

Aligning Energy Efficiency Programs with a Decarbonization Future: Developing Pathways and Strategies to Address Embodied Carbon

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ABSTRACT

While energy efficiency programs provide valuable contributions to building decarbonization efforts, these contributions are currently focused exclusively on reducing operational energy and associated emissions. Programs targeted at new construction and retrofit markets in the commercial and residential sectors can make larger decarbonization impacts by thinking beyond the energy used in building operation.

Through their proximity to owners, designers, and contractors, energy efficiency programs have the potential to reduce the embodied carbon of projects (i.e., the emissions created by the manufacture, transportation, and disposal of construction materials) by influencing the materials used in construction. Programs can already influence choices such as insulation type through their performance requirements—but these choices can have unforeseen impacts on the true carbon emissions from building construction. If the policy frameworks governing energy efficiency programs were to require program administrators to approach decarbonization more holistically, it would likely facilitate developing programs that realize their full decarbonization potential.

Building on a paper to be presented at the 2022 IEPEC conference which establishes a rationale for expanding the focus of energy efficiency programs from operational energy to include embodied carbon and explores the progress made in lowering technical barriers to achieving this goal, this paper uses interviews with experts in embodied carbon and a review of existing research to explore the program design implications of addressing embodied carbon, including market entry points, incentive structures, and practical considerations for program implementation. It also addresses policy barriers to the adoption of a holistic carbon-reduction focus by energy efficiency programs and explores possible paths forward.

Introduction

Emerging research shows that addressing the carbon dioxide (CO₂) and carbon dioxide equivalent (CO₂e) emissions associated with building construction materials is a critical component in decarbonizing the building sector. The emissions resulting from extracting, manufacturing, transporting, and disposing of building materials are often referred to as “embodied carbon emissions,” or more recently “material carbon emissions” (MCE) (Magwood et al 2021).¹ Reducing the energy used to operate a building, which typically involves improving equipment efficiencies and the thermal performance of the building shell, creates reductions in “operational carbon emissions” (OCE). The scale of emissions reductions achievable through using lower-MCE materials in new construction or retrofits can dwarf those achievable through

¹ <https://carbonleadershipforum.org/embodied-carbon-101/>

reducing OCE (Magwood et al 2021; Magwood, McArleton, & Racusin, 2019). Yet regulatory and programmatic interventions aimed at improving energy efficiency and reducing emissions are currently focused only on the OCE of buildings. The implications are serious: pursuing greater OCE reductions through improving a building's shell with higher-MCE materials like spray foams can cause net *increases* in the total emissions associated with the building compared to using lower-MCE materials such as cellulose (Magwood, McArleton, & Racusin, 2019). In Canada, research demonstrated that when OCE reductions from meeting more-stringent energy code requirements are achieved using high-MCE materials, it can require decades—and in some cases centuries—for those OCE reductions to offset the upfront-MCE emissions caused by the high-MCE material choices (Magwood et al 2021).² Code compliant buildings that use materials with lower MCE yield lower overall carbon emissions than high-performance buildings that use higher MCE materials like spray foams (Magwood, McArleton, & Racusin, 2019).³

This paper does not focus on the statistical case for why all programs and practitioners working on energy in the building sector should focus on MCE reductions. Research from organizations like the Endeavor Center, Builders for Climate Action, and The World Green Building Council have done admirable work on this front, which we cite above and throughout this document.⁴ Rather, this paper acknowledges the centrality of MCE in any successful effort to reduce emissions in the building sector and offers pathways for energy efficiency programs to embrace MCE reductions and achieve greater relevance in the fight against climate change. Energy efficiency programs aimed at improving building energy performance, such as the example of residential new construction (RNC) programs, which we use throughout this paper—are susceptible to the scenario described above in which the material-agnostic pursuit of OCE reductions can yield overall net carbon increases.

