Literature Research and Analysis Implementation of Buy Clean Programs

Maryland Buy Clean Technical Assistance

MARYLAND DEPARTMENT OF GENERAL SERVICES | MARYLAND GREEN BUILDING COUNCIL
US CLIMATE ALLIANCE PROJECT (C-20435) | PREPARED BY GREENPLUM STREET LLC

Maryland
DEPARTMENT OF GENERAL SERVICES

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PURPOSE

Research and analysis of federal and state Buy Clean for cement and concrete programs.

SCOPE

Buy Clean or embodied carbon reduction policies are approaches that has been applied at the federal, state, or local level and also used by some private developers. In the initial literature review search, there are a substantial number of potential sources which have collected and mapped existing Buy Clean programs both in the US and internationally. Many offer guidance on the *adoption* of procurement policies or manufacturer *solutions* to low embodied carbon cement or concrete. This Maryland Buy Clean Study (Study) will focus on the successful *implementation* of Buy Clean policies required per the Procurement of Construction Materials Act (HB 261) of 2023.

FOCUS ISSUES

Procurement policies leverage the purchasing power of governments to standardize embodied carbon emissions reporting and reward companies doing their part to reduce emissions. Now that the Maryland policy is in place, the work of the Department of General Services (DGS) commences to implement the policy. This Study will focus on key implementation elements of the Procurement of Construction Materials Act (HB 261) for a successful realization of the policy:

1. [4-903 (A1)] Producers of eligible material [cement and concrete] to submit Environmental Product Declarations (EPD) to the department or [4-904 (B2)] similarly robust life cycle assessment (LCA) method that includes uniform standards in data collection.
2. [4-905 (A2)] Obstacles the Department, Bidders or Offerers have encountered in identifying and quantifying embodied carbon in building materials.
3. [4-905 (B)] Method that the Department used to develop Maximum Global Warming Potential for each category of eligible material [cement and concrete].

METHODOLOGY

References from specialist users (ACI, ASHRAE, CLF, GCCA, IPCC, MIT, NRMCA, PCA, RMI, USGBC) were searched as well as the official governmental or agency sites (CA, CO, EPA, GSA, Marin County, MN, MA, MD, Portland, NJ, NY, OR, TX, WA). Relevant papers were also taken and inspected from reference lists. The following search terms in Google were used to initially identify publications: 'Buy Clean', 'green procurement', 'environmental product declaration', 'life cycle assessment', 'decarbonization', 'concrete', 'cement', 'IRA', 'concrete standard', 'LEED', 'Green Globes', 'low-carbon materials', 'embodied carbon', and 'green procurement'. Further keywords were employed in reaction to cited papers in order to extend the search.

The criteria for inclusion in the review were are follows: articles and research papers that consisted of Buy Clean policies, codes, standards, research, legislation, environmental data-analysis, performance of legislative actions, empirical data that could be used referring to policies implemented at comparable levels to Maryland Buy Clean. The date range was taken from the last 10 years to include most relevant and up-to-date sampling. Exclusions applied to articles concerning Buy Clean adoption, proposed decarbonization policies not adopted, blog and editorials for opinion purposes. Only papers that employed comparative studies that can be web linked and downloaded are included in Endnotes. Interviews and discussions with Katie Poss, Building Transparency; Diane Warner, NW Cement Council; Matthew Lemay, NRMCA; Lionel Lemay, NRMCA; Bruce Chattin, WACA; Mariane Jang, NYS OGS provided valuable insight and were welcomed inclusions.

EXECUTIVE SUMMARY

Buy Clean is a policy mechanism by which governments seek to reduce the environmental impact of construction material supply chains by establishing emissions disclosure and performance standards for key product categories. The federal government, several states and local jurisdictions have enacted similar Buy Clean laws to transform the marketplace. Maryland's governor signed the *Eligible Projects – Procurement of Construction Materials* bill (Buy Clean Maryland Act) into law in 2023 and has committed the state to prioritize efforts that support the procurement of lower-carbon infrastructure materials in state-funded projects. With cement and concrete's carbon emissions from building construction in the United States representing a significant contribution annually, "eligible" low carbon materials in the Act addresses the emissions of these materials used for capital projects.

The tool to communicate transparent information about the life-cycle environmental impact of products is an Environmental Product Declaration (EPD) based on a product's Life Cycle Assessment (LCA). The Act requires bidders to submit EPDs of cement or concrete mixture used in the construction of an eligible project to the Maryland Department of General Services (DGS) by December 31, 2024; and require the DGS to establish a maximum acceptable global warming potential for eligible materials by January 1, 2026. Given these requirements, this Study focuses on key implementation opportunities for a successful realization of the policy.

The use of EPDs to communicate environmental impacts is not new. Voluntary green rating systems and mandatory codes and standards have required the submission of EPDs for products delivered to the project site for the past decade. The US Green Building Council's LEED rating system, the Living Building Challenge and GBI Green Globes have material transparency requirements. These voluntary actions have already been regularly utilized by private organizations such as Apple, Google, Amazon, CalPERS and others to address their supply chain emissions as part of company policy when constructing new buildings. Similarly, building codes and standards are starting to consider embodied carbon in addition to operational energy performance as a means to address public safety in construction projects. ASHRAE 189.1/International Green Construction Code, California Green Building Code and the American Concrete Institute are setting minimum life safety standards for embodied carbon of concrete materials. These measures typically come in the form of collection of permanently installed products sourced from different manufacturers and/or reduction of environmental impacts as compared to an equivalent baseline.

Several jurisdictions have implemented Buy Clean policies with varying degrees of success. Each Buy Clean policy has a different scope, regulatory framework, incentives, and mechanisms for implementation. Many policies require agencies to consider the embodied carbon emissions of industrial "eligible materials" – concrete, structural steel, carbon steel rebar, flat glass and/or mineral wool board insulation – while others solely focus on cement and/or concrete. The Buy Clean policies emphasize reducing its global warming potential (GWP), specifically the cradle-to-gate embodied carbon impact, using EPDs.

The Buy Clean California Act was the first procurement legislation to incentivize manufacturers to produce fewer emissions to compete for state projects. Cement was included in the original bill but was amended out of the final law. Nevertheless, there are key takeaways from the implementation of the Act regulating other eligible materials that are worth noting. This include understanding the unique nature of each material's supply chain; improved education for both the applicants and the awarding authority; and allowing exclusions and waivers to support measured adoption. Marin County, California and Portland, Oregon did not wait for their respective states to implement Buy Clean before adopting their own policies. These local jurisdictions took a year or more to collect concrete usage data and stakeholder feedback before determining the GWP threshold (limits) values. New York and Colorado took a similar phased approach and considered industry benchmarks to set limits. Like Maryland's EPD Assistance Fund, Minnesota, New Jersey and Oregon assisted manufacturers in mitigating the cost burden of developing EPD. Exclusive to Minnesota and Washington, both address labor conditions along with emissions data. In almost all case, providing model specification, incentivizing compliance, and providing accessible training and compliance guidance are recommended actions for the successful implementation of Buy Clean.

PART I INTRODUCTION

Section 1.1 MARYLAND BUY CLEAN

On April 4, 2023 Maryland Governor Wes Moore signed the *Eligible Projects – Procurement of Construction Materials* bill (Buy Clean Maryland Act) into law[i]. The Act instructs the Maryland Department of General Services (DGS) to assess the global warming potential (GWP) impact of each category of cement or concrete mixture used in the construction of a public project. Beginning **July 1, 2026**, state agencies would be required to specify in each solicitation for a government-funded construction project the cement or concrete mixture that would be used in the building materials and prioritize proposals with the lowest carbon (a.k.a. carbon dioxide) footprint. The Act will require bidders to submit environmental product declarations (EPDs) of cement or concrete mixture used in the construction of an eligible project to the DGS by **December 31, 2024**; require the DGS to establish a maximum acceptable global warming potential for certain categories of eligible materials by **January 1, 2026**; and establish an Environmental Product Declaration Assistance Fund to support the development of certain EPDs.

Buy Clean is a policy mechanism by which governments seek to reduce the environmental impact of construction material supply chains by establishing emissions disclosure and performance standards for key product categories. Four states, led by California, have enacted similar Buy Clean laws to transform the marketplace. In addition, Maryland joined other states- California, Colorado, Hawaii, Illinois, Maine, Massachusetts, Michigan, Minnesota, New Jersey, New York, Oregon, and Washington- as signatories to the Federal-State Buy Clean Partnership[ii], a collaborative initiative. These state governments have committed to seeking lower-carbon infrastructure materials, including concrete and steel, in state-funded projects. These states have committed to prioritize efforts that support the procurement of lower-carbon infrastructure materials in state-funded projects, and to collaborate with the federal government and one another to send a harmonized demand signal to the marketplace. The U.S. Climate Alliance is providing the availability of policy, technical, and analytical assistance to help participating members advance their state-level Buy Clean efforts.

These policies are the federal and states' responses to align with the landmark Paris Agreement. Signed on 22 April 2016 – Earth Day – at UN Headquarters in New York, the Paris Agreement brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. The central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to increase the ability of countries to deal with the impacts of climate change, and at making finance flows consistent with a low GHG emissions and climate-resilient pathway.

The Paris Agreement requires all Parties (signatory countries) to put forward their best efforts through "nationally determined contributions" (NDCs) and to strengthen these efforts in the years ahead. This includes requirements that all Parties report regularly on their emissions and on their implementation efforts. There will also be a global assessment every 5-years to assess the collective progress towards achieving the purpose of the agreement and to inform further individual actions by Parties.

Section 1.2 EMBODIED CARBON IN CONSTRUCTION MATERIALS

To realize the ambitions of the Paris Agreement all sectors of the economy must decarbonize. Currently, buildings account for 39% of energy related global CO_2 emissions[iii], demonstrating the importance of the building and construction sector in fulfilling these ambitions. Of this sector contribution, 28% comes from operational carbon with 11% arising from the energy used to produce building and construction materials[iv], usually referred to as embodied carbon. Most of a building's total embodied carbon is released **upfront** in the product stage at the beginning of a building's life. Unlike with operational carbon, there is no chance to decrease embodied carbon with updates in efficiency after the building is constructed[v].

The emissions from materials used to construct buildings and infrastructure, and those installed later during maintenance and renovation, represent a significant source of embodied carbon in the lifecycle of materials. Globally, cement and steel are two of the most important sources of material-related emissions in construction. **Cement manufacturing** is responsible for around 7% of global carbon emissions[vi], with steel also contributing 7-9% of the global total[vii] of which around half can be attributed to buildings and construction. Both cement and steel require very high temperatures during production, making them energy intensive and, in both cases, the chemical reactions that take place during manufacture also release carbon dioxide directly.

Globally, much of the energy for industrial heat is still supplied by fossil fuels such as coal, oil and gas, though waste and biofuels are increasingly used in some industries and in some parts of the world. Recent research shows that it is feasible to decarbonize these sectors[viii]. Global cement consumption is projected to increase by 12-23% by 2050[ix], while global steel production is forecast to grow by 30% over the same period, with recycled secondary steel growing faster than the primary production[x].

Upfront embodied carbon emissions from building construction in the United States is estimated at up to 370 million tons of CO_2e annually[xi]. At these levels, even small reductions in embodied emissions could prevent millions of tons of CO_2 emissions each year. These reductions can be achieved with design and material choices available today by leveraging material-efficient design, dematerialization, and readily available low embodied-carbon building materials. Transitions to clean, renewable energy will begin to accelerate the decarbonization of high-emitting material manufacturing sectors, and a wide range of emerging technologies show promise for dramatic reductions in emissions intensity. The building industry has a unique opportunity to become a key player in global carbon dioxide removal efforts using current and developing carbon-efficient materials.

