliance training, has strategic value and multiple benefits for building industry professionals, including:

- Long-term predictability and understanding that codes will continue to be updated every several years, supporting ongoing investments in education and continuous improvement in building practices;[26]
- Increased access to resources for net-zero construction, including a public repository of information to support shared knowledge among builders, contractors, CEOs and inspectors, and consumers; and
- Increased marketplace accountability that levels the playing field and prevents contractors who cut corners from undercutting those who build to code.

Certain aspects of net zero building codes carry their own benefits, including:

- Emphasizing carbon-sequestering, low-carbon building materials such as cross-laminated timber and wood-fiber insulation will:
  - Increase economic activity in the forest products industry;
  - Benefit rural economies by creating more demand for wood, with higher returns for landowners;
  - Improve forest management by creating markets for low value and small trees; and
  - Improved forest management could in turn improve wildlife habitats.
- Reducing high-GWP materials will:
  - Drive massive reduction of emissions of the most dangerous greenhouse gases emissions, including those associated with refrigerants and foaming agents.
- Requirements for new buildings to be EV-ready and PV-ready will:
  - Ease the cost-effective rollout of future electric infrastructure as demand for electric vehicles grows;[27] and
  - Make future PV system installation more cost-effective by reducing the need for infrastructure upgrades, ensuring solar technical feasibility, and planning for PV system optimization.

Crucially, these recommendations leverage expertise at Efficiency Maine, increase partnerships with the Code Bureau, and support real-world use of building codes.

Costs –

[26] PSA encourages municipal employees who work with codes to exercise their voting authority in the IECC code-making process, which is currently being underutilized due to lack of awareness.

[27] Full electrification of transportation will require tens of thousands of Level 2 charging stations located where people live and work. This infrastructure will be vastly more expensive to retrofit than to install during new construction or substantial renovation of buildings and parking garages and lots. For multi-family buildings, one study found that the average cost of an EV-ready parking space was roughly $900 when incorporated into initial construction, whereas a retrofit cost nearly $4,000 per parking space (See Plug-In Electric Vehicle Infrastructure Cost-Effectiveness Report for San Francisco, p.1).

The long-term cost savings and co-benefits of stringent building codes generally offset the upfront administrative and construction costs. Considerations include:

- Training should be free or very low cost to contractors and code staff, so expenses would include the actual cost of training plus administration costs such as supporting collaboration with other training entities and maintaining a repository of shared resources. Training would scale based on the needs (e.g. code compliance baseline and degree of change in each code update cycle) but could range between $50,000 - $100,000 per year.
- Code compliance studies are essential to tracking the real-world implementation and impact of progressively more stringent codes and could cost $100,000-$200,000 every three years.
- Increased funding for training and other compliance-increasing strategies and resources should be targeted to where they are most needed, including Maine's smaller and more rural communities where compliance levels are likely lower and the need for training and education higher.

Certain aspects of net zero building codes carry their own costs:

- Mass-timber construction costs are decreasing and can be roughly competitive with steel and concrete construction.[28, 29] As with all new materials and techniques, Maine builders face a learning curve and local manufacturing needs to ramp up. As construction companies gain expertise working with new wood products and locally produced materials become more widely available there could be substantial mid-term cost savings.
- Low-GWP replacement products are readily available throughout the construction market and will become more cost-effective as supply ramps up to meet demand. Incorporating low-GWP materials at the time of construction will remain more cost-effective than retrofitting.
- EV-ready and PV-ready buildings carry upfront costs to building owners and developers associated with factors such as:
    - Adequate sizing of transformer and electrical service to accommodate future electrical loads;
    - Installation of dedicated electrical circuits and empty plastic conduit with the capacity to eventually support EV charging stations;[30] and
    - Installation of appropriate roof-mounting hardware for PV panels, dedicated electrical circuits for a calculated size future solar PV array, and empty plastic conduit routed from the future PV system to the building's electrical panel.

[28] For example, Zachau Construction opted to use cross-laminated timber in two housing projects currently under construction in Portland and South Portland. Building the vertical shafts (stairs and elevators) on these projects out of CLT rather than concrete masonry units provided significant savings in winter conditions (temporary heating), construction duration, and labor. These savings were achieved despite incurring $45,000 per project in shipping costs to get the CLT from Montana to Maine because Maine does not (yet) have a CLT fabrication plant.

[29] One study comparing costs of steel, concrete, and several CLT options concluded that a reduction in construction time of 61% was achieved when CLT was used instead of steel and concrete. (Source: O., Espinoza, M., Laguarda-Mallo, University of Minnesota Twin Cities. "Cross-Laminated Timber VS. Concrete/Steel: Cost Comparison Using a Case Study." August 2016.)

[30] For commercial construction, EV-readiness would require a defined percentage of vehicle parking spaces to accommodate future charging stations. EV-ready codes often set that target at 50% to accommodate future EV growth.

Financing institutions have the opportunity to support this effort by developing loan programs that recognize the long-term cost savings of net-zero construction and support more debt to offset initial capital costs.

Equity -

Achieving net zero building codes in all new construction has the potential to assist all segments of the population:

- Making applicability of building codes uniform across all jurisdictions and improving compliance tends to ensure that tenants -- both residential and commercial -- experience lower energy costs and greater resilience to supply interruptions.
- Improving energy efficiency through progressively more stringent and more widely implemented building codes is the low-cost way to overcome the "split incentive" barrier between landlord & tenant.

Outreach through the Maine Municipal Association has highlighted the challenges of stringent code enforcement policies on under-resourced communities. Particular attention must be given to supporting these communities with training and public education about the multiple economic, health, and climate benefits of code compliance.

Increasing the use of wood and other bio-based building materials should benefit rural economies, including landowners, loggers, and workers in the forest products industry, and local economies more generally.

Proven strategy & feasibility –

Stringent building codes -- including net zero, EV-ready, and PV-ready codes -- are in effect in other jurisdictions, and there are model codes that can be adapted and tailored to Maine. For example:

- ZERO Code provides code-adaptable language that defines the energy efficiency measures and on-site renewable energy production and/or off-site renewable energy procurement for zero-net-carbon new buildings.
- Boston 2020 Guidebook for Zero Emissions Buildings identifies performance criteria tailored to Boston's specific climate, portfolio, density, and resiliency goals and provides resources for developers, designers, and builders to advance proven, cost-effective design and construction strategies for buildings that are zero carbon, cost roughly the same to construct and less to operate, and are healthier for occupants.[31]
- California building codes feature:
    - Building Energy Efficiency Standards [Section 110.10]

[31] In developing the Guidebook for Zero Emissions Buildings, Boston's Department of Neighborhood Development found that there is little-to-no cost increase for for building to Zero Emission Building standards. Construction cost increases range from 2.5% or less before rebates and incentives are considered. Rebates and incentives have the potential to make these buildings less expensive to build, with additional long-term operational savings.

- Solar-ready provisions[32] that require space, pathways for connections, and adequate structural capacity of roof systems to support solar systems. Provisions:
  1. do not require the systems to be installed and are not mandatory unless specifically adopted by state agency or referenced in adopting ordinance;
  2. apply to new detached one- and two-family dwellings and townhouses with not less than 600 square feet of roof area oriented between 90 and 270 degrees of true north; and
  3. except buildings with permanently installed on-site renewable energy system and buildings where all areas of the roof are in full or partial shade for more than 70% of daylight hours annually.
- Green Building Standards[33] with EV-ready provisions, including:
  1. One- and two-family dwellings and townhouses must provide a raceway to accommodate a 240-V circuit, capacity to install a 40-amp minimum branch circuit, and a permanent, visible "EV CAPABLE" label on the service panel.
  2. For multifamily dwellings, 10% of total residential parking spaces shall be EV spaces. Calculations shall be rounded up to the nearest whole number and construction documents shall indicate the location of the spaces.
  3. New hotels and motels shall provide EV spaces.
  4. Some exceptions are allowed where there is no commercial power supply or where there is evidence that meeting the requirements would increase utility costs by more than $400 per dwelling unit.
- Flexibility for more stringent municipal provisions such as the City of Berkeley's ban on natural gas hookups on new low-rise construction.[34]

Mass-timber buildings are now a proven and standard construction technique, with notable examples in New England. Policies to support mass-timber construction have been implemented in Washington and Oregon (building code modifications), New Zealand (public financial incentives), and Europe (embodied carbon regulation). Barriers to implementation include opposition from the steel and concrete industries. In addition, because the technology for mid-rise buildings is unfamiliar to most in the building community, engineers, architects, construction companies, and developers will need additional training and demonstration projects such as those already provided through the federally supported WoodWorks program.

Maine faces particular challenges in implementing net zero codes and transitioning to low-GWP building materials, including:

- Building industry professionals have limited capacity for code compliance and enforcement, and a lack of clarity about when and how the code will be updated compounds these challenges. 2019 Legislation enhances predictability by requiring the

[32] 2019 California Residential Code - https://codes.iccsafe.org/content/CARC2019/chapter-1-scope-and-application

[33] CA Title 24, Part 11 [Chapter 4.106.4]

[34] Potential barriers to banning installation of new fossil-fired HVAC systems include: supply chain for alternative appliance systems; supply chain and infrastructure for biomass fuel delivery; lack of infrastructure to accommodate additional electric load; social acceptability; and a high likelihood for industry and public pushback.

MUBEC board to adopt the most current or previous version of the IECC code[35] and a roadmap to implementing net zero codes by 2035 will offer additional continuity. Lessons from other jurisdictions include:
    - Washington State and Vermont have similar code roadmap approaches, with long-term target dates for energy codes and strategies to make steady progress in shorter-term blocks.
        1. Washington law requires codes in 2030 to achieve 70% net energy reduction over 2006 codes.
        2. Vermont's comprehensive energy plan directs all new construction to be zero carbon by 2030.
    - Other states offer robust training and education for the building code to code officials, and also in cases to the construction industry.
- Compliance with current codes is not uniformly well understood in Maine. Though MUBEC applies statewide, enforcement is not required in towns with fewer than 4000 residents, and in 2008 the Public Utilities Commission found that 84% of newly built homes did not meet the existing (IECC-2003) code.[36] Updated real-world data is necessary to direct compliance efforts where they are most needed. Lessons from other jurisdictions include:
    - The U.S. DOE is currently conducting residential energy code compliance studies in 10 states and has established procedures for measuring compliance through field studies.[37]
    - In Rhode Island, efficiency program administrators include savings achieved through code compliance programs in their three-year efficiency plans, getting "credit" that offsets program costs.[38]
- Supply chains for low-GWP materials have not yet been developed.
    - While Maine has significant raw materials for the manufacture of cross-laminated timber, wood-fiber insulation, and other low-GWP materials, we have not yet been successful in bringing the product manufacture to the state. Continued efforts to attract this industry to Maine will benefit the state with jobs and reduced product costs.
- New materials and techniques may receive pushback from the construction industry and building contractors for reasons including:
    - Higher initial costs during the transition period;
    - Implementation challenges, including for refrigerant management;[39] and
    - Funding, training, technical, and informational barriers. In order to increase adoption, policies and regulations on recycling/management of refrigerants need to be formulated and implemented. Strong regulations such as a complete ban on venting of refrigerants and accountability of refrigerants must be introduced in legislation. Economic incentives for recovery, recycling, and destruction of

[35] 10 MRSA Chapter 1103 - https://www.mainelegislature.org/legis/statutes/10/title10sec9722.html

[36] Maine Public Utilities Commission and MaineHousing. "Report on LD 1655: Building Energy Codes". January, 2008.

[37] See https://www.energycodes.gov/compliance/energy-code-field-studies

[38] See Rhode Island Residential New Construction (RNC) Program

[39] Refrigerant management is difficult to implement as the appliances are distributed. There are weak regulations on controlling leakage of refrigerants, end-of-life recovery, and refrigerant. Further, there are no economic incentives for the recovery of refrigerants.

refrigerants, such as the issue of carbon credits under the Kyoto protocol, would help increase the adoption.

Legal authority -

- Maine's Uniform Building and Energy Code[40] (10 MRSA Chapter 1103) requires Maine to adopt the most current or previous version of the IECC code and to establish a Stretch Code. MUBEC is currently being updated to the 2015 IECC code; the MUBEC board will begin reviewing the 2021 codes when they are released in September 2020 and anticipates adopting them in 2021. The 2021 IECC code should be adopted in full, including all EV-ready provisions.
- Additional legislative direction is needed for Efficiency Maine to measure code compliance, set benchmarks for increasing compliance, and allowing programs that increase compliance to count in its Triennial Plan.

Resilience and Adaptation -

High-performance buildings are inherently more resilient than standard construction. For example, better insulation and air sealing helps high-performance buildings maintain comfortable temperatures during power outages, enhancing the safety of vulnerable residents during extreme weather events.

Resiliency benefits could be enhanced by code provisions that:

- Encourage distributed generation (See Strategy 6: Modernize and Optimize the Grid);
- Require resiliency considerations in the design of infrastructure (e.g., placement of heating system on third floor in flood-prone zones); and
- Integrate land value taxation to drive more efficient decision-making related to building location and utilization.

Cross-cuts with other strategies and work groups?

- Strategy 2: Transition to Cleaner Heating and Cooling Systems
  Mechanical licensing recommendations detailed in Strategy #2 would ensure uniform quality control and safe installation/servicing of HVAC systems in new construction.

- Strategy 3: Improve the Efficiency and Resiliency of Existing Building Envelopes
  Contractor training programs detailed here would also support energy efficiency retrofits in existing buildings.

- Strategy 6: Modernize and Optimize the Grid
  High efficiency and grid-integrated homes have the potential to reduce demand, and especially peak demand, on the electric grid.

- **Natural & Working Lands Working Group**
  Emphasizing carbon-sequestering, low-carbon building materials such as cross-laminated timber and wood-fiber insulation will increase economic activity in the forest products industry; benefit rural economies by creating more demand for wood, with higher returns

[40] 10 MRSA Chapter 1103 - https://www.mainelegislature.org/legis/statutes/10/title10sec9722.html

for landowners; and improve forest management by creating markets for low value and small trees. Improved forest management could in turn improve wildlife habitats.

6. Rationale/Background Information
Raw material from draft proposals:

Compliance: A key feature of this proposal is generating real-world data about code compliance so that resources to increase the use of the code can be targeted. Let's put our resources where they are demonstrably needed, to conserve taxpayer/ratepayer spending on programs.

High GWP Products: While traditional insulation products like spray foam can save customers heating fuel, some types also emit significant GHG during or after production.

Requiring EV Chargers in Building Codes:
Subsequent versions of the Building Code – which gets updated every 3 years, starting with adoption of the 2021 version of the IECC codes – must require new construction to be designed and built with:

Strategy 2: Transition to Cleaner Heating and Cooling Systems

1. **Describe the Recommended Strategy and how it addresses Maine's climate resiliency and mitigation goals.**

   This strategy will accelerate a transition to cleaner heating and cooling systems used in Maine buildings. Thermal energy use in Maine's buildings accounts for approximately 28% of the state's energy consumption and 39% of the state's total greenhouse gas (GHG) emissions between the residential, commercial, and industrial sectors.[41] Nearly 70% of the fuels currently used for heating in Maine are either oil or propane, and the GHG emissions profile of those fuels is fairly high.[42] There is a growing opportunity in Maine to transition to new technologies for heating (and cooling) that produce comparatively lower GHG emissions than the current combination of fuels and heating systems. For example, high-performance, mini-split ductless heat pumps achieve vastly higher efficiencies than combustion alternatives when converting energy to useful heat, and they run on electricity which, in Maine, is relatively clean and on a pathway to being primarily derived from clean, renewable sources. Even using today's power mix from the grid, a single high-performance, mini-split ductless heat pump saves 117 lb CO2/MMBtu compared to a typical existing oil-fired boiler (i.e., 60% less GHG per Btu) and 110 lb CO2/MMBtu compared to a typical new oil-fired boiler.[43] Other fuel and technology combinations can also achieve significant GHG reductions compared to traditional combinations. In addition to electrification, this strategy advances near-term opportunities for

[41] Maine Department of Environmental Protection (DEP). "Eighth Biennial Report on Progress toward Greenhouse Gas Reduction Goals." January 2020. p. 9.
[42] EIA Maine State Energy Consumption Data, 2017
[43] Calculations by Efficiency Maine using evaluated program data. (April 2020).

high-efficiency gas and modern wood heating systems and longer-term options for renewable gas and renewable oil.

2. **What is your measurable outcome for this strategy, assuming all recommended actions to implement the strategy are achieved?** [Pending modeling results]

    a. For mitigation strategies:
        i. What is the estimated CO2e savings (metric tons) by 2025, 2030, 2050?

- Scenario 1 -- Maximum Electrification[44]
    - Leads to 24% greenhouse gas emissions reductions by 2030; 90% by 2050
    - Assumed 90% of households have heat pumps and 90% of commercial heating load is electrified by 2050, plus assumed baseline weatherization levels (2.2% cumulative residential space heat energy reduction) by 2050

- Scenario 2 -- Maximum Electrification Plus Weatherization
    - Leads to 26% greenhouse gas emissions reductions by 2030; 91% by 2050
    - Same as Scenario 1, plus assumed buildings are weatherized to reduce 20% cumulative residential space heat load by 2050
    - Assumes elements of Strategy #3 [Improve the Efficiency and Resiliency of Existing Building Envelopes]
- Scenario 3 -- Electrification-Renewable Fuels Hybrid
    - Leads to 33% greenhouse gas emissions reductions by 2030; 91% by 2050
    - Assumed that by 2050, 67% of households have heat pumps and 60% of commercial heating load is electrified by 2050, same baseline weatherization as H1, and the remaining load in 2050 is primarily supplied with other low-carbon fuels (i.e., biodiesel, fuel oil blends, and natural gas)
- Expansion of Wood Heat
    - Assumed 15% of home heating is converted to wood pellets in 20 years (by 2040).
    - Maine Pellet Fuels Association estimates that converting from oil heating to a pellet boiler, using pellets from Northern New England, conservatively reduces CO2 by 50% from a Maine home. If a strategy to replace fossil fuel with 4,185 wood pellet heating systems or businesses per year for 20 years, the estimated reductions in metric tons of CO2 are: 477,500 by 2025; 1.5 million by 2030, 11.5 million by 2050.

        ii. What is the cost effectiveness of those reductions (cost per pound of CO2e reduced) and the total cost?

            1. For efficient wood heating: The Maine Pellet Fuels Association estimates that offering an incentive of $10,000/home to replace a fossil fuel heating system with a pellet boiler to 15% of Maine homes would have a total public cost of $837 million. They further calculate that if those

[44] See appendix p. 2 for detailed results. Baseline scenario assumes continued efforts to install residential retrofit heat pumps with baseline weatherization efforts. That is 2.2% cumulative residential space heat energy reduction by 2050 through weatherization and 41% of households have heat pumps or legacy resistance heating by 2050.

pellet boilers save 4,785,000 tons of CO2, this initiative would cost approximately $175 of public funds per ton of CO2 saved.

2. For other measures, see analysis from modelers.

b. Are outcomes measurable with current monitoring systems? Yes.[45]

3. What specific actions would be required to implement the strategy, including but not limited to legislation or regulation.

1. Accelerate Maine's transition to low-carbon heating systems for residential and commercial space heating by expanding financial incentive programs and phasing in progressively tighter regulations for space heating systems (or fuels) sold or installed in Maine.

a. Financial incentives

i. Extend Efficiency Maine incentives for qualifying heat pumps and MaineHousing initiative for installing heat pumps for qualified LIHEAP households to 2030.

ii. For high-efficiency natural gas systems, recommend a $3,000 state tax credit for residential conversions ($4,000 state tax credit for conversions by qualifying low-income homeowners).[46,47]

iii. For efficient wood heating, fund the Wood Energy Investment Program.[48]

iv. After regulations are phased in (see below), extend and refocus incentives as needed to overcome specific barriers for priority sub-sectors of the market (e.g., low and moderate income households, small businesses, globally competitive businesses, etc.).

b. Regulations

[45] For efficient wood heating: Installations of incentivized pellet boiler systems are already accounted for by Efficiency Maine. Bulk pellet deliveries to residences are recorded by the firms making such deliveries. The Gunn study of CO2 reductions achieved by replacing fossil fuel heating with pellet heating is peer-reviewed, published, and widely accepted.

[46] The Working Group did not reach consensus around whether to encourage natural gas conversions. Some members feel strongly that because natural gas is a cleaner, lower-emissions fuel than heating oil, such incentives are appropriate. Other members feel that these emissions reductions do not justify the infrastructure expansions required to meet new demand, especially given the availability of high-efficiency electric heat pumps and Maine-made biomass alternatives.

[47] Acadia Center does not support financial incentives for natural gas systems, as customers can access greater fuel cost savings and cut pollution more by converting to heat pumps. Unlike heat pumps, natural gas conversions require the addition of new gas pipes or upkeep of the existing system, locking in higher greenhouse gas emissions for decades while increasing costs for all gas customers because the utility passes on these infrastructure costs.

[48] Legislation already exists establishing the Wood Energy Investment Program (LD 912), to be administered by Efficiency Maine with input from the Finance Authority of Maine. LD 912 was passed by both Maine Senate and House in 2019; is pending, in carryover status, pending appropriation. Efficiency Maine also has an ongoing pellet boiler incentive program which can be expanded if appropriations are forthcoming. In addition, Maine PUC is presently in the rulemaking process (PUC Docket 2019-00177) regarding legislation signed into law which generates funding through Renewable Energy Certificates for generators of thermal energy.

i. Phase-out financial incentives for space heating systems (or fuels) sold/installed in Maine as tighter regulations are phased-in or as low-carbon systems become the norm.

c. Establish "Lead-by-example" procurement policies establishing low-carbon standards for heating system purchased with State funding (See Strategy 4: Lead by Example in Publicly-Funded Buildings)

2. Accelerate Maine's transition to low-carbon heating systems for residential and commercial water heating by expanding financial incentive programs and phasing in progressively tighter regulations for water heating systems (or fuels) sold or installed in Maine.

a. Extend financial incentives for installations of low-carbon, high-efficiency systems;
b. Phase-in progressively tighter regulations for water heating systems (or fuels) sold/installed in Maine; and
c. Establish "Lead-by-example" procurement policies establishing low-carbon standards for heating system purchases with State funding.

3. Develop mechanical licensing standards to ensure uniform quality control and safety of systems installation and servicing.

4. What is the timeframe for this strategy?

	Short term (2022)	Mid-term (2030)	Long-term (2050)	2070-2100
To implement	1. 140,000 heat pumps installed by 2025 by continuing EMT HP programs 2. 47,000 HP water heaters installed by 2025 by continuing EMT HPWH programs 3. 15,000 efficient natural gas boilers added annually starting immediately 4. 4,185 pellet boilers installed per year starting	1, High-efficiency NG boilers: 15,000 installed very year through 2026 (100,000 total; 25,000 low-income) 2. Heat Pumps - 270,000-370,000 (depending on efficiency gains) cumulative mini-split units (or equiv. MMBtu) installed in homes 3. Regulations on new appliances start at this point; new appliances purchased after this point must meet	Wood heat: Ideal for the next 25 years as Maine pivots to more renewables and renewable electrification	

	immediately	regulated standards.		
To realize outcomes		Meet 20% of space heating load w/ high-performance heat pump systems	Wood heat: 2045 (or sooner) when 15% of buildings heating w/ modern wood systems Meet 90% of space heating load w/ high-performance electric heat pump systems Meet 90% of direct water heating w/ high-performance electric heat pump tech	

5. Please analyze the Recommended Strategy against the following criteria.

Action 1 Accelerate Maine's transition to low-carbon heating systems for residential and commercial space heating by expanding financial incentive programs and phasing in progressively tighter regulations for space heating systems (or fuels) sold or installed in Maine

Workforce -

- This strategy will continue to promote jobs in the trades including for HVAC installers, plumbers, and electricians. For example, there are more than 400 active small businesses in Maine selling and installing heat pumps, each of which employs one or more installers.
- For natural gas initiatives --
    - Leverage volume-buying opportunities among Maine-based manufacturers and distributors of natural gas equipment, piping, valves and other ancillary needs.
    - Utilize vetted and qualified Maine-based HVAC contractors to perform the conversion projects – retaining the cash payments for the projects within the State.
- Engage with junior colleges and trade schools to promote and expand programs to train individuals in HVAC careers. Eastern Maine Community College in Bangor currently has such a program, which could serve as a model.

- Wood heat initiatives could retain or create about 48,000 jobs, primarily in rural Maine. There are currently 100 logging companies employing over 1,200 people in rural Maine.

Benefits (non-workforce) -

- This strategy is highly scalable, technically- and economically-feasible, and has the potential to achieve very significant GHG reductions.
- Various configurations of these heating systems, especially the heat pump water heaters, are cost-effective using the Total Resource Cost test and will generate annual savings on operating costs.
- Heat pump technology
    - is versatile and may be suitable in single family homes, affordable housing and multi-family apartments, and commercial buildings;
    - is two to three times less expensive to operate than electric resistance technology and less expensive to operate than fossil-fuel heating systems;
    - runs on electricity, which requires no indoor combustion, improves indoor air quality by reducing the amount of carbon monoxide emissions and leaks of fossil fuels, and is increasingly generated by clean power (solar, wind, hydro);
    - provides air-conditioning more efficiently than other technologies that provide air conditioning;
    - allows for heating system downsizing where heat pumps are sized to the home's actual heating needs;
    - coupled with weatherization and integrated heating controls can achieve greater overall efficiencies;
    - are commercially available and widely used globally and are effective even in cold Maine winters; and
    - may be installed to supplement (without removing) existing heating systems or may be configured to provide a whole-home heating solution.

- High-efficiency gas heating systems:
    - Natural gas-fired systems
        - reduce greenhouse gases by 27% when compared to fuel oil;
        - can be easily and affordably converted to in areas served by natural gas distribution systems;
        - are projected to have low operating costs for the foreseeable future;
        - would be a lower-carbon backup heat source, relative to fuel oil, for homeowners who have added an electric heat pump;
        - have lower carbon monoxide emissions than other units;
        - can use renewable gas blends; and
        - can drive economic development from pipeline expansion.
        - Homes with natural gas service have a 4% higher resale value than homes heated with less-clean fuels (according to the National Association of Home Builders). As a result, residents of many neighborhoods where there are no pre-existing natural gas pipelines are campaigning to bring natural gas to their streets.
    - Renewable gas and renewable oil systems

- have the potential to provide low-carbon heating where heat pumps are not practical or economical;
- provide a diversity of ultra-low carbon options to complement electric heat pumps; and
- have the potential to use traditional heating distribution systems.

- High-efficiency wood heating systems:
  - Assist the forest products industries of Maine by
    - providing a vital outlet for waste generated by Maine's forest products sector;
    - building markets for non-sawlog quality wood for energy so Maine can improve its forests' health, sequester more carbon, and have significant environmental and economic benefits statewide and regionally; and
    - stabilizing fuel costs for Maine homeowners, business firms, and public buildings.
  - Local representatives of the industry indicate that:
    - Shifting 15% of Maine's heating load to sustainable forest resources instead of fossil fuels will generate income tax revenues of approximately $22.9 million annually, based on job retention and creation.
    - 100% of each dollar spent on heating with renewable Maine-made wood fuel remains within Maine, unlike fossil fuels which export about 68% of every dollar outside the state. This will contribute to a strong and more independent energy economy and will also support the creation and retention of tens of thousands of Maine jobs.
    - There is an economic multiplier effect of keeping heating dollars in Maine.
  - While Maine's oil delivery firms were initially seen to be disadvantaged by the introduction of modern wood heating, experience has shown that firms can expand their activities to include pellet delivery.

Costs –

- As new, low-carbon technologies enter the marketplace, they commonly carry a price premium for the capital cost and installation. In such cases, it is often necessary to offer financial incentives (e.g., rebates, tax credits, sales tax exemptions, low-interest loans) to overcome higher up-front costs compared to the established/incumbent traditional systems.

- Heat Pumps:
  - The average cost in recent years for a single-head, EMT-qualifying mini-split ductless heat pump, including equipment and installation, is $3,750.
    - Costs are about 50% more for multiple-heads and about 30% less when costs of customer acquisition are avoided (e.g., when installed for eligible low-income dwellings).
    - In a typical Maine home, whole-home heat pump systems cost at least three times as much as single-head systems; in smaller homes, including mobile homes, one or two mini-split heat pumps should be sufficient to heat the

space.
    - Financial incentives currently offered by EMT include:
        - 1,000 for a Tier 2 install and another $500 for a second Tier 2 install; and
        - $500 for a Tier 1 install and another $250 for a second head or a second Tier 1 outdoor unit.
        - Funding for this level of incentives is available and authorized through 2023.
    - Many commercial properties are suitable for configurations of heat pump technology, including mini-split ductless heat pumps with one or more heads, ducted systems, or Variable Refrigerant Flow (VRF) technology.

- Natural Gas:
    - The cost of a new high efficiency natural gas boiler for a typical Maine home is approximately $6,000 - $8,000, which includes adding internal piping and removal of the homeowner's old heating system.
    - Local distribution companies (LDCs) in Maine will typically install a new service line at no cost to the homeowner.
    - The benefits of conversion include a reduction in energy costs during the heating season of approximately $600 for the average Maine homeowner.
    - The necessary investment by a homeowner will include installation of new natural gas equipment and necessary piping; removal of old equipment and fuel oil tank; and other reasonable ancillary costs.
    - Expanding natural gas infrastructure would require significant capital cost investments from utilities and would be a tradeoff with other priorities, e.g., electrification and renewable generation.

- Renewable Fuels:
    - Renewable gas and renewable oil fuels are not yet commercially competitive and are likely to cost significantly more than traditional fuels. See cost estimates prepared for the "Heating Sector Transformation in Rhode Island: Pathways to Decarbonization by 2050," by the Brattle Group.[49]

- Wood Heat:
    - An average new pellet boiler measure cost is around $13,000 installed, depending on balance of system costs (such as an automated feeding system and hopper).

Equity -

- There is a high potential to address equity through a graduated system of financial incentives and strategic allocation of federal funding. For example:
    - Significant funding from MaineHousing and Efficiency Maine is currently being allocated to provide mini-split heat pumps to low-income households; and

[49] See, Brattle Group, "Heating Sector Transformation in Rhode Island: Pathways to Decarbonization by 2050," April 22, 2020, pp. 33-37 and Figure 23 at p. 40.

- Current programs serve low- and moderate-income customers with elevated incentives for heat pumps or other high-efficiency heating systems.
- For natural gas heating systems:
  - Maine Natural Gas currently offers a $1,500 cash rebate and Summit Natural Gas offers up to $3,400, with higher rebates for low-income natural gas consumers converting to natural gas.
  - The proposed initiative would be available statewide to residential homeowners – primarily in dense, urban and rural populations throughout the State. It may not be economical to convert homes to natural gas in certain sparsely-populated rural areas.
  - At least 25,000 conversions should be targeted to low-income homeowners.[50]
- For wood heat systems:
  - Rural Maine communities participating in Maine's forest products industry will be immediate beneficiaries of expanded modern wood heating.

Proven strategy & feasibility –

- The framework and experience to administer financial incentives (e.g., for electric heat pumps, high-efficiency gas boilers, and efficient wood heat) are already in place at Efficiency Maine.
  - Existing heat pump and heat pump water heater programs are highly popular.
- Maine's community colleges and trade associations have training facilities, trainers, and courses offered for HVAC technicians, including for the installation and servicing of heat pumps. Major manufacturers of heat pumps also offer training.
  - There ihttp://www.energy.ri.gov/documents/HST/RI%20HST%20Final%20Pathways%20Report%204-22-20.pdf s capacity to expand these course offerings if needed.
- Vermont, the region's second coldest state, has installed heat pumps in about 1% of its homes per year since 2015.
- For modern wood heat systems, there is precedent for wide-scale promotion programs in the state of Upper Austria, Austria, which is similar to Maine in population size and percentage of forested land, as well as in portions of Northern Italy, Southern Germany, and Scandinavia. With regard to wood heating of schools, the State of Vermont serves as a model.
- The University of Maine has an excellent product testing facility for wood pellets. Maine Forest Service has sponsored a Wood Energy Assistance Team which assists public officials considering modern wood heating.
- Renewable gas and renewable oil are both technically feasible, but economic commercialization at scale has not yet been demonstrated. For a good introduction to renewable gas and renewable oil, see, Brattle Group, "Heating Sector Transformation in Rhode Island: Pathways to Decarbonization by 2050."[51]

Legal authority -

[50] This recommendation was brought forward by Bangor Natural Gas. Some Work Group members raised questions about extending public and private investments in fossil fuel infrastructure and heating systems.

[51] Brattle Group, "Heating Sector Transformation in Rhode Island: Pathways to Decarbonization by 2050," April 22, 2020, pp. 17-25.

- Efficiency Maine Trust Act (35-A MRSA Sections 10110, 10111 and 10119) authorizes the Trust to provide incentives for high-performance heating systems and water heating systems; Section 10110(2) also directs the Trust to consider beneficial electrification.
- Funding of the Maine Wood Energy Investment Program (LD 912) or establishment and substantial funding of a similar program with Efficiency Maine, targeted solely to the promotion of modern wood heating in Maine. 35-A MRSA establishing (Section 10103) Efficiency Maine's authority to promote "alternative energy resources", which are specifically defined (Section 10102(3) to include "wood pellets".
- Legislature has authority to offer tax credits or tax deductions on the purchase of qualifying models of equipment
- Adopt provisions in the building code governing new construction for residential and commercial buildings for both space and water heating
- Consider applying Executive Order 13 FY19-20 from Gov. Mills to influence procurements using state funds.

Resilience and Adaptation -

- Heat Pumps:
  - When fitted with smart controls, heat pumps and heat pump water heaters can be managed to reduce peak demand on the grid, thus improving grid reliability.
  - When combined with onsite generation/storage, systems that use electricity (such as heat pumps) can provide heating during power outages.
- Natural gas:
  - is domestically-sourced and the cleanest-burning hydrocarbon fuel;
  - can be reliably provided directly to the home via a utility distribution system; and
  - can serve as backup/supplemental heating source during times of frigid winter temperatures for homes relying primarily on electric heat pumps.
- Renewable gas:
  - can be sustainably and locally manufactured through a variety of techniques, including using renewable power generation to produce hydrogen via electrolysis of water.
- Wood Heat:
  - Maine's forests are renewable and are certified as responsibly managed lands (8.5 million acres), with 100 logging companies harvesting 5.5 million tons annually under third party certification by the Rainforest Alliance, working collaboratively to sequester over 60% of the state's carbon emissions.[52]
  - Maine has the most developed pellet heating infrastructure of any state, including:
    - four pellet manufacturing firms (Ashland, Athens, Strong, and Sanford);
    - a firm (Bethel) assembling high quality pellet heating equipment for distribution throughout the U.S. and Canada;
    - hundreds of HVAC installers trained in pellet heating;
    - a good number of bulk pellet delivery vehicles; and

[52] Maine Climate Council Science and Technical Subcommittee, *Scientific Assessment of Climate Change and Its Effects in Maine*, Phase I "Working Document," pg. 20. February 2020.

▪ a high quality pellet testing facility (UMaine).
Cross-cuts with other strategies and work groups? • Train HPWH installers to coordinate with heat pump installers • Consider energy audit prior to heating/cooling system improvements • Synergy with building envelope upgrades – encourages the stacking of energy savings benefits • Establish fuel-neutral funding • Establish a Maine Energy Corps – expand workforce • Building codes, regarding new installation and design/placement requirements • See also, suggestion for a Fuel-Neutral Funding mechanism described in Strategy #3, as a potential source of funds for financial incentives to promote low-GHG heating systems.

Action 2 Accelerate Maine's transition to high-performance heat pump technology for residential and commercial water heating by expanding financial incentive programs and phasing in progressively tighter regulations for water heating systems (or fuels) sold or installed in Maine

Workforce - • Modest but high potential to employ plumbers   ○ Synergy with Maine Clean Energy Corps
Benefits (non-workforce) - • High economic benefits to customers – high-efficiency heat pump water heater (HPWH) systems pay themselves off despite higher up-front cost (three times more efficient than an electric resistance water heater) • Switching to HPWH can save a typical Maine household hundreds of dollars annually • HPWH also help dehumidify spaces – often basements • HPWH improve home affordability (realtor input indicates that consumers are highly concerned about monthly energy costs and willing to invest in energy efficiency up front) • HPWH have the ability to store and dispatch energy using remote or automated controls

Costs –
 	
• Average cost of heat pump water heater retrofit/conversion:
  ○ equipment = $1,000–1,200;
  ○ installation = $300-600
• HPWH save customers significant annual operating costs when they displace oil, propane or electric water heating alternatives
• Some share of future grid upgrades will be attributable to this strategy; although as noted under Resiliency, the water tanks can be used to store thermal energy and provide valuable load management (e.g., converting surplus renewable generation to useful thermal heat or reducing peak demand).

Equity -

- High potential to address equity, especially since many low-income single-family homes currently rely on electric resistance water heaters and are thus excellent candidates for a replacement with a HPWH.
- EMT offers free HPWH installations for Low-Income Heat Energy Assistance Program (LIHEAP) customers.

Proven strategy & feasibility –

- The core elements of this strategy are already being implemented with success
- Existing heat pump and heat pump water heater programs are highly popular
- One BIH Working Group member said, "EMT's heat pump water heater rebate program is the best deal in the state."
- Strong feasibility but harder to achieve with tankless coils (see R&D opportunities)
- Must identify suitable spaces (HPWH as currently designed and manufactured are not suitable for certain interior spaces).

Legal authority -

- Efficiency Maine Trust Act (35-A MRSA Sections. 10110 and 10119), as above
- Legislature authority to establish tax credits or tax deductions, as above
- Consider applying Executive Order 13 FY19-20 from Gov. Mills to influence procurements using state funds, as above
- Require open source controls on heat pump water heaters to enable future load management programming

Resilience and Adaptation -

- When fitted with smart controls, heat pumps and heat pump water heaters can be managed to reduce peak demand on the grid, thus improving grid reliability.

Cross-cuts with other strategies and work groups?

- Train HPWH installers to coordinate with heat pump installers
- Consider energy audit prior to heating/cooling system improvements
- Synergy with building envelope upgrades – encourages the stacking of energy savings benefits
- Establish fuel-neutral funding
- Establish a Maine Energy Corps – expand workforce

Action 3 Develop mechanical licensing to ensure uniform quality control and safety of systems installation and servicing

Workforce -

- The need for licensed mechanical contractors will increase, expanding the opportunities for good-paying careers in the building trades

- The mechanical trades are largely unlicensed and therefore lack the uniform quality control that a large scale, statewide decarbonization effort will necessitate. By removing this uncertainty, we can remove a major variable from this process while focusing on delivering a product to Mainers that will both have an impact on their pocketbooks as well as on the environment.
- Mainers will see an increased demand for good-paying careers in the mechanical contracting field.

Benefits (non-workforce) -

- Students will have a clear pathway at continuing education via apprenticeships and lifelong learning.
- Worker safety will increase.
- Systems will be installed and maintained properly and consistently.
- Customers will have the piece of mind of safe and well-trained personnel completing the work.

Costs –

- The State will have to fund staff to manage a licensure Board, though that can be funded and sustained through fees associated with registering and maintaining a license.
- Contractors and/or individuals would be charged a fee for maintaining a state license.
- Oftentimes labor organizations, such as unions, incorporate industry-leading training free of charge to their members as a part of their labor/management partnership.

Equity -

- All populations will benefit from the work of safe, well-trained and licensed mechanical contractors.

Proven strategy & feasibility –

- Many states across the country have mechanical licensing in some form. Maine already licenses a number of trades, with the requisite oversight Boards. The roadmap in Maine is clear.
- We have a top-notch community college and career and technical school system that have robust programs designed to equip learners with the knowledge they need to get a head start on their careers in the mechanical trades.
- Licensure plan can and should be self funding and self sustaining
- Maine has existing labor/management training facilities and DOL-registered apprenticeship programs
- The Maine State Building & Construction Trades Council and the directly impacted affiliates listed below stand ready to help the state and its partners implement this strategy as appropriate. There are also multiple examples of mechanical licensing structures that have been put in place in states around the country that can be used as a template in part as Maine builds their structure.

