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REPORT

A DESIGN GUIDE TO STATE AND LOCAL LOW-CARBON CONCRETE PROCUREMENT

© Architect of the Capitol

Workers spreading concrete during the Cannon Renewal Project at the US Capitol in Washington, DC, June 2016.

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ACRONYMS

ASTM - American Society for Testing and Materials

EPD - Environmental Product Declaration

GHG - Greenhouse Gas

ISO - International Organization for Standardization

LCA - Life-Cycle Assessment

NRMCA - National Ready Mixed Concrete Association

PBS - Performance-Based Specification

PCR - Product Category Rule

PLC - Portland-Limestone Cement

RCA - Recycled Concrete Aggregate

SCM - Supplementary Cementitious Material

About This Guide

Concrete is the most common building material on earth.[1] However, its main binding ingredient, Portland cement, is a leading source of industrial carbon dioxide pollution, accounting for approximately 7 percent of global greenhouse gas emissions annually.[2]

Nearly one-third of all concrete used for construction in the United States is procured by state and local governments.[3] Such an outsize market influence is leading a growing number of state and local governments to focus greater attention on concrete and its use in public projects as an element within broader decarbonization policy and strategy. This report offers an actionable survey of leading approaches that leverage public sector purchasing as a tool to reduce the emissions of this ubiquitous building material, create a market for cleaner alternatives, and drive continuous innovation in the sector.

The analysis draws extensively from approaches that are being implemented, adapted, and advocated for in state and municipal jurisdictions all over North America today.

- The **Introduction** provides a brief overview of concrete's relevance to climate change as a significant source of emissions and examines the reasons why public procurement at the state and local level can play a critical role in its decarbonization.
- **Section I** defines six key principles that can inform effective procurement policy design.
- **Section II** presents five specific policy levers that, individually and in combination, can contribute to effective public procurement of low-carbon concrete.
- The **Conclusion** describes the different dynamics that can influence the impact of these policy levers when they are combined in a common strategy.
- **Appendix I** offers a detailed synopsis of common cement and concrete decarbonization pathways, and existing state and local low-carbon concrete policies are covered in **Appendix II**.

The most effective policies will combine changes to both procurement standards and material specifications. For example, procuring agencies that offer financial bonuses or incentives for superior climate performance must also put in place specification systems that are not overly prescriptive and thus grant contractors latitude to select from a range of lower-carbon products and methods.

This guide aims to both provide actionable guidelines for practitioners and inspire further thinking, experimentation, and adaptation in this vital area of climate policy and action. Readers are encouraged to think both practically and creatively about the principles and policies presented here and how each relates to specific real-world conditions in their state or locality. Deploying concrete decarbonization policies at the state and local level is a relatively new climate solution, yet the United States has already seen a diverse range of concrete decarbonization approaches across different jurisdictions. Using this guide, local and state governments can keep this trend going by continuing to produce new ideas, strategies, and lessons that will contribute to the collective knowledge and efficacy of policymakers everywhere.

Introduction

CONCRETE IS A SIGNIFICANT CONTRIBUTOR TO CLIMATE CHANGE

Concrete is the second-most commonly used material on earth (after water) and is by far the world's most common building material.[4] Approximately 18 billion tons are produced annually around the globe.[5] Its distinct physical, performance, supply, and cost characteristics make it, quite literally, a foundation of the modern built environment.

Concrete's value as a building material is undeniable, but its present and future relationship to our changing climate is complex. As a mainstay of construction, concrete is valued for its strength, versatility, and durability—all properties that will be indispensable to achieving greater climate resilience in our built environment in the coming years. Further, concrete possesses a unique capacity to sequester ambient carbon over its life span through the gradual chemical process of *carbonation*. Between 1930 and 2019, an estimated 21 billion tons of ambient carbon dioxide (CO_2) were locked into concrete and other cementitious products, globally, by carbonation.[6]

However, the embodied carbon content of concrete exceeds the level of carbon that the material can ultimately sequester within any timeframe relevant for addressing climate change. This is largely because the process of manufacturing Portland cement, the ingredient that gives concrete its unique structural properties, is extremely emissions intensive. While typically making up no more than 15 percent of concrete by volume in most applications, it accounts for approximately 80 percent of the material's carbon emissions.[7] Globally, the Portland cement industry is responsible for 7 percent of total anthropogenic CO_2 emissions and would be the third-largest emitter in the world if it were a country.[8] In the United States, 92 cement plants reported emissions of 67 million metric tons of carbon dioxide equivalent (CO_2e) to the U.S. Environmental Protection Agency (EPA) in 2019, roughly 10 percent of the industrial sector's direct reported emissions.[9]

An overhead view of a worker using a concrete mixer to create concrete at a construction site in Los Angeles, California.

CONCRETE AND CEMENT: RELATED BUT NOT THE SAME THING

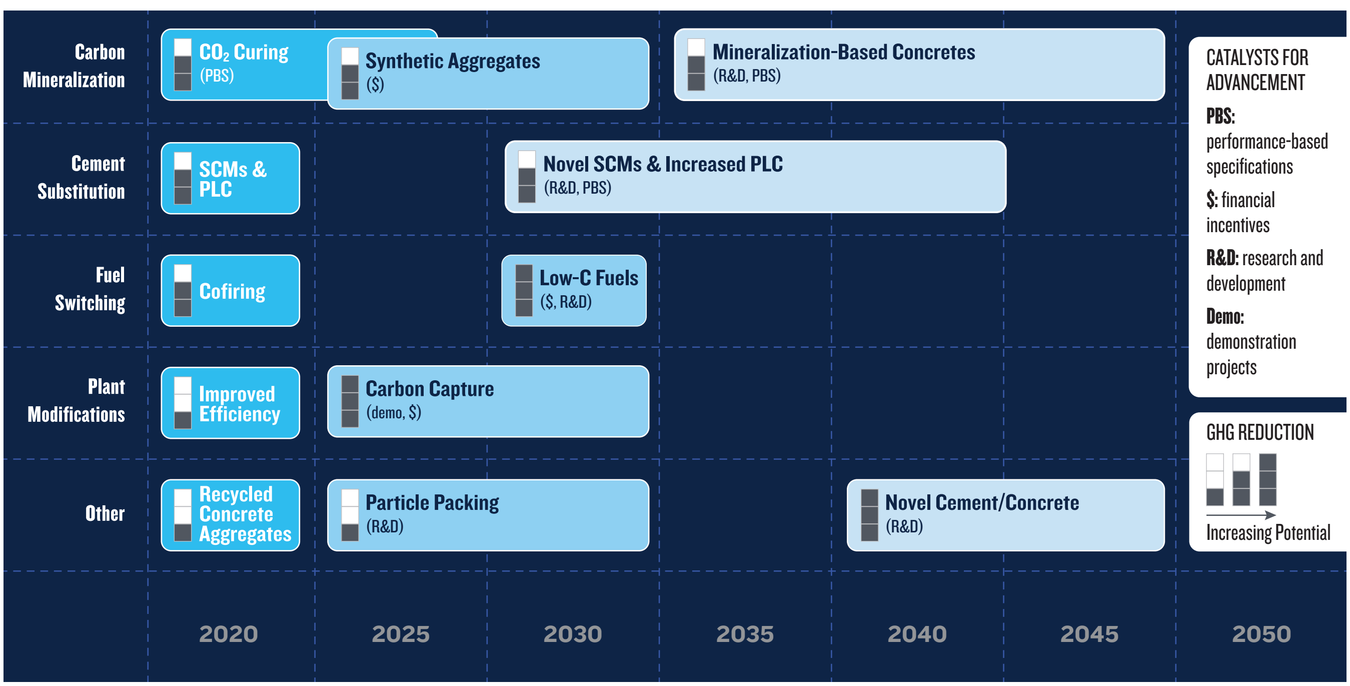
- CEMENT is one component of concrete. It is the powdery substance typically made of lime and clay that hardens after being combined with water to bind together the different components of concrete.
- CONCRETE is the finished construction material that commonly consists of cement, water, aggregate (usually a mix of sand and gravel), and air. Concrete uses cement to bind and harden into a solid mass.