Section 1.3 MARYLAND CLIMATE SOLUTIONS NOW ACT

In 2022, the Maryland General Assembly passed the Climate Solutions Now Act (CSNA)[xii], establishing the GHG reduction goals. Maryland is required to reduce statewide GHG emissions 60% from 2006 levels by 2031 and achieve net-zero emissions by 2045. For comparison, the U.S. has set national goals to reduce emissions 50% (compared to 2005 levels) by 2030, and to reach net-zero emissions by 2050. Net-zero emissions means that the total GHG emissions from Maryland's economy will be equal to the GHGs removed from the atmosphere through natural and technological systems annually. Maryland has already reduced GHG emissions faster than almost any other state, achieving a 30 percent reduction in statewide emissions from 2006 levels in 2020[xiii]. The Maryland Department of the Environment was required to develop a strategy to achieve the 2031 greenhouse emissions goal and stay on track to achieve net zero emissions by 2045. The Maryland's Climate Pollution Reduction Plan published 28 December 2023[xiv] outlines opportunities to implement a sustainable path where incentives are provided but are also practical and methodical. Key elements related to decarbonization of the building industry include but not limited to:

- State Incentives for Building Decarbonization- Provides substantial new funding for projects that improve energy efficiency and reduce emissions from residential, commercial, and institutional buildings statewide

- Buy Clean - Requires producers of cement and concrete mixtures to submit EPDs to the state and for the state to establish a maximum acceptable global warming potential values for each category of eligible materials.
- State Incentives for Industrial Decarbonization - Supports decarbonization activities in Maryland's industrial sector.
- Sustainable Materials Management - Sets goals for GHG emissions reductions, material-specific recycling rates, and overall statewide recycling and waste diversion rates.

Until recently, emissions reductions in the building sector have focused on the building's operational phase – improving energy efficiency to reduce operational carbon emissions. While these are necessary efforts, they do not cover all building sector-related emissions that need to and can be reduced. The existing building stock needs to be renovated, while new buildings need to be built with low-carbon materials, and according to the most climate-friendly practices. Accounting for these emissions requires robust measurements, verifiable disclosures, and reliable datasets.

Section 1.4 MEASUREMENT AND DISCLOSURE

Section 1.4.1 Definitions

- **Embodied carbon** refers to the GHG emissions arising from the manufacturing, transportation, installation, maintenance, and disposal of building materials. In contrast, operational carbon refers to the GHG emissions due to building energy consumption.
- An **Environmental Product Declaration (EPD)**[xv] is a report that discloses a product's environmental impact as determined by a life cycle assessment (LCA) and has been independently verified to be in accordance with ISO 14025 – Type III environmental declarations – Principles and procedures.
- **ISO 14025**[xvi] specifies the principles and procedures for the development of Type III environmental declarations.
- **ISO 14040**[xvii] **and 14044**[xviii] specify the principles, framework, and requirements for conducting a life cycle assessment.
- **ISO 21930**[xix] specifies the requirements to develop EPDs for construction products and services.
- A **life cycle assessment (LCA)**[xx] is a study to determine the environmental impact of a product, process, or service over its life cycle.
- A **product category rule (PCR)**[xxi] is a set of rules, requirements and guidelines used to develop an EPD for a product group.
- A **program operator (EPD PO)**[xxii] is an independent party that operates an EPD development program are responsible for identifying and creating the PCRs for EPDs.
- **Greenhouse gases (GHGs)** are those that trap heat in the earth's atmosphere. Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs) are types of GHGs[xxiii]. While all GHGs have the effect of trapping heat, each gas has a different amount of impact.
- **Global Warming Potential (GWP)**[xxiv] is an index used to determine the energy absorption caused by the emission of different gases associated with a product, normalized to an equivalent mass of carbon dioxide over a period of 100 years. It quantifies various gaseous emissions that contribute to global temperature rise and expressed as CO_2-equivalent (CO_2e) in units of kg for the declared unit volume of 1 cubic meter (m^3).

Section 1.4.2 Environmental Product Declarations (EPD) are independently verified and registered documents that communicates transparent information about the life-cycle environmental impact of products. EPDs adhere to strict regulations and standards and are often valid for five years. EPDs are developed from an in-depth **LCA** of a material or product in accordance with a consensus-established **PCR** document. That is, LCAs are comprehensive environmental evaluations conducted according to

International Organization for Standardization (ISO) standards. Whereas EPDs are shorter, simpler, and verified versions of the LCA to make them easier to understand and communicate to stakeholders. Because EPDs are used by organizations for communication purposes, they do not contain sensitive company details or product information like the bill-of-materials (i.e., the product's exact recipe).

Section 1.4.3 Life Cycle Assessments (LCAs) that complies with standards in the ISO 14040 series and ISO 21930 are used to analyze and quantify the environmental impacts of a product, system, or process. This product LCA examines inputs of materials and energy and outputs of emissions, wastes, and products from raw material production to end-of-life. Environmental impact assessment tools use the total emissions and wastes to quantify the potential environmental impacts for a variety of characterization factors.

In North America, LCA practitioners conduct life-cycle impact assessments using the U.S. Environmental Protection Agency's (EPA) Tool for the Reduction and Assessment of Chemical and other environmental Impacts (TRACI)[xxv] methodology, which evaluates a product across a set of environmental impact categories. These typically include global warming potential (GWP), smog formation, ozone depletion, acidification, eutrophication, and possibly other impacts depending on the code/standard or entity (e.g. project specification or regulation) requiring EPDs. The primary impact of interest for Buy Clean reporting for **cement** and **concrete** in EPDs is GWP.

Section 1.4.4 Product Category Rules are developed for specific product categories and EPDs generated based on different PCRs should not be compared to assess environmental performance. PCRs offer calculation rules and guidelines to ensure comparability between EPDs within the same product category by following the same calculation methods and reporting guidelines (e.g., what environmental indicators to report on).

There are different PCRs established to develop EPDs for cement, ready-mixed concrete, precast concrete, concrete pipe, masonry block, and other construction materials and building products. EPDs for upstream materials used in concrete – cementitious materials, aggregates, and admixtures are available and used as input data to develop EPDs of concrete mixtures.

Section 1.4.5 Scope of EPDs[xxvi]

There are four life-cycle phases related to a project – manufacture of products, construction, use, and end-of life. The scope of an EPD will be based on the included life-cycle phases as follows:

- **Cradle-to-Gate**: Includes the impacts associated with upstream material extraction or manufacture (A1), transportation to production location (A2), and production of the product up to the gate of the location of manufacturer (A3). This is referred to as a Type III EPD representing life-cycle stages A1-A3 defined in European standard EN 15804. Most PCRs for construction products, including concrete, are developed for this scope of EPD.
- **Cradle-to-Site**: Includes the impacts of cradle-to-gate plus the transportation to the project site (stage A4) and construction (A5). The scope of this EPD covers impacts through the end of construction of a project.
- **Cradle-to-Grave**: Includes the impacts of cradle-to-site, plus the impacts associated with the use phase of a structures life-cycle: use (B1), maintenance (B2), repair (B3), replacement (B4), operational energy use (B6), and operational water use (B7); and the end-of-life phase: demolition (C1), transport of demolished material (C2), waste processing (C3), and disposal (C4). The scope of this EPD would be applicable to designers and can capture benefits of design and use of construction materials that result in reduced energy consumption and waste, and longer service life with reduced maintenance and repair through the use phase; and aspects such as carbonation that absorbs atmospheric CO_2 at the end-of-life stage.

Section 1.4.6 Types of EPDs

There are several types of EPDs that are publicly available:

- **Industrywide EPDs (IW-EPD)**: These EPDs are intended to represent the whole industry for the product described in the EPD. Typically, the document holder will be a trade group rather than an individual company.
- A **product-specific** EPD represents a product from a single manufacturer which can be either:
  - **Companywide EPDs** (i.e. multiple-facility): These EPDs typically represent a single entity but the data will represent multiple facility locations. GWP may be reported as a multifacility average or reported separately for each facility location.
  - **Single-facility EPDs**: These EPDs represent a single entity and single facility.

Section 1.4.7 Limitations of EPDs

It is tempting to definitively compare the results of EPDs conducted by different entities. However, the current system for EPDs in the US was developed for compliance with the LEED building rating system (see Section 1.5.1), not policy or code. The green rating systems encourage manufacturers to measure the environmental footprint of their products. However, the credits do not require manufacturers to lower their footprint, nor is there a requirement for a footprint threshold and to make comparisons. An EPD offers valuable data, but making effective use of it and avoiding the pitfalls of overconfidence in its precision requires an understanding of its limitations and inherent uncertainties:

A. **Functional equivalence**—Products that serve the same purpose and meet the same performance standards within the building or infrastructure design. Different product types within the same product category have varying performance characteristics that may or may not make them comparable[xxvii]. In LEED a "product" is defined by the distinct function it serves. For example, footings, foundations walls, shear walls, bearing walls, columns, beams, slabs, early-strength slab, sidewalks and parking areas, each with a unique mix design, would all be considered different products or functions. In addition, LCA methodologies and assumptions (scope, boundaries, data) can vary widely enough to preclude meaningful comparison of products, even when their EPDs are based on the same PCR.

B. **Data reliability (Supply chain specific vs industry average)—**Data in LCA tools and software solutions can vary in age, quality, accuracy, and detail, and are often based on proxies and statistical averages that don't reflect the nuances of specific products or materials. Data collected may be made up of either (a) primary data from the actual facilities and processes in the product supply chain (a.k.a. supply chain specific), or (b) from generic or representative data from a database or similar source (e.g. industry average)[xxviii]. LCAs sometimes rely on industry averages (also called secondary data) due to a lack of actual raw data (primary data). For instance, imported cement from Turkey or China. This may lead to results that are inaccurate or misleading.

C. **Scope of impact assessment**—Social and human health impacts are largely excluded from EPDs, as is ecotoxicity.

D. **Trade-off awareness**—Sole focus on the embodied carbon may neglect other environmental impacts considered by the EPA's TRACI methodology or significant lifetime operations impacts.

E. **Biogenic carbon**—Most EPD's GWP calculation doesn't account for biogenic carbon that's been sequestered by plants during photosynthesis, and then temporarily stored in wood products and will be released at the end of life[xxix].

F. **Ingredient information**—EPDs focus on environmental impacts and list some of a product's components but don't typically disclose the full ingredient list or the ingredients' toxicity. Health product declarations (HPDs)[xxx], "Red Lists[xxxi]" and "Declare" Labels[xxxii]" were created to fill this gap.

G. **Hazard-aware impacts**—In hazard-prone areas, hazard-induced maintenance costs and replacement can be significant over the lifetime of a building. In fact, the costs and carbon impacts of hazard-related repairs can exceed the initial building cost[xxxiii].

Section 1.5 BUY CLEAN IN CODES, STANDARDS & RATING SYSTEMS

The trend to curb embodied carbon is not limited to governments. Green rating systems, codes and standards require the submission of EPDs for products delivered to the project site. Credit achievement through reporting and optimizing the GWP limits is a form of Buy Clean utilizing EPDs. Again, these EPDs rely on the results of product life-cycle assessments to provide information on several environmental impacts related to the manufacture of the product in the resulting EPDs, including global warming potential, ozone depletion, acidification, eutrophication, and ozone creation.