At the project level, RNC programs can influence material choices with their performance requirements. Pushing homes to achieve a lower Home Energy Rating System (HERS) score in most climates requires an improved building envelope with higher R-values and better air sealing. Research by Magwood et al. (2021) and Jungclaus et al. (2021) indicates that insulation, concrete, and exterior cladding are the material types with the largest impact on total MCE of a low-rise residential building. (To focus the discussion, this paper will use insulation as an example throughout when discussing programmatic strategies to address MCE.⁵) The means by which RNC program participants make building shell upgrades can determine the success of a participating project in creating true emissions reductions. We cannot take for granted that the enrollment of another participant into a new construction program has created decarbonization benefits without understanding the materials used to construct the more efficient structure.

² This research factors in the emissions intensity of the power grid in the analysis. Low-carbon (or “cleaner”) grids make it increasingly difficult for OCE reductions to match the scale of reductions available from addressing MCE.

³ The authors recognize that more stringent building energy codes can influence the decision-making processes around construction materials in similar ways, at larger scales. The relative influence of energy efficiency programs and energy codes will vary based on the stringency of the code, the presence of a “stretch” energy code, the performance standards of the program, and the program’s penetration in the target market. Our focus here is on the implications of program designs that seek to maintain separation from code-level performance or industry standard practice (ISP), should that be more efficient than code.

⁴ [Embodied carbon call to action report | World Green Building Council \(worldgbc.org\);
https://www.worldgbc.org/bringing-embodied-carbon-upfront-report-webform](https://www.worldgbc.org/bringing-embodied-carbon-upfront-report-webform)

⁵ The authors of this paper explored the MCE impacts of insulation choice in real homes in the Northeast as part of another paper on embodied carbon to be published as part of the proceedings for the 2022 International Energy Program Evaluation Conference.

Narrow Mandates: Regulatory Constraints on Programs and MCE

Legislative frameworks governing energy efficiency programs do not require programs to address MCE. They also do not provide the latitude for interested program administrators to do so. If energy efficiency programs were empowered and incentivized to influence both insulation levels and insulation type, or material selection more broadly, it would open a new dimension of decarbonization potential. A major step in this direction would be to implement the social cost of carbon into cost effectiveness testing used by utility regulators and create avenues for program administrators to factor in all the ways their activities impact carbon outcomes. With the right insulation materials, participating homes could even become carbon sinks—with building shells that store more carbon than is emitted to create them—without sacrificing operational energy reductions. At the very least program administrators could begin to ensure their activities are not creating unforeseen emissions under a framework in which energy reduction goals and decarbonization goals are misaligned.

Research on building practices in RNC markets shows that insulation materials such as closed-cell spray foam and rigid foam board—which offer a high R-value per inch but are also high in MCE—are becoming more common in several markets (NMR Group, 2016, 2020). Closed-cell spray foam is an increasingly important tool for builders to meet more stringent energy efficiency requirements, whether they are RNC program participation requirements, or the performance thresholds set by stretch energy codes. In many jurisdictions, the success of efficiency programs in achieving high market penetration and increasingly building energy code stringency make it difficult for RNC programs to realize substantial OCE savings. Because programs are given narrow mandates to capture OCE savings and are often subject to cost-effectiveness testing, the path forward is typically new variations on old approaches to lower OCE as measured in utility bills. In some cases, program administrators are developing new program designs to push building practices to even higher performance standards, such as Passive House or Zero-Net Energy. Low-rise residential Passive design relies in large part on a heavily insulated building shell to lower the space conditioning load significantly. While Passive design is considered a gold standard in building performance, this creates a new version of the same problem—increase insulation R-values and air sealing performance with the wrong materials and any OCE reductions are negated or outweighed by MCE increases.

With an expanded mandate and flexibility to direct funding streams at MCE reductions, RNC programs could spend less time wringing all possible OCE savings out of the market and leverage program resources and their market position to boost efforts to reduce MCE. RNC programs have existing relationships with key market actors (or “trade allies”), access to training resources and forums, and a large marketing presence that can be adapted to push practices that focus on both OCE and MCE. In this paper the authors explore the ways in which current program strategies offer pathways to address MCE at multiple market entry points and discuss how specific market actors can be engaged in support of mitigating both OCE and MCE in participating projects. Without legislative and regulatory changes, it is unrealistic for utility-sponsored efficiency programs to expand their focus and expenditures from OCE to include both OCE and MCE. However, the legislative landscape is shifting enough in some jurisdictions that this evolution is becoming more realistic. Below, we will suspend disbelief and discuss how program administrators can use adjustments to legislation governing program activities and implement MCE reduction activities into program designs. Once the necessary regulatory

evolution occurs, many of the ideas explored here can be applied to non-residential new construction as well as to residential and commercial retrofit programs (Nedzinski et al 2021).

