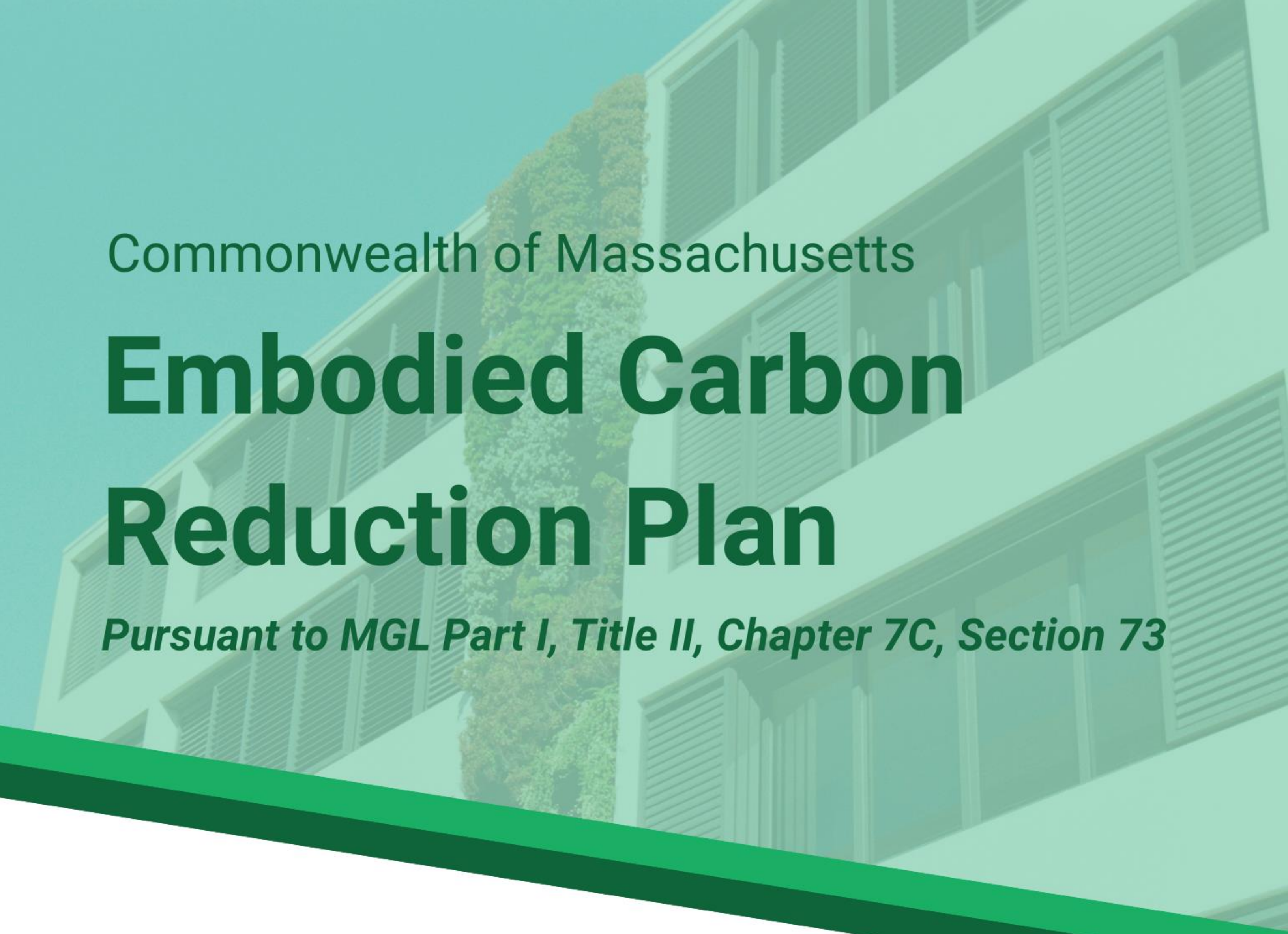

Commonwealth of Massachusetts

Embodied Carbon Reduction Plan

Pursuant to MGL Part I, Title II, Chapter 7C, Section 73

Prepared by the **Embodied Carbon Intergovernmental Coordinating Council** for the Massachusetts Legislature

January 2026

Executive Summary

Stop reading for a moment and look around you. You are no doubt surrounded by a structure—a building with walls and glass windows and concrete, perhaps steel or wood. If you look outside, you probably see other structures, sidewalks, and asphalt-paved streets. Or maybe you are riding in a train car, on steel tracks, pulling into a station stop with concrete platforms. Embodied carbon (EC) represents the greenhouse gas (GHG) emissions associated with the full life cycle of manufactured materials, objects, and structures in the built environment from raw material extraction, manufacturing, transport, construction, and maintenance through end-of-life disposal. For a multistory office building with a paved parking lot, that might include hundreds of cubic yards of concrete, tons of asphalt, tons of steel, window assemblies, and hundreds of board feet of wood—each among the highest EC emitting materials.

Embodied carbon is the sleeping giant when it comes to sources of climate pollution. For decades, the focus has been on reducing operational emissions, for example, from electric lighting, heating and cooling, appliance use, and mechanical systems. In recent years, governments and businesses have begun to understand that EC represents billions of tons of emissions released through the ordinary life cycle of building materials. Indeed, EC can account for up to fifty percent of a building's lifetime emissions, depending on asset type.[1] Globally, EC of building and infrastructure materials is responsible for ten to fifteen percent of total GHG emissions.[2]

Innovation in design processes and low EC materials science are revolutionizing how we think about and construct the built environment. State procurement policies are crucial drivers of that innovation, sending a market signal to materials manufacturers and the architecture, engineering, and construction (AEC) industries. Importantly, these innovations can yield lower cost projects; for example, building reuse/renovation reduces EC and is often a far more cost-effective choice, especially for capital budget constrained states. And, low or zero EC materials of construction are increasingly cost competitive, in many circumstances having no or very low additional cost.[3] In recent years, a number of

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[1] See KPMG, *Embodied Carbon, The Missing Half of GHG Emissions* (2023), available at https://kpmg.com/kpmg-us/content/dam/kpmg/pdf/2023/esg-embodied-carbon.pdf

[2] "Buy Clean Policies: Overview + Implementation." *Carbon Leadership Forum*, https://carbonleadershipforum.org/buy-clean-policies-overview/

[3] See RMI, *Low Carbon Concrete in the Northeastern United States* (June 27, 2020) ("In a national marketplace survey conducted by the US General Services Administration, over 55 percent of the 130-plus businesses surveyed said that their low-embodied carbon products cost about the same as their conventional concrete products."), available at https://rmi.org/low-carbon-concrete-in-the-northeastern-united-states/; RMI, *Reducing Embodied Carbon in Buildings, Low-Cost High Value Opportunities* (July

states, including California, Colorado, Maryland, Minnesota, New Jersey, New York, and Oregon have enacted policies to reduce EC of state-procured construction materials.

With that opportunity in mind, in late 2024, the Massachusetts Legislature passed, and Governor Healey signed into law, An Act promoting a clean energy grid, advancing equity, and protecting ratepayers. The law requires the establishment of an intergovernmental council (Council), made up of representatives of state government agencies and quasi-governmental authorities, as well as representatives from the Legislature and five gubernatorial appointees with various construction expertise. The Council was charged with preparing this embodied carbon reduction plan (Plan).

With this Plan, the Commonwealth has set a course to (1) embed consideration of EC into State building and infrastructure planning and decision-making, design, and procurement; and (2) reduce EC of both procured construction materials and covered projects. Notably, the Council and this plan acknowledge that the most effective ways to lessen EC impacts are to reduce overall volumes of new work through building and material reuse and scoping capital investments to only the size needed to meet needs, avoiding unnecessary construction.

This recommended phased approach to environmental product declaration (EPD) and material quantity (MQ) data collection for certain substantial vertical (building) and horizontal (infrastructure) projects—voluntary starting in 2026 and mandatory in 2027—will allow for greater understanding of current baseline EC for core materials. That learning sets the stage for implementing, in 2028, project-averaged global warming potential (GWP) limits for asphalt, ready-mix concrete, steel reinforcement, and structural steel used in covered vertical and horizonal construction projects. In addition, to facilitate high-impact early design improvements, Whole Building Life Cycle Assessment (WBLCA) will be required for new building construction or major building renovation projects involving at least 20,000 square feet and advertised for prime contract after mid-2027.

To ensure the success of this Plan, the Council has included recommendations concerning continuing education for relevant staff; procedures for periodic review of covered materials and GWP stringency; establishment of a technical advisory committee (TAC) to the Council; further piloting of deconstruction and reuse opportunities; low EC technology market development; and regulatory alignment for the broader market.

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conventional concrete products.”), available at https://rmi.org/low-carbon-concrete-in-the-northeastern-united-states/; RMI, *Reducing Embodied Carbon in Buildings, Low-Cost High Value Opportunities* (July 2021)(“ . . .[E]mbodied carbon can be reduced by 19%–46% in mid-rise commercial office, multifamily, and tilt-up-style buildings by leveraging low- and no-cost measures.”), available at https://rmi.org/wp-content/uploads/dlm_uploads/2021/08/Embodied_Carbon_full_report.pdf

Leading by example, the Commonwealth's Plan will boost technical innovation and market demand for low EC materials and cost-effectively reduce EC emissions, protecting our communities from the increasingly costly and harmful impacts of climate change.

Summary of Recommendations

RECOMMENDATION 1: AGENCY PROCEDURES & DECISION MAKING
Covered Agencies that manage construction should undertake a comprehensive analysis of their construction processes and identify key decision points that influence EC. Agencies should use this analysis to develop organization-specific plans and revise specifications documents based on findings. Covered Agencies should report the findings of these analyses along with a full implementation plan to the Climate Chief by mid-2026.

RECOMMENDATION 2: EDUCATION
Using the Council as a convener and making use of resources available from nonprofit and voluntary associations, the state should provide educational materials to stakeholders throughout the supply chain, both within and outside of state agencies. By April 2026, DCAMM and MassDOT should submit to the Climate Chief a plan for educating relevant staff on the EC policy outlined in this plan.

RECOMMENDATION 3: ENVIRONMENTAL PRODUCT DECLARATION (EPD) & MATERIAL QUANITY (MQ) REPORTING
To understand the relative EC intensity of different materials, Covered Agencies, by mid-2027, should collect EPD and MQ data for listed materials used in Covered Projects.

RECOMMENDATION 4: GLOBAL WARMING POTENTIAL (GWP) THRESHOLDS
*Covered Agencies should establish project-average GWP thresholds for **ready-mix concrete, structural steel, steel rebar, and asphalt** by mid-2028. To further promote market uptake of low EC materials, the Council should also provide a definition of "low-embodied carbon" material.*

RECOMMENDATION 5: WHOLE BUILDING LIFE CYCLE ASSESSMENT (WBLCA)
To understand how design can be optimized to reduce EC, it is recommended that by 2027, the Commonwealth require cradle-to-grave WBLCA for new building construction or major building renovations over 20,000 square feet in any single building managed by a Covered Agency.

RECOMMENDATION 6: TECHNICAL ADVISORY COMMITTEE (TAC)
In order to review industry preparedness, market acceptance, and technology readiness for increased stringency in regulations, the Council shall convene a technical advisory committee that will, every two years:

- Review materials subject to EPD reporting requirements and GWP limits and recommend new materials for inclusion;

- Review and, where appropriate, recommend decreasing GWP limits at the materials level and updating data sources informing thresholds;
- Monitor the standards and reliability of WBLCA analysis and develop framework for project-level EC intensity limits;
- Develop baseline measure for the EC emissions associated with state projects and set long- and intermediate-term targets for overall reduction of the state's EC carbon portfolio.

RECOMMENDATION 7: DECONSTRUCTION AND REUSE

Given the emerging nature of the field of deconstruction and reuse, DCAMM should develop protocols and implement exploratory pilot projects to better understand opportunities and challenges presented by reusing structures and building materials. Specifically, the Commonwealth should:

- Increase cross-agency collaboration to establish protocol for deconstruction and reuse of Commonwealth building assets through formal participation on the Department of Environmental Protection (DEP) Reduce and Reuse Deconstruction Workgroup;
- Increase pilot deconstruction projects within Covered Agencies that manage building assets and report to Council on learnings;
- For select DCAMM demolition projects, conduct salvage assessments for products and materials that may be sold, repurposed or reused;
- Expand workforce development programs to include deconstruction training programs; and
- Support the development of a market for deconstructed materials.

RECOMMENDATION 8: MARKET DEVELOPMENT

The Executive Office of Economic Development (EOED) should continue to build awareness of existing state programs that support innovative low-embodied carbon (low EC) technologies and identify opportunities to further catalyze business growth and market development.

- Drive awareness of available state programs for businesses developing low EC technologies; and
- Explore opportunities for further catalytic support to help scale low EC technologies.

RECOMMENDATION 9: BUILDING CODE

The Board of Building Regulations and Standards (BBRS) and the Council should work to develop a pathway towards adoption of EC reporting in base building code, first through incentive-based measures.

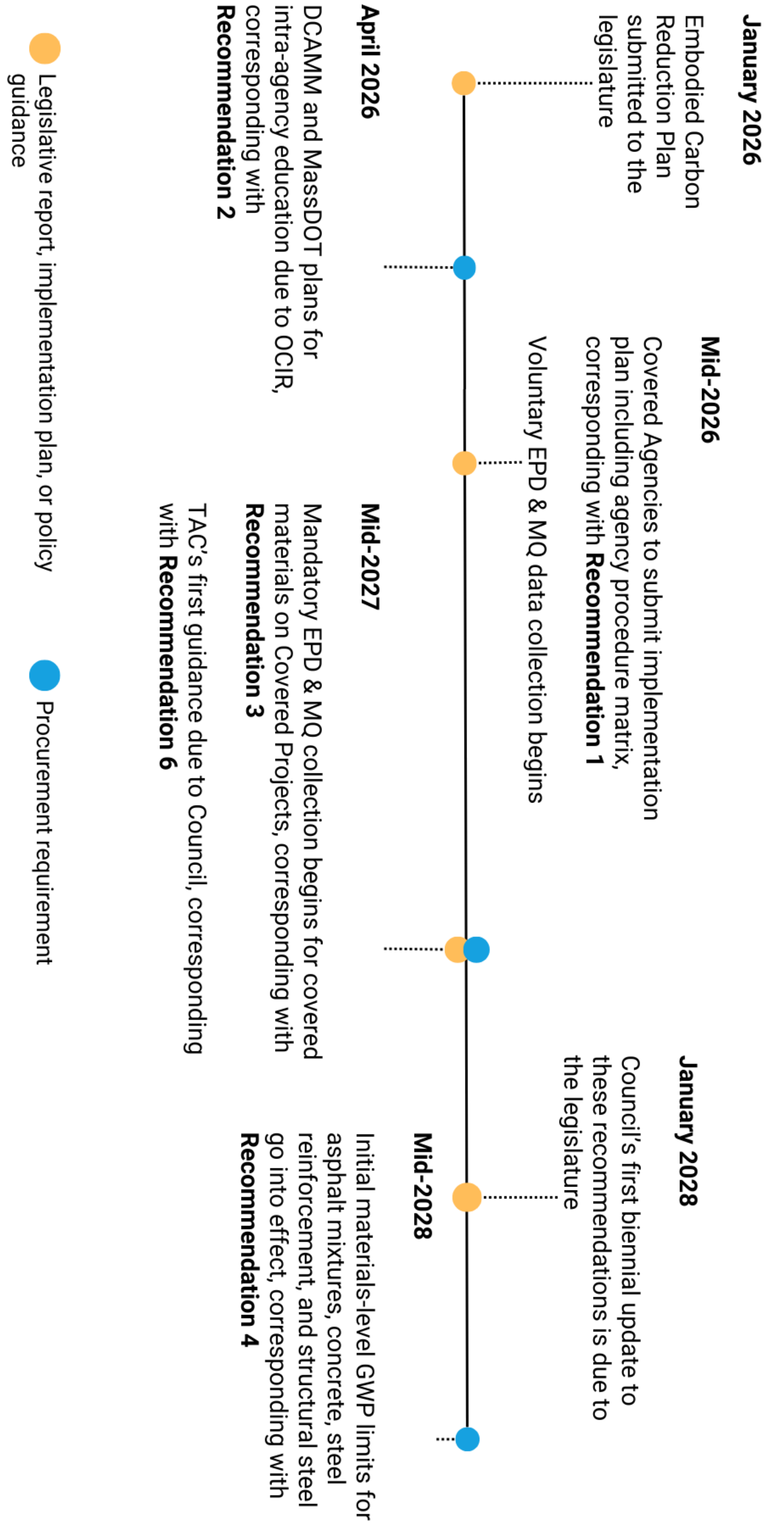

Figure 1: Recommended timeline for implementation

Table of Contents

Acknowledgements

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Council Members

The report of the Council would not have been possible without the valuable contributions of each of the Council members, who shared their expertise over the course of the year to help guide the Council's work and shape these recommendations.