Section 1.5.1 Voluntary Green Certification Systems

Both private and public building owners and operators are using third-party green building certification programs to optimize and assess the environmental attributes and performance of new construction and existing buildings. This includes GWP, as measured in CO_2e. Design and construction professionals have seen the integration of disclosure as well as optimization criteria in green building certification programs:

Section 1.5.1.1 Leadership in Energy and Environmental Design (LEED)

Developed by the US Green Building Council (USGBC), LEED is a voluntary rating system that provides building owners and operators with a framework for identifying and implementing measurable green building design, construction, operation, and maintenance solutions. It is the world's most widely used green building certification program and utilizes a point system in multiple credit categories to receive certification. The LEED version 4 (2012) Materials & Resources' Building Product Disclosure and Optimization Credit[xxxiv] achievement requires the design team to:

- Option 1. Collect at least 20 different permanently installed products sourced from at least five different manufacturers that meet one of the disclosure criteria including Products with a publicly available, critically reviewed life-cycle assessment conforming to ISO 14044, Industry-wide Type III EPD, or Product-specific Type III EPD, including external verification and external critical review; and/or
- Option 2. Use least 5 permanently installed products sourced from at least three different manufacturers that have a compliant embodied carbon optimization report or action plan separate from the LCA or EPD.

Section 1.5.1.2 Living Building Challenge

The Living Building Challenge (LBC)[xxxv], a green assessment system with strong decarbonization commitments, has included embodied carbon reduction among its "imperatives" since its inception in 2006. In 2018, the International Living Future Institute (ILFI), which oversees the LBC introduced a separate Zero Carbon program encompassing both operational and embodied emissions. Certification of new buildings entails embodied carbon disclosure of all the embodied carbon associated with the materials and construction using LCAs and EPDs for alignment with the Embodied Carbon Reductions Imperative.

- New and existing buildings must demonstrate a twenty percent reduction in the embodied carbon of primary materials compared to an equivalent baseline.
- All projects must select interior materials with lower than industry baseline embodied carbon emissions for product categories for which data is readily available.
- Product-specific embodied carbon data should be sourced from EPDs.

Section 1.5.1.3 GBI Green Globes Rating System

Green Globes is a credible practical, and cost-effective green building rating system. The rating system evolved from the Canadian Green Globes program; a web-based, interactive green building tool based on Building Research Establishment Environment Assessment Method (BREEAM). BREEAM, which was developed in the United Kingdom in 1990, was the world's first sustainability assessment method for buildings. The US GSA and DOE issued statements recognizing Green Globes as well as the U.S. Green Building Council's LEED rating system as the only two systems approved for use for federal buildings. The

ANSI/GBI 01-2021: Green Globes Assessment Protocol for Design, New Construction, and Major Renovations' Materials Assessment Area[xxxvi]: Product Life Cycle credit utilizes critically reviewed LCA and EPDs for credit achievement.

Product manufacturers provide one or more of the following for a minimum of fifteen products that evaluate the cradle-to-gate product life cycle of the total products used is necessary to be awarded points.

1. Third-party verified Type III EPDs according to ISO 21930: 2017 or ISO 14025: acceptable through December 31, 2024; or
2. Third-party Multiple Attribute Product Certification; and/or
3. Third-party verified product LCA based upon ISO 14040: 2006 and ISO 14044: 2006.

Section 1.5.2 Mandatory Building Codes

Building codes have been one of the most influential tools to address urgent societal issues. The building codes have addressed life safety and the energy codes have addressed operational emissions. The codes now continue protecting the public by addressing embodied carbon as a base minimum requirement:

Section 1.5.2.1 ASHRAE 189.1/International Green Construction Code

As of 2017, ASHRAE/ICC/USGBC/IES Standard 189.1, Standard for the Design of High-Performance Green Buildings (ASHRAE 189.1) serves as the technical basis for the International Green Construction Code (IgCC). Unlike LEED or Green Globes, the IgCC provides the minimum requirements for a high-performance green building. Embodied carbon emissions are now being addressed in the national green code[xxxvii]. The ASHRAE 189.1 Committee adopted measures for EPD reporting and mandatory low-carbon building product procurement requirement in 2023.

1. Project teams must select 30 EPDs for a minimum of 20 distinct building products. The combined cost of these products must account for 25% of the total construction product costs. Additionally, building products that cost 5%+ of the estimated material costs must be included.
2. A jurisdiction option (JO), Section 9.4.2 Product Procurement, allows adopting jurisdictions to opt into a measure that requires building products' GWP limits be at or below 125% of the IW-EPD. The design team can identify which 10 products comply, if products cost 5% or more of the building product costs and that, in total, the products equal 15% or 20% of product costs.

Section 1.5.2.2 California Green Building Standards Code

Effective July 1, 2024, the updates to the California Green Building Standards Code (CALGreen) Part 11, Title 24, will be the first state-wide code to mandate emission reductions that occur from materials and construction activity. The measures apply to nonresidential commercial building projects over 100,000 square feet and school building projects over 50,000 square feet. CalGreen takes a broad life-cycle approach to embodied carbon and considered building reuse and LCAs valued methods to reduce embodied emissions.

The eligible materials include hot-rolled structural steel sections, hollow structural steel sections, steel plate, concrete reinforcing steel, flat glass, light-density mineral wool board insulation, heavy-density mineral wool board insulation and ready-mixed concrete.

Projects will be required to comply with one of three pathways:

1. Building Reuse: Reuse at least 45% of an existing structure and enclosure. When reuse is combined with new construction, the total addition area using this pathway is limited to double the area of the existing structure.
2. Performance path: Complete a whole building lifecycle assessment (WBLCA) demonstrating 10% lower embodied carbon emission measured in Global Warming Potential (GWP) than a baseline project design.
3. Prescriptive path: Document EPDs for listed materials (steel, glass, mineral wool, concrete) that are on average lower than a specified threshold of global warming potential (a.k.a. limit). This Prescriptive method allows use of products that have GHG emission impacts up to 175% of IW

average EPDs GWP limits (with concrete using the NRMCA SW Regional benchmark values). Weighted average is allowed.

In addition, the CALGreen measures can also be voluntarily adopted by cities and counties to advance their own carbon reduction and climate action plans using aspirational Tiers supporting local "reach codes" while increasing consistency across the state.

Section 1.5.2.3 ACI 323 Low-Carbon Concrete Code

The American Concrete Institute (ACI) is introducing the first code on low embodied carbon concrete and is a fundamental steppingstone towards helping the industry lower its environmental footprint. The proposed ACI 323 Low-Carbon Concrete Code is in addition to (overlay) and does not substitute governing building or structural design codes and standards such as ACI 318. Hence, it does not address strength, rheology, serviceability, durability, integrity of concrete structures, or construction means and methods. The first iteration of the document has been rapidly developed in less than a year and is slated to be published in 2024.

Major private organizations such as Apple, Google, Amazon, Honda, Bank of America, PG&E, CalPERS and others are addressing their supply chain emissions as part of company policy. They are building their headquarters and data centers to highest green certification standards. Microsoft and Skanska USA even developed a free online tool, the Embodied Carbon in Construction Calculator (EC3), that allows benchmarking and assessment in embodied carbon of various products.

PART II CONCRETE AND CEMENT

Section 2.1 CONCRETE AND CEMENT

Section 2.1.1 **Concrete** is unique among building materials with its formulation highly influenced by its application. Concrete can be made stronger, lighter, more flowable, stiffer, or less permeable depending on performance requirements. All these formulations can be made at the same factory, within minutes of one another. Concrete is economical, available nearly everywhere, and made from the most abundant materials on the planet, usually from local sources. Concrete can be mixed at a job site, or "ready mixed" and batched for delivery from a central plant.

In its basic form, **concrete**[xxxviii] is composed of cement, water and aggregates that are combined to form a plastic, durable material. Plastic means concrete that is proportioned and mixed for delivery to a customer in an unhardened state. Water, air, aggregate (sand, stone or gravel) with or without admixtures or fibers make up about 90% of the volume of concrete mixtures. Between 7% to 15% is cement by mass depending on the performance requirements for the concrete. The process of mining sand and gravel, crushing stone, combining the materials in a concrete plant and transporting concrete to the construction site requires comparatively very little energy compared to the manufacture of cement. The amounts of carbon dioxide embodied in concrete are primarily a function of the cement content in concrete mixtures.

Section 2.1.2 **Cement** is manufactured from a combination of naturally occurring minerals - calcium (60% by weight) mainly from limestone or calcium carbonate, silicon (20%), aluminum (10%), iron (10%) and small amounts of other ingredients and heated in a large kiln to over 1500 °C (2700 °F) to convert the raw materials into **clinker**[xxxix]. For the most part, CO_2 is generated from two different sources during the cement manufacturing process:

- Use of fossil fuels in the burning process
- Calcination, when calcium carbonate is heated and broken down to calcium oxide with the release of CO_2.

The most commonly used cement is called **portland cement**. It contains about 92% to 95% clinker by weight. Some companies produce blended cements that incorporate other industrial byproducts that have cementitious properties, thus reducing the amount of clinker in the cement but most produce straight portland cement. Concrete producers then combine portland cement aggregates and water to make concrete. Most concrete today uses a significant amount of industrial byproducts such as fly ash, slag cement and silica fume to supplement a portion of the cement used in concrete. These industrial products, which would otherwise end up in landfills, are called **supplementary cementitious materials** (SCM). The use of SCMs in concrete work in combination with portland cement improves strength and durability in addition to reducing the CO_2 embodied in concrete by as much as 70%, with typical values ranging between 15 and 40%.

On average, 1 kg of CO_2 are emitted for every kg of portland cement produced in the U.S. The average quantity of portland cement is around 250 kg/m^3 (420 lb/yd^3). This average quantity has consistently decreased with better optimization of concrete mixtures and increased use of SCMs such as fly ash, slag cement and silica fume. As a result, approximately 100 to 300 kg of carbon dioxide is embodied in every cubic meter of concrete depending on the quantity of cement and SCMs.

Section 2.2 INDUSTRY DECARBONIZATION AMBITIONS

Cement manufacturing emissions are often considered among the most challenging to decarbonize due to a variety of market, regulatory, and infrastructure barriers. There is no other material that can do all that cementitious concrete can, and the demand for the product is not likely to change. The chemical process of turning limestone into clinker releases carbon dioxide as a byproduct requires extremely high temperatures which limits the industry's ability to use renewable energy sources. The constituent ingredients for concrete are widely available and inexpensive therefore lacking economical and scalable alternatives. Fortunately, the cement and concrete industries have committed to meet the challenge of reducing its carbon footprint.

Section 2.2.1 The Global Cement and Concrete Association (GCCA) set out a net zero pathway to help limit global warming to 1.5^{O}C with its 2050 Cement and Concrete Industry Roadmap for Net Zero Concrete[xl]. The industry has already made progress with proportionate reductions of CO_2 emissions in cement production of 20% over the last three decades. The roadmap represents a significant acceleration of decarbonization measures achieving the same reduction in only a decade. It outlines a proportionate reduction in CO_2 emissions of 25% associated with concrete by 2030 from 2020 as a key milestone on the way to achieving full decarbonization by 2050.