Methods

The discussion below is a synthesis of findings and feedback derived from a literature review, eight in-depth interviews (IDIs) with building sector practitioners and embodied carbon experts, and past program evaluations performed by the authors. The evaluations referenced in this paper included primary data collection from on-site field work at newly constructed homes and IDIs with building professionals involved in the Passive House movement. With the quantitative case for addressing MCE ably made by other researchers cited here, this paper provides a qualitative assessment for how efficiency program administrators can adapt their program designs to address both OCE and MCE. We do not attempt to derive statistically significant conclusions or characterize entire markets or market actor populations. The practitioners who took part in the eight IDIs performed for the writing of this paper comprised builders, engineers, architects, HERS raters, and other experts who are studying or practicing methods to reduce MCE in buildings. IDIs lasted between 45 minutes and an hour. The interviewees were drawn from author lists of key reports included in the literature review, recommendations of fellow interviewees, and presenters from conferences and webinars attended by the authors. The literature review included reports and knowledge resources published by private and non-profit organizations focused on energy, climate change, and the built environment. Reports and resources were located through web searches, citations in presentations and webinars, and through recommendations from interviewees.

Programmatic Paths for MCE Reductions

Below we discuss realistic approaches to implementing MCE reductions in the activities of traditional efficiency programs once MCE has been legislated into the purview of efficiency programs, allowing program administrators to claim MCE savings and apply funding to MCE reduction strategies. Traditional energy efficiency programs are often classified as either taking a resource acquisition or market transformation approach. While some resource acquisition programs contribute to market transformation, the two frameworks typically have different scopes, timeframes, and strategies. Market transformation happens over time, with more significant changes manifesting five to ten years out. Because much of the MCE impact happens upfront, before the building is completed, it will be essential for programs to take immediate steps to curb MCE. The first step an efficiency program should take to address MCE is an aggressive resource acquisition approach, essentially purchasing GHG emissions out of the market with incentives to use low-MCE materials. Once this approach is off the ground, program administrators should assess the market, including supply chains and essential actors, for the construction materials they wish to address in their MCE approach and develop a broader market transformation strategy. Given the scale of emission reductions needed to limit the impacts of climate change, moving beyond participants to influencing the broader market to embrace low-MCE materials as standard practice should be the ultimate goal for any program that chooses to address MCE as part of its approach.

Currently, low-MCE building products, and especially products that sequester carbon, have a limited presence in the marketplace. Any concerted effort to work MCE considerations into program activities would need to be accompanied by strategies to link participating practitioners with vendors offering low-MCE products. In the meantime, influencing the RNC sector to focus on low-MCE materials like cellulose insulation can help mitigate MCE contributions while the market for low-MCE products and products that sequester carbon can grow and mature. Below, we discuss how the market is addressing certain technical barriers to addressing MCE in new construction and retrofit efficiency programs. We then discuss market entry points and market actors that programs can collaborate with to limit the MCE of new buildings developed with support from energy efficiency programs and, eventually, of buildings developed without program support.

Addressing Technical Barriers and Metrics

Determining the embodied carbon impact of a project requires three key steps: on-site data collection, accurate details on the emissions of a specific material, and standardized metrics that allow for comparison between projects. One takeaway from IDIs with practitioners working on MCE is how much of the on-site data collection required to quantify MCE is already done in existing energy consulting work. The Northeast Home Energy Rating System Alliance (NEHERS) embodied carbon working group points out that data collection in typical Home Energy Rating System (HERS) energy audits can provide much of the volumetric and material classification data needed to quantify the MCE associated with insulation, foundations, and other components.⁶ HERS raters collect data on the building shell, including framing depth and the R-value of the insulation installed. Good practice for raters includes creating entries in energy modeling software that provide additional descriptions of the insulation type. Slight adjustments in the level of detail captured during the HERS audit can ensure that all on-site data needed to accurately quantify MCE contributions from insulation and concrete are captured in HERS audits. Beyond collecting data, HERS raters work with RNC programs to verify performance and offer technical support to builders and homeowners. Their status as energy advisors offers a promising path to introducing MCE considerations to the market.