Co-Chairs

- Melissa Hoffer, Massachusetts Climate Chief, Office of Climate Innovation and Resilience (OCIR)
- Adam Baacke, Commissioner of the Division of Capital Asset Management and Maintenance (DCAMM)

Members

- Senator Michael Barrett, Senate Chair of the Joint Committee on Telecommunications, Utilities and Energy
- Wayne Capolupo, Representing the Massachusetts Senate Minority Leader Bruce Tarr
- David Hart, Representing the House Chair of the Joint Committee on Telecommunications, Utilities and Energy, Representative Mark Cusack

- John Tzimorangas, Representing House Minority Leader Representative Bradley Jones, Jr.
- Colton Andrews, President of Western MA Building Trades Unions, representing the Building Trades
- Luciana Burdi, Representing the CEO of the Massachusetts Port Authority
- Beverly Craig, Representing the CEO of the Massachusetts Clean Energy Center (MassCEC)
- Katherine Eshel, Representing the General Manager of the Massachusetts Bay Transportation Authority (MBTA)
- Professor John Fernández, licensed architect and Professor and Director of the Building Technology Program in the Department of Architecture at the Massachusetts Institute of Technology (MIT)
- Mark Fine, Representing the Secretary of the Executive Office of Administration and Finance
- Eric Friedman, Representing the Secretary of the Executive Office of Energy and Environmental Affairs
- Michael Gryniuk, structural engineer and Principal at Cora Structural
- Sarah Kalish, Representing the Secretary of the Executive Office of Economic Development
- Patrick Kenny, structural engineer; Representing the Chair of the Board of Building Regulations and Standards
- Caroline Murray, Regional Sustainability Manager and Project Executive at Turner Construction Company
- Jenny Raitt, Executive Director of the Northern Middlesex Council of Governments
- Jason Robertson, Representing the Secretary of the Executive Office of Transportation
- Amy Stitely, Representing the Secretary of the Executive Office of Housing and Livable Communities

List of Figures

List of Tables

Glossary of Terms

Asset reuse – Repurposing or extending the life of an existing building or infrastructure project in-situ (or portion of a project, such as structure or envelope) rather than demolition and new construction.[4]

Adaptive reuse – When a building is reused in a different capacity, such as a former office building being converted into apartments.[5]

Carbon Dioxide Equivalent (kgCO_2e) – A unit of measurement that expresses the impact of different greenhouse gases relative to carbon dioxide, allowing for a single value to represent the combined effect of emissions. Used for tracking EC impacts.

Carbon Intensity (kgCO_2e) – The amount of carbon emissions associated with a specific activity, material, or process, expressed per unit, such as per square foot or square meter.

Cradle-to-Gate – A term for the life cycle of a product from raw material extraction to the point when it leaves the factory "gate." Often used to describe the scope of a partial life cycle assessment.

Cradle-to-Grave – A term for the life cycle of a product from raw material extraction to its end-of-life disposal (e.g., incineration, reuse, etc.). Often used to describe the scope of a life cycle assessment.

Deconstruction – The process of disassembling a building or material components so that its materials and components may be salvaged for reuse or responsible diversion.

Division of Capital Asset Management and Maintenance (DCAMM) – DCAMM is responsible for capital planning, public building construction, facilities management, and real estate services for the Commonwealth.

Embodied Carbon (EC) – The total amount of greenhouse gas emissions (GHG) associated with the extraction, manufacturing, transportation, installation, maintenance,

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[4] "EMBODIED CARBON LIFE CYCLE ASSESSMENT REFERENCE GUIDE." *City of Boston*, July 2025, www.bostonplans.org/getattachment/69ec4044-85bc-415e-93b7-e13cc1cc8742

[5] Ibid.

and disposal of building materials over their total lifecycle. Typically expressed in Global Warming Potential, $kgCO_2e$.

Embodied Carbon Intensity (ECI) – The total EC of a project divided by the size. Typically expressed in Global Warming Potential per area, i.e., $kgCO_2e/ft^2$.

Embodied Carbon Intergovernmental Coordinating Council (ECICC) – The Council was established by the 2024 law, An act promoting a clean energy grid, advancing equity and protecting ratepayers, and was charged by the legislature with producing this set of recommendations.[6]

Environmental Product Declaration (EPD) – A document that reports environmental impacts of a product based on the assessed impacts from a product life cycle assessment (LCA). There are three types of EPDs. Type III EPD's are rigorous, third-party verified declarations that must conform to international standards and follow the rules for that product category. A product-specific EPD represents one manufacturer's product. An industry-average or industry-wide EPD represents an industry average GWP for a product type. For building materials, these typically include the "cradle-to-gate" or (A1-A3) life cycle impacts.

International Organization for Standardization (ISO) – A non-governmental organization that publishes international standards for a variety of industries, including standards for life cycle assessment and EPD publication.

Global Warming Potential (GWP) – A common unit of measurement expressed in Carbon Dioxide Equivalent (CO2e) used to standardize the impacts of different GHGs, usually expressed in a 100-year time period.

Life Cycle Assessment (LCA) – A systematic set of procedures for compiling and evaluating the inputs and outputs of materials and energy, and the associated environmental impacts directly attributable to a product or process throughout its life cycle. LCA provides an estimate of GHG emissions over all (or a portion of) the asset's life cycle.

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[6] Massachusetts General Laws (MGL) Part I, Title II, Chapter 7C, § 73, full text listed in Appendix A https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter7C/Section73

Major Renovation – Any project that includes extensive heating, ventilation, and air conditioning (HVAC) renovation; extensive envelope modifications; and extensive interior rehabilitation.

Operational Carbon – The GHG emissions produced during the day-to-day operation of a building or infrastructure, primarily from energy used for heating, cooling, lighting, ventilation, and powering equipment, essentially encompassing the carbon footprint of a building while it is in use.

Product Category Rules (PCR) – A set of guidelines, published for each material type, or "product category," for conducting LCA studies and developing EPDs.

Salvaged and reused materials – Previously used materials or products that require limited to no processing for reinstallation and use on the same or a different project. Salvaged materials refer to materials that were deliberately deconstructed and reclaimed, stored, and distributed for use on a separate project. Material reuse is the installation of a previously used material or product that requires limited to no processing for reinstallation and use on the same project, typically within the same site by the same owner. This may still require deconstruction and re-installation. Salvaged and reused materials do not refer to recycled content in manufactured materials or designs that create a future potential for reuse. A material that requires some minimal level of reprocessing (e.g., resawing salvaged lumber) would still be considered a reused and salvaged material.[7]

Whole Building Life Cycle Assessment (WBLCA) – A cradle-to-grave assessment that includes most or all of the building scope elements (structure, enclosure, interiors, mechanical systems, etc.) and reports on environmental impacts, namely GWP, of those elements.

[7] Ibid.

Introduction

What is Embodied Carbon

Embodied Carbon (EC) refers to the greenhouse gas (GHG) emissions associated with the life cycle of a product from cradle to grave. For example, the EC of one ton of cement includes all emissions associated with that product's raw material extraction, transportation (including fuel use), installation, maintenance, and end-of-life disposal. The term is often used to describe emissions associated with the life cycle of construction materials and projects, which are the focus of this report. In contrast to **operational carbon**, or emissions resulting from energy use during an asset's service life (such as heating, lighting, or equipment operation), EC is emitted in large part *before* the project is in use. Policies implemented to mitigate GHG emissions have, until recently, focused nearly exclusively on operational carbon. EC associated with construction materials represents a large and growing portion of projects' overall emissions, with the production of materials used for building and infrastructure projects accounting for approximately ten to fifteen percent of global GHG emissions.[8] The primary sources of EC in construction vary by project type but are consistently dominated by high-impact materials such as concrete, steel, asphalt, aluminum, and glass.

Embodied Carbon Measurement

Embodied emissions are expressed in terms of Global Warming Potential (GWP), a measure of the global warming impact of a given product, based on emissions associated with its production. GWP is reported in a common unit: carbon dioxide equivalent (CO_2e), a standardized metric used to compare the warming effect of different gasses relative to carbon dioxide (CO_2). GWP impacts are determined through life cycle assessment (LCA), a standard analytical methodology used to account for the life cycle impacts of a given product or system. LCA is governed by international standards from the International Organization for Standardization (ISO)—including ISO 14040,9 ISO 14044,10 and ISO 21930.11 These standards require that emissions be reported in kilograms of CO_2 equivalent (kgCO_2e).

[8]"Buy Clean Policies: Overview + Implementation." *Carbon Leadership Forum*, https://carbonleadershipforum.org/buy-clean-policies-overview/

[9] International Organization for Standardization (ISO). "Environmental management — Life cycle assessment — Principles and framework." ISO 14040, 2006. ISO, https://www.iso.org/standard/37456.html

[10] International Organization for Standardization (ISO). "Environmental management — Life cycle assessment — Requirements and guidelines." ISO 14044, 2006. ISO, https://www.iso.org/standard/38498.html

[11] International Organization for Standardization (ISO). "Sustainability in buildings and civil engineering works

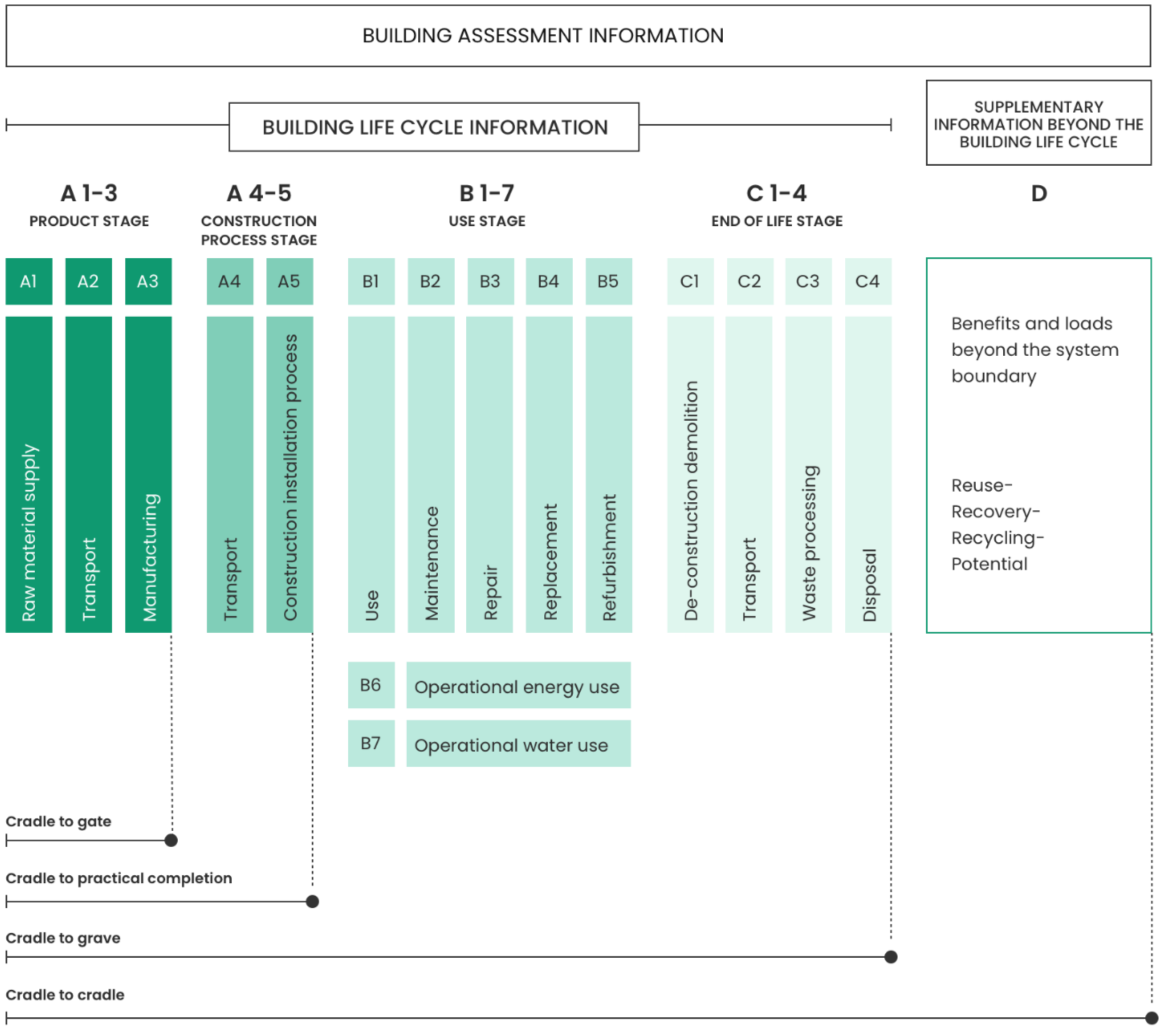

Figure 2: Building Life Cycle Modules[12]

In construction, LCA includes stages from raw material extraction and manufacturing (represented in Figure 2 above as A1–A3), through transport and installation (A4–A5), to use, maintenance, and end-of-life (B and C stages). All EC quantification stems from this methodology, whether conducted at the product level or at the whole asset scale.

At the product level, environmental impacts are communicated through **Environmental Product Declarations (EPDs)**—third-party verified documents based on product-specific LCAs, developed according to ISO standards and product category rules (PCRs). One can

— Core rules for environmental product declarations of construction products and services." ISO 21930, 2017. ISO, https://www.iso.org/standard/61694.html

[12] "Life Cycle Stages." *One Click LCA*, https://help.oneclicklca.com/en/articles/275901-life-cycle-stages

think of them as comparable to an ingredient label on a food product, but reporting on environmental impact, rather than nutritional value. EPDs can be product-specific (representing one manufacturer's product) or industry-average (representing a larger portion of the industry for a product type). EPDs are commonly available for materials such as concrete, steel, asphalt, glass, and insulation, and are used to compare products within a material category. For example, a designer might use EPDs to select a concrete mix with lower EC while maintaining structural performance requirements. However, EPDs are currently only available for certain products, and they typically cover only the initial “cradle-to-gate" life cycle stages (A1–A3), unless extended data are provided.

At the project scale, EC is assessed through **Whole-Building Life Cycle Assessment (WBLCA)** or, more broadly, project LCA for infrastructure. These assessments estimate the total EC associated with a project's life cycle, from extraction and manufacturing of materials to construction, use and end-of life. An assessment typically begins with estimating the quantities of all the materials systems in a project—commonly structure, enclosure, interiors—and using emissions factors by material derived from life cycle emissions data. WBLCA tools are increasingly integrated into design workflows and are required by some policies and certification programs (e.g., LEED, Buy Clean, or local EC limits).

While both EPDs and WBLCA are based on LCA methodology, they serve different purposes. EPDs offer granular, product-scale data that supports procurement and transparency at the material level, while WBLCA provides a more comprehensive view of EC across an entire project, supporting design trade-offs and whole-life analysis. Used together, EPDs and WBLCA offer can be used as complementary strategies to reduce EC—one focused on material procurement, the other on project-scale impact.

National, State, and Local Policy Landscape

Efforts to regulate GHG emissions at the state and federal level have historically focused primarily on the emissions associated with the generation and consumption of energy, across sectors such as electricity generation, building energy and electricity use, and transportation. Governments have only recently begun to focus on mitigating EC emissions. In 2017, California became the first state to pass a law aimed at reducing EC of state-procured construction materials. Seven other states—New York, New Jersey, Colorado, Oregon, Maryland, Minnesota, and Washington—have since followed with “Buy Clean” procurement laws that establish reporting requirements and, in some cases, set EC limits for building and infrastructure materials in state procurement. These laws typically encourage or require collection of EPDs for a set of materials—such as concrete, cement, steel, asphalt, glass, and wood—and then establish GWP limits for those materials. Government buying power can send a strong market signal to materials manufacturers and the architecture, engineering and construction (AEC) industries to encourage the development of and demand for materials and processes that reduce EC. California has also gone a step further to develop a provision on EC in its "CalGreen" green building standards code, which includes multiple pathways for compliance. Paths to compliance include building reuse of at least forty-five percent of existing structure and enclosure, WBLCA and a demonstrated ten percent reduction from a baseline, or EPD submission for listed materials that demonstrate GWP under the state-required threshold. While CalGreen is separate from the base building code, it is the first example of a state enacting mandatory EC emissions controls that apply to most large public and private buildings.[13]

State and Municipal Efforts in Massachusetts

The primary Commonwealth agencies in charge of construction and building management are DCAMM and MassDOT, with DCAMM managing the vast majority of the state's building assets, including higher education institutions, public safety facilities, and courthouses, and MassDOT managing state highways, bridges, and other transportation-related infrastructure. Both agencies publish designer guidelines and procedures that are frequently adopted and modified by municipalities for their own purposes.

Various Commonwealth agencies and authorities, including DCAMM and MassDOT, as well as select municipal governments, have already begun working towards reducing EC. In response to the 2023 *Recommendations of the Climate Chief*, DOER's Leading by Example Division, in conjunction with DCAMM and MassDOT, produced recommendations in 2024 for an initial "Buy Clean" strategy for the Commonwealth.[14] As well, the Massachusetts Stretch Energy Code, which DOER administers, includes an optional bonus point for EC. The Massachusetts Port Authority (Massport) uses the LEED rating system to collect EPDs, with a minimum certification requirement of LEED Gold with LEED Zero Carbon for buildings. Massport's 2025 Sustainability Design Guidelines reference LEED credits for Materials and Resources (MR). Municipalities including Boston, Cambridge and

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[13] AIA California. "Calgreen Mandatory Measures for Embodied Carbon Reduction." *AIA California*, 8 Dec. 2023, https://aiacalifornia.org/news/calgreen-mandatory-measures-for-embodied-carbon-reduction/
[14] Hoffer, Melissa. "Recommendations of the Climate Chief." *Mass.Gov*, Office of Governor Maura Healey. https://www.mass.gov/files/documents/2023/10/24/CLIMATE%20REPORT.pdf

Newton have adopted zoning rules and requirements for building life cycle assessments that require reporting of EC and encourage reductions.