Legal authority -

Resilience and Adaptation - • Properly installed and maintained mechanical systems are critical to the meeting of any greenhouse gas reductions
Cross-cuts with other strategies and work groups?

6. Rationale/Background Information

Thermal energy use in Maine's buildings accounts for approximately 28% of the state's energy consumption and 39% of the state's total greenhouse gas emissions between the residential, commercial, and industrial sectors. The residential sector alone accounts for 19% of Maine's emissions, second to the Transportation sector. Over 60% of Maine households use fuel oil as their primary energy source for home heating, which is a larger share than in any other state.

With assistance from Efficiency Maine Trust (EMT) programs, 45,000 high performance heat pumps and 25,000 heat pump water heaters have been installed throughout the State just in the past several years. These products and programs have been studied in Maine and Vermont and other states. Analysis confirms that the products work well in the Maine climate and save money over the life of the product.

For the next three years, EMT and MaineHousing have sufficient funding to provide incentives or full project costs for approximately 20,000 units per year. Beyond the third year, EMT may need to re-allocate existing revenue streams to this objective or find new funds. Beyond 2025, EMT may have no funds to promote this objective unless decisions are made at the Public Utilities Commission (PUC) and/or the Maine Legislature to authorize funding.

Strategy 3: Improve the Efficiency and Resiliency of Existing Building Envelopes

1. **Describe the Recommended Strategy and how it addresses Maine's climate resiliency and mitigation goals.**
   This strategy will promote increased efficiency and resiliency of the existing building envelopes that house Maine's residents, businesses, and institutions. Heating and cooling the spaces in these buildings is annually responsible for 39% of GHG emissions in Maine.[53] While other strategies look at ways to convert the types of fuels and equipment used to provide space heating and water heating, this strategy focuses on reducing the heating load on those systems by "weatherizing" -- reducing air leakage and improving insulation levels -- in existing buildings.

   Maine has successfully implemented weatherization programs to improve the energy efficiency of more than 20,000 market-rate homes since 2010, and many thousands more through the

[53] Maine DEP, "8th Report on Progress toward GHG Reduction Goals," January 2020, p. 9.

low-income programs of MaineHousing and the CAPs.[54] These improvements have reduced energy usage and carbon emissions, increased resident comfort, built home equity, saved residents money, and offered opportunities to remediate mold, lead, and other health hazards. Building on the results of these ongoing programs administered by MaineHousing and the Efficiency Maine Trust,[55,56] This strategy proposed increasing existing weatherization initiatives in order to achieve a statewide 20% reduction in heating load by 2050.

2. **What is your measurable outcome for this strategy, assuming all recommended actions to implement the strategy are achieved?**

    a. For mitigation strategies:
        i. What is the estimated CO2e savings (metric tons) by 2025, 2030, 2050?
            1. Data from the Weatherization Assistance Program indicates that the average 2008 carbon saved per household was 23 metric tons.[57]
            2. Data from ACEEE indicates that "energy efficiency upgrades could cut energy use and emissions by about 18% for homes and 23% for commercial buildings, and smart control technologies[58] could cut another 11% for homes and 18% for commercial buildings. Electrification of remaining loads adds an additional 13% in emissions reductions."[59]

        ii. What is the cost effectiveness of those reductions (cost per ton of CO2e reduced) and the total cost?
            1. The average cost of an Efficiency Maine residential weatherization project is $6,800, saving an average of 2,192 pounds of CO2 per year. For every $3.10 invested, one pound of carbon is saved.[60]

    b. Are outcomes measurable with current monitoring systems?

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[54] This does not reflect homes that made improvements on their own, without participation in an Efficiency Maine program.

[55] Halfway There: Energy Efficiency Can Cut Energy Use and Greenhouse Gas Emissions in Half by 2050, Nadel and Ungar, ACEEE. September 2019. Assumes 30% reduction of energy from retrofit (p. 11), 65% of homes retrofit by 2050 (2% per year), and 80% of commercial floor area retrofit by 2050.

[56] Residential Efficiency Retrofits: A Roadmap for the Future, Neme, Gottstein, Hamilton, May 2011. Average savings per retrofit might gradually increase over time, from 30% to above 50% (pp. 37-38).

[57] Weatherization Works - Summary of Findings from the Retrospective Evaluation of the U.S. DOE's Weatherization Assistance Program, Oak Ridge National Laboratory, 2014.

[58] Smart control technologies offer opportunities to cut emissions and manage the electric load. Details below and in Strategy 6: Modernize and Optimize the Grid.

[59] Halfway There, page v.

[60] Calculations compiled by Efficiency Maine using real program data. Benefit-to-cost results were calculated using the primary cost-effectiveness test used by Efficiency Maine. See appendix for full results.

i. Yes. Existing protocols for data tracking and periodic evaluations by Efficiency Maine and MaineHousing will enable measurement of outcomes.

3. **What specific actions would be required to implement the strategy, including but not limited to legislation or regulation?**

a. Expand access to weatherization programs for low- and moderate-income households.

i. Accelerate the rate of whole-house retrofits in low-income households, as defined by eligibility for the federal Weatherization Assistance Program.
   1. Increase economic incentives for low-income homeowners and owners of rental properties.
   2. Increase the income threshold higher to better serve middle income households.[61]
   3. Expand education regarding heating cost savings and low-interest loans.

ii. Amend the existing program to replace aging mobile homes,[62] which are often barely insulated and structurally inadequate, with new, high-efficiency modular homes which can be manufactured in Maine.
   1. Expand the definition of qualifying mobile homes to include those built after 1976.
   2. Inform owners and renters of substandard manufactured homes about opportunities to purchase replacement homes that are the same cost to own and operate as their failing homes due to the trade-off of crushingly high fuel bills for stable financing packages.
   3. Work with interested buyers from start to finish to help determine eligibility for incentives to cover the cost of removing an old mobile home, apply for low-interest financing options with no down payment, select a design, and draw up a contract with the builder.

iii. Expand reach of initiatives to supply and install low-cost insulating window inserts that function as interior-mounted storm windows improve the warmth and comfort of homes, lower heating costs, and reduce CO2 emissions.[63]

b. Weatherize existing market-based dwellings.

i. Expand financial incentives and financing for market-based weatherization, including in multifamily rental properties.

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[61] Before ARRA, the eligibility threshold for WAP was 150% of the Federal Poverty Level (FPL). The post-ARRA eligibility level is 200% FPL. There are examples of state WAPs where 250% FPL thresholds have been established with utility funds.

[62] MaineHousing's Pre-1976 Mobile Home Replacement Initiative provides income-eligible Maine residents with an opportunity to replace qualifying mobile home they own and occupy as their primary residence with a new ENERGY STAR® certified manufactured home.

[63] Window inserts are relatively simple to construct and can be built locally using the community-workshop method. Window Dressers, a volunteer-driven nonprofit organization that relies on this model, is Maine's largest producer insulating window inserts.

1. One option might be to provide payroll loans to active and retired public employees for home energy improvements, administered in coordination with the Maine Public Employee Retirement System.[64]

ii. Encourage weatherization improvements as the first step toward improved energy efficiency and resiliency in existing buildings, in line with building science best practices. Tackling weatherization first enhances the cost-effectiveness of subsequent improvements such as heat pump installations. Options include:
    1. Develop and distribute educational materials to inform consumers about the benefits of a weatherization-first strategy;
    2. Vary heat pump incentives, offering larger financial incentives when heat pump installations are paired with weatherization improvements;
    3. Encourage or require[65] energy audits at the time of sale for residential buildings to enhance transparency for home buyers and provide energy performance information at a time that it can be acted upon;
    4. Encourage or require[66] that weatherization be performed before making other improvements.

iii. Establish a Maine Clean Energy Corps that trains the workforce of the future while providing outreach to residents throughout the state, focused on one town or neighborhood at a time.[67] Volunteer or entry-level staff would:
    1. Inform the public of programs and rebates that are available and helps them to identify what is needed in their home;
    2. Provide assistance for elderly or disabled residents by installing low-cost energy measures; and
    3. Help to create a project pipeline for efficiency contractors, reducing the 'acquisition costs' of new projects.

iv. Conduct a feasibility pilot of systematized deep energy retrofits that address technical barriers to large-scale, minimally-disruptive improvements, including a lack of economical exterior insulation and industrialized installation methods.
    1. Identify non-landmark, non-historic housing stock appropriate for this pilot project, including modular or tract housing, duplexes, and triplexes;
    2. Employ laser scanning of houses and factory panelization of insulation systems to install R-40 wall & roof insulation, in combination with triple

[64] Though PERS offers an attractive path to administering payroll loans for more than 100,000 members, Working Group members voiced concern that such a program would unfairly favor public employees.

[65] The Working Group did not reach consensus around whether to *encourage* or *require* the energy audits at the time of sale, but agreed that energy audits should be an on-ramp for long-term solutions.

[66] The Working Group did not reach consensus around whether to *encourage* or *require* the weatherization-first approach, but coalesced behind offering tiered incentives for heat pumps, with the largest incentives available only when paired with weatherization. Some members feel strongly that because weatherization enhances the energy- and cost-savings potential of heat pumps, a requirement is appropriate. Other members, including Efficiency Maine, feel that such requirements may be counterproductive, citing concerns that weatherization-first policies may depress adoption of cost-effective heating system upgrades.

[67] There is strong support for establishment of a Maine Clean Energy Corps or perhaps, more broadly, a Maine Climate Corps that could address the public outreach and assistance needs identified across Working Groups.

glazed windows, from the exterior of houses with minimal disruption to inhabitants;[68] and
3. Assess technical infrastructure and workforce needs required to deploy these measures at scale.

v. Establish fuel-neutral funding mechanisms for weatherization projects.
1. Current programs are too limited and funded by electric ratepayers.[69] Despite the state's high reliance on heating oil and propane, these unregulated fuels do not contribute to Efficiency Maine program funding.
2. One option is to extend the energy efficiency surcharge now levied on electricity and natural gas to heating oil and propane and to use that revenue to fund the weatherization program expansion proposed by this Working Group.[70]

c. Require commercial building energy benchmarking and labeling/disclosure.

i. Require commercial buildings over a certain square footage to track and report their energy usage, providing a baseline understanding of how much energy is being used in individual buildings and/or across an entire building stock.
1. Data gained through benchmarking can be used at the individual building level for behavioral changes or capital improvement projects.
2. Data can also be used by city or state officials to establish policies and programs that require performance improvements over time.

ii. After one reporting cycle, the lowest performing buildings can be targeted for improvements through utility incentive programs, grants, operational changes, and/or building operator trainings.

iii. Longer term outcomes can be realized through building performance standards based on 3-5 years of data collection.

d. Establish incentives for participating in smart device load management programs.

i. Beneficial electrification of heating and transportation will add new loads to the regional electric grid. Incorporating incentives for participation in smart device programs into existing weatherization programs will support intelligent load management programs that lower peak demands on the system, thereby lowering infrastructure costs.

ii. See Strategy 6: Modernizing and Optimizing the Grid for details.

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[68] Energiesprong is a model for this net zero retrofit approach, which relies on new technologies such as prefabricated facades, insulated rooftops with solar panels, smart heating, and ventilation and cooling installations to complete whole-house refurbishments in less than 10 days. Energiesprong originated in the Netherlands and has inspired programs such as RetrofitNY in New York State and Rocky Mountain Institute's REALIZE, currently being piloted in California.

[69] Most funding for programs to reduce heating fuel reduction in buildings come from RGGI, which generates $10 million/year -- enough to provide core efficiency support to fewer than 1% of households in need.

[70] The Industrial Energy Consumers Group (IECG) strongly supports this proposal.

4. What is the timeframe for this strategy?

	Short-term (2022)	Mid-term (2030)	Long-term (2050)	2070 -2100
To implement	Given that this strategy expands existing programs, implementation could begin as soon as funding is secured.			
To realize outcomes	Weatherization offers immediate benefits in energy-savings and occupant comfort/health.			

5. Please analyze the Recommended Strategy against the following criteria.

Workforce -

Expansion of existing programs brings familiar workforce challenges -- including training skilled labor, increasing the number of contractors participating in weatherization programs, and ramping up administrative systems -- and a variety of opportunities. Benefits include opportunities to:

- Leverage existing workforce development structures such as those established through the American Recovery and Reinvestment Act of 2009 (ARRA);
- Train heat pump installers/heating contractors to complete energy audits to facilitate the bundling of efficiency improvements;
- Foster public-private partnerships, such as the proposed Maine Clean Energy Corps, that train volunteers or entry-level workers to promote weatherization measures and build the trained workforce needed to transition every home to clean energy solutions;[71]
- Create pathways for publicly and privately employed workers to earn certification from accredited training organizations, including the Building Performance Institute (BPI) and the Interstate Renewable Energy Council (IREC), both under the guidance of the Department of Energy (DEOE); and
- Build demand for weatherization services sufficient to support new small businesses.

[71] The collaboration between AmeriCorps, Efficiency Maine, and Window Dressers demonstrates the potential of this workforce development strategy.

Workforce development should be tied to Maine's Economic Development Strategy, and linked to the state's Economic Recovery Committee. This is an opportunity to fundamentally improve the quality and valuation of trades jobs in Maine by modernizing training and other efforts.

Benefits (non-workforce) -

In addition to significant reductions in heating fuel use and associated cost savings and emissions reductions, weatherization measures in affordable housing and market-based dwellings offer a host of co-benefits, including:

- Economic benefits through decreased energy costs, including greater disposable income for served households and reduced flow of dollars out of Maine economy;
- Improved occupant health, especially when weatherization is coupled with remediation of mold, lead, and other hazards;
- Improved public health due to lower emissions and cleaner air;
- Enhanced resiliency and maintained comfort, even during power outages;
- Increased effectiveness of heat pump installations; and
- Increased equity and home value for owners.

Mobile Home Replacement offers additional co-benefits, including:

- Enhanced safety, economic protection, fuel poverty alleviation for vulnerable residents;
- Enhanced resilience in extreme weather events, which disproportionately affect residents of structurally inadequate home, and power outages;
- Support for an ownership economy that can lift up lower income households; and
- Potential to create quality manufacturing jobs connected to the traditional forest products industry.

Current weatherization methods are time- and workforce-intensive because they are tailored to each home and installed on site. A Deep Energy Retrofit Pilot would test the feasibility of economical exterior insulation strategies that can be deployed at scale to radically improve the comfort and ease of heating existing Maine homes with minimal disruptions to the interiors of buildings and their occupants.

Commercial energy benchmarking provides wide-ranging benefits to building owners, state and local governments, and energy-service providers, including:

- Increased market awareness and visibility of building energy usage;
- Actionable information to help building owners take control of energy costs; and
- Transparency and ready comparison between similar buildings, creating the opportunity to focus efforts (and funding) where they are most needed.

Costs –

Many of the recommendations submitted by this Working Group will deliver long-term cost savings but can only be implemented with additional upfront resources.

Cost considerations for expanding weatherization programs include:

- The national low-income Weatherization Assistance Program (WAP) has a program-wide savings-to-investment ratio (SIR) of 1.4 and a program-wide SIR of 4.1 when health and safety benefits were included.[72],[73] Because the housing stock in Maine is the oldest in the US and the cost of fuel is high, the average SIRs are likely to be higher.

- Primary funding for WAP is provided by the U.S. Department of Energy and passes through MaineHousing to the nine subgrantee weatherization agencies in the state. These agencies also receive funding from Efficiency Maine for selected weatherization activities.
  - FY 2019 DOE allocations for Maine's WAP are approximately $3.5 million, a 20% increase over FY 2018.
  - WAP may be expanded at the federal level through an economic recovery package, similar to ARRA activities in 2009.

- In non-low-income homes, Efficiency Maine's weatherization programs to reduce heating fuel are currently limited to funds available from RGGI, which generates $10 million/year and is allocated across and shared by multiple sectors, including industrial, commercial and small business. The share allocated to market-based weatherization each year has ranged from $2.5 million - $3.5 million.
  - Unlike electricity and natural gas, heating fuel markets do not contribute to Efficiency Maine program funding.
  - Securing fuel-neutral funding such as an energy efficiency surcharge on unregulated fuels would make RGGI funds more available for beneficial electrification, with less distortion of energy markets (i.e., less need for fuel markets to fund electrification and electric ratepayers to fund heating fuel reductions).
  - An efficiency surcharge of 5 cents/gallon would raise roughly $25 million/year. Assuming Efficiency Maine continues to achieve a benefit to cost ratio of roughly 2:1, the surcharge would have a net present benefit of roughly $40-45 million per year.
  - The surcharge would have some economic impact, but pale in comparison to natural fluctuations in heating fuel prices, which can go up or down by 5 cents/gallon on a weekly basis, and by $1/gallon on an annual basis.
  - Long term effects of the surcharge could include helping to reduce the volatility of fuel prices by reducing peak demand.

- Efficiency Maine also maintains a Revolving Loan Fund to finance loans up to $15,000 for weatherization. The fund is nearly completely invested and would require new capitalization in order to significantly expand loan offerings.

[72] Weatherization Works

[73] Weatherization Assistance Program -- National Evaluations: Summary of Results, U.S.D.O.E.

- There is a need to develop additional funding mechanisms, perhaps by developing a stakeholder group of lenders to make available innovative loan products and programs to promote them, as well as traditional products such as:
  - a revolving Green Home loan program;[74]
  - the unsecured Efficiency Maine Trust loan;
  - Property Assessed Clean Energy (PACE) loans;
  - fuel-switching loans from new providers; and
  - HELOCS and cash out mortgage refinancing at attractive rates.

- Financing strategies could leverage greater private investment and reduce the total public cost of programs for middle (and upper) income homes, leaving more resources for low-income households.

- A Clean Energy Corps program with 10 service members would cost ~$600,000 including transportation, management, efficiency measures, and other program expenses for a year. AmeriCorps (Corporation for National and Community Service) could provide ~$200,000 of this cost. Including community volunteers could help reduce costs.

Scaling up systematized Deep Energy Retrofits would likely require investment of millions of dollars, but could leverage research capabilities of the University of Maine and partnerships with organizations such as passivhausMAINE. There is also an opportunity to apply for DOE-EERE funds and other grants.

Costs associated with building energy benchmarking programs are primarily attributed to the implementation and enforcement of such a policy, including staffing requirements to develop the policy, notify building owners, market and train building owners, and perform data analysis.[75] Factors such as building sizes and the number of covered buildings have an impact on costs. Free tools such as EPA's Portfolio Manager, the industry standard for benchmarking, can be utilized to minimize costs. Additionally, utilities can be engaged to provide data to building owners in a straightforward manner, streamlining the process and reducing costs.

Equity -

Weatherization has the potential to assist all segments of the population, but is likely to be proportionately more impactful, economically, on lower income homes. Because additional resources are needed to scale up Maine's existing weatherization programs, particular attention must be given to equity, including:

- Extending the energy efficiency surcharge now levied on electricity and natural gas to heating oil and propane would have a disproportionate impact on heavy-heating low-

[74] Revolving Loan Funds, U.S. DOE

[75] Section 3.8 of LBNL's Evaluation of U.S. Building Energy Benchmarking and Transparency Programs: Attributes, Impacts, and Best Practices provides additional details of the costs of setting up a benchmarking program.

income households. This must be remedied through a disproportionate investment of the funds on weatherizing low income households.
- Funding should be targeted to communities that are less able to convert away from heating fuel, including rural areas where access to building improvement services are more limited.

Mobile home replacement addresses the needs of at-risk residents. Above average unemployment rates, high housing costs, old inefficient housing stock, and long, expensive commutes are prevalent among owners and renters of rural, substandard mobile homes and manufactured housing. These factors often result in high poverty rates and increased vulnerabilities, which are exacerbated by the poor air quality and structural inadequacy of these dwellings. Replacing failing homes with higher quality, safer, more affordable homes supports an ownership economy that can lift up lower income households.

A Deep Energy Retrofit Pilot would systematize weatherization improvements, reducing costs and logistical barriers. The more uniform design of workforce housing, duplexes, and triple deckers, which often makes them more affordable for low- and moderate- income Mainers, is particularly appropriate for this program.

Proven strategy & feasibility –

Many of the recommendations submitted by this Working Group would scale up proven strategies.

Weatherization: Maine's energy efficiency programs include all the important elements necessary to weatherize existing dwellings, including trained and experienced administrative staff, a network of skilled contractors, software for energy analysis and inventory control, lead funding and oversight organizations (MaineHousing and Efficiency Maine), legislative support, and more. Program expansion will be informed by the lessons of the 2009 ARRA expansion. Additional resources will be required to scale up these efforts, and other jurisdictions offer helpful precedents, including:

- Clean Energy Corps established in jurisdictions including Montana[76] and New York City.[77]
- Vermont has a small heating fuel efficiency surcharge, and several other states allow electricity ratepayer funds to be used for efficiency measures that reduce heating fuel use.

There are proven models for scaling up Deep Energy Retrofit, including:

- Energiesprong, a public-private partnership which originated in the Netherlands, relies on new technologies such as prefabricated facades, insulated rooftops with solar panels, smart heating, and ventilation and cooling installations to complete whole-house refurbishments in less than 10 days. Energiesprong has implemented zero energy retrofits in almost 5,000 units over the past five years, with another 100,000 planned across Europe.
- RetrofitNY in New York State

[76] https://www.energycorps.org/

[77] https://www.greencityforce.org/service-corps/about-service-corps/

- Rocky Mountain Institute's REALIZE, which is being piloted in California, combines demand aggregation and supply chain coordination to deploy high-quality, prefabricated mass-scale retrofit packages that are easy to install and are financed through utility cost savings.

Mobile Home Replacement: Modular replacements for older mobile homes is part of an existing low-income program at MaineHousing. Other states, including Vermont, have successful programs to build and deliver Zero Energy Modular (ZEM) homes that give residents of failing homes the opportunity to purchase and operate replacement homes without increasing costs, thanks to the replacement of high fuel bills with stable financing packages.[78]

Benchmarking is already occurring at the local level in Maine, including in Portland and South Portland, and at the state level in many other states in the region.[79] Connecticut and New Hampshire started by benchmarking state owned buildings. New Jersey rolled out programs that require commercial buildings over a certain square footage to track and report their energy usage. Key information related to process-oriented best practices, policy recommendations, and program structure can be leveraged from these models to help inform efforts in Maine.

Legal authority - Existing weatherization programs could be scaled up without additional legal authority, but legislative action would be necessary to secure additional resources.

- Maine has evaluated a variety of potential funding options in the past.[80]
- Efficiency Maine's enabling statutes must be amended according to funding sources.
  - Amend 35-A MRSA 10119 to address the Efficiency Maine program for weatherization if funds are derived from grants or assessments on heating fuels.
  - Amend 35- A MRSA 10111 to address the Efficiency Maine program for weatherization if funds are derived from assessments on natural gas utilities.
- Authorizing legislation would be needed if Maine were to establish a fuel-neutral surcharge and direct its use; legislation could also include directives for utilities to participate in financing programs developed in coordination with Efficiency Maine.[81]

Resilience and Adaptation - Weatherization is the key to reducing carbon emissions and right- sizing electric, HVAC, and solar systems. Strategies to improve the efficiency of Maine's building stock also enhance resilience by reducing the state's dependence on imported fossil fuels, mitigating greenhouse gas emission, and hardening buildings against extreme weather events..

Cross-cuts with other strategies and work groups?

- Strategy 1: Improve the Design and Construction of New Buildings
  Contractor training to support building code compliance in new construction (Strategy 1) would also support code-compliant retrofits of existing buildings.
- Strategy 4: Lead by Example in Publicly-Funded Buildings

[78] See also, Vermod, maker of the ZEM replacements for mobile homes for low-income Vermonters

[79] NEEP has compiled a list of state and municipal benchmarking programs here.

[80] E.g., Efficiency Maine, "Heating Fuels Efficiency and Weatherization Fund - Final Report," December 15, 2010.

[81] See Title 38 MRS secs 545 and 545-B; See LD 866 from 2009

Strategy 3 details weatherization programs that could be utilized to retrofit state-owned buildings.

- Strategy 6: Modernize and Optimize the Grid
  Opportunities to reduce, shift, and otherwise manage Maine's growing electric load through smart device load management systems are detailed in Strategy 6, and can be incorporated into weatherization improvements through targeted incentives.

6. Rationale/Background Information

**Please footnote substantive disagreements among the Working Group members

See above

7. Stakeholder Comments

The MaineHousing EHS Weatherization Team agrees given the age of Maine's housing stock that there is a significant need for weatherization services across the state. Expanding the current Weatherization Assistance Program is in line with MaineHousing's mission to assist all Maine people.

Strategy 4: Lead-By-Example in Publicly Funded Buildings

1. **Describe the Recommended Strategy and how it addresses Maine's climate resiliency and mitigation goals.**

   This strategy will highlight the State's leadership role in climate resilience and mitigation by accelerating the timeline of Strategy 1 (Improve the Design and Construction of New Buildings) in publicly-funded buildings. It will amend the rules and policies for procurement of affordable housing, state government buildings, and schools at the K-12, community college, and university levels. Swiftly adopting best practices in these highly-visible, collectively-funded and -utilized buildings will demonstrate the feasibility of practices outlined in Strategy 1, offer important experience and learning for implementation statewide, and maximize the economic and climate benefits of high-performance construction for taxpayers.

   Lead-by-example (LBE) policies ensure that publicly-funded construction meets best practices for building materials, techniques, and systems. This can significantly reduce buildings' energy costs and limit embodied and operational carbon, delivering immediate benefits to building occupants and taxpayers. In addition, LBE projects increase awareness of and experience with emerging construction practices, provide benchmark data on a continual basis, and stimulate the market for new materials that could be manufactured in Maine, including cross-laminated timber and wood-fiber insulation. Maine could maximize these benefits by identifying and/or creating educational resources around the value and benefits of low-carbon, high-performance residential and commercial buildings and requiring LBE projects to track and report energy performance. The design, construction, and performance of "showcase" projects could also be documented to demonstrate what is feasible and familiarize construction professionals with

new materials and technologies. Lessons learned from the State's experience can inform the more stringent building codes being promoted statewide.

2. **What is your measurable outcome for this strategy, assuming all recommended actions to implement the strategy are achieved?** [Pending modeling results]

    a. **For mitigation strategies:**
        i. **What is the estimated CO2e savings (metric tons) by 2025, 2030, 2050?**
        Needs further modeling

        ii. **What is the cost effectiveness of those reductions (cost per ton of CO2e reduced) and the total cost?**
        Avesta Housing's analysis of the costs of all new construction affordable housing projects built between 2005 and 2016 concluded that buildings designed to a higher efficiency standard than those that were simply designed to code compliance saw an average of 3% increase in initial costs for 50% annual operating cost savings.[82]

    b. **Are outcomes measurable with current monitoring systems?**
    MaineHousing closely monitors project construction costs and operational costs as well as energy consumption per square foot to assess the efficiency of its affordable housing properties. Though Title 5 MRS Title Chapter 153: Public Improvements requires that new or substantially renovated state buildings set an energy-use target that exceeds by at least 20% the energy efficiency standards in effect for commercial and institutional buildings pursuant to MUBEC,[83] the regulation does not require a mechanism for reporting or disclosure. Language could be added to enforce and disclose the building's progress toward such targets.

3. **What specific actions would be required to implement the strategy, including but not limited to legislation or regulation?**

    a. **Amend state rules and policies for affordable housing to further incentivize energy efficiency, clean heating and cooling, distributed energy resources, and emissions reductions.**
        - Leverage the Qualified Allocation Plan (QAP) to improve energy performance, cost-efficiency, and occupant comfort in affordable housing. Nearly all new, rent-restricted multifamily housing in Maine, and in every U.S. state, is governed by a QAP. This document is revised and approved annually through the State's rulemaking process and sets out the requirements and incentives which housing developers use to determine the details of their proposed projects: where they will be located, who they will serve, how they will be constructed, etc.
        - Add points for high-performance design, electric vehicle charging infrastructure, and use of wood products, including cross-laminated timber instead of steel or concrete,

[82] See Appendix pg. 10 for full results.

[83] https://www.mainelegislature.org/legis/statutes/10/title10sec9722.html

and wood-fiber insulation instead of rigid foam or other approaches. These "adders" are common in the competitive QAP processes in many states, including New Hampshire, but have not been adopted in Maine.[84]

- In addition to reducing carbon emissions, such investments would support Maine's growing renewable resource economy and would likely drive affordable housing developers to explore these building materials as they go through the design process.

b. Amend procurement rules for state government, University of Maine, and Maine Community Colleges to achieve low embodied carbon, zero emissions, zero-energy, and resilience in new construction by 2025.

- Set energy and GHG reduction targets for new state construction projects in line with U.S. Climate Alliance goals.
- Demonstrate and/or give preference for low-carbon building materials such as cross-laminated timber and wood-fiber insulation.
- Incorporate electric vehicle supply equipment (EVSE) charging infrastructure.

c. Require 100% clean electricity in Maine public schools by 2025 and amend Standards & Guidelines for New School Construction & Major Renovation Projects to accelerate the transition to low embodied carbon, zero emissions, zero-energy, and resilience.

- Connect school districts to resources that help locally-owned and -operated K-12 schools produce or procure clean electricity such as Energy Saving Performance Contracting and Power Purchase Agreements for solar.
- Though Maine's K-12 educational facilities are owned and operated at the local level, there are opportunities for the State to encourage school districts to prioritize energy efficiency and clean heating and cooling, including:
  - Leverage triennial maintenance and capital improvement plans[85] to make schools more efficient, reduce their emissions, reduce future tax burden, and provide an educational example for all students.
  - Strengthen Maine DOE's Standards & Guidelines for New School Construction & Major Renovation Projects[86] to promote zero carbon schools that maximize cost-saving efficiency and conservation measures and improve the overall health and well-being of students, staff, and community.

d. Demonstrate the successful use of low-carbon building materials, including those made in Maine, and high-efficiency systems through "showcase" projects.

[84] MaineHousing does not support this recommendation to award "points for promises" of high-performance design specifications and/or use of wood materials. This opposition does not reflect a lack of support for energy efficient affordable housing; MaineHousing observes that it has been a leader in this area, beginning with the introduction of Green Building Standards in 2005, and increased the construction cost cap by 3% for projects that receive Passive House certification.

[85] Maine school districts are encouraged to establish and practice sound management policies that develop, preserve, and protect their facilities, and are required to document those policies in maintenance and capital improvement plans (20-A MRS §4001 sub-§7). These plans must be updated every three years and must require content detailed in Maine DOE's Rules Chapter 64, Section 2.

[86] Maine DOE developed Standards & Guidelines for New School Construction & Major Renovation Projects with assistance from practicing design professionals to assist school units and their architects in public school design.

- Showcase LBE projects that meet more stringent building codes before those standards are implemented statewide, incorporate low-carbon building materials, and employ low-carbon building strategies, including use of wood structural systems in low- and mid-rise commercial buildings. Highlighting these projects—whether in affordable housing, state government, higher education, or K-12 schools—will demonstrate their feasibility, grow Maine's renewable resource economy, and increase workforce experience with new materials and practices.
- Require these showcase projects to document the materials and strategies used, to track building performance data, and to report learning and assessment of what worked after one year of data is collected.

4. What is the timeframe for this strategy?

	Short-term (2022)	Mid-term (2030)	Long-term (2050)	2070 -2100
To implement	QAP adders for high-performance design and low-carbon building materials implemented 2021 Procurement rules for state gov and higher education incentivize high performance buildings by 2025	Public K-12 schools transition to 100% clean energy		
To realize outcomes		Showcase projects increase familiarity with and drive adoption of high performance building strategies and low-carbon materials		

5. Please analyze the Recommended Strategy against the following criteria.

Workforce - LBE policies will:

- *Prevent job loss* by accelerating the transition of Maine's existing construction jobs to high-performance building practices;

- *Create new jobs* by increasing demand for high-performance buildings services, including design, construction, renewable energy, and energy efficiency; and
- *Stimulate Maine's building materials market* by increasing demand for low-carbon construction materials, including Maine-made wood-based projects such as cross-laminated timber (CLT) and wood-fiber insulation.[87]

Benefits (non-workforce) - LBE policies have a variety of expected co-benefits, including:

- Accelerated transition to high-performance, low-carbon buildings;
- Accelerated electrification of transportation;
- Increased economic activity, including in green building design, construction, and manufacture of Maine-made, low-carbon building materials;
- Improved occupant health, comfort, and productivity, including for low-income residents of high-performance affordable housing units; state employees working in new, high-performance buildings; and students in retrofitted public schools;
- Efficient energy use in all new state-owned and/or -funded buildings, with associated cost-savings and reduced strain on the electric grid;
- More resilient state-owned buildings, with the potential to serve as community shelters during extreme weather events; and
- Showcase projects offering opportunities for building trades workers, students, and the public to learn about clean energy and energy efficiency technologies and their benefits.

Costs – What are the estimated fiscal costs and other costs to carry out this program. To the state? To municipalities? What resources do you anticipate needing to inform Mainers about the strategy and the opportunity/costs of the strategy? Where would financing likely come from?

- There is likely to be a modest increase (3-5%) in the upfront costs of constructing highly energy-efficient and low embodied-carbon buildings, which would be more than offset over time by reductions in operating costs and energy usage.
    - Analysis of Avesta Housing's new construction projects between 2005 and 2016 indicates that high-performance design and construction correlates with significantly lower operating costs, as measured by utility bills. Bayside Anchor, the only Avesta property built to Passive House standards, incurs energy costs approximately 63% lower than average for a typical building of the same size.
- Building industry professionals (architects and engineers, builders, insulation and HVAC installers) will need training programs like those detailed in Strategy 1 to gain experience and comfort with new materials and practices. Additional resources should include:
    - Educational materials around the value and benefits of low-carbon, high-performance residential and commercial buildings; and
    - Case studies with benchmark data from showcase projects.
- Several existing financing mechanisms can defray the upfront costs of higher performance building design and construction, including:
    - Energy Saving Performance Contracting can be used to finance the up-front cost of energy efficiency upgrades based on projected long-term energy savings; and

[87] See details about the benefits of CLT and wood fiber insulation in Strategy 1.

○ Power Purchase Agreements for solar reduce the cost of electricity from day one.
Equity - LBE policies benefit low-income, rural, and vulnerable residents and/or communities in a variety of ways, including: • All members of the State benefit from superior building design, cleaner air (reduced GHG emissions), and lower operational costs. • Residents of Maine's islands have the state's highest energy costs. Along with low-income Mainers, these rural residents benefit the most from lower heating and electric bills as a result of improved energy efficiency. • Low-income Mainers and people of color suffer disproportionately from asthma, which is aggravated by poor building conditions. These communities also suffer disproportionately from climate-related health impacts. Beginning Maine's transition to high-performance design and construction in affordable housing and educational settings will deliver the health benefits of green buildings most quickly to those who need them most. • Increasing the availability of electric vehicle charging infrastructure statewide. • LBE policies enlist building industry professionals across the state, including in rural and/or vulnerable communities, in establishing a new normal for Maine buildings, giving those who might be left behind the opportunity to lead. • Renewable resource sectors, including wood-based materials such as cross-laminated timber and wood fiber insulation, will benefit from increased demand.
Proven strategy & feasibility – LBE policies are a proven strategy to demonstrate the feasibility and cost-efficacy of innovative practices in collectively-funded and -utilized spaces. Though adoption of net zero building practices is not yet widespread in Maine, there are numerous examples of LBE at the state and local level, including: • Many states, including New Hampshire, have provisions in their Qualified Allocation Plans (QAP) which incentivize affordable housing developers to design to a high efficiency standard. • The University of Maine and Bowdoin College were among ten institutions to receive Mass Timber University Grants showcasing the architectural and commercial viability of mass timber in building construction.[88] Funding from the U.S. Department of Agriculture Forest Service is supporting design and engineering work, cost studies, and construction code review to support the construction of mass timber buildings on college campuses. Additional federal programs create new opportunities for innovative wood products which contribute to diversified rural economies and support sustainable forest management.[89] • The number of Zero Energy buildings across the United States and Canada has increased tenfold since 2010, and encompasses 80 million square feet of commercial building space.[90] • New York City's stringent "stretch" building code, implemented January 1, 2019, has fostered well-vetted, energy-saving proposals that will help NYC to meet its 80 x 50 climate goal (80% reduction in GHG emissions by 2050).[91]

[88] https://www.fs.usda.gov/news/releases/mass-timber-university-grant-program-projects-support-forest-health-and-vibrant

[89] https://www.fs.usda.gov/naspf/programs/wood-education-and-resource-center/wood-innovations-home

[90] https://newbuildings.org/hubs/zero-energy/#case-studies

[91] NYC Local Law 048 of 2020 (Intro No. 1816-A) adopts the provisions of the 2020 ECCCNYS, aligns them with the Administrative provisions of the NYC Construction Codes, aligns with the provisions of the NYSERDA NYStretch

- Cities such as Boston,[92] Boulder, Santa Monica, and the District of Columbia are instituting similarly aggressive building standards, and Governors in Oregon and North Carolina are stepping forward with executive orders directing state agencies to follow New York's lead with goals set for carbon reduction and clean energy in new construction.
- Several school districts have committed to 100% clean energy in their schools, including Red Wing, Minnesota and San Francisco, California.[93]

Legal authority - No new statutory authority is required to implement LBE policies. Existing authority includes:

- The Qualified Allocation Plan is updated through the state's rulemaking process and requires the Governor's signature. This process gives the Governor an important opportunity to ensure that the document aligns with her or his priorities and policy goals and does not require legislative approval. Past Governors have used the QAP process to further their policy goals.
- Maine statute already calls for LBE by requiring improvement of energy efficiency in state-funded construction.[94] The statute could be strengthened with language that specifically calls for net zero buildings, electric vehicle charging infrastructure, and a life-cycle cost analysis that explicitly considers embodied carbon.[95]
- Adding a cost to carbon can be helpful when doing Life Cycle Analysis (LCA) for building systems, but it is not necessary, as long as the LCA also includes CO2 associated with various building systems being considered and not just costs.

Resilience and Adaptation - LBE policies contribute to making Maine communities more resilient to climate vulnerabilities by making state-funded buildings more efficient, reducing their emissions, reducing future tax burden, and providing an educational example for all students.

Cross-cuts with other strategies and work groups?

- Strategy 1: Improve the Design and Construction of New Buildings
  Strategy 4 accelerates the timeline of Strategy 1 in state-funded buildings, forging a pathway for statewide implementation of stringent building codes and adoption of low-carbon, Maine-made building materials.
- Strategy 3: Improve the Efficiency and Resiliency of Existing Buildings
  Strategy 4 calls for retrofitting public K-12 schools through many of the same steps in Strategy 3 and could utilize the Maine Clean Energy Corps outlined in that strategy.
- **Transportation Working Group**

Energy Code-2020 as required by Local Law 32 of 2018, and adopts additional requirements. See http://alignny.org/wp-content/uploads/2015/04/ClimateWorks_Report_R5_LowerRes.pdf for details.

[92] City of Boston, Department of Neighborhood Development, 2020 Guidebook for Zero Emission Buildings (ZEBs)

[93] https://greenschoolsnationalnetwork.org/100-clean-energy-school-districts-a-growing-movement/

[94] 5 M.R.S.A. §1764-A, https://www.mainelegislature.org/legis/statutes/5/title5sec1764-A.html

[95] The life cycle analysis of alternative structural systems is readily achievable using open source software, such as the EC3 Carbon in Construction Calculator developed by the Carbon Leadership Forum in association with the University of Washington (http://www.carbonleadershipforum.org/projects/ec3/), and includes in-forest impacts, (e.g. reductions in both carbon sequestration and the carbon stored in the trees harvested and creation of logging waste that decays, as well as the emissions from burning biomass.)