Concrete has been around for millennia, and its method of production has remained effectively unchanged over the past two centuries: A combination of sand and gravel, or "aggregate," is blended with Portland cement, water, air, and other trace components in various proportions to meet the structural and performance needs for scores of different applications. Ready-mix concrete is blended and then poured and applied at the point of use. With the same inputs, concrete masonry units ("block"), pavers, and other precast products are cured in heated kilns and then shipped on pallets to construction sites.

However, a growing spectrum of alternative production materials and technologies throughout concrete production are today being incorporated into these age-old processes to both improve structural performance and reduce the emissions of concrete, and many more are on the horizon. Some of these are highly innovative and cutting-edge and are just now emerging. Others are decidedly low-tech and already well established in practice but could be much more extensively deployed.

Major emissions reduction strategies include cement substitution, cement plant modification and fuel switching, carbon utilization in concrete, carbon capture and storage, and other material and life cycle–related innovations and processes. These strategies and some of their existing and emerging forms are displayed in Figure 1 below and summarized in Appendix I.

FIGURE 1: AVAILABLE TECHNOLOGIES TO PRODUCE LOW-CARBON CONCRETE



SCM: supplementary cementitious material.
PLC: Portland-limestone cement.
RCA: recycled concrete aggregates.

Achieving low-carbon concrete will require a continuous process of substitution, modification, and optimization over time. A successful process will necessarily involve many stakeholders and will transition concrete in its many forms from a net climate liability today to a climate-neutral or even net beneficial material in the future.

The rate at which innovation and change occur in the concrete industry in the coming years can be greatly influenced and accelerated by the policy decisions of local, state, and federal governments. As more legislatures, executives, agencies, and authorities seek effective ways to meet economy-wide emissions reduction targets, policies focused on decarbonizing concrete are imperative.

EXPLAINER 1: DEFINING "LOW-CARBON CONCRETE"

The term "low-carbon concrete" does not refer to a single, discrete product but rather a spectrum of approaches that alone or in combination reduce the GHG emissions of concrete relative to more conventional specifications and practices. For this reason, lower-carbon concrete is perhaps a more accurate designation, because it communicates the relative and highly variable nature of emissions reductions for this material.

Here are some important factors that policymakers should consider in regard to low-carbon concrete:

- **Emissions reductions in concrete can be achieved cumulatively throughout the material's full life cycle, not just through a single change.** This includes via component selection; manufacturing, transportation, and construction processes; and post-construction maintenance, repair, and disposal or reuse.
- **Emissions reductions are maximized when individual reduction factors are combined, or "stacked," in the same concrete mix or end product.**
- **Most emissions reductions can be implemented by existing cement and concrete producers.** Lowering carbon in concrete will largely involve the decisions and actions of established cement and concrete producers, rather than the emergence of separate successor industries and actors.

PUBLIC SECTOR PROCUREMENT CAN CATALYZE CONCRETE DECARBONIZATION

More than one-third of all concrete produced in the United States is purchased by federal, state, and local governments.[10] Public procurement, therefore, is an important mechanism for decarbonizing concrete. This substantial government demand can be leveraged in high-impact ways to influence the availability, cost, and rate of acceptance of low-carbon concrete alternatives in the economy at large.

As high-volume early adopters, local, state, and federal governments can boost demand for existing and emerging methods and materials that deliver emissions reductions. This will help private sector providers of low-carbon alternatives scale more rapidly, accelerating cost reductions and building supplier capacity and market resilience. And multiple other critical advances follow when the public sector becomes a customer: the formulation of standards, the maturation of contracting and supply chains, and investment in the essential human capital needed to transition to lower-carbon formulations economy wide.

Finally, early acceptance by state-level buyers means that emerging technologies and materials will undergo rigorous testing and evaluation by state agencies before they can be adopted. Having that stamp of approval paves the way for local governments, as well as institutional and private sector decision makers who rely on state-provided material evaluation and specifications, to adopt new materials.

The idea of sustainable public procurement has a long history at both the national and the subnational scale. Indeed, sustainable procurement is explicitly recognized as a component of U.N. Sustainable Development Goal 12: "Ensure sustainable consumption and production patterns." Sustainable procurement programs can be narrowly designed to reduce the environmental footprint of government operations or included as part of a broader strategic effort to accelerate rates of innovation and market acceptance. Examples of public procurement's impact on climate and environmental technology commercialization include different forms of renewable energy such as solar photovoltaics, which benefited critically from consistent and almost exclusive long-term public sector demand during the industry's early stages. Public procurement has also supported other climate-friendly products and services involving transportation and vehicles, information technology, appliances, lighting, water, and many elements of construction and building management.[11]

In the United States, state and local governments have consistently been ahead of the federal government in setting binding emissions reduction targets and formulating policies to ensure that they are achieved. Therefore, it is not surprising that most policy activity and experimentation related to concrete decarbonization are occurring at the state and local level, including sustainable procurement. Low-carbon concrete purchasing standards and programs have already been proposed or implemented in several states including California, Colorado, Minnesota, New Jersey, New York, and Washington, as well as multiple municipalities (see Appendix II).

Additionally, while federal policies might be appropriate for emissions reductions in other sectors, factors specific to concrete actually make state- and local-level policy and regulation a more effective approach. There are several reasons. First, concrete materially differs by location. Its components in any given place or application will vary depending on local supply and environmental factors.[12] A concrete mix specified for the foundation of a new office building in Phoenix, Arizona, may be different from one used for the same application in Albany, New York. Consequently, concrete testing, standards, and regulations must be adapted to local conditions. Therefore, policy that aims to improve the climate and environmental impacts of the material must take into account local and regional variation in practices, codes, and standards.

Second, concrete is produced by thousands of locally and regionally owned and operated production facilities. Suppliers must be local because ready-mix concrete—which represents more than 70 percent of the concrete market—must be used the day it is made. [13] Avoiding premature hardening or setting is essential. This makes production and delivery scheduling highly time sensitive and critically important. Last-minute modifications are often required to deliver the right mix at the right time and the right cost. These requirements add complexity to the task of monitoring and assessing emissions performance, necessitating local capacity and involvement on the ground.

Finally, while the federal government wields considerable authority over public infrastructure investments, federal project funding for construction is largely distributed to and deployed by states. For example, the National Highway Performance Program and the Surface Transportation Block Grant Program annually provide more than $30 billion in capital funding that is divided among states to meet their local transportation infrastructure needs.[14] This funding structure empowers state and local governments to drive change in their infrastructure projects.

Together these factors mean that state and local governments must play a prominent role in driving high-impact strategies to reduce concrete emissions.