DCAMM currently is spearheading a pilot deconstruction project to analyze the challenges and benefits of deconstruction and reuse practices MassDOT has already begun utilizing techniques that reduce EC intensity of materials, including incorporating cementitious substitutes for Portland Cement—such as recycled slag and fly ash; using Type 1L Portland Cement in concrete mix designs that reduce overall Portland Cement volumes; developing pilot projects to research and study the effects of high recycled asphalt product (RAP); using up to fifteen percent RAP in all mix designs; and using a warm mix asphalt additive that allows much lower mixing temperatures than standard pavement mixes.

Legislative Mandate and a Coordinated Approach for the Commonwealth

Notwithstanding these efforts, the Commonwealth lacks a comprehensive, coordinated approach to monitoring and reducing EC. To address that gap, in 2024, the Massachusetts Legislature passed *An Act promoting a clean energy grid, advancing equity and protecting ratepayers,* which included provisions establishing the Council and setting forth its charge to research and draft a plan to encourage the measurement and reduction of EC in state-managed construction and beyond.[15]

This Plan sets forth a comprehensive, phased approach for Commonwealth agencies and certain quasi-state authorities that manage construction to track EC and ultimately reduce it through actions including design change, product substitution, and reuse of structures and materials. Integrating agency efforts and creating state-wide resources to facilitate cross-agency knowledge sharing and analysis will be vital to this process. Data collection and monitoring across agencies will enable the Commonwealth to establish baseline EC emissions data and track progress towards reductions. Setting clear, consistent standards and guidance at the agency level has the potential not only to reduce state project EC but also creates a template to be followed by municipalities. As well, the Commonwealth can learn from the examples of other states and municipalities to implement proven measures faster.

Process

The Council's recommendations reflect a ten-month long process of collaboration, research, stakeholder engagement, and expert guidance from Council members and other

[15] Ibid.

experts. This included monthly Council meetings and three public hearings, during which the Council sought expertise, advice and feedback from stakeholders throughout the AEC industries.

Recommendations of the Council

These recommendations focus on the most important initial levers for monitoring and reducing EC in state-managed construction. Importantly, this set of recommendations represents a *first step* toward reducing EC across the state's construction activities. Establishing a well-defined, phased plan for reductions in limits over time allows industry to adapt, adjust, and innovate to prepare for the standards of the future. The Commonwealth's strategy must remain dynamic—capable of responding to new data, emerging technologies, market feedback, and stakeholder input. Additionally, ensuring the safety and durability of the built environment is of high importance. As new products with lower carbon emissions become available, and as limits decrease, durability of these materials must be analyzed to ensure lower emitting materials do not jeopardize structural integrity.

Applicability of recommendations and covered agencies and projects

The legislation which formed the Council charged the group with making recommendations "with respect to major building and transportation projects of executive offices, departments, divisions, centers, agencies and authorities of state and municipal governments."[16] A Covered Project, therefore, is a "major building and transportation project" of an executive office, department, division, center, agency and authority that is:[17]

> 1) for use by, or a facility whose construction or substantial renovation is managed by, an executive office, department, division, center, agency or authority of state government, or whose project management is delegated under the provisions of M.G.L. Chapter 7C, Section 5; and
>
> 2) located on publicly-owned property.

[16] Ibid, § 73(c).

[17] "Major construction project" shall be defined under Recommendation 3. Separate definitions are provided for vertical and horizontal construction.

A covered agency is any executive office, department, division, center, agency and authority of the Commonwealth that falls within, or reports to an entity that falls within, the definition of "Executive office" as set forth in Massachusetts General Laws Chapter 6A, Section 2 (Covered Agency).[18]

Constitutional offices and municipalities are encouraged to follow these recommendations.

Vertical Construction vs. Horizontal Construction

When considering reducing EC in the built environment, it is important to acknowledge the varying needs of different construction applications. A key distinction is between building projects, known as "vertical construction," and infrastructure projects, known as "horizontal construction." Buildings—such as offices, schools, and residences—typically involve repetitive structural systems, shorter design and construction timelines, and have more accessible data on MQs and EPDs. In contrast, infrastructure projects—such as roads, bridges, tunnels, and water systems—often span longer timelines, involve different procurement processes, and utilize material-intensive systems with unique performance and durability requirements. Materials used in infrastructure face harsher conditions, particularly in Massachusetts, and need to withstand freeze-thaw conditions, de-icing salt exposure, weather, and forces exerted by vehicles. Specific applications such as bridge decks, marine applications, wastewater, industrial, or corrosive environments may face additional exposures.

Due to these differing requirements and use cases, this report draws a clear distinction between recommendations for construction that is "vertical," (buildings), versus "horizontal," (infrastructure). Table 1 below illustrates which recommendations apply to which type of construction. In all future updates to this report and any additional legislative or executive action on EC, the Council recommends that this delineation between requirements for vertical and horizontal construction is clearly maintained.

There are some nuances to the definition of what constitutes vertical and horizontal construction, and while agencies such as MassDOT and MBTA *primarily* manage horizontal construction, those agencies also occasionally construct buildings. For the purposes of clarity and simplicity, this report will refer to "vertical construction agencies" as those

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[18] This list includes administration and finance, education, energy and environmental affairs, health and human services, housing and economic development, labor and workforce development, public safety and security, technology services and security, transportation and public works and veterans' services. MGL Part I, Title II, Chapter 6A, § 2, https://malegislature.gov/Laws/GeneralLaws/PartI/TitleII/Chapter6A/Section2

which *primarily* manage the construction of buildings. “Horizonal construction agencies” shall be agencies which *primarily* manage infrastructure construction.

As the primary state agencies managing vertical and horizontal construction respectively, DCAMM and MassDOT shall act as agency leads enacting and producing guidance on these recommendations to other agencies and departments.

Applicability of recommendations by construction type

Recommendation	State-managed* **Vertical** Construction	State-managed **Horizontal** Construction	Private Construction Market
1: Agency Procedures & Decision Making	✓	✓	✗
2: Education	✓	✓	✗
3: EPD & MQ Reporting	✓	✓	✗
4: GWP Thresholds	✓	✓	✗
5: Whole Building Life Cycle Assessment	✓	✗	✗
6: Technical Advisory Committee	✓	✓	✗
7: Deconstruction and Reuse	✓	✗	✗
8: Market Development	✓	✓	✗
9: Building Code[19]	✓	✗	✓

Table 1: Applicability of Recommendations by construction type

[19] Note that, while changes to the building code would impact the broader market, this document only includes recommendations for the future incorporation of EC into code and does not reflect actual changes to code. This chart indicates that this recommendation would apply to the broader market *if adopted by the BBRS*.

**This refers to "state-managed" construction which also meets the applicability requirements outlined in the section above.*

It is recommended that Covered Agencies that manage construction should **submit a written report to the Climate Chief**, by **mid-2026**, detailing the plan for implementing the recommendations which are applicable to their primary construction type.

Part I — Foundational Organizational Practices & Education

Recommendation 1: Agency Procedures & Decision Making

Recommendation

It is recommended that Covered Agencies that manage construction undergo an analysis of processes—focusing on the largest and most carbon-intensive construction project types—with attention to the phases in the project with the greatest potential for reducing EC, including, in particular, the design phase and other earlier phases that evaluate any potential for asset reuse.

It is recommended that Covered Agencies complete this analysis and submit as a part of their implementation plan to the Climate Chief by **mid-2026**. Reports may include a graphic visualization (see DCAMM and MassDOT example below) of the agency's procedure, outlining where decisions may reduce EC, and a written statement indicating where and how specifications documents will be revised to include considerations of EC.

Discussion

While materials choices offer incremental reductions in EC, the greatest impact comes from decisions made earlier in the project initiation and design. Initial project decisions on whether a functional need actually requires a capital project, for example, can have an outsized impact. If an agency lead determines that such a need could be met through consolidation and maximization of existing assets, rather than a new construction, they would effectively avert *all* of the EC emissions of a new building. This type of analysis can consider whether an existing facility should be renovated or reused. Additional scoping and design leads to important choices about the size and footprint of a project, as well as the material volume, material source, and potential for reuse and salvage of materials. A building initially scoped to be 100,000 square feet, for example, might be able to serve all the same functions at 75,000 square feet. With minimal burden of analysis or data collection, simple, innovative decisions such as these can drastically reduce EC. Moreover, many such decisions may result in other beneficial impacts, including cost savings, reduction in operational emissions, and waste diversion through reuse. Additionally, changes to procedure and specifications documents that include greater consideration of EC can be implemented immediately and provide agencies with flexibility and autonomy to find creative solutions to reduce EC.

Given that DCAMM primarily manages vertical construction and MassDOT primarily manages horizontal construction, the Council recommends that Covered Agencies model their matrices after either DCAMM or MassDOT, whichever best matches the type of construction they most frequently undertake. Procedures at the MBTA, for example, are likely to better fit the "horizonal" construction model, as exemplified by MassDOT. Agencies such as Department of Conservation and Recreation (DCR) will likely better match DCAMM's procedure. That said, each Covered Agency's procedure will likely have aspects that are unique to its projects and can be reflected in its matrix.

Following Covered Agencies' development of their matrices, the Council recommends that, where appropriate, specifications documents be amended to reflect specific points at which EC should be considered. For example, DCAMM's Designer Procedures and Guidelines provide direction and guidance to Designers who work on DCAMM projects (and can also be used by other awarding authorities).[20] The guidelines already reference points where carbon impacts should be considered. These could be enhanced with additional detail to clarify key areas where designers should address EC, such as: ensuring projects are a sound capital investment (2.3); the Study Phase when developing and evaluating alternative design concepts for implementing the proposed project (5.3); and in the Design Phase, including Design Development (DD) and producing Construction Documents (CD).

Vertical Construction

Included below is an example of such an exercise for DCAMM's procedures. The graphic below and DCAMM's more detailed decision matrix (currently under development, but a draft version is included as an illustrative example in Appendix B) aims to identify the decision points along a project's progression that can influence the project's final EC totals. The matrix also identifies the principal staff roles within DCAMM that have influence over the respective decision point. Finally, the matrix provides an overview of beneficial choices available, as well as tools to influence the decision and potential additional incentives.

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[20] "Designer Procedures and Guidelines." *Mass.Gov*, Division of Capital Asset Management and Maintenance, https://www.mass.gov/info-details/designer-procedures-and-guidelines

DCAMM's matrix is presented below in Figure 3.

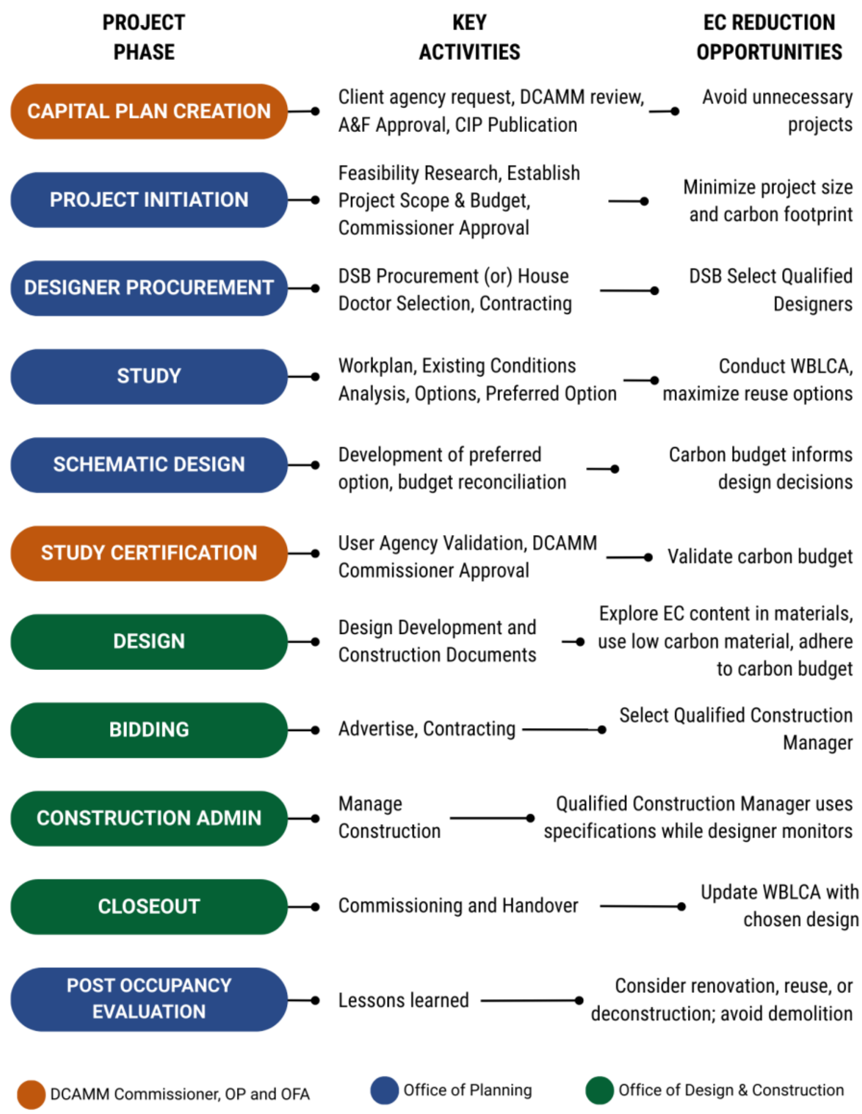

Figure 3: DCAMM Project Construction Activities and EC Impact

Horizontal Construction

On the infrastructure side, MassDOT has an in-depth Project Development process that includes prescriptive standards that prioritize safety and asset longevity through specific design and material requirements. This design process has been developed to comply with the applicable prescriptive standards from the Federal Highway Administration (FHWA), American Association of State Highway and Transportation Officials (AASHTO), Americans with Disabilities Act (ADA), and Manual on Uniform Traffic Control Devices (MUTCD) to name a few. MassDOT's proven approach to innovation is through a cycle of research and industry coordination, monitoring of results, followed by overall MassDOT-wide incorporation into the design standards. MassDOT's matrix is presented below in Figure 4.

MassDOT Project Construction Activities and Embodied Carbon Impact – Interstate and limited Access Paving

Project Phase	Key Activities	Embodied Carbon Opportunities
Step 1: Planning and Needs Assessment	Pavement Management System – data-driven approach prioritizes interstate roadway segments based on pavement condition ratings.	Pavement program focus on preservation of asset.
Step 2: Project Initiation	Project proponent (Pavement Management Section) initiates a project request.	Prompt project identification to ensure that the right project is done at the right time.
Step 3: Preliminary Project Scope and Cost – Project Approval	Review project type options (crack seal/Ultra Thin Overlay; Overlay, Mill & Fill; Complete Roadway Reconstruction; Rough Estimate of Costs/Funding Source Established).	Select project type that provides appropriate level of preservation to extend useful life of roadway structure at least life-cycle costs and lowest embodied carbon.
Step 4: Project Development and Design	Further refine details of the project, including: appropriate limits of project; determine thicknesses of pavement removal and new pavement installed; determine the appropriate mix design.	Select project details that provides appropriate level of preservation to extend useful life of roadway structure at least life-cycle costs and lowest embodied carbon.
Step 5: Programming of Funds for Project	Funding appropriation identified uploaded to Capital Improvement Plan.	N/A
Step 6: Procurement	Plans, specifications and cost estimate to contractors for bidding; contractor prequalification; date of bid opening advertised; bids opened and analyzed; contract is awarded; notice to proceed issued.	Changes to design can only be through addenda between advertise and bid opening.
Step 7: Construction	Project stays active from the notice to proceed date to the final acceptance date. Contractor identifies means and methods, and select pavement supplier from a list of pre-certified suppliers.*1	Contractor performs work in reasonable conformance with plans/specs/estimate. Material substitutions or project changes incorporated into the work only after submission and approval of contract amendment.
Step 8: Closeout	Contractor finishes all work, punch list; final inspection.	Project improvement result in extended life of roadway structure. The program goal is to have project repair cycles for all interstates and state highway to keep the facilities at a functional level of service indefinitely.

Roles:
- MassDOT Pavement Management/Office of Planning (Steps 1–3)
- MassDOT Project Management – Chief Engineer (Steps 4–6)
- MassDOT Deputy Admin. Chief of Construction-District Office (Steps 7–8)

*1 Debris from excavation or demolition are the contractor's responsibility to properly dispose of. In addition, contractor can choose to stockpile materials for re-use such as asphalt RAP.

Figure 4: MassDOT Decision Matrix

A Role for Non-Construction Agencies

While Covered Agencies that manage construction are the primary focus of this report, **all Commonwealth agencies** have a role to play in reducing EC when considering their space utilization and resource needs. Upstream decision making should weigh whether functional needs can be met without a building project or with a project of reduced scope. For example, DCAMM's "Future of Work" initiative consolidated DCAMM staff from three floors of office space to one by implementing flexible reservations of office and conference space. An additional example is the Salem State University (SSU) project, SSU BOLD, an effort to review the University's capital needs with the goal of maximizing the efficiency of resource use. SSU is establishing a compact and efficient campus core that will maximize programmatic synergies and streamline operations. At the same time, in modernizing facilities that will remain, SSU is enhancing the academic experience for students by fostering innovation and providing critical resources. This type of efficiency-oriented decision making not only has carbon benefits but also maximizes taxpayer dollars by optimizing space utilization and allowing potentially valuable land resources to be put to other purposes, such as housing.

Recommendation 2: Education

Recommendation

The Commonwealth should provide state-specific employee educational content focused on practical, low cost and high impact methods of reducing EC and meeting state requirements and to deliver these trainings for a minimum of three years. The focus should be on short, practical, "lunch-and-learn" style sessions tailored to specific roles and types of state procurement.