Ensuring the visibility and availability of electric vehicle charging infrastructure is one of the greatest challenges to transportation electrification. LBE policies that incorporate this infrastructure will support the electrification strategies proposed by the Transportation Working Group.

- **Community Resilience, Emergency Management, and Public Health Working Group**
  The Public Health Working Group proposes to incentivize the achievement of carbon neutrality within 6 years by Maine's four major health systems (MaineHealth, Central Maine Medical Center, Northern Light Health and MaineGeneral), extending the scope of LBE policies described here. These systems account for ~27 hospitals across Maine. (In addition, there are ~11 independent, and much smaller, hospitals, which would be incentivized to adopt a similar goal over a longer period).

- **Natural & Working Lands Working Group**
  Emphasizing carbon-sequestering, low-carbon building materials such as cross-laminated timber and wood-fiber insulation will increase economic activity in the forest products industry; benefit rural economies by creating more demand for wood, with higher returns for landowners; and improve forest management by creating markets for low value and small trees. Improved forest management could in turn improve wildlife habitats.

6. Rationale/Background Information

**Please footnote substantive disagreements among the Working Group members

Lead-by-Example initiatives are a means to accelerate the statewide adoption of the model building standards and practices highlighted by Strategy 1. By mandating green standards in government-owned or leased buildings, the Maine state government can promote local market transformation that encourages best practices in construction, operation, and maintenance. Plus, publicly-funded buildings that operate more efficiently save tax-payer dollars while reducing resource consumption and carbon emissions. Other benefits of green government buildings include improved indoor air quality, daylighting, and the use of less toxic materials, providing a healthier environment for occupants and employees. Finally, government facilities that build with low-embodied carbon materials can support Maine-based markets for building materials and services.

Strategy 5: Accelerate the Decarbonization of Industrial Use and Processes

1. **Describe the Recommended Strategy and how it addresses Maine's climate resiliency and mitigation goals.**

   This Recommended Strategy includes two components focused on emissions from Maine's industrial sector.

   a. *Expand funding for industrial energy efficiency program offerings through the Efficiency Maine Trust (EMT).*

Industrial facilities in Maine have historically shown strong and active participation in energy conservation programs. There is still more cost-effective energy efficiency opportunity (electric and thermal) that could be pursued in this sector. EMT offers incentives through the Commercial and Industrial (C&I) Custom Program, but funding for these projects is limited due to various reasons, which include statutory provisions, allocation of RGGI funds to programs benefiting other sectors, and lower than anticipated RGGI revenues. Expansion of funding for incentives and technical assistance through EMT would allow Maine to target more GHG reduction from the industrial sector.

b. *Pursue a long-range plan for industrial fuel switching in process heating.*

According to the Maine DEP, the industrial sector is responsible for 9% of CO2 emissions from fossil fuel combustion in Maine.[96] Achieving GHG reduction goals in this sector will likely require significant shifts away from these fuels to cleaner alternatives. Some fuel switching opportunities can be both cost-effective and reduce GHG emissions, such as by converting from use of unregulated fossil fuels to natural gas and increasing efficiencies through use of Combined Heat and Power (CHP). Other opportunities, such as shifting to renewable gas or renewable oil (i.e., hydrogen rich fuels produced using renewable energy electrolysis or using carbon capture and sequestration) are not close to being commercially available and competitive (see Section 6, below). Maine should support demonstration/pilot projects of industrial fuel switching opportunities in the near term in order to accelerate their development and deployment in the longer term. The Work Group also proposes establishing the Maine Industrial GHG Task Force, representing a cross-section of industrial consumers, state government, and academia, to study and propose long-range plans for GHG mitigation from this sector.

2. **What is your measurable outcome for this strategy, assuming all recommended actions to implement the strategy are achieved?** [Pending modeling results]

   a. For mitigation strategies:
      i. What is the estimated CO2e savings (metric tons) by 2025, 2030, 2050?

         TBD

      ii. What is the cost effectiveness of those reductions (cost per ton of CO2e reduced) and the total cost?

         TBD

   b. Are outcomes measurable with current monitoring systems?

3. **What specific actions would be required to implement the strategy, including but not limited to legislation or regulation.**

[96] Maine DEP, "8th Report on Progress toward GHG Reduction Goals," Jan. 13, 2020, Figure 6, p. 9.

a. Action 1 -- Expand funding for industrial energy efficiency program offerings through EMT.

- Legislature to establish additional and/or expand existing funding streams. These may include, but are not limited to:
    - additional electric procurement revenues gained by assessing large electricity users (transmission and subtransmission [T&ST] customers are currently exempt from paying into or receiving incentives from the EMT electricity conservation funds)[97] or
    - a new energy conservation assessment on unregulated heating fuels so that EMT may allocate a larger portion of its RGGI funds to the industrial sector and T&ST customers.)[98]
    - Consider targeted tax incentives for investments in qualifying capital projects.
- The EMT Board should vote to deem commercial cannabis grow operations eligible for participation in EMT programs.
    - These customers are currently *ineligible* to receive funds from EMT. See EMT Board vote December 13, 2017. This action would allow EMT to include the energy-intensive cannabis growing sector in its assessment of cost-effective energy efficiency investment opportunity in Maine, thereby securing the corresponding electric procurement budget to fund incentive programs.

b. Action 2 -- Pursue a long-range plan for industrial fuel switching in process heating.

- Establish the Maine Industrial GHG Task Force, industry-led, comprising a cross-section of consumers responsible for significant industrial process emissions of GHG, as well as State government -- the Maine DEP, GEO and EMT -- and the University of Maine, to study and propose long-range plans for GHG mitigation from this sector.
- Using feedback from the task force, the Maine Climate Council should:
    - establish appropriate GHG reduction targets for industrial process emissions in the State by 2030 and 2050, with consideration for impacts on the competitiveness of the in-state manufacturers, the availability and cost of alternative fuels or industrial processes that could lower GHGs, and impacts on jobs and local tax revenues, and the trajectory of the State's progress in achieving the statewide carbon reduction requirements.
    - Examine regulatory barriers to pilot/demonstration project implementation and propose fixes to Legislature.
    - Support grant applications for pilot projects that use, or shift to, alternative fuels or carbon capture and sequestration, using existing grant programs (e.g., Maine Technology Institute, UMaine) or federal grants where available, with particular focus on renewable gas and renewable oil applications

[97] The IECG strongly opposes this option on the grounds that it would undo a legislative compromise made during the negotiations to adopt the Regional Greenhouse Gas Initiative.
[98] The IECG strongly supports this option.

- Natural gas local distribution companies (LDCs) may offer promotions to industrial customers along existing distribution networks.
- Authorize bonding funding source, such as MTAF proposed in Strategy #6, to fund prototype projects for fuel switching, innovative CHP/storage/demand management projects that further fuel switching.

4. What is the timeframe for this strategy?

(letters correspond to 3 components of strategy, noted above)

	Short-term (2022)	Mid-term (2030)	Long-term (2050)	2070 -2100
To implement	(a) Once funding secured, EMT can begin offering incentives immediately (b) Demonstration pilots and regulatory barrier assessment can begin now.			
To realize outcomes	(a) GHG reductions can begin soon thereafter (depending on project construction duration), but all relatively short-term (b) fuel switching to natural gas is a short-term solution	(b) some benefits attributable to pilot projects/early adopters of alternative fuels	(b) Widespread shift to alternative fuels (i.e., meaningful GHG reductions from this strategy) is likely to take years of successful demonstration, reductions in costs.	

5. Please analyze the Recommended Strategy against the following criteria. [See below the summary table for raw data for individual actions]

a. Action 1 -- Expanding funding for industrial energy efficiency program offerings through EMT.

- **Workforce**
  - Increased jobs associated with added competitiveness of ME industry and energy services sector, helps keep these manufacturing jobs in Maine
  - Potential for lost jobs if industrial customers determine additional assessments sufficiently diminish profitability to warrant closure[99]
- **Benefits**
  - Lower energy costs for industrial customers (cost-effective investments)
  - Improves competitiveness of ME industry by reducing operating costs
  - Supports businesses and jobs in ME energy services sector
  - If an energy conservation assessment were placed on unregulated heating fuels, such as heating oil and propane, this would free up limited RGGI funds to be reallocated for other purposes, such as funding GHG-reduction projects at the largest industrial customers
- **Costs**
  - Industrial customers' share of incremental up-front capital cost of projects
  - Potentially significant costs to the largest industrial customers through their contributing to funding source(s) used for EMT programs
  - Potential negative economic impact if industrial customers determine additional assessments sufficiently diminish profitability to warrant closure
- **Equity**
  - Depends on funding sources – equity concerns can be mitigated if funds follow model of "those who pay in are eligible"
  - Past programs have had the experience of certain very large consumers paying significantly more into funding without a proportionate opportunity to receive incentives or grants back in return.
- **Proven strategy & feasibility**
  - This Action constitutes an expansion of a current policy that is working effectively, leveraging existing EMT program administration and funding, coupled with motivated and sophisticated industrial consumers.
- **Legal authority**
  - Efficiency Maine has established the precedent of using energy conservation funds to promote Combined Heat and Power (CHP) projects in Maine
  - Consider targeted tax incentives for investments in qualifying capital projects
  - Remove moratorium on cannabis sector business participation in EMT programs
- **Resilience & adaptation**
  - Improving the efficiency of Maine's largest industrials reduces their vulnerability to rising transmission and distribution costs and makes them more competitive in a global marketplace. This in turn helps to keep jobs and tax base in Maine.
  - If there are more stringent regional or federal regulations on carbon, Maine's manufacturers, who are major employers and contributors to the tax base, will be well positioned if they have taken steps to maximize the efficiency of their production and minimized their exposure to carbon prices.

[99] According to IECG, for large manufacturers every increase of $60,000 in annual costs sparks consideration of a reduction of 1 full time employee (FTE).

- **Cross-cuts with other strategies**
    - Related to strategy under "Maximize the Efficiency of Electricity Use and the Grid" (i.e., this strategy is dependent on continuation of EMT programs)

b. Action 2 -- Pursue a long-range plan for industrial fuel switching in process heating.

- **Workforce**
    - More secure jobs associated with added competitiveness of ME industry and energy services sector
- **Benefits**
    - Position Maine manufacturing to be competitive in a future carbon-constrained economy
    - Contribute to broader market development/technology acceleration while also determining what works best for Maine industry
- **Costs**
    - Industrial customers' share of incremental upfront capital cost of projects (maybe)
    - Risk of not achieving return on RD&D expenditures
    - Potential costs of incentives/grants, measurement and verification
- **Equity**
    - Potential externalities associated with alternative fuels may have environmental justice implications (e.g., nuclear waste disposal)
    - Expand on implications for rural communities re: forest product facilities
- **Proven strategy & feasibility**
    - ME forest products industry – there are few places as good as Maine to test biomass-related technologies/processes
    - Regulatory barriers – Need to simplify landscape/process for prototyping and demonstration projects in general.
    - Industry reluctance to dedicate resources to unproven alternative fuels, technology, or processes when the status quo is reliable and low-cost.
    - Long time horizon for seeing GHG reduction impact
- **Legal authority**
    - Promoting more demonstration and/or pilot projects will involve examining regulatory barriers to such project implementation and proposing fixes to Legislature.
- **Resilience & adaptation**
    - Potential to diversify and locally manage fuel supplies for major employers making them less vulnerable to price spikes or supply interruptions
    - Adding distributed generation, including through CHP, at Maine's manufacturers and other very large consumers will help to insulate them from interruptions in electricity delivery, which also helps to stabilize the grid. This can be particularly helpful in areas of the grid that are vulnerable to reliability problems.
- **Cross-cuts with other strategies**
    - Strategy #6 - Grid Modernization
    - See also the Energy Work Group's strategy recommending that the Maine PUC be authorized to enter long-term contracts with Combined Heat and Power projects.

6. Rationale/Background Information

a. *Expanding funding for industrial energy efficiency program offerings through the Efficiency Maine Trust (EMT).*

- There remains considerable cost-effective energy efficiency opportunity in industrial facilities:
  - *Thermal* - The US DOE estimates that between 20% and 50% of all energy input to industrial facilities is rejected as thermal energy. The sources of rejected thermal energy include the exhaust stacks from boilers, furnaces, dryers, and evaporators, the heat of compression from the compressed air system, and thermal energy that is carried away from equipment with process cooling water and rejected to the environment. Basic heat recovery can significantly reduce this inefficient use of energy and reduce GHG in the process. The potential savings in Maine is large.
  - *Electric* – LED lighting retrofits, Variable Frequency Drive (VFD) flow control for fans and pumps
  - Combined Heat and Power (CHP)
- Reasons customers are not capturing opportunity on their own:
  - Cost. Payback horizons for publicly held industrial consumers, competing in global markets, tend to be shorter than the simple payback often experienced on energy conservation or fuel-switching investments.
  - It is challenging to identify suitable end-uses for recovered energy, such as in a large CHP project
  - Limited focus on energy recovery in the design community.
- Limited funding to incentivize these projects for industrial customers:
  - Projects that save unregulated fuels (such as #2 distillate fuel) through heat recovery or otherwise may be funded by EMT using RGGI funds. However, at current forecasted revenues, and given competing demands for RGGI funds for such initiatives as weatherization and oil or propane upgrades, there will not be enough RGGI funding available to satisfy all of the opportunity in the industrial sector. This concern does not extend to natural gas customers.
  - Projects to save electricity (e.g., LED retrofits, VFDs) are funding constrained for the very largest electricity customers in Maine. These customers, taking electricity service at the Transmission and Sub-transmission level (T&ST), are exempt from the assessments that fund the utility's procurement of electricity conservation (delivered by EMT) and are therefore ineligible for EMT electric efficiency programs. Some funding from RGGI is theoretically possible for this, but as noted above, current forecasted revenues from RGGI may not be sufficient to meet the multiple other priorities that have been established for those funds (e.g., home weatherization, pellet boilers, oil and propane upgrades) and still have enough left over to meet this opportunity for T&ST customers.
  - Projects to save electricity for customers in the cannabis sector are not eligible for funding from EMT based on a policy adopted by the EMT board on December 13, 2017. As such, this energy-intensive sector was not included in EMT's analysis of cost-effective investment opportunity, and therefore does not have the corresponding budget to fund incentives. If this policy is reversed, EMT can seek additional funding through the electric procurement and begin providing incentives.

b. *Pursue a long-range plan for industrial fuel switching in process heating.*

- Among the more "market-ready" opportunities:
  1. Fuel switching to natural gas – can be cost-effective where customers are situated along existing pipeline infrastructure or where compressed natural gas or liquid natural gas can be

economically delivered.

2. Combined Heat and Power (CHP) -- Work Group members and stakeholders identified considerable regulatory barriers associated with grid interconnection and establishing microgrids.

- Unlike the low-carbon alternatives currently available for heating and transportation, the industrial sector does not currently enjoy low-carbon options that are commercially available and cost-competitive. Advancing mid-century GHG targets through this sub-sector will require advances in alternative fuels. To the degree those advances require research and development, it is likely that the level of investment required will exceed what Maine government and Maine's manufacturers can generate, and that most of the investment will come from the federal government or out-of-state energy interests. However, Maine does have manufacturers that could -- whether due to their large physical plant, energy intensive uses, rural location, and proximity to wind, hydro and biomass supplies -- provide useful hosts for demonstration projects to pilot new technologies. In particular, Maine has significant renewable energy resources that could be located close to those manufacturers, providing attractive opportunities to demonstrate uses of renewable gas.
- Potential study industries: cement, paper, forest products, ship building
- Potential study areas:
    1. *Hydrogen combustion*
        - Barriers – production of hydrogen currently involves significant GHG emissions, but improving (with carbon capture, use and storage [CCUS] and renewable-powered electrolysis); challenges with distribution infrastructure
        - Advantages – can achieve high temperatures (needed for ME cement and chemical industries); industries using NG can readily exchange one gaseous fuel for a new one with modest retrofits;
            - Potential ME-specific opportunity -- excess wind power generation in Aroostook County (with limited ability to export out of state) could be used to produce hydrogen (energy-intensive); colocation with industry for local use of fuel
    2. *Biomass and biofuel combustion*
        - Barriers – scaling to meet demand will be a challenge (low energy density), costs associated with storage and drying
        - Advantages – abundant supply in Maine; multiplier effect in local economy
    3. *Electrical heating* (including radiative heating, heat pumps)
        - Barriers – may require substantial plant redesign, burdens on the grid
        - Advantages – high controllability of temperatures and duration, low maintenance, low emissions when powered by renewables
    4. *Nuclear heat production* (including conventional and advanced systems)
        - Barriers – safety concerns, nuclear waste, cost
        - Advantages – significant volume of low-carbon heat
    5. *Radio Frequency Drying*
        - Barriers – Technology still under development
        - Advantages – Effective for food and agricultural products. Might be able to find applications in the forest products or food processing industry.

Strategy 6: Modernize and Optimize the Grid

1. **Describe the Recommended Strategy and how it addresses Maine's climate resiliency and mitigation goals.**

To meet Maine's GHG emission reduction targets, large portions of the energy used in the Maine economy will need to be converted from higher carbon-emitting sources, like fossil fuels, to electricity—a transition referred to as beneficial electrification—and this electricity must increasingly come from renewable and clean generation sources. To foster this transition, Maine needs a cohesive set of policies to ensure that the state's electricity transmission and distribution system (the "grid") is properly sized, equipped, planned, and managed and that it is capable of integrating a wide variety of generation sources (supply) and loads (demand). The system must be big enough to handle the amount of supply being put onto the grid, but no bigger than necessary, so that electricity remains affordable and competitive. It must be nimble enough to accommodate instantaneous changes in variable generation sources supplying power as well as the peaks, valleys, and shifting of loads that are demanding power. Achieving this requires better, more integrated resource planning,[100] regulations, and new technologies including smart controls. It also will benefit from optimizing the size of the transmission and distribution electrical grid, as it is impacted by the reach of energy conservation programs and distributed energy resources (DERs) to reduce the size and duration of peak demand and the overall amount of supply needed.

This strategy proposes steps to modernize and optimize the grid, based on these assumptions and understandings:

- Assuming Maine switched all fossil fuel use to 100% beneficial electrification of the space heating, industrial and transportation sectors, the grid may need to deliver as much as 3 times more electricity with a peak of 5 times current levels.[101]
- Improving the efficiency and management of electricity consumption will help Maine to meet carbon emission goals through increased beneficial electrification of space heating, water heating, and transportation.
- Enabling laws of Maine's State agencies (including the PUC) generally do not specifically include reference to statutorily established carbon reduction requirements,[102] which may limit the criteria these agencies consider in their rulemakings and decision-making and impede their ability to advance the statutory carbon reductions.
- Beneficial electrification and other strategies that reduce carbon generally are under-valued and under-financed within the state.
- Widespread expansion of beneficial electrification and renewable (variable) generation will drive the need for significant investments in transmission and distribution (T&D) infrastructure and is likely to entail logistical and political challenges.
- Load Management - The new loads added with beneficial electrification will need to be managed intelligently to lower the peak demands on the system and thereby limit infrastructure costs. It will be helpful if the new loads are configured and equipped in ways

[100] See also, MCC Energy Work Group, recommendation to establish a "Power Sector Transformation Stakeholder Process".

[101] Silkman, "A New Energy Policy Direction for Maine," p. 28, November 2019; see also, The Brattle Group, "Heating Sector Transformation in Rhode Island: Pathways to Decarbonization by 2050," April 22, 2020 presenting an alternative electrification scenario, assuming that two-thirds of a state's thermal load converts to electricity while the remaining one-third shifts to a decarbonized fuel, such as renewable gas or renewable oil, and shows that the requirements of the grid and renewable generation are reduced significantly.

[102] See, 38 MRSA §576-A, which provides "By January 1, 2050, the State shall reduce gross annual greenhouse gas emissions to at least 80% below the 1990 gross annual greenhouse gas emissions level."

so they can contribute to reducing and shifting demand (EMT, pg. 57)[103] and provide balancing support to the grid in concert with renewable generation.
    - To accomplish this beneficial electrification transformation, upwards of 40% of the electrical grid's loads can be and should be deferrable in time frames from seconds to hours. This means that the loads can intelligently defer or augment loads at the correct times helping balance the variable renewable energy generation profile. (Aikin, pg. 59).
    - Current PUC regulations are built around policies that promote flat rate pricing which is a barrier to incentivizing demand shifting. Pricing electricity based upon location and time of use will improve balancing of the grid and incentivize new usage patterns. Electricity pricing based on location/timing of electricity use on the grid is being addressed in many jurisdictions in the U.S.[104] that benefit the grid and foster new intelligent technologies that can be designed and built in Maine.
- Grid planning and procurement for scaling of distributed generation (DG) into the grid is based on short planning horizons. Horizons should be at the scale of the system asset life (30-50 years). Also, DG is typically undervalued, not fully accounting for the value to system operations over the lifetime of the assets deployed at their particular location. Further, the integration of clean DG can be accelerated by valuing generation payments based upon demonstrable benefits to the balancing of the system through expanded Non-Wires-Alternative (NWA) like regulation. NWA's should be expanded based upon a least cost principle over the length of the asset class.
- Granular data for policy and investment decisions on the distribution grid are not easily obtained for stakeholders. Encourage the publishing of granular distribution grid data promoting to owners and developers of distributed energy projects the additional value to be obtained by location decisions.
- The Maximum Achievable Cost-Effective (MACE) mandate, also sometimes called the "all cost-effective" mandate, is established in statute requiring the electricity utilities and the natural gas utilities to procure (pay for), through programs administered by the Efficiency Maine Trust, all energy conservation resources where the net present value of the benefits exceeds the net present value of the costs. The current status of this policy in Maine has some limitations. There is currently a statutory cap on the size of Efficiency Maine programs (though the cap has not been hit since it was put in place). Also, the benefits that are counted in the benefit-cost analysis of electricity savings is limited.
- Maine policy is not currently integrated to maximize the synergies between building code changes (Strategy 1), transition to clean heating and cooling systems (Strategy 2) and industrial decarbonization (Strategy 5) to maximize electricity load efficiency, conservation and demand response.

2. **What is your measurable outcome for this strategy, assuming all recommended actions to implement the strategy are achieved?**

    a. For mitigation strategies:

[103] References marked in parentheses are to the original author(s) of the point or recommendation being presented, and the page number on which it appears in the original compilation of straw proposals made by the Work Group on Buildings, Infrastructure and Housing.

[104] See California TOU rate structure- https://www.utilitydive.com/news/california-utilities-prep-nations-biggest-time-of-use-rate-roll-out/543402/

i. What is the estimated CO2e savings (metric tons) by 2025, 2030, 2050?
2025: 500,000
2030: 1,000,000
2040: 8,000,000
2050: 22,000,000[105]

ii. What is the cost effectiveness of those reductions (cost per ton of CO2e reduced) and the total cost?

Determining the costs and benefits of this multifaceted strategy, when integrated with related strategies from this and other Work Groups, requires more data and analysis than the Work Group was able to develop. It will be necessary to consider costs, both public and private, of developing new and smarter grid capacity, new generation sources, new equipment or controls to manage load, and programs to support those additions. In the end, if this strategy is accompanied by renewable energy generation sufficient to meet Maine's RPS targets, and to significantly electrify heating and transportation, it could be critical to meeting the state's requirement to reduce GHG emissions by 80% by 2050. .

b. Are outcomes measurable with current monitoring systems? Generally, yes.

3. **What specific actions would be required to implement the strategy, including but not limited to legislation or regulation.**

a. Action 1 -- Right-Size and Stabilize the Grid

i. To mitigate the barriers to integrating high levels of renewable energy into the grid (3 to 5 times larger T&D grid infrastructure), form a state commission of energy experts tasked with:
   1. providing the legislature and PUC technical support;
   2. developing a state planning document with strategies to cost effectively design and rebuild the electrical grid over a 30-year timeframe;
   3. updating the plan every 5 years; establish goals for carbon emission reductions to meet legislative goals; and
   4. integrating, in a holistic way, distributed energy resources (DERs), beneficial electrification, intelligent controls, and storage.

ii. Advance a suite of policies to promote greater use of clean Distributed Energy Resources (DERs):
   1. Establish a statewide "Green Bank" or "Maine Renewable Investment Bank" (MREIB) to provide low-interest, bond-supported financing for grid scale, distribution scale, residential scale, and technology development initiatives modeled after the Connecticut Green Bank and

[105] Silkman, pg. 57.

managed by the scaling of existing programs like the Efficiency Maine Trust and Maine Technology Institute.[106]

2. Increase the support for pilot and demonstration projects that support new technologies stabilizing the grid with both streamlined permitting, interconnection and funding through a program like Maine Technology Institute and the Green Bank.
3. Incentivize homeowners receiving heat pump rebates to receive assessment for photovoltaic (PV) solar panels.
4. Enhance the continuity of operations through DERs using microgrids and other techniques supporting the community during disasters.
5. Expand financing to promote grid-interactive energy efficient buildings to maintain equilibrium of the grid through intelligent grid control managing load and storage (similar to Efficiency Maine's loan programs for residential energy upgrades and small business energy upgrades).

iii. Enhance policies that increase the integration of community, industrial, and consumer based microgrids that enhance self-sufficiency and climate goals.

iv. Maximize demand-side management by continuing funding for Efficiency Maine Trust Programs.

1. Continue the policy of requiring the utilities to pay for Efficiency Maine programs to deliver Maximum Achievable Cost-Effective (MACE) electric energy conservation resources and natural gas conservation resources.
2. At the appropriate time, the Legislature should:
    a. Review ineligibility of T&ST customers;[107] and
    b. Amend or remove the cap on electricity conservation funding (currently set at 4% of total consumer spending in Maine on electricity).
3. Efficiency Maine should pursue:
    a. More aggressive consumer education programs
    b. More aggressive harvest of retrofit opportunities

b. Action 2 -- Value electricity generation and consumption based upon the cost of providing the service both temporally and by location.

i. Support the modernization of electricity pricing by incentivizing consumer-level management of loads to support the grid through time-of-use (TOU) and real-time based locational pricing;

ii. Develop grid scale payment structures supporting and incentivizing DER projects that promote and enhance stabilization of the grid on a least cost basis including providing developers with supporting bonus pricing that benefits electrical grid system stability that meets the plan developed in Action 1 (a1).

[106] See Connecticut Green Bank - https://ctgreenbank.com/

[107] The IECG strongly opposed this suggestion.

c. Action 3 -- Review and reform government agency enabling statutes to include climate requirements in decision-making.

i. Review enabling laws of state agencies, including the Maine PUC, and suggest amendments where necessary to align with state carbon reduction requirements and the State's Climate Action Plan.

1. One Work Group member recommended placing *societal* costs and benefits, including emissions reductions, on an equal footing with other life-cycle costs at the center of agency decision-making so that regulatory processes would screen for investments that account for carbon emissions.[108]
2. Maine has made substantive strides in addressing climate mitigation through legislative and executive action. However, the agencies charged with advancing climate goals are often hampered by enabling laws that do not align well with the goal of reducing carbon. Regulatory frameworks may limit the scope of state agency decision-making in carbon-intensive sectors such as electric and gas utilities, transportation, and buildings and land use, and may serve as a barrier to strong climate progress.

d. Action 4 -- Promote planning and implementation of beneficial electrification of space heating, water heating, and transportation consistent with meeting Maine's long-term carbon reduction requirements.

i. The emissions-reductions gains of beneficial cannot be realized without thoughtful, coordinated grid modernization and optimization.

ii. The rationale for and steps toward beneficial electrification are detailed in:

1. Cross-reference Buildings Work Group Strategies 1, 2, 3, 4 and 5.
2. Cross-reference Transportation Work Group strategies promoting Electric Vehicles

4. What is the timeframe for this strategy?

	Short-term (2022)	Mid-term (2030)	Long-term (2050)	2070 -2100
To implement				
To realize outcomes				

5. Please analyze the Recommended Strategy against the following criteria.

[108] This recommendation was made by the Acadia Center. See also, The Public Utilities Commission and Why It Must be Reformed, May 11, 2020. The IECG does not support the general recommendation to reform agencies' enabling legislation as proposed here.

Action 1 Right-Size and Stabilize the Grid

Workforce -

- A well-implemented grid modernization and optimization plan would be a model for the world and bring new companies and technologies to the state of Maine making it a jobs leader in this area.

Benefits (non-workforce) -

- Grid modernization, generally:
  - Optimizes the use of DERs to maintain equilibrium on the grid at the "least cost;"
  - Would greatly lower the need and cost of storage technology;[109] and
  - Increases resilience of our infrastructure, protects life and safety in natural disasters, provides cleaner air and increased economic activity.

- Promoting DERs
  - A robust financing program will use public funding to leverage private capital to increase the availability of and accelerate funding for projects throughout Maine. It will help to address current funding gaps, and reduce risk for banks, credit unions and other financial institutions to invest in Maine's clean energy economy.
  - This financing program could help to fund many of the other climate solutions strategies, including projects ranging from home weatherization to grid-scale renewable energy.
  - Promoting PV at the same time that other energy conservation or HVAC projects are being performed helps overcome the barriers customers experience initiating PV projects and enhances adoption rate of renewable energy systems.
  - *Green Bank* -- The Clean Energy Fund will make investments, rather than provide rebates, and will re-invest in new projects as loans are paid back. This can fund efficiency, clean energy, and electric vehicles, and has the potential to fund agriculture, forestry, and other climate solutions that require upfront capital to achieve longer-term savings.
  - *MREIB* -- The energy sector generally is a low investment enterprise and the MREIB could provide another funding source at reasonable rates beyond utility rate recovery.

- Expanding and extending energy conservation programs:
  - These programs are well-established, third-party evaluated and reported, and generally well understood and appreciated by stakeholders and policymakers.
  - Energy conservation programs save more money than they cost and are market-ready.
  - The value of saved energy has a multiplier effect in local economy.

Costs –

[109] Additional modeling would be required to quantify potential savings.

- To achieve a renewable grid over 30 years without technology improvements and integrated policy changes like grid interactive buildings, distributed controls and distributed energy resources will add billions of dollars in cost.
- Introducing more "load management" to maximize the efficiency of the grid itself may incur incremental costs to the current energy conservation programs. The cost is dependent on the size and scope of opportunity that meets the "cost-effectiveness" standard. Prior years have been on the order of $40-50 million/year in program funding. Introducing more "load management" and grid interactive buildings to maximize the efficiency of the grid itself may incur incremental costs to new construction but be offset by increased building efficiency and lowered operating costs.
- *Green Bank* -- $100+ million upfront capitalization of the Maine Clean Energy Fund. This is an investment that would generate interest. It could come from bonds, State funds, an investment by the Public Employee Retirement System, or from a National Climate Bank or other grant funding.
- *MREIB* -- The only cost would be the cost of implementation, which could be provided by a small percentage added to fairly low bond money secured by the State of Maine.

Equity -

- Certain sectors of the economy face steeper barriers to participate in energy conservation programs for a variety of reasons (e.g., limited discretionary income, limited time/resources, limited inventory/services in their area). Programs can be designed to overcome these barriers by creating tiered financial incentives and targeting outreach efforts to the affected groups/areas.
- Green Banks commonly offer credit enhancements, reducing credit and lending requirements for low-income populations or those with poor credit.
- Financing helps address funding gaps. Rebates may not work if families or businesses cannot afford the remaining cost of the project after a rebate; Tax credits don't work for low-income families or those without tax liability.

Proven strategy & feasibility –

- *Green Bank* -- The CT Green Bank has used ~$180 million in public funds to leverage more than $1 billion in private capital over the last 8 years. In the past year, they've used $41 million to attract more than $310 million in private investment. The CT Green Bank funded more than 7,600 residential solar installations in the last year, including home energy audits for more than 80% of those homes.[110]
- Numerous other states have similar programs including: NY, NV, NJ, RI, HI, CO.
- *MREIB* -- Addresses the barrier of getting investment dollars into technology businesses that can make fundamental improvements to renewable energy and grid infrastructure technology but are hampered by lack of outside investment. One of the largest barriers in new technology development is the implementation of pilot projects. This program could be used to greatly expand the work of the Maine Efficiency Trust in promoting pilot projects. Maine could be seen as a leader in the renewable energy technology space.
- Both the Maine Technology Institute and the Efficiency Maine Trust have financing initiatives that could provide useful precedent, experience or a foundation to build on.

[110] https://ctgreenbank.com/fy19-annual-report/

- The idea of dynamic demand management to balance the grid is a new idea requiring careful study but the technology is becoming available at scale.
    1. The Grid Wise Architecture Council (GWAC) is the main advisory board for grid modernization for the Department of Energy has plans for this transformation.[111]
    2. The Department of Energy, standards organizations, and private industry are all working on grid modernization with new applications being deployed.

Legal authority -

- Electric Efficiency Programs (continue MACE)
    - Review limitations on Efficiency Maine's energy conservation funding and eligibility for programs in 35-A MRS Sections 10110 and 10111.
- 35-A MRSA Chapter 99 (Property Assessed Clean Energy Act)

Resilience and Adaptation -

- Significant GHG emissions are associated with the inefficient use of electricity, both at the equipment/measure itself and based on location/timing of electricity use on the grid.
- Grid modernization and optimization improves the reliability of the grid, promotes demand response located behind-the-meter, and optimizes the use of DERs to maintain equilibrium on the grid at the "least cost."

Cross-cuts with other strategies and work groups?

- Strategy #5 - Industrial

Action 2 Value electricity generation and consumption based upon the cost of providing the service both temporally and by location.

Workforce -

- Neutral impact

Benefits (non-workforce) -

- Helps balance high levels of renewable generation at the lowest cost

Costs –

- Rate structures are designed to be revenue neutral
- These new rate structures could be phased in over time starting with TOU rates, and potentially bill support for low income residents. (see Equity)

Equity -

[111] A working group member is a member of the Grid Wise Architecture Council.

○ Programs can be phased in and designed to support low income consumers but value is socialized over the entire state.
Proven strategy & feasibility – ○ The technologies have and are being proven by national labs and in other states (CA, IL, HI), and are being tested in Maine.
Legal authority - ○ Hawaii, California, and Illinois have implemented electrical grid pricing changes. ○ In Maine and elsewhere there are examples of microgrids that incorporate pricing and load management innovation. ○ The National Labs (PNNL-LBL and NREL) and private institutes like the Rocky Mountain Institute have shown the benefits of grid modernization.[112]
Resilience and Adaptation - ○ Increases benefits of distributed generation/storage/load management making stakeholders more self-sufficient.
Cross-cuts with other strategies and work groups? ○ Strategy 3 and 4 and Energy WG

Action 3 Review and reform government agency enabling statutes to include climate requirements in decision-making

Workforce - • Creates new jobs and builds needed infrastructure to electrify, install DER and other non-wires alternatives, electrify homes and businesses • Eliminate some jobs involved in fossil gas pipeline extensions
Benefits (non-workforce) - • Enables optimized use of DERs and least cost grid operations • Enables appropriately valued health, jobs, and other non-energy benefits • Eliminates wasteful spending and stranded costs for fossil-fuel related infrastructure that is inconsistent with climate goals
Costs – • May incur incremental costs for additional process and modeling

[112] https://gridlab.org/works/grid-modernization-playbook-report-download-test/

• Enables consideration of full range of costs (hopefully to avoid costs)
Equity - • Benefit - Enables consideration of equity and justice concerns in decision-making
Proven strategy & feasibility – • NY has recently required all agencies to create plans to meet climate goals • Relatively new idea, but common-sense reform

Legal authority -
• PUC enabling statute
  • Add climate to mandate
  • Consider expanding benefits and costs to be evaluated in decision-making to include societal costs of carbon
• Regulatory process
  • Create climate plan specific to PUC
  • Update decision-making protocol to include robust benefit cost analysis

Resilience and Adaptation - • Reduces significant GHG emissions associated with continued use of fossil fuels and inefficient use of electricity • Enables improved reliability of the grid and optimized use of DERs • Enables consideration of resilience and adaptation strategies when making investment and planning decisions
Cross-cuts with other strategies and work groups? • Enables use of other strategies, particularly when immediate short-term rate impact appears high, but is dwarfed by long-term benefits.

Action 4 -- Promote Planning and Implementation of Beneficial Electrification of Space Heating, Water Heating, Transportation consistent with meeting Maine's long-term carbon reduction requirements.

- Cross-reference Buildings Work Group Strategies 1, 2, 3, 4 and 5.
- Cross-reference Transportation Work Group strategies promoting Electric Vehicles

6. Rationale/Background Information

See above.

6a. Additional Resources

- Pilots and resources in Maine concerning Dynamic Load Management:
    - Isle au Haut - https://dynamicgrid.ai/wp-content/uploads/2020/05/Dynamic-Grid-Isle-au-Haut-Microgrid-2020.pdf
    - Dynamic Grid Technology - https://dynamicgrid.ai/technology/
    - Transactive Energy - https://dynamicgrid.ai/wp-content/uploads/2020/05/Dynamic-Grid-Transactive-Energy-2020.pdf
- Dynamic Load Management, or "Transactive Energy:" https://www.gridwiseac.org/about/transactive_energy.aspx
- Decision-Makers Checklist: https://www.gridwiseac.org/pdfs/gwac_te_checklist_dec2016_pnnl_25658.pdf

Appendix Supporting the Report of the Buildings, Infrastructure, and Housing Working Group

June 5,2020

Table of Contents

Modeling Results and Assumptions

1. Thermal Scenario Results

Prepared by Synapse Energy Economics, Inc. (May 12, 2020)

TABLE 1: Scenarios Analyzed

Baseline	H1	H2	H3
Continued efforts to install residential retrofit heat pumps—baseline efficiency	**Full Electrification—baseline efficiency**	**Electrification—aggressive efficiency**	**Electrification—baseline efficiency and low carbon fuels**
2.2% cumulative residential space heat energy reduction by 2050 through weatherization 41% of households have heat pumps or legacy resistance heating by 2050	2.2% cumulative residential space heat energy reduction by 2050 through weatherization 90% of households have heat pumps and 90% of commercial heating load is electrified by 2050	20% cumulative residential space heat energy reduction by 2050 through weatherization 90% of households have heat pumps and 90% of commercial heating load is electrified by 2050	2.2% cumulative residential space heat energy reduction by 2050 through weatherization 67% of households have heat pumps and 60% of commercial heating load is electrified by 2050 Remaining load in 2050 is primarily supplied with biodiesel and fuel oil blends and renewable natural gas

Heat Pump Adoption

- There are two types of heat pump adoption modeled for residential space heating: heat pump retrofits and whole home heat pumps

Heat pump retrofits displace fuel oil consumption in households that choose to maintain their legacy heating system

These heat pump installations are specified as a number of households each year

The fraction of total heating load provided by heat pumps increases from 39% in 2020 to 57% in 2030

Whole home heat pumps replace legacy heating systems upon burnout

These heat pump installations are specified as a percentage of all new heating systems installed to replace retiring legacy heating systems

- In the commercial sector, only heat pumps replacing the entire legacy heating system upon burnout are considered

Baseline and H1/H2 Residential Heat Pump Adoption

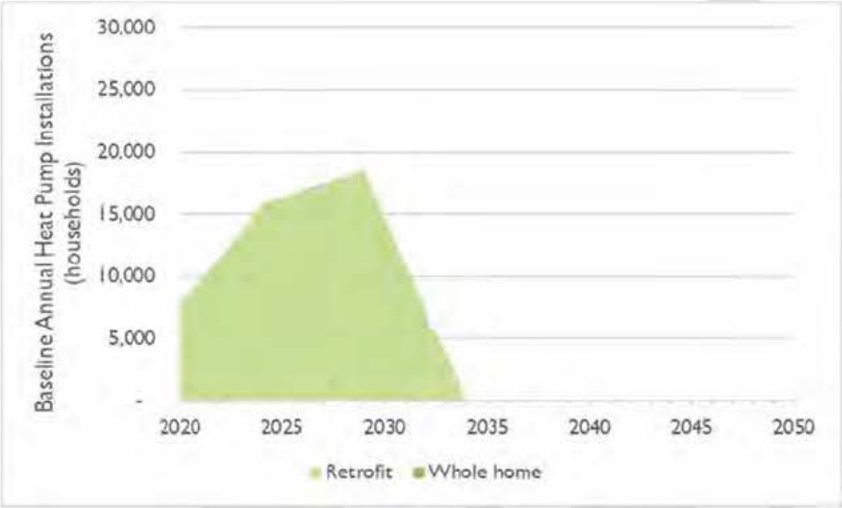


FIGURE 1 WWW.SYNAPSE-ENERGY.COM | ©2020 SYNAPSE ENERGY ECONOMICS INC. ALL RIGHTS RESERVED.