Environmental product declarations (EPDs) for key materials provide the product-specific emissions data needed to determine overall project emissions for building shell insulation.⁷ EPDs remain a work in progress due to inconsistent reporting and quantification methodologies but offer a promising framework for understanding the emissions associated with a product and comparing emissions within product categories (Lewis et al. 2021). NEHERS, among others, has advocated for software solutions that facilitate the synthesis of energy modeling data with EPDs. Ekotrope, which offers a popular HERS energy modeling tool, has shown flexibility to adapt to specific program needs, as through the adjustments they have made to the HERS energy modeling tool to include participation verification for the new Mass Save[®]

⁶ <https://www.nehers.org/embodied-carbon>

⁷ EPDs contain data on the global warming potential (GWP) of materials. Global warming potential is a measure of the quantity of energy the emission of one ton of a gas will absorb over time, with one ton of carbon dioxide used as a reference. As such, CO₂ will always have a GWP of 1. The timeframe used to determine GWP is typically 100 years. EPDs and GWP data are released by product manufacturers or third-party organizations.

All-Electric RNC program offering.⁸ Builders for Climate Action has already linked energy modeling data with material EPD data in their research, developing a tool in conjunction with Natural Resources Canada to export volumetric building data from the HOT2000 modeling software and combine it with EPD data.

For energy efficiency programs, standardized metrics that track total MCE and allow for simple comparison across projects are essential to establishing a baseline comparison point for program participants and for determining appropriate performance thresholds. NEHERS has proposed enhancing the widely used HERS score with embodied carbon data to quickly and broadly increase the attention paid to the total GHG emissions in the RNC sector. Builders for Climate Action has proposed a Carbon Use Intensity (CUI) metric that combines MCE and OCE (including the emissions intensity of the grid) (Magwood et al 2021). CUI would offer a comprehensive, unified metric to allow for comparison of emissions intensity between homes and enable the development of regulations to govern emissions allowances in the building sector.

Determining Baselines and Incentive Structures

While the metrics discussed above are useful to quantify emissions impacts for entire buildings, efficiency programs also require standalone, measure-level values for specific materials of interest (e.g., insulation, concrete) that are quantified outside of traditional kWh or MMBtu measurements of OCE. One approachable metric is pounds of MCE for a component per square foot of conditioned floor area. Volumetric data from HERS audits covering the building shell can be combined with the GWP obtained from material EPD to yield an emissions value that would be divided by conditioned square footage of the project. This allows programs to introduce MCE considerations at the measure-level (e.g., focusing on insulation at first) alongside the traditional operational energy focus, and eventually transitioning to a wholistic carbon drawdown approach based on the CUI metric or a carbon-comprehensive HERs score.

Determining incentive levels and boundaries for limiting the MCE of participating projects requires a baseline to compare against. In many states, programs collect baseline data on the building characteristics of non-program homes to create a “typical” reference home against which program homes are compared. Baseline data includes insulation type and thickness, structural details of the building shell, and building shell measurements. A baseline MCE value can be calculated using existing baseline data if the necessary granularity is present. The most accurate baseline value would be weighted by the volumetric prevalence of each insulation type in the sample.

MCE incentives could be made available for homes and buildings that are able to meet program performance requirements using materials that do not create higher MCE than the baseline home. This arrangement sets both MCE and OCE on the downward trajectory needed to address climate change. For incentives aimed at upstream or midstream markets, programs must determine the level at which a product would qualify for incentives and an incentive scale to apply to emissions reductions. Material qualification for incentives could be tied to EPD data, for example by choosing specific GWP values or products that represent the MCE “ceiling” above which a material does not qualify for incentives.