DCAMM and MassDOT should lead efforts for intra- and interagency education for vertical and horizontal construction, respectively. It is recommended that both agencies submit a plan to the Climate Chief for educating their staff on new procedures by April 30, 2026.

Discussion

In 2024, MassCEC sponsored the Embodied Carbon Challenge, providing educational content and awarding prizes for public and private building designs that showcased replicable, low-cost approaches to reducing EC in vertical construction. The competition drew strong engagement, with over 560 design, contractor, and sustainability professionals making use of the associated training and software tools.

Additional targeted, audience-specific education is critical to achieving meaningful EC reductions. Audiences for education should include state project managers, design teams and contractors involved in state-procured buildings and transportation projects.

- Courses should be designed to meet **continuing education requirements** for typical credentials needed by construction and design professional (for example AIA, LEED Green Associate and other LEED professionals, Construction Supervisor License, Phius, PHI, etc.).
- Training should be offered **at low or no cost** to professionals working on state-funded projects.
- Delivery formats should include options for **live virtual sessions**, **in-person trainings**, and **on-demand recordings** with brief quizzes for credit verification.

Examples of Potential Course Topics

- How to procure low-emissions concrete in Massachusetts
- Embodied carbon of major structural systems
- Meeting EPD reporting and GHG limit requirements for Massachusetts transportation projects
- Demolish or renovate? – Tools for evaluation and examples of building reuse
- Achieving meaningful EC reductions on LEED projects
- Practical examples of deconstruction and reuse of materials

Require representatives from construction agencies to participate in trainings. DCAMM-trained representatives will then support agency project management staff.

Broader education

To broaden impact, similar audience-specific content could be developed and offered to professionals working on Massachusetts municipal projects and private development.

Examples might include:

- Reducing EC in Multifamily Housing
- Reducing EC in Schools
- Reducing EC in Libraries
- Low EC specifications and practices for Massachusetts municipal Departments of Public Works (DPWs)
- Technical guidance
- Webinars
- A series of factsheets addressing major issues in designing and building low EC buildings

Part II — Core Reporting & Material-Level Requirements

Recommendation 3: EPD & MQ Reporting

Recommendation

The Council recommends that, for projects whose prime contract or contract for construction is advertised after mid-2027, Covered Agencies begin collecting EPD and MQ data for a focused set of high-impact materials, specifically: asphalt mixture, precast concrete, ready-mix concrete, steel reinforcement (rebar), structural steel, structural wood, and window assemblies. The Council recommends that Covered Agencies report starting in mid-2027; agencies are encouraged to begin collecting data on a voluntary basis in 2026.

Collecting MQ data in tandem with EPDs is critical. Expressing quantities per unit of material (e.g., cubic yard of concrete, ton of steel, square yard or tons of asphalt) allows reported GWP values to be multiplied by those quantities to estimate the total EC of those materials. While this represents only cradle-to-gate emissions (A1 – A3)—which typically represent the majority of EC for the materials listed—it may capture a smaller share for bio-based or other material types. Even so, it offers a valuable first-order estimate of EC and establishes a foundation for future benchmarking.

Materials subject to recommended reporting requirements are listed in Table 2 below.

Materials Subject to Requirements

Material	**EPD Reporting**	**MQ Reporting**	**Reporting Year** (Voluntary)	**Reporting Year,**(Required)
Asphalt Mixture	Yes	Yes	2026	2027
Precast Concrete	Yes	Yes	2026	2027
Ready-Mix Concrete	Yes	Yes	2026	2027
Steel Reinforcement (Rebar)	Yes	Yes	2026	2027
Structural Steel	Yes	Yes	2026	2027
Structural Wood	No	Yes	2026	2027
Window Assemblies	Yes	Yes	2026	2027

Table 2: Material Reporting Requirements

Projects Subject to EPD & MQ Requirements

Construction Type	**Projects Subject to Requirements**
Vertical Construction	Any state-managed new construction or major renovation project, as defined by Leading By Example (LBE) Guidelines, which exceeds 20,000 square feet in a single building.[21] For Covered Agencies that are not subject to E.O. 594, any state-managed new vertical construction or redevelopment project which exceeds 50,000 square feet.[22]
Horizontal Construction	Any state-managed Interstate or limited access highway pavement project which exceeds 40 lane miles of reconstruction.[23] Any MBTA-managed new construction or full rebuild project (excluding rolling stock) over $50 Million in construction value.[24]

Table 3: Project subject to reporting requirements; vertical and horizontal

[21] Ibid.
[22] Collection of mandatory EPDs and MQ on federally funded projects will require approval from any relevant federal agencies.
[23] Collection of mandatory EPDs and MQ on Federally aided projects will require FHWA approval
[24] Collection of mandatory EPDs and MQ on federally funded MBTA projects will require approval from federal funding agencies, including but not limited to the U.S. Federal Transit Administration (FTA) and the U.S. Federal Railroad Administration (FRA).

Discussion

Understanding Materials Supply Chains

These covered materials have a wide diversity of supply chains, manufacturing scale and processes, all of which influence a manufacturer's ability to decarbonize. Policy for encouraging decarbonization of these materials must take into consideration their unique processes and supply chains.

Ready-Mix Concrete

Ready-mix concrete production is highly local, with batching plants distributed across Massachusetts. Most plants source their Ordinary Portland Cement (OPC) from a small number of regional suppliers, which means the regional availability of lower carbon cement mixes is a strong factor in the ability for concrete producers to source lower impact cements. Optimized mix designs and supplementary cementitious materials (SCMs) provide the greatest opportunities for reduction, as cement typically accounts for the majority of EC in concrete.

Ordinary Portland Cement (OPC)

Cement used in Massachusetts is generally produced at a limited number of kilns in the northeastern United States or eastern Canada, with feedstocks and fuels drawn from regional and global supply chains. While not typically imported from overseas, OPC sourcing remains concentrated and carbon-intensive due to clinker production. Decarbonization depends on clinker substitution, process efficiency, and fuel switching at these kilns.

Precast Concrete

Precast elements are fabricated in regional plants serving multiple states and transported to job sites. This controlled manufacturing allows for optimized batching, curing, and reduced waste, but often requires a higher concentration of OPC, which is the most carbon intensive element. Precast producers use higher amounts of OPC to support quick curing and stripping of formwork, which allows them to keep production volumes high and their prices competitive.

Structural Steel

Structural steel is part of a national and global supply chain. There are two primary means of producing steel: electric-arc furnace (EAF) and blast-furnace/basic-oxygen furnace (BF/BOF). Most U.S. production uses EAF and is comprised of high quantities of recycled scrap, while imported steel — produced by blast-furnace/basic-oxygen furnace (BF/BOF) methods — often carries much higher EC. Importantly, for both structural steel and rebar materials fabricated for federally reimbursed highway, transit and rail construction projects, Build America/Buy America (BABA) provisions apply. BABA requirements require that these steel products be domestically produced.[25] This domestically produced steel already has, in most cases, lower EC.

Steel Reinforcement (Rebar)
Reinforcing steel is primarily produced through domestic EAF processes, making it among the lower-carbon steel products. However, similar to structural steel, imports can occur depending on market supply, and imported rebar often carries higher GWP values due to energy-intensive production abroad. Regional electricity mix and transport distance further influence total emissions for both structural steel and steel rebar.

Asphalt Mixtures
Asphalt production is regional and highly localized, with plants located near aggregate sources and project sites. Aggregates are locally quarried, but the bitumen binder is derived from global petroleum supply chains, linking emissions to refinery practices and energy intensity. The process for producing the asphalt mixture is highly carbon intensive since it involves burning fossil fuels to reach temperatures of 325 to 350 degrees Fahrenheit. GWP reductions can be achieved through warm-mix technologies and increased recycled asphalt pavement (RAP) content and simpler methods, like covering aggregate piles to keep them dry so the burners have less moisture to burn off during production.

Window Assembly
The supply chain for the window assembly, especially large unitized systems typically utilized in commercial office construction, is geographically dispersed across the US. EPDs for the assembled window product (glazing, frame, sealants and more) are currently available from some manufacturers. Typically, most of the EC of a window unit is due to the energy-intensive process of melting raw materials at high temperatures to make flat glass, which can account for roughly 70–80

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[25] Build America, Buy America (BABA) Act. Division G, Title IX of the Infrastructure Investment and Jobs Act (IIJA), Public Law 117–58. 15 Nov. 2021. https://www.energy.gov/management/build-america-buy-america

percent of the total cradle-to-gate emissions for insulating glass units (IGUs), with the remainder from fabrication, heat treatment, and coatings.

These materials were selected because they represent a large share of total EC emissions, are procured in high volumes across state projects, and have standardized EPD methodologies and established market coverage that enable consistent reporting. By focusing on high-volume, high-emission materials first, the Commonwealth can establish an accurate baseline that tracks the largest volume of EC while minimizing reporting burden on project teams and suppliers. Materials that did not meet one or more of the criteria were not included in the initial scope—not due to lack of relevance, but because reliable EPD data and verification mechanisms are in a nascent stage. Their exclusion does not depart from legislative intent; rather, it reflects a focus on materials with immediate readiness and impact.

Three materials listed for consideration in the legislation which are not included in the reporting framework are cement, glass, and wood. Cement is excluded from formal reporting as it is a feedstock for concrete, and its emissions should therefore be captured within the EPDs for concrete. As capacity develops for facility-specific EPDs (defined in Table 4), concrete EPDs will implicitly include information on the EC of cement used.

Glass has been excluded because the majority of glass used in construction is part of window systems and EPD data are often reported by the window assembly as a whole, rather than by the glass alone. For this reason, the Council recommends collection of full window assembly EPDs, rather than glass.

With respect to wood, there are a wide variety of wood products used in different construction applications, from decorative to structural. The Council focused on structural wood and excluded it from EPD reporting at this time due to uncertainties in the standards surrounding life cycle impacts. Of note, mass timber—large, engineered wood products used in structural systems—is growing in popularity as a green choice in building construction and is often touted as carbon neutral or even negative. The underlying assumptions of forestry and economic models that make such claims, however, are not accepted by consensus.[26] Mass timber may have the potential to reduce EC through carbon storage, prefabrication efficiencies, and lower-energy manufacturing, but current research and available data do not yet support consistent, verifiable reporting. Life-cycle impacts depend on forest management practices, product sourcing, transportation, and end-of-life treatment, all of which vary widely and remain the subject of ongoing study.

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[26] Sohngen, B., Baker, J.S., Favero, A. *et al.* "Carbon implications of wood harvesting and forest management." *Nature* 646, E18–E19. 10 July, 2025. https://doi.org/10.1038/s41586-025-09380-6

More research and attention to carbon accounting for the full life cycle impacts of wood products, including developing a reliable data standard to monitor forest practices and track full life-cycle carbon, is required. The Council charges the TAC with considering how the Commonwealth can improve data transparency, supply-chain traceability, and long-term monitoring of the impacts of wood products.

As data quality, analytical standards, and market capacity improve, the Council expects to expand the scope of this reporting framework in future updates to this plan, with particular interest in wood, insulation, gypsum, concrete masonry units.

Reporting Framework

To ensure consistency, comparability, and long-term usefulness of data collected across state agencies, the Council recommends adoption of a standardized reporting framework that governs both EPD and MQ submissions.

Under this framework:

- EPDs should be submitted at the shop drawing/material submittal stage, when specific products and suppliers are selected.
- MQ estimates should be submitted at the shop drawing/material submittal stage to calculate GWP compliance (for materials also subject to GWP thresholds), and final data based on actual quantities procured and installed should be submitted at project closeout.

A consistent, statewide reporting framework ensures that material- and project-level EC data can be aggregated across agencies, compared against thresholds, and used to establish future policy benchmarks.

EPDs:

To maximize accuracy and traceability, the Commonwealth should adopt a tiered hierarchy of EPD data quality:

EPD Tier	Description	Acceptability
Tier 1: Facility-specific EPD	Reflects the environmental impacts of a product from a specific manufacturing facility or plant. Examples: the ready-mix supplier for concrete; the steel mill for structural steel or rebar.	**Preferred / Required where available**
Tier 2: Product-specific EPD	Represents a specific product line but may aggregate data from multiple facilities.	Acceptable if Tier 1 is not available
Tier 3: Industry-average EPD	Published by a trade association or consortium representing typical performance across producers.	Acceptable only in early phases; to be phased out as facility-specific data become available

Table 4: EPD Definitions and Acceptability

Over time, all covered materials should transition to facility-specific EPDs to align with leading national standards and improve the precision of state-level benchmarks.

Material Quantities (MQs):

Quantities should be reported in standardized units of measure (e.g., cubic yards for concrete, tons for steel, tons or square yards for asphalt) and tied to the corresponding EPD entry.

Each submission should include:

- Material category (as defined in Appendix C);
- Project phase and quantity source (material submittal or project completion);
- Quantity value and unit;
- Associated EPD reference number or manufacturer.

To support consistent comparisons, all data should follow a common schema based on existing frameworks (see Appendix D for an example Material Reporting Schema). This ensures that reported materials align with recognized classification systems and can be integrated into the Commonwealth's centralized data repository. For example, OmniClass Table 21 provides a framework for classifying physical elements of a building based on their function (e.g., supporting, enclosing, servicing, etc.), which could be used by the Commonwealth to classify materials within functional use categories.[27]

Submission Process

The Council recommends that all required EPD and MQ data be submitted electronically through a **centralized state reporting platform**. The platform should support both agency staff and external project teams and ensure accuracy, transparency, and long-term usability of data.

This digital infrastructure will serve as the backbone for consistent EC reporting, enabling Massachusetts to:

- Understand the actual volume/tonnage and carbon intensity of materials used in the Commonwealth;
- Establish statewide baselines and inform future threshold adjustments;
- Track total EC impacts across all covered projects;
- Identify opportunities to reduce EC in future procurements;
- Reduce redundancy by eliminating repeated requests to manufacturers and contractors;
- Improve efficiency and minimize administrative burden for agencies and project teams.

The Executive Office of Administration and Finance (A&F), the Executive Office of Technology Services and Security (EOTSS), DCAMM, and MassDOT should collaborate to determine system requirements and configuration, long-term hosting and security, administrative roles and responsibilities, integration with agency procurement systems, data governance protocols and user access levels.

[27] "About OmniClass." *CSI*, Construction Specifications Institute (CSI), https://www.csiresources.org/standards/omniclass/standards-omniclass-about

Investing in adequate data infrastructure with capacity for data collection, analysis, and additional services such as user education and guidance will reduce staff time needed to administer and audit a buy clean program, minimizing the burden on agency staff.

Recommendation 4: GWP Thresholds

Recommendation

For any qualifying project whose prime construction contract or design contract is advertised after mid-**2028**, it is recommended that Covered Agencies set a maximum GWP for asphalt mixtures, concrete, steel reinforcement, and structural steel on the project. Separate thresholds are indicated for vertical and horizonal construction, due to the differing durability and performance requirements for those applications.

It is recommended that these initial materials-level GWP thresholds apply through a **project-averaging approach.** This means that, for example, rather than each incremental cubic yard of concrete on a project needing to meet a certain threshold, the *average* GWP of all of the concrete on a project must meet the threshold. This allows design teams to balance material choices and sources across a project while still meeting overall reduction targets.

The maximum allowable project GWP will be expressed in terms of a ρ multiplier. Therefore, the threshold *for each material* can be calculated as follows:

> To calculate a weighted average GWP, first determine the baseline weighted average GWP (GWP_b) for each material category or product sub-category (e.g., steel I-shapes, steel HSS).
>
> This is done by multiplying the material quantity for each mix or product sub-category (MQ_n) by the applicable industry-average GWP for that mix or product sub-category ($GWP_{ind,n}$), summing across all mixes or products from that materials class, and dividing by the total material quantity used on the project:

$$GWP_b = ((MQ_1 \times GWP_{ind,1}) + (MQ_2 \times GWP_{ind,2}) + (MQ_3 \times GWP_{ind,3})) / (MQ_1 + MQ_2 + MQ_3)$$

The maximum allowable weighted average GWP (GWP_{max}) for that project will then be calculated as follows:

$$GWP_{max} = \rho \times GWP_b$$

To ensure compliance on a project, calculate project-specific weighted average ($GWP_{project}$) by multiplying the MQ for each mix by the actual GWP reported on a facility or product-specific EPD for that mix or product ($GWP_{product,n}$), summing across all mixes or products, then dividing by the total material quantity, as follows:

$$GWP_{project} = ((MQ_1 \times GWP_{product,1}) + (MQ_2 \times GWP_{product,2}) + (MQ_3 \times GWP_{product,3})) / (MQ_1 + MQ_2 + MQ_3)$$

If $GWP_{project} < GWP_{max}$, *then the project is compliant for that material.*

Material Category	**Buildings /** Vertical Construction (ρ)	**Infrastructure** / Horizontal Construction (ρ)
Asphalt Mixtures	0.95	1.15
Ready-Mix Concrete	0.95	1.15
Steel Reinforcement	0.95	0.95
Structural Steel	0.95	0.95

Table 5: ρ-Values (Maximum Allowable GWP Multipliers by Material and Construction Type)

Projects Subject to GWP Threshold Requirements

Construction Type	Projects Subject to Requirements
Vertical Construction	Any state-managed new construction or major renovation project that is subject to Leading By Example (LBE) Guidelines[28] and exceeds 20,000 square feet in a single building. For state entities that are not subject to E.O. 594, any state-managed, 100% state-funded new vertical construction or redevelopment project which exceeds 50,000 square feet.
Horizontal Construction	Any state-managed, 100% state funded Interstate or limited access highway pavement project which exceeds 40 lane miles of reconstruction. Any MBTA-managed, 100% state or MBTA bond funded new construction or full rebuild project (excluding rolling stock) over $50 Million in construction value.