- In the baseline scenario (Figure 1), heat pump retrofits increase in line with Maine's 2025 goal and continue in line with ISO New England projections through 2029
- After 2029, heat pump installations are phased out to capture existing policies only

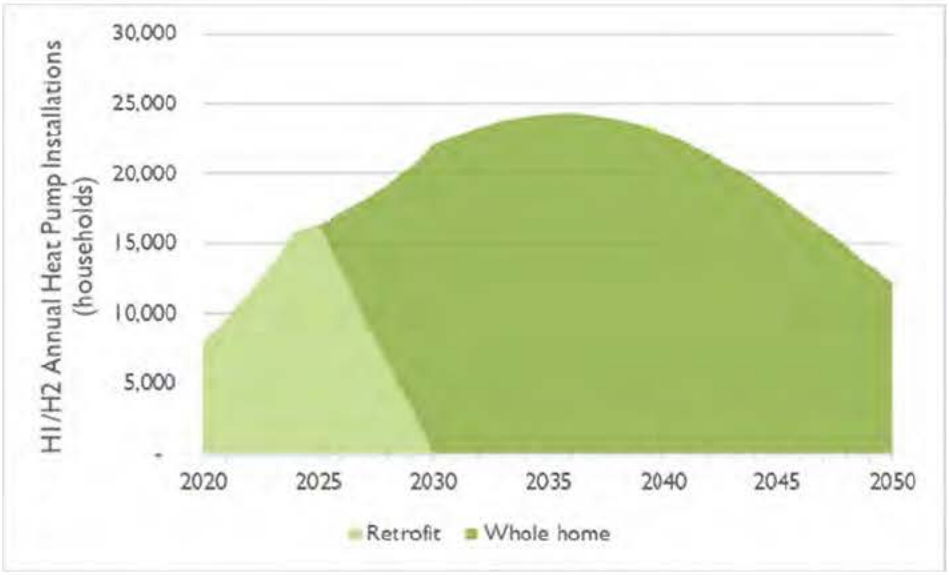


FIGURE 2 WWW.SYNAPSE-ENERGY.COM | ©2020 SYNAPSE ENERGY ECONOMICS INC. ALL RIGHTS RESERVED.

- Whole home heat pumps attain 100% market share when replacing systems that burn out by 2030
- In the H1 and H2 scenarios (Figure 2), heat pump retrofits are phased out in the late 2020s as whole home heat pump installations increase

H3 Residential Heat Pump Adoption

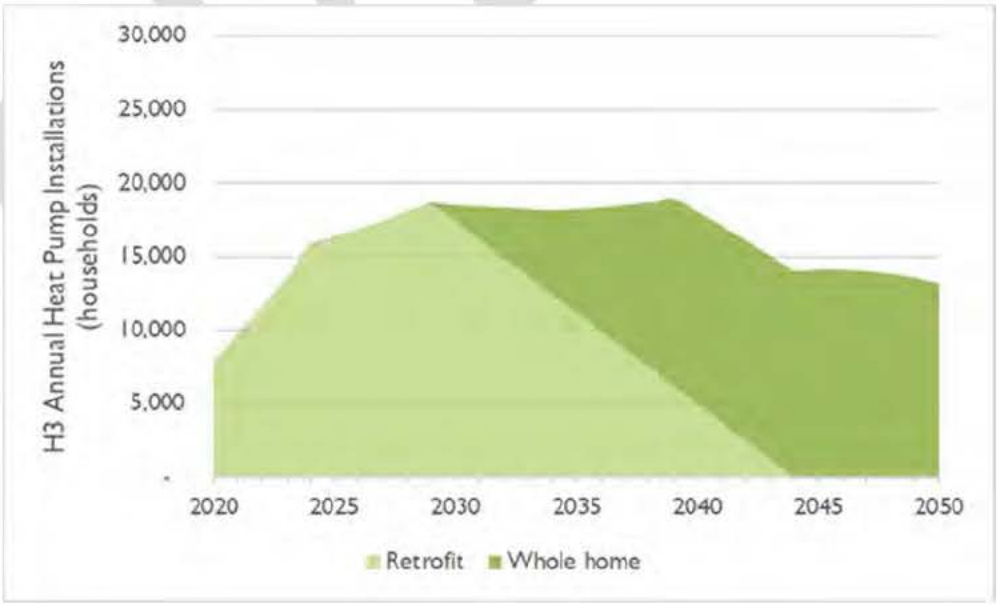


FIGURE 3 WWW.SYNAPSE-ENERGY.COM | ©2020 SYNAPSE ENERGY ECONOMICS INC. ALL RIGHTS RESERVED.

- In the H3 scenario, heat pump retrofits continue through 2044

- Relative to H1 and H2, more heat pump retrofits are completed, but fewer whole home heat pumps are installed
- Whole home heat pump market share increases between 2029 and 2039 to 50% of households replacing fuel oil and natural gas and 100% of households replacing propane

Commercial Heat Pump Adoption

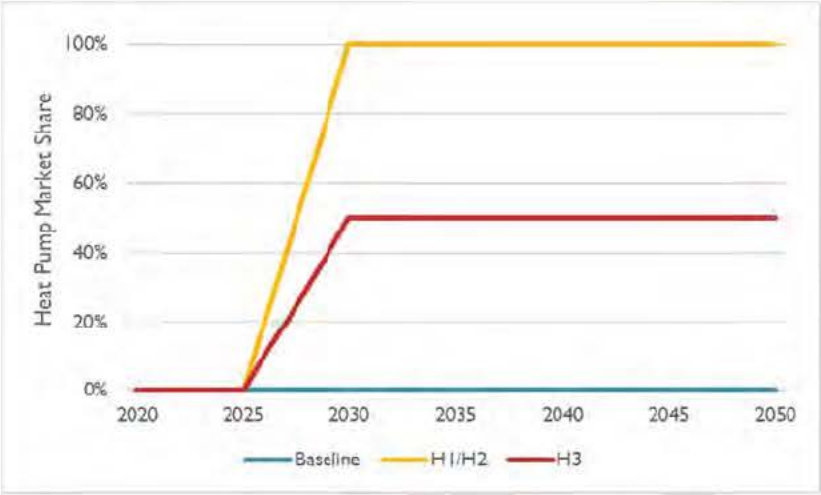


FIGURE 4 WWW.SYNAPSE-ENERGY.COM | ©2020 SYNAPSE ENERGY ECONOMICS INC. ALL RIGHTS RESERVED.

- All commercial heat pump adoption is assumed to occur when the existing heating system burns out or is otherwise retired
- No heat pump adoption is included in the baseline
- In the H1 and H2 scenarios, heat pump adoption increases to 100% market share in 2030
- In H3, market share increases to 50% in 2030

Biofuel Modeling in Scenario H3

- Wood, biodiesel, and renewable natural gas (RNG) are all included in the H3 scenario

Wood is primarily utilized in the residential sector, while biodiesel and RNG displace fuel oil and natural gas in both the residential and commercial sectors

Biodiesel and RNG are assumed to be drop-in replacements for fuel oil and natural gas, respectively

Today, B20 (a fuel oil blend that includes 20% biodiesel) is more common than B100 (100% biodiesel), but a 2019 report from Brookhaven National Laboratory found no "clear technical barrier which would limit the use of biodiesel in home heating systems"

- Resource availability was not independently evaluated as part of this work

We referenced a December 2019 ICF study evaluating the RNG resource potential in determining how much RNG could be produced in Maine

- RNG, biodiesel, and wood are all assumed to be carbon neutral

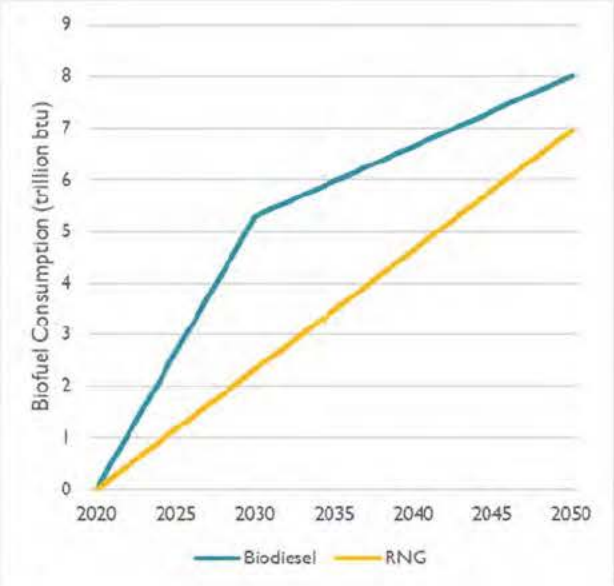


FIGURE 5 WWW.SYNAPSE-ENERGY.COM | ©2020 SYNAPSE ENERGY ECONOMICS INC. ALL RIGHTS RESERVED.

- RNG and biodiesel availability increase over time
- By 2050, we assume that 15 trillion btu of biodiesel and RNG are available

RNG is assumed to supply all natural gas demand in 2050

Emissions and Energy Consumption

Baseline Greenhouse Gas Emissions

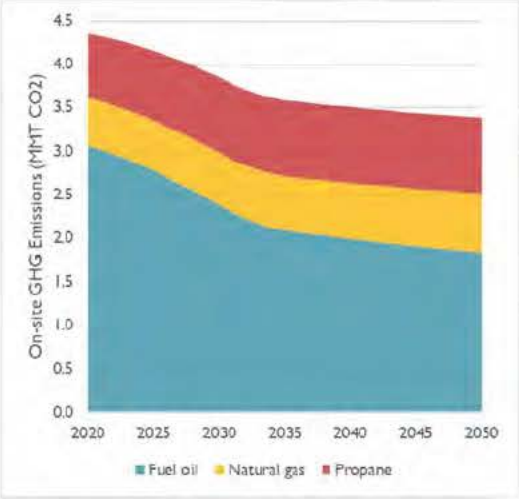


FIGURE 6 WWW.SYNAPSE-ENERGY.COM | ©2020 SYNAPSE ENERGY ECONOMICS INC. ALL RIGHTS RESERVED.

- Fuel oil accounts for most thermal sector emissions
- Fuel oil emissions also decrease the fastest as retrofit heat pumps are installed
- Natural gas and propane emissions grow over the projection period

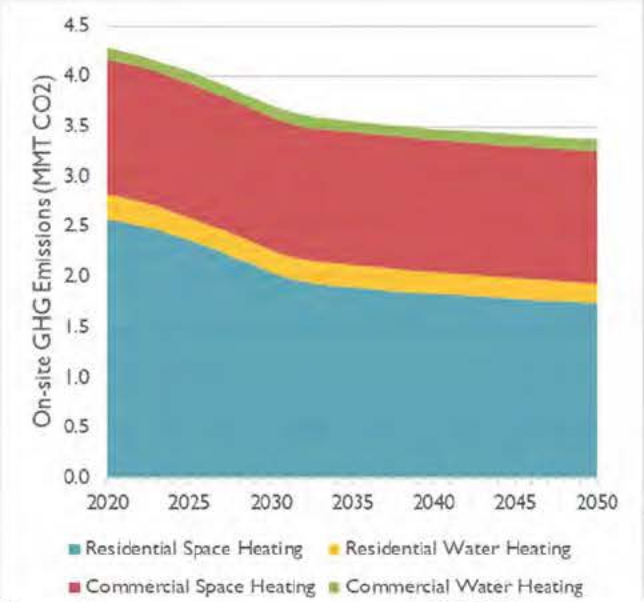
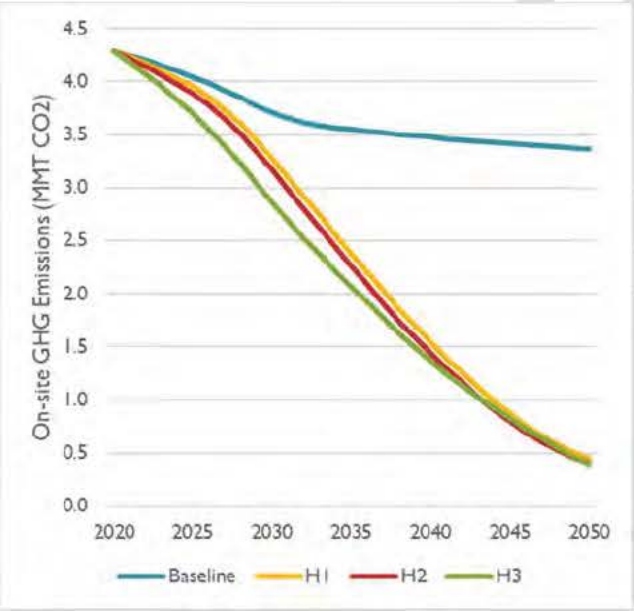


FIGURE 7 WWW.SYNAPSE-ENERGY.COM | ©2020 SYNAPSE ENERGY ECONOMICS INC. ALL RIGHTS RESERVED.

- Space heating is the largest emitting end use
- The residential sector produces more emissions than the commercial sector

Greenhouse Gas Emissions – Scenario Results



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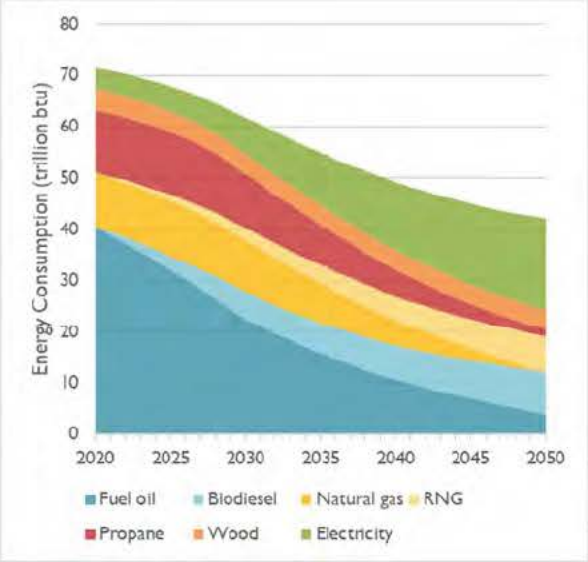
- The H3 scenario leads to the greatest emissions reductions by 2030 due to substitution of biofuels for fuel oil and natural gas

TABLE 2

Scenario	2020-2030	2020-2050
Baseline	14%	21%
H1	24%	90%
H2	26%	91%
H3	33%	91%

H3 Total Space and Water Heating Energy Consumption



- By 2050, energy consumption for space and water heating decreases to 42 trillion btu, primarily due to the high efficiency of heat pumps
- RNG displaces all fossil natural gas consumption in 2050
- Biodiesel displaces 67% of fuel oil consumption

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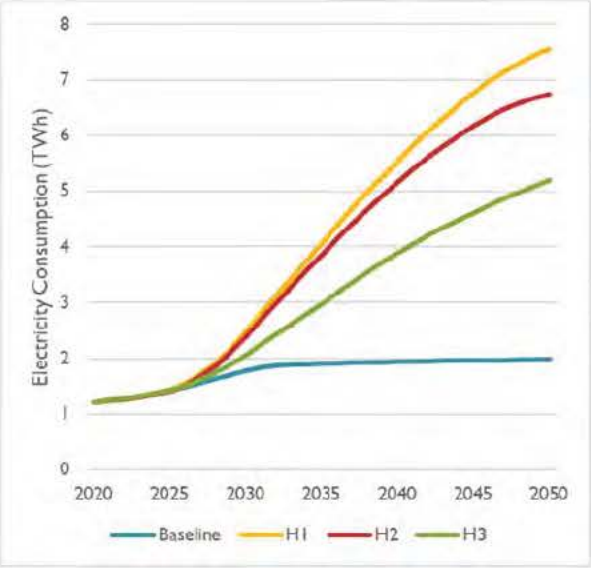
Space and Water Heating Electricity Consumption



- By 2050 electricity consumption for space and water heating grows to 7.6 TWh, 6.7 TWh, and 5.2 TWh in the H1, H2, and H3 scenarios, respectively
- For comparison, Maine's total electricity consumption in 2017 was about 11.2 TWh
- Weatherization in the H2 scenario saves 0.9 TWh per year by 2050 relative to the H1 scenario, while biofuels in H3 save 2.4 TWh
- Electricity consumption for space cooling is not included in the chart

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2. High-Performance New Construction Cost-Effectiveness

Single family analysis prepared by Energy Resources Group, based on the National Renewable Energy Lab's (NREL) "Building Energy Optimization Tol" (BeOpt) and RMI (2018) "The Economics of Zero Energy Homes."

TABLE 3: NEW SINGLE FAMILY BUILDS – SUMMARY OF INCREMENTAL COST AND CO_2 SAVED

Scenario	Climate Zone (IECC)	Incremental Cost (Present Value)	MMBTU/Year Savings	CO_2/Year Savings (lbs)	Cost (PV)/CO_2 Saved
Single Family, Portland	6	-$395.00	63.30	9,238.63	-$0.04
Single Family, Bangor	6	-$809.00	72.10	10,522.99	-$0.08
Single Family, Caribou	7	$855.00	81.50	11,894.91	$0.07

Notes:

- Present value costs and MMTU savings calculated using the BeOPT inputs outlined for climate zones 6 and 7 in RMI's (2018) report, but using weather inputs specific to each city in Maine.
- Uses 2,200-square-foot, three-bedroom, two-bathroom single-family detached home with a two-car garage.
- "Baseline" scenario envelope and HVAC properties reflect requirements for each climate zone in the IECC 2009 energy code.
- "Proposed" scenarios reflect minimum requirements for zero energy home (ZERH) (excluding low flow hot water fixtures, ENERGY STAR appliances, LED lighting, DOE ZERH Certification, smart thermostat, and solar photovoltaic).

Multifamily new construction analysis based on Avesta Housing (2020a-c) data on multifamily projects in Maine 2015-2019.

TABLE 4: NEW MULTIFAMILY BUILDS – SUMMARY OF INCREMENTAL COST AND CO_2 SAVED

Building Design	Initial Costs	Operating Costs/Year	MMBTU/Year	CO_2/Year (lbs)	Initial
Per Ft²					
Code Compliance	$164	$1.80	0.09	10.48	–
Passive Design	$165	$0.99	0.03	4.27	–
High Performance	$161	$0.84	0.04	4.83	–
LEED	$170	$0.95	0.04	5.48	–
All Non-Code Compliance	**$165**	**$0.90**	**0.04**	**4.89**	–
Incremental Difference from Code Compliance					
Passive Design	$0.87	-$0.81	-0.06	-6.21	$0.14
High Performance	-$3.19	-$0.96	-0.05	-5.64	-$0.57
LEED	$6.02	-$0.85	-0.05	-5.00	$1.20
All Non-Code Compliance	**$0.37**	**-$0.89**	**-0.05**	**-5.59**	**$0.07**
% Difference from Code Compliance					
Passive Design	0.5%	-44.9%	-68.1%	-59.2%	–
High Performance	-1.9%	-53.4%	-57.5%	-53.9%	–
LEED	3.7%	-47.2%	-50.9%	-47.7%	–
All Non-Code Compliance	**0.2%**	**-49.7%**	**-58.0%**	**-53.3%**	–

Strategy 1: Improve Design and Construction of New Buildings

1. Develop a roadmap for building codes to reach net zero carbon new construction by 2030

D., Voorhees

A) Establish a target for Maine building energy codes to be net zero carbon by 2035 through incremental improvements every three years (use model codes to the extent they meet that trajectory.)

- Amend statute to establish target date and provide key definition of net zero carbon new construction
- Direct EMT, in consultation with MUBEC Board & Code Bureau, to develop a long-term plan for how the code will be amended incrementally to achieve the target and what strategies will be used to encourage continual improvement in building practices
- Authorize MUBEC board to adopt building code stronger than model code, starting in 2027, if doing so is necessary to achieve target date in a timely, incremental manner.
- Direct MUBEC board to adopt a stretch code that requires net zero carbon by 2027 (2030?)
- Direct EMT & Code Bureau/Board to begin incorporating elements in code that require lower embodied carbon, starting no later than 2027
- Require all state-financed buildings to use the stretch code

B) Evaluate code compliance every three years (Efficiency Maine), use measured compliance levels to set benchmarks for improvement, and target resources (Efficiency Maine and Maine Code Bureau) toward actions to achieve those benchmarks (e.g. training or other actions).

- Direct EMT to evaluate compliance with the energy code in the residential and commercial sector, with geographic differentiation (or at least in towns <2000, 2000-4000, >4000 population), for the purpose of establishing a moving code baseline for the following 3-4 years
- Require an updated compliance evaluation ever 3-4 years
- Direct EMT to estimate benefits and costs of estimated statewide non-compliance, require estimated cost
- Direct EMT to incorporate into its Triennial Plan measures or actions that increase code compliance above the baseline – or increase the use of the stretch code by municipalities – in coordination with Code Bureau
- These measures or actions can include but are not limited to:
    - Education for builders, contractors and other parts of the industry
    - Training for code inspectors
    - Educational materials or resources
    - Incentives for builders, contractors, code inspectors or others
    - Education, outreach or financial support for municipalities to adopt the stretch code
- Encourage EMT & Code Bureau to target its measures to the building practices, geographies, or building subsectors (e.g. single family homes) most needed to increase compliance, while also ensuring that populations in rural or lower-income communities receive adequate support to get the benefits of energy codes
- Allow EMT to include energy savings beyond baseline compliance levels (including savings from stretch code) in its calculation of Maximum Achievable Cost-Effective savings

Modeling this recommendation

- Estimate carbon savings for 2030 and 2050
- Estimate numbers of new buildings (square footage) constructed each year and retirement of existing homes and other buildings (square footage) – where is that data?
- Use data from EMT to estimate MMBTU/sq ft for buildings retired over the 10 & 30 years – probably use low estimates of energy efficiency, assuming older/inefficient buildings most likely to be retired/replaced
- Assume starting compliance of 70% for commercial, 40% for residential (??) for 2015 code

- Calculate rough carbon/energy savings percentage increase per code cycle from 2020-2035
- Assume compliance increases 3% per year (??)
- Estimate benefits and costs… how? Need both incremental construction costs, energy savings, and "administrative" costs
- Don't model stretch code or embodied carbon at this stage

Which MCC goal does this strategy help to achieve?

X Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

☐ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:

- Energy efficiency in new construction is one of the most cost-effective carbon mitigation strategies, however many barriers prevent their full employment, including:
  - Lack of awareness and skills among some segments of construction industry
  - Lack of enforcement support and/or training in some communities
- We lack information about actual construction practices and compliance with existing codes (let alone new codes that will be adopted every several years)
- Energy efficiency standards will need to increase over time to meet climate & energy goals

Is there a model for this, either in Maine or in other jurisdictions?

Yes. Washington State and Vermont have similar code roadmap approaches, with long-term target dates for energy codes and strategies to make steady progress in shorter-term blocks.

- Washington law requires codes in 2030 to achieve 70% net energy reduction over 2006 codes
- Vermont's comprehensive energy plan directs all new construction to be zero carbon by 2030

Many states measure code compliance, some states make it a regular program. The procedures for measuring compliance through field studies are well understood. (The US DOE is currently conducting residential energy code compliance studies in 10 states.) In Rhode Island, efficiency program administrators spend money on increasing code compliance (and get "credit" for the savings against their three-year efficiency plans.)

Other states also do more robust training and education for the building code, at least to code officials, but also in cases to construction industry.

What are the benefits of this solution?

- Increased efficiency and indoor air quality of new buildings **lowers energy costs** significantly and ***improves health***
- Increased health, safety and affordability benefit all taxpayers through **reduced burden on social systems** (from emergency room visits to fire response to LIHEAP subsidies).
- Long-term **predictability** for building industry – understanding that codes will continue to be updated every several years helps them invest in continuous improvement & education
- Creates regular **real-world information** about the actual energy efficiency of new construction
- Increased funding for actions that increase the real-world use of the code, actions that can be **targeted** to where they are most needed
- Leverages **expertise** at Efficiency Maine, increases **partnership with Code Bureau**

What are the costs?

- Code compliance studies could cost $100,000-$200,000 every three years
- Upfront construction costs would be offset by energy savings if we continue to use model codes
- Training would scale based on the needs (e.g. code compliance baseline and degree of change in each code update cycle) – but could range between $50,000 - $100,000 per year.

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When does implementation begin and what is the expected duration?

Starts immediately with baseline code compliance study, setting benchmarks for compliance. Training will be needed in 2020 around the 2015 update. Anticipating the adoption of the 2021 code in 2022, this framework could be integrated into the next Efficiency Maine Triennial plan (2022).

- When is the outcome realized?

Pathway/roadmap leads to zero carbon standards by 2035, but training and education likely be needed to achieve high compliance in years after that.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

It is likely that compliance levels are lower, and need for training and education higher, in Maine's smaller and more rural communities. This can be remedied by Efficiency Maine and the Code Bureau targeting training or other compliance-increasing strategies/resources at the communities that most need them.

Getting squarely on a pathway of periodic code updates coupled with targeted training or other compliance strategies will take time. This proposal is appealing because it is a "start now", slow & steady, approach to a big problem. We won't get everything right immediately, but if we start now, we have time.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

Many building industry professionals will benefit from more uniform application of the building energy code. Builders who build to the code will be less likely to be undercut in the market by those who don't.

Households are the biggest winners, with lower energy costs. New homes today are the 15 year-old homes of 2035, so over time building codes directly benefit a larger and larger segment of the population.

Existing resources/data that could help implement this strategy:

- Are there major data gaps related to this strategy?

A key feature of this proposal is generating real-world data about code compliance so that resources to increase the use of the code can be targeted. Let's put our resources where they are demonstrably needed, to conserve taxpayer/ratepayer spending on programs.

Modeling suggestions:

Increased efficiency of the total building stock above a baseline (e.g. energy efficiency in codes increases X% every 3 years times compliance increasing Y%, times square footage built each year.)

Are there rules or legislation that might help enact this strategy?

- Legislative target for 2035 of net zero building code adoption, as compliment to existing requirement for code updates according to model code cycles
- Legislative direction for Efficiency Maine to measure code compliance, set benchmarks for increasing compliance, and allowing programs that increase compliance to count in its Triennial Plan.
- Training & education program development in partnership between Efficiency Maine and Code Bureau, with room for flexibility over time to respond to real-world data on compliance.

2. Expand Contractor Training and Certification for Net-Zero Standards, R. Patane

BUILD EFFICIENCY MAINE REFERRAL LIST OF CONTRACTORS TRAINED AND CERTIFIED IN NET-ZERO STANDARDS; LEAD SIGNIFICANT EXPANSION OF TRAINING AND CERTIFICATION PROGRAMS IN COLLABORATION WITH OTHER OF ORGANIZATIONS CURRENTLY DOING TRAINING.

Which MCC goal does this solution (e.g., policy or program) help to achieve?

☒ Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

☒ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this solution will address:

(1) Homeowners and small apartment building owners have no easy way to take the first step in retrofitting or building to net-zero standards; current contractors typically represent a specific product and not a holistic problem- solving consulting approach so it can't address a multi-faceted situation (2) Contractors and code enforcement staff

Examples in Maine or in other jurisdictions? Many organizations in Maine train contractors and code enforcement staff

What are the benefits of this solution? Makes resources easily available to consumers willing to retrofit or build to net-zero standards -- Efficiency Maine can be a one-stop shop for consumers making the first step

What are the costs of this solution? Training should be free or very low cost to contractors and code staff, so cost would be the actual cost of training plus the administration of a collaboration with other training entities

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When should implementation begin and what is the expected duration?

SHORT TERM: agree on net zero standards; reach out to training entities to form partnerships

LONG TERM: build Efficiency Maine capacity to promote certified contractors and to assist to on select a contractor

- When is the outcome realized? When a consumer can easily find a trained contractor on EMs list

What are some Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?

Workforce capacity: may need to recruit workers from out of state or improve retention of young Mainers who leave

What populations, communities, or sectors will be impacted by this strategy? (Where appropriate, please indicate how they may likely be impacted)

Please identify existing resources/data that could help develop and implement this strategy:

Maine community college system

Maine Building & Construction Trades Council Sanford Technical Center and other technical schools E2Tech Losing Job Corps

Brunswick Landing

Businesses such as Hancock Lumber and Eldredge Lumber who train employees and private contractors

Modeling suggestions: Developing a model set of standards and an apprenticeship program would make the training certification uniform.

3. Establish State Energy Corps Partnerships with VISTA/AMERICORPS Program

Which MCC goal does this solution (e.g., policy or program) help to achieve?

☒ Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

☒ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this solution will address:

Lack of capacity in municipalities limits their ability to take action to reduce emissions

Is there a model for this solution, either in Maine or in other jurisdictions? Montana Energy Corps Program, Lonni Starcevich, Pgm Director 406-533-6651, lonnis@mcat.org
What are the benefits of this solution? Adds capacity and skills to municipal staffs at low or no cos; Vista volunteers add capacity to staff on climate action plans and emissions inventories; Americorps volunteers perform direct service on projects in communities such as weatherization, with emphasis on low- and moderate-income families
What are the costs of this solution?
A) Cost of managing program of recruiting, vetting, and placing Vista/Americorps volunteers in cities & towns
B) Program management can also be staffed with Vista members
C) Cost to state or municipality of each Vista/Americorps volunteer: $6500/year plus assistance finding housing
What is the timeframe for implementation? Short-term, mid-term, or long-term? Short term: negotiate w Vista

- When should implementation begin and what is the expected duration?

Begin negotiation with Vista ASAP; recruitment of volunteers begins in February each year. Begin recruiting towns to act as sites simultaneously

- When is the outcome realized? Outcome is realized when Vista volunteers are placed; also when their work results

What are some Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
Lack of affordable housing for Vista/Americorps volunteers, who earn a little over $1,000/mo. Recruiting volunteers outside Maine or even from one town to another in Maine faces the difficulty of finding housing for them
What populations, communities, or sectors will be impacted by this strategy? (Where appropriate, please indicate how they may likely be impacted)
Low- and moderate-income households are the focus of the Vista/Americorps program, so they would be particularly But increasing the number of programs like weatherization, emissions inventories and climate action planning would everyone.
Please identify existing resources/data that could help develop and implement this strategy:
Maine's Office of Public Service;

- What major data gaps are related to further developing or implementing this strategy?

Energy use data from CMP has not been available; Heating and auto gas usage is similarly unavailable.
Modeling suggestions:
Easily accessible models for estimating a community's energy footprint would be a key assist to municipalities

4. Commercial Building Energy Benchmarking

Which MCC goal does this strategy help to achieve?

- **Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050**

Describe the problem/barrier that this measure will address:

- **A key first step to reduce emissions associated with building energy consumption is to understand how much energy is being used in individual buildings or across an entire building stock. Data gained through benchmarking can be used at the individual building level for behavioral changes or capital improvement projects. Data can also be used by city or state officials to establish policies and programs that require performance improvements over time.**

Is there a model for this, either in Maine or in other jurisdictions?

- **Yes, benchmarking is already occurring at the local-level in Maine and at the state-level in many other states in the region. Portland and South Portland have already adopted building energy benchmarking ordinances. Many states in the region, such as Connecticut and New Hampshire start by benchmarking state owned buildings. Others, such as New Jersey, have rolled out programs that require commercial buildings over a certain square footage to track and report their energy usage. Key information related to process-oriented best practices, policy recommendations, and program structure can be leveraged from these models to help inform efforts in Maine.**
- **NEEP has compiled a list of state and municipal benchmarking programs here.**

What are the benefits of this solution?

- **Benefits of building energy benchmarking include:**
  - **Gaining data to better assess how buildings across a jurisdiction are performing**
  - **Equipping building owners with actionable information to take control of energy costs**
  - **Uncovering potential utility bill issues**
  - **Providing a baseline to systemically reduce energy consumption in buildings through policies such as building energy performance standards**
  - **Increasing market awareness and visibility of building energy usage**

What are the costs?

- **Costs associated with a building energy benchmarking program are primarily attributed to the implementation and enforcement of such a policy. Factors such as building sizes and the number of covered buildings have the largest impact on costs. Costs are largely associated to staffing requirements to develop the policy, notify building owners, market and train building owners, and perform data analysis. Free tools such as EPA's Portfolio Manager, the industry standard for benchmarking, can be utilized to keep costs low. Additionally, by engaging utilities data can be provided to owners in a straightforward manner which helps to reduce costs and streamline the process.**
- **Section 3.8 of LBNL's Evaluation of U.S. Building Energy Benchmarking and Transparency Programs: Attributes, Impacts, and Best Practices provides additional details of the costs of setting up a benchmarking program.**

What is the timeframe for implementation? Short-term, mid-term, or long-term? –

- **The program can be implemented in the short term, while the data gained through this process can be used in the mid-to-long term to help Maine meet its climate goals.**

When does implementation begin and what is the expected duration? –

- **The implementation process for this type of program can be highly variable dependent on many factors. The stakeholder engagement process, policy development, and educational activities can typically take upwards of one year. The duration of this type of program is usually a multi-year process. States and cities have had benchmarking programs for 10+ years to continually assess and facilitate energy savings actions.**

When is the outcome realized?

- **Outcomes of a building energy benchmarking program will likely be realized in a phased manner:**
  - **Building owners may detect utility billing issues going through the benchmarking process which can lead to cost savings**
  - **After one reporting cycle, the lowest performing buildings can be targeted for improvements through utility incentive programs, grants, operational changes, and/or building operator trainings**

- **Longer term outcomes can be realized after 3-5 years of data collection. The governing body can use benchmarking data to develop building energy performance standards or other programs that mandate energy reductions in buildings.**

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

- **One barrier for Maine may be working with the utilities to provide data in a streamlined fashion. To overcome this issue, it is recommended that the Public Utilities Commission and the local utilities are engaged throughout the program development process.**
- **Maine benefits by being able to learn from other state programs that have been in place for a number of years. Maine can also take advantage of assistance from local and regional organizations that have previously worked on benchmarking efforts. Furthermore, there are already two cities in Maine that have adopted benchmarking policies which helps build support for this type of program.**

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

- **Benchmarking should provide wide-ranging benefits to building owners, state and local governments, and energy-service providers. Disadvantaged stakeholders include any populations that are unfamiliar with their energy data and how to make improvements, although this issue can be mitigated by outreach and educational activities.**

Existing resources/data that could help implement this strategy: - Are there major data gaps related to this strategy?

- **Due to the fact that benchmarking is not a new strategy, there is a significant amount of existing resources, data, and other information to help implement this strategy in the market today.**
- **EPA, DOE, NEEP and others have existing resource that show the benefits of benchmarking. These organizations also have model language and can provide additional assistance in the policy development phase.**

5. Commercial Benchmarking

Introduction

This strategy calls for requiring all public and commercial buildings over 5,000 square feet to benchmark their energy usage on an annual basis. All of the data can be tracked in the EnergyStar Portfolio Manager website for free. This could be tied to requirements for energy performance (kBTU/sf) or efficiency improvements (25% improvement by 2025).

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *This will track and help to mitigate the energy consumption and emissions from most of the public buildings and commercial buildings in Maine.*
2. What problems/barriers will this strategy address?
    a. *This will help to identify the least efficient buildings to focus on for efficiency retrofits.*
    b. *This helps building owners to understand how their buildings compare to others of the same use type.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Many states and cities have energy and water benchmarking requirements for buildings:* https://www.buildingrating.org/jurisdictions
    b. *Benchmarking is required for more than 10 billion square feet of real estate throughout the US.*

c. *Some of these jurisdictions tie the benchmarking requirement with minimum thresholds for energy performance or efficiency gains.*

4. What are the benefits of this strategy?
    a. *Provides transparency on energy use of public buildings and commercial buildings.*
    b. *Reaches thousands of buildings throughout the state.*
    c. *Verifiable metric for tracking energy performance over time.*
    d. *Encourages comparison between similar buildings and creates the opportunity to focus efforts (and funding) where they are needed most.*
5. What are the costs of this strategy?
    a. *EnergyStar Portfolio Manager is free to use.*
    b. *In many jurisdictions, the utility company can export data directly to Portfolio Manager for free.*
    c. *Building owners or managers would need to input annual heating fuel consumption.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Perception of being a burden for business owners.*
    b. *Requiring CMP, Emera and other utilities to export information to Portfolio Manager.*
    c. *Training building owner or building managers how to use Portfolio Manager*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Public Buildings*
    b. *Building owners*
    c. *Improving efficiency in public buildings benefits all taxpayers.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *EnergyStar Portfolio Manager is free to use:* https://www.energystar.gov/buildings/facility-owners-and-managers/existing-buildings/use-portfolio-manager
    b. *Fact sheet on benchmarking from the Institute for Market Transformation:* https://www.imt.org/resources/fact-sheet-energy-benchmarking-and-transparency-benefits/

6. Phase-out Installation of Petroleum/Gas Combustion Appliances in New Construction/Major Renovations

Introduction

This strategy addresses the reduction of fossil fuel use in residential and commercial structures by banning the sale or installation of gas or oil combustion appliances, including those for heating and cooking, by 2030 followed by phasing out the sale of fossil fuels.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *All goals above*
2. What problems/barriers will this strategy address?
    a. *The reduction of emissions caused by fossil fuel use in residential and commercial buildings*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *None known.*
4. What are the benefits of this strategy?
    a. *Enhances adoption rate of fossil fuel free heating systems and decrease overall energy use.*
5. What are the costs of this strategy?
    a. *Unknown*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Mid term*

7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Supply chain for alternative appliance systems.*
    b. *Supply chain and infrastructure for biomass fuel delivery*
    c. *Lack of infrastructure to accommodate additional electric load.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *All*
9. Identify existing resources/data that could help develop and implement this strategy.
10. Modeling suggestions for this strategy.
    a. *Berkeley, California - a ban on natural gas hookups on new low-rise construction.*

7. Require EV-Ready design/construction

Which MCC goal does this strategy help to achieve?

⊗Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

□ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:

Full electrification of transportation will require tens of thousands of Level 2 charging stations located at places people live and work. This infrastructure will be vastly more expensive to retrofit than to install during new construction or substantial renovation of buildings and parking garages and lots.

Planning and accommodating future electric charging infrastructure is low cost to implement during construction and the technical issues are simple to accommodate. It only requires adequate electrical service at the construction site and empty conduit run to future charge station location.

For multi-family buildings, one study found that the average cost of an EV-ready parking space was roughly $900 when incorporated into initial construction, whereas a retrofit cost nearly $4,000 per parking space.

Is there a model for this, either in Maine or in other jurisdictions? Unknown.

What are the benefits of this solution? Ease of roll out of future electric infrastructure as demand for electric vehicles grows.

What are the costs? Making buildings EV Ready will require:

Adequate transformer sizing to accommodate future electrical loads.

Empty plastic conduit run to a defined percentage of vehicle parking spaces. Recommend 50% of parking spaces to accommodate future EV growth.

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When does implementation begin and what is the expected duration?

Immediately.