Section 2.2.2 The US Portland Cement Association (PCA) have committed to the goal of reaching carbon neutrality throughout the cement-concrete-construction value chain by 2050[xli]. Published in 2021, the Roadmap to Carbon Neutrality involves the entire value chain, starting at the cement plant and extending through the entire life cycle of the built environment to incorporate the circular economy. This approach to carbon neutrality leverages relationships at each step of the value chain which include the production of clinker, the manufacture and shipment of cement, the production of concrete, the construction of the built environment, and the capture of carbon dioxide using concrete as a carbon sink.

Section 2.2.3 The US National Ready Mixed Concrete Association (NRMCA) -To help concrete producers reduce their carbon footprint, the NRMCA signed on to the 2030 Challenge for Products in 2012[xlii]. The 2030 Challenge for Products is a global challenge to specify and manufacture products that meet a carbon footprint below the industry average and subsequently improve on this reduction to 50% by 2030 and carbon-neutral by 2050. In support of the Challenge, NRMCA became an EPD Program Operator to facilitate the development and verification of EPDs and establish industry baselines for concrete. NRMCA has also helped develop a PCR that provides instructions on how to conduct and report EPDs.

The NRMCA was selected for a grant from the U.S. EPA in June of 2024 that will help concrete producers accelerate their drive to carbon neutrality. The grant will implement a five-year work plan that updates the carbon reduction ambition to achieve carbon neutrality earlier by 2045[xliii].

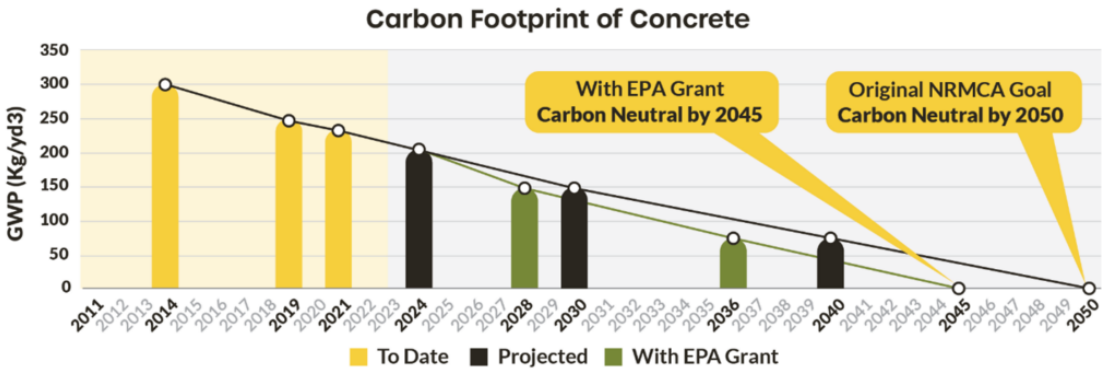

Image courtesy of NRMCA.

Section 2.3 INDUSTRY CARBON REDUCTION LEVERS

Levers to decarbonize the cement and concrete sector to reach the level of deep decarbonization required by the 1.5ºC goal indicate a wide range of opportunities to reduce emissions. Many of these opportunities are already being implemented today, such as energy efficiency improvements, fuel switching, and reduction in clinker content in cement or cement content in concrete. Breakthrough technologies such as carbon capture and permanent geological storage (CCS), bioenergy with carbon capture and storage (BECCS), electrification or novel binders will also be needed to allow the sector to make significant emissions reductions.

The Rocky Mountain Institute (RMI) summarized reductions in concrete through six primary levers with descriptions paraphrased from NRMCA, GCCA, and IEA, and the applicable percentage reduction from baseline in 2022[xliv]:

1. Efficiency in concrete production (14%): Optimized mix design, optimized constituents, and better quality controls
2. Savings in cement and binders (12%): Portland clinker cement substitution, improved mix purity, and replacement with supplementary cementitious materials
3. Decarbonization of electricity (6%): Decarbonization of the electricity grid where cement and concrete production facilities are sited
4. Savings in clinker production (14%): Increased thermal efficiency and use of alternative/waste fuels, decarbonated raw materials, and hydrogen fuel sources
5. Carbon capture and use/storage (46%): Direct, on-site carbon capture and sequestration at cement plants
6. CO_2 sink: recarbonation (8%): Uptake of the CO_2 emitted during cement production reabsorbed into the concrete as a carbon sink

The methods above were organized in ascending order of complexity and cost, from the perspective of the concrete producer. Near-term reductions can be achieved by strategies such as efficient mix design, with more robust decarbonization enabled by investments by cement manufacturers. In the near term, most concrete-sector carbon reduction will come from mix designs with a focus on minimizing clinker. In the long term, responsibility will fall on cement manufacturers to decarbonize their operations.

PART III LEGISLATIVE ACTIONS

Section 3.1 BUY CLEAN IMPLEMENTATION

Section 3.1.1 Structure of Buy Clean

As in Maryland, federal and other state and local governments are developing ambitious new policies to curb carbon emissions. Each Buy Clean policy has a different scope, regulatory framework, incentives, and mechanisms for implementation. Many policies require agencies to consider the embodied carbon emissions of industrial "eligible materials" – concrete, structural steel, carbon steel rebar, flat glass and/or mineral wool board insulation – when contracting for capital projects. Some solely focus on cement and/or concrete.

The Buy Clean bills emphasize reducing its global warming potential (GWP), specifically the cradle-to-gate embodied carbon impact, by identifying emissions in construction products using reporting tools. The burden is placed on the bidding contractor to deliver environmental disclosure reports, such as Environmental Product Declarations (EPD), and select material providers with lower GWP impacts. Further, many agencies are developing "maximum acceptable" GWP (e.g. limits) of materials to which materials must comply to be considered for contract bidding. The type of limit to be set by the named agency may also vary depending on the policy design.

Two components that are key to understanding this the requirements:

- **Disclosure:** Requirement to disclose the carbon footprint of covered products using a facility-specific EPDs.
- **Limits**: Requirements that a product's carbon footprint be below a maximum allowable GWP value (i.e., limit) established by a government agency or third party. These limits may decrease over time at intervals to reflect decreases in the industry average GWP due to reductions in industrial emissions.

Section 3.1.2 GWP Limits, Thresholds

Typically, the agency or research team use the following steps to assign "maximum acceptable" GWP limit values to each category[xlv]:

1. Select the product category.
2. Gather and assess the available LCA data.
3. Evaluate the representativeness of available data sources to select one of the following methods:
    a. Method A: Use the collection of product-specific EPDs (including facility-specific EPDs) to calculate an average.
    b. Method B: Use the industry-wide EPD value (e.g. from an industry association).
    c. Method C: Use the industry-wide EPD and adjust the value to meet the goals of the policy (e.g. 85%, 100%, 150%, etc. of industry-wide EPD value).

    If none of these options prove adequate, because there is not yet sufficiently representative data, then the category is not yet ready for a reliable GWP limit.
4. Assign a "maximum acceptable" GWP limit value.

Section 3.1.3 Benchmarks

It is helpful to understand the industry baselines as the backdrop to the limits being established in varying Buy Clean policies.

As a concrete EPD program operator, the NRMCA used data collected in developing the LCA and IW-EPD for concrete to develop a set of regional benchmarks for key environmental impacts. The Benchmarks Report represents the environmental impacts of products with varying strengths for different applications and exposure conditions at the national level and eight NRMCA regions. From the NRMCA National and Regional LCA Benchmark (industry average) Report - v3.2 (2022)[xlvi]. All values are baseline GWP (kg CO_2e /m^3). The national value for 4000 psi is highlighted as a reference point for comparing the varying limits being developed.

Table 3.1.1 NRMCA National and Regional Benchmarks for Ready Mixed Concrete (2022) in $kgCO_2e/m^3$

	2500 psi	3000 psi	4000 psi	5000 psi	6000 psi	8000 psi	LW 3000 psi	LW 4000 psi	LW 5000 psi
Pacific Southwest	257	279	323	378	401	456	500	546	594
Pacific Northwest	235	261	316	386	408	487	518	575	632
Rocky Mountains	232	255	301	358	379	440	484	532	580
South Central	226	245	286	336	356	409	468	510	555
North Central	241	264	312	372	394	460	487	537	591
Southeastern	247	268	309	360	382	435	478	521	562
Great Lakes	232	255	303	363	383	452	499	551	603
Eastern	240	264	314	378	399	472	517	573	628
National	240	262	**308**	365	385	446	492	540	588

For cement, the Portland Cement Association (PCA) published industry-wide EPDs based on the survey of cement manufacturers posted at ASTM International, a program operator[xlvii]. Four main categories of cement are covered; ASTM C150 portland cement, ASTM C595 portland-limestone cement, ASTM C595 blended cements, and ASTM C91 masonry cement produced in North America.

Table 3.1.2 Production Stage Cradle-to-gate EPD Results for ASTM C-150 Portland Cement (2023)[xlviii]

Impact Category and Inventory Indicators	Unit	Per 1 metric ton
Global warming potential, GWP 100, IPCC 2013	$kgCO_2$ eq	919
Ozone depletion potential, ODP	kg CFC-11 eq	2.05E-05
Acidification potential, AP	kg SO_2 eq	1.74
Eutrophication potential, EP	kg N eq	1.02
Smog formation potential, SFP	kg O 3 eq	32.8
Abiotic depletion potential for non-fossil mineral resources, ADP elements*	kg Sb eq	1.56E-04
Abiotic depletion potential for fossil resources, ADP fossil*	MJ LHV	4365
Renewable primary resources used as an energy carrier (fuel), RPRE *	MJ LHV	138
Renewable primary resources with energy content used as material, RPRM *	MJ LHV	3.55
Non-renewable primary resources used as an energy carrier (fuel), NRPRE *	MJ LHV	4361
Non-renewable primary resources with energy content used as material, NRPRM *	MJ LHV	4.75
Global warming potential - biogenic, GWPbio *	kg CO_2 eq	0.34
Emissions from calcination*	kg CO_2 eq	480
Emissions from combustion of waste from renewable sources*	kg CO_2 eq	0.260
Emissions from combustion of waste from non-renewable sources*	kg CO_2 eq	51.1

Section 3.2 BUY CLEAN LEGISLATIVE ACTIONS

Section 3.2.1 BUY CLEAN CALIFORNIA

Section 3.2.2.1 Background

In 2017, California signed into law the Buy Clean California Act[xlix] (BCCA), a procurement policy designed to mitigate embodied carbon by prioritizing the use of low-carbon materials in public works projects. It is published under California Public Contract Code, section 3500-3505. The idea was to use its considerable procurement power to incentivize manufacturers to produce fewer emissions in the manufacturing of their products. To compete for state infrastructure projects, project teams would be required to disclose the embodied carbon of their materials, or the total amount of emissions produced over their lifecycle, and compete on the basis of climate impact in addition to cost.

Section 3.2.2.2 Eligible Material

The BCCA targeted carbon emissions associated with the production of structural steel (hot-rolled sections, hollow structural sections, and plate), concrete reinforcing steel, flat glass, and mineral wool board insulation. Cement was included in the original bill but was amended out of the final bill.

Section 3.2.2.3 Minimum Project Threshold[l]

Public construction contracts of $1,000,000 and above, entered into on or after July 1, 2022.

Section 3.2.2.4 Setting Limits

When used in public works projects, the eligible materials must have a global warming potential (GWP) that does not exceed the limit set by Department of General Services (DGS). DGS obtained data from publicly available EPDs to determine and set a material's limit as the industry average of facility-specific GWP. DGS shall review the maximum acceptable global warming potential for each category of eligible materials and may adjust the number downward to reflect industry improvements on January 1, 2025, and every three years thereafter.