Table 6: Projects subject to GWP thresholds; vertical and horizontal

Discussion

Establishing Initial Thresholds

Setting clear thresholds for GWP ensures consistency, fairness, and measurable progress in reducing EC. Thresholds provide transparency for suppliers, drive innovation toward lower-carbon materials, and enable the Commonwealth to track reductions over time.

For initial thresholds, the Commonwealth will rely on **publicly available industry-average GWP data** (e.g. National Ready-Mix Concrete Association (NRMCA), American Institute of Steel Construction (AISC), Asphalt Institute, etc.). While this data is often reported regionally, there can still be wide variation across the reported regions. Understanding that actual GWP numbers can be highly localized, the Council will charge the TAC—outlined in the Recommendation 6—with assessing on a continual basis the sufficiency of state-collected data to begin setting thresholds based on internal data.

[28] Ibid.

Materials included in data reporting requirements but excluded from this initial threshold framework include precast concrete, structural wood, and window assemblies. In the case of precast, this is because there is insufficient EPD data to determine a regional benchmark with sufficient certainty at this time. For wood, the methodological gaps in current EPDs described in the previous recommendation mean that there is not reliable data to set meaningful thresholds. For window assemblies, there are a wide variety of assembly types that might be used on a project; moreover, MQ will be collected based on the number of units rather than volume of component materials, which complicates setting limits for all the glass within any given assembly. The Council charges the TAC with continually reviewing the availability of sufficiently broad data to begin setting thresholds for these materials.

When sufficient data is collected, the TAC should review and adjust thresholds based on Massachusetts-specific data. Importantly, the publishing body should have the authority to *reduce* or *maintain* limits on this four-year cycle, but not to increase ρ-Values over time. In other words, the policy should have a schedule for increasing stringency but shall not be subject to relaxed or reduced stringency once thresholds are set. Notably, since thresholds are expressed in relative terms (ρ-Value multiplier), if Massachusetts specific data arise which indicate that industry average data sets are not representative of local supply chains, updating the data source (rather than the ρ-Value) will maintain the rationale for stringency level as detailed below, while more accurately reflecting actual supply chains in Massachusetts.

Rationale for Initial ρ-Values (Why Most Are < 1.0)

This framework establishes initial ρ-values that require modest reductions below current industry-average EC performance. In most cases, ρ is set to 0.95, meaning projects must achieve a 5% reduction relative to today's typical GWP for that material category.

Massachusetts is adopting this approach for three main reasons:

- **A ρ-value of 1.0 preserves the status quo.**
  A ρ of 1.0 would simply ask projects to match the current average GWP for each material. This would send no decarbonization signal and would not move the market toward lower-carbon alternatives.
- **A five percent reduction is achievable in the near term using readily available practices.**
  For materials like ready-mix concrete, structural steel, reinforcing steel, and asphalt mixtures, a five percent improvement over the industry average is readily achievable through standard optimization (e.g., increased SCM use, improved

batching consistency, better mix selection, or lower-emission mill selection) without requiring the use of emerging or untested technologies. For ready-mix concrete, for example, SCMs have regularly been used in the industry for more than 30 years.[29] Notably, for many producers, this five percent "improvement" over industry average will not require *any changes* to processes, as their products are already achieving these numbers or even lower.

- **Small but real reductions build market capability.**
  The purpose of the initial ρ-values is to begin establishing operational discipline around collecting EPDs, understanding GWP drivers, and making incremental procurement and design adjustments. This creates the foundation for deeper reductions **between now and** 2035 and 2050. In short, a ρ of 0.95 reflects an achievable first step that sends a meaningful signal to industry, without imposing undue burden on early projects.

Cost of Lower-Carbon Materials

Cost implications were a principal focus of Council discussions with respect to setting limits and requirements. Understanding that the Commonwealth must use its capital and resources efficiently and effectively, it was important to the Council to ensure that proposed recommendations would not foreseeably lead to increased project costs.

Through discussions with and feedback from experts in the construction industry and materials research field, however, it became clear that achieving initial reductions in EC (between 10-30% over baseline) for materials such as ready-mix concrete has minimal cost implications for most listed material types. In fact, depending on the supplementary materials used and local market availability, certain lower EC concrete mixes can be *less* costly than traditional mixes using OPC.[30] Importantly, different SCMs have different impacts on curing, durability, permeability, and hardened properties; depending on application, these impacts could be favorable but may not be suitable for every application.[31] Moreover, the initial proposed set of targets have been chosen to be readily achievable by industry, and a slow decrease in these thresholds over time should facilitate EC reductions with minimal cost implications.

"TECHNICAL BULLETIN AD-01: Supplementary Cementitious Materials." *Euclid Chemical*, www.euclidchemical.com/fileshare/Literature/Technical_Bulletins/AD-01-Supplementary_Cementitious_Materials.pdf

[30] Marandi, N., Shirzad, S. Sustainable cement and concrete technologies: a review of materials and processes for carbon reduction. *Innovative Infrastructure Solutions.* **10**, 408. 29 July 2025. https://doi.org/10.1007/s41062-025-02213-5

[31] Ibid.

Waivers

Although cost implications should be minimal in most cases, a waiver process can allow for flexibility in cases where costs are significantly impacted. Covered Agencies should establish and set forth in relevant guidance a waiver process specifying extenuating circumstances which qualify for exemption, such as where supply-chain limitations, technical requirements, or significant cost impacts make compliance with GWP thresholds temporarily infeasible.

Intermediate 2035 and 2050 Targets

To align state policy with long-term decarbonization trajectories across the construction materials sector, Massachusetts should establish intermediate 2035 targets and long-term 2050 targets for embodied-carbon reduction. These targets are expressed as future ρ-values tied to today's baselines.

Milestones are essential for:

- Providing predictability to agencies, designers, owners, and suppliers;
- Allowing sufficient lead time for capital investments, such as plant upgrades, alternative cementitious binders, or low-carbon steelmaking technologies;
- Ensuring that consistent progress is made throughout the 2028–2050 period;
- Supporting procurement planning, including updating specifications, EPD templates, and contractual requirements.

Without intermediate targets, the state risks insufficient near-term progress and potential disruption if stringent standards are introduced too suddenly.

Framework for 2035 and 2050 Values

Future ρ-values should reflect the decarbonization commitments and roadmaps published by the relevant industries:

- Cement and Concrete: The Global Cement and Concrete Association has committed to net-zero concrete by 2050, with substantial reductions by 2030–2035.[32]

[32] "Concrete Future: The GCCA 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete." *Global Cement and Concrete Association*, https://gccassociation.org/concretefuture/

- Structural Steel and Reinforcement: Various U.S. steel producers have outlined pathways for deep reductions and eventual near-zero steelmaking by 2050.[33]
- Asphalt Mixtures: National commitments (e.g., "The Road Forward") target net-zero pavements by 2050.[34]

Refer to Appendix E for suggested 2035 and 2050 ρ-values. These ρ-values therefore represent deep reductions relative to today, while acknowledging that residual emissions may persist in 2050 and may require carbon removal or offsets to achieve net-zero on a portfolio basis.

Defining "Low Embodied Carbon" Materials

As outlined above, initial GWP limits will need to be set at levels that are fairly achievable with current materials manufacturing processes. This means that, for the time being, GWP limits are not likely to meaningfully drive demand for highly innovative low-carbon materials.

Therefore, supplemental to these limits, the Council recommends that the Commonwealth publish an official definition, for each listed material, of the GWP coefficient sufficiently low to qualify as "low-embodied carbon." This definition would not be used as a requirement or threshold on projects but rather could be used to support the adoption of these products through incentive programs such as grants or procurement incentives.

In its first report to the Council, the TAC should establish a set of criteria for what constitutes **"Low Embodied Carbon Material."** This definition should encapsulate any material that demonstrates a substantial reduction in GWP relative to the baseline for its material type (for example, 40 percent - 50 percent or more below average), verified through facility-specific EPDs. This definition should be proposed by the TAC, reviewed by the Council, and when approved, made public through the Council's two-year report to the legislature. The definition should be adapted over time as technology progresses and Massachusetts-specific data become available. Importantly, such a definition would only indicate that a design or mix of a material is *relatively* lower carbon than other designs from this same material class and functional use. As it will be relative to each material, this definition should not be used to compare the use of different material types on a project.

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[33] "Structural Steel Sustainability." *American Institute of Steel Construction (AISC)*, https://www.aisc.org/sustainability

[34] "The Road Forward: A Vision for Net Zero Carbon Emissions for the Asphalt Pavement Industry." *National Asphalt Pavement Association (NAPA),* https://www.asphaltpavement.org/forward

Part III — Project-Level Requirements

Recommendation 5: Whole Building Life Cycle Assessment (WBLCA)

Recommendation

Short term

For all **new building construction or major renovation projects involving at least 20,000 square feet within a single building**, which are advertised for prime contract after mid-2027 and managed by a Covered Agency, project teams should conduct WBLCA to assess a project's total global warming potential in CO_2e. The 20,000 square foot threshold was chosen for consistency with E.O. 594, which requires state agency-led building projects to achieve LEED Silver Certification and adhere to Massachusetts Specialized Opt-In code requirements.[35] LEED projects are able to earn points for WBLCA, so this additional requirement complements pre-existing requirements.

WBLCA should be conducted as an iterative process, with at least one conducted during the **design phase** to inform alternatives, and one conducted at end of Construction Design using CD information. To understand the relative EC performance of a design, designers should reference published averages for ECI of similar building types and sizes, such as the Carbon Leadership Forum Benchmark Report v2.[36] Designers should provide a narrative about why the building materials and systems were chosen.

Required scope of analysis to achieve compliance with this requirement is outlined in Appendix F.

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[35] Ibid.

[36] Benke, Brad, et al. "Embodied Carbon Benchmark Report: Embodied Carbon Budgets and Analysis of 292 Buildings in the US and Canada." *Carbon Leadership Forum (CLF)*, CLF and University of Washington (UW) Life Cycle Lab, April 2025, https://carbonleadershipforum.org/clf-wblca-v2/

Long term

Project-Level EC Thresholds
Importantly, the above short-term recommendation only includes a requirement for project teams to *analyze* the total EC and embodied carbon intensity (ECI), or the EC per unit of area, of projects and does not set requirements for *reducing* EC at a project scale.

There are two primary approaches that can be used to set requirements for reducing EC at the building scale:

- **A relative baseline:** this approach asks project teams to report the total EC emissions of the project based on actual design and then construct an imagined "typical" building design to compare against the proposed design. LEED v4 and CalGreen Code both take this approach to WBLCA requirements, asking projects to demonstrate a reduction in EC over a counterfactual baseline building. The benefit of this approach is that it accounts for potential differences in data assumptions across tools. From a policy perspective, a baseline building approach is an excellent way to motivate every project to explore embodied carbon reductions using WBLCA, compared to an absolute benchmark approach where all projects that fall under the threshold are not motivated to engage further. The disadvantage of this approach, however, is that it is possible, based on today's limited guidance and standardization of baselines, to achieve compliance by creating an over-designed "baseline" building, making comparative EC reductions easy to achieve without considering any actual design improvements.

- **An absolute benchmark:** this approach seeks to set a single standard based on reference EC emissions of buildings, typically categorized by use type (e.g., multifamily residential, educational, office, etc.). Such benchmarks would need to be sourced from a sufficiently large data set, with WBLCA data collected from actual building projects. Several jurisdictions in Canada, including Vancouver and Toronto, have adopted this approach. The benefit of this approach is that it ensures that projects are meeting one verified standard, limiting the ability to construct an inflated baseline. This approach primarily motivates the most EC-intensive projects to address their absolute impacts but does little to motivate EC reduction for projects that meet the limit without taking any actions. The disadvantage of this approach is that standards and tools available for conducting WBLCA are not nuanced, standardized, or granular enough to ensure analyses are comparable on an absolute level. Different tools use different assumptions and data inputs, sometimes resulting in significant differences in results across tools.

Weighing the relative benefits and disadvantages of each approach, the Council recommends that future updates to the state's EC policy for vertical construction projects focus on **setting absolute benchmarks** on EC at the project level, when data and standards are sufficient to do so. However, given the current lack of standardization of analytical tools, the Council does not recommend adopting project-level caps at this phase of implementation. Over the next two to five years, standards currently in development, such as ASRAE 240P, may provide meaningful new guidance to improve the validity and comparability of WBLCA.[37] Moreover, as state agencies gain experience with WBLCA and conduct the analysis for more projects over time, a body of Massachusetts-specific data will be developed and available to facilitate regionally specific caps.

As outlined under Recommendation 6, the TAC should advise the Council on setting **project level carbon budget** for EC in future updates to this document. The TAC may also consider recommendations regarding alternative compliance pathways, such as reusing some minimum percentage of building structure, or one for pursuing full points for a whole building lifecycle credit and associated reductions against a baseline in a green building rating system such as LEED v5.

For example, compliance pathways may include:

- Building Reuse: Reuse at least a certain percentage of an existing structure (e.g., forty-five percent in CalGreen);
- Performance via budget: Not exceed carbon budget for building type and size;
- Performance via reduction: Demonstrate reduction against baseline project design (e.g., ten percent in CalGreen, Max 6 points in LEED v 5 for forty percent reduction in GWP).

Analysis of Operational vs. Embodied Carbon Trade-offs

WBLCA can quantify the *total* carbon impacts of a building across its entire life—from raw material extraction through demolition and disposal. Depending on scope, it can capture

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[37] "NEWS: ASHRAE and International Code Council Announce Second Public Review Period for Proposed Emissions Quantification Standard." *ASHRAE*, American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE), 16 June 2025, https://www.ashrae.org/about/news/2025/ashrae-and-international-code-council-announce-second-public-review-period-for-proposed-emissions-quantification-standard

both EC (the emissions from constructing the building) and operational carbon (the emissions from running the building).[38] Ultimately, the use of a full WBLCA (with modules B6-B7 included) can offer guidance on reducing both operational and embodied carbon emissions and reveal complementary actions, as well as tradeoffs, between the two.

As an example, the reuse of a building's structure and enclosure often reduces EC in the short term, but project teams should also consider the impact of retrofits to operational carbon. Of interest, Denmark has set a carbon budget that incorporates both operational carbon and EC over the lifespan of the building. This encourages design teams to consider tradeoffs such as the amount of insulation added to a building. Increased insulation may reduce operational carbon over time, but increase EC up front, and the tradeoff should be carefully considered. DCAMM has requested legislative changes to MGL ch. 149 § 44M to both correct an inconsistency in the law and to expand life-cycle cost analysis evaluations to include the value of avoiding both operational and embodied carbon emissions, in order to facilitate consideration of this dynamic, and will continue to pursue a legislative solution.

Discussion

While collecting EPDs on a variety of projects is an important starting place, EPDs only tell a portion of the carbon life of a product as compared to a WBLCA. EPDs typically include a "cradle-to-gate" analysis of a product's emissions (modules A1 – A3), meaning all the emissions associated with the manufacturing of a product up until it is transported from the factory for use on a job site. Nothing about the product's use, maintenance, and end of life is included in the scope of the typical EPD. Moreover, requiring EPDs for only a sub-set of materials would not yield a comprehensive picture of total project EC.

A WBLCA provides project owners and design teams with a better understanding of the full life cycle impacts of design decisions. Examining EC at the project initiation and design phases has a much greater potential for reducing total carbon of the project than reducing the marginal emissions of a given material. Imagine a project that has two design options

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[38] Life cycle modules B6-B7, which, which analyze operational emissions, are not typically included in required scope for EC policy mandating WBLCA. However, their inclusion, when feasible, could facilitate better consideration for both EC and operation carbon.

for a building of the same size and purpose: the first design includes plans for a structure that would require twenty percent more concrete than the second design—for example, as the result of differences in the spacing and dimensions of the structural bay. Choosing the second design, even if using traditional concrete mixes, will automatically result in twenty percent lower EC for the concrete on the project. Then, where appropriate, the design team could further reduce EC by selecting concrete mixes with lower GWP intensity.

Data Validity, Accuracy, and Completeness

It is often useful to use project-level LCA and product-specific EPDs in conjunction with each other due to the relative limitations and strengths of each approach. Importantly, while WBLCA is a more *complete* analysis, it often requires using generalized, proxy data, and involves more assumptions about the project's life cycle and end use. The cradle-to-gate LCA included in the scope an EPD for specific products is often more *accurate* to the actual emissions of that product's life cycle because it is informed by actual data rather than assumptions. WBLCA, on the other hand, provides a more complete picture, but may be *less accurate* to the actual embodied emissions of the building that is ultimately constructed. The accuracy of WBLCA can be improved where project specific data are available, but there will always be some level of uncertainty in a cradle-to-grave WBLCA, as the "end of life" will always rely on assumptions about demolition and material disposal.

Basic WBLCA methodology

The first step of any LCA is to determine the **scope and goals** of analysis. To ensure transparency and comparability, it is critical to establish the **physical system boundaries, life cycle phases** and **impact categories** included in a given WBLCA analysis. Physical system boundaries refer to the components of the building which are included in the analysis (i.e. structure, enclosure, interiors). Life cycle phases, as outlined in the introduction section on *Embodied Carbon Measurement*, are standardized set of modules (labeled A1-C4) which divide the phases of a product's life cycle into discreet categories to facilitate analysis. Impact categories are the metrics being determined by the analysis. For EC, the relevant impact category is GWP, typically expressed in kgCO2e. To provide more context, this number might be normalized into kgCO2e per Square Foot or Gross Floor Area (ECI).[39]

Once a goal and scope are determined, WBLCA involves compiling a "bill of materials" — a comprehensive list of all of the materials and products that make up in the building's components. The life cycle impacts of each product on this bill of materials are then aggregated to provide an estimate of the full impact of the project.