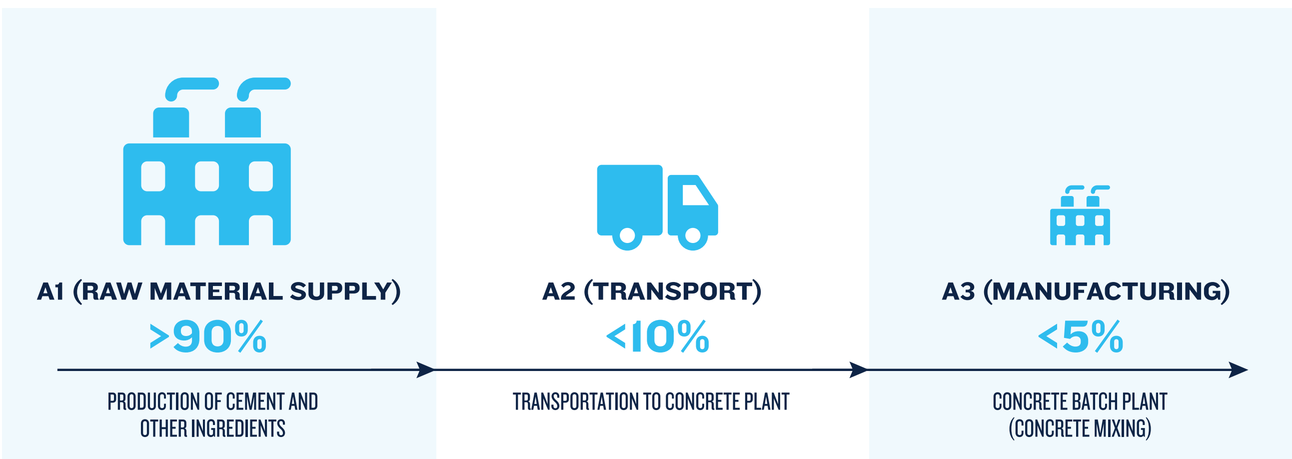
EXPLAINER 2: EMBODIED CARBON EMISSIONS VERSUS OPERATIONAL CARBON EMISSIONS

Carbon emissions are produced at multiple points during the lifetime of any manufactured material, such as concrete. These emissions are grouped into two categories:

- **Embodied carbon emissions** are those that occur during the raw material extraction, upstream production, transportation, and manufacturing stages before the material is used.
- **Operational carbon emissions** occur during the material's operational life after manufacturing and construction.

Concrete's climate impact is overwhelmingly a function of the embodied carbon emissions associated with the Portland cement manufacturing process.

FIGURE 2: RELATIVE CONTRIBUTION TO CONCRETE'S CRADLE-TO-GATE EMBODIED CARBON EMISSIONS[15]



Cement-related embodied carbon emissions can be further divided into "process" and "combustion" emissions. About 60 percent of the emissions in cement production are due to process emissions, where CO_2 is released as a chemical by-product of limestone calcination. The remaining emissions are from combusting fossil fuels (most commonly coal) at temperatures of up to 1,500 °C.[16]

At present, mandating or incentivizing reductions in embodied emissions can be considered the "low-hanging fruit" for overall emissions reductions in the concrete industry. This is because the tools available to quantify and verify embodied emissions, which must be reported in environmental product declarations (EPDs; see Explainer 3), already exist and continue to evolve along with other analytical resources. However, an important policy objective going forward must be to improve methods to more accurately account for concrete's post-construction operational carbon emissions.

Section I: Foundations

SIX GUIDING PRINCIPLES FOR MODEL CONCRETE PROCUREMENT DESIGN

State and local governments will approach low-carbon concrete procurement in different ways, depending on local priorities and existing regulatory and market conditions. However, lessons learned from leading jurisdictions and the private sector point to six key principles for program success.

I. Assess concrete on its own terms as an industry, material, and emissions source, starting with acknowledging that concrete is both complex and here to stay.

A yard of concrete is very different from a gallon of fuel or a kilowatt of electricity when it comes to realizing emissions reductions. Effective procurement policy design must acknowledge this reality.

This starts with a clear understanding that concrete is a deceptively complex material and industry. It is produced in countless variations to meet the specific structural, cost, and environmental requirements of hundreds of distinct construction applications. Small differences in mix designs can have big implications for how the material performs during construction and over its full life cycle, as well as for its embodied and operational carbon emissions. Local supply and environmental factors further differentiate how concrete is produced and used across different contexts. Production is also highly distributed and fragmented, taking place across the nation in thousands of local facilities that are owned and operated largely by independent local and regional producers.

Taken together, this inherent variability adds significant complexity to the task of measuring and reducing concrete's embodied carbon emissions. Further, more concrete, not less, will be manufactured in the future.[17] The material will be heavily relied on in the coming decades to meet the structural and resiliency needs of construction in an increasingly climate-volatile world, characterized by more intense precipitation and other weather events. Consequently, reducing emissions related to concrete will largely entail its transformation rather than its displacement. From a policymaking perspective, this makes concrete's emissions a very different kind of problem to solve compared to other major emissions sources.

A cement mixer truck driving through Manhattan, New York City.

2. Structure procurement rules and criteria to both promote greenhouse gas reduction pathways that are viable today and drive continuous improvement over time.

Reducing concrete emissions will involve many changes related to material components, manufacturing processes, operations, and construction and maintenance practices. Today, many proven, market-ready options can be implemented to cost-effectively advance this goal (see Figure 1). Accordingly, procurement-based policies must be designed to expand the use of the solutions currently available.

However, attaining the ultimate long-term objective of transforming concrete into a climate-neutral or even climate-positive material will necessitate the adoption of materials and practices that are just now emerging or still in an early premarket research phase. A comprehensive procurement policy framework must include mechanisms that accelerate the adoption of an ever-widening portfolio of innovations and improvements over time.

> "What we need in our [low-carbon procurement] programs is both to ensure that everybody is using current best practices, but also that we are providing incentives for people to innovate, do new things, and to get us to even better current best practices."
>
> —REBECCA DELL, PHD, CLIMATEWORKS FOUNDATION, IN TESTIMONY BEFORE THE U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON ENERGY AND COMMERCE, MARCH 18 2021.

3. Ensure that emissions reduction objectives align with standards and regulations that support long-term value, quality control, and safety.

As a building material that forms the foundations of our homes, buildings, and other structures, any emissions reduction objectives must not compromise structural integrity and public safety. Policy interventions that aim to decarbonize concrete must be directly integrated and aligned with evolving quality and safety standards, codes, and regulations.

Concrete production and use are closely bound up with cost, value, and safety outcomes that affect the public at large. This fact has led to stringent liability conditions related to material and project review and approval, engendering a justifiably high degree of caution and deliberation among the public authorities and civil engineering professionals who set and enforce concrete standards and certify projects. Safely realizing change will necessitate close collaboration and partnership between public authorities and private sector actors across the concrete manufacturing, construction, architecture, and civil engineering fields.

4. Prioritize understanding of different stakeholder experiences to ensure fairness and avoid unanticipated negative effects after implementation.

Achieving meaningful emissions reductions for this material will succeed only through collaboration between public and private actors. Policymakers must be attuned to how different proposals can have distinct implications, intended or not, for specific stakeholders. Therefore, it is necessary for policymakers to solicit perspective and knowledge from the private sector rather than simply impose new rules and regulations.

For example, the slow rate of change to concrete standards and specifications is often attributed to a prevailing culture of caution both within state agencies and among civil engineers. Policymakers must understand and design policies that consider the specific conditions that contribute to and sustain such a culture, such as the capacity and resource constraints of state agencies and the realities of personal legal liability that professional civil engineers face vis-à-vis project review and approval.

Further, policies must consider that the concrete industry is highly diversified and made up of firms that vary considerably in resources, scale, and scope of activities. New procurement policies designed to reduce carbon emissions from concrete production via mandates and/or incentives must be sensitive to this reality. This requires close consideration of how different approaches might advantage or disadvantage different actors, in particular small, local, and/or minority- and women-owned businesses.

5. Anchor policy design in rigorous analysis of real-world data.

Due to regional differences and the variety of applications, the embodied and operational carbon emissions of the concrete industry vary considerably. This makes developing an accurate measurement of emissions both on the individual project level and at industry scale a challenging and complex undertaking. Gaining insight into the actual emissions of concrete used in the real world therefore depends on the collection and analysis of high-quality data across thousands of locations and applications.

Any sound procurement strategy must be informed by actual, verifiable, and specific data (see Explainer 3). This will require a continual investment of time and resources to evolve existing tools to give more accurate measurements and to account for new production methods that will come online in the future.

6. Ensure that policies aiming to reduce concrete's climate impact do not add unintended environmental or health burdens for local communities.

Many factors that support emissions reductions in concrete also deliver parallel environmental co-benefits. For example, the creation of Portland cement not only accounts for most of concrete's greenhouse gas emissions but also releases hazardous air pollutants; reducing the use of Portland cement would reduce both types of emissions. Additionally, the use of established and emerging cement substitutes (supplementary cementitious materials, or SCMs) such as fly ash, slag, and ground-glass pozzolan can divert, repurpose, and immobilize what would otherwise be waste products collecting in landfills.