⁸ https://www.ekotrope.com/blog/ekotrope-now-supports-the-mass-save-all-electric-home-incentive?mc_cid=42d3862cdf&mc_eid=180f965d3a

Downstream Market Interventions

In some states, baseline studies of new homes show steadily decreasing HERS scores and increasing amounts of spray foam and rigid foam board in building shells. States like Massachusetts are increasingly seeing builders pull attics and basements into the conditioned space of the home to get mechanical equipment inside the conditioned envelope and improve envelope performance (NMR 2016; NMR 2020). Spray foam insulation makes sealing attic rafters much easier, while foam board is a common method for insulating foundation walls. As downstream RNC programs continue to push for more operational energy savings and better insulation practices (e.g., Grade I insulation and containing equipment and ducts in conditioned space) the use of high-MCE materials can be expected to increase. Downstream RNC programs risk negating decarbonization impacts from OCE savings or even worsening the climate crisis via MCE increases.

Insulation choices are often made by builders before the homeowner chooses a new home, or on behalf of the homeowner. For some custom homes, the homeowner may drive the choice of materials. In each case, HERS raters provide guidance on how to achieve preferred home energy outcomes. Getting buy-in from homeowners, builders, and HERS raters is key to driving better MCE outcomes in RNC programs. Using low-MCE materials in some cases will necessitate design changes and thus must be factored into the project as early as possible. Program participation requirements are growing more stringent, and builders and contractors must find standard practices that cost-effectively meet these requirements. Proving to builders and homeowners that low-MCE products can be used without increasing project costs will be essential. Incentives can help, but beyond that the program should be prepared with case studies and incremental cost analyses that can provide guidance and peace of mind. Research by Magwood et al (2021) and Jungclaus et al. (2021) suggests that choosing low-MCE materials does not necessarily increase construction costs, but more research is needed to reflect conditions in local markets. Below, we cover how efficiency programs can engage several key market actors to create better MCE outcomes.

HERS Ratets

As trusted sources of building efficiency information, HERS raters are positioned to educate builders and homeowners on the effectiveness and benefits of low-MCE materials while collecting the data needed to quantify the MCE of materials used. As HERS raters become better educated on low-MCE materials, they can share with builders the common issues they observe with air sealing when using low-MCE products and avoiding spray foams. The HERS rating system is reaching more homes than ever before, with a 24% increase in the total number of homes assigned a HERS score (and thus engaging with a HERS rater) in 2020 compared to 2019.⁹

For program administrators to leverage HERS raters in new approaches to limit MCE in participating projects, programs will need to implement education and awareness-building efforts in addition to enhanced HERS rater incentives. Rater incentives would address the increased data collection burden under a framework like that suggested by NEHERS, which relies on the rater to provide volumetric material data. Raters must be sure that insulation type is available for every shell entry they make, in addition to the volumetric and R-value data they already collect.

⁹ <https://www.resnet.us/articles/demand-for-hers-ratings-grows-by-24-in-2020/>

HERS raters may also be asked to conduct multiple iterations of diagnostic testing with a blower door to help builders identify air sealing deficiencies in the building envelope when using new insulation products. HERS rater incentives could be per home (or per unit for multifamily) much the same way programs currently offer HERS rater incentives for facilitating program participation.

Certified Passive House Consultants (CPHCs) and other certified Passive House professionals occupy similar market positions to HERS raters and can provide similar contributions to low-MCE building approaches. Indeed, professionals in the Passive House space have demonstrated sensitivity to embodied carbon in past studies, indicating in IDIs that they prefer to avoid spray foams and other high-MCE materials in favor of dense pack cellulose and other natural products (NMR Group, 2020). In markets like Massachusetts, where program administrators implement a Passive House RNC offering, CPHCs and other Passive design experts may already be spreading information about low-MCE approaches.