There are a variety of online tools which are commonly used for WBLCA, such as Tally, Athena Impact Estimator, BEAM, and One Click LCA.

Comparable Life Cycle Trade-Offs for Horizontal Construction

This recommendation does not currently include any requirements for project-level LCA for infrastructure projects. This is both because project-scale LCA is less well adopted within infrastructure construction *and* because EPD-level data for the listed materials is relatively more representative of full EC impact for infrastructure projects than it may be for buildings, as many infrastructure projects involve fewer types of materials than buildings. However, EC impacts from the construction stage (A5) in particular are expected to be even higher for infrastructure assets than for buildings. It would be advantageous to start performing asset-scale LCA on infrastructure projects to better understand opportunities and gaps, even if not yet required.

There are some general life cycle trade-offs which should be taken into account by project teams. Concrete pavements generally demonstrate a significantly longer service life than asphalt. Concrete pavement life expectancy is thirty to fifty years compared to twelve to twenty years for asphalt pavement. This will ultimately result in fewer reconstructions and major rehabilitation cycles over the analysis period. While concrete carries higher initial EC intensity due to cement production and more energy intensive manufacturing, its extended lifespan, reduced maintenance frequency, and ability to maintain structural and functional performance for decades can offset much of that upfront impact. In contrast, asphalt typically offers a lower initial EC burden, but requires recurring mill and fill operations, periodic overlays, and more frequent interventions that accumulate substantial embodied

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[39] Other impact categories which might be assessed include depletion of the stratospheric ozone layer, acidification of land and water sources, eutrophication, formation of tropospheric ozone, and depletion of nonrenewable energy resources.

"Building Life-Cycle Impact Reduction." LEED v4.1. U.S. Green Building Council (USGBC), *https://www.usgbc.org/credits/new-construction-core-and-shell-schools-new-construction-retail-new-construction-data-27*

carbon over time. When these life cycle effects are modeled across a standard analysis window, the durability and long-term performance of concrete often reduce total life cycle EC relative to asphalt, despite the initial trade off. However, within Massachusetts, high traffic volumes on major corridors limit the feasibility of timely asphalt-to-concrete reconstruction cycles; lanes cannot remain out of service long enough to perform asphalt to concrete reconstruction without causing severe mobility impacts. Asphalt milling and paving on Interstates, state highways, and high-volume municipal roads can typically be scheduled during off-peak hours, allowing full roadway capacity to return before traffic increases. In contrast, concrete roadway construction requires longer, continuous closures to complete the work. These extended traffic restrictions represent a significant operational constraint and must be carefully considered in planning. The impacts of chloride intrusion and freeze–thaw cycles associated with harsh Massachusetts winters must also be taken into account. That said, MassDOT just completed an intersection on US1 in Newburyport where concrete was used in place of asphalt, using forty percent slag, and is planning to perform its second concrete pavement project in 2026. This application was in a low volume area that had roadway widths that allowed stage construction with minimum traffic impacts. Evaluating and piloting these types of projects when feasible has the potential co-benefit of EC reduction.

Most of MassDOT's annual pavement program is categorized as "pavement preservation" and comprised of asphalt surface treatments between three-quarters of an inch and two-inch in thickness. This program is designed to maintain the roadways at the highest feasible level of serviceability at the lowest cost and resulted in considerable reductions in asphalt usage since the program's inception. Such preservation-minded decision making has the benefit of maximizing state funds and reducing the overall new material added to the system, therefore reducing EC emissions.

MassDOT performs a Life Cycle Cost Analysis (LCCA) utilizing an incremental benefit cost model within its Pavement Management System to select projects and preservation treatments. To optimize the condition of the highway network, this process includes a condition assessment coupled with a ten-year condition forecast. A decision matrix with twelve treatment options is applied network-wide to determine which projects and treatments optimize pavement conditions, ensuring only the projects having the highest incremental benefit cost over a ten-year analysis period are selected. After consultation with the Council, MassDOT proposes modifying its Pavement Management System to incorporate the use of GWP in its project and treatment selection processes to develop a network level LCA analysis. This LCA analysis will provide a framework to supplement future decisions on low carbon materials and low carbon pavement treatments.

Part IV — Governance, Review, and Continuous Improvement

Recommendation 6: Technical Advisory Committee (TAC)

Recommendation

Following the publication of this initial report, the Council will continue to meet on a quarterly basis and submit an updated plan to the legislature every two years. However, given the technical nature of managing GWP limits and nuances of EPD and LCA data, the Council will convene a technical advisory committee (TAC) as a subcommittee. In alignment with the Council's legislatively mandated reporting period, the TAC should submit guidance to the Council on each topic listed below every two years, by mid-year of the reporting year.[40]

The Council will charge the TAC with providing technical guidance on the following matters:

- **Material subject to reporting requirements and GWP thresholds:** Over time, EPDs may become more readily available for certain materials which are known to have high EC intensity, but do not yet have reliable standards for EPD methodology. The TAC should assess industry readiness to produce EPDs to determine whether it should be included in subsequent requirements.

- **Stringency and data source of materials-level GWP thresholds:** Current proposed limits are suggested for their relative achievability, but as industry adapts to new standards, they will more easily be able to achieve targets. GWP limits should be reduced over time on a schedule that allows the Commonwealth to meet long term targets. The TAC should also assess the sufficiency of state-collected data and determine an appropriate timeline to transition away from industry databases to state-level data.

- **Transition to project-level thresholds:** Consider an appropriate time for vertical construction to transition to project-level EC thresholds based on WBLCA data. The

[40] For example, given that the Council's next legislatively mandated update is due on January 1, 2028, the TAC should submit guidance to the Council by July 1, 2027

TAC should monitor the development of new standards governing WBLCA analyses and advise the Council on the prospect of establishing project-level EC budgets alongside reductions in operational carbon emissions. The TAC should also review the viability for introducing systematic project-level LCA analysis for infrastructure projects.

- **Monitoring progress and setting time-bound targets:** Develop baseline measures for the EC emissions associated with state projects and set long- and intermediate-term targets for overall reduction of the state's EC carbon portfolio. The two-year threshold review cycle should reference long-term goals to ensure the Commonwealth is tracking towards overall reduction targets.

Discussion

A separate subcommittee with additional technical expertise is necessary because careful consideration of industry preparedness and progress, market acceptance, and technology readiness requires a more varied set of technical backgrounds than the current makeup of the Council. The TAC should report to the Council and will receive staff and administrative support from DCAMM and the Climate Office.

The group should consist of members with the following professional expertise, including at least:

- Two structural or civil engineers
    - One specializing in buildings
    - One specializing in infrastructure
- One materials scientist
- One architect
- One individual knowledgeable on the development of ASTM standards and Product Category Rules (PCRs)
- One LCA/EPD expert
- Technical representatives[41] of materials industries, including:
    - Concrete (e.g., NRMCA or MACAPA)
    - Steel (e.g., AISC)

[41] *"Technical representatives"* of industry shall be an individual with direct experience developing PCRs or EPDs for the stated material type

    - Asphalt (e.g., Asphalt Institute or Massachusetts Asphalt Pavement Association)
    - Wood (e.g., American Wood Council)
- One representative Construction industry (e.g. Construction Industries of Massachusetts)
- One economist specializing in the construction industry
- One climate expert
- One representative from each of the following state agencies:
    - DCAMM
    - MassDOT
    - MBTA
    - Department of Energy Resources (DOER)
- One representative from a research nonprofit specializing in EC, such as the Carbon Leadership Forum (CLF) or Rocky Mountain Institute (RMI)
- One climate labor representative

PART V — Emerging Initiatives & Market Enablement

Recommendation 7: Deconstruction and Reuse

Recommendation

Deconstruction and reuse offer great potential for EC reductions but are characterized here as "emerging" because meaningful implementation of these practices will require a shift in cultural norms and significant logistical changes in construction practices. Deconstruction in buildings is the *intentional, systematic dismantling* of a structure so that materials and components can be recovered, reused, or recycled, rather than demolished and sent to landfill. Whole or partial building reuse, also referred to as adaptive reuse, is the process of repurposing an existing structure for a new use—often quite different from its original function—while retaining most of the building's form, structure, and materials. Both deconstruction and adaptive reuse provide the potential to substantially reduce EC in the built environment.

Given the emerging nature of the field of deconstruction and the complicated logistical challenges presented by material reuse, the Council recommends that state agencies that manage building construction or waste diversion focus efforts in this area on **knowledge-gathering**, **capacity building**, and **market development.**

Measures that will support these goals are outlined in more detail below and include:

- Regularly convening agencies on the subject through an existing MassDEP Workgroup;
- Increasing pilot deconstruction projects;
- Conducting salvage assessments on select DCAMM projects to identify materials with reuse potential;
- Investing in workforce development programs for deconstruction;
- Supporting the development of a market for deconstructed materials.

Discussion

While measuring and understanding the impacts of construction through EPDs and WBLCA is an important means to reduce EC, one of the most impactful ways to reduce EC is to choose *not to build* a new building or use new materials in the first place. To provide a simplified example: imagine that UMass has a former student dormitory proximate to where DCAMM is looking to build an office building. DCAMM could construct a new building from scratch, and UMass could demolish that former dorm and put the land to other use. But if DCAMM were to instead retrofit that building into an office building, without changing any of the structural elements and maximizing material reuse, that project would automatically avoid one hundred percent of the nearly all of the EC emissions that would have been associated with those structural elements and materials in a new building. Moreover, opting for reuse of an existing structure and its component materials offers both carbon reductions and the important co-benefit of waste diversion.

While deconstruction offers great opportunity, there are significant barriers to adopting the practices industry-wide. These include a lack of storage options for salvaged materials, limited workforce for deconstruction trades, and currently low market demand for reused materials in the wider marketplace.

Cross-Agency Collaboration

As a part of its Reduce & Reuse Action Plan, MassDEP formed a group of stakeholders called the Deconstruction Workgroup in September of 2022, which has convened on a number of topics relating to building deconstruction and material reuse.[42] This group brings together a broad audience to help inform and guide MassDEP program and policy development through educating stakeholders, exchanging ideas and experiences, and building connections. Given there is a pre-existing convening around this topic within state government, the Council recommends that the state continue to tap into this Workgroup—with greater engagement with agencies who manage building assets—as a forum for establishing a protocol for deconstruction and reuse of the Commonwealth's assets.

In October of 2025, MassDEP held an in-person workshop on deconstruction, convening members of state agencies, municipal governments, construction industry, salvage materials companies, asset owners, and other stakeholders. This session was an excellent first step towards developing concrete steps to promote deconstruction and reuse, and the Council encourages MassDEP and the Workgroup to continue convening similar action-oriented discussions with a wide range of stakeholders as the state considers deconstruction policies and guidance. MassDEP's consultant, Sustainable Performance Institute, is preparing a report with recommendations stemming from its in-person workshop, due late January 2026.

Increase Pilot Projects

DCAMM has already initiated one deconstruction pilot project, where two nearly identical buildings will be demolished. One will be deconstructed based on new specifications utilizing a deconstruction/salvage approach. The other will be demolished as per DCAMM's standard specifications. Differences in approach, costs, and results will be carefully analyzed. This is an important first step to understanding how to implement deconstruction on a wider scale.

To begin developing a portfolio of pilot projects with observations and learnings, the Council recommends that DCAMM and other agencies that manage building construction continue to develop more pilot deconstruction projects. These should cover a range of building use types, sizes, and scopes of deconstruction. Projects can combine deconstruction and demolition to start experimenting with the practice on a smaller scale. DCAMM's Interiors team also has experience salvaging furnishings and furniture for reuse, which is an easy starting place for reuse that other agencies could replicate. Agencies should document successes and challenges with these pilots and use the MassDEP workgroup as a forum to share lessons learned.

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[42] "Reduce & Reuse (R&R) Working Group & Deconstruction Workgroup." *Mass.Gov*, Commonwealth of Massachusetts, Department of Environmental Protection (MassDEP), https://www.mass.gov/lists/reduce-reuse-rr-working-group-deconstruction-workgroup-archive

Salvage Assessments

Any pilot deconstruction project should undergo a salvage assessment—a walkthrough by a design professional to review which materials have potential applications for reuse. As salvage assessment is not a standardized practice or trade, the industry could benefit from the state setting an example for what standardized assessments might include. State pilot projects with a deconstruction element, therefore, should conduct salvage assessments, focusing on identifying existing materials (make, model, finish and quantities as applicable) that have potential for salvage and reuse via donation, secondary markets, repair, onsite redeployment, or manufacturer takeback programs.

DCAMM should develop guidance on what building elements should be evaluated in a standardized salvage assessment.

Workforce Development

Traditional demolitions are overseen by specific, specially trained demolition professionals. The skills required for demolition are different from those required for deconstruction, which involves the careful dismantling and separation of materials to enable reuse. As with salvage assessments, deconstruction is not yet a standardized practice, though there are local practitioners with some experience. The Commonwealth can help advance a standard framework for training and certification in this field by adding deconstruction as a focus within existing climate and clean energy workforce programs.

Market Development

While the subsequent section overviews market development for the larger market for low-EC construction materials and processes, it is worth drawing particular attention to market development specifically in the context of deconstruction.

The Commonwealth should consider how best to support the development of a robust circular economy for building materials, with particular attention to:

- Storage solutions to enable materials without immediate reuse applications to be diverted from the waste stream and used for future projects;
- Technology solutions that facilitate cataloguing of materials in the marketplace so that buyers' and sellers' needs can be matched.

Operational vs. Embodied Carbon Trade-offs

While reuse of a building's structure and enclosure often averts GHG reductions in the short term, project teams should also consider the impact of retrofits to operational carbon. "Pay off" times—or the amount of time that the EC associated with the construction of an asset is outweighed by the operational emissions of the life cycle of the asset—vary from building to building. A study by Preservation Green Lab and Skanska, for example, found a range of ten to eighty years for a building's operational emissions to eclipse its initial EC emissions.[43] Often, it is easier to build a new construction to the highest standard of energy efficiency, but depending on a number of factors, initial EC emissions may outweigh operational emissions for longer than the building even remains standing. For this reason, it is important that project teams carefully consider the operational versus EC trade-offs—including energy efficiency of a retrofit and the theoretical service life of the building—when determining if building reuse is the best choice for GHG reduction over time. That said, if a retrofit is able to achieve the same energy efficiency standard as a new construction, renovation will likely result in overall GHG savings in most cases.

Reuse in Horizontal Construction

This recommendation does not currently include any requirements for horizontal construction or infrastructure assets, but those industries are already implementing certain best practices. Notably, public transportation infrastructure is managed using a life cycle asset management approach, monitoring maintenance, overhaul, renewal and replacement needs on an ongoing basis to ensure the existing transit system is maintained in a State of Good Repair (SGR).[44] The majority of the MBTA's capital investment program represents SGR maintenance, renovations and rehabilitation of existing infrastructure, and upgrades to improve accessibility and customer experience. The MBTA invests significantly in rehabilitation and overhauls of existing assets, from bridge rehabilitation to commuter rail locomotive overhauls, often extending an asset's useful life multiple times over. Many projects also include elements of historic preservation. For example, as part of the Green Line Extension, the MBTA rehabilitated the Lechmere Viaduct, listed on the National Register of Historic Places, wrapping its underpinnings and ensuring materials used were consistent with the Viaduct's original design; at Copley, more than ninety percent of an original Beaux Arts headhouse was put back in place after accessibility upgrades were

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[43]"The Greenest Building: Quantifying the Environmental Value of Building Reuse." *Living Future*, Preservation Green Lab, https://living-future.org/wp-content/uploads/2022/05/The_Greenest_Building.pdf

[44] "MBTA Transit Asset Management Plan | 2022." *MBTA*, https://www.bostonmpo.org/data/calendar/pdfs/2024/0307_MPO_MBTA_TAM_Plan.pdf

completed, with original components repaired using 20th century blacksmithing techniques. The public transit industry also engages in extensive salvage and reuse activity. Where infrastructure must be replaced, the MBTA has historically issued procurements to remove, recycle and recover materials, such as replaced transit rail. The MBTA also acquires salvaged materials from peer agencies for reuse, such as bridge deck panels from the Big Dig and the Tappan Zee Bridge that are being recycled into mini-high platforms on the commuter rail to accelerate delivering accessibility on the regional network. Furthermore, new public transit infrastructure, which may represent significant upfront EC in construction, may have low operational carbon emissions or in many instances yield significant dividends in terms of avoided carbon emissions due to the infrastructure's core function of providing low-carbon mass transportation. In particular, the MBTA's rapid transit system runs on electricity that the Authority has sourced from 100 percent renewable sources since 2021, making all passenger trips on the Orange, Green, Red and Blue Lines carbon-free.

Recommendation 8: Market Development

Recommendation

The above recommendations are all implicitly concerned with market development, as they intend to use the power of state procurement to drive demand for less carbon intensive materials, designs, and practices. While these are meaningful drivers of the market in and of themselves, this recommendation focuses on concrete actions and programs administered by the Commonwealth that might further drive market development.

In that vein, the Executive Office of Economic Development (EOED) will continue to lead efforts to build awareness of existing state programs that support innovative low EC technologies and identify opportunities to further catalyze business growth and market development.

- Drive awareness of available state programs for businesses developing low EC technologies; and
- Explore opportunities for further catalytic support to help scale low EC technologies.

