Charting the Carbon: Navigating Policies and Program Pathways for Embodied Carbon

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ABSTRACT

Embodied carbon represents 11 percent of global carbon emissions and intersects widely with other key areas, such as building decarbonization, energy efficiency, and the upstream industrial production of building materials. As clean energy programs reduce the operational carbon in buildings, embodied carbon will increase as a share of overall building emissions. However, in progressive states like California, few programs exist to encourage the adoption of low-embodied carbon building materials beyond policies like Buy Clean California and CALGreen. This generally leaves the embodied carbon market underregulated due to still-developing statewide and local policies, despite clear opportunities to harmonize embodied carbon strategies with clean energy planning, market education, and incentive frameworks. Energy efficiency has demonstrated success through a variety of program designs, policy models, and delivery approaches, which can be broadly categorized as upstream, midstream, and downstream. Embodied carbon work should follow a similar model, using proven approaches to achieve market impacts while also developing new solutions across the value chain: procurement mandates, industry specifications, best practices, and financing support (upstream); performance-based vendor incentives (midstream); and customer incentives (downstream).

Addressing embodied carbon is crucial for overall carbon emissions reductions and can reproduce the successes of past clean energy approaches, however, it is currently a missing component of building decarbonization policies and programs. Upstream, midstream, and downstream approaches to reduce embodied carbon have similar transformational potential as clean energy policies, and this paper will provide examples of potential approaches and solutions from California that could be applied nationally.

Introduction

Buildings and construction are significant drivers of efforts to achieve net-zero policies such as California's AB 2446 which requires a 40% net greenhouse gas (GHG reduction of building materials by 2035. According to leading sector estimates, the built environment is responsible for roughly 40 percent of global energy-related carbon emissions, with operational energy use in buildings accounting for 28 percent and materials and construction accounting for an additional 11 percent (World Green Building Council). Thus, even aggressive progress on operational efficiency and clean energy leaves a substantial share of emissions embedded in the materials and processes used to construct and renovate buildings.

Embodied carbon (EC) refers to the greenhouse gas (GHG) emissions associated with the lifecycle of buildings' materials, construction activities and end of life (Lambert, Lewis). EC is unique because it is largely emitted **upfront**—during extraction, manufacturing, transport, and installation of construction materials—before a building is even occupied. Unlike operational emissions, which can be reduced over time through energy efficiency (EE), controls, commissioning, and grid decarbonization, EC generally functions as a one-time pulse: once the concrete is poured and the steel is installed, those emissions are effectively **locked in**.[1] For other products such as mechanical, electrical, and plumbing (MEP) systems or interior furnishings, there may be more opportunities to reduce EC as they are typically replaced more frequently during a building's lifecycle. This timing matters for decarbonization roadmapping because near-term emissions drive near-term warming, and large quantities of "upfront carbon" risk being largely unaddressed during a building's lifecycle.

Yet, at present, EC interventions are undervalued as an immediate climate impact strategy. Information and tooling gaps exist, such as inconsistent Environmental Product Declarations (EPDs) and non-standardized lifecycle data. Additionally, material costs for low-EC products are not readily available, leading to a general perception of "green premiums" when cost-neutral alternatives may exist. Uneven procurement practices also constrain the ability of owners, designers, and builders to compare options and select lower-EC materials at scale. Thus, even when project teams are motivated, their procurement options are bound by what manufacturers disclose, what builders are used to and what suppliers stock, making early adoption of low-EC building materials difficult to shift underlying market demand.

Limited information, insufficient product availability, and a lack of transparent pricing are not unique barriers to EC and have been addressed through EE programs with one key distinction: policy intervention is essential to ensure that program funding is directed to address market gaps in the most efficient and effective manner. These outcomes are being addressed via upstream and midstream delivery channels such as public procurement ("Buy Clean"), EC provisions in codes, and performance standards to create transparent baselines and incentivize low-EC materials production, yet, there are still missing market development element such as incentive programs to accelerate market transformation (MT) for EC.