Builders and Insulation Contractors

For low-MCE materials to gain traction in the market, builders and contractors must attain a level of familiarity and comfort with them. With more stringent energy codes and increasing program performance requirements, builders and insulation contractors are less likely to be willing to experiment with new materials because of the risk to meeting projects' cost and performance goals. Incentives focused on MCE can help boost the adoption of new types of insulation, but education and awareness-building showing that these products are tested and trustworthy will be critical to wider adoption of low-MCE materials. Piggybacking MCE presentations and workshops on existing energy code trainings that frequently bring builders and other practitioners together is one approach that makes logistical sense. Using low-MCE materials may introduce new design strategies that require different approaches to common practices like using spray foam to air-seal a home. Code trainings typically include resources covering the building envelope and air sealing and are a promising forum to which to add training on air sealing and insulating with non-traditional low-MCE materials, including straw bale, waste textiles, and other organic materials. In addition, efficiency programs should work to connect builders and insulation contractors with companies offering low-MCE materials and encourage these parties to offer education and training on the most effective use of their products. A theme that emerged in interviews with embodied-carbon advocates is the importance of market signals from trusted insulation brands that they offer and recommend newer, natural products with lower MCE.

Architects

Designing homes that use low-MCE materials can create unique challenges, and in some cases will require nontraditional approaches that depart from typical features, such as the 2x6 stud wall seen in most new construction. As home efficiency requirements increase in base energy codes, stretch energy codes, and efficiency programs, achieving the necessary building shell efficiency with lower R-value-per-inch materials may require double stud walls, panelized components, or other adjustments. In addition, low-MCE designs could include reduced use of concrete, such as by avoiding basements in favor of slab-on-grade designs. This means a low-MCE approach must be factored into the initial project design, before construction begins. Educating architects about the availability of low-MCE materials, and how home designs can

best accommodate them, will be another important factor in increasing adoption of low MCE materials. Many architects that work with RNC programs and in the custom homes market share a desire to create sustainable structures and can be assets in building awareness around true low-carbon homebuilding.

Homebuyers

Building demand among consumers for true low-carbon homes is critical to supporting MCE considerations downstream. While costs, location, layouts, and aesthetic considerations will continue to drive decision-making for many home buyers, efficiency characteristics are an important consideration for many people. Studies have over time found that high-efficiency homes with ratings like ENERGY STAR[®]-certified tend to sell faster and for a price premium over homes without energy ratings (Freddie Mac 2020). Reorienting consumer understanding of what a low-carbon home is can help to shift how homebuyers approach conversations with builders and realtors. As more states and municipalities pass legislation and regulations with explicit decarbonization goals, low-MCE homes can be advertised as the true model for sustainable and responsible home building.

Midstream Market Interventions

Midstream market interventions targeting building material suppliers and distributors will be important to getting more low-MCE materials into the supply chain. This intervention strategy allows programs to reach a broader population of downstream market actors by engaging with their suppliers. It also increases the confidence market actors have with low-MCE materials by making these materials readily available from trusted local contacts.

Some efficiency programs have taken a midstream approach to spur market transformation of certain types of HVAC and water heating equipment, such as heat pumps. These programs have engaged with distributors in their service territory to eliminate some of the common pitfalls of downstream interventions, such as incentive paperwork and conducting outreach to various large, diverse, and fragmented market actor populations. Midstream offerings can also include developing marketing materials for use by distributors and suppliers that highlight the low-MCE materials and their subsidized prices.

Another midstream framework that has broader market transformation aims but may also provide near-term advantages is the ENERGY STAR Retail Products Platform (ESRPP). The ESRPP is a program approach in which participating program administrators pool efficiency program resources and create a unified implementation process to influence retailers more efficiently to stock incentivized products in the face of diminishing program savings opportunities.¹⁰ The products covered by the ESRPP include appliance types often found in many mature efficiency rebate programs. However, in regions where multiple program administrators are invested in addressing MCE in participating products, an ESRPP-like approach of pooling resources and taking unified programmatic steps to influence the stocking practices of insulation distributors could speed up regional adoption of low-MCE materials. Fragmented program efforts in individual service territories may struggle in the near term to impact MCE beyond small groups of environmentally conscious custom builders. Given the

¹⁰ https://www.energystar.gov/partner_resources/energy_star_retail_products_platform

upfront emissions impacts of MCE, balancing near-term impacts with long-term, permanent change is key.