Discussion

Key Challenges in Low EC Tech Sector

The path to scale can be challenging for businesses developing low EC technologies. Scaling requires significant upfront capital investments, access to early customers willing to adopt innovative materials, and availability of suitable land and power. The Council hosted a "Low Embodied Carbon Tech Roundtable" to better understand the needs of businesses in this sector and how the state can play role in developing the market to support growth. The following key challenges facing startups and growth-stage businesses developing low EC technologies emerged from that discussion and additional stakeholder feedback.

- **Capital** – Companies must raise substantial upfront investment to achieve economies of scale and become cost-competitive with traditional materials.
- **User Acceptance** – Uncertain path to user acceptance for new technologies in slow-to-change industry. Demonstrations are important, but not sufficient.
- **Costs of Doing Business** – Land, labor, transportation, and power are expensive.
- **Site Needs** – Businesses report a limited availability of large sites and appropriate facilities with access to sufficient power and infrastructure for at-scale operations.

Current State Offerings and Example Use Cases

Massachusetts offers a broad portfolio of programs across multiple offices to support business growth, many of which can be leveraged by low-EC technology businesses.

Team MA Organizations – A coordinated network of state agencies and quasi-public partners ("Team MA")—shown in Figure 5—supports business development across all stages and sectors, including dedicated resources for early- and growth- stage businesses in climatetech, manufacturing, and technology sectors.

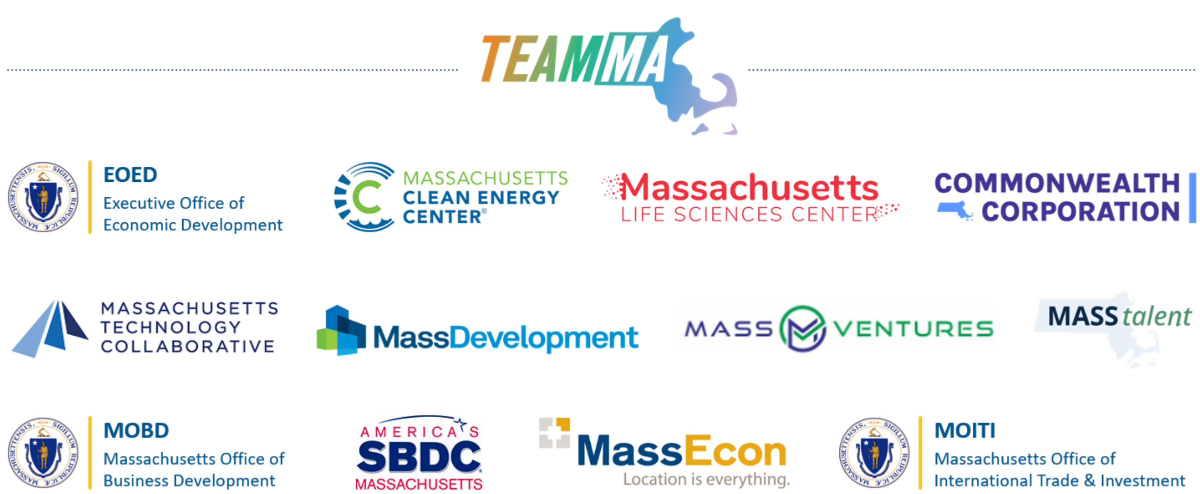

Figure 5: Team MA Organizations

Programs Addressing Capital Needs & Costs of Doing Business – Based on initial review, there are over a dozen industry-agnostic and sector-specific programs administered by Team MA agencies that have potential to support low EC tech businesses, outlined in Figure 6 below. These include grants, equity investments, tax incentives, loans, and subsidies to help businesses through commercialization phases from early-stage R&D to pilot, demonstration, and facility construction. Eligible uses of funds align with the typical costs incurred by businesses as they scale (e.g., equipment, construction, workforce training).

Note: Final applicant eligibility determination depends on program-specific criteria. Additionally, some of the programs listed aren't currently accepting applications.

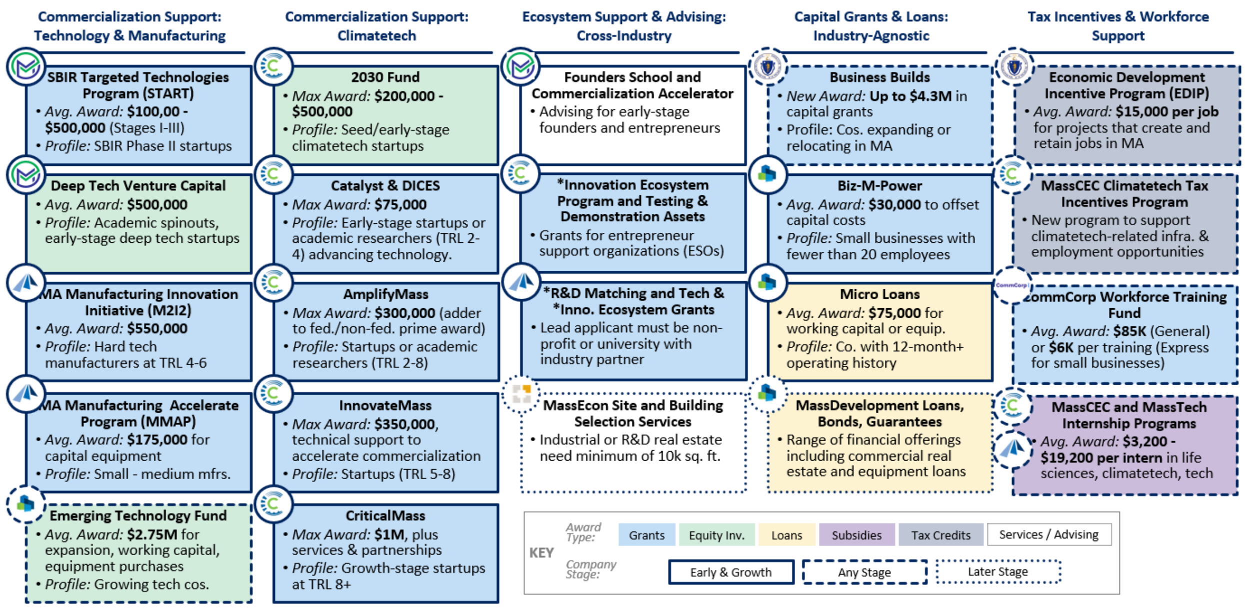

Figure 6: Relevant Existing Economic Development Programs offered by Team MA

In late 2025, two new programs launched that are a fit for low EC businesses: **Business Builds Capital Grant Program** (Figure 6) and **MassCEC Climatetech Job and Facilities Tax Incentive Program** (Figure 6 and Figure 7). Business Builds provides capital reimbursement grants to businesses making climate-friendly investments in facilities and equipment. The Climatetech Tax Incentive Program offers tax credits to companies creating new jobs and / or investing in facilities that meet eligibility criteria.

The MassCEC programs shown in Figure 7 below provide further detail on resources that are particularly relevant to early- and growth- stage climatetech businesses.

Note: "TRL" refers to Technology Readiness Level.

MassCEC 2030 Fund • *Max Award*: **$200,000 - $500,000** • *Award Type*: **Equity investment** • *Profile*: **Seed & early-stage** climatetech startups • *Annual Timing*: Rolling	**MassCEC AmplifyMass** • *Max Award*: **$300,000** • *Award Type*: **Grant** / adder to prime award (federal or non-federal) • *Profile*: Climatetech startups or academic researchers at **TRL 2-8** • *Annual Timing*: Annual	**MassCEC InnovateMass** • *Max Award*: **$350,000**, plus technical support to accelerate commercialization • *Award Type*: **Grant** • *Profile*: Climatetech startups at **TRL 5-8** • *Annual Timing*: Three Rounds
MassCEC Catalyst & DICES • *Max Award*: **$75,000** • *Award Type*: **Grant** • *Profile*: Early-stage startups (**TRL 2-4**) or academic researchers • *Annual Timing*: Two Rounds (Jan-Mar, Aug-Sep)	**MassCEC Climatetech Tax Incentives Program** • *Max Award*: Up to **$20,000** per job or up to **50%** of facility upgrades, dependent on lease / own structure • *Profile*: Climatetech cos. • *Annual Timing*: One Round (Dec-Feb)	**MassCEC CriticalMass** • *Max Award*: **$1,000,000**, plus services and partnerships • *Award Type*: **Grant** • *Profile*: Growth-stage (**TRL 8+**) climatetech startups • *Annual Timing*: One Round (Jul-Sep)

Figure 7: Subset of MassCEC programs and incentives

Businesses can explore state resources through the Massachusetts **Business Front Door**, a platform to connect with Team MA partners and receive tailored guidance on relevant programs.

Illustrative examples of how low EC tech businesses might utilize these programs include:

- *MassDevelopment Emerging Tech Fund* – This program offers loans to technology companies for expansion, working capital, or equipment purchases. This could help a growth-stage EC business interested in setting up manufacturing operations.

- *MassCEC InnovateMass* – This program provides grant funding and technical support to climatetech startups (TRL 5-8) applying with one or more demonstration project partners. This could help accelerate commercialization and bridge the "valley of death" for EC businesses approaching this critical inflection point.

- *MassCEC CriticalMass Program* – This program provides grant funding, specialized services, and partner matchmaking to growth-stage climatetech startups with a strong track record of successful demonstration projects interested in deploying TRL 8+ innovations in Massachusetts. This may be of particular interest to EC companies transitioning from pilot projects to commercial deployments.

Fostering User Acceptance: Programs such as, CriticalMass, directly address challenges around user adoption through partner matchmaking. Additionally, a Mass Timber Accelerator Program is planned for spring 2026 (run by MassCEC with partner organizations) that will provide technical assistance to projects that replace steel and concrete structural materials, reduce time to build, and improve information about forestry practices of harvested wood.

Navigating Site Needs: Beyond funding, Team MA partners also offer tailored advising services to address specific site needs, such as, site and building selection services through MassEcon, and a dedicated Permitting Ombudsperson in the Executive Office of Economic Development to serve as a key point of contact and liaison for businesses through state and municipal permitting processes.

Improving Concrete Climate Impact Transparency: MassCEC offers a grant program for Massachusetts ready-mix concrete producers to help offset the costs of software and third-party verification needed to provide EPDs for their concrete mixes. More than half of the Commonwealth's ready-mix concrete producers have already participated. The program will continue to support concrete companies while building market demand for lower emission concrete.

Possible Opportunities to Explore

While current offerings address many of the sector's challenges (capital, operating costs, user acceptance, and site needs), there may be opportunities to explore further catalytic support for innovative low EC technologies and to help traditional materials manufacturers comply with reporting requirements and meet thresholds. To support the production of EPDs, the state should consider expanding EPD grant programs beyond concrete to other material classes where EPD production is limited and there is in-state material production.

To support innovative technologies, there are opportunities to explore ideas raised during the ECICC's "Low Embodied Carbon Tech Roundtable," including: purchase guarantees and long-term purchase agreements, pilot projects to demonstrate tech viability with potential to ramp into offtake agreements, trusted centralized testing methods, shared real estate infrastructure or plant facilities, pre-permitted ready sites, and regional cooperation among states. The Commonwealth should continue to keep open dialogues with industry, both in the traditional manufacturing sector and innovative technology companies.

PART VI — Regulatory Alignment for the Broader Market

Recommendation 9: Building Code

Recommendation

All of the preceding recommendations focus on Commonwealth-managed construction projects or state-led initiatives. However, the Council is also charged with considering how to best approach incorporating EC into the Massachusetts building code. The Massachusetts building codes regulate new building construction and renovations, which offer an opportunity to decrease EC emissions across the Commonwealth, both in public and private building construction. The Board of Building Regulations and Standards (BBRS) is the body responsible for developing standards and requirements for the core set of Massachusetts building codes, covering structural, mechanical and a host of other code sections. Including EC measures in the base building code, whether incentive- or compliance-based, has the potential to drive real market transformation and promote lower-carbon construction industry-wide.

Short-term

- BBRS should incorporate energy efficiency credits for low carbon concrete and insulation into the base state building code;[45]
- DOER should consider aligning thresholds for low GWP concrete in stretch and specialized energy codes with these recommendations in future updates.

Long-term

In consultation with the TAC, the BBRS should determine the appropriate timeline to adopt base building code provisions aimed at reducing EC, with multiple paths to achieving compliance. Such an approach would allow compliance either through:

- Reusing a percentage, for example, forty to sixty percent of a building's structure and enclosure;
- Conducting a WBLCA with a demonstrated percentage reduction in EC from a theoretical baseline project and/or an absolute benchmark; or
- Submitting EPDs for required materials which meet the required thresholds for GWP limits.

[45] The 11th edition of this code is under development, with BBRS anticipating finalizing it in 2028.

Discussion

The BBRS codes are complemented by Specialized codes covering plumbing, fire prevention, electrical and energy among others, which are addressed by other boards and agencies. Section 43 of the 2024 Climate Law that established the Council also amended the "duties and powers" of the BBRS by adding the term "reduction in embodied carbon." With this addition, the first clause in the BBRS' "duties and powers" reads as follows:

> "Uniform standards and requirements for construction and construction materials, compatible with accepted standards of engineering and fire prevention practices, energy conservation, **energy efficiency, reductions in greenhouse gas emissions, reductions in embodied carbon,** and public safety." *(additions in bold)*

This provides a clear mandate for the BBRS to include provisions across its building codes to reduce EC emissions in construction.

Appendices

Appendix A – S.2967 § 4, 193rd (Massachusetts, 2023 - 2024)

SECTION 4. [*Section 30 of chapter 7C of the General Laws, as appearing in the 2022 Official Edition*] is hereby further amended by adding the following section:-

Section 73. (a) As used in this section, the following words shall have the following meanings unless the context clearly requires otherwise:-

“Division”, the division of capital asset management and maintenance.

“Environmental product declaration” or “EPD”, an independently verified and registered declaration that provides a life cycle assessment of a product’s global warming potential and facilitates a comparison of environmental impacts between products fulfilling the same function; provided, however, that such declaration shall be a Type III or higher as defined by theInternational Organization for Standardization (ISO), 14025:2006, or substantially similar life cycle assessment and comparative methodologies that have uniform standards in data collection and scientific integrity, and any pertinent product category rule developed in conformance with ISO 14025:2006.

“Global warming potential”, a numeric value that measures the total contribution to global warming from the emission of greenhouse gasses or the elimination of greenhouse gas sinks.

“Life cycle assessment” or “LCA”, an assessment used to calculate the environmental 31 primary and secondary impacts of a product, service or process over the lifetime of such product, service or process.

“Low-embodied carbon material”, material used in building and construction that has been verified by the division to embody carbon emissions that are sufficiently low, based on a threshold set by the division, as compared to the embodied carbon emissions of a conventional material fulfilling the same function.

(b) There shall be within the division, but not subject to the control of the division, an embodied carbon intergovernmental coordinating council. The council shall consist of:

the commissioner of capital asset management and maintenance or a designee, who shall serve as co-chair; the climate chief or equivalent climate official within the office of the governor or a designee, who shall serve as co-chair; the secretary of energy and environmental affairs or a designee; the secretary of transportation or a designee; the secretary of housing and livable communities or a designee; the secretary of administration and finance or a designee; the secretary of economic development or a designee; the chief executive officer of the Massachusetts Port Authority or a designee; the general manager of the Massachusetts Bay Transportation Authority or a designee; the chief executive officer of the Massachusetts clean energy technology center or a designee; the chair of the board of building regulations and standards or a designee; the chairs of the joint committee on telecommunications, utilities and energy or their designees and the house and senate minority leaders or their designees, who shall serve as nonvoting members with respect to any spending matters; and 5 persons who shall be appointed by the governor, 1 of whom shall be a representative of the building trades, 1 of whom shall be a general contractor, 1 of whom shall be a licensed architect with expertise in using low embodied carbon materials of construction, 1 of whom shall be a structural engineer who shall be a licensed professional engineer with expertise in using low-embodied carbon materials of construction, and 1 of whom shall be the executive director of a regional planning agency. The council shall not be a public body as defined in section 18 of chapter 30A; provided, however, that the council shall hold a public meeting not less than quarterly while the council is developing the plan pursuant to subsection (f).

(c) The council shall prepare an embodied carbon reduction plan, which shall include, but shall not be limited to, strategies to measure, monitor and reduce embodied carbon. The plan shall: (i) with respect to major building and transportation projects of executive offices, departments, divisions, centers, agencies and authorities of state and municipal governments, include, but not be limited to, steps to encourage and, where appropriate, recommend requiring: (a) environmental product declarations for construction materials commonly used in such projects; and (b) the use of low-embodied carbon materials, with particular attention to cement and concrete mixtures, steel, glass, asphalt and asphalt mixtures and wood, in such projects; (ii) review progress in research, development and commercialization of low-embodied carbon technologies and materials in the government, private and nonprofit sectors within and outside of the commonwealth; (iii) make recommendations for establishing a process to set, on or before January 1, 2026, maximum global warming potential values for products likely to be used in such building and transportation projects including, but not limited to, cement and concrete mixtures, steel, glass, asphalt and asphalt mixtures and wood; (iv) develop recommended procedures for the use of: (a) EPDs in state government contracting and procurement; and (b) low-embodied carbon materials in the commonwealth, where available and at reasonable cost, including conditions under which waivers may be obtained; (v) examine current laws, regulations, policies and guidelines that affect the use of EPDs and low-embodied carbon materials in the private and nonprofit sectors and recommend laws, regulations, policies or guidelines to increase the use of EPDs and low-embodied carbon materials; and (vi) consider interactions between embodied carbon and operational carbon to ensure policy recommendations to reduce embodied carbon will also contribute to the reduction of operational carbon. The council shall consider: (i) the best approaches to integrate the reduction of embodied carbon into the state building code, including the stretch and specialized stretch energy code pursuant to section 96 of chapter 143 and the state building code; and (ii) best practices to incentivize and enhance the reuse of building materials and decrease building demolition.