However, it is essential that all concrete decarbonization methods be subject to rigorous and transparent environmental assessments to ensure that their production or use does not directly or indirectly create risks for human health or ecosystems. Procurement policies must take these externalities into account as part of a fully transparent policy design process that allows for comment and input by the public.

FIVE POLICY LEVERS TO DECARBONIZE CONCRETE THROUGH PUBLIC PROCUREMENT

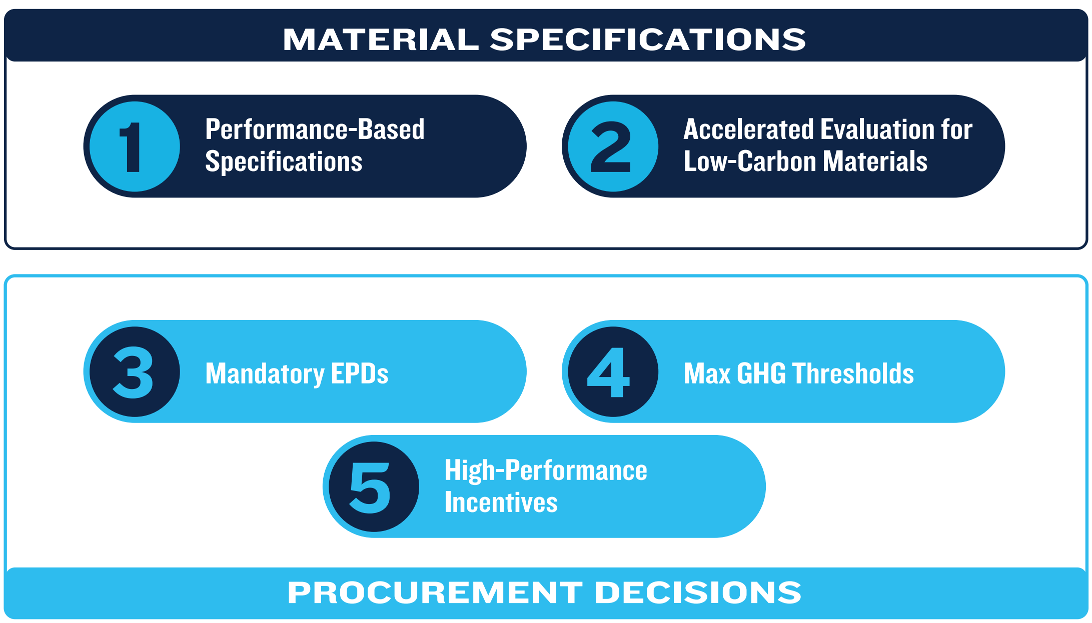
Policymakers have multiple interventions to consider when designing low-carbon concrete procurement programs. These interventions can be implemented in isolation to effect specific targeted changes or mitigate particular barriers or risks. However, combining several policy interventions can multiply the overall impact.

Policy interventions will involve either key changes to specific procurement decisions or changes to material specifications. Within these two categories, some interventions are necessary for others to take maximum effect (see Conclusion). For example, the impact of climate performance incentives for providers (a procurement decision) is highly contingent on the implementation of both performance-based standards and regularly updated agency-approved materials lists (both of which directly relate to specification practices).

However, implementing all five policy levers will maximize the extent and rate of decarbonization achieved.

MATERIAL SPECIFICATIONS

FIGURE 3: CORE ASPECTS OF EFFECTIVE PROCUREMENT RECOMMENDATIONS



Lever 1. Shift from prescriptive to performance-based specification standards.

As cement and concrete technology has advanced, the specifications used by state and local jurisdictions have not kept pace. Concrete specifications today are generally prescriptive and focus on limiting types and quantities of specific ingredients and material proportions (e.g., specifying a range of water/cement ratios).

While innovations in concrete manufacturing can meet desired material performance criteria, they are restricted from use in some jurisdictions because they do not meet the current prescriptive material specifications. In short, new alternatives with improved performance and lower carbon emissions are outside of the recipe-based prescriptive standards today.

Replacing prescriptive specifications with ones based on performance (e.g., a strength of 5,000 psi, a chloride ion penetration of < 1,500 coulombs, and a shrinkage limit of 0.05 percent) is the next logical step in concrete's evolution.[18] In many cases, performance-based standards exist but are not used; this presents an opportunity for fast assessment and implementation. The National Ready Mixed Concrete Association (NRMCA) and a diverse coalition of stakeholder organizations are already advocating for performance-based specifications for concrete, focusing on improved quality, customer choice, and, increasingly, environmental and climate considerations.[19]

A broad shift away from prescriptive specifications and toward performance-based standards by state and local authorities is a critical precondition for innovation and ultimately material transformation in the concrete sector.

> "Moving from prescriptive specifications to performance-based specifications is the next logical step in the evolution of the concrete construction industry."
>
> —LIONEL LEMAY, COLIN LOBO, PHD; AND KARTHIK OBLA, PHD[20]

Lever 2. Establish accelerated materials evaluation and testing by state departments of transportation for low-carbon materials.

State departments of transportation (DOTs) play a critical role in governing specification standards related to concrete, as well as how it is produced and used. This is true both for concrete directly procured by state agencies for publicly funded projects and for projects initiated by local governments, which commonly rely on state specifications for local construction. DOTs maintain approved product lists that designate equipment, materials, and methods that are permitted for use in state construction projects in alignment with existing standards. Approved lists change as DOT staff receive, test, and approve new products submitted by suppliers for evaluation.

Many DOTs are capacity constrained, and this to a large degree dictates the schedule and pace of evaluation and acceptance in any given state. Further, certain types of material evaluation are inherently time and data intensive and cannot be expedited beyond what is technically required to complete them. The full evaluation process, from application submission to final approval (or rejection), varies by state but is often a lengthy, uncertain, and expensive one for applicants. The time, business risks, and opportunity costs that must be borne by solution providers can discourage innovation.

However, states can implement policies to help expedite the evaluation process for suppliers and manufacturers. For example, products that demonstrate emissions reduction benefits via third-party assessment could be made eligible for a fast-tracked evaluation and approval. Ideally, state DOTs could not only accelerate the process where possible but also establish a reasonable, guaranteed window for process completion. This would require additional investments in DOT capacity to process and complete evaluations internally or to subcontract evaluations to an independent technical partner. Depending on available resources and state budgetary priorities, these investments could be funded in part by premium fees paid by applicants, or by public funds.

EXPLAINER 3: EPDS AND GHG EMISSIONS: HOW LIFE-CYCLE ANALYSIS ACCOUNTS FOR CARBON IN CONCRETE

Currently, the most established method of reporting concrete emissions is through environmental product declarations (EPDs). Similar to nutrition labels detailing a food product's nutritional content, an EPD details a product's environmental impacts. These include GHG emissions (commonly referred to in EPDs as global warming potential, or GWP), which is a measurement of carbon dioxide equivalent, or CO_2e (e.g., CO_2, CH_4, N_2O on a CO_2-equivalent basis), per cubic meter of concrete.