Notably, the DGS excluded the GWP contribution from material fabricators (i.e. companies that complete additional processing after a product's manufacture but before its use in a construction project) when establishing the new GWP limits. The BCCA allows awarding authorities to specify a GWP lower than the limit set by DGS but does not prescribe the method.

Table 3.2.1: BCCA GWP limits for eligible materials

Eligible Material	Maximum Acceptable GWP Limit[1]For Unfabricated Product (Cradle-To-Gate)[2]	Maximum Acceptable GWP Limit[1]For Fabricated Product (A1 Module Only)[3]
Hot-rolled structural steel sections	1,010 kg CO_2eq.[4]or 1.01E+03 kg CO_2eq. for one metric ton of structural steel.	1,080 kg CO_2eq. or 1.08E+03 kg CO_2eq. for one metric ton of structural steel.
Hollow structural sections	1,710 kg CO_2eq. or 1.71E+03 kg CO_2eq. for one metric ton of structural steel.	1,830 kg CO_2eq or 1.83E+03 kg CO_2eq for one metric ton of structural steel.
Steel plate	1,490 kg CO_2eq. or 1.49E+03 kg CO_2eq. for one metric ton of structural steel.	1,590 kg CO_2eq. or 1.59E+03 kg CO_2eq. for one metric ton of structural steel.
Concrete reinforcing steel	890 kg CO_2eq. or 8.90E+02 kg CO_2eq. for one metric ton of bar.	920 kg CO_2eq. or 9.20E+02 kg CO_2eq. for one metric ton of bar.
Flat glass	1,430 kg CO_2eq. or 1.43E+03 kg CO_2eq. for one metric ton of glass.	N/A
Light-density mineral wool board insulation	3.33 kg CO_2eq. for 1 $m^2$of insulation at R_{SI}=1.[5]	N/A
Heavy-density mineral wool board insulation	8.16 kg CO_2eq. for 1 $m^2$of insulation at R_{SI}=1	N/A

[1] GWP limit is based on a 100-year lifetime impact and excludes biogenic carbon.
[2] Use this column to determine compliance when an EPD declares unfabricated product GWP. Compare manufacturer cradle-to-gate GWP (i.e., the sum of information modules A1-A3) to the limit.
[3] Use this column to determine compliance when an EPD declares fabricated product GWP (compare GWP from information module A1 to the limit). These limits are derived from the unfabricated product GWP and account for the waste in the fabrication process.
[4] Kilogram carbon dioxide equivalent.
[5] Thermal resistance (R_{SI}) with a value of 1m^2K/W (square meters x degrees Kelvin per watt).

Section 3.2.2.5 Waivers and Exemptions[li]

1. Technically Infeasible.
    a. The EPD is beyond its period of validity and cannot be renewed because the PCR has expired and has not been renewed.
    b. The particular material is not covered by the scope of the relevant PCR, for example, a type of steel that is not included in the PCR for structural steel.
2. Significant Increase in Project Cost.
    An EPD is not required if the total material cost for any covered product is less than $25,000.
3. Significant Time Delay.
4. One Source for Material (Sole Source)-where there is only one viable material supplier in order to allow for competitive pricing. Examples are where no other producers or vendors have made EPDs available or do not meet the GWP threshold.
5. Emergency-as defined in PCC 1102, may be used as the basis of an exception request.

Section 3.2.2.6 Obstacles and Lessons

The BCCA required DGS to submit a report to the Legislature by July 1, 2023, on any obstacles to the implementation and effectiveness of the BCCA in reducing GWP within the first year of full program implementation[lii]. While cement and concrete were not included in the bill, there are key takeaways from the report worth noting:

- Although the BCCA was signed into law in 2017 and amended to include a two-year phase-in period introducing stakeholders to EPDs and BCCA requirements, a steep learning curve still existed for stakeholders to understand how to comply with the program.
- Due to the lack of availability of facility-specific EPDs, DGS used industrywide EPDs to set the initial GWP targets, however facility-specific EPDs are still required on eligible projects.
- When responding to awarding authority document requests, stakeholders submitted incorrect EPDs (industrywide vs. facility-specific), used inconsistent EPD terminology, and exhibited difficulty in identifying the correct GWP for compliance.
- The DGS spent three years developing maximum GWP thresholds for steel construction products, which were published at the end of 2020. However, these thresholds were withdrawn and the DGS developed new thresholds and published in collaboration with the California Air Resources Board in 2022.
- Due to its implementation infancy, there was a minimal amount of information available to assess the BCCA's effectiveness to reduce GWP.
- The description of eligible material categories could be statutorily broadened to allow some flexibility for DGS and the awarding authorities to target the appropriate product.
- Allow exclusion of emissions during steel fabrication.
- Allow setting of separate limits for different products within each category of materials.
- Introduce exemptions that could be taken by the awarding authorities.

Section 3.2.2 MARIN COUNTY, CALIFORNIA, LOW EMBODIED CARBON CONCRETE CODE

Section 3.2.2.1 Background

Funded by Bay Area Air Quality Management District (BAAQMD)'s 2018 Climate Protection Grant Program under "Fostering Innovative Strategies with long-term impacts in reducing GHG emissions", Marin County adopted first-of-its-kind effort to address embodied emissions in an area of local government control. As of November 19, 2019, all projects placing concrete within unincorporated Marin County must comply with concrete or cement composition standards that maintains adequate strength and durability while reducing embodied carbon emissions. The county partnered with engineers, and academia, and a robust stakeholder group to develop model code language for adoption and low embodied carbon concrete specifications for residential and nonresidential applications.

The code specifies that the building department will require documentation prior to issuance of applicable building permits and prior to approval of construction inspections following placement of concrete. At time of permit issuance, the applicant will be required to demonstrate compliance with embodied carbon reductions via Cement Limit or Embodied Carbon. Weighted average of all concrete mixes in the project is acceptable. At time of inspection, the building department will require batch certificates and/or EPDs and review that they are consistent with the information submitted on the compliance form. When deviations from compliance occur, the code specifies that the chief building official is authorized to require evidence of equivalent carbon reductions from the portions of remaining construction of the project to demonstrate alternative compliance with the intent of the code.

The following parties must use the Cement Limit or Embodied Carbon form[iii] to comply:

a. The Design Professional (e.g., Engineer, Architect, Responsible Applicant) is responsible for specifying, submitting the compliance form for permission to build, and should work with the contractor pouring concrete to specify the mix design(s).
b. The Contractor pouring concrete should work with the design professional to source appropriate concrete as specified and the ready-mix supplier to obtain a batch receipt (i.e., proof) of the concrete poured. The contractor is also responsible for re-submitting a completed compliance form for final inspections.

Ready mix suppliers can pre-clear their concrete mix designs to be publicly listed as a pre-qualified vendor by completing a form online or submitting a hard copy to the planning desk. Pre-qualified vendors and their design mixes will be placed on the County's Low-Carbon Concrete Requirements landing page.

Section 3.2.2.2 Eligible Material

The regulation targeted carbon emissions associated with the production of cement and concrete.

Section 3.2.2.3 Minimum Project Threshold

None published as of writing.

Section 3.2.2.4 Setting Limits

In order to evaluate the cement and embodied carbon (GWP) impacts for different concrete mix designs in use in Northern California, a wide set of data was analyzed. Over 400 mix designs were collected, primarily for projects within San Francisco. The set included:

a. data from the NRMCA LCA report for the US and Pacific Southwest (PSW), which includes California,
b. data from ClimateEarth, which include one major ready-mix producer in the Bay Area as well as producers in Seattle and Texas

c. data collected by structural engineers in the Structural Engineer's Association of Northern California[liv].

Table 3.2.2: Marin County GWP limits – Two Pathways

	Cement limits for use with any compliance method 19.07.050.2 through 19.07.050.5	**Embodied Carbon limits** for use with any compliance method 19.07.050.2 through 19.07.050.5
Minimum specified compressive strength f'_c, psi (1)	**Maximum ordinary Portland cement content, lbs/yd^3 (2)**	**Maximum embodied carbon, kg CO_2e/m^3, per EPD**
up to 2,500	362	260
3,000	410	289
4,000	456	**313**
5,000	503	338
6,000	531	356
7,000	594	394
7,001 and higher	657	433
up to 3,000 lightweight	512	578
4,000 lightweight	571	626
5,000 lightweight	629	675

(1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits.
(2) Portland cement of any type per ASTM C150 or ASTM C595.

Section 3.2.2.5 Waivers and Exemptions

The county acknowledging that some applications necessitate higher cement content, the stakeholder group identified two reasons for allowable increases beyond the thresholds. The first allows a 30% increase over thresholds for applications that require high early strength. The second is an allowance for cement products that show low embodied carbon by plant-specific EPDs. The latter applies only to the cement limits, not the GWP limits. Additionally, the chief building official may grant exemptions for hardship or infeasibility for reasons such as lack of commercial availability, disproportionate cost increase, or historic preservation.

Section 3.2.2.6 Obstacles and Lessons

Some opportunities for potential complication were noted:

- When multiple mixes are specified to achieve lower GWP limits, yet have the same strength (psi), when the project is in construction, teams may be inclined to pour the same (higher GWP) mix for efficiency.
- Seasonal shortages in fly ash may become more common due to closure of coal plants and cleaner burning technologies. The pilot project teams were mostly able to use slag instead. In the future, alternative cementitious materials such as ground glass pozzolan – that are not a direct byproduct of fossil fuel industries – are expected to enter the market.
- Additional applications needing high early strength that were encountered in the pilot project but not listed in the code language included retaining walls needing to be backfilled quickly, sidewalks that need to be open for traffic right away, and slabs on grade that need to support construction equipment. The general description of qualifying applications, as opposed to only offering a specific list, provided a sufficient catch-all for these when needed.
- It was not clear whether the requirements applied to site work and whether "precast" included concrete masonry units (CMU). The pilot projects were used to test the feasibility of the limits and process for these types of concrete applications and had mixed results. It is recommended that other jurisdictions clarify whether these are in or out of scope ahead of time.

Section 3.2.3 PORTLAND, OREGON, LOW-CARBON CONCRETE PURCHASING PROGRAM

Section 3.2.3.1 Background

In 2016 the City of Portland published its Sustainable Supply Chain Analysis with the goal of establishing a variety of policies to guide it's work on sustainability. The analysis identified purchases from the construction sector as a top contributor of supply chain GHG. The City then established its Low-Carbon Concrete Initiative to reduce the overall carbon intensity of the concrete mixes used on City projects starting January 2020. In 2022 the City established GWP thresholds and corresponding implementation strategies to reduce the carbon intensity of the concrete used on City projects. Compliance can be:

a. Concrete Embodied Carbon Thresholds – Per Mix.
b. Concrete Embodied Carbon Thresholds – Project Average.

Section 3.2.3.2 Eligible Material

Portland Cement Concrete (PCC), including: Commercial Grade Concrete (CGC), Plain Concrete Pavement (PCP), and High-Performance Concrete/Structural Concrete (HPC) for City construction projects.

Section 3.2.3.3 Minimum Project Threshold

For use over 50yd^{3}on a City-owned or solicited construction projects.