(d) The council shall meet regularly and seek data, input and advice related to EPDs and low-embodied carbon materials from stakeholders, which shall include, but not be limited to, companies, contractors and subcontractors involved in construction, architecture, engineering, design and procurement and organizations and associations of such companies, contractors and subcontractors, academic and nonprofit institutions with relevant missions and activities, labor organizations involved in construction and transportation, organizations focused on environmental, energy and climate policy and perspectives and groups representing consumers, including, but not limited to, low income consumers. The council shall hold not less than 3 public hearings in geographically diverse areas of the commonwealth prior to finalizing the plan.

(e) The division and the executive office of energy and environmental affairs shall provide administrative support to the council.

(f) The council shall update the plan and submit the updated plan and a progress report at least every 2 years to the senate and house committees on ways and means, the joint committee on state administration and regulatory oversight and the joint committee on telecommunications, utilities and energy and shall cause the plan and the report to be publicly available on the website of each cabinet official, executive office, department, division, center, agency and authority represented on the council.

Appendix B – DCAMM Embodied Carbon in Construction Decision & Impact Matrix, Illustrative Draft

Project Stage	Key Decisions	Who Makes or Influences Decision	Impact on Embodied Carbon	Beneficial Choices	Tools to Influence Decision
Initial Project Discussion	Does the functional need require a capital project?	Agency Leaders, DCAMM Planners	Capital projects all involve embodied carbon emissions	Avoid unnecessary capital project	Policies and standards to guide planning decisions
	What size facility is required?	Agency Leaders, DCAMM Planners, Designer	Scale of project directly relates to level of emissions	Minimize SF of project area	Policies that standardize and formalize goals of maximizing space efficiency
Option Development & Evaluation	Renovate/reuse existing facility or build new?	Agency Leaders, DCAMM Planners, Designer	Reuse and renovation avoids embodied carbon	Maximize reuse options	Policies and standards to guide planning decisions
Scoping of Recommended Solution	Establish project-scale life cycle carbon budget or limit	DCAMM, Designer	Ensures that carbon emissions inform project design decisions	Carbon budget limits can be phased in to align with policy objectives and practical considerations	Policies, standards, or requirements in statute, executive order, or codes
	Define size of facility or work area	Agency Leaders, DCAMM Planners, Designer	Scale of project directly relates to level of emissions	Minimize SF of project area	Policies that standardize and formalize goals of maximizing space efficiency
	Consider reuse of existing facilities	Agency Leaders, DCAMM Planners, Designer	Reuse and renovation avoids embodied carbon	Maximize reuse options	Policies and standards to guide planning decisions

Project Stage	Key Decisions	Who Makes or Influences Decision	Impact on Embodied Carbon	Beneficial Choices	Tools to Influence Decision
Scoping of Recommended Solution (cont.)	Define design life of facility	DCAMM, Designer	Design life impacts timing of significant spike in embodied carbon emissions from replacement	Increasing design life delays future embodied carbon emissions peaks	Policies and standards to guide planning and design
	What structural system will be used?	DCAMM, Designer	Structural materials tend to have among the highest GWP among construction materials and options vary considerably	Select lower GWP solutions that use renewable and carbon absorptive materials; reduce volumes of structural materials overall	Policies and standards to guide planning and design
Design Development & Construction Document Preparation	Minimize necessary material volume	DCAMM, Designer	Material volume, particularly for high GWP materials, directly impacts embodied carbon emissions	Revise standard agency specifications to eliminate unnecessary requirements that trigger excess material use; incorporate project-specific design choices to lower material use	Policies and standards to guide design decisions and specifications

Project Stage	Key Decisions	Who Makes or Influences Decision	Impact on Embodied Carbon	Beneficial Choices	Tools to Influence Decision
Design Development & Construction Document Preparation (cont.)	Specify low GWP materials, incl. concrete	DCAMM, Designer	Material content can influence carbon emissions for high-GWP materials like concrete and steel	Establish and phase in targets to lower maximum carbon emissions from materials with high GWP content (including concrete and steel); incorporate lower GWP targets into project specifications	Policies, standards, or requirements in statute, executive order, or codes
	Design and detail for deconstruction & salvage	DCAMM, Designer	Design specifications for construction assemblies, connection mechanisms, and details can influence the ease and viability of material salvage for reuse when the facility reaches end of life	Design for disassembly including the use of removable fastening systems; avoid unnecessary adhesives and hazardous materials	Policies and standards to guide design decisions and specifications
	Specify reuse of materials	DCAMM, Designer	Designs can incorporate salvaged material content, both as reused assembled materials and by requiring post-consumer recycled content in new materials (including backfills, insulation materials, etc.)	Maximizing specification of reused materials and material feedstocks avoids embodied carbon from material extraction and manufacture.	Policies and standards to guide design decisions and specifications
	Specify low-carbon concrete	DCAMM, Designer			

Project Stage	Key Decisions	Who Makes or Influences Decision	Impact on Embodied Carbon	Beneficial Choices	Tools to Influence Decision
Contractor Selection/Bidding	Specifying and selection of subcontractors with capability to deliver low GWP materials, particularly concrete subs/plants	Prime Contractor, Statutory Bidding Process (Filed Sub-bid trades), Designer, DCAMM	Particularly for high-GWP materials like concrete and steel, different suppliers employ different sourcing of component materials and different manufacturing processes that require different levels of carbon emissions	Awarding authority can establish standard specification for GWP limits in material content and production methods; Designers can establish similar limits in project specifications; prime contractor can choose suppliers and non-filed sub-trade subcontractors to minimize GWP	Policies and standards to guide project specifications and requirements
Construction	Review of materials submittals for compliance with specifications	Prime Contractor, Designer	Contractors and suppliers submit material selections to designer for review and approval for compliance with agency and project-specific specifications (including those designed to lower GWP) before procuring and installing	Designer should ensure compliance by rejecting submittals that don't meet specified requirements	Policies and standards to guide design decisions and specifications

Project Stage	Key Decisions	Who Makes or Influences Decision	Impact on Embodied Carbon	Beneficial Choices	Tools to Influence Decision
Construction (Cont.)	Specifying and sourcing of materials relative to GWP in fabrication	Prime Contractor, Designer	Particularly for high-GWP materials like concrete and steel, different suppliers employ different sourcing of component materials and different manufacturing processes that require different levels of carbon emissions	Awarding authority can establish standard specification for material sourcing relative to carbon emissions; Designers can establish similar limits in project specifications; prime contractor can choose suppliers and non-filed sub-trade subcontractors to minimize GWP	Policies and standards to guide project specifications and requirements
	Specifying and sourcing of materials relative to transportation distances	Prime Contractor, Designer	Particularly for materials that are heavy or otherwise difficult to transport, transportation distance between source locations and construction sites can significantly impact embodied carbon emissions	Awarding authority can establish standard specification for GWP limits in material content and production methods; Designers can establish similar limits in project specifications; prime contractor can choose suppliers to minimize GWP (and cost) associated with materials transportation	Policies and standards to guide project specifications and requirements
Facility Operation & Maintenance					

Project Stage	Key Decisions	Who Makes or Influences Decision	Impact on Embodied Carbon	Beneficial Choices	Tools to Influence Decision
End of Life	Renovate/reuse or demolish	Agency Leaders, DCAMM	Decision about future of the facility once original user no longer needs it can result in varying levels of avoided embodied carbon emissions from future projects.	Renovation and reuse of any surplus facilities, by the Commonwealth or by others following disposition, can avoid embodied carbon if this is done in lieu of new construction.	Policies and standards to guide planning decisions
Deconstruction	If not reused, deconstruction vs. demolition	DCAMM	If removal of the facility proves warranted, the level of deconstruction and material salvage can impact embodied carbon emissions avoidance.	Maximizing deconstruction and salvage of materials for reuse in their current form or as feedstock for fabrication of new materials can eliminate embodied carbon associated with the production and use of new materials.	Policies and standards to guide design decisions and specifications

Appendix C – Material Category Definitions

All Materials:

- System Boundary: LCA stages A1 – A3

Concrete

- Industry Average EPD source: NRMCA regional average (e.g., Eastern Region or appropriate national baseline)
- Includes ready-mix, self-consolidating concrete, lightweight concrete
- Industry-average values used for BPA calculation

Structural Steel

- EPD source: AISC national average
- BOF/EAF weighted average
- Includes shapes, plate, hot-rolled members

Steel Reinforcement

- EPD source: Concrete Reinforcing Steel Institute (CRSI) or mill-specific averages
- EAF-based rebar production

Appendix D – Material Quantity (MQ) Reporting Schema

D.1 Purpose and Principles

This Appendix defines a simple, standardized schema for reporting Material Quantities (MQ) at project closeout. The schema is designed to:

- Minimize reporting burden for contractors;
- Align with how materials are commonly procured and tracked;
- Be compatible with the GWP threshold framework; and
- Support basic benchmarking by material type and use.

Contractors shall submit MQ data where each row represents a unique combination of:

- Project,
- Material category, and

- Subcategory fields (e.g., strength class, shape type, element type).

All quantities must reflect actual materials procured and installed.

D.2 Common Fields (All Materials)

All MQ submissions should use the following core fields:

Field Name	Description	Example
Project_ID	Unique project identifier (assigned by agency)	DCAMM-2029-001
Agency	Contracting Agency	MassDOT
Contract_ID	Prime contract identifier	781234
Material_Category	One of: Concrete, Precast Concrete, Structural Steel, Steel Reinforcement, Timber, Asphalt Mixtures	Concrete
Subcategory_1	Material-specific field (see D.3)	4 ksi
Subcategory_2	Material-specific field (see D.3)	Superstructure
Quantity	Total quantity for this category combination	1,250
Unit	Native unit for the material (see D.3)	Cubic Yards
Notes (optional)	Optional clarifying information	Includes podum levels 2-4

Additional optional fields (e.g., supplier name, EPD_ID) may be added by agencies but are not required under this schema.

D.3 Material-Specific Schema

D.3.1 Concrete (Cast-in-Place)

Goal: Keep concrete organized by strength class and broad location in the structure.

- Material_Category: Concrete
- Subcategory_1 (Strength Class):
- Report as a labeled strength “bucket”: e.g., 3 ksi, 4 ksi, 5 ksi, 6 ksi, >6 ksi
- Subcategory_2 (Location):
- One of: Foundation, Substructure, Superstructure, Sitework
- Unit: cubic yards (preferred) or cubic meters (if metric is used consistently on the project)

Project_ID	Material_Category	Subcategory_1	Subcategory_2	Quantity	Unit
DCAMM-2029-001	Concrete	4 ksi	Foundation	900	Cubic yards
DCAMM-2029-001	Concrete	5 ksi	Superstructure	1,250	Cubic yards

D.3.2 Precast Concrete

Goal: Group precast by element type, not by mix design.

- Material_Category: Precast Concrete
- Subcategory_1 (Element Type):
- Examples: Double Tee, Beam, Column, Wall Panel, Spandrel, Barrier
- Subcategory_2 (Location/Use):
- Optional but recommended: Building, Bridge, Barrier, Other
- Unit: cubic yards (volume) or tons (mass), depending on how the precast is tracked. Choose one and apply consistently per project.

Example row:

Project_ID	Material_Category	Subcategory_1	Subcategory_2	Quantity	Unit
MassDOT-2030-015	Precast Concrete	Barrier	Bridge	120	Tons

D.3.3 Structural Steel

Goal: Keep it very simple: by shape family.

- Material_Category: Structural Steel
- Subcategory_1 (Shape Family):
- One of: W-Shape, HSS, Channel/Angle, Plate, Other Rolled Shapes
- Subcategory_2:
- Optional (e.g., Building, Bridge, Tower), or left blank
- Unit: tons

Example row:

Project_ID	Material_Category	Subcategory_1	Subcategory_2	Quantity	Unit
DCAMM-2029-001	Structural Steel	W-Shape	Building	450	tons
DCAMM-2029-001	Structural Steel	HSS	Building	75	tons
MassDOT-2030-015	Structural Steel	Plate	Bridge	60	tons

D.3.4 Steel Reinforcement (Rebar)

Goal: Organize by bar size (and optionally coating type), since that is how quantities are typically tracked.

- Material_Category: Steel Reinforcement
- Subcategory_1 (Bar Size):
- e.g., #4, #5, #6, #8, #10, Mesh
- Subcategory_2 (Coating Type):
- e.g., Black, Epoxy-Coated, Galvanized, Stainless
- Unit: tons

Example row:

Project_ID	Material_Category	Subcategory_1	Subcategory_2	Quantity	Unit
MassDOT-2030-015	Steel Reinforcement	#5	Epoxy-Coated	85	tons

D.3.6 Asphalt Mixtures

Goal: Keep this as simple as possible: asphalt is just asphalt, with an optional layer type.

- Material_Category: Asphalt Mixtures
- Subcategory_1 (Layer Type) – Optional:
- e.g., Surface, Base/Binder, Other
- If agencies prefer, this field can be left blank and all asphalt reported in aggregate.
- Subcategory_2:
- Optional; may be left blank
- Unit:
- Preferred: tons (mass) or square yards with assumed thickness defined separately

Example row:

Project_ID	Material_Category	Subcategory_1	Subcategory_2	Quantity	Unit
MassDOT-2030-015	Asphalt Mixtures	Surface		6,400	tons

Appendix E – Future Target ρ-Values for 2035 and 2050

The 2035 and 2050 ρ-values establish the long-term decarbonization trajectory for construction materials used in Massachusetts. These future targets are intentionally set at levels that reflect both the technical potential of the materials industries and the time required for large-scale supply-chain transformation. The 2035 values represent a significant but achievable reduction—generally in the range of 25–35% below today's industry-average GWP—for materials such as concrete, precast concrete, structural steel, reinforcing steel, and asphalt mixtures. These values align with published decarbonization roadmaps from the cement, steel, and asphalt industries, which anticipate substantial emissions reductions by the early-to-mid 2030s through improved manufacturing efficiency, lower-carbon raw materials, increased supplementary cementitious materials, electrification, improved mix design, and expanded use of recycled content.

The 2050 ρ-values represent deep physical decarbonization consistent with global and national "net-zero" pathways. These values are intentionally set at levels reflecting substantial reductions in process emissions and supply-chain impacts—typically 50 to 70 percent below today's baseline for most materials. The 2050 targets do not require zero GWP in the materials themselves but instead represent the EC performance expected from fully decarbonized material production systems.

By defining intermediate targets for 2035 and long-term targets for 2050, Massachusetts provides suppliers, designers, and public agencies with the necessary planning horizon to modernize manufacturing processes, update specifications, transition procurement practices, and scale the technologies required for deep decarbonization. These targets also prevent backloading all emissions reductions into the final years of the transition and instead promote consistent, achievable progress across the full 2028–2050 period.

Material Category	**Construction Type**	**2028 (Initial)**	**2035 (Intermediate Target)**	**2050 (Long-Term Target)**
Asphalt Mixtures	Infrastructure / Horizontal	1.15	0.95	0.50
Concrete	Buildings / Vertical	0.95	0.75	0.30
	Infrastructure / Horizontal	1.15	0.95	0.50

Steel Reinforcement	Buildings + Infrastructure	0.95	0.80	0.35
Structural Steel	Buildings + Infrastructure	0.95	0.80	0.35

Table 7: Example Future Maximum Allowable GWP Multipliers (ρ-Values) for 2035 and 2050

Notes:

- **2035 ρ-values represent a 25–35% reduction relative to today's industry-average GWP.**
  These values align with published decarbonization pathways for concrete, steel, and asphalt mixtures, which project substantial emissions reductions by the early 2030s through increased SCM use, improved plant efficiency, lower-carbon fuels, higher recycled content, and early adoption of carbon capture and clean energy.
- **2050 ρ-values represent deep physical decarbonization of material supply chains.**
  These values reflect the expected performance of near-zero concrete, lower-carbon steelmaking (EAF with renewable electricity and green hydrogen), and advanced asphalt technologies. While residual emissions may remain in 2050, the physical GWP performance of materials is expected to fall by 50–70% relative to today.
- **2050 targets do not require literal zero GWP in the materials themselves.**
  Instead, they define the EC performance level that decarbonized material systems are expected to achieve by 2050. True net-zero outcomes will likely involve a combination of low-carbon production, carbon capture, alternative binders, renewable energy, and limited offsetting or carbon removal.

Appendix F – Required Scope for WBLCA

Unless otherwise specified, WBLCA analysis on projects subject to requirements should include, at a minimum, **above and below-grade structure and enclosure** and should assume a **60-year service life**. Projects should report total embodied carbon (kgCO2e) and normalized per gross floor area in units of embodied carbon intensity (ECI).

The analysis should at a minimum cover the following lifecycle phases:

Phase	Analysis scope	Data required
Before use		

A1–3 Production stage	Included	Project-specific inventory
A4 Transport	Included	Project-specific inventory or proxy values
A5 Construction	Included	Project-specific inventory or proxy values
During use		
B1 Use of products	Optional	Proxy values
B2 Maintenance	Optional	Proxy values
B3–4 Repairs and replacements	B3 Repairs Optional; B4 Replacement included	Proxy values
B5 Refurbishment	Optional	Proxy values
B6 Operational energy use	Not included (separate analysis)	
After use		
C1 Demolition work	Optional	Proxy values
C2 Transport	Included	Proxy values
C3 Waste processing	Included	Proxy values
C4 Disposal	Included	Proxy values