Current Embodied Carbon Policy Activity

EC policy remains relatively nascent across the U.S. although it is increasing in some jurisdictions.. Recent national tracking efforts identify approximately 43 incentive-based programs and 13 agency-led initiatives addressing EC across federal, state, and local jurisdictions (Carbon Leadership Forum. n.d.a.). While this proliferation signals growing policy

[1] EC in already-built buildings is an important reason to encourage building reuse as well as low-EC retrofits.

momentum, most programs remain limited in scope, are pilot-oriented, or are focused primarily on disclosure rather than binding performance thresholds.

Federally, EC received formal recognition through the Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA), which collectively allocated substantial funding for lower-EC construction materials, industrial decarbonization, and EPD development. Federal implementation has largely proceeded through procurement authority. Agencies such as the U.S. General Services Administration and the Federal Highway Administration have incorporated Buy Clean principles into project delivery, prioritizing lower-global-warming-potential (GWP) steel, concrete, asphalt, and glass in federally funded construction.

This procurement-based model leverages federal purchasing power to stimulate upstream manufacturing change. Rather than regulating private construction directly, federal policy creates market demand signals that incentivize producers to generate third-party verified EPDs and invest in lower-EC production processes. Importantly, these initiatives also support methodological standardization, addressing one of the key barriers to EC scaling: fragmented measurement and verification (M&V) practices.

At the state level, policies range from procurement mandates to performance-based tax incentives and financing mechanisms, as noted in Figure 1 below.

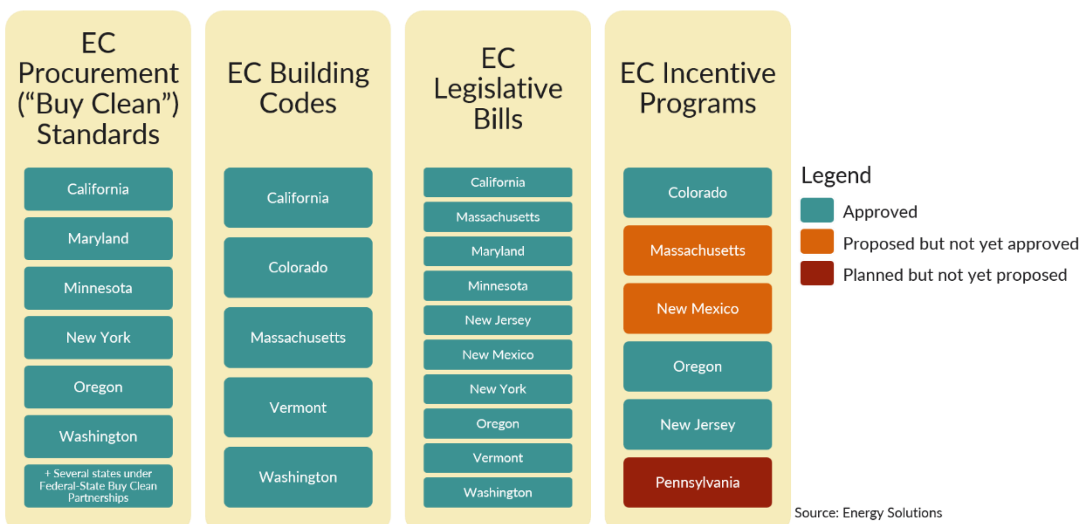

Figure 1: Summary classification of various state-level EC activities across different jurisdictions. Source: Energy Solutions

State-Level Procurement ("Buy Clean") laws in embodied carbon policies (Diedrich) show various activities happening across states.

- California's Buy Clean California Act (BCCA) requires state-funded projects to procure certain types of steel, flat glass, and mineral wool insulation that meet maximum GWP thresholds and are verified by EPDs.
- Washington enacted Buy Clean legislation, requiring disclosure of EPDs and establishing maximum acceptable GWP limits for certain construction materials used in public projects.

- New York has implemented Buy Clean concrete guidelines applicable to state-funded construction projects. New York's approach requires EPD disclosure and establishes GWP benchmarks for structural concrete procured through state agencies (Marx Okubo).

Likewise, some states have incorporated EC in their respective building codes.