Section 3.2.3.4 Setting Limits

Process steps used by City of Portland EPD program for concrete include:

Phase 1: EPD Requirements (2019)

From 2019 the City's Initiative involved 1) establishing a product-specific EPD requirement for concrete mixes used on City projects and conducting pilot tests of lower-embodied carbon concrete mixes as compared to 100% cement mixes.

Phase 2: Data Collection, including Lower Carbon Concrete Pilot Projects[lv]

The City used EPD data collected since 2020, City concrete usage data, stakeholder feedback, the NRMCA Member National and Regional Life Cycle Assessment Benchmark (Industry Average) Report, and related applicable data to determine the GWP threshold (limits) values.

Phase 3: Establish Global-Warming Potential (GWP) Thresholds (2022)

Table 3.2.3 City of Portland Low Embodied Carbon Concrete Thresholds

	Maximum GWP (kg CO_2e)/m^3		
Concrete Strength (psi)(1)	Portland Cement Concrete (PCC) including: Commercial Grade Concrete (CGC), Concrete Pavement, High- Performance Concrete (HPC)/Structural Concrete	Lightweight Concrete	Controlled Low-Strength Material (CLSM)
2500	235		235
3000	261	518	
4000	**316**	575	
5000	386	632	
6000	408		
8000	487		
(1) For concrete strengths between the stated values, use linear interpolation to determine cement and/or embodied carbon limits, rounded to the nearest whole number.			

Section 3.2.3.5 Waivers and Exemptions

1. A concrete mix for which the total projected use (volume) is less than 50yd^3 over the entire project is not subject to the EPD and corresponding GWP threshold requirement.
2. EPDs for concrete mixes supplied by a mobile mix concrete producer may be a "Portland Metro Area Industry Average EPD for Mobile Mixers" in lieu of a product-specific EPD so long as their firm is listed on the EPD as a participating producer, the applicable mix designs are the same as what was submitted for the EPD, and that the EPD is 3rd party verified and within its 5-year period of validity.
3. A prime contractor may seek a temporary exemption to the GWP threshold if the applicable concrete producer can demonstrate that supply chain constraints outside the producer's control mean that producing a compliant mix for the application is temporarily not possible.
    a. For projects using multiple mixes and pursuing a Project Average compliance approach, a prime contractor shall demonstrate that the supply chain constraint is such that it affects all project mixes or enough project concrete volume that it is not possible to meet the GWP threshold through the Project Average approach.
    b. A supply chain constraint exemption request is only valid when the timing of the constraint aligns with when the mix is actually needed on the project. Supply chain constraint exemptions shall be project specific and only valid for the duration of the supply chain constraint or duration of the formation of a unique concrete element of the project.

Section 3.2.3.6 Obstacles and Lessons[lvi]

Oregon Department of Environmental Quality worked in partnership with the Oregon Concrete and Aggregates Producer Association (OCAPA) to establish and provided free access to a web-based EPD tool, limited technical assistance, and a monetary reimbursement incentive specifically for concrete production. Producers were able to use the EPDs as a consumer facing label to submit as City's Pre-approved list, gain "points" in rating systems, or use the EPD for targeting internal process improvements.

Pilot sidewalk projects (2020) -the low-carbon mixes met the City's concrete performance specifications, were well received by the concrete finishers, were cost-neutral or less expensive, and performed well in in the post- project visual inspections – all while reducing the carbon footprint of an average sidewalk ramp by 23- 34%.

On March 2022, Governor Kate Brown signed the **Buy Clean Oregon** Bill into law[lvii] requiring state regulators to conduct LCAs for select construction and maintenance materials used for public infrastructure projects and also identify funding for medium- and heavy-duty zero-emissions charging infrastructure. As signed the law does not set GWP limits. It requires EPDs for concrete, asphalt, and steel for DOT projects to assess strategies to reduce GHG emissions. The agencies will develop a grant program to assist bidders for EPDs and will not considering the EPDs for bid or proposal before January 1, 2027.

Section 3.2.4 NEW YORK BUY CLEAN CONCRETE & EXECUTIVE ORDER 22

Section 3.2.4.1 Background

The NYS Buy Clean Concrete[lviii] implement S542A, signed into law as State Finance Law 135-d on December 2021, effective June 2022. The law calls for the Office of General Services (OGS) to establish guidelines requiring the procurement of low embodied carbon concrete on projects deemed appropriate by the office. The law is intended to accelerate the use and innovation of low-carbon concrete in state projects. Starting January 1, 2025, EPDs must be submitted for all concrete mixes used in qualifying state construction projects and must demonstrate that they achieve an environmental impact below the limits set by New York State.

Meanwhile On September 20, 2022, New York State Governor issued Executive Order 22: Leading by Example[lix] (EO22) to streamline the administration of the State's sustainability and climate directives and set new goals for the environmental performance of State agencies and authorities. Executive Order 22, under which state agencies are required to collect New York-specific data from common construction materials, including concrete, which will be used to set lower limits on GHG emissions from concrete, starting in 2027. The two legislative actions worked in conjunction to develop guidance for low embodied concrete and other materials[lx]. The OGS utilized the consulting services of NGO Building Transparency along with the free online tool, the Embodied Carbon in Construction Calculator (EC3), that allows collection, benchmarking and assessment[lxi].

1. Phase 1: Voluntary concrete GWP limits and EPDs
   Between Jan 1, 2024, and Dec 31, 2024, contracts for relevant projects will ask for the EPDs of concrete mixes, where available, and use the EPDs to compare against New York State's voluntary concrete GWP limits.
2. Phase 2: Mandatory concrete GWP limits and EPDs
   Starting Jan 1, 2025, the New York State's voluntary concrete GWP limits above will become mandatory limits. Between Jan 1, 2025 and Dec 31, 2025, contracts for relevant projects will require concrete mixes procured to certify a GWP lower than the New York State's GWP limit in the relevant compressive strength category, in the form of an EPD, and additional certifications as required by each agency as outlined below.
3. Phase 3: Revised mandatory concrete GWP limits and EPDs
   Starting Jan 1, 2027, or at an appropriate date, New York State will revise (lower) the mandatory concrete GWP limits in the table shown above.

Starting January 1, 2025, contractors and subcontractors doing work involving low embodied carbon concrete shall certify, upon completion of the milestone or project, that all procured low embodied carbon concrete utilized on the project meets the minimum standards in these guidelines, by providing: 1) an acceptable EPD and 2) a document stating the GWP of the concrete mix used (indicating comparison to New York State's concrete GWP limit), to demonstrate that the GWP of the concrete mix is lowered than New York State's GWP limit for concrete. State agencies should review and approve certification documentation submitted by the contractor to confirm that the minimum certification requirements have been met. Certification requirements should be maintained for the duration of the contract. Sample contract language is provided in the EO22 Embodied Carbon guidance documents[lxii].

Section 3.2.4.2 Eligible Material

Concrete, asphalt, steel (rebar, hollow structural sections, fabricated steel plate, hot-rolled sections, cold-formed & galvanized); glass (flat glass, processed glass, insulating glazing units)

Section 3.2.4.3 Minimum Project Threshold

This guidance is for New York State contracts, over $1 million, and that contain one or more of the following materials in quantities over the disclosure limit. For concrete mixes 50 cubic yards or more;

asphalt mixes 16,854 pounds (or 10 cubic yards) or more; steel 20,000 pounds or more for rebar, 5,000 pounds or more, for all others; glass 2,000 square feet or more.

NYS Department of Transportation (DOT) contracts greater than $3 million which include a concrete pay item with estimated quantity of at least 200 cubic yards signed after October 1, 2023,

Section 3.2.4.4 Setting Limits

New York State's initial mandatory emissions limits (measured in $kgCO_2e$) are based on 150% of the NRMCA regional baselines, equivalent to 150% of the average emissions for concrete mixes in the Eastern Region. These limits will be in effect starting in 2025. In 2027, the limits will be revised using New York-specific data collected through the E.O. #22 reporting effort. They will be progressively lowered in 2027 and in subsequent years, representing a commitment to gradually reducing emissions from the concrete sector.

Table 3.2.4 Maximum GWP ($kgCO_2e$) Limits for NYS Buy Clean Concrete guidelines
(relevant for Phase 1 and Phase 2)

Specified compressive strength (f'c in PSI)	**NYS Buy Clean Concrete GWP Limits** in kilograms of carbon dioxide equivalent per cubic yard - $kgCO_2e/ y^3$ (in kilograms of carbon dioxide equivalent per cubic meters- $kgCO_2e/ m^3$)
0 - 2500	275 (360)
2501 - 3000	302 (395)
3001 - 4000	360 **(471)**
4001 - 5000	434 (568)
5001 - 6000	458 (600)
6001 - 8000	541 (708)

Section 3.2.4.5 Waivers and Exemptions

If, during the progress of an eligible state contract for low embodied carbon concrete, a concrete mix cannot be found that meets the requirements of the contract and these guidelines, the prime contractor may request a waiver from the agency. The head of the State agency may determine that a waiver is appropriate and issue a waiver from these guidelines. In instances where the agency chooses to grant a waiver, contractors and suppliers should be directed to continue to reduce the GWP of the concrete mixes as much as possible.

When requesting a waiver, the contractor must document the following for the State agency's consideration:

(i) the concrete mix(es) being given the exemption, including compressive strength;
(ii) provide documentation of mix composition if no EPD is available;
(iii) the reason for the exemption, for example, the only available suppliers in the local area currently not being able to produce EPDs yet, or unavailability of materials to produce low embodied carbon mixes;
(iv) the methods that will be used to reduce concrete GWP on the project. If no methods were taken, contractor should set forth the reason(s);
(v) any other factors affecting the decision to grant a waiver.

Section 3.2.4.6 Obstacles and Lessons

None reported as implementation has not started.

Section 3.2.5 US GSA LOW EMBODIED CARBON CONCRETE STANDARD

Section 3.2.5.1 Background

The Inflation Reduction Act of 2022[lxiii] provided $3.375 billion to the US General Services Administration (GSA) to invest in federal buildings to help reduce carbon emissions and catalyze innovation. Section 60503 appropriated $2.15 billion for the procurement of low embodied carbon construction materials. This implemented an EPD disclosure standard for concrete and asphalt materials in construction, modernization, and paving projects. GSA developed IRA Low Embodied Carbon (LEC) material requirements to specify some material attributes when contracting for construction services that are funded in whole or in part by GSA's IRA Low Embodied Carbon appropriation.

Concrete suppliers are required to demonstrate compliance with maximum emissions standards set by GSA. Contractors will need to provide a product specific cradle-to-gate third-party verified EPD verifying the amount of embodied carbon involved in the product's extraction, transportation, and manufacture. The standard identifies specific limits for allowable embodied carbon based on concrete mix type and strength, which represent a 20% reduction from industry recommended limits.

Section 3.2.5.2 Eligible Material

These IRA low embodied carbon material requirements apply to Section 60503-funded purchases of four key construction materials: concrete (and cement)[lxiv], asphalt**,** steel, and glass**.** Construction product assemblies (such as window assemblies or rebar-reinforced concrete) qualify for IRA funding if at least 80% of the assembly's total cost or total weight comprises materials that meet these requirements.

Where provision of concrete that qualifies under these GSA IRA Limits is practical, GSA's IRA Limits for Low Embodied Concrete must be used. Where provision of concrete that qualifies under these GSA IRA Limits is impractical, GSA's IRA Limits for Cement may be applied to the cement being used in the concrete mix given:

- A concrete EPD accounts for the whole mix design, including quantitative impacts of specific cements, aggregates, and admixtures.
- If a concrete EPD is provided to demonstrate compliance, a cement EPD doesn't need to be submitted to GSA. Cement is an input to concrete mixes, and its GWP is accounted for in the concrete EPD.