Upstream Market Interventions

Upstream market interventions, which target product manufacturers, are essential tools to spur broader market adoption of high efficiency technologies. A major example is the lighting industry and light emitting diode (LED) bulbs, for which many lighting programs worked with manufacturers to move markets by providing incentives to manufacturers who used them to buy down the costs of LED bulbs they shipped to distributors and retailers when they were first introduced to market. This type of approach can be an effective method to transition the market away from certain product types or efficiency levels, especially when more jurisdictions provide incentives to manufacturers. These strategies can limit first costs of new materials that have not achieved the same economies of scale as traditional insulation types. In addition, getting recognized manufacturers on board with low-MCE materials sends market signals down the supply chain that the products are trustworthy and ready for wide use.

Small-scale and Regional Manufacturers

Until large, national manufacturers put a concerted effort behind creating and advertising low-MCE materials, connecting interested homeowners and practitioners to the numerous smaller or regional manufacturers of low-MCE insulation and building materials is a vital early step. There are multiple certified products currently available covering insulation, masonry, and structural building needs that are low carbon and even carbon-storing.¹¹ At the local or regional level, program administrators should collaborate with embodied carbon advocates to link smaller manufacturers with practitioners, ensuring that these smaller companies can build their businesses and benefit from increased focus on embodied carbon in building products. Small-scale manufacturers can be invited to trainings and events that piggyback on code trainings or other scheduled gatherings that are organized by or in conjunction with efficiency programs. Programs can use their relationships with trade ally organizations to invite representatives from these manufacturers to industry events as well. Including practitioners who have worked with these materials in the field is an essential piece of this process, as applicable case studies showing the effectiveness of new products and practices are a common request of market actors when they are encouraged to adopt new approaches.

National Manufacturers

Trusted manufacturers that have been relied on to provide insulation materials for years will bring much needed name recognition to new low-MCE products. Their name recognition can help build distributor and contractor trust in the materials. If low-MCE materials comprising plant-based or waste-stream products are not picked up by large players in the market who can provide educational- and awareness-building resources to aid in their sales approach, it will be more difficult to get widespread buy-in from contractors who can be wary of trying new products in the field.

¹¹ <https://carbonleadershipforum.org/carbon-storing-materials/>

Some low-MCE materials may need further testing and certification by familiar organizations to increase trust in the materials' safety, longevity, and quality. In addition to financial support to boost the production or sourcing of low-MCE materials by manufacturers, programs could provide financial support to manufacturers for testing and certifying materials for structural integrity and fireproofing. In interviews, respondents mentioned the importance of such certification as a crucial step to establishing widely shared belief in the legitimacy of new products in the market. Programs can also work to increase the attention given to low-MCE materials by manufacturers through education, connecting market actors, and recurring communication. Program administrators could offer to assist with advertising new products to trade allies through their own dedicated communication channels. If insulation manufacturers have corporate sustainability goals that are reported publicly, a focus on low-MCE insulation products can be pitched to them as another way to meet those goals and serve as fodder for marketing campaigns.

Prefabricated Home and Component Manufacturers

While conventional upstream programs would likely target the specific materials manufacturers, programs could also explore program opportunities that exist with manufacturers of prefabricated homes. This includes manufactured (i.e., "HUD") and modular home manufacturers and panelized building assembly manufacturers (i.e., walls, floors, or roofs). For example, programs could connect prefabricated home manufacturers with low-MCE insulation manufacturers. Low-MCE panelized products like structural insulated panel (SIPS) made with cellulose or straw could be integrated in modular building processes with relative ease. While currently operating in a niche market, these manufacturers could act as early adopters, providing high-performance low-MCE homes and panelized components to the market.

Other Program Considerations

Implementing program support for low-MCE materials also introduces new opportunities for the quantification of non-energy impacts (NEIs) and further changes to the cost-effectiveness equation for RNC and similar programs. Health benefits from better indoor air quality (IAQ) is an existing NEI that is factored into the cost-effectiveness testing for other efficiency programs that may be relevant to low-MCE materials if they displace spray foam insulation containing compounds linked to increased risk of asthma or other respiratory conditions. Another major NEI from well-designed distribution channels that utilize local suppliers are economic benefits such as local job impacts that may result from increased business going toward smaller regional manufacturers of low-MCE materials (for example companies that use straw from local farms). Should programs spur increased local manufacturing of low-MCE materials, they may want to quantify multiple additional benefits in their communities. This includes energy and emissions saved from reduced mileage for material transport and even environmental justice gains where manufacturing processes reliant on harmful chemicals are reduced.