- When is the outcome realized?
- Upon full installation of Level 2 charge station at future date.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

No specific Maine barriers that are different than other locations.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy? All vehicle users in the state. Short term minor costs to building owners and developers.
Existing resources/data that could help implement this strategy: https://www.ase.org/blog/electric-cars-are-here-so-why-are-we-still-building-homes-arent-ready-charging-them https://www.swenergy.org/cracking-the-code-on-ev-ready-building-codes http://evchargingpros.com/wp-content/uploads/2017/04/City-of-SF-PEV-Infrastructure-Cost-Effectiveness-Report-2016.pdf https://www.evconnect.com/tax-incentives/
Modeling suggestions:
Are there rules or legislation that might help enact this strategy? Atlanta GA https://drive.google.com/file/d/1sM2Y_ttE1vvVQrGbfdjxyY8DPiO4v4oL/view Boulder CO https://assets.bouldercounty.org/wp-content/uploads/2017/03/building-code-2015.pdf Palo Alto CA code https://www.menlopark.org/DocumentCenter/View/14341/Staff-Handout---H6

8. Ban high global warming potential insulation products

Introduction

Many common building insulation products are manufactured with blowing agents that have dangerously high global warming potential. These insulation products save customers money, but create more global warming than the fossil fuels their installation is displacing. It is urgent that these products be withdrawn from the market immediately in Maine and nationwide. These products include common insulation products like Extruded Rigid Foam Insulation (XPS, "pink" and "blue" rigid foam) and Closed Cell Spray Foams that use HFO blowing agents. These blowing agents have a potency of up to 1,400X the global warming potential of CO2.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. Mitigate greenhouse gas emissions in the state immediately.
2. What problems/barriers will this strategy address?
    a. *Insulation products that save customers fuel but cause more damage to the atmosphere than the fossil fuels they replace.*
    b. *Close a Regulatory gap for damaging building products.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *The EU has banned these products already and they have ready replacements from major manufacturers.*
4. What are the benefits of this strategy?
    a. *Immediately reduce the global warming created by the construction of new & renovated buildings.*

5. What are the costs of this strategy?
    a. *Unknown, but replacement products are readily available throughout the construction market.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Legal unknown, supply chain changes.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Construction industry members.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. EPA.gov: Transitioning to low-gwp alternatives in building/construction foams
        i. https://www.epa.gov/sites/production/files/2015-07/documents/transitioning_to_low-gwp_alternatives_in_building_and_construction_foams.pdf
    b. *EPA.gov: Significant New Alternatives Policy (SNAP)*
        i. *https://www.epa.gov/snap/substitutes-polystyrene-extruded-boardstock-and-billet*
    c. *Known product substitutes:*
        i. *XPS (extruded polystyrene) > EPS (expanded polystyrene) and Poly-Isocanurate*
        ii. *High-GWP Closed Cell Spray Foam > Low-GWP Closed Cell spray foam with HFO / Solstice blowing agents*
    d. *Environmental Building News discussion of the issue and calculator:*
        i. *https://www.buildinggreen.com/news-article/avoiding-global-warming-impact-insulation*
        ii. *https://www.buildinggreen.com/sites/default/files/articles/insulation_gwp_tool_v_1-2.xlsm*
        iii. *https://www.greenbuildingadvisor.com/article/avoiding-the-global-warming-impact-of-insulation*

Insulation Material	R-value R/inch	Density lb/ft³	Emb. E MJ/kg	Emb. Carbon $kgCO_2/kg$	Emb. Carbon $kgCO_2/ft^2$•R	Blowing Agent (GWP)	Bl. Agent kg/kg foam	Blowing Agent GWP/ bd-ft	Lifetime GWP/ ft²•R
Cellulose (dense-pack)	3.7	3.0	2.1	0.106	0.0033	None	0	N/A	0.0033
Fiberglass batt	3.3	1.0	28	1.44	0.0165	None	0	N/A	0.0165
Rigid mineral wool	4.0	4.0	17	1.2	0.0455	None	0	N/A	0.0455
Polyisocyanurate	6.0	1.5	72	3.0	0.0284	Pentane (GWP=7)	0.05	0.02	0.0317
Spray polyurethane foam (SPF) – closed-cell (HFC-blown)	6.0	2.0	72	3.0	0.0379	HFC-245fa (GWP=1,030)	0.11	8.68	1.48
SPF – closed-cell (water-blown)	5.0	2.0	72	3.0	0.0455	Water (CO_2) (GWP=1)	0	0	0.0455
SPF – open-cell (water-blown)	3.7	0.5	72	3.0	0.0154	Water (CO_2) (GWP=1)	0	0	0.0154
Expanded polystyrene (EPS)	3.9	1.0	89	2.5	0.0307	Pentane (GWP=7)	0.06	0.02	0.036
Extruded polystyrene (XPS)	5.0	2.0	89	2.5	0.0379	HFC-134a[1] (GWP=1,430)	0.08	8.67	1.77

1. XPS manufacturers have not divulged their post-HCFC blowing agent, and MSDS data have not been updated. The blowing agent is assumed here to be HFC-134a.

9. Policy to eliminate high global warming HFC refrigerants from buildings and vehicles

Which MCC goal does this strategy help to achieve?

⊗Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

□ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:

Every refrigerator and air conditioner contains chemical refrigerants that absorb and release heat to enable chilling. Refrigerants, specifically CFCs and HCFCs, were once culprits in depleting the ozone layer. Thanks to the 1987 Montreal Protocol, they have been phased out. HFCs, the primary replacement, spare the ozone layer, but still have **1,000 to 9,000 times greater capacity to warm the atmosphere than carbon dioxide**.

Because 90 percent of refrigerant emissions happen at end of life, effective disposal of those currently in circulation is essential. After being carefully removed and stored, refrigerants can be purified for reuse or transformed into other chemicals that do not cause warming.

Is there a model for this, either in Maine or in other jurisdictions?

States: CA, WA, CT, MD, NY, VT

https://www.pewtrusts.org/en/research-and-analysis/blogs/stateline/2019/04/22/these-states-are-not-so-chill-about-air-conditioners-hfcs

Federal: https://www.nrdc.org/experts/david-doniger/bipartisan-hfc-bill-launched-house-matching-senate-plan

https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/HR5544_AIM%20Leadership%20Act_1.pdf

What are the benefits of this solution?

Massive reduction of the most dangerous greenhouse gas emissions immediately.

What are the costs?

https://www.drawdown.org/solutions/materials/refrigerant-management

https://www.nrdc.org/experts/david-doniger/bipartisan-hfc-bill-launched-house-matching-senate-plan

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When does implementation begin and what is the expected duration?

Immediately.

- When is the outcome realized?
- As soon as refrigerants are safely removed from use.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

Refrigerant management is difficult to implement as the appliances are distributed. There are weak regulations on controlling leakage of refrigerants, end-of-life recovery, and refrigerant. Further, there are no economic incentives for the recovery of refrigerants. Funding, training, technical, and informational barriers are also some of the limitations for adoption of the solution.

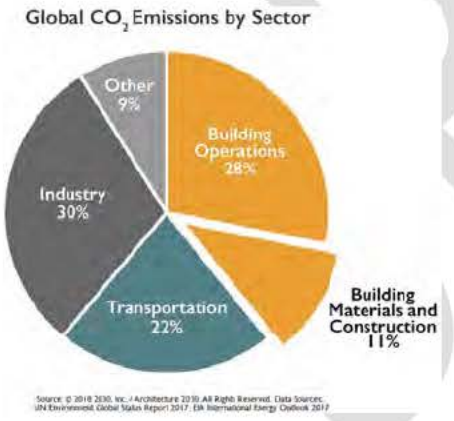
In order to increase adoption, policies and regulations on recycling/management of refrigerants need to be formulated and implemented. Strong regulations such as a complete ban on venting of refrigerants and accountability of refrigerants must be introduced in legislation. Economic incentives for recovery, recycling, and destruction of refrigerants, such as the issue of carbon credits under the Kyoto protocol, would help increase the adoption.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?
Existing resources/data that could help implement this strategy: https://www.drawdown.org/solutions/materials/refrigerant-management - Are there major data gaps related to this strategy?
Modeling suggestions:
Are there rules or legislation that might help enact this strategy? https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/HR5544_AIM%20Leadership%20Act_1.pdf

10. Embodied Carbon Reduction Strategies

Prepared by SMRT Architecture with assistance from New England Forestry Foundation and support of the Acadia Center.

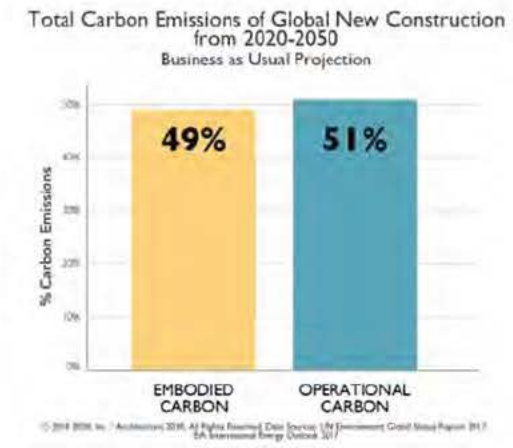
Background: To date most of the focus on carbon reduction in the built environment has been on ***operational carbon*** - how to reduce heating, cooling and electrical loads and thereby reduce energy consumption. Emerging in the industry is a new focus on reducing ***embodied carbon.*** Embodied carbon or upfront carbon is the carbon emissions associated with building materials. The extraction, manufacturing and transportation of building materials and the process of construction all are carbon intensive activities. At building end of life, demolition, removal, and disposal of building materials also have a significant carbon impact.



Architecture 2030 in their 2018 Global Status Report cites Building Operations at 28% of global greenhouse gas emissions (GHG) while Embodied Carbon is at 11%. In some cases, embodied carbon can account for as much as half of a building's total carbon footprint depending on life of the building and materials used.

With the anticipated volume of new construction significantly increasing globally, addressing embodied carbon reduction is critical to achieving GHG emission reduction goals. Because building operational efficiency is improving, embodied carbon will become an increasingly

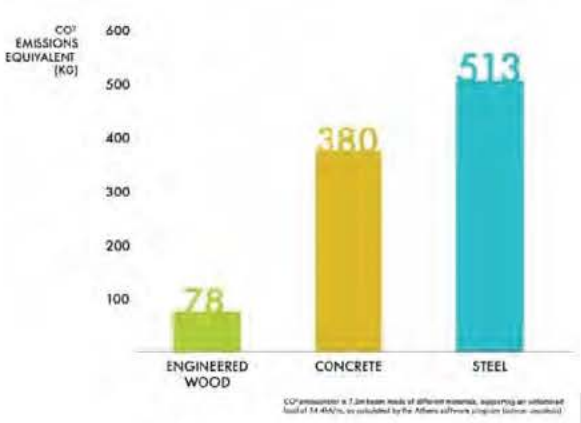
larger percentage of the overall GHG emissions associated with the built environment. Predictions are that by 2050, if we continue with "business as usual" embodied carbon will roughly equal operational carbon.



This statistic is a wake-up call to the environmental movement and the building industry. Unlike operational carbon, once a building is constructed the "upfront carbon" impact cannot be reduced. The time to address embodied carbon is ***before*** a building is constructed.

Critical considerations to reducing embodied carbon are as follows:

- New Construction or Reuse/Repurpose:
    - Before deciding a "new construction" solution is warranted – evaluate all the options. Is there an existing building that can be renovated/expanded rather than build new?
- Plan for efficiency: Buildings designed with flexible, multi-functional spaces and efficient circulation and adjacencies provide opportunities to minimize total square footage. The smaller the building, the smaller the upfront carbon footprint.
- Material Selection:
    - Structural systems account for roughly 80% of embodied carbon in commercial construction. "Mineral based construction materials" cement, steel and glass are materials with extremely high embodied carbon. With cement currently the source of 8% of global GHG emissions. While bio-based construction materials such as wood (including mass timber/engineered wood) are alternatives with significantly lower embodied carbon.



- Selecting low carbon materials such as green concrete, recycled steel, and biobased insulation are excellent carbon reduction strategies. Tracking embodied carbon content by requesting third party validated Environmental Product Declarations (EPDs) from manufacturers and suppliers is an emerging strategy in the design and construction industry that is raising the awareness of embodied carbon in the built environment. Some states (California passed Buy Clean California legislation in 2017) require EPDs for specific materials including steel and cement on all state funded construction projects.

- Wood and other bio-based materials provide a "double benefit" in construction. They not only are materials with inherently low embodied carbon, they also naturally *store carbon and can be regrown to sequester more.* If we replace some of our cement/steel structures with wood and other bio-based materials, we avoid the carbon intensive extraction/manufacture of cement and steel AND create a carbon storage positive in our built environment. While harvesting wood reduces storage in the forest, a significant portion of that carbon is captured in the wood of the building, and over time the forest regrows, recapturing any carbon lost. Advanced silvicultural practices can reduce the time needed to recapture the carbon and Maine is well positioned to develop and apply those practices.

- Mass Timber and Wood Composites have been evaluated and approved for structural use in buildings up to 18 stories high. Wood structures have been proven to be structurally adequate, durable and firesafe. Code changes are underway in many states and municipalities making mass timber an allowable building structure alternative.

Given the significant and growing impact embodied carbon has on global GHG, it is critical that the Maine Climate Council consider adopting policies to address the reduction of embodied carbon in our built environment. Maine with its vast forest lands (89% of Maine is forest) has a unique opportunity to put our wood to work in addressing embodied carbon reduction.

In this proposal, we outline a series of strategies that will contribute to achieving the GHG reduction goals of the Maine Climate Council through the reduction of embodied carbon in our built environment.

1. **Describe the Recommended Strategy and how it addresses Maine's climate resiliency and mitigation goals.**

REDUCE EMBODIED CARBON IN NEW CONSTRUCTION:

Significantly increase the use of wood and other bio-based materials in Maine's commercial new construction enabling us to:

a) Reduce GHG emissions attributed to our built environment
b) Use our forest resources sustainably and thereby expand the vitality of Maine's forest sector for generations.
c) Expand the use of and bring to commercial success the wood composites developed at the University of Maine.
d) Lead the way in the Northeast in promoting the use of bio-based materials and wood structural systems driving industry change, market expansion and thereby the growth of Maine's forest economy.
e) Benefit Maine's rural communities through the creation of "green" jobs.

This strategy proposes a series of measures focused on **MITIGATION** goals.

A) AWARENESS & EDUCATION:

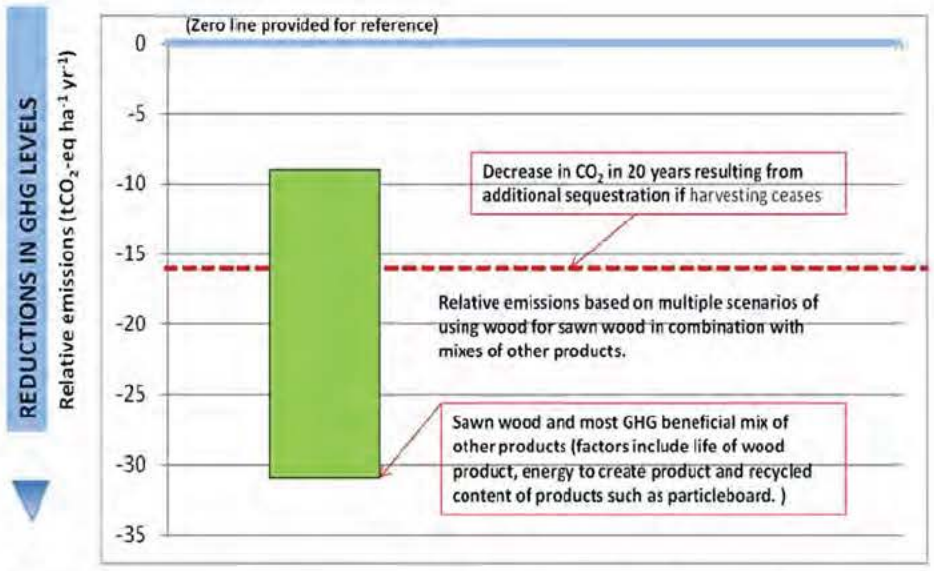
Significant change requires *awareness and education* before buy-in is achieved. Because the issues of embodied carbon are relatively new to the climate conversation, we propose awareness and education as key first steps to the successful implementation of an Embodied Carbon Reduction program in Maine.

Basic calculations of embodied carbon and comparisons between steel & concrete vs. wood structures produce compelling results yet the design and construction industry is hampered in moving to materials with less embodied carbon because their experience with these materials is limited, considered "alternative" and the availability of locally manufactured bio-based materials including wood composites and engineered wood products is extremely limited in Maine. Although the Advanced Structures and Composites Center at the University of Maine has "significant expertise in the manufacturing and testing of wood and wood composites and has conducted dozens of federal and industrial trials annually since the laboratory opened in 2000" there is currently a lack of awareness, few resources, few examples and therefore no significant "market" for wood structures in commercial construction in Maine.

Maine could establish a partnership between. the Maine Climate Council, the University of Maine Advanced Structures Composite Center and Maine design and construction industry professionals to specifically to ***raise awareness, educate, and advocate*** for the use of Wood/Wood Composites/Bio-based in Maine commercial buildings. This group would be responsible for identifying and/or creating the educational resources that can be made widely available across the state around the

value and benefits of expanding the use of wood in Maine construction. This group would be responsible for developing the "case for wood" benefits and opportunities and effective outreach programs promoting the use of wood in commercial construction. Creating the "Wood is Good" education program is a critical first step in setting the context for successful reduction of embodied carbon. The State of Maine, municipalities, school districts, private sector developers (industrial and commercial), Real Estate Professionals, Maine Housing Authority, University of Maine System etc. all need the "primer" on reducing embodied carbon. An excellent reference resource is the Urban Land Institute's Embodied Carbon in Building Materials report. 2019 https://americas.uli.org/wp-content/uploads/sites/2/ULI-Documents/Greenprint-Embodied-Carbon-Report_FINAL.pdf

Of critical importance to the education/awareness effort will be the development of accurate modeling and data that demonstrates the significant impact reducing embodied carbon has in mitigating GHG. While WoodWorks provides a tool for calculating the GHG reductions in a single building (e.g. 570 $MtCO_2$ in stored carbon and avoided emissions for the 160,000 sq ft Cross Insurance Center in Bangor), and, as shown in the figure below, we know that substituting wood for other materials can significantly reduce GHG emissions, we lack reliable modelling of the cumulative potential over 30 years for Maine and New England as a whole.



Relative greenhouse gas emissions over 20 years comparing use of wood to use of non-wood substitutes (based on UK conifer forests with a history of sustained yield management).
Source: Simplified by R. A. Giffen, but based on Figure 5.12 and Table 5.2 from Matthews (2014).

- From a global perspective, Oliver et al. (2014) analyzed the size of the opportunity to reduce GHG emissions by substituting wood for other building materials and

concluded that substitution could reduce emissions worldwide by 14 -31% simply from using existing timber growth.

B) PILOT PROJECTS:

Maine could build projects demonstrating the successful use of wood/wood composites in low to mid-rise commercial construction; experience in other regions of the US and the world show that the industry will then begin to see the value and benefit of wood structures in place of concrete and steel and move naturally in that direction. We need an opportunity to "showcase" projects with low embodied carbon and document the multiple benefits they provide. The State of Maine can lead the way. We propose that the State identify a pilot project to serve as a "low embodied carbon" demonstration. When the State identifies and funds a needed construction project for a State agency or service the State can issue an RFP with a specific call for "low embodied carbon innovation" challenging the design community to respond with carbon reduction strategies. During the planning and construction of the project the project team would be required to document the whole life cycle of the building, calculating the embodied carbon in the building structure, the potential for carbon sequestration and make this information available to the general public on the State website.

Another strategy to begin to move the industry to explore embodied carbon reduction would be for the State to require the evaluation of carbon reduction strategies on State funded projects including the evaluation of a "wood structure alternative". The State could make the submission of a building structure life cycle analysis a requirement on new state construction projects. The life cycle analysis of alternative structural systems is readily achievable using open source software, such as the EC3 Carbon in Construction Calculator developed by the Carbon Leadership Forum in association with the University of Washington (http://www.carbonleadershipforum.org/projects/ec3/), and explicitly including in-forest impacts, e.g. reductions in both carbon sequestration and the carbon stored in the trees harvested and creation of logging waste that decays (limbs, tops, stumps, and roots), as well as the emissions from burning biomass.

C) MOVING THE INDUSTRY FORWARD:

To date, Maine has no established embodied carbon reduction targets (either voluntary or code mandated). To effectively "move the needle" on embodied carbon the State could set targets, incentivize projects that achieve embodied carbon reductions, track progress, and provide benchmark data on a continual basis. Alternatively, the State could work to develop standards for embodied carbon in different types of new construction. In either case, proposed steps to move the industry forward are as follows:

- Modeling to determine level of embodied carbon reduction achievable through use of wood and other bio-based products in place of mineral based products.

Propose modeling low, medium and high range over 5, 10, 15- and 30-year periods. In this regard please note that accounting for reductions requires acknowledging that construction materials that are imported in to Maine, e.g. steel, have GHG impacts and need to be included In the Maine Climate Council's baseline.

- Adoption of code provisions to allow Low (1-5 story) and Mid-rise (6-12 story) wood structural systems in commercial buildings in Maine.
- Create a voluntary but incentivized (tax reduction?) stretch goal for building owners undertaking new construction to reduce embodied carbon and contribute to Maine's GHG reduction targets. Alternatively, Maine could require an in-lieu fee be paid by building owners if they elect not to pursue GHG reduction targets. Require the Use Life Cycle Analysis tool (EC3 or other validated 3rd party software with the caveats listed earlier) to determine compliance with reduction targets.
- Establish training programs through community and technical/vocational colleges in new wood construction techniques such as working with cross-laminated timber. This could take the form of expanding programs such as Kennebec Valley Community College Sustainable Construction program (https://www.kvcc.me.edu/academics/information/programs-of-study/sustainable-construction/).
- Expand funding for the University of Maine's Advanced Structures and Composites Center to partner with the state to develop further opportunities and technologies (https://composites.umaine.edu/) and educational resources and outreach.
- Provide state incentives for cross-laminated timber mills siting in Maine. This could take the form of providing zero interest financing through the Finance Authority of Maine, TIFs etc.

2. What is your measurable outcome for this strategy, assuming all recommended actions to implement the strategy are achieved?

This strategy mitigates climate change by reducing the greenhouse gas emissions associated with building materials and construction in low-rise (1 to 5 story) and mid-rise (6 to 12 story) commercial buildings. The strategy relies on requiring Life Cycle Analysis calculations for building structural systems and lowering embodied carbon over time. Establishing targets and measuring outcomes against these targets on an annual basis will be required. Measurement will be in terms of:

a) Total tons of carbon emissions avoided through reduced embodied carbon of building materials. Actual against target.
b) Total tons of carbon sequestered in building structures over a specific duration.

a. For mitigation strategies:
    i. The estimated CO2e savings (metric tons) by 2025, 2030, 2050
    TBD
    The cost effectiveness of those reductions (cost per ton of CO2e reduced) and the total cost **TBD**

b. Are outcomes measurable with current monitoring systems?

Yes. Validated, Third Party Embodied Carbon Calculators are open source and readily available to the building industry.

3. **What specific actions would be required to implement the strategy, including but not limited to legislation or regulation. Examples include: establish a program or a fund, conduct additional research, provide education or training, coordinate with other parties/agencies/states, etc. Considering the recommended actions listed, who, if they can be named, are the specific actors needed for implementation?**

A range of options exist for how to reduce embodied energy in new construction in Maine – they include:

A. Quantifying the GHG benefits of reducing embodied energy in different types of new construction in Maine – existing studies suggest that they could be very significant but are not Maine specific and/or
B. Increasing awareness of the opportunity – Maine could establish a partnership between the Maine Climate Council, the University of Maine, and construction industry professionals to increase awareness and/or
C. Building "pilot projects" to demonstrate what is feasible and familiarize construction professionals with the technologies and/or
D. Making designs for wood structure alternatives a required part of new state, or state sponsored, construction projects and/or
E. Adopting code provisions to allow wood buildings up to 18 stories in height and/or
F. Creating a voluntary embodied energy stretch goal for new construction in Maine and/or
G. Providing financial incentives for projects that meet goals for reducing embodied energy and/or
H. Expanding worker training programs on the use of materials with low embodied energy and/or
I. Increasing funding for the University of Maine Advanced Structures and Composite Center and/or
J. Providing state and local financial incentives to locate CLT mills in Maine and/or
K. Developing embodied energy statistics for different types of new construction in Maine and/or
L. Advocating through the coalition of Northeastern Governors for a New England-wide effort to reduce embodied energy in new construction

4. **What is the timeframe for this strategy?**

Implementation could occur very rapidly as the technologies are proven with new mass timber buildings in operation or construction in Massachusetts, New Hampshire, Connecticut and Rhode Island. Climate benefits would occur immediately and continue/increase out to 2100 as forests used as sources for the wood regrow.

	Short-term (2022)	Mid-term (2030)	Long-term (2050)	2070 -2100
To implement	X	X		
To realize outcomes	X	X	X	X

5. **Please analyze the Recommended Strategy against the following criteria. (Each Working Group can add its own sector-specific criteria as appropriate.)**

Workforce - Will the strategy create new jobs, prevent job loss, or cost the state jobs?	This strategy will create new jobs in the manufacturing of materials with low embodied energy, e.g., wood and other bio-based products. It will also create jobs for workers skilled in construction with these materials. It will reduce jobs in manufacturing and construction with mineral based steel and concrete which have much higher embodied energies and are largely produced in distant locations.
Benefits (non-workforce) - What are the expected co-benefits of this strategy (e.g., improved health, increased economic activity, wildlife habitat connectivity, reduce natural hazard risk, increased recreation, avoided damage)?	This strategy will result in increased economic activity in the forest products industry and benefit rural economies. It will create more demand for wood, with higher returns for landowners. Depending upon how the technology for lower embodied energy materials develops and how it is implemented (e.g., the specifications for feedstocks), it could improve forest management by creating markets for low value and small trees. Improved forest management could in turn improve wildlife habitats.
Costs – What are the estimated fiscal costs and other costs to carry out this program. To the state? To municipalities? What resources do you anticipate needing to inform Mainers about the strategy and the opportunity/costs of the strategy? Where would financing likely come from?	Implementing the strategy will require additional work to establish the program and monitor its results. This will result in additional work at both the state and the local level. So, for example, at the state level, officials will have to work to create the program; and at the local level, code enforcement officers will have this added to their responsibilities. It is not clear that this will result in increased costs or simply shift priorities. As proposed, there would be minor direct costs to provide tax incentives for establishment of cross-laminated timber mills, to expand workforce training programs, and to increase research efforts at the University of Maine. Costs of mass-timber construction have decreased and are now roughly competitive with steel and concrete construction so no additional costs for the actual construction are anticipated; as construction companies build expertise in working with wood and locally produced materials become more widely available there could be substantial mid-term cost savings.

Equity - Is this strategy expected to benefit or burden low-income, rural, and vulnerable residents and/or communities? What outreach has been/will be undertaken to understand the impact of the strategy on front-line communities?	This strategy should benefit rural economies, including landowners, loggers, and workers in the forest products industry, and local economies more generally. There should be substantial benefits to rural communities in Maine without significant extra costs for urban communities, and possibly with cost savings in urban communities over time.
Proven strategy & feasibility – Has this strategy been implemented successfully elsewhere? Is it feasible with today's technology? What barriers to implementation exist (e.g., financial, structural, workforce capacity, public/market acceptability)?	Mass-timber buildings are now a proven and standard construction technique. Examples include the John W. Olver Design Building at the University of Massachusetts, the North Hall residence building at the Rhode Island School of Design, the 90 Arboretum Drive office building at Pease Tradeport in New Hampshire, and the new 5-story, 14 unit affordable housing project recently announced in Boston. Strategies to support such construction have been implemented through the U.S. Forest Service's Wood Innovations Grants and through public policies like those proposed here. Policies to support mass-timber construction have been implemented in Washington and Oregon (building code modifications), New Zealand (public financial incentives), and Europe (embodied carbon regulation). Barriers to implementation include opposition from the steel and concrete industries. In addition, because the technology for mid-rise buildings is unfamiliar to most in the building community, engineers, architects, construction companies, and developers will need additional training and demonstration projects such as those already provided through the federally supported WoodWorks program.
Legal authority - Does the strategy require new statutory (legal/legislative) authority?	New legislation may be required to establish the standard in Maine and in other states. New appropriations may be required to implement supporting strategies.

6. Rationale/Background Information

U Maine Center for Research on Sustainable Forests, Link to State of Maine's Carbon Budget
https://crsf.umaine.edu/forest-climate-change-initiative/carbon-budget/

Urban Land Institute Embodied Carbon Report for Real Estate Industry:
https://americas.uli.org/wp-content/uploads/sites/2/ULI-Documents/Greenprint-Embodied-Carbon-Report_FINAL.pdf

Link to EC3 Embodied Carbon Calculator – Carbon Leadership Forum
http://www.carbonleadershipforum.org/projects/ec3/

Increase in the use of wooden construction can reduce greenhouse gas emissions significantly and create new markets for materials like wood and other bio-products with low embodied energy. See for example https://newenglandforestry.org/2020/01/31/new-study-implications/. Additional materials and references available from New England Forestry Foundation on request.

11. Fixing Carbon Accounting

A., Wright

This strategy calls for full carbon life cycle assessments and embodied to be considered for building materials. This includes a cradle to grave approach - addressing carbon and pollution emissions from a product's inception to its disposal.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaptation and resilience to the impact of climate change.]
    a. *All goals above.*
2. What problems/barriers will this strategy address?
    This strategy is necessary in order to ensure we are addressing climate change honestly and fully. Materials that are generated outside of the State of Maine, or that will eventually be harmful to our climate in the long run. This strategy will allow us to think about past short term benefits, and realize the long term risks and benefits to products.
3. Is there a model for this strategy, either in Maine or in other jurisdiction?
    Not that I can find, but lots of research: https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.438
4. What are the benefits of this strategy?
    This strategy allows us to have a realistic view on how much carbon we are putting into the atmosphere - and closes a loophole by keeping Maine from "outsourcing" its emissions.
5. What are the costs of this strategy? *Enacting the policy is limited, but it will cause costs as it will change how much we need to lower our emissions.*
6. What is the timeframe for implementation (short- , mid- , or long-term)? *Short term*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)? *Supply chain & capacity*
8. What populations, communities, or sectors will be impacted by this strategy? *Scientists, policy makers*
9. Identify existing resources/data that could help develop and implement this strategy.
    https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.438
    https://www.researchgate.net/publication/284275575_Multiple_carbon_accounting_to_support_just_and_effective_climate_policies

12. Actively Promote the HERS Index

J., Bassett Schwerin, Green Broker and Realtor

Which MCC goal does this strategy help to achieve?

Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

Describe the problem/barrier that this measure will address:

To reduce the greenhouse gas emission of the buildings in the state, particularly residential buildings but also commercial buildings, we need to 1. weatherize the building to reduce the energy demand, then 2. electrify the HVAC and DHW to migrate fossil fuel combustion in the building to efficient electric appliances, then 3. Solarize the electric demand, including EV to achieve net zero. Weatherization includes an energy audit, air sealing of leaks, insulation of accessible parts of the envelope, consideration of radon and air ventilation. A HERS Index rating should be performed at the conclusion of this or, if there are plans to electrify and solarize, a HERS rating could be done at the conclusion of all three measures.

Is there a model for this, either in Maine or in other jurisdictions?

There are 2.7 million HERS rated buildings in the US. In New England alone there are 1000 times more HERS ratings than in Maine, many of these as a result of a state run program to promote and incentivize getting the HERS rating.

What are the benefits of this solution?

Weatherization is the invisible energy efficiency measure. There is no curb appeal. No bragging rights. And although you will notice a difference in your utility bill after a year, even that can be difficult to associate with your investment.

A pile of utility bills on the kitchen counter for the open house when it comes time to sell doesn't easily translate into a higher sales price, nor may it move an appraiser to support that price premium if you are able to convince a buyer. The HERS Index is a rating system that is easy to apply to any building of any age in any neighborhood. A 100 means that the building efficiency is equivalent to the 2006 IECC energy code. Maine buildings average 108. A higher score means the building is less efficient while a lower score is more efficient. A 54 means it is as efficient as an EnergyStar home. A 0 means that the building is Net Zero, i.e. it makes as much energy as it consumes.

We have the MPG rating for cars and light trucks. We have the Energy Guide label for appliances. We have the Nutrition label for packaged food. Consumers are used to these and rely on them to make purchases. A home is the single largest investment and most expensive material object most people own, and that's why we need a rating system to reward investments in energy efficiency by monetizing them in resale. You cannot track what you cannot measure, so we need it on a policy level to show how we are doing in meeting our goals.

What are the costs?

I will work with RESNET, Efficiency Maine Trust and other regional state agencies to provide this data. A HERS rating is more than the cost of a blower door test, which is about $350, more than an energy audit, which is about $750, maybe in the $1500 range depending on the complexity of the building, but I have not researched this sufficiently to base anything on.

What is the timeframe for implementation? Short-term, mid-term, or long-term? –

In the short term, we are adopting new building energy codes in Maine that require a blower door test for an occupancy permit, and for those, it would be possible to offer a small incentive to builders and buyers to complete a HERS score at the same time. Rolling out a training program to the trades involved with home construction, brokerage, financing, etc. would take research and planning to roll out in the medium term. A long time horizon is necessary to achieve ubiquity of the score, but fortunately RESNET, the independent group that supervises HERS raters and scoring, has ambitious plans to exponentially increase the ratings around the county.

When does implementation begin and what is the expected duration? –

This should begin ASAP and be sustained a future time when the public expects it to be available to make a purchase or lending decision.

When is the outcome realized?

At a future time when the public expects it to be available to make a purchase or lending decision.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

There are many barriers. Maine has an older housing stock; the average homes were built are 58 years old. Only about 1% of our total stock is built new every year. Homes are typically one-offs, not typically modular or tract homes that are very similar. Two-thirds of Maine homes are heated with oil that is all imported and is the second worst polluting fuel next to coal. We have a shortage of skilled builders and trades people. For every barrier, however, there is a benefit in overcoming it. We also have a well-developed and capable administrator in Efficiency Maine Trust, a progressive and smart Governor, and a very effective legislature all working towards achieving our goals to get to zero emissions.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

All communities will benefit, with the possible exception of people with vested interests in maintaining the fossil fuel infrastructure, although they could benefit if they so desired.

Existing resources/data that could help implement this strategy: - Are there major data gaps related to this strategy?

RESNET maintains a database of HERS ratings and raters. There are not many of either, so we would need to get more people trained and qualified to rate buildings with the HERS score. The Maine MLS has for several years had fields for buildings having a HERS score and for what the score is. NorthEast Energy Efficiency Parnetships has developed software under grants from DOE to auto-populate the HERS rating and other data into the MLS when an address that has been rated is listed for sale, and is in discussions with the Maine MLS about implementing it. I have cited evidence in a white paper available at https://mainegreenbroker.com/re-me-blog of higher resale values due to having a HERS scores compared to homes without HERS scores.

Modeling suggestions: Are there rules or legislation that might help enact this strategy?

I have not drafted any legislation at this time.

For more information about the opportunity for promoting HERS Index ratings in Maine, please read my white paper, A HERS Score Monetizes Invisible Energy Efficiency Investments, https://mainegreenbroker.com/re-me-blog. Thank you for your consideration.

Strategy 2: Transition to Cleaner Heating and Cooling Systems

1. Accelerate Maine's Transition to High-Performance Heat Pump Technology

Prepared by the Efficiency Maine Trust

Which MCC goal does this strategy help to achieve?
X Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050
□ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:
Located in Climate Zones 6 and 7, Buildings in Maine must provide heat and hot water to occupants through extended periods of low temperatures. Mainers spend between $2,500-$4,000 annually for heat in a typical home.
Petroleum heating fuels (oil, kerosene, and propane) heat more than 7 in 10 residential dwellings, and most non-residential spaces. A significant portion of domestic hot water in homes and businesses is heated with petroleum fuels.

Petroleum heating fuels are the largest contributors to GHG from the Residential and Commercial sectors among Buildings.

Petroleum heating fuels are not native to Maine, are imported, and are subject to price volatility in response to global events.

Is there a model for this, either in Maine or in other jurisdictions?

New York, Washington, Oregon, and Vermont are other states aggressively promoting the transition to high-performance heat pump technology. Among them, Maine is the national leader.

What are the benefits of this solution?

Compared to other fuel-technology combinations, high-performance, air-source heat pumps offer the following advantages:

Efficiency: With ductless "mini-split" technology, high-performance heat pump systems experience extremely high efficiency in the distribution system within the building compared to hydronic, steam, or forced hot air systems. Optimized use of inverters and the refrigeration cycle enables high-performance, cold-climate heat pumps to achieve a year-long average Coefficient of Performance (COP) of 2.7, peaking at more than 3.0 during the shoulder seasons. The technology is improving year-over-year. The "grid" supply of electricity is also getting more efficient year-over year.

Cost – 2-3X less expensive to operate than electric resistance technology; less expensive to operate than fossil-fuel heating systems. Cost-effective, using Total Resource Cost test, compared to all petroleum-fueled heating systems. Switching to heat pump technology can save a typical Maine household hundreds of dollars annually on both space and water heating (see attached).

GHG – Assuming today's marginal emissions rate from ISO-New England, factoring in inefficiencies at the generator and line losses (but not imports):

(a) Compared to an oil-fired boiler, a high-performance heat pump saves ____ tons of CO2/year.
(b) Compared to a propane-fired boiler, a high-performance heat pump saves ____ tons of CO2/year.
(c) Compared to an existing, average NG-fired boiler, a high-performance heat pump saves ____ tons of CO2/year.
(d) Compared to a new, high-efficiency NG-unit, a high-performance heat pump saves ____ tons of CO2/year.
(e) Compared to a tankless coil coming off an oil-fired boiler, a heat pump water heater saves ____ tons of CO2/year.

A single, high-performance heat pump can easily displace 27.5 MMBtu per year in a typical Maine household.

Comfort and control – Heat pumps can be digitally controlled to deliver comfort. In both heating and cooling modes, they can be managed with timers or programmed to adjust to signals. For HPWHs in particular, the tanks provide the opportunity to store heat for later use as a load management strategy.

What are the costs?

<u>Heat Pumps</u>

Average cost in recent years = $3,750 for a single-head, EMT-qualifying heat pump, including equipment and installation. About 50% more for multiple-heads.

Financial incentives offered by EMT = $1,000 for a Tier 2 install and another $500 for a second Tier 2 install. $500 for a Tier 1 install and another $250 for a second head or a second Tier 1 outdoor unit.

<u>Heat Pump Water Heaters</u>

Average cost of equipment = $1,000–1,200

Incremental cost = $600-800

Installation cost = $300-600

Increased electricity costs more than offset by lower petroleum fuel costs.

Some share of future grid upgrades will be attributable to this strategy.

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When does implementation begin and what is the expected duration?

Immediate/ongoing.

- When is the outcome realized?

TBD

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages

For the next 3 years, EMT and MaineHousing have sufficient funding to provide incentives or full project costs for approximately 20,000 units per year. Beyond Year 3, EMT may need to re-allocate existing revenue streams to this objective or find new funds. Beyond Year 5, EMT may have no funds to promote this objective unless decisions are made at the PUC and/or the Legislature to authorize funding.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

Consumers: Low Income – Single Family Homes show an SIR > 1 and the potential to save considerable money for the residents. Heat pump technology, using mini-splits or VRFs, may also be a suitable application in Affordable Housing/apartments. All residential SFH. Most commercial buildings.

Vendors: Small businesses that sell/install/service heat pumps and supply houses (such as FW Webb).

Competitors: Incumbent fuel suppliers and traditional equipment vendors may compete with heat pumps/electricity (although many now offer heat pump equipment).

Existing resources/data that could help implement this strategy:

45,000 high performance heat pumps and 25,000 heat pump water heaters have been installed with assistance from EMT programs. These products and programs have been studied in Maine and Vermont and other states. Analysis confirms that the products work well in the Maine climate and save money at current prices.

- Are there major data gaps related to this strategy?

  There is limited data on the prevalence of tankless coil systems used for producing domestic hot water.

Modeling suggestions:

Model the effects of installing 2 high-performance EMT-qualifying heat pumps per home for every SFH and condo in Maine.