FIGURE 4: GENERIC EPD GRAPHIC

ENVIRONMENTAL IMPACTS

Declared Product:
Mix 301-1 • Airport Plant
3000 RESIDENTIAL FLYASH NON AIR
Compressive strength: 3000 psi at 28 days

Declared Unit: 1 m^3 of concrete

Global Warming Potential (kg CO_2-eq)	289
Ozone Depletion Potential (kg CFC-11-eq)	7.6E-6
Acidification Potential (kg SO_2-eq)	0.89
Eutrophication Potential (kg N-eq)	0.41
Photochemical Smog Creation Potential (kg O_3-eq)	17.7

Total Primary Energy Consumption (MJ)	2,034
Nonrenewable (MJ)	1,957
Renewable (MJ)	77.2
Total Concrete Water Consumption (m^3)	3.11
Batching Water (m^3)	0.14
Washing Water (m^3)	0.02
Nonrenewable Material Resource Consumption (kg)	2,268
Renewable Material Resource Consumption (kg)	1.88
Hazardous Waste Production (kg)	0.01
Nonhazardous Waste Production (kg)	8.72

Product Components: crushed aggregate (ASTM C33), natural aggregate (ASTM C33), Portland cement (ASTM C150), fly ash (ASTM C618), batch water (ASTM C1602), admixture (ASTM C494)

An EPD is a "Type III environmental declaration," as defined by the international standards ISO 14025 and 21930. The standards require that an EPD be verified by a third party and follow guidelines defined by a product category rule (PCR). A procurement policy that requires EPDs would refer to specific PCRs, like those established by the National Science Foundation for different product categories, including concrete and cement. When used to inform procurement decisions, the most precise comparisons require "product specific" EPDs, meaning the data being considered must correspond to a specific manufacturing plant for a specific product, rather than an industry average. Concrete EPDs should also be "supply chain specific," meaning that the upstream emissions data for ingredients are specific to the facilities within the supply chain, rather than averages. For example, a bill currently under consideration in the state of Washington would require supply chain–specific data for components that contribute at least 80 percent of a product's GHG emissions.[21]

EPDs can be produced by specialists within a specific plant, company, or trade organization, or by a third party (e.g., Climate Earth, Athena). In all cases, EPDs require third-party verification.

If a manufacturer wants to produce its own EPDs, the equipment and knowledge to do so can present barriers in some cases. New automated digital EPD tools require an initial consultation and setup cost, which can be as high as $8,000 per plant, with pricing based on the number of plants subscribed by a single company.[22] To help smaller producers, tax credits or rebates could be established to help defray setup costs. For example, Oregon introduced a $3,000-per-plant rebate for EPD setup costs in 2020, and a similar tax credit has been proposed in both New York State and New Jersey.

Programs for EPD development have a long history in the green building sector; they've been well established in many European and Asian countries for decades—as early as 1989 in Norway.[23] While EPDs have limitations, they continue to evolve and remain the most robust life-cycle assessment tool for quantifying and verifying embodied carbon at the product and plant level. At a minimum, EPDs for a given product category can be compiled to indicate the range of environmental impacts of construction materials in that category within a state or municipality, as described in our discussion of Lever 3, below.

Still, there are some limitations to the use of EPDs. Currently, EPDs for construction materials are based on "cradle to gate" boundary conditions, meaning that the data reflect environmental impacts from raw material acquisition, transportation to the manufacturing site, and the production process. As previously mentioned, impacts during the material's operational life can also play a significant role in its overall life cycle environmental impact. Because EPDs cannot evaluate full life-cycle impacts, they can be used only to compare materials within the same product category rather than comparing different categories to each other (e.g., concrete versus asphalt versus wood). Additionally, current concrete PCRs do not require supply chain–specific data for EPDs. As EPDs evolve, they should develop methods to include operational emissions and supply chain–specific data in the evaluation of materials to better inform procurement decisions.

PROCUREMENT DECISIONS

Lever 3. Require EPDs for public construction contracts. Empower concrete vendors to participate with EPD-setup tax credits or rebates.

The first step toward developing procurement standards that favor low-carbon concrete is to collect data on embodied emissions. Most construction materials, like steel, glass, and wood, have standard compositions across the nation and globe, making it relatively easy to establish a baseline of average embodied carbon emissions per unit of product. For example, a ton of hot rolled steel from California is the same as a ton of hot rolled steel from China, regardless of the process used to produce it. Collection of EPDs will reveal the emissions associated with the production of that steel, allowing agencies to understand the industry average of emissions and develop a target value for its projects that favors low-carbon products.

For concrete, on the other hand, properties and emissions can vary significantly by state and region, depending on local factors (like climate and geology) and project purpose (e.g., bridge, sidewalk, or building foundation). Because industry average emissions are not necessarily useful information in this case, establishing limits to embodied concrete emissions will require specific data from actual local projects and applications. To mitigate the challenges this presents, state and local governments should require EPDs to be submitted when projects are constructed. Data collected on the environmental impact of diverse project types can then go on to inform future procurement decisions.

Many jurisdictions have taken this first step toward developing low-emission procurement standards. At the beginning of 2020, the city of Portland, Oregon, began requiring that all new concrete submitted for inclusion on the city's preapproved mix design list be accompanied by a product-specific Type III EPD (see Explainer 3). Data from the collected EPDs were used to establish a maximum acceptable GHG emissions standard for new concrete mixes, which will take effect in 2022.[24]

Other state DOTs have taken steps in this direction. In California, EPDs are required for concrete mixes purchased by the High-Speed Rail Authority or acquired for use in select pilot projects funded by CalTrans.[25] The Minnesota DOT developed a road map that puts forth a staged approach in which a period of EPD collection and analysis will precede the latter's use in procurement decisions.[26]

The cost of generating EPDs are not negligible, especially for small companies lacking a multitude of plants to drive unit costs down (see Explainer 3). In the early phase of requesting EPDs, states should offer either tax credits or rebates that help defray the initial costs of EPD generation for manufacturers.

Lever 4. Set maximum GHG emissions thresholds that become more stringent over time.

To encourage the rapid adoption of concrete technologies that minimize environmental impacts, a GHG emissions threshold for concrete should be established. Bidders would have to meet this threshold as a minimum requirement to be eligible for project selection.

A GHG emissions threshold can be enacted in different ways.[27] However, rules in California and Colorado demonstrate essential policy elements that should be included. First, the threshold should be informed by data from local concrete mixes. The Colorado law includes a period, beginning in 2022, during which local mixes will be reviewed and a GHG emissions threshold will be developed; it will not be imposed until 2025. In California, the collection of EPDs by CalTrans also exemplifies an intent to be informed by local data.

> "With concrete we are talking about commodity products. . . . It's not like an iPhone or a flat panel TV where you have early adopters who are willing to pay more for that product . . . and help drive it down in price. For commodities . . . we have to have policy that does that . . . and if you look at the history of American innovation, that's how we do innovation. It's not about picking winners. It's about creating opportunities for new technologies to win. And if you don't do that you are picking a winner, and that's the *incumbent*."
>
> —JESSE JENKINS, PHD, ASSISTANT PROFESSOR OF MECHANICAL AND AEROSPACE ENGINEERING, PRINCETON UNIVERSITY

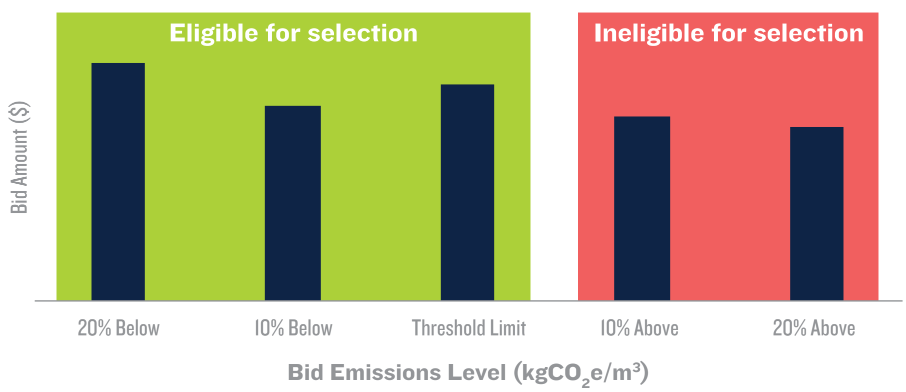
Second, the threshold should be decreased incrementally, requiring producers to continually improve their emissions profile. The California and Colorado laws both mandate incremental updates to the GHG emissions threshold, every three years in California and every four years in Colorado. Both laws require increasing stringency. Any changes to the threshold should reflect what the majority of the market is capable of producing. For example, this could mean setting the threshold at the 60th percentile of GHG emissions reported by bidders for a given concrete mix within the last three years.