Conclusion

It is concerning to think that, in their efforts to push projects to increase energy efficiency, efficiency programs can influence material choices that create unforeseen emissions. Recent legislative advances that more aggressively pursue decarbonization have not yet addressed the decarbonization potential of efficiency programs. To apply the strategies and connections that have been grown and fine-tuned over many years by energy efficiency programs to both OCE **and** MCE, state legislatures need to make regulatory changes that allow program administrators to divert resources toward new targets and claim savings from MCE reductions. One crucial change is to alter regulatory frameworks to bring the social cost of GHG emissions into the consideration of program implementors. Most energy efficiency programs result from narrowly scoped directives from legislatures for utility companies or other program administrators to reduce energy consumption. Such directives aim to realize cost savings by reducing customer fuel spending and delaying infrastructure upgrades but do not fully consider impacts on GHG emissions. These programs are also governed by regulatory requirements to avoid increasing ratepayer spending.

Act 129 in Pennsylvania provides an example of an energy efficiency directive that shows how energy efficiency efforts can become misaligned with GHG emissions progress. Act 129 is Pennsylvania's main energy-efficiency program law, and it focuses solely on the state's large electric distribution companies, directing the companies to reduce *electric* consumption specifically. Under this framework energy efficiency programs can claim savings from switching electric heating and water heating equipment to fossil fuel systems. Such interventions reduce electric consumption and support the directive of Act 129 but may be counter to achieving larger decarbonization goals. If the legislature were to alter the focus of Act 129 or pass a new law to require the utilities to consider the social cost of carbon in their cost-effectiveness equations, programs could be rewarded for advancing decarbonization and consumption reduction simultaneously.

Even if regulations were to direct programs to consider carbon emissions, a lack of specificity can hamper a focus on MCE. In 2021, Massachusetts enacted "An Act creating a next-generation roadmap for Massachusetts climate policy" which required the "social cost of greenhouse gas emissions" to be included in the cost-benefit equations for energy efficiency programs in the state. This was a crucial step that allowed energy-efficiency program administrators to claim benefits from emissions reductions. Indeed, program administrators nearly quadrupled their incentives for heat pumps once they could claim savings from efficiency gains *and* reduced emissions. However, the law did not specifically direct the cost-effectiveness calculations to include "lifecycle emissions" or MCE. The current Massachusetts three-year plan for energy-efficiency offerings does not mention opportunities to claim savings from reduced MCE. It is also not clear if increases in MCE resulting from traditional program activities (e.g., the increased adoption of high-MCE spray foam insulation in residential new construction) will be factored against benefits in the cost-effectiveness evaluations. In the absence of specific legislative directives, the task of determining how to include the social cost of carbon in cost-effectiveness equations falls to the Department of Public Utilities. Massachusetts is at the forefront of empowering (and requiring) energy efficiency programs to address carbon emissions; however, it too has much to navigate and resolve before MCE becomes a target for programs.

To decarbonize the building sector, we must reduce both OCE and MCE. The infrastructure developed over the last several decades in RNC and similar programs can be used to create an effective platform for reducing MCE in the building sector over the short and long-term. Technical resources to incorporate MCE measurement into typical energy efficiency programs have been developed and continue to be refined and made more widely available. If energy efficiency programs do not start accounting for MCE, they risk failure to effectively contribute to climate change mitigation in their pursuit of OCE reductions. Regulatory frameworks should be refigured to encourage or require energy efficiency programs to account for MCE. Program implementors can begin to imagine and plan for MCE-targeted programs so that they can initiate such programs as soon as possible. Humanity is far behind the pace of emissions reductions needed to avoid catastrophic temperature increases from anthropogenic climate change.¹² Reducing MCE through material choices creates upfront, immediate emissions reductions, while OCE improvements are realized incrementally over the lifespan on the building. Every new home that is built with high-MCE insulation and other construction materials is another missed opportunity to truly decarbonize the building sector.

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