Model the effects of supplying 75% of non-residential space heating using heat pump technology.

Model the technical potential of HPWHs in Maine out to 2050, including replacing ERWH and tankless coils, accounting for the lives of investments and opportunities for replacement on burnout throughout this timeframe. Estimate the number of unconditioned basements in Maine.

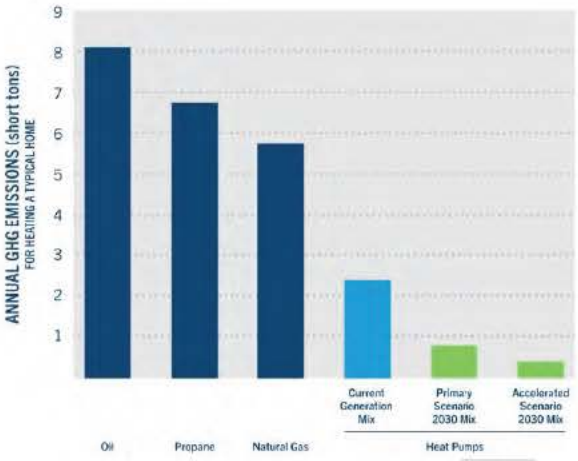
Model the effects of installing a HPWH in 75% of Maine homes.

Model the GHG savings/$ spent for heat pumps vs. weatherization.

Are there rules or legislation that might help enact this strategy?

Consider these actions:

1. Extend funding beyond 2025 for EMT and MaineHousing financial incentive programs
2. Set minimum HSPF ratings (i.e., "appliance standards") for the sale of heat pumps and HPWH in Maine
3. Offer tax credits on the purchase of qualifying models
4. Adopt provisions in the building code governing new construction for residential and commercial buildings for both space heating and water heating
5. Require open source controls on heat pump water heaters to enable future load management programming



2. Electrification of Commercial Hot Water Systems

J., Thompson

Introduction

Maine needs to move multifamily and commercial buildings that require large amounts of hot water off of natural gas boiler systems and onto to electric heat pump and reverse cycle chiller systems.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *Mitigation of greenhouse gas emissions in the state.*
2. What problems/barriers will this strategy address?
    a. *Lack of technical knowledge of large scale electric hot water system implementation.*
    b. *Current high market cost of large-scale hot water delivery systems due to low market penetration.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Unknown.*
4. What are the benefits of this strategy?
    a. *Remove barriers to electrification of large-scale hot water delivery systems, reduce natural gas use.*
5. What are the costs of this strategy?

a. *TBD.*

6. What is the timeframe for implementation (short-, mid- , or long-term)?
    a. *Medium term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *The System has the potential to generate substantial energy savings,*
    b. *The System has low monetary savings potential when referenced against an abnormally cheap heating fuel like natural gas.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Multifamily, commercial, hospitality, and industrial building owners.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *Ripcord Engineering study:*
        i. *https://owncloud.ripcordengineering.com/index.php/s/sCHLETQmWbcuCxT?path=%2F6_Project%20Data%2FDesign_Process%2F12_Plumbing%2F01_Efficiency%20Maine*
10. Modeling suggestions for this strategy.
    a. *See Ripcord Engineering study referenced above.*

3. Provide Financial Incentives for High-Efficiency Boilers

J., Livengood

Program Summary:

In the most recently published "***Biennial Report on Progress toward Greenhouse Gas Reduction Goals" (January 2018)*** and "***Maine Prepares for Climate Change" - 2019 Update***, the Maine Department of Environmental Protection, in its executive summary section, listed a number of major milestones and cited two key observations related to specific actions that translated to significant progress being made on the State's greenhouse gas emissions goals in 2030 and 2050. In both observations, Natural Gas is specifically mentioned as the key driver in lowering the State's carbon dioxide ("CO2") emissions.

1. Annual carbon dioxide emissions from the electric power sector have decreased by 73% since they peaked in 2002 largely by replacing high carbon fuels with natural gas.

2. Statewide CO2 emissions remain at least 10% lower than 1990 levels in large part because of the use of lower carbon fuels such as natural gas and increased efficiencies.

As a result of these observations, it is recommended that the Buildings, Infrastructure, and Housing Working Group proposes a "High-Efficiency Boiler Carbon Reduction Program" that will have a near-term impact on lowering overall emissions. The program will motivate homeowners to replace less-efficient, more-emission-producing residential heating systems with new high efficiency boilers. Consumers would receive either a refundable state income tax credit or a non-refundable state income tax credit with a "carry forward" attribute to incentivize them to convert their heating equipment from fuel oil to natural gas.

According to data compiled by Maine's four local distribution companies, over the last decade, by replacing inefficient oil systems to highly efficient natural gas, the State's LDCs have reduced carbon emissions by an estimated 450,000 metric tons. That is the equivalent of taking nearly 100,000 cars off the road.

Potential barriers that this solution will address:

Maine has some of the oldest housing stock in the country and is the most fuel-oil-dependent state, with more than 60 percent of the state's 550,000 households relying on fuel oil as their primary energy source for heat. In other cold-climate states, the percentage of homes heated with natural gas is more than 60 percent, according to the U.S. Energy Information Association. CO2 emissions generated from a typical Maine residential homeowner using fuel oil for space heating amounts to 15,680 pounds annually, and as a result, fuel oil contributes a significant amount of greenhouse gases in the atmosphere. The use of natural gas, the cleanest burning hydro carbon available, in a space heating application can significantly reduce CO2 emissions and contribute meaningfully to near- and mid-term efforts in reducing greenhouse gas emissions and achieving the State's defined emission reduction goals. In addition, natural gas has historically proven to be very cost effective when compared to fuel oil, saving Mainers money on their energy bills and increasing the value and marketability of their homes, while offering a number of convenience factors – including not having to schedule fuel deliveries or checking tank levels.

Is there a model for this solution, either in Maine or in other jurisdictions?

There is currently a similar conversion program in Maine that promotes the installation of 100,000 heat pumps in the State by 2025, and this recommended natural gas-related Program will supplement those efforts. The heat pump program offers rebates of up to $2,000 for equipment and installation for lower-income homeowners, and up to $1,500 for other homeowners. The heat pump conversion program does reduce emissions, but Maine's cold climate typically requires homeowners to have another heating source, such as fuel oil or propane. In addition, natural gas is immediately ready for consumption, whereas electric energy is more expensive as it requires another energy source to generate electric power (in most cases, the other energy source is natural gas) and results in a portion of that energy never making it to the customer because of line loss.

A number of utilities in the Northeast provide cash rebates (typically $1,000) for fuel oil-to-natural gas conversions including: National Fuel Gas, Orange & Rockland Utilities, PECO Energy, and New Jersey Natural Gas. Two Maine LDCs – Maine Natural Gas and Summit Natural Gas – provide conversion rebates as well. Maine Natural Gas offers a $1,500 cash rebate and Summit Natural Gas offers up to $3,400, and higher rebates for low-income consumers. In addition, all of Maine's LDCs actively promote the conversion process from fuel oil to natural gas.

An example of another Legislature utilizing incentives is the State of Utah. The equivalent to the Maine Department of Environmental Protection, the Utah Department of Environmental Quality ("DEQ"), considers home wood burning stoves the low-hanging fruit in their efforts to curb wintertime emissions. Wood burning stoves emit as much pollutants as 200 homes heated with natural gas. As a result, the DEQ provides a $3,800 rebate to homeowners for converting wood burning stoves to natural gas equipment. Similarly, when the current disparity between Maine's residential heating sources (which includes more than 60 percent of homes using fuel oil) and the residential heating sources in other cold climate states (natural gas 60% and fuel oil 6%) is considered, the State of Maine is also provided an excellent opportunity to meaningfully and cost effectively reduce CO2 emissions through the use of natural gas equipment.

What are the benefits of this solution?

Utilizing natural gas for space heating significantly reduces greenhouse gases – by 27 percent when compared to fuel oil. Converting Maine homes from fuel oil to natural gas will meaningfully help to achieve near-term greenhouse gas emission targets. This solution will also provide homeowners with energy cost savings and other economic value and conveniences. Natural gas is especially the right solution for cold-climate states like Maine. The American Council for an Energy-Efficient Economy ("ACEEE") reports that "regular" heat pumps are sufficient for heating down to 20 degrees (F) and cold-climate heat pumps are sufficient down to 5 degrees (F). But in areas where temperatures get below zero, less efficient homes (not properly weatherized) need an oil/propane/natural gas backup. As a result of these weather dynamics, natural gas would be the best backup heat source for a homeowner who has added an electric heat pump.

What are the costs of this solution?

Maine LDCs will typically install a new service line at no cost to the homeowner. The cost of a new high efficiency natural gas boiler for a typical Maine home is approximately $6,000 - $8,000, which includes adding internal piping and removal of the homeowner's old fuel system. It is recommended that a $3,000 state tax credit be offered to provide Maine homeowners with an incentive to convert, and a $4,000 state tax credit for conversions completed by qualifying low-income homeowners. Private-sector financing partners should also be considered to help drive affordability, economics and volumes needed to maximize environmental impact.

The benefits of the conversion will include a reduction in energy costs during the winter heating season of approximately $600 for the average Maine homeowner, CO2 reductions of 3,560 pounds per home, an increased value of the home following conversion of approximately 4% (according to the National Association of Home Builders), and a number of other conveniences – not needing to call for fuel deliveries or checking tank levels.

What is the timeframe for implementation? Short-term, mid-term, or long-term?

Implementation can start immediately. Maine's LDCs have many miles of natural gas main where services can be run to qualifying homes right away, once the winter season ends and digging permits can be provided. Strategic, new natural gas main can also be installed under short-, mid-, and long-term timeframes through the LDCs' capital project budgets.

- When should implementation begin and what is the expected duration? o Implementation can start immediately with very little start-up costs since the program is essentially consumer driven.
- When is the outcome realized? o Outcomes will be realized almost immediately as homes are converted to natural gas, with an estimated 15,000 annual conversions being completed statewide through 2026.

What are some of the Maine-specific barriers to implementation (e.g. legal, resources, standard practice, supply chain, workforce capacity, etc.)?

There are three Maine-specific barriers to the High-Efficiency Boiler Carbon Reduction Program:

- Maine State Legislature approval would be needed to implement a state income tax credit (whether that be a refundable tax credit or non-refundable tax credit with a carry forward attribute).
- Maine's harsh winter season only allows for digging to install new natural gas main and new natural gas services from April 1 to late-December.
- The workforce capacity of HVAC contractors in the State may be stretched.

What populations, communities, or sectors will be impacted by this strategy? (Where appropriate, please indicate how they may likely be impacted)

The Maine High-Efficiency Boiler Carbon Reduction Program will be available statewide to residential homeowners – primarily in dense, urban and rural populations throughout the State. It may not be economical to convert homes to natural gas in certain sparsely-populated rural areas.

Please identify existing resources/data that could help develop and implement this strategy: What major data gaps are related to further developing or implementing this strategy?

Funding for the Program will be provided through the Maine State Legislature. In terms of program implementation, existing natural gas conversion programs at Maine's LDCs can provide a number of "best practices" to help implement the program as efficiently and cost effectively as possible. There may be lessons learned from the existing Heat Pump Program that may be helpful as well. Data gaps may include HVAC contractors' ability to manage additional workload and equipment inventory requirements needed to fully implement the program; this would have to be investigated to see if such gaps exist.

Modeling suggestions:

Estimate that approximately 15,000 natural gas high-efficient natural gas boilers would be installed statewide each year going forward for a total of 100,000 conversions completed by year-end 2026. Assume that 25,000 of the installations over the term of the Program are completed for low-income (eligible for the Home Energy Assistance Program (HEAP) and the Central Heating Improvement Program (CHIP)) homeowners.

"High-Efficiency Boiler Carbon Reduction Program"

Recommendation:

The Buildings, Infrastructure, and Housing Working Group recommends implementing a new statewide program, in addition to the existing heat pump program, to provide Maine homeowners the opportunity to replace antiquated heating systems with high-efficient boilers fueled by natural gas during a period that begins immediately and extends to year-end 2026. Estimating that 100,000 fuel oil systems are replaced during the timeframe, 70 million gallons of fuel oil could be replaced by a significantly lower carbon-based fuel that is a cleaner and more-efficient. This program will meaningfully help the State's efforts to achieve its greenhouse gas reduction goals. Natural gas emits 27% less carbon dioxide ("CO2") than fuel oil, and has been the key contributor in reducing emissions throughout the State since emission goals were put in place in 2003. In addition, Mainers can be expected to, on average, secure approximately $600 in annual energy savings by converting to natural gas from fuel oil. There also may be opportunities to partner with Efficiency Maine and private entities to provide value-added services such as air sealing and insulation opportunities or financing options to further improve energy efficiency in the home and make the Program more economically viable.

Based on Maine's most recent estimate of 15 million metric tons of CO2 emissions and the State's goal of 11.9 million metric tons of CO2 emissions by 2030, the High-Efficiency Boiler Carbon Reduction Program would reduce CO2 emissions by a cumulative 348 million pounds, or 5.1% of the remaining goal.

Listed below are key aspects of the Program:

- High-efficient natural gas boiler installations will be available to homeowners through year-end 2026
- At least 25,000 conversions are allocated to low-income homeowners (those eligible for the Home Energy Assistance Program (HEAP) and the Central Heating Improvement Program (CHIP))
- State income tax credits provided to low-income homeowners are limited to $4,000 for fuel oil conversions, and the tax credit cannot exceed the amount of the conversion project less any rebates provided from other sources.
- State income tax credits to non-low-income homeowners are limited to $3,000 for fuel oil conversions and the tax credit cannot exceed the amount of the conversion project less any rebates provided from other sources.
- The necessary investment by a homeowner will include installation of new natural gas equipment and necessary piping; removal of old equipment and fuel oil tank; and other reasonable ancillary costs.
- The state income tax credits listed above will significantly reduce payback periods and private-sector financing options would help improve affordability and economics.
- Regulated LDCs will be responsible for infrastructure needs to the home – including natural gas main and the natural gas service and meter.

Natural gas as a fuel used in a high-efficiency boiler offers a number of advantages:

- Natural gas is affordable and prices are expected to stay low for the foreseeable future.
- Natural gas is the cleanest burning hydro carbon fuel.
- Natural gas is domestic and abundant since the U.S. is the global leader in the production of natural gas.
- Natural gas is reliable since like other utilities services it is provided directly to the home.

- Homes with natural gas service have a 4% higher resale value than homes heated with less cleaner fuels (according to the National Association of Home Builders). In response, many neighborhoods, where there are no pre-existing natural gas pipelines, are campaigning to bring natural gas to their streets.

By supplementing the State's existing Heat Pump Program, a High-Efficiency Boiler Carbon Reduction Program provides an additional compelling option for Maine homeowners:

- Natural gas heat is *cozier*. Gas systems deliver warmer 120-degree heat compared to 90-degree air produced by electric heat pumps.
- Natural gas is immediately ready for consumption. Electric energy is a secondary power source that requires another energy source (typically natural gas) to generate electric power.
- Natural gas boilers typically have a much longer life expectancy than heat pumps. According to the U.S. Energy Department, a typical natural gas furnace has a life expectancy of 15-30 years, whereas a heat pump's life expectancy is 15 years.
- The program provides a homeowner with a backup heating source during times of frigid winter temperatures.

In addition to the environmental benefits and value to Maine residents, the High-Efficiency Boiler Carbon Reduction Program could benefit the State of Maine with a number of opportunities to help foster stimulus in its economy:

- Leverage volume-buying opportunities among Maine-based manufacturers and distributors of natural gas equipment, piping, valves and other ancillary needs.
- Utilize vetted and qualified Maine-based HVAC contractors to perform the conversion projects – retaining the cash payments for the projects within the State.
- Provide Maine consumers (that convert their homes to natural gas) with additional discretionary spending funds from energy cost savings and state tax credits to reinvest in their local economies.
- Engage with junior colleges and trade schools to promote and expand programs to train individuals in HVAC careers. (Eastern Maine Community College in Bangor currently has such a program.)
- In general, home values should increase modestly which should lead to higher real estate tax receipts for municipalities within the State.

Closing Consideration:

In conclusion, it was 2003 when the Maine Legislature first called for a target of lowering greenhouse gas emissions. We have made great strides in achieving their goal – nearly achieving the 20 percent reduction from 1990 levels that was targeted. Based on recent data from Maine's Department of Environmental Protection, natural gas has been the key contributor to this success. And when you consider Barack Obama's comments at his State of the Union address in 2014 – "America is closer to energy independence than we've been in decades. One of the reasons why is Natural Gas – if extracted safely, it's the bridge fuel that can power our economy with less of the carbon pollution that causes climate change" – it is clear that Natural Gas can be a key solution in achieving our near-term goal to significantly reducing greenhouse gas emissions.

Thank you for considering this recommendation. It provides numerous opportunities to collaborate with other members of this Working Group to help resolve barriers and drive implementation.

4. Expand Efficient Wood Heating

Goal: Convert 15% of Maine's homes and businesses from fossil fuels to efficient wood heating by 2030, Maine Pellet Fuels Association (MPFA) and the Professional Logging Contractors of Maine (PLC)

• Maine's forests are renewable and are certified as responsibly managed lands (8.5 million acres), with 100

logging companies harvesting 5.5 million tons annually under third party certification by the Rainforest Alliance, working collaboratively to sequester over 60% of the state's carbon emissions.

• Wood energy production using existing Maine-based infrastructure and technology would reduce net carbon emissions by 85%.

• Maine would increase income tax revenue by approximately $22.9 million annually. Further, the state would retain or create about 48,000 jobs due to this policy.

To achieve these outcomes, there are three main goals that need to be pursued. Maine, in its last legislative session, enacted MRSA §3210 "to encourage the use of renewable, efficient and indigenous resources" including "wood or wood waste" and should now seize on this opportunity to:

1. Substantially reduce CO2 emissions created by fossil fuels for building heat in Maine;
2. Nurture a homegrown energy economy that grows the fuel and builds, installs, and maintains the infrastructure;
3. Encourage increased certification of Maine's forests and logging practices, capable of producing a neverending source of energy

MPFA and PLC jointly believe that there are multiple solutions to our climate challenges and support all forms of green and renewable energy production. This is consistent with those energy solutions already identified in Maine statute (MRSA §3210). Therefore, we should be working to stimulate the uses of those energy sources in all that we do.

Goal 1: Substantially reduce CO2 emissions created by fossil fuels for heat in Maine

According to the Maine Climate Council Scientific and Technical Subcommittee, Maine's forests "sequester over 60% of the state's annual [carbon] emissions, while the forest industry sector is statewide, multi-faceted, and provides between $8-10B in direct economic impact." With proper management, Maine has the opportunity to increase this sequestration significantly and essentially work towards a carbon-neutral status as a state by 20458 and have 100% of retail sales electricity come from renewable resources by 2050 pursuant to the goals stated in MRSA §3210.

It has been well established that in order to properly manage a forest for its maximum health, harvesting is necessary although logging can initially seem counter-intuitive to forest growth and carbon sequestration. Responsible forest management practices have shown that when a tree is cut and another replanted or room is made for younger trees to grow, the forest as a whole can sequester far more carbon than if old trees are left to rot or burn. When trees are left to die naturally, they release methane which is "second only to carbon dioxide in its importance as a greenhouse-gas emission linked to global warming."

Premium sawlogs are a vital component of the forest industry in Maine, but other parts of the tree and the residuals from sawmill operations are equally important and should also be utilized for higher value products, rather than decomposing and producing methane. Wood pellets, chips, and other wood byproducts are commonly made from sawmill residuals.

"Significant energy benefits accrue from using wood products, which commonly are underestimated or uncounted in project based carbon offset accounting rules."13 And, these products are renewable per state policy already.14

Wood is a sustainable replacement for millions of gallons of oil, propane, and natural gas. And, this replacement can be a constant source of central heat and domestic hot water that is made without the negative impacts from refining and burning fossil fuels. Modern pellet consuming furnaces and boilers achieve efficiency rates well above 80%, with some condensing boilers reaching 96% efficiency.

By building markets for non-sawlog quality wood for energy, Maine can improve its forests' health, sequester more carbon, and have significant environmental and economic benefits statewide and regionally.

If 15% of Maine homes18 switch to wood from fossil fuels, it would mean approximately 195,000 Mainers would be using renewable Maine-made fuel, contributing to Maine's forests' health, and putting 100% of each dollar spent on heating back into the Maine economy. "Given the carbon benefits of Maine made pellet fuel, accounting for the carbon footprint from the transportation and production of wood pellets, pellet boilers reduce net carbon emissions by at least 85% compared to heating oil." Maine easily has the capacity to provide efficient wood fuel for 15% of Maine homes and businesses. That demand for low grade wood would only somewhat offset losses in demand in recent years due to permanent closing of a number of Maine paper and biomass energy facilities.

Goal 2: Nurture a homegrown energy economy that grows the fuel and builds, installs, and maintains the infrastructure
When Maine transitions just 15% of its heating dependency to sustainable forest resources instead of fossil fuels, it will see an increase in income tax revenues of approximately $22.9 million annually based on job retention and creation, and the multiplier effects associated with no longer sending money out of the state to pay for heating oil and propane imported from refineries in other states. Building wood energy markets will sustain key components of the Maine forest products sector that are challenged by the decline in demand for wood by pulp and biomass electricity markets.

"Maine's loggers are a vital part of the state's forest products sector, which is worth an estimated $8.5 billion annually. Maine's logging industry contributes $882 million to the state's economy each year and supports more than 7,300 direct and indirect jobs in the state." Already, Maine's forest products sector and those that support it are and have been contributing considerably to the Maine economy. The contributions to the market with well-tested and proven efficient wood heating technologies will enable Maine to emerge as a frontrunner amongst U.S. states in terms of contributions to its economy from its own natural resources. It will no longer be dependent on foreign fuel sources, or their volatile prices.

Currently, Maine's heating relies very heavily (over 80%) on fossil fuels with 61.3% using heating oil, 11.4% propane, and 7.7% natural gas.23 "Data from the US Department of Energy shows that about two-thirds of Maine households use fuel oil for home heating, the highest level of dependency in the US."24 Contrast that with the fact that wood is a lower cost source of heating energy. Using renewable Maine-made wood fuel, as stated previously, will keep virtually 100% of each dollar spent on heating costs within Maine, unlike fossil fuels which export about 68% of every dollar outside the state. Tens of millions of dollars would be kept in Maine and this will contribute to a strong and more independent energy economy. It will also support the retention and creation of tens of thousands of Maine jobs.

With a policy encouraging home and business owners in the state to convert to wood heating, we will be able to utilize Maine-produced wood fuel from Maine's sustainably managed forests. The infrastructure for each of these steps exists currently to support this change to a homegrown energy economy.

Goal 3: Encourage continued certification of Maine's forests and loggers capable of producing a neverending source of efficient wood energy
Maine has the responsibility and ability to continue to manage its forests responsibly to benefit the environment and the state's economy. Its greatest natural resource is its forests. Maine is approximately 89% forested. 93% is privately owned land, and the 10 largest entities that manage forests account for nearly 8 million acres.

Further, 50% of Maine's forests are certified to one of the three major forest certification standards (Forest Stewardship Council (FSC), the Sustainable Forestry Initiative (SFI)31, and the American Tree Farm System (ATFS)). Additionally, there are 100 logging companies in Maine, Master Logger certified. These 100 companies employee over 1,200 people in rural Maine, harvest 5.5 million tons of wood annually and are 3rd party certified through the Rainforest Alliance. The Rainforest Alliance is a certification body and is one of the founding members of FSC.

Sustainable forest management is critical to addressing climate change and Maine is an international leader. By using wood for heat and domestic hot water, Mainers are putting their money where their mouth is. When wood fuel is consumed, the carbon that it releases is directly offset by the carbon stored in our forests when trees regrow. "In contrast, returning carbon released by burning fossil fuels to its source would require millennia." Through the process of photosynthesis, our forests sequester carbon on a daily basis.

Using local wood instead of fossil fuels directly supports rural communities as well as healthy, sustainable forests by maintaining a carbon balance or a net carbon sink and it's one way that individuals can contribute to solving our climate crisis. Maine Wood Pellets in Athens maintains FSC on its product because nearly 100% of its raw material comes from certified forests.

The case for good forest management and a healthy forest products industry is that without it, forests stagnate. Good forest management maximizes the forests' health, yield, and carbon sequestration capabilities. With declining demand for forest products, forests are lost to decay or fire which does not help reduce net carbon emissions in the long run. In fact, "over the entire forest you'll eventually reach a plateau, after which the net in-forest growth and carbon accumulation rates decline—

eventually to zero" which means that by managing the forests we can do much better than zero. By responsibly managing forest health and sustainability, forests can provide the traditional products such as lumber but also can provide a source of clean low-carbon energy forever.

Managing forests for long-term sustainability is the responsibility of the landowners, the loggers, the consumers, the pellet and chip producers, and each person within the carbon cycle. It's not just one industry, but the combination of several. Producers of wood products (loggers, landowners and mills) should be encouraged to pursue or maintain 3rd party certification for the sources that they receive their raw materials from.

"The world's forests store 283 billion tons of carbon in their biomass." And in the U.S. specifically, the EPA has stated that, "forests have been historically and are currently a net sink of carbon…Use of biomass for bioenergy can support the management of U.S. forests and can lead to increased carbon sequestration from U.S. forests over time" which led the EPA to the conclusion that from the point of combustion, wood pellets and chips are a carbon neutral fuel in direct contrast to burning fossil fuels. All fuels, prior to consumption, have a carbon footprint.

We recommend adopting a policy to promote and stimulate Mainers to utilize homegrown energy because it capitalizes on Maine's natural resources. Furthering this policy doesn't require importation or invention of any new technology or capabilities for the state. It will allow Maine to reduce net carbon emissions by using wood for efficient energy production and to increase state revenue and benefit the labor market – all while providing a never-ending source of energy.

Which MCC goal does this strategy help to achieve?

X Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050 – please see the attached policy proposal

Describe the problem/barrier that this measure will address:

Greenhouse gas emissions from heating of buildings

Is there a model for this, either in Maine or in other jurisdictions?

State of Upper Austria, Austria, which is similar to Maine in population size and percentage of forested land. Portions of Northern Italy, Southern Germany, and Scandinavia are also models of wood pellet and chip heating. With regard to wood heating of schools, State of Vermont serves as model.

What are the benefits of this solution?

- Immediate greenhouse gas reduction of more than 50 % when replacing fossil fuels. Greater reduction as forest plantings grow towards maturity.
- Substantial employment increases, particularly in rural Maine
- Economic multiplier effect of annually keeping hundreds of millions of Maine heating dollars in Maine
- Increased income tax revenue from above
- Vital outlet – in the face of reduced demand from Maine pulp and paper industry--for waste food generated by Maine's forest products sector.
- Stabilized fuel costs for Maine homeowners, business firms, and public buildings

What are the costs?

Initial outlay of public funds to enable purchase of heating systems which are more expensive than fossil-fuel systems

What is the timeframe for implementation? Short-term, mid-term, orlong-term?

Short term – long term: —Ideal for the next 25 years as Maine pivots to more renewables and renewable electrification

- When does implementation begin and what is the expectedduration?

Begin now; expand until 2045.

- When is the outcome realized?

2045 (or sooner) whenever 15% of Maine's buildings are heated with modern wood systems

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

Barriers:

Relative cost of modern wood-fueled systems compared to fossil-fuel heating. This barrier will decrease substantially, as it has for solar, as market demand increases and installers become experienced.

Maine-specific advantages:

Most forested state in the U.S. High percentage of Maine lands are certified for sustainable harvesting and production practices. Maine already has a wood pellet production infrastructure superior to that of other states, including: a plant assembling internationally acclaimed high quality pellet boilers; four wood pellet production facilities; a substantial number of bulk pellet delivery trucks; a large number of trained pellet heating equipment installers; the experience of an international firm (Jackson Laboratories) heating an entire campus with wood pellets; similarly, the experience of dozens of Maine schools heating with wood pellets or chips (as result of $13 million made available to the Maine Forest Service with federal ARRA 2008-2010; recent Maine legislation establishing Renewable Energy Credits for heating with wood chips and pellets.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

Rural Maine communities participating in Maine's forest products industry will be immediate beneficiaries of expanded modern wood heating. Taxpayers supporting the heating of public buildings will benefit from stabilized heating costs (Governor's Energy Office statistics show that over the past 7 years pellet fuel is significantly less expensive than oil and half the price of propane).

While Maine's oil deliveries firms were initially seen to be disadvantaged by the introduction of modern wood heating, experience has shown that firms can expand their activities to include pellet delivery.

Existing resources/data that could help implement this strategy:

The University of Maine has an excellent product testing facility for wood pellets. Maine Forest Service has sponsored a Wood Energy Assistance Team which assists public officials considering modern wood heating. Governor's Energy Office regularly tracks heating prices for different fuels, including wood pellets.

Are there major data gaps related to this strategy?

The Governor's Energy Office tracks only prices for heating pellets bulk-delivered to residences. The prices for bulk delivery to larger buildings are very substantially less.

Modeling suggestions:

State of Vermont with regard to successful expansion of modern wood heating to schools. New Hampshire Public Utilities Commission and Massachusetts Energy Office for implementation of Thermal Renewable Energy Credits.

Are there rules or legislation that might help enact this strategy? Funding of the Maine Wood Energy Investment Program (LD 912) or establishment and substantial funding of a similar program with Efficiency Maine, targeted solely to the promotion of modern wood heating in Maine.

5. Establish fuel-neutral funding for programs to reduce heating oil in existing buildings

D., Voorhees

Proposal: Extend energy efficiency surcharge now levied on electricity and natural gas to heating oil and propane, using revenue to fund energy efficiency and weatherization programs that reduce heating fuel use –programs which are now a) too limited and b) funded by electricity ratepayers.

***** Many of the proposals submitted to BIH to-date could only be implemented if there were additional resources available.**

Which MCC goal does this strategy help to achieve?

X Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

☐ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:

- Maine's resources for reducing heating fuel use are mismatched against our need, and create inequities in energy markets
- Programs to fund heating fuel reduction in buildings are woefully inadequate to the scale of the challenge: most of the funds come from RGGI, which generates $10 M year (enough to provide core efficiency support to less than 1% of households in need).
- Heating fuel markets do not contribute to Efficiency Maine program funding, unlike electricity and natural gas. RGGI funds are ultimately paid by electricity consumers.
- Innovative strategies to increase weatherization/efficiency and reduce fuel use—such as super-facilitated consumer financing—are stymied by lack of funds.

Is there a model for this, either in Maine or in other jurisdictions?

Vermont is the closest parallel, with a small heating fuel efficiency surcharge. Several other states allow electricity ratepayer funds to be used for efficiency measures that reduce heating fuel use (which is an alternative strategy Maine could consider.)

Of course most states do not have nearly the high dependence on unregulated fuels that Maine does. Only Vermont and New Hampshire come close (with moderately high levels in Massachusetts, upstate New York and parts of the upper mid-west.)

What are the benefits of this solution?

- Significant reductions in heating fuel use, lowering energy costs and emissions while increasing public health
- Economic benefits through reduced flow of dollars out of Maine economy (translating to new jobs in building

efficiency and especially in the larger economy)

- Financing strategies could reduce the total cost of programs for middle (and upper) income homes, leaving more resources for low-income households.
- Less reliance on RGGI funds could make those funds more available for beneficial electrification (with less distortion of energy markets; e.g. less need for fuel markets to fund electrification and electric ratepayers to fund heating fuel reductions.)

What are the costs?

- An efficiency surcharge of 5 cents/gallon would raise roughly $25 million/year
- Assuming Efficiency Maine continues to achieve a benefit to cost ratio of roughly 2:1, the surcharge would have a net present benefit of roughly $40-45 million per year
- The surcharge would have some economic impact, but pale in comparison to natural fluctuations in heating fuel prices, which can go up or down by 5 cents/gallon on a weekly basis, and by $1/gallon on an annual basis.
- Heavy heating low-income households would pay a inequitable share of the cost of the surcharge, which must be remedied through a disproportionate investment of the funds on weatherizing low income households.

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When does implementation begin and what is the expected duration?
- When is the outcome realized?

This proposal could be started in 2021 through an act of the legislature. Heating oil use crept up the last year data is available after a decade of declines. Heating oil prices are also relatively low right now. That makes it a perfect time to begin increased investment in reducing heating fuel dependency, to better insulate (pun intended) Maine households from future heating costs.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

- Maine's ability to increase efficiency of buildings and heating systems

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

As noted above, the strategy will be most equitable if funds are invested aggressively in low-income households and communities less able to convert away from heating fuel. This should include an emphasis on rural communities, where access to building improvement services are more limited.

Existing resources/data that could help implement this strategy:

- Are there major data gaps related to this strategy?

Modeling suggestions:

- Increased rate of building efficiency, using existing Efficiency Maine performance metrics

• Public health benefits of building efficiency improvements can now be estimated much more robustly
Are there rules or legislation that might help enact this strategy? Authorizing legislation would be needed for the surcharge and directing its use Legislation could also include directives for utilities to participate in financing programs developed in coordination with Efficiency Maine (e.g. on bill financing with capital from Efficiency Maine)

6. Development and Implementation of Mechanical Licensing to Ensure Uniform Quality Control and Safety of Systems Installation and Servicing

J., Shedlock

Bold action is required from every sector of Maine's economy if we are to meet the aggressive goals set out by the Maine Climate Council. Our strategies undoubtedly reply upon a shift away from fossil fuels and toward more renewable energy in order to meet greenhouse gas emissions goals. We know that any and all new residential, commercial and industrial construction must be built with that standard in mind, including addressing their heating, ventilation and air conditioning systems. We also know that at base level, existing housing stock must be retrofitted with new energy efficient HVAC systems. Experts also generally agree that legacy HVAC systems are best to remain in place and in peak operating order to be used as a backup for when the demand calls for their use.

As we implement aggressive new policies and usher in a new way of life for many Mainers, we must realize that we are indeed asking a lot of our neighbors. We must understand that "the way we've always done it" to many Mainers feels comfortable, is not broken and, as a result, doesn't need to be fixed. That is why it is imperative that we understand that we only have one chance to get this right. We must ensure that any and all work on mechanical systems performed on new and existing residential, commercial and industrial structures are performed by licensed mechanical contractors so that we can be sure that the work performed is done safely, correctly, uniformly, and in a way that we can have the highest assurance that the outcomes we promise are the outcomes we can we deliver.

Mechanical licensing includes the: heating, ventilation, air conditioning, refrigeration, pipe fitting, fire sprinkler, sheet metal and insulation trades. Implementing a licensure program surrounding these trades removes an unpredictable and, by extension, costly, variable from the process of reaching our greenhouse gas reduction goals. Agreeing upon a uniform set of safety, training and certification standards will level the playing field and ensure quality control across the state. It will provide home- and business owners with the piece of mind they need that the work being performed is being completed by an individual or a team that has been vetted and held to account by a governing entity backed by a universally agreed-upon set of standards across the industry.

Nationwide, state mechanical licensure is not a new phenomenon. We must utilize this readily available tool in Maine to give ourselves the best chance possible to successfully reduce greenhouse gas emissions while at the same time provide an opportunity for Mainers to build careers in a rewarding field with long-term growth potential.

Which MCC goal does this strategy help to achieve?

● **Mitigation of greenhouse gas emissions:**

○ Properly installed and maintained mechanical systems are critical to the meeting of any

greenhouse gas reductions

● **Job growth and transition to a lower carbon economy:**

○ The need for licensed mechanical contractors will increase, expanding the opportunities for good paying careers in the building trades

Describe the problem/barrier that this measure will address:

Currently, the mechanical trades are largely unlicensed and therefore lack the uniform quality control that a large scale, statewide decarbonization effort will necessitate. By removing this uncertainty, we can remove a major variable from this process while focusing on delivering a product to Mainers that will both have an impact on their pocketbooks as well as on the environment.

Is there a model for this, either in Maine or in other jurisdictions?

Many states across the country have mechanical licensing in some form. Maine already licenses a number of trades, with the requisite oversight Boards. The roadmap in Maine is clear.

What are the benefits of this solution?

The benefits of mechanical licensing are numerous: Worker safety will increase. Systems will be installed and maintained properly and consistently. Training and certifications will be more uniform throughout the industry. Expectations of both employees and employers will be clear. Customers will have the piece of mind of safe and well-trained personnel completing the work. Mainers will see an increased demand for good-paying careers in the mechanical contracting field. Students will have a clear pathway at continuing education via apprenticeships and lifelong learning.

What are the costs?

The State will have to fund staff to manage a licensure Board, though that can be funded and sustained through fees associated with registering and maintaining a license. Contractors and/or individuals would be charged a fee for maintaining a state license. Any additional training deemed necessary by the Licensing Board will be borne by the contractor and/or the licensee. It should be noted that oftentimes labor organizations, such as unions, incorporate industry-leading training free of charge to their members as a part of their labor/management partnership.

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When does implementation begin and what is the expected duration?

o Enabling legislation for a Mechanical Licensing Board should happen immediately.

o Implementation of licensure can then begin after enactment/rules promulgated

・New mechanical contractors should be incorporated into the licensure process immediately

・Policy decisions can be made regarding a timeline on how long existing contractors have to meet new licensure requirements

- When is the outcome realized?

o Outcomes are realized when there is a Mechanical Licensing Board in place and we are making headway in ensuring that work completed in Maine is done by safe, licenced and well-trained mechanical contractors.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

We know that change is slow and difficult. Implementing mechanical licensing is no different. Contracting businesses and individuals who have been operating for years by a certain set of rules (or no rules at all) will likely reject the effort to put in place a set of guidelines by which the industry should operate. We must be resolute in showing leadership in the face of the status quo, because we know that a patchwork system with little to no meaningful regulation does not guarantee the surety that we need as we embark on a major transformation of Maine's environment landscape.

We will also likely be told that the government does not have the resources to implement such a policy. Aside from the fact that a licensure plan can and should be self funding and self sustaining, we know the costs associated with

not investing in uniform safety, training and quality control when it comes to the environmental outcomes of our mechanical systems. The state government has a role to play, just as they do with the dozens of other state licensure boards and commissions that are deemed important enough for state resources.
We are fortunate, however, in Maine, we have a state-of-the-art (and expanding) pipe fitting and HVAC joint union labor/management training facility in Augusta as well as a cutting edge union labor/management sheet metal training facility in Lewiston. Maine DOL-registered apprenticeship programs currently exist for pipe fitting and HVAC via the United Association Local 716 Plumbers, Pipefitters & HVAC Techs. The sheet metal trade apprenticeships are registered in Maine through the Sheet Metal Workers Local 17. The insulation trade is currently in the process of registering their program in Maine via the Heat & Frost Insulators & Allied Workers, Local 6. That program is currently registered with the US Department of Labor. Nationally, the sprinkler fitting apprenticeship program is registered with the US Department of Labor via the United Association Local 669, Road Sprinkler Fitters.
We also have a top-notch community college and career and technical school system that have robust programs designed to equip learners with the knowledge they need to get a head start on their careers in the mechanical trades. There are also a number of employers across the state who participate in registered apprenticeship programs and contribute to the worker pool and knowledge base in Maine.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

All populations will benefit from the work of safe, well-trained and licenced mechanical contractors. The economy will also benefit in that there will be a growing job market for these highly-trained professionals.

Existing resources/data that could help implement this strategy:

The Maine State Building & Construction Trades Council and the directly impacted affiliates listed below stand ready to help the state and its partners implement this strategy as appropriate. There are also multiple examples of
mechanical licensing structures that have been put in place in states around the country that can be used as a template in part as Maine builds their structure.

- United Association, Local 716 Plumbers, Pipefitters & HVAC Techs
- Sheet Metal Workers, Local 17
- Heat & Frost Insulators & Allied Trades, Local 6
- United Association, Local 669, Road Sprinkler Fitters

Other organizations and institutions that can be engaged to help develop and implement this process include the community college system, the career and technical school system, other organizations who represent mechanical contractors as well as subject matter experts and practitioners in the field.
Modeling suggestions:
Are there rules or legislation that might help enact this strategy?
Many states have implemented mechanical licensing. Further, Maine currently has numerous licensing boards so there is precedent to follow.