Finally, some current policies include a higher emissions allowance for certain concrete materials. This is exemplified by the Bay Area Low-Carbon Concrete Code in Marin County, which increases the GHG emissions threshold by 30 percent for concrete that requires high early strength.[28] In Colorado, the threshold can be waived if a concrete mix that meets the threshold cannot be provided at a reasonable price or on a reasonable basis. If a provision like this is included, policymakers should aim to maximize the emissions impact of the procurement policy by clearly defining which cases can receive special allowances or waivers, and they should consider making this definition more stringent over time.

Lever 5. Create GHG emissions incentives, such as bid discounts or high-performance bonus payments, to drive innovation acceptance.

A GHG emissions threshold on its own does not necessarily incentivize innovation. A threshold only provides a cap. In other words, a product that is, say, 10 percent below the GHG emissions threshold is treated the same as a product that is 20 percent below the threshold (Figure 5). And the lowest-cost eligible bid is likely to be chosen, even if another bid would be more beneficial to the environment. An incentive mechanism should be established to reward emissions reductions and drive innovation.

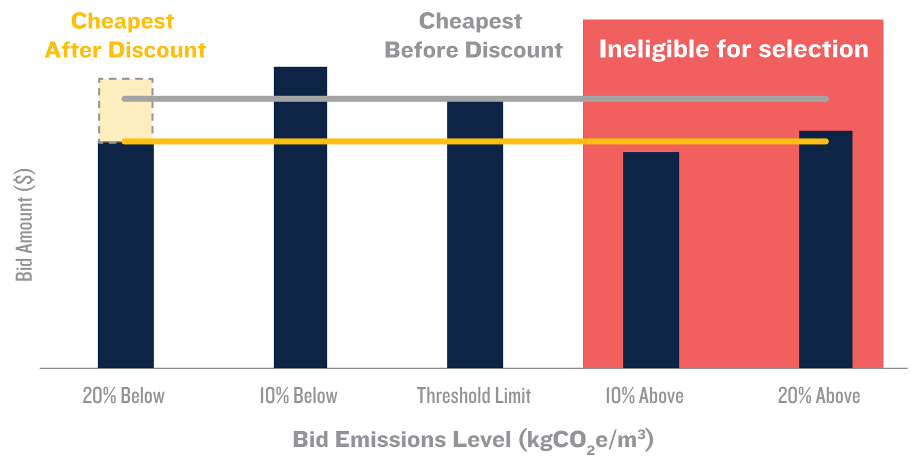
FIGURE 5: COMPARISON OF PROJECT BIDS IN PROCUREMENT POLICY WITHOUT INCENTIVES



There are several mechanisms through which incentives could be provided, either at the project bidding stage or after the construction stage. One option is to apply climate performance price discounts during the project bidding stage, with an artificial discount being applied to bids with lower-emitting materials during project evaluation. For example, contractors would submit an EPD with their bid, and the bids would be evaluated on the basis of (1) specification compliance, (2) price, and (3) embodied emissions, in that order. Price discounts would then be applied to bids according to their relative emissions levels, with superior performers receiving the largest discounts. The procuring body would still pay the full price proposed by the bidder but would evaluate the bid as if it were cheaper.

An example is shown in Figure 6, where bids present EPDs with different reported emissions levels. Bids with emissions exceeding the threshold are ineligible for selection, even if they are cheaper. In this case, the bid with an emissions level equal to the threshold limit is initially cheaper than the bid with a 20 percent lower emissions level. However, after the lowest-emitting bid receives a discount, it becomes the cheapest during the evaluation stage, and would be selected.

FIGURE 6: DEMONSTRATION OF DISCOUNT-BASED INCENTIVE IN PROJECT PROCUREMENT

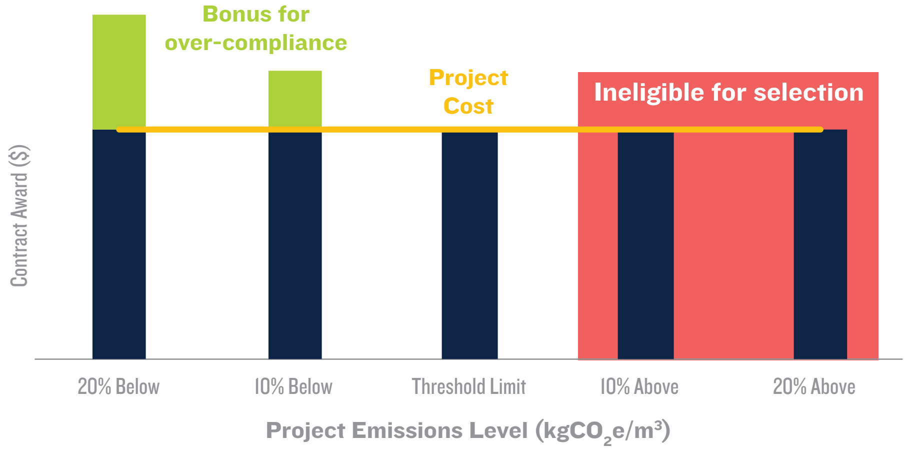


A version of the bid discount approach was proposed in legislation in both New York State and New Jersey with the first versions of the Low-Embodied-Carbon Concrete Leadership Act (LECCLA). In both instances, a maximum 5 percent base price discount would be applied to the top-performing bid, with lesser discounts proportionally applied to other bids relative to the top performer. Further, additional discounts could be awarded to favor more nascent technologies with particularly high decarbonization potential, like mineralization-based concretes.

An alternate approach is to award a post-construction bonus depending on the emissions level achieved by a project relative to a maximum emissions threshold. This incentive mechanism has been included in a revised version of the New Jersey Low Embodied Carbon Concrete Leadership Act, as well as in the New York Climate Forward Concrete Leadership Act of 2022, and is similar to the one established by the Buy Clean Colorado Act. To incentivize additional emissions reductions, projects that are a certain amount below the threshold receive a monetary bonus on top of the project cost. For example, as shown in Figure 7, a project that has an emissions level 10 percent below the maximum threshold would be paid a 3 percent bonus, and a project 20 percent below the threshold would get a 6 percent bonus.

> "With an incentive–disincentive model [for concrete procurement], if you are good, you are rewarded. If you are not good, there is a disincentive. And as the overall industry and local competitors continue to innovate . . . the baseline for incentives and disincentives continues to be adjusted to drive innovation."
>
> —JOHN HARVEY, PHD, PROFESSOR OF CIVIL AND ENVIRONMENTAL ENGINEERING, UNIVERSITY OF CALIFORNIA, DAVIS

FIGURE 7: POST-CONSTRUCTION INCENTIVE EXAMPLE



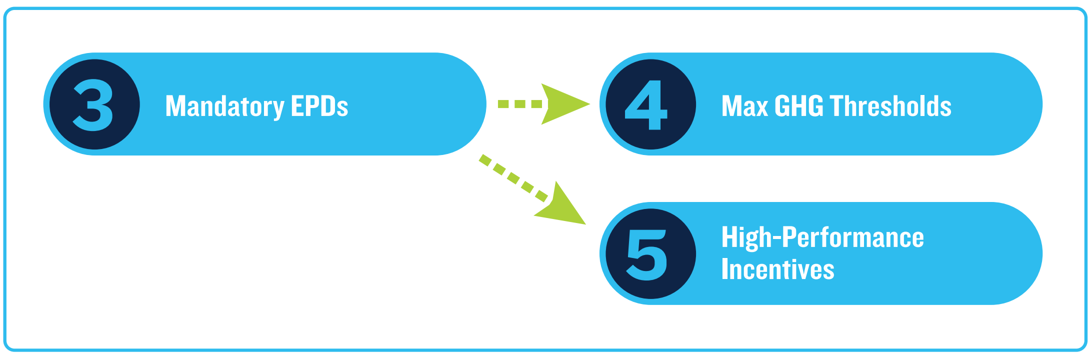
Incentives for innovations in projects are already provided through programs like the National Highway Performance Program, under which payments may be increased by 5 percent for "innovative project delivery" (e.g., extended service life, accelerated delivery time, increased product quality).[29] A similar incentive could be offered for submitting EPDs during project construction.