Section 3.2.5.3 Minimum Project Threshold

These requirements apply to all GSA projects that use at least ten (10) cubic yards of concrete.

Section 3.2.5.4 Setting Limits

The Federal government ensured a deliberate road to implementation:

8/16/2022	Inflation Reduction Act	12/22/2022	EPA Interim Determination
10/4/2022	Buy Clean Industry RFI	1/25/2023	Public Draft Version
		5/16/2023	Pilot GSA Requirements

Based on the EPA's interim determination, materials/products qualify if their product-specific GWP is in the best performing 20 percent (Top 20 percent or lowest 20 percent in embodied greenhouse-gas emissions), when compared to similar materials/products (for example, materials/products within the same product category that meet the same functional requirements). If materials/products in the Top 20 percent are not available in a project's location, then a material/product qualifies per this determination if its GWP is in the Top 40 percent (lowest 40 percent in embodied GHG emissions). If materials/products in the Top 40 percent are not available in a project's location, then a material/product qualifies per this determination if its GWP is better than the estimated industry average. The GWP standards vary by mix strength and align approximately with the NRMCA's national average GWP value, as reported in its industry-wide EPD.

Table 3.2.5.1 GSA IRA Limits for Low Embodied Carbon Concrete

	GSA IRA Limits for Low Embodied Carbon Concrete (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per cubic meter - $kgCO_2e/ m^3$)		
Specified concrete strength class (compressive strength [f'c] in pounds per square inch [PSI])	**Top 20% Limit**	**Top 40% Limit**	**Better Than Average Limit**
≤2499	228	261	277
3000	257	291	318
4000	284	326	**352**
5000	305	357	382
6000	319	374	407
≥7200	321	362	402
Add 30% to these numbers for GWP limits where high early strength concrete mixes are required for technical reasons.			

Table 3.2.5.2 GSA IRA Limits for Low Embodied Carbon Cement

GSA IRA Limits for Low Embodied Carbon Cement (EPD-Reported GWPs, in kilograms of carbon dioxide equivalent per metric ton - $kgCO_2e/t$)		
Top 20% Limit	**Top 40% Limit**	**Better Than Average Limit**
751	819	858

Section 3.2.5.5 Waivers and Exemptions

- Construction product assemblies can also qualify for IRA funding where at least 80% of the assembly's total cost or total weight comprises IRA-qualifying material such as low embodied carbon cement.
- Where materials/products with GWPs that meet the Top 20 percent or Top 40 percent are currently not available at a particular IRA-funded job site, unavailability shall be documented explaining how materials/products were searched for and how the selected materials/products were validated to have a GWP better than the industry average for the applicable product category and region.
- If it is not feasible to meet GSA's EPD requirement or GWP limits, the [prime contractor] shall ask the GSA project manager to request a P100 waiver. The [prime contractor] shall outline and provide evidence of the specific circumstances that make compliance infeasible. For example, the only concrete suppliers within the maximum transport range for the mix design:
    a. are small businesses that have not yet invested in EPDs; or
    b. do not yet offer mixes that meet GSA's GWP limits, e.g. because lower-carbon materials are unavailable, or do not meet specific client-driven performance requirements.

  Any requests for waivers from the GWP limits must include the strategies, if any, that will be used to reduce GWP to the extent feasible. Such strategies include, but are not limited to, the use of alternative cements, supplementary cementitious materials, or alternative aggregates.

Section 3.2.5.6 Obstacles and Lessons

Where feasible, EPDs must also rely on facility-specific data, including for the supply chain's associated unit processes, such as concrete's upstream cement plant, rather than industry or manufacturer average data. If an EPD containing facility-specific data for the material's most greenhouse-gas intensive processes is unavailable, an EPD without such data that meets Compliance Documentation criteria and is sufficient.

Section 3.2.6 COLORADO BUY CLEAN

Section 3.2.6.1 Background

With the passage of HB21-1303: Global Warming Potential for Public Project Materials[lxv] (aka Buy Clean Colorado (BCCO)) Act (C.R.S. 24-92-117) moves the state toward the ambitious climate goals of its 2021 GHG Pollution Reduction Roadmap[lxvi], which plans to cut overall GHG emissions to half their 2005 levels by 2030 and eliminate GHG emissions by 2050. The Office of the State Architect (OSA) will administer a program pertaining to all construction projects for state agencies and institutions of higher education whereas the Colorado Department of Transportation (CDOT) will administer a program relevant to CDOT's horizontal construction projects only. Contractors must submit product-specific EPDs to the design team before the material will be approved for installation.

This law requires the OSA to establish a maximum acceptable global warming potential (GWP) limit for each category of eligible materials. These materials are the focus for Buy Clean Colorado due to their high carbon emissions impact and volume use in public projects and since reducing the impact of these materials will provide the greatest reduction of GHG emissions during the construction of State public projects. Through design optimization and responsible selection of materials, reduction of embodied carbon emissions from building materials can be accomplished. The proposal is part of a larger initiative to reduce Colorado's industrial sector emissions by 20% of their 2015 levels by 2030, and aligns with an array of newly signed laws.

Section 3.2.6.2 Eligible Material

The BCCO Act applies to Asphalt and Asphalt Mixtures, Cement and Concrete Mixtures, Glass, Post-tension Steel, Reinforcing Steel, Structural Steel, Wood Structural Elements,

Section 3.2.6.3 Minimum Project Threshold

"Eligible project" means a public project defined as any construction, alteration, repair, demolition or improvement of any land, building, structure, facility, or other public improvement for which appropriation or expenditure of moneys is over $500,000 and for which an agency of government issues a solicitation on or after January 1, 2024.

Section 3.2.6.4 Setting Limits

For products with industry available data, the OSA determined the initial GWP thresholds based on the industry average of GWP emissions for that material. For products demonstrating less than 50% U.S. market share, OSA chose to include uncertainty within the GWP limit. The OSA is required to update the GWP limits at a minimum of every 4 years. However, OSA may update the table that follows on an annual basis determined by the availability of EPDs as they have a 5-year life. For the Ready Mix Concrete categories, the cement GWP impact is considered within each strength category. Therefore, projects that meet the Ready Mix Concrete GWP Limit for the required strength category meet the associated cement GWP limit. For concrete strengths between the stated values, use linear interpolation to determine embodied carbon limits, rounded to the nearest whole number. Weighted average ("in aggregate") is allowed.

Table 3.2.6 Maximum Acceptable Global Warming Potential (GWP) Limits (2024)

Asphalt and Asphalt Mixtures[3]	**1. Asphalt Mixtures** (1 metric ton): 85 kg CO_2 eq.
Cement & Concrete Mixtures[4]	**1. Ready Mix Concrete** (in kgCO_2e/m^3 or kilograms of carbon dioxide equivalent per cubic meter) at 28 days:
	a. 2500 psi: 232
	b. 3000 psi: 255
	c. 4000 psi: **301**
	d. 5000 psi: 358
	e. 6000 psi: 379
	f. 8000 psi: 440
	g. Lightweight (LW) 3000 psi: 484
	h. LW 4000 psi: 532
	j. LW 5000 psi: 580
	2. Cement (in kg CO_2e/t or kg of carbon dioxide equivalent per metric ton): 1,112
Glass[5]	**1. Flat Glass** (1 metric ton): 1510 kg CO_2 eq.
Post-Tension Steel[6]	No sufficient data to set a valid threshold at this time
Reinforced Steel[7]	**1. Fabricated Steel Reinforcing Bar "Rebar"** (1 metric ton): 1030 kg CO_2 eq.
Structural Steel[8]	**1. Fabricated Hot-rolled steel** (1 metric ton): 1220 kg CO_2 eq.
	2. Fabricated Plate steel (1 metric ton): 1730 kg CO_2 eq.
	3. Fabricated Hollow Structural Sections (1 metric ton): 1990 kg CO_2 eq.
Wood Structural Elements[9]	**1. Wood Framing/ Softwood Lumber** (1 m^3): 63.12 kg CO_2 eq
	2. Plywood (1 m^3): 219.32 kg CO_2 eq
	3. OSB Sheathing (1 m^3): 242.58 kg CO_2 eq
	4a. Laminated Strand Lumber (1 m^3): 274.90 kg CO_2 eq
	4b. Laminated Veneer Lumber (1 m^3): 361.45 kg CO_2 eq
	5. Glued Laminated Timber (1 m^3): 137.19 kg CO_2 eq

1) Only consider permanently installed materials.
2) OSA subcategories align with available products, product categories, and building codes.
3) Inclusive of all paving asphalt mixes supplied.
4) Subcategories based upon regional compressive strength specifications at 28 days 5 Designs specify processed glass and flat glass is a component of processed glass assemblies.
5) Zero post-tension steel subcategories identified at this time. 7 Rebar is the only identified subcategory for Reinforced Steel at this time.
6) Structural steel subcategories as defined by AISC Code of Standard Practice (ANSI/AISC 303-16). HVAC units as manufactured do not need to conform.
7) Subcategories based upon available IW-EPDs. Only consider permanently installed wood products.

Section 3.2.6.5 Waivers and Exemptions

The Colorado Department of Transportation and Office of State Architect can issue waivers if:

1. Providing an EPD for an eligible material would be “technically infeasible” or NOT available:
    a. EPDs beyond period of validity.
    b. not covered by the scope of the relevant PCR.
    c. The material with an EPD does not meet the strength, serviceability, stability, or other structural requirements as necessary for the project.
2. Significant project cost
3. Significant time delay
4. Sole Sourced material
5. Reused or recycled material

6. Emergency
7. No eligible materials utilized in project

Section 3.2.6.6 Obstacles and Lessons

The OSA was unable to establish maximum acceptable GWP limits for several categories of eligible materials due to the lack of industry data currently available.

To overcome manufacturers' cost hurdle of obtaining EPDs, the state recently passed the Colorado State SB 22-051: Credit Sales Tax for Building Materials[lxvii]. Beginning July 1, 2024, all sales, storage, and use of eligible decarbonizing building materials are exempt from state sales and use tax. "Eligible decarbonizing building materials" are building materials that have a maximum acceptable global warming potential as determined by the OSA and that are on a list of eligible materials maintained by the office based on EPDs voluntarily submitted by manufacturers.

Section 3.2.7 NEW JERSEY LOW EMBODIED CARBON CONCRETE LEADERSHIP ACT

Section 3.2.7.1 Background

Beginning in 2024, the New Jersey Low Embodied Carbon Concrete Leadership Act[lxviii] (LECCLA) (S-287) will offer tax incentives to concrete producers who provide mixes with a reduced carbon footprint on state-funded projects. This law signed by Governor Murphy went into effect on July 30, 2023, and applies to tax years beginning on or after January 1, 2024. Under the law, concrete mixes with Global Warming Units (GWUs) below a threshold to be established by the NJ Department of Environmental Protection are eligible for tax credits amounting to 8% of the cost of the contract.