7. Incentivize the installation of ducted recovery ventilation systems

Maine Indoor Air Quality Council

Which MCC goal does this strategy help to achieve?

Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

Describe the problem/barrier that this measure will address:

The Challenge:

As the state moves towards higher efficiency buildings to meet its carbon reduction targets, care will need to be taken to ensure the health and safety of building occupants through provision of adequate ventilation.

Most buildings have one primary purpose: they are for people. If in the process of achieving Maine's carbon reduction targets we create indoor environments that are unhealthy for people, then we have failed to achieve this foundational purpose of having a building.

The comments that follow primarily address concerns for residential properties in Maine. Commercial buildings already have a robust set of standards and professional certification that set them apart from the needs that exist for Maine homes. The building codes for Maine are currently undergoing a significant revision and rulemaking process, and once complete, Maine's code for homes will likely include minimum standards for ventilation. In extremely air tight homes, the need for fuel-burning systems is reduced, and thus reduces carbon emissions. However, some ventilation strategies, such as exhaust-only ventilation, may not be sufficient to:

- *Exhaust pollutants that can make people sick out of some areas of the home.*
- *Provide fresh air to the people in it*
- *Maintain energy-efficiency*

The preferred method to ventilate a home for both health and energy-efficiency is through installation of fully-ducted, recovery ventilation systems, such as ERVs (Energy Recovery Ventilators) and HRVs (Heat Recovery Ventilators).

Proposed Solution:

Because of the increased cost to install ERVs/HRVs, some homeowners may balk at installing them in their homes. The Maine Indoor Air Quality Council therefore recommends development and implementation of a process that provides builders and homeowners with a financial incentive to install ducted recovery ventilation systems.

Is there a model for this, either in Maine or in other jurisdictions?

- *Use of recovery ventilation systems have been part of the Canadian building code for decades.*
- *Use of financial incentives to increase installation and use of products, practices and appliances has been a long-standing strategy here in Maine.*

What are the benefits of this solution?

Ducted recovery ventilation not only exhausts pollutants and provides fresh air for the building occupants, it also saves energy overall through the energy transfer that occurs in the core of the unit: incoming cold fresh air is pre-warmed by outgoing warm stale air, reducing the overall cost of exchanging the air in the home. I have attached a fact sheet from the Maine Indoor Air Quality Council that explains this concept.

What are the costs?

1) Cost to run an ERV/HRV: Studies have been done that address the costs/savings of using ducted recovery ventilation. (see: H/ERV Cost Effectiveness: Building Energy Simulations and Economic Analysis for Single Family Detached Dwelling Units, prepared by Newport Partners LLC for the Home Ventilating Institute.) These studies show:

- *Running an ERV/HRV does use more electricity to run than exhaust-only ventilation solutions*
- *However, running an ERV/HRV saves energy (heating and cooling) overall due to the efficiencies achieved through transfer of heat and moisture in the core.*
- *The energy savings from running the unit means occupants not only save more than the cost of installation, they also save more than the cost of running the unit.*

2) Cost to develop and market an incentive program: unknown

What is the timeframe for implementation? Short-term, mid-term, or long-term? –

Short term.

When does implementation begin and what is the expected duration?

Implement as soon as possible and continue until use of these systems is common practice in Maine.

When is the outcome realized?

Homeowners will experience improved indoor air quality and energy savings as soon as a unit is installed and turned on in a home.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

Barriers: cost.

Advantages: Maine is a cold climate, and the energy savings from air tight construction and use of ERVs/HRVs will more than cover the cost of installation of building features, AND provide excellent indoor air quality.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

- *All populations, communities, and sectors benefit from improved indoor air quality.*
- *The cost to install systems can be a barrier. Financial incentives would increase adoption of ducted, recovery ventilation.*

Existing resources/data that could help implement this strategy: - Are there major data gaps related to this strategy?

Efficiency Maine would be the most likely entity to achieve this goal. Cost effectiveness for Maine and ensuring incentives for ventilation products meet their mission would need to be explored.

Modeling suggestions: Are there rules or legislation that might help enact this strategy?

Experience in Canada and California.

Strategy 3: Improve Efficiency and Resiliency of Existing Building Envelopes

1. Expand Maine's Weatherization Assistance Program (WAP) for Low-Income Households

R., Karg

Introduction

The primary objective of this strategy is to expand the existing Maine Weatherization Assistance Program (WAP) so that it is able to weatherize a significant percentage of existing dwellings in Maine.

The WAP, a national low-income program, has been active in Maine since 1977. Primary funding, provided by Department of Energy (DOE), passes through MaineHousing to the nine subgrantee weatherization agencies in the state (FY 2019 DOE allocations for Maine are approximately $3.5 million, a 20% increase over FY 2018). For a number of years, Efficiency Maine has also provided funding for selected weatherization activities performed by the agencies, including replacement of inefficient refrigerators.

The WAP in Maine already includes all the important elements necessary to weatherize existing dwellings, including trained and certified staff, a skilled contractors/crews network, software for energy analysis and inventory control,

trained and experienced administrative staff, lead funding and oversight organization (MaineHousing), national support from DOE, legislative support on both national and state levels, and more.

There is a significant precedent for expanding the WAP on a national and state level: the American Recovery and Reinvestment Act or 2099 (ARRA). Although this historic "ramping up" of WAP encountered a number of expansion and contraction problems, much was learned during the process. This experience will be valuable for expansion to limit carbon production.

This strategy does have support on a national scale at this time; it would probably be a part of a Clean Future Act or Green New Deal.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. All goals listed above with a concentration on fuel oil use reduction in existing homes.
2. What problems/barriers will this strategy address?
    a. *Coordination between WAP funding sources, including DOE, Efficiency Maine, and other possible sources.*
    b. *WAP is designed as a low-income program. It is important to move the income threshold higher so that middle income households/dwellings can be addressed. Before ARRA, the eligibility threshold for WAP was 150% of the Federal Poverty Level (FPL). The post-ARRA eligibility level is 200% FPL. There are examples of state WAPs where 250% FPL thresholds have been established with utility funds.*
    c. *Average job cost limits would need to be increased. Currently the DOE limit is $4669. Some states have been able to leverage funds to increase the average limit (one example increased the state average limit to $10,000).*
    d. *Repairs and deferrals would need to be addressed with additional funding. These are significant repairs or problems with dwellings that are beyond the funding limits and/or expertise of WAP guidelines that do not save energy/carbon, but are important to rectify before energy/carbon-saving measures are implemented. Examples include leaking roofs, lead paint, sources of asbestos, and mold.*
    e. *Workforce development issues are a challenge, as they were during ARRA. However, as a result of ARRA, the workforce development structure is more advanced now.*
    f. *The WAP now requires that energy-saving measures pay back during the median service life of the measure; the simple formula used for this Savings-to-Investment Ratio (SIR) is SIR = (saving/cost) x discounted life. The WAP must, on average, demonstrate an SIR of one as a minimum; a dollar return for each dollar of public money spent. Currently, external cost/benefits such as carbon creation/savings, IAQ diminishment/improvement, etc., are not included. If these externalities were included in the calculation of the SIR, a truer appraisal of the economics of weatherization would be possible.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Yes, the Weatherization Assistance Program (WAP), various home performance programs, various Efficiency Maine programs, and expansion for ARRA in 2009.*
4. What are the benefits of this strategy?
    a. *Energy/carbon savings from improvements to existing housing stock in Maine.*
    b. *Greater disposable income for served households.*
    c. *Increasing effectiveness of heat pump installations in existing homes with high heat loads.*
5. What are the costs of this strategy?

a. *Funding will be a challenge. It is possible that such a WAP expansion will begin on the national level as part of a Clean Future Act or Green New Deal. This is probably a more practical strategy than Maine acting alone on a WAP expansion.*

6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *For the duration of carbon reduction efforts in Maine.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *All the usual expansion challenges, including finding skilled labor, training, administrative ramping up, and more. See question 2, above.*
    b. *A history of short term weatherization efforts that attract a new motivated workforce but do not have adequate funding time periods to ensure this workforce can make a carerrs of their training.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Primarily lower income residents. In order to achieve objectives, expansion must go beyond low-income into middle-income sectors.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *Efficiency Maine has some data on efficiency levels in existing housing stock. More is needed.*
10. Modeling suggestions for this strategy.
    a. *Current WAP.*
    b. *Use ARRA (2009) expansion of WAP.*

NOTE: As of 1/28/2020, Karg has not communicated with anyone from the administration of the WAP at MaineHousing regarding this strategy. An attempt was made, but there is no response yet.

2. Weatherize existing dwellings before other improvements

R., Karg

Introduction

This strategy calls for the cost-effective weatherization of any dwelling before any other energy/carbon-saving measures are completed. Generally, the benefits from insulating and tightening an existing dwelling to cost-effective levels are more favorable than any other energy/carbon-saving measures. This is not likely to change.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
2. What problems/barriers will this strategy address?
    a. *This strategy increases the chances of achieving the most cost-effective return for each dollar spent on energy/carbon-saving measures.*
    b. *It will increase the effectiveness of heat pump installations by reducing the heating load requirements of existing homes.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Yes, the Weatherization Assistance Program (WAP), various home performance programs, various Efficiency Maine programs.*
4. What are the benefits of this strategy?
    a. *Enhances cost-effectiveness of energy/carbon conservation measures.*
5. What are the costs of this strategy?
    a. *No additional costs, but, of course, this depends on how the accounting is done.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Should be an adopted strategy with any conservation strategy.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?

a. *None.*

8. What populations, communities, or sectors will be impacted by this strategy?
    a. *All, but probably lower income more than upper income.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *No data gaps. Nothing new to learn here.*

3. Energy Audit at Time of Sale

A., Wright

Introduction

This strategy calls for requiring an energy audit including a Home Energy Rating System (HERS) Score for every residential building at the time of sale. This provides a benchmark for the efficiency of the home, similar to the gas mileage of a car. This also informs any home buyers about the energy improvement needs of the home at a time when they can act on it, by financing the efficiency or clean energy improvements into their mortgage through an Energy Efficient Mortgage, 203(k) or FHA Solar Loan.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *This advances all of the goals of the climate council by making homes more efficient, reducing their emissions for residents of all income levels*
2. What problems/barriers will this strategy address?
    a. *Most home buyers are unaware of the utility expenses or inefficiencies of a home before it is purchased. After they've lived in it for a year and experienced high energy bills, it is too late to access low-interest capital to finance the costs of energy improvements, and many have spent their available cash resources on their mortgage deposit.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Yes, this is a requirement in Austin, TX:* https://austinenergy.com/ae/energy-efficiency/ecad-ordinance/ecad-for-residential-customers
4. What are the benefits of this strategy?
    a. *Enhances adoption rate of efficiency and clean energy systems.*
    b. *Provides transparency to home buyers before they close on a new home.*
    c. *Provides energy performance information at a time that it can be acted upon.*
    d. *Reaches ~18,000 homes per year throughout the state.*
5. What are the costs of this strategy?
    a. *$200-$300 for an energy audit prior to the sale. This can be financed into the mortgage, particularly if improvements are made.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Training HERS raters, or training home inspectors as HERS raters.*
    b. *Training Realtors and lenders on a new step in the home sale process.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Residential homeowners, could also be applied to apartments and rentals (disclosure for landlords to provide estimated energy costs)*
    b. *Real Estate industry*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *Home Energy Rating System:* https://www.hersindex.com/

b. *FHA Energy Efficient Mortgage:* https://www.hud.gov/program_offices/housing/sfh/eem/energy-r
c. *FHA Solar Loan:* https://www.hud.gov/sites/documents/SOLAR-WIND.PDF
d. *VA Energy Efficient Mortgage:* https://va.org/energy-efficient-va-home-loans/

4. Require Energy Audit as Prerequisite to Heat Pump Incentives

A., Wright

Introduction

This strategy addresses the reduction of fossil fuel use in residential and commercial structures by linking heat pump incentives to level 1 or 2 energy audits. Prior to being eligible for heat pump rebates, customers would be required to provide proof of an energy audit. Heat pump customers and installers would then be provided with the energy audit that would give them information about the building heating load and major deficiencies and direct the homeowner into the existing weatherization rebate program.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. All goals above
2. What problems/barriers will this strategy address?
    a. *Weatherization should be done before heat pump installs. This prevents oversized system installation, unnecessary energy use, and additional cost for the consumer.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *None known.*
4. What are the benefits of this strategy?
    a. *Enhances adoption rate of fossil fuel free heating systems and decrease overall energy use.*
5. What are the costs of this strategy?
    a. *Additional cost to homeowner for energy audit. Could be offset through an increase in the heat pump rebate or a change to the weatherization rebate.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Expanding the workforce capacity, training heat pump installers/heating contractors to complete energy audits.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Homes, other residential, and small commercial.*
9. Identify existing resources/data that could help develop and implement this strategy.
10. Modeling suggestions for this strategy.

5. Establish a Maine Clean Energy Corps

A., Wright

Introduction

This strategy calls for creating a 'Clean Energy Corps' of AmeriCorps members and community volunteers to help homes improve their efficiency. The Maine Clean Energy Corps (MCEC) will help install LED lightbulbs, low-flow showerheads, Window Dressers and other low-cost measures in homes throughout Maine, while educating families about the efficiency improvements that are possible and funding or rebate programs available to them. The MCEC will provide door to door outreach one neighborhood at a time, ensuring that every residence learns how their

home can be more efficient. The MCEC members will be trained as home energy auditors and gain experience with installing weatherization measures, creating the trained workforce needed to transition every home to clean energy solutions.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *This advances all of the goals of the climate council by making homes more efficient, reducing their emissions for residents of all income levels, and training the workforce needed.*
2. What problems/barriers will this strategy address?
    a. *Many homeowners are unaware of the options available for improving the efficiency of their home, and the programs and rebates offered.*
    b. *Maine will need to train a large workforce to implement residential efficiency improvements in every home statewide.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Yes, Montana has a similar AmeriCorps program:* https://www.energycorps.org/
    b. *New York City does as well:* https://www.greencityforce.org/service-corps/about-service-corps/
4. What are the benefits of this strategy?
    a. *Enhances adoption rate of efficiency and clean energy systems.*
    b. *Provides outreach to residents throughout the state, focused on one town or neighborhood at a time.*
    c. *Provides assistance for elderly or disabled residents by installing low-cost energy measures.*
    d. *Informs the public of programs and rebates that are available and helps them to identify what is needed in their home*
    e. *Trains the workforce of the future.*
    f. *Creates a project pipeline for efficiency contractors, reducing the 'acquisition costs' of new projects.*
5. What are the costs of this strategy?
    a. *A Clean Energy Corps program with 10 service members will cost ~$600,000 including transportation, management, efficiency measures, and other program expenses for a year. AmeriCorps (Corporation for National and Community Service) could provide ~$200,000 of this cost. Including community volunteers could help reduce costs.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short-mid term. AmeriCorps grants can have a lengthy application process, but the state could set up a similar program with community volunteers to start.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Host agency eligible for AmeriCorps funding.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Homes, apartments, and other residential buildings*
    b. *Low income communities*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *Corps Network:* https://corpsnetwork.org/
    b. *Corporation for National and Community Service:* https://www.nationalservice.gov/

6. Manufactured Housing – Affordable Replacement Program

J., Thompson

Which MCC goal does this strategy help to achieve?

⊗Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

⊗Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:

Many mobile home residents in Maine are faced with a significant challenge; while their incomes are often low, their energy costs are high. The aim of the replacement program is to increase access to zero-energy modular homes that are reasonably affordable.

The program would work with interested buyers from start to finish to help determine eligibility for incentives to cover the cost of removing an old mobile home, apply for low-interest financing options with no down payment, select a design, and draw up a contract with the builder. With no monthly fuel bills, the intent is to work with potential homeowners to make the upfront investment possible in a home that will pay off over time.

Some of the most at risk Maine residents are owners and renters of rural substandard manufactured housing. Above average unemployment rates, high housing costs, old inefficient housing stock, and long, expensive commutes are prevalent in these areas. These factors often result in high poverty rates and increased vulnerabilities. Extreme weather events, which are becoming more common, disproportionately affect low income people whose homes tend to be less resilient and who have fewer resources to recover from natural disasters. For these reasons there is a dire and growing need for more single-family, *quality* affordable housing across the nation.

The buildings are typically HUD Code built 2x3 walls, barely insulated, bad air quality, structurally inadequate dwellings that create fuel poverty due to high bills for residents with no other options.

Programs exist in other states that are successfully building and delivering Zero Energy Modular (ZEM) homes that give residents of the failing homes replacement homes that are the same cost to own and operate as the failing homes due to the replacement of crushingly high fuel bills with stable financing packages.

Maine Modular builders are ready to produce these homes but there are significant financing and delivery barriers that will need State of Maine support to implement.

Is there a model for this, either in Maine or in other jurisdictions?

ZEM program from VEIC in Vermont. The Vermod product is the result of this program.

What are the benefits of this solution?

Safety, economic protection, fuel poverty alleviation to Maine residents with the highest risk.

What are the costs? Financing support required.

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- When does implementation begin and what is the expected duration?

Immediately.

- When is the outcome realized?
- Upon construction and installation of new manufactured homes to Maine residents.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

Availabilty of Pennsylvania manufactured housing that does not have to meet Maine Building Codes due to HUD Code loopholes. These PA homes subject Maine residents to high fuels costs and short lifespan housing because of overly low construction costs.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

Current Maine residents of Manufactured Housing.
Existing resources/data that could help implement this strategy: https://www.veic.org/media-room/insights/insights/2019/04/29/breaking-down-barriers-for-zero-energy-modular-homes https://vermodhomes.com https://www.vtrural.org/programs/climate-economy/innovator/EfficiencyVT https://www.vtrural.org/programs/climate-economy/innovator/EfficiencyVT
Modeling suggestions:
Are there rules or legislation that might help enact this strategy? Unknown.

7. Deep Energy Retrofit technical feasibility pilot

N., Beal

Introduction

Maine needs to remove the technical barriers that prevent a rapid deployment of Deep Energy Retrofit to existing Maine houses. The need to rapidly remove all fuel oil systems from existing Maine houses will require more than heat pumps and weatherization. It will require an industrialized installation method of R-40 wall & roof insulation in combination with triple glazed windows from the exterior of houses with minimal disruption to inhabitants. This project is technically advanced and will require laser scanning of houses in combination with factory panelization of insulation systems to deploy at scale.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *All goals above.*
2. What problems/barriers will this strategy address?
    a. *A lack of economical exterior insulation strategies to radically improve the comfort and ease of heating existing Maine houses.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Province of Ottawa CA is currently in pilot phase of similar project, as is Holland.*
4. What are the benefits of this strategy?
    a. *Radically improve the performance of existing Maine homes with minimal disrupting to the interiors of buildings or their inhabitant's lives.*
5. What are the costs of this strategy?
    a. *To be determined by the technical Pilot Phase.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Long term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Lack of technical infrastructure: building assessment & factory fabrication.*
    b. *Lack of currently trained workforce at this practice.*
    c. *Unknown costs and timing.*

8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Existing home owners of non-Landmark / non-Historic homes.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *PEER Project Canada 2016-2021, Mark Carver*
    b. *CanmetENERGY, Ottawa*
    c. *Energiesprong*

8. Payroll Loans for Public Employees

A., Wright

Introduction

Maine needs to improve financing options for residential energy improvements. This strategy calls for offering low-interest loans to all public employees for cost-effective efficiency and clean energy projects on their homes. These loans would be repaid through a payroll deduction. This program could be administered in coordination with the Maine Public Employee Retirement System and could be offered to every PERS participant, both active public employees and retirees. There is no greater investment than improving the efficiency, comfort and affordability of your home.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *All goals above.*
2. What problems/barriers will this strategy address?
    a. *A lack of low-cost financing for residential energy projects.*
    b. *Maine PERS has ~$1 billion invested in fossil fuel companies, which increase climate change and emissions.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Nevada offers loans to state employees for efficiency projects up to $6,000.*
4. What are the benefits of this strategy?
    a. *Provide upfront funding for a large number of residential projects with a simple loan repayment mechanism that limits risk of default.*
5. What are the costs of this strategy?
    a. *This program requires administration and management.*
    b. *This requires upfront capitalization to fund investment in the projects.*
    c. *The Maine Public Employee Retirement System has ~$1 billion invested in fossil fuel companies. This could be divested from fossil fuels and re-invested in clean energy in the state, starting with the homes of PERS participants.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Requires coordination with Maine PERS to implement.*
    b. *Requires legislative changes.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Public employees and retirees within the Maine Public Employee Retirement System includes more than 100,000 individuals.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *Nevada Direct Energy Assistance Loan:* http://energy.nv.gov/Programs/Direct_Energy_Assistance_Loan/

9. Weatherize Homes

J., Bassett Schwerin, Green Broker and Realtor

Abstract: Weatherization first is the key to reducing carbon emissions and right sizing electric HVAC and solar. A survey of Maine homes found up to 73% of the energy loss in buildings could be reduced without invasive measures, resulting in significant reductions in the use of high carbon dioxide emitting fossil fuel. A 'Moonshot' approach is called for to fund the Efficiency Maine Trust goal of weatherizing all homes whose owners cooperate by 2030. A variety of funding mechanisms are presented.

Framing the Challenge

The State of Maine has established broad goals to reduce our carbon emissions to 45% of 1990 levels by 2030 and 80% by 2050. Buildings contribute about 1/3 of carbon emissions in the state. Oil is the heating fuel for two-thirds of the buildings in the state, with a typical combustion efficiency of 80%, meaning that it releases 1/5 of the carbon content into the atmosphere as greenhouse gas. For many reasons, including geography, geology, and history, significant infrastructure for less polluting natural gas was not built and it is now too late to consider building it. We are already seeing frightening climate changes in our own coastlines and the Gulf of Maine, accelerating the consensus behind our carbon reduction goals. We must weatherize first, then electrify, then solarize our buildings while adding solar, wind and other renewables to our electric grid.

Buildings in Maine are on the old side relative to other states. A landmark study done for Efficiency Maine Trust in 2015 by NMR concluded that 73% of Maine's housing stock of 583,483 homes as of the available Census data were built prior to 1990, likely prior to any building energy codes. The average air leakage rate is higher than other states in the region at 11.2 ACH50, and is the "single greatest source of heat loss in Maine single family homes."[1] Along with air sealing, insulating ceilings, basements, foundation walls, joists and frame floors could reduce heat loss by 73%.[2] All of these areas are largely accessible to work crews, unlike walls, windows, and ducts.

Weatherization is the process of saving energy by fortifying the building envelope to reduce the unwanted transfer of heat and heated air through walls, floors, ceilings, openings in them. The process should be:

- An energy audit to determine where the envelope is failing.
- Air sealing cracks and openings in the envelope.
- Adding insulation, especially where access is non-invasive, such as in attics, floors and foundations.
- Consider testing for radon and adding mechanical ventilation.
- Complete a HERS rating and update if electrification and solarization are being done in close sequence.

Not addressing this opportunity to reduce heat loss by up to 73% in buildings is simply contrary to the principle that energy saved is the most cost effective. Furthermore, not weatherizing buildings means the equipment you are sizing for the building has to work nearly 3 times as hard or be 3 times larger in capacity. Then moving on to solarize that excess capacity results in excess solar needed to create the energy, so costs have been compounded if you didn't reduce your demand first.

We may have a Renewable Portfolio Standard on paper, but the Standard Offer Disclosure Label for CMP electricity supply to consumers and small businesses is bid without regard to the renewable energy already in the state. This year the Standard offer has 36.4% renewable energy sources. Last year it was 16.5%, including 6.0% from coal. The year before it was 34.4% from renewable sources.[3] The most recent Maine State Energy Profile issued by the DOE EIA showed the state producing two-thirds of its energy from renewable sources. In an effort to keeps rates

[1] https://www.efficiencymaine.com/docs/2015-Maine-Residential-Baseline-Study-Report-NMR.pdf.
[2] Ibid

[3] https://www.maine.gov/mpuc/electricity/standard_offer/disclosure_labels.shtml

down, we are not utilizing our own renewable energy, so although replacing fossil fuel with electric heat pumps does reduce carbon emissions[4], the electricity is not as green as we think; all the more reason to use less through weatherization.

The Tipping Point for Climate Awareness

Buildings in Maine are also almost always one-off, custom, stick built on site with few modular or tract housing, meaning that standardization and automation of the work involved in air sealing and insulating buildings is not going to result in equivalent economies of scale like mass producing heat pumps and solar panels. It is labor intensive, messy, head-scratching and in many cases likely thankless work. Homeowners who could choose between a kitchen remodel and a weatherization project seem to always choose tangible over intangible, right? In the trenches selling energy efficient homes before their time, a whole slew of techniques to justify the extra spend have been developed by Green Brokers.

But the times they are a changing. The National Association of Home Builders Research Center conducted consumer surveys in 2012 and again in 2015 asking prospective home buyers how much more they would pay for a home that cost less to operate. In 2012 it was $7095 and in 2015 it was $10,732. Millennials are a cohort even more demanding energy efficient buildings, but often they can't afford a new home as first time buyers; they will be much more receptive to doing an energy retrofit on an existing building, or purchasing one where that work has been done by the seller and documented with a decent HERS rating.

The invisible factor of air sealing and insulation can be addressed by a full-on promotion of the HERS Index.[5] Being armed with a HERS Index Rating between 0 and 54 or even 70 would go a long way towards assisting brokers to get sellers of energy efficient homes more for their property and allowing appraisers to back them up to the underwriters of mortgage bankers, as well as enticing buyers to pay somewhat more to save a lot over the course of ownership.

A 'Moonshot' Project

We must give this everything we've got. Here is the math for weatherization. There are 426,479 homes in Maine built before 1990.[6] Efficiency Maine Trust has weatherized 50,000 of them over a ten-year span from 2010 to 2019. Maine Housing has weatherized 3000 of them for a total of 53,000.[7] That leaves 373,479. We have ten years to reach our goal of all buildings weatherized that want to cooperate. Without knowing how many that is, let's say 25% of homeowners do not want the benefits of saving a lot of money and having a more comfortable space and, if cash flow is the reason, can't qualify for a low-income program or short term loan. That leaves 280,109 homes to weatherize. The Efficiency Maine Trust states in its Triennial Plan IV that were additional funding to be identified, it could ramp up to 35,000 homes per year, which would achieve this goal even if more people than the 75% estimate want to get on board[8].

We have a defined and worthy goal, and a quite competent agency in Efficiency Maine Trust to administrate the goal. Let's brainstorm what it would take. Hopefully, a plan such as Jay Inslee put forth while he was a Presidential

[4] https://www.efficiencymaine.com/beneficial-electrification-study/
[5] https://mainegreenbroker.com/re-me-blog A HERS Index Rating Monetizes Invisible Investments in Energy Efficiency
[6] Op. cit.
[7] https://www.efficiencymaine.com/docs/FY19-Annual-Report_final.pdf
[8] https://www.efficiencymaine.com/triennial-plan-iv/

candidate[9] or a version of the Green New Deal[10][11][12][13][14]will cut loose federal funds for carbon reduction projects. We should be ready with proposals even if we can't see where the funds are coming from now or how much they will be. If the stimulus funds for climate action become available, we need to be ready with programs to point it to where it needs to go. Weatherization of all Maine housing stock must be a plan on the table.

What if a year from now Federal funds to help finance weatherization are not forthcoming? We need to develop more funding mechanisms. We should develop a stakeholder group of lenders to make available innovative loan products and programs to promote them, as well as traditional products such as:

- a revolving Green Home loan program[15];
- the Efficiency Maine Trust loan (without a lien);
- Property Assessed Clean Energy (PACE) loans are a common mechanism in many regions whereby the funds to make energy efficiency improvements are tied to the property, not the property owner, and follow the property in theory at the time of resale, if not satisfied beforehand[16], however according to one source while the state enables PACE loans, none are in effect[17];
- HELOCS and cash out mortgage refinancing at attractive rates.

With interest rates already at historic lows, this is an opportunity that should be maximized immediately. Here is an opportunity to use interest rate buy downs to attract early adopters to borrow money for energy efficiency improvements at below market rates. Today, mortgage interest rates are below 3.5% for good borrowers but the EMT energy loan rate is 5% and a cash out refi costs the borrowers and extra point. A modest amount of stimulus and an awareness program coupled with active stakeholder training and outreach would kick-start the momentum.

Tax deductions benefit middle to high income homeowners, as do rebates, but are not as effective with low income homeowners. Low interest loans also may not be accessible to low income homeowners, who will need grants to cover the costs. Philanthropic sources of funding should be actively sought.

Innovative new funding mechanisms should be identified where they have been successful in neighboring states and make sense for Maine. These could include

- bonding for establishing a variety of green initiatives including financing for weatherization[18];
- Energy Efficient Mortgages give borrowers a better rate or qualify them for a higher principal to purchase a home with lower utility bills, a funding mechanism long overdue for Maine[19];
- Energy Savings Performance Contracting, a type of financing extensively developed and tested by DOE in over a dozen states whereby a third-party lender finances the energy efficiency project for a state or municipality or group of them[20].
- At some future point when Mainers make peace with or take over electric utilities, on-bill financing has worked in may other places as a financing mechanism where the utility loans the consumer funds to make

[9] https://www.jayinslee.com/issues/.evergreen-economy
[10] https://www.nytimes.com/2019/02/21/climate/green-new-deal-questions-answers.html
[11] https://www.mikebloomberg.com/policies/plan-for-100-percent-clean-power
[12] https://elizabethwarren.com/plans/climate-change
[13] https://joebiden.com/climate/
[14] https://berniesanders.com/issues/green-new-deal/
[15] https://www.energy.gov/eere/slsc/revolving-loan-funds
[16] https://www.energy.gov/eere/slsc/property-assessed-clean-energy-programs
[17] https://database.aceee.org/state/financial-incentives
[18] https://www.energy.gov/eere/slsc/bonding-tools
[19] https://www.energy.gov/eere/slsc/energy-efficient-mortgages
[20] https://www.energy.gov/eere/slsc/energy-savings-performance-contracting

energy efficiency improvements and is repaid by an extra charge on the bill, avoiding a lien on the property[21]; USDA RD has a program whereby the utility can borrow the money at Treasury rates to in turn lend to customers who pay it back on their bills[22].

The use of third-party leasing for solar arrays, PACE loans, or other financing involving lien encumbrances can complicate the transfer of residential property and as such are not as desirable, for example in times of real estate market contraction when prices are falling. We are not in those times now, but we never seem to anticipate them in advance.

Energy efficiency investments pay for themselves in savings on utility bills, but they are invisible in the home sales transaction, so to make them stand out we need to promote the HERS Index rating as the final step in the weatherization process.[23] Consumers already rely on the MPG rating for cars and light trucks, the Energy Guide sticker on appliances, and the Nutrition Food Labels, and with 2.7 million HERS ratings and a major campaign from its coordinator RESNET to rapidly expand its use, its time to promote it in a big way in Maine. Demonstrating that there is a way to show a buyer, appraiser, and lender the value that is inside the building envelope such that the market will pay more for that will give homeowners the confidence to invest in weatherization measures.

Finally, training and getting input from stakeholders must be much more active than it is currently. Long term we need a tracking mechanism to more readily see where we are in achieving our goals and sharing that data with stakeholders and the public.

Summary

We have set ambitious but essential goals to reduce carbon emissions in the atate, one-third of which come from the building sector. Maine is challenged by an old, leaky, uninsulated housing stock fueled 2/3 with dirty oil, but as the Portland motto Dirigo demonstrates, we Mainers rise again. Studies indicate that up to 73% of the buildings heat and hot air losses could be reduced without invasive measures. The order of business must be to weatherize first, then electrify, then solarize. Not doing so results in over-sizing electric heat pumps and in turn oversizing rooftop solar, and uncomfortable occupants still losing heat. Approaches to weatherization including getting a HERS index rating for the building are discussed as well as fourteen financing mechanisms to use. The paper concludes we have to give this a 'Moonshot' effort, with or without a Green New Deal funding coming from Washington, and we have the urgency, ingenuity, funding options, and competent organization in Efficiency Maine Trust to get the job done.

Strategy 4: Lead-by-Example in Publicly Funded Buildings

1. Opportunities for Near-Term Progress Towards Meeting the Goals of the Maine Climate Council through Maine's Affordable Housing Sector

Prepared by representatives from Avesta Housing, Kaplan Thompson Architects, Portland Housing Authority, the Maine Affordable Housing Coalition, and Wright-Ryan Construction

Which MCC goal does this strategy help to achieve?
□ X Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050
□ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:
Unlike many other states, Maine does not currently incentivize affordable housing developers to build highly energy efficient buildings… despite the ease of doing so and the likely strong response from the developer community.

[21] https://www.energy.gov/eere/slsc/bill-financing-and-repayment-programs
[22] https://www.rd.usda.gov/programs-services/energy-efficiency-and-conservation-loan-program
[23] https://mainegreenbroker.com/re-me-blog A HERS Rating Monetizes Invisible Investments in Energy Efficiency

Is there a model for this, either in Maine or in other jurisdictions? Yes. Many states, including New Hampshire, have provisions in their Qualified Allocation Plans (QAP) which incentivize affordable housing developers to design to a high energy efficiency standard.

What are the benefits of this solution? Ensuring that Maine's newly built affordable housing properties are designed and built to high energy efficiency standards will help the state reach its climate goals. It could also assist in efforts to strengthen and grow Maine's renewable resource economy.

What are the costs? There is likely to be a modest increase in the up-front cost of building highly energy efficient buildings, which would be offset over time by reductions in operating costs and energy usage.

What is the timeframe for implementation? Short-term, mid-term, or long-term? Short term

- When does implementation begin and what is the expected duration? The rules governing the creation of new affordable housing in Maine (the QAP) are currently being revised and will likely go to rulemaking in April or May. Those rules will likely not be updated again until the spring of 2022.

- When is the outcome realized? As soon as 2021, when projects funded later in 2020 will begin construction.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages? No barriers.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy? Renewable resource sectors will benefit, as well as those who will pay lower heating and electric bills as a result of improved energy efficiency. No one would be disadvantaged.

Existing resources/data that could help implement this strategy: see attached [below]

Are there rules or legislation that might help enact this strategy? No legislation needed; the Qualified Allocation Process is updated through the state's rulemaking process and requires the Governor's signature. Past Governors have used the QAP process to further their policy goals.

Proposal Submitted to the Working Group on December 17, 2019 (Supporting Evidence)

The development of nearly all new, rent-restricted multifamily housing in Maine, and every U.S. state, is governed by a document known as the Qualified Allocation Plan (QAP). The QAP sets out the requirements and incentives which housing developers use to determine the details of their proposed projects: where they will be located, who they will serve, building specifications, etc. Once approved, these projects are obligated to maintain their affordability for at least 45 years.

The QAP is generally undertaken annually and is approved through the state rulemaking process. The MaineHousing staff and board of commissioners typically put the following year's QAP out for formal rule-making in the spring, following discussions with housing practitioners and other concerned parties, and then bring it to the Governor for final approval by late spring or early summer. This process gives the Governor an important opportunity to ensure that the document aligns with her or his priorities and policy goals *and does not require legislative approval.*

The following suggestions for changes to the QAP would reduce energy use and carbon emissions in Maine's building sector, while simultaneously promoting our green economy:

- Unlike many other states, including New Hampshire, Maine's QAP does not currently incentivize developers to design to a high energy efficiency standard. **Adding points for proposals which are designed to a Passive House standard** would likely be highly successful in driving the development community to such an approach and would demonstrably affect energy usage and operating costs at affordable properties. The up-front costs of building a property to Passive House standards are about 5% higher than building to typical code requirements, and it is advisable to add energy modeling and

commissioning services to such budgets, so the properties which elect to design to the Passive House standard should be allowed to exceed existing MaineHousing cost caps by 7.5 or 8%. Long term reductions in energy usage and operating costs will more than offset the increase in initial capital investment. See reverse for real-world data that demonstrates the direct relationship between higher design standards and reduced energy use and operating costs in affordable housing developments.

- **Adding points for a proposed project's use of wood products**, including cross-laminated timber instead of steel or concrete, and wood-fiber insulation instead of rigid foam or other approaches, would likely drive affordable housing developers to explore these building materials as they go through the design process. In addition to reducing carbon emissions, such investments would support Maine's growing renewable resource economy.
- **Carve out brownfield remediation and solar energy generation from MaineHousing's cost caps**, to avoid discouraging affordable housing developers from proposing projects which would include such elements. Special grants and tax credits are often available to help pay for the incremental costs involved.
- **Require all affordable housing properties, regardless of which design standard is chosen, to collect basic data** on the electric, heat and hot water energy usage generated by the building(s) and share that data with MaineHousing and/or Efficiency Maine. Analysis of this data will provide state officials and other stakeholders with important information about the success of various design and operating approaches and help guide future building strategies across sectors.

Additional opportunities for progress, outside of the QAP, which do not require legislative approval:

- **Ensure that the PUC incentivizes affordable housing developers who design highly energy efficient building enclosures to install electric resistance heating systems.** Buildings which receive public subsidies to create rent affordability are currently not allowed to use electric resistance heating systems unless they go through the process of getting a waiver from the PUC, which is cumbersome and causes problematic project delays. Governor Mills' electric heat pump bill (LD 1766) included a provision that requires the PUC to create a new rule which would allow affordable housing developers to obtain that waiver up front, so long as they can demonstrate that the building envelope will be built to highly energy efficient standards. This rule has not yet been published by the PUC. Making the new waiver process as simple as possible would encourage the use of electricity rather than fossil fuels to heat affordable multifamily buildings.
- **Restore Efficiency Maine's Advanced Building Program**, which was very helpful in encouraging innovation and increasing the energy efficiency of affordable properties before program funding ran out.
- **Consider ways to target MaineHousing's first-time homebuyer subsidies** in a way that would encourage the purchase of homes which utilize heat pumps or satisfy basic energy efficiency requirements.

Actual energy usage data demonstrates the direct relationship between more efficient building design and reductions in both energy use and operating costs in affordable housing:

The chart below lists all of Avesta Housing's new construction projects between 2005 and 2016. Collecting and aggregating the utility bills (electric, heat and water) for these projects allowed the organization to understand how building design (noted at far right) ultimately correlates with their energy use and operating costs, which has significant implications for their long-term feasibility.

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AVESTA HOUSING - NEW CONSTRUCTION IN MAINE 2005-2016

Property	C.O. Year	Units	Gross Floor Area	Total MMBTU	MMBTU/ Unit	MMBTU/ Sq. Ft.	Total Operating Costs (elec, heat, water)	Total Operating Costs/Unit	Total Operating Costs/ Sq. Ft.	Building Design
Ridgewood II	2015	24	23,026	644	27	0.028	$20,374	$849	$0.88	LEED
Bayside Anchor	2016	45	37,815	1,095	24	0.029	$37,474	$833	$0.99	Passive Design
Young Street	2015	28	25,594	816	29	0.032	$24,127	$862	$0.94	High Performance
409 Cumberland	2015	57	56,286	2,337	41	0.042	$44,398	$779	$0.79	High Performance
Oak Street Lofts	2012	37	25,263	1,504	41	0.060	$25,431	$687	$1.01	LEED
Cascade Brook	2012	30	29,278	1,753	58	0.060	$47,096	$1,570	$1.61	Code Compliance
Thomas Heights	2015	18	13,452	916	51	0.068	$21,836	$1,213	$1.62	Code Compliance
Huston Commons	2016	30	21,375	1,605	53	0.075	$34,607	$1,154	$1.62	Code Compliance
Logan Place	2005	30	18,407	1,604	53	0.087	$27,065	$902	$1.47	Code Compliance
Pearl Street II	2013	54	36,123	3,594	67	0.100	$54,998	$1,018	$1.52	Code Compliance
Florence House	2010	25	31,345	3,144	126	0.100	$79,922	$3,197	$2.55	Code Compliance
Pearl Place	2007	60	29,156	3,629	60	0.124	$56,533	$942	$1.94	Code Compliance

Bayside Anchor, Avesta's only property built to a Passive House standard, incurred actual heating and electricity costs of $53.69 per unit per month (or $28,993 for all 45 units for the year) in 2018. Local utility allowances published by Portland Housing Authority show that a reasonable cost for heating and electricity in a more typically designed building of Bayside Anchor's size is about $146 per unit per month, or $78,840 annually.