Conclusion: Combining Policy Levers Multiplies Impact

Concrete—the material that has held our public infrastructure together for centuries and will continue to do so for the foreseeable future—comes at a cost to our climate. There are a multitude of available and emerging pathways for reducing the embodied and operational carbon of concrete, but most face regulatory and/or economic barriers to acceptance.

Each of the policy levers put forward in this guide can help overcome these barriers in direct and indirect ways and drive change in the industry. And when integrated in a comprehensive program, different levers can interact to unlock powerful dynamics that multiply and accelerate impact. Accordingly, the potential efficacy of certain levers will be limited if they are implemented in isolation. The following examples outline the most significant multipliers that can be achieved when several levers are implemented together.

A. Mandating product—and supply chain—specific EPDs (Lever 3) will produce granular, local emissions data for concrete that can be used to establish appropriate local GHG emissions thresholds (Lever 4) and incentives (Lever 5).



Data collection that accounts for concrete's material variability is necessary for any effective low-carbon procurement approach. Environmental product declarations (EPDs) are crucial to quantifying the embodied carbon at the individual facility and mix design level.

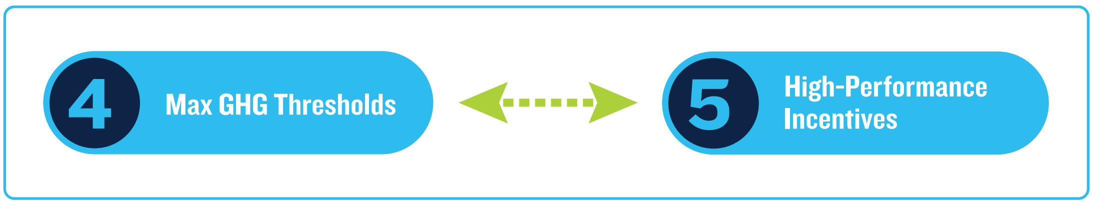
When contractors are required to submit EPDs at the bid or construction phase for concrete used in public construction projects, state and local governments gain detailed, locally specific emissions data sets for different concrete applications and mixes. These data can then be used to establish and continually modify GHG emissions thresholds and incentives based on local variable conditions.

B. The impact of emissions incentives (Lever 5) will be enhanced when performance-based specification standards (Lever 1) and expedited material evaluation and approval (Lever 2) are also in place.

Both emissions-based bid price discounts and post-construction bonuses are market-based mechanisms that reward innovation and superior emissions performance. However, the ability of such incentives to catalyze change will be only partially realized if prescriptive specification standards continue to govern materials selection. Standards prescribing specific concrete inputs and proportions limit the ability of vendors to consider alternate materials and methods that reduce emissions. Performance-based specifications, by contrast, liberate vendors to explore and incorporate a broader range of potential options, provided that they meet or exceed strength, durability, and other necessary performance criteria.

Further, even when performance-based specifications are in effect, materials, products, and methods that have not been formally evaluated and approved by state DOTs will remain functionally disqualified from consideration in most instances. Therefore, policies that reduce the time, cost, and uncertainty of the evaluation and approval process for suppliers will help ensure that state-approved lists include a robust spectrum of safe and market-ready low-carbon options.

C. Maximum GHG emissions thresholds (Lever 4) and incentives (Lever 5) reinforce each other.



GHG emissions–based bid discounts can be implemented without emissions thresholds, and doing so has some benefits. This approach would allow state and local governments to realize tangible carbon reductions and generate diverse EPD data sets that could subsequently inform locally appropriate maximum emissions thresholds.

However, establishing thresholds and incentives simultaneously delivers the greatest benefits. Thresholds ensure that a minimum climate benefit will be attained. They can also serve as minimum starting points for bid discounts or post-construction bonuses, with firms that perform better than the emissions threshold becoming eligible for such incentives. Further, as vendors respond to incentives over time by embracing new carbon-reducing materials and methods, cost and emissions data gained through this process can further inform incremental threshold modifications.

In conclusion, leveraging public procurement to decarbonize a ubiquitous but highly diversified material like concrete demands a multifaceted policy approach, and one that can be adapted to the specific technical, economic, and supply conditions that prevail in different state and local contexts. Moreover, the ultimate efficacy of the different policies employed—such as those put forth in this guide—will arise in large part from how those policies dynamically interact, rather than simply from the sum of their individual parts.

Therefore, it is the final recommendation of this guide that state and local policymakers give thorough consideration to the relational dependencies and impact multipliers that link each lever together in real-world practice. Each of the levers elaborated in this guide can indeed deliver incremental advancement toward lower concrete emissions. However, sustaining a rate of progress that matches the sobering timeline for action that the global climate emergency now imposes on local communities all over the United States will best be attained through the maximum integration of these levers in a single, comprehensive program that can be strengthened over time.

Appendix I: Common Cement and Concrete Decarbonization Pathways

CEMENT PLANT MODIFICATIONS

Efficiency improvements at cement plants

There exist several technologies that can be implemented within a cement plant to increase its energy efficiency, thus decreasing emissions. These technologies range from raw materials handling improvements to improved kiln technologies and optimized process control techniques. Best available technologies have been outlined in the United States and the European Union.[30]

Carbon capture

Emissions can be reduced by capturing CO_2 from the flue gas emitted by cement kilns and storing them safely and permanently underground. Because the concentration of CO_2 within flue gas is higher than concentrations in ambient air, cement kilns offer a low-hanging fruit for industrial carbon capture. Carbon capture and storage can contribute to significant reductions in embodied carbon of concrete without altering concrete composition.[31] While carbon capture has not been fully demonstrated at cement plants, design and demonstration projects are currently underway in Colorado and Norway.[32] In Belgium, a new cement production system called direct separation, which eases the effort of carbon capture, is being tested through Project LEILAC.

Fuel switching

Cement clinker is normally produced by using fossil fuels like coal to heat limestone to a high temperature (up to 1,500 °C). Because of the high temperatures required for cement production, options for alternative fuels are limited. One study considered several applicable low-carbon heat sources (hydrogen, biofuels, and electric resistive heating) and found that all are currently prohibitively expensive and require advances in technology and system integration to become feasible.[33] In the case of biofuels and biogas, preference should be given to those derived from biowastes.[34] Alternatively, wastes (e.g., waste biomass, municipal waste) can be used to reduce fossil fuel combustion while often decreasing fuel costs.[35] In all cases of fuel switching, careful analysis should be performed to ensure that emissions are reduced on a full life-cycle basis and that they do not cause other detrimental effects to human health or the environment.

CONCRETE MANUFACTURING MODIFICATIONS

Supplementary cementitious materials and Portland limestone cement

Supplementary cementitious materials (SCMs) can be added to concrete to reduce the total amount of cement used per cubic meter of concrete. Replacing portions of cement with SCMs lowers costs and emissions associated with cement. Use of SCMs is well established in industry, where the most common materials are coal fly ash and blast furnace slag. However, the ability to increase use of these SCMs is limited, as the coal industry is being phased out and nearly all blast furnace slag in the United States is already utilized in concrete.[36] Several other materials could be used as SCMs to varying degrees; some are used already (e.g., silica fume), while others require more research (e.g., copper slag).[37]

Another option is to replace a certain amount of cement with limestone, creating what is often referred to as Portland limestone cement (PLC). Most localities in the United States allow up to 15 percent of cement to be replaced with limestone in a given concrete mixture, but some European jurisdictions allow up to 35 percent. However, replacing cement with limestone affects the final properties of concrete, and increased proportions of limestone may not be suitable for all purposes.[38] Additional research is required to identify specific cases where limestone addition could be maximized.