- Five (5) percent by reducing embodied carbon in concrete by:
    a. improving energy efficiency at the cement plant or concrete plant stages;
    b. substituting low-carbon fuels for carbon-intensive fuels at the cement plant or concrete plant stages;
    c. using locally sourced ingredients in concrete mixes, reducing transportation-related emissions;
    d. reducing cement content in concrete mix by substituting materials such as fly ash, slag, or recycled ground-glass pozzolan (collectively known as supplementary cementitious materials, or SCMs), to reduce the quantity of emissions-intensive cement in the mix;
    e. capturing and storing point source carbon emissions during the cement plant or concrete plant stages; or
    f. utilizing and storing carbon in concrete.
- An additional three (3) percent tax credit will be available to producers who use carbon capture utilization and storage (CCUS) technology in the concrete manufacturing process. The two tax credits can be combined.
- To limit the program's fiscal impact, the total amount of tax credits that can be issued each year is $10 million, to be issued on a first-come-first-served basis. And no single concrete producer can claim more than $1 million in credits per year.

Section 3.2.7.2 Eligible Material

The regulation targeted carbon emissions associated with the production of concrete.

Section 3.2.7.3 Minimum Project Threshold

Beginning in 2024, concrete producers who supply at least 50 yards of concrete for state funded construction projects will be eligible for a performance-based tax credit.

Section 3.2.7.4 Setting Limits

None published as of writing. The Department of Environmental Protection, in consultation with the Director of the Division of Taxation in the Department of the Treasury, shall provide thresholds for low embodied carbon concrete and concrete that incorporates carbon capture, utilization, and storage technology to qualify for a tax credit.

Section 3.2.7.5 Waivers and Exemptions

None published as of writing.

Section 3.2.7.6 Obstacles and Lessons

None reported as implementation has not started. One criticism is that the state has only allocated $10 million in tax credits per year to qualifying companies, and no producer may win more than $1 million in credits in any year.

Section 3.2.8 MINNESOTA BUY CLEAN BUY FAIR

Section 3.2.8.1 Background

Signed into Law by Governor Walz in 2023[lxix] as a part of the Natural Resources, Climate and Energy Omnibus Bill, Article 12, Section 1: Construction Materials; Environmental Analysis creates an Environmental Standards Procurement Task Force[lxx] by October 2023, which will advise the Department of Administration and MN State DOT on EPD collection requirements, procurement process, industry incentives, GWP limits, and other aspects. It also establishes an EPD grant program.

The pilot program to be established by July 2024 seeks to obtain from vendors an estimate of the material production life cycle GHG emissions of products selected by the departments from among those procured including quantity of materials, EPDs, manufacturer, Supplier Code of Conduct, production facilities, working conditions in a publicly accessible database.

$310,000 in grants will be awarded the first year to assist manufacturers to obtain EPDs for used to build roads and other transportation infrastructure. Of this amount, up to $10,000 is for the reasonable costs of the department to administer that section. This appropriation is available until June 30, 2027.

Section 3.2.8.2 Eligible Material

Eligible materials include (1) carbon steel rebar; (2) structural steel; (3) concrete; or (4) asphalt paving mixtures.

Section 3.2.8.3 Minimum Project Threshold

Eligible projects include (1) new construction of a state building larger than 50,000 gross square feet of occupied or conditioned space; (2) renovation of more than 50,000 gross square feet of occupied or conditioned space; (3) new construction or reconstruction of two or more lane-miles of a trunk highway; or (4) in a state building whose renovation cost exceeds 50 percent of the building's assessed value.

Section 3.2.8.4 Setting Limits

None published as of writing. The state must establish GWP limits for concrete by January 2026, and for steel and asphalt paving mixtures by January 2028.

Section 3.2.8.5 Waivers and Exemptions

None published as of writing.

Section 3.2.8.6 Obstacles and Lessons

Similar to Washington State's Buy Clean Buy Fair Act, manufacturers note the lack of available data on labor conditions from supply chain sources.

Section 3.2.9 WASHINGTON BUY CLEAN BUY FAIR

Section 3.2.9.1 Background

On March 28, 2024 Washington State Governor Inslee signed the landmark Public Building Construction And Renovation—Environmental And Labor Reporting (Buy Clean, Buy Fair (BCBF)) legislation, which addresses embodied carbon by requiring reporting on environmental and workforce impacts associated with the production of building materials used in state. Beginning July 1, 2025, contractors for eligible public projects must report product quantities, a current EPD, the manufacturer name and state/province and country. If available, health product declarations, a supplier code of conduct, and office of minority and women-owned business enterprises certifications must be reported. The bill also requires reporting of working conditions data, performance-based specifications for concrete, and continued use and maintenance of a Buy Clean Buy Fair Reporting Database.

Prior to BCBF's adoption, the Washington State Legislature in 2021 commissioned a pilot study, the Buy Clean Buy Fair (BCBF) Washington Project. This project required the University of Washington (UW) College of Built Environments to develop a reporting database to collect environmental and labor information from state construction projects and conduct a case study using pilot projects. The Department of Commerce used recommendations from the pilot to develop a BCBF program that encourages broader adoption of EPDs, supports project teams with reporting requirements, tracks procurement data for concrete, wood, and steel used in state building projects, and convenes stakeholders to explore opportunities to strengthen market demand and supply of low-carbon building materials[lxxi].

Section 3.2.9.2 Eligible Material

The policy applies to a specific set of products across four materials categories: structural concrete, reinforcing steel, structural steel, and engineered wood products. Structural materials account for 80 percent of a building's embodied carbon footprint.

Section 3.2.9.3 Minimum Project Threshold

The policy applies to public construction projects larger than 50,000 gross square feet or building renovation projects where the cost is greater than 50 percent of the assessed value and the project is larger than 50,000 square feet.

Section 3.2.9.4 Setting Limits

None currently as the requirements for compliance is primarily reporting. By December 1, 2024, the Department of Commerce must convene a technical work group to identify opportunities and barriers for using and producing low-carbon materials, promote high labor standards in manufacturing, and preserve and expand low-carbon material manufacturing in Washington.

Section 3.2.9.5 Waivers and Exemptions

None published as of writing.

Section 3.2.9.6 Obstacles and Lessons

The BCBF requirements have not commenced as of this writing. However, several lessons can be learned from the pilot project in 2022[lxxii]. The submission of the pilot project materials was somewhat incomplete. The submitted EPDs were manufacturer-specific, not supply chain-specific. As a result, they lacked the necessary level of data specificity to be supply chain-specific. Material quantities submissions were not always complete because the project had not completed construction or because the contractor was unresponsive to the data request.

After debrief interviews with the pilot project teams, the research team condensed the lessons learned into the following recommendations for the state, should the program extend beyond the pilot:

- Provide model specifications so owners can use a reliable and consistent set of contract requirements and instructions to set reporting requirements. This will assist contractors in becoming accustomed to these requirements as they become more widespread in the industry.
- The model specifications should include: A recommended timeline for when the contractors should start reaching out to suppliers and initiating the EPD requisition process.
- Provide financial assistance for EPD creation. There is usually a high upfront cost for a manufacturing plant to produce its first EPD. This can be a significant burden, especially for smaller companies.
- Provide educational resources for owners, contractors, and suppliers on how to navigate the BCBF requirements.
- Provide a list of pre-qualified consultants who can create EPDs.
- Have a dedicated staff person for the BCBF Program to answer questions and facilitate it.
- Work with industry groups to conduct outreach to educate contractors and owners on the reporting program.

Section 4.1 CONCLUSION

Programs like Buy Clean are important to help entities reach their carbon targets, execute climate action plans, reduce embodied carbon, develop consistent regulations, and support economic competitiveness. Buy Clean actions in federal, state, county and city governments are the first wave of enforceable standards to emerge from addressing embodied carbon in public projects, and, more specifically, its stated intention of leveraging the procurement function in pursuit of its climate change policy objectives. Buy Clean in codes and standards are assisting owners and developers address the impacts of climate change and demonstrate an ongoing commitment to decreasing greenhouse gas emissions in construction materials.

However, implementation of Buy Clean policies is not easy. There is no consensus on how best to implement the policies. Several jurisdictions have seen delays in implementations due to lack of data, lack of understating of the reporting tools, lack of EPDs in parts of the country, geographic variations in supply chain, and ever-changing technologies for decarbonization. Legislative language must be converted to the comprehensive set of interconnected codes that are designed to govern new construction, renovations, and repairs. Suppliers must be encouraged to adopt new environmental reporting tools. Support must be provided to contractors and facilitate the process and maximize the chances of successful reporting. For concrete, scheduling is at the heart of carbon reduction as design elements that allows for longer cure times can have increased SCMs. Yet at the bid stage the contractor has not set the schedule potentially submitting inappropriate EPDs. Jurisdiction staff must be trained to understand the new reporting tools, data-tracking and project bid awarding processes.

Implementation of Buy Clean include a combination of:

1. Planned actions in the form of climate action plans, pledges, executive order and commitments.
2. Updates to building codes, by-laws and regulations and incentive programs.
3. Stakeholder engagement which includes academia, researchers, non-governmental organizations, industry, design professionals and contractors.
4. Analysis of supply chain data including availability of materials, geography, geology, and emerging technology.
5. Updating forms, specifications and alignment to ease implementation.
6. Phases for implementation, waiver process and reporting tools.

There are key findings about how to implement Buy Clean Maryland. It impacts a diverse group of stakeholders, not just those who manufacture eligible materials. Most programs phase in implementation requirements over several years to mitigate many of the perceived costs and challenges. Phasing in requirements allows manufacturers to create EPDs and build capacity to meet policy requirements, project teams to receive training on compliance and government agencies to refine requirements and implement lessons learned from early adopters. Government-industry partnerships and stakeholder engagement can inform policy development and garner industry support.

The Carbon Leadership Forum (CLF) provided an excellent summary based on findings from the 2019 Buy Clean Washington Study[lxxiii] commissioned by the State of Washington. Several recommendations which include both “carrots” and “sticks” reflect the findings from this Study noted as examples below.

- Mitigating Cost Burden of EPD Development (Examples: New Jersey, Oregon, Minnesota)
  - Partner with industry associations and other organizations to support the development of free tools that simplify EPD creation
  - Set compliance exemption criteria for small businesses
  - Provide tax breaks or other incentives for creation of EPDs
- Data Collection (Examples: New York, Washington)
  - Utilize existing, publicly accessible tools such as EC3 and databases to collect and store EPDs and material quantities to make good decisions
  - Screen out worst performers

    - Provide accessible training and compliance guidance
- GWP Threshold Development (Examples: New York, Oregon, CalGreen)
    - Adopt uncertainty ranges to avoid contested compliance
    - Use standards established by third-party organizations such as NRMCA
    - Set a high initial standard that decreases over time to meet goals (e.g. 125% of average)
- Verifying Compliance (California, Oregon, US GSA, New York, Marin County, Colorado)
    - Begin with incentivizing compliance (instead of penalizing non-compliance) and phase in requirements
    - Set compliance exemption criteria or a hardship clause
    - Provide model specifications (NRMCA, CO, Marin)
    - Provide training and support

This guidance aims to help the State of Maryland understand the various actions required to implement Buy Clean Maryland but does not prescribe which actions should be prioritized, as this is up to the Department of General Services and the Maryland Green Building Council. This Study provides the opportunity to explore the process of setting up and running a Buy Clean reporting program. Other states and jurisdictions offer insights and lessons learned about how they supported contractors, designers, jurisdiction staff and facilitate the reporting process to maximize the chances of successful reporting. Maryland can take advantage of these opportunities and leapfrog major obstacles from an operational standpoint.

This Study has been possible through the generous support of the US Climate Alliance.
To learn more, go to https://usclimatealliance.org/

ENDNOTES

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