- $78,840 - $28,993 = $49,847 in annual savings (cost reduction of about 63%)

2. Require 100% Clean Energy in Maine Schools by 2025

A., Wright

Introduction

This strategy calls for transitioning every school in Maine to 100% clean energy by 2025. This will reduce the long-term energy costs and reduce tax burden, and will demonstrate energy best practices for all future generations. Many schools lack adequate insulation, and are in need of energy efficiency improvements. Schools can use ground-source (geothermal) heat pumps to provide heating and cooling at a fraction of the cost of oil or propane. Every school should be powered by solar, either on the building's roof or a nearby solar farm. Schools are one of the most-used buildings in the community, so prioritizing school energy retrofits will serve as an example to everyone. Green Schools programs improve indoor air quality, and improve learning outcomes for students. This should be combined with comprehensive clean energy education programs to teach every student how they can reduce energy consumption at home and implement other climate solutions.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *This advances all of the goals of the climate council by making schools more efficient, reducing their emissions, reducing future tax burden, and providing an educational example for all students.*
2. What problems/barriers will this strategy address?
    a. *Many schools are incredibly inefficient, and have massive energy bills.*
    b. *Maine needs to prepare students to address climate change.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?

   a. *Several school districts have committed to 100% clean energy in their schools, including San Francisco:* https://greenschoolsnationalnetwork.org/100-clean-energy-school-districts-a-growing-movement/
4. What are the benefits of this strategy?
   a. *Cost savings. Energy efficiency alone can save U.S. school districts upward of a quarter of their energy costs, $2 billion per year.*
   b. *Student health. Clean energy upgrades including HVAC upgrades and repairs, lighting changes, and moving to clean stoves in cafeterias can tangibly improve student health.*
   c. *Academic performance. Student achievement is significantly improved by improvements in thermal control, ventilation, lighting, and air quality, all of which can be provided through efficiency and clean energy upgrades.*
   d. *Greater equity. Low-income students and students of color suffer disproportionately from asthma, which is aggravated by poor building conditions. These communities also suffer disproportionately from climate-related health impacts.*
   e. *Climate change mitigation. School districts can offset their significant energy-related climate impacts with a commitment to 100% clean energy.*
   f. *STEM and sustainability education. New opportunities for students to learn about clean energy and energy efficiency technologies and their benefits.*
   g. *Community resilience. Combining solar and batteries to "island" schools as energy self-sufficient locations for community shelters during disasters assists communities in navigating climate impacts.*
   h. Source: https://greenschoolsnationalnetwork.org/100-clean-energy-school-districts-a-growing-movement/
5. What are the costs of this strategy?
   a. *Energy Saving Performance Contracting can be used to finance the upfront cost based on the long-term energy savings:* https://www.naesco.org/what-is-an-espc
   b. *Power Purchase Agreements for solar reduce the cost of electricity from day one.* https://www.seia.org/research-resources/solar-power-purchase-agreements
6. What is the timeframe for implementation (short- , mid- , or long-term)?
   a. *Short-mid term. This should be prioritized within the next 5 years.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
   a. *Cost/financing*
   b. *Local decision-making processes vary*
8. What populations, communities, or sectors will be impacted by this strategy?
   a. *Students*
   b. *Every community would benefit.*
9. Identify existing resources/data that could help develop and implement this strategy.

a. *US Green Building Council Center for Green Schools:* https://www.centerforgreenschools.org/
b. *Green Schools National Network:* https://greenschoolsnationalnetwork.org/
c. *Envirolution efficiency and clean energy curriculum, funded by the National Science Foundation, builds student skills and helps them assess how their homes and their schools can use less energy:* https://envirolution.org/project-recharge-curriculum-info/

10. Modeling suggestions for this strategy.

Strategy 5: Accelerate the Decarbonization of Industrial Processes

1. Expand funding for Efficiency Maine program offerings to improve efficiency and co-generation for industrial customers

Prepared by the Efficiency Maine Trust

A. Description of Strategy *(including problem/barrier it will address)*:

High-level overview: There remains considerable cost-effective energy efficiency opportunity (electric and thermal) in industrial facilities. Many customers are not capturing this opportunity on their own. Some are leveraging EMT incentives through the C&I Custom Program to do so, but funding for these projects is limited. Expansion of funding for incentives and technical assistance through EMT would allow Maine to target more of this low-hanging fruit.

Additional funding streams may include, but are not limited to:

- additional electric procurement revenues gained by assessing large electricity users (transmission and subtransmission [T&ST] customers are currently exempt)
- a larger dedicated portion of Regional Greenhouse Gas Initiative (RGGI) funds (if EMT's other RGGI-funded programs secure alternative funding sources [e.g., energy conservation assessment on unregulated heating fuels]).
- Not a funding stream for EMT per se, but related financial incentive – consider targeted tax incentives for investments in qualifying capital projects.

Detail:

- There remains considerable cost-effective energy efficiency opportunity in industrial facilities:
  - *Thermal* - The US DOE estimates that between 20% and 50% of all energy input to industrial facilities is rejected as thermal energy. The sources of rejected thermal energy include the exhaust stacks from boilers, furnaces, dryers, and evaporators, the heat of compression from the compressed air system, and thermal energy that is carried away from equipment with process cooling water and rejected to the environment. Basic heat recovery can significantly reduce this inefficient use of energy and reduce GHG in the process. The potential savings in Maine is large but to date many customers have not taken advantage of it.
  - *Electric* – LED lighting retrofits, Variable Frequency Drive (VFD) flow control for fans and pumps
  - Combined Heat and Power (CHP)
- Reasons customers are not capturing opportunity on their own:
  - Cost. Payback horizons for publicly held industrial consumers, competing in global markets, tend to be shorter than the payback on these types of efficiency projects.

- Awareness regarding the magnitude of the opportunity (it is never the top priority)
- Challenge in identifying appropriate end-uses for recovered energy
- Limited focus on energy recovery in the design community.

- Limited funding to incentivize these projects for industrial customers:
  - Projects to save unregulated fuels (e.g., through heat recovery) may be funded by EMT using RGGI funds. However, at current forecasted revenues, there will not be enough RGGI funding available to satisfy all of the opportunity. (Note: this problem does not extend to natural gas customers).
  - Projects to save electricity (e.g., LED retrofits, VFDs) are funding constrained for the very largest electricity customers in Maine. These customers, taking electricity service at the Transmission and Sub-transmission level (T&ST), are exempt from the assessments that fund the utility's procurement of electricity conservation (delivered by EMT) and are therefore ineligible for EMT electric efficiency programs. Some funding from RGGI is theoretically possible for this, but as noted above, current RGGI forecasted revenues from RGGI are not sufficient to meet the multiple other priorities that have been established for those funds (e.g., home weatherization) and still have enough left over to meet this opportunity for T&ST customers.

B. Criteria for Evaluating & Prioritizing Strategies

Criteria & Considerations --	Group Comments & Notes:
1. GHG – Scale and timeframe of potential reductions	Scale – • TBD. Industrial GHG emissions accounted for 1.42 MMTCO2 (9%) of ME's GHG emissions. Opportunity for reductions through energy efficiency in this sector has not been quantified. Timeframe – • Implementation = short-term (once funding secured, EMT can begin offering incentives immediately. GHG reductions can begin soon thereafter (depending on project construction duration), but all relatively short-term) • Duration – until all cost-effective opportunity is captured (5-20 yrs)
2. Economic benefits (e.g., lower energy costs, economic development)	• Lower energy costs for industrial customers (cost-effective investments) • Improves competitiveness of ME industry • Supports businesses and jobs in ME energy services sector
3. Economic costs (e.g., incremental capital costs, operations costs, etc.)	• Industrial customers' share of incremental upfront capital cost of projects • Costs to those contributing to funding source(s) used for EMT programs • Potential negative economic impact if industrial customers determine additional assessments sufficiently diminish profitability to warrant closure
4. Impact on jobs	• Increased jobs associated with added competitiveness of ME industry + energy services sector

	• Potential for lost jobs if industrial customers determine additional assessments sufficiently diminish profitability to warrant closure	
5. Other Benefits (e.g., health/safety, productivity, etc.)	•	
6. Feasibility / Practicality (e.g., legal, technological, supply chain/trades, public/consumer acceptance, scale of cost/funding needs, precedents)	• Simple implementation (leverages existing EMT programs/administration/funding mechanism) • Challenges in securing funding • Industrial customers resistant to paying electricity conservation assessments	
7. Equity (e.g., cost impacts on disadvantaged groups, accessibility to disadvantaged groups)	• Depends on funding sources – equity concerns mitigated if these follow model of "those who pay in are eligible"	
8. Other strategic value (e.g., prerequisite to other critical strategies; potential synergy with other strategies)	• Related to strategy relating to "Maximize the Efficiency of Electricity Use and the Grid" (i.e., this strategy is dependent on continuation of EMT programs)	
9. Cost-effectiveness ($/GHG reduced)	- TBD	
Other Comments		

C. **Inputs for modeling** – what are the variables to model? Does this data exist somewhere already?

- EMT has not conducted a bottom-up opportunity study in some time – this would be helpful to determine the amount of funding required.
- For thermal opportunity, could use US DOE estimate that between 20% and 50% of all energy input to industrial facilities is rejected as thermal energy.

D. **Other existing resources/data** that could help implement this strategy? (e.g., Is there a model for this, either in Maine or in other jurisdictions?)

- EMT programs

E. **From strategy to action** – are there specific steps or actions that we should name now? (e.g., rules, legislation, roles)

- Establish an assessment for energy conservation on unregulated heating fuels to free up RGGI funds to use for T&ST customers
- Remove electric assessment exemption for T&ST customers
- Consider targeted tax incentives for investments in qualifying capital projects

F. Status of Strategy

a. Lump the strategy into 1 of 2 groups – *Group A*

i. Group A = simple, doesn't warrant much more work at BIH workgroup level

2. Incentivize Industrial Fuel-Switching

- Promote demonstration projects for low-carbon alternative fuels (e.g., hydrogen, ammonia)
- Shift from petroleum fuels to natural gas

3. Promote Research and Demonstration Projects for Industrial Process Heating

Prepared by the Efficiency Maine Trust

Strategy: Promote Research, Development and Demonstration Projects for Industrial Process Heat Alternatives

Which MCC goal does this strategy help to achieve?

X Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050

☐ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:

- Several emerging technologies hold promise for decarbonizing industrial process heating, but are not currently market-ready or cost-effective.
- Promoting research, development and demonstration (RD&D) projects in these areas will accelerate their development and deployment, and help the market determine which best satisfy the requirements of different types of industrial customers (most notably, temperature requirements)
- Potential study industries: cement, paper, forest products, ship building
- Potential study areas
  1. Hydrogen combustion
  2. Biomass and biofuel combustion
  3. Electrical heating (including radiative heating, heat pumps)
  4. Nuclear heat production
  5. Application of post-combustion carbon capture, use and storage (CCUS) to industrial heat supply
  6. Concentrated Solar Power (reflecting and concentrating solar radiation onto a small area)
  7. Radio Frequency Drying (using electromagnetic energy to induce volumetric heating due to frictional interaction between molecules)

Is there a model for this, either in Maine or in other jurisdictions?

- US Department of Energy grant programs

What are the benefits of this solution?

- Attract/expand grant activity at UMaine
- Position Maine manufacturing to be competitive in a future carbon-constrained economy

What are the costs?

- Costs of incentives/grants, measurement & verification
- Risk of not achieving return on RD&D expenditures

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- RD&D is short term with an eye to achieve actionable results mid/long-term.

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

A. On RD&D generally:

- Barriers – funding, long time horizon, dedicating resources to unproven alternative fuels, technology or processes when the status quo is reliable and low-cost.
- Advantages
  - contribute to broader market development/technology acceleration while also determining what works best for Maine industry.
  - Leverage federal grant funds?

B. On the actual technologies/study areas:

1. Hydrogen combustion
   - Barriers – production of hydrogen currently involves significant GHG emissions, but improving (with CCUS and renewable-powered electrolysis); challenges with distribution infrastructure
   - Advantages – can achieve high temperatures (needed for ME cement and chemical industries), industries using NG can readily exchange one gaseous fuel for a new one with modest retrofits.
2. Biomass and biofuel combustion
   - Barriers – scaling to meet demand will be a challenge (low energy density), costs associated with storage and drying
   - Advantages – abundant supply in Maine; multiplier effect in local economy
3. Electrical heating (including radiative heating, heat pumps)
   - Barriers – may require substantial plant redesign, burdens on the grid
   - Advantages – high controllability of temperatures and duration, low maintenance, low emissions when powered by renewables
4. Nuclear heat production (including conventional and advanced systems)
   - Barriers – safety concerns, nuclear waste
   - Advantages – significant volume of low-carbon heat
5. Application of post-combustion carbon capture, use and storage (CCUS) to industrial heat supply
   - Barriers – infrastructure needed to transport and geologically store large volumes of CO2.
   - Advantages – doesn't require significant changes to industrial processes
6. Concentrated Solar Power (CSP)
   - Barriers – land use requirements, capital intensive
   - Advantages – conducive to thermal storage molten salts (see CGEP report below)
7. Radio Frequency Drying
   - Barriers – Technology still under development
   - Advantages – Effective for food and agricultural products. May find applications in forest products industry.

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?

- Industrial customers.

Existing resources/data that could help implement this strategy:

- Reports
  - Columbia University Center on Global Energy Policy (CGEP). Low-Carbon Heat Solutions for Heavy Industry: Sources, Options and Costs Today. October 2019.
  - Innovation for Cool Earth Forum. ICEF Industrial Heat Decarbonization Roadmap. December 2019.

Modeling suggestions:

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Are there rules or legislation that might help enact this strategy?

- Establish funding stream to support grants
- Encourage UMaine to engage

4. Prioritize energy efficiency upgrades in wastewater treatment plants/require energy savings potential assessments for all facilities

A., Wright

Introduction

This strategy calls for all wastewater treatment plants projects to do an complete energy analysis of the entire plant to identify potential energy savings and to then use best practices.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. *Wastewater treatment is one of the largest consumers of energy in society. Reducing the*
2. What problems/barriers will this strategy address?
    a. *Most home builders and owners are unaware of the high GWP of spray foam.*
    b. *Even though spray foam is an expensive form of insulation, in some situations, it may be more expensive to add a thermal break to the wall or roof system than using spray foam as it is currently regulated.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?

. *TBD*

4. What are the benefits of this strategy?
    a. *Possible reduction of embodied CO2e in construction depending on which other materials are used.*
    b. *Increase energy efficiency of buildings by eliminating the energy losses caused by thermal bridging.*

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5. What are the costs of this strategy?

. *NA*

6. What is the timeframe for implementation (short-, mid-, or long-term)?

. *Short term.*

7. What is the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Changing the construction trades understanding of materials GWP*
    b. *Training and education of builders and architects on multiple design details that interrupt thermal bridging.*

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8. What populations, communities, or sectors will be impacted by this strategy? *Residential and light commercial property owners, architects, builders, and code enforcement officers.*
9. Identify existing resources/data that could help develop and implement this strategy.
10. Modeling suggestions for this strategy.

Strategy 6: Modernize and Optimize the Grid

1. Enhance planning and procurement procedures to maximize the use of cost-effective electricity efficiency, conservation, demand response located behind-the-meter

Efficiency Maine Trust

Which MCC goal does this strategy help to achieve?

- **X** Mitigation of greenhouse gas emissions in the State: 45% reduction by 2030, 80% by 2050
- ☐ Addresses adaptation and resilience to the impacts of climate change

Describe the problem/barrier that this measure will address:

- Significant GHG emissions associated with the inefficient use of electricity (both at the equipment/measure itself and based on location/timing of electricity use on the grid)
- Grid challenges associated with widespread beneficial electrification (i.e., investments in transmission and distribution (T&D) infrastructure required to meet increased demand and integrate new supply can involve significant financial, logistical, and political undertakings). Reducing and shifting demand mitigates these needs.
- MACE (Maximum Achievable Cost-Effective, also sometimes called the "all cost-effective" mandate) funding for EMT programs is established/required by statute and presumes PUC funding approval every 3 years. If MACE policy is eliminated, energy and GHG savings would be lost.

Is there a model for this, either in Maine or in other jurisdictions?

- Efficiency Maine Trust – Triennial Plan III and Triennial Plan IV (current)
- Other states with "all cost-effective" mandates = California, Connecticut, Massachusetts, Rhode Island, Vermont, and Washington

What are the benefits of this solution?

- Continuation of current effective policy, leveraging existing administrative body (EMT) and private sector networks
- Cost-effective

What are the costs?

- Dependent on the size and scope of opportunity that meets the "cost-effectiveness" standard. Prior years have been on the order of $40-50 million/year in program funding.
- Introducing more "load management" to maximize the efficiency of the grid itself may incur incremental costs to the current energy conservation programs

What is the timeframe for implementation? Short-term, mid-term, or long-term?

- Short term and mid-term

What are some Maine-specific barriers to implementation (resources, timeframe, etc.)? Maine-specific advantages?

Barriers

- EMT's self-imposed limits on the pace of retrofitting

Advantages

- Programs are well-established, third-party evaluated, reported, generally well understood and appreciated

by stakeholders and policymakers.
- Programs save more money than they cost and are market-ready
- Value of saved energy has a multiplier effect in local economy

What populations, communities, or sectors will benefit from this strategy? Who might be disadvantaged by the strategy?
- Benefits: all sectors
- Disadvantaged: Certain sectors of the economy face steeper barriers to participate in energy conservation programs for a variety of reasons (e.g., limited discretionary income, limited time/resources, limited inventory/services in their area). Programs can be designed to overcome these barriers by creating tiered financial incentives and targeting outreach efforts to the affected groups/areas.

Existing resources/data that could help implement this strategy:

- Avoided Energy Supply Cost Study for New England (2018), as updated from time to time;
- Efficiency Maine Trust Technical Reference Manuals (for commercial and residential measures).

Modeling suggestions:

- Current MACE potential for industrial sector and cannabis sector

Are there rules or legislation that might help enact this strategy?

- Electric Efficiency Programs (continue MACE)
  - Review ineligibility of T&ST customers
  - Amend or remove the 4% cap on funding
  - Remove EMT's prohibition on program participation from cannabis industry
- Appliance Standards
  - Expand list of covered products (e.g., Distributed Energy Resources – DERs)
  - Enhance compliance strategies
- Utility Rates
  - Explore rates reflecting value of load management and conservation

Program Ideas - expansion of existing EMT programs (not requiring rules/legislation):
- More aggressive consumer education and outreach
- More aggressive harvest of retrofit opportunities

2. Beneficial Electrification and Intelligent Grid Controls

K., Aikin

Introduction

As we expand our renewable energy generation capability the grid will become much more variable. This can be mitigated by massive amounts of energy storage, export of power (requiring massive transmission lines) or a program to build what is called by some as the "next, next grid"

To get to a zero-carbon future we also need to electrify the entire energy system. This includes making every building fully electric including transportation. However, when we do this the peak loads on the system will greatly expand, with up to 3 times increase in grid infrastructure, requiring investment in the electrical grid costing above 20 billion dollars.

The addition of renewable generation that is variable and electrification of most of our energy needs can work together intelligently to balance each other. This will be the lowest cost system and is technological feasible.

The new loads added to the system need to be controlled intelligently and provide balancing support to the grid working in concert with renewable generation. To accomplish this transformation to full electrification efficiently upwards of 40% of the systems loads need to be adaptable. This means that the loads can intelligently defer or augment loads at the correct times helping balance the variable renewable energy generation profile.

There are four components to this proposal

- Expansion of the electrification of energy loads (space heating and transportation) modeled upon the work by the Maine Energy Efficiency Trust
- Addition of Thermal storage for space heating making current electric heat pumps more adaptable and able to contribute to electric grid balancing.
- Introduction of at least Time of Use (TOU) and Demand pricing of retail electricity or ideally real-time pricing that would incentivize smart energy use and the introduction of intelligent controls. This would make smart controls a good investment as well as both electrical storage and thermal storage technologies.
- Investment in intelligent next generation controls that can allow loads to contribute to the balancing of variable generation and loads.

This would provide value to the entire grid; the grid would become greener with more energy use being electrified and more intelligent and easier to control renewable generation. It would also cost less than providing massive amounts of energy storage that even at projected cost reductions (if they happen) will be cost prohibitive costing greater than 50 billion dollars.

1. **Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]** Address greenhouse gas emissions by increasing the percentage of renewable energy in the grid. It would increase resilience by providing increased distributed energy throughout the grid and the controls to "keep the lights on".
2. **What problems/barriers will this strategy address?**
    a. the control of variable generation.
    b. The challenge moving to a fully electrified energy system
    c. The cost of battery storage
3. **Is there a model for this strategy, either in Maine or in other jurisdictions? No**, although the Grid Wise Architecture Council (GWAC) is the main advisory board for grid modernization for the Department of Energy (the author is a member of the council) has plans for this transformation.
4. **What are the benefits of this strategy?** Expanded integration of renewable energy generation projects and electrification of energy use.
5. **What are the costs of this strategy?** I estimate that this would cost about 800 million dollars over 20 years that is only 1-5% of the estimated cost of the lowest energy storage and grid infrastructure scenario.
6. **What is the timeframe for implementation (short- , mid- , or long-term)?** 5-20 years
7. **What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?**
8. Regulations concerning variable retail pricing

9. This is an entire new idea that would require careful study but the technology is becoming available at scale.
10. **What populations, communities, or sectors will be impacted by this strategy?** The electrical grid and all communities served
11. **Identify existing resources/data that could help develop and implement this strategy.** The Department of Energy, Grid Wise Architecture Council, private Industry and the National labs.
12. **Modeling suggestions for this strategy.** Much has already been done. Modeling is ongoing by the National Labs, DOE and private industry.

3. Value Distribution Level Renewable Energy Projects Appropriately in Non-Wires Alternative (NWA) Analysis

K. Aikin

Introduction

The objective of this strategy is to expand the ability to finance large scale Renewable Energy infrastructure and Technology infrastructure placed upon the grid either behind or in front of the meter. This program can be modeled after the existing Maine Technology Institute requiring significant participation from outside investment. The program could also be designed to prioritize investments in grid infrastructure that provide the most capability and in early years support pilot projects.

1. **Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]** Address greenhouse gas emissions by increasing the percentage of renewable energy.
2. **What problems/barriers will this strategy address?**
    a. The gap in financing resources for renewable energy projects
    b. The barrier of getting investment dollars into technology businesses that can make fundamental improvements to renewable energy and grid infrastructure technology but are hampered by lack of outside investment
    c. One of the largest barriers in new technology development is the implementation of pilot projects. This program could be used to greatly expand the work of the Maine Efficiency Trust in promoting pilot projects. Maine could be seen as a leader in the renewable energy technology space.
    d. Utilities are low investment enterprise and the MREIB would provide another funding source at reasonable rates beyond utility rate recovery.
3. **Is there a model for this strategy, either in Maine or in other jurisdictions?** Yes, Both the Maine Technology Institute and the Efficiency Maine Trust.
4. **What are the benefits of this strategy?** Expansion of renewable energy generation and technology investments.
5. **What are the costs of this strategy?** The only cost would be the cost of implementation that could be gotten with a small percentage added to fairly low bond money secured by the State of Maine.
6. **What is the timeframe for implementation (short- , mid- , or long-term)?** 2 years with an investment horizon of 30 years
7. **What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?** None anticipated
8. **What populations, communities, or sectors will be impacted by this strategy?** All residents
9. **Identify existing resources/data that could help develop and implement this strategy.** Efficiency Maine Trust and Maine Technology Insitute although greatly expanded staff and resources
10. **Modeling suggestions for this strategy:**
    a. State Economist to look at the costs of implementation and availability of bond money and cost

Maine Technology Institute estimate of resources required

4. Encourage the Granular Distribution Grid Data

K., Aikin

Introduction

The state of Maine now has a Non-Wires Alternative Coordinator. At this time it is unsure how that new position will improve the injection of distributed energy into the grid in the form of NWA's but one area of concentration should be an effort of providing more data to renewable energy developers so they can propose interconnection of their projects not only in areas that can accept the power but places that can provide the most value to the grid.

This requires information from Maine utilities detailing the loads, generation and capacity of all of their distribution lines. The States of New Hampshire and Vermont provided limited information already and this can be duplicated in Maine and should be greatly expanded.

This proposal could also be expanded by providing a state wide study funded by the NWA coordinator to survey and locate areas for high impact projects so that developers can focus on those areas.

1. **Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]** Address greenhouse gas emissions by increasing the percentage of renewable energy in the grid.
2. **What problems/barriers will this strategy address?**
    a. The lack of information of where renewable energy projects can be sited within the distribution grid easily.
    b. The challenge of long interconnection cues.
    c. The challenge of prioritizing grid investments.
3. **Is there a model for this strategy, either in Maine or in other jurisdictions?** Yes, Vermont and New Hampshire
4. **What are the benefits of this strategy?** Expansion of renewable energy generation projects in the places where they do the most good for the grid infrastructure.
5. **What are the costs of this strategy?** The cost would be the cost of implementation of a web portal to display the information and perhaps some soft costs by the utilities.
6. **What is the timeframe for implementation (short- , mid- , or long-term)?** 1 year
7. **What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?** Federal Energy Regulatory Commission rules and push back from the Utilities.
8. **What populations, communities, or sectors will be impacted by this strategy?** The electrical grid and all communities served
9. **Identify existing resources/data that could help develop and implement this strategy.** Maine Public Utilities Commission
10. **Modeling suggestions for this strategy:** System Engineering modeling of the value renewable energy at the distribution level. Multiple companies can provide this information. My company Introspective Systems is developing software to accomplish this on a granular level. But companies like Stantec and Burns and McDonnel can do this on a project by project basis.

5. Subsidize Electric Vehicle (EV) Level 2 Residential Car Charging Stations

J., Thompson

Introduction

Maine needs a rapid uptake of Electric Vehicles to reduce our greatest fossil fuel use (transportation). New & existing buildings are currently not installing EV Level 2 charge stations or even creating EV level 2 charge station ready buildings. Rebates and subsidy are needed to spur installation of EV charge stations across the state. Two

levels of rebate can be created: full Level 2 installation assistance, or "EV ready" buildings with empty conduit run from electric panel to vehicle parking location.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. All goals above.
2. What problems/barriers will this strategy address?
    a. *Lack of EV charging infrastructure in new & existing buildings.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *Unknown.*
4. What are the benefits of this strategy?
    a. *Create thousands of small scale charge stations across the state, spurring rapid adoption of EV purchasing.*
5. What are the costs of this strategy?
    a. *Typical to other rebate strategies.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Lack of awareness of EV infrastructure goals*
    b. *Old electrical infrastructure in existing buildings with low electrical capacity.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *All building owners.*
9. Identify existing resources/data that could help develop and implement this strategy.

6. Incentivize homeowners receiving heat pump rebates to receive assessment for photovoltaic solar panel

J., Thompson

Introduction

This strategy calls for increasing renewable energy production in single family homes by linking solar site evaluations to heat pump installations funded by Efficiency Maine rebates. Heat pump customers would receive a solar site assessment during their heat pump installation field work activity that will leave them with information about their properties solar panel viability.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
    a. Increase renewable energy production in the state.
2. What problems/barriers will this strategy address?
    a. *Photovoltaic solar panel installations require too much effort on the part of customers to initiate site evaluations, search out installers, and manage highly technical issues involving electrical equipment on their own.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
    a. *None known.*
4. What are the benefits of this strategy?
    a. *Enhances adoption rate of renewable energy systems.*
5. What are the costs of this strategy?

   a. *Estimated 1 hour extra on site during heat pump install plus 1 hour in office to generate report.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
   a. *Short term.*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
   a. *Field team training.*
8. What populations, communities, or sectors will be impacted by this strategy?
   a. *All, but customers with pre-existing with financial ability to undertake additional costs beyond a heat pump installation will be primarily effected.*
9. Identify existing resources/data that could help develop and implement this strategy.
   a. *Google Sunroof mapping project: https://www.google.com/get/sunroof*

7. Expand Financing for Grid-Interactive, Energy Efficient Buildings

7a. Establish a Statewide Green Bank

A., Wright

Introduction

This strategy calls for creating a statewide Clean Energy Fund modeled after the Connecticut Green Bank. The Clean Energy Fund will invest in climate solutions projects like energy efficiency and clean energy. It will use public funding to leverage private capital to increase the availability and accelerate funding for projects throughout Maine. It will help to address current funding gaps, and reduce risk for banks, credit unions and other financial institutions to invest in Maine's clean energy economy.

1. Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]
   a. *This advances all of the goals of the climate council by providing a source of funding for efficiency, clean energy, and other climate solutions.*
2. What problems/barriers will this strategy address?
   a. *For most homes and businesses, the upfront cost of efficiency and clean energy projects is the biggest barrier to implementation.*
   b. *Tax credits don't work for low-income families or those without tax liability.*
   c. *Rebates don't work if families or businesses can't afford the remaining cost of the project after a rebate.*
3. Is there a model for this strategy, either in Maine or in other jurisdictions?
   a. *Yes, the Connecticut Green Bank has 9 years of experience:* https://ctgreenbank.com/
   b. *Numerous other states have similar programs including: NY, NV, NJ, RI, HI, CO.*
4. What are the benefits of this strategy?
   a. *This will help to fund many of the other climate solutions strategies.*
   b. *The Clean Energy Fund will make investments, rather than provide rebates, and will re-invest in new projects as loans are paid back.*
   c. *The CT Green Bank has used ~$180 million in public funds to leverage more than $1 billion in private capital over the last 8 years. In the past year, they've used $41 million to attract more than $310 million in private investment!*
   d. *The CT Green Bank funded more than 7,600 residential solar installations in the last year, including home energy audits for more than 80% of those homes.* (**https://ctgreenbank.com/fy19-annual-report/**)

e. *By providing the funding needed to implement climate solutions, this will create jobs, reduce GHG emissions, and increase state and local tax revenues.*
f. *Green Banks commonly offer credit enhancements, reducing credit and lending requirements for low-income populations or those with poor credit.*

5. What are the costs of this strategy?
    a. *$100+ million upfront capitalization of the Maine Clean Energy Fund.*
    b. *This is an investment that would generate interest. It could come from bonds, State funds, an investment by the Public Employee Retirement System, or from a National Climate Bank or other grant funding.*
6. What is the timeframe for implementation (short- , mid- , or long-term)?
    a. *Short-term*
7. What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?
    a. *Legislation is required to create a public or quasi-public agency.*
8. What populations, communities, or sectors will be impacted by this strategy?
    a. *Residential, commercial, public buildings*
    b. *This can fund efficiency, clean energy, and electric vehicles, and has the potential to fund agriculture, forestry, and other climate solutions that require upfront capital to achieve longer-term savings.*
    c. *Projects can range from home weatherization to grid-scale renewable energy.*
9. Identify existing resources/data that could help develop and implement this strategy.
    a. *Maine legislation (LD1634) for a Clean Energy Fund:* https://legislature.maine.gov/legis/bills/display_ps.asp?LD=1634&snum=129
    b. *Coalition for Green Capital:* http://coalitionforgreencapital.com/
    c. *Connecticut Green Bank:* https://ctgreenbank.com/

7b. Maine Renewable Energy Investment Bank (MREIB)

K., Aikin

Introduction

The objective of this strategy is to expand the ability to finance large scale Renewable Energy infrastructure and Technology infrastructure placed upon the grid either behind or in front of the meter. This program can be modeled after the existing Maine Technology Institute requiring significant participation from outside investment. The program could also be designed to prioritize investments in grid infrastructure that provide the most capability and in early years support pilot projects.

1. **Which MCC goal does this strategy help to achieve? [Mitigation of greenhouse gas emissions in the State; 45% reduction by 2030, 80% by 2050, Addresses adaption and resilience to the impact of climate change.]** Address greenhouse gas emissions by increasing the percentage of renewable energy.
2. **What problems/barriers will this strategy address?**
    a. The gap in financing resources for renewable energy projects
    b. The barrier of getting investment dollars into technology businesses that can make fundamental improvements to renewable energy and grid infrastructure technology but are hampered by lack of outside investment
    c. One of the largest barriers in new technology development is the implementation of pilot projects. This program could be used to greatly expand the work of the Maine Efficiency Trust in promoting pilot projects. Maine could be seen as a leader in the renewable energy technology space.
    d. Utilities are low investment enterprise and the MREIB would provide another funding source at reasonable rates beyond utility rate recovery.

3. **Is there a model for this strategy, either in Maine or in other jurisdictions?** Yes, Both the Maine Technology Institute and the Efficiency Maine Trust.
4. **What are the benefits of this strategy?** Expansion of renewable energy generation and technology investments.
5. **What are the costs of this strategy?** The only cost would be the cost of implementation that could be gotten with a small percentage added to fairly low bond money secured by the State of Maine.
6. **What is the timeframe for implementation (short- , mid- , or long-term)?** 2 years with an investment horizon of 30 years
7. **What are the Maine-specific barriers to implementation (e.g., legal, resources, standard practice, supply chain, workforce capacity, etc.)?** None anticipated
8. **What populations, communities, or sectors will be impacted by this strategy?** All residents
9. **Identify existing resources/data that could help develop and implement this strategy.** Efficiency Maine Trust and Maine Technology Insitute although greatly expanded staff and resources
10. **Modeling suggestions for this strategy.**
    a. State Economist to look at the costs of implementation and availability of bond money and cost
    b. Maine Technology Institute estimate of resources required.

8. Policy Brief on Electrifying Maine's Energy Needs

K., Aikin

To begin with, Maine should adopt strategies that can be embraced by all sides. To address climate change, we can no longer pit North Woods vs. Portland; Rural vs. Urban; etc. Everyone must benefit, and everyone must contribute.

It is not enough just to build more renewables. We must innovate across the full spectrum of solutions. In addition to new generation, we must adopt innovations in transmission, distribution, load management, and storage. These systems must work together to address multiple challenges at the same time. A broad, creative and integrated approach is the key to efficiency, cost effectiveness, avoided waste, and redundancy.

- We will be hard pressed to put 500 industrial wind turbines (3 times current levels) and their transmission lines into the North Woods. It is better to prepare for the next generation of offshore wind resources and technologies that can contribute materially to our generation mix and add to our economic vitality by exporting advanced engineering to the rest of the world, while continuing to ensure that land-based wind projects meet economic, energy, and environmental criteria

- Well distributed solar power has the potential to expand throughout the grid. When solar power is properly sited, interconnected, compensated with clear rules for ownership, and integrated with energy storage, it can provide renewable generation while also reducing congestion in distribution networks. It can also add value to individual customers and increase resiliency.

- While emphasis on storage is appropriate, storage should be combined with system controls to balance the grid and make the entire system more efficient by increasing grid capacity and reliability, Battery storage costs have evolved rapidly and projections show a decline in capital costs, with cost reductions by 2025 of 10-52% but we should not count on these assumptions to make long-term policy decisions. Innovation in storage technologies is crucial to making all forms of intermittent renewable power feasible and economical. Maine should evaluate a host of different solutions, some in use and others being developed. These include newer lithium ion chemistries, flow batteries, super-capacitors, compressed air, flywheels, and pumped storage, as well as utility-scale and distributed storage. The state should experiment with pilot sites, favored pricing, university support, and funding subsidies to become a leader in these technologies.

- Computerized, automated grid controls must link all components of the system. Controls allow us to take best advantage of the flexibility available from the mix of loads and variable flows that renewables generate. Automated management and timing of the load, including responsive demand that can make the most of

low-cost intermittent generation, is a low-cost way to eliminate overbuilding of generators and storage, reduce redundancy and save billions of dollars.

SPECIFIC POLICY PROPOSALS:

1. REGULATORY REFORMS TO ACHIEVE A CLEAN AND RESILIENT GRID. Despite Maine's commitment to climate and renewable energy targets, it has not yet empowered state agencies to fully support these targets in their decision-making. State agencies' enabling statutes are silent on climate or give only weak prioritization in agency decisions. For example, the Maine Public Utilities Commission charter mandates that the Commission prioritize the immediate rate impacts and a company's opportunity to earn a fair return, rather than the full suite of costs and benefits related to energy over a longer time horizon. Maine should update all agency mandates to assign their responsibility to regulate in alignment with state policy goals to minimize climate impacts and consider the full costs of energy investments and other climate impacts in all decisions.

2. MAINE RENEWABLE ENERGY TECHNOLOGY INVESTMENT BANK: Economist Richard Silkman has proposed creating a Maine Electric Generation Authority. It has merit. The question is whether the state itself really needs to be a generator and are there alternative market designs that would better align with Maine's public policies and goals. An alternative approach would be to create a Maine Renewable Energy Investment Bank (MREIB) modeled after the Maine Technology Institute. The bank could borrow money at, say, 2.5% and lend it out at, say, 2.75% for projects that provide the greatest value to the grid. This would expand technology businesses, new as well as old, and draw capital into the state for projects that meet our renewable energy goals and that promote economic activity and provide access to rooftop and community solar to low- and moderate-income residents of the state.

3. PUBLISH DISTRIBUTION LEVEL LOAD PROFILES: Require utilities to publish information about load levels and line congestion so that developers may better focus their investments where needed in the grid. New renewable energy should be positioned where it is most effective to modernize the grid and support the massive expansion required to decarbonize Maine's energy supply.

   Vermont and New Hampshire have already adopted rules to make such information public. Maine should do the same. Utilities should release granular data at the distribution level with details of load profiles and grid conditions over a 10-year planning period for every distribution circuit in the state. This will expand opportunities for private and public investment in Non-Wire Alternatives (NWA's).

4. VALUE DISTRIBUTED ENERGY PROJECTS BASED ON GRID VALUE: Pay a small bonus to renewable energy developers to reward them for well-designed projects in locations that provide the greatest value to the grid and that improve the functionality of other grid investments. Providing less than a penny per kWh to such projects can unlock billions of dollars of private investment.

5. BENEFICIAL ELECTRIFICATION: Expand beneficial electrification by promoting heat pumps and thermal storage bundled with associated building efficiency improvements, and electrify other energy needs for industrial applications, process heat, and transportation. These new loads should be inter-connected and made interactive and responsive as recommended in policy six

6. SUPPORT INTERACTIVE AND SMART LOADS: Adopting Time of Use (TOU) and real-time valuation of electric supply and demand can unlock private investment---both behind and in-front of the meter. A grid transformed in this way can make nearly 40% of loads interactive with supply that is responsive to pricing signals, thus eliminating redundant storage and generation.

   The Department of Energy is focused on Transactive Energy as a key strategy for grid modernization. Many states are also exploring methods for valuing electricity to users based upon the real-time cost of delivering power at the moment of demand. Companies throughout the world are developing these interactive and smart grid technologies.

Maine could invest in these opportunities through the Energy Investment Bank. The Maine Efficiency Trust is already supporting limited pilot programs, combining beneficial electrification, distributed energy, storage, and cybersecurity in an integrated fashion. If these efforts were expanded exponentially, Maine could become a national leader by adopting such technologies throughout its grid.

Interactive, automated controls are relatively inexpensive ways to save billions on redundant storage and generation, while making the grid more responsive to both customers and utilities alike.

PROMOTE COMMUNITY ENERGY PROJECTS AND MICROGRIDS: While investing in renewable generation and interactive load controls can make a profound difference, community microgrids can as well. The Investment Bank could provide low-cost capital for local projects sponsored by communities and private entities to bring new community energy sources into the system and allow individual users to participate in the solution.