Both SCMs and PLC can be used right now in certain scenarios (depending on performance specifications and SCM availability), and their utilization could be expanded pending further study. Research should be coupled with a shift of local concrete standards to performance-based specifications so that such new concrete formulations may be approved.

Recycled concrete aggregate (RCA)

At the end of its life, concrete can be crushed and recycled as aggregate for new concrete. Concrete pavements have been recycled into new pavements since the 1940s. Concrete is recycled in at least 41 states, but is still limited in many jurisdictions due to specification limitations and cost uncertainties.[39] As a general rule, recycled concrete aggregate can replace up to 30 percent of natural aggregate without significant performance impacts.[40] Recycling of concrete waste could be coupled with separation of cement paste fines, which could subsequently be reacted with CO_2 to form an SCM, but this technology requires more research.[41]

Particle packing optimization

In concrete, aggregate in an array of sizes is used, with smaller particles like sand fitting in the gaps left between larger particles like gravel. The remaining volume between aggregate particles is filled by cement. There are methods that optimize the array of particle sizes in order to minimize the amount of cement used while maintaining or improving performance properties.[42] Using this method, cement use could be reduced by up to 50 percent, reducing emissions by up to 25 percent.[43]

Novel cements and concretes

There are up-and-coming technologies that could be transformative for cement production. For example, technology developed by Sublime Systems electrochemically calcines limestone at room temperature, producing a concentrated stream of CO_2 and oxygen ideal for carbon capture. This process can be powered by cheap renewable energy, and if paired with carbon capture, it could eliminate nearly all emissions from cement production.[44] Another startup is Brimstone Energy, which aims to eliminate the process emissions from conventional cement production by calcining non-limestone starting materials. By using materials like basalt, the company can extract the calcium to use for cement production and use the leftover silicate materials to make SCMs.[45] Both of these companies can produce cement that is identical in composition to ordinary Portland cement, alleviating any hurdles posed by prescriptive specifications.

Carbon mineralization: curing, SCM enhancement, and synthetic aggregate

CO_2 captured from flue gases or directly from the air can be utilized to produce concrete or aggregates.[46] The production of synthetic aggregates from CO_2 is currently carried out at three facilities in the United Kingdom by O.C.O. Technologies and is in development in California by Blue Planet, Ltd. O.C.O Technologies produces aggregates using residues from municipal solid waste incineration plants, and benefits from avoiding high landfill taxes. Additional financial incentives may be necessary to make synthetic aggregate production feasible in the United States.

CarbonCure and CarbonBuilt make different concrete products. CarbonCure injects CO_2 into wet concrete mixtures, storing the CO_2 and creating a stronger concrete product that requires 7 percent less cement than conventional concrete. While the company's technology has been used in projects across North America, such use is still limited in some jurisdictions due to lack of performance-based specifications. CarbonBuilt uses industrial wastes like fly ash to produce an alternative concrete mixture that can be directly reacted with CO_2 within flue gas, as demonstrated using flue gases from coal and natural gas power plants. The company is still working to bring this technology to scale. Similar to CarbonCure, CarbonBuilt's formulations are restricted by prescriptive specifications.

Appendix II: Summary of Existing State and Local Low-Carbon Concrete Procurement Policies

There are currently several examples of movement toward low-carbon concrete procurement policies across the United States. The following active policies and programs are listed in alphabetical order by state.

CALIFORNIA

Bay Area Low-Carbon Concrete Code (Marin County, California)

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓	✓			✓

GHG emissions thresholds are currently used at the local level by California's Marin County as required by the Bay Area Low-Carbon Concrete Code, adopted in November 2019. The code specifies a maximum amount of Portland cement and embodied carbon emissions per unit volume of concrete.[47] Allowances are given to concrete that requires high early strength (increased limit of 30 percent) or approved cements with a plant-specific EPD below 1,040 kg CO_2e/t. The code does not mention an incremental decrease in the emissions threshold.

CalTrans EPD Pilot Program

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓				

CalTrans has collected EPDs on select pilot projects, with the aim of determining baseline environmental impacts of the concrete mixes used.[48]

California High-Speed Rail Authority's Sustainability Plan

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓				

The authority plans to decrease its Scope 3 emissions by requiring EPD submission for purchased concrete mixes.[49]

Buy Clean California—amendment to include concrete as a material subject to maximum emissions thresholds

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓	✓	✓		✓

In February 2021, AB-1365 was introduced in the California State Assembly.[50] The legislation directs the state to include concrete as a regulated material within the state's existing Buy Clean procurement program. This would make concrete selection for state projects subject to maximum GHG emissions thresholds and would mandate the submission of EPDs by contractors. The legislation also would require the state to develop performance-based standards for concrete specification for state projects. Further, it proposes that a maximum performance discount rate of 5 percent be applied to proposals with GHG emissions "below the 20th percentile of the range of GHG emission data" collected from EPDs during the previous year.

COLORADO

Buy Clean Colorado

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓	✓			

In Colorado, the recently passed Buy Clean Colorado Act requires the office of the state architect and the DOT to establish policies including a GHG emissions threshold for concrete and other construction materials by 2025. The threshold may be made more stringent every four years.[51] This bill requires contract bids to be submitted with EPDs starting in 2022; hence it effectively will collect data for three years to inform the setting of GHG emission thresholds.

HAWAII

Resolution to Consider CO_2 Mineralization Concrete (Honolulu)

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs

In April 2019, Honolulu passed a municipal resolution that requires the consideration of "carbon dioxide mineralization concrete for all future city infrastructure projects utilizing concrete."[52] This resolution was the basis of a similar resolution passed by the U.S. Conference of Mayors in June 2019 and subsequently adopted by the city of Austin, Texas.

MINNESOTA

Minnesota DOT Road Map

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
~				

The Minnesota DOT developed a road map that stated the collection of EPDs should precede use of EPDs in procurement decisions.[53]

NEW JERSEY

Low-Embodied Carbon Concrete Leadership Act

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓	✓	✓		

This is currently introduced (2021) legislation in both chambers of the New Jersey Legislature. As law it would direct the state Department of Environmental Protection to (1) establish lower carbon concrete specifications with GHG thresholds, and (2) award performance bonus payments of up to 8 percent of the contracted price to concrete manufacturers that deliver Type III EPD-verified mixes with GHGs that are at least 10 percent lower than the current threshold. The bonus payment would take the form of a tax credit. The legislation also would establish a $3,000 tax credit to help defray the upfront cost associated with EPD technology setup at concrete plants.

NEW YORK

Low-Embodied Carbon Concrete Leadership Act

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs

This legislation was passed by the New York State Legislature in June 2021 and signed into law by the executive in December 2021. It directs state agencies to develop low-carbon concrete standards for state-funded projects. The standard will be developed and proposed by a state-convened stakeholder group consisting of relevant experts from public and private sectors.

NEW YORK/NEW JERSEY

Port Authority of New York and New Jersey

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓				

The agency is reducing the prescribed amount of cement in some of its concrete mixes by 25 percent and is requiring EPDs from contractors to inform future emissions-related decisions.[54]

OREGON

The Low-Carbon Concrete Initiative (Portland)

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓	✓			

At the beginning of 2020, the city of Portland began requiring all new concrete being submitted for inclusion on the city's preapproved mix design list to include a product-specific Type III EPD. Data from the collected EPDs were used to establish a maximum acceptable GHG emissions threshold for new concrete mixes, which will go into effect in 2022.[55]

WASHINGTON

House Bill 1103: Improving Environmental and Social Outcomes With the Production of Building Materials

EPD Collection	GHG Thresholds	Incentives	Accelerated Evaluation	Performance-Based Specs
✓				

The proposed bill requires EPDs to be submitted with materials in construction products, including concrete, steel, and engineered wood. The EPDs must include supply chain–specific data for any components that contribute at least 80 percent of the product's GHG emissions (e.g., for concrete-cement).[56]

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