- CALGreen incorporates EC requirements through three pathway options—building reuse, GWP material thresholds, and whole-building lifecycle assessment for certain large commercial buildings and school projects—representing the first state in the nation to include mandatory EC building code requirements.
- Massachusetts also addresses EC as part of its stretch code, which is one of the most rigorous energy codes in the country. Municipalities can also opt-in to a specialized, more stringent code (Steven Winters Associates).
- Vermont adopted a stretch code that addresses the GWP of insulation materials and was the first state to include EC in its residential energy codes (Vermont Department of Public Service).

Other states are experimenting with performance-based incentives targeting upstream material production or adoption within building projects, however, more market interventions are needed to animate the EC market.

- Pennsylvania's House Bill (HB) 1711 establishes a Low-Embodied Carbon Concrete Performance Incentive Program that provides financial incentives to vendors supplying concrete at least 20 percent below regional GWP baselines for public projects.
- New Jersey's Low Embodied Carbon Concrete Leadership Act creates a tax credit of up to eight percent of contract value for qualifying lower-EC concrete producers.
- Oregon's Low-Embodied Carbon Housing Program supports affordable housing projects achieving at least a 10 percent reduction in EC, linking material decarbonization with housing equity objectives.
- Colorado has expanded its Commercial Property Assessed Clean Energy (C-PACE) framework to include EC improvements, integrating EC into established clean energy financing mechanisms.
- Massachusetts explored integrating EC within its statewide energy efficiency planning framework, although rate affordability concerns ultimately constrained its inclusion in the 2025–2027 Energy Efficiency and Decarbonization Plan.
- New Mexico passed HB 153, a groundbreaking bill to leverage EPDs in order to drive industrial decarbonization while also providing rebates to purchasers of low-carbon construction materials. The bill also included the Industrial Carbon Reduction Act with incentives for reducing carbon emissions from eligible industrial facilities by 40 percent relative to an industry benchmark. Unfortunately, this bill was vetoed by New Mexico

Governor Grisham due to cited prescriptive and inflexible provisions. However, she also directed the Environment Department to implement key provisions in 2026, and thus the bill's underlying policies may still influence future program offerings.

Local governments continue to serve as policy laboratories, deploying EC through green building incentives, permitting reforms, and adaptive reuse programs.

- Cities such as Seattle and Austin integrate EC criteria into voluntary green building programs. Seattle's expedited permitting program requires EPD disclosure for structural concrete and primary steel framing, while Austin's energy green building rating system includes EPD credits, material quantity tracking, and, in its multifamily program, GWP limits. Seattle also offers development capacity / density bonuses for projects meeting green building requirements. These initiatives leverage reputational and time-based incentives rather than regulatory mandates.
- Denver has piloted funding and technical assistance for commercial projects meeting building-level EC intensity targets during design and construction.
- Los Angeles and Phoenix administer adaptive reuse programs that indirectly reduce embodied emissions by avoiding demolition and new material production. Municipal initiatives promoting mass timber adoption further illustrate local experimentation in lower-EC structural systems.
- Marin County's EC policy is built into its Low-Carbon Concrete Code, a local building code amendment that requires all public and private projects pouring concrete to use low-EC concrete (Marin County Community Development Agency). It offers both prescriptive (cement-limit) and performance (EC/GWP-based) compliance pathways for meeting these standards as part of building permitting.

Agency-Led Infrastructure Procurement: Caltrans

State transportation agencies are also significant actors in EC policy due to the carbon intensity of infrastructure materials. By being a major purchaser of cement, the California Department of Transportation (Caltrans) has the market power to influence EC purchase considerations beyond vertical building construction practices. See Figure 2 below for a breakdown of cement usage in various uses.

Beginning in 2025, Caltrans required contractors on qualifying projects to submit product-specific, third-party verified EPDs for high-volume materials, including asphalt mixtures, Portland cement concrete, and concrete masonry units. Caltrans has adopted a data-first strategy focused on disclosure, standardized reporting, and database development. Contractors must report cradle-to-gate GWP values and material quantities, enabling the agency to develop a statewide dataset of transportation material emissions. Thus, Caltrans helps to establish baseline standards for low-EC cement applications which can spill over to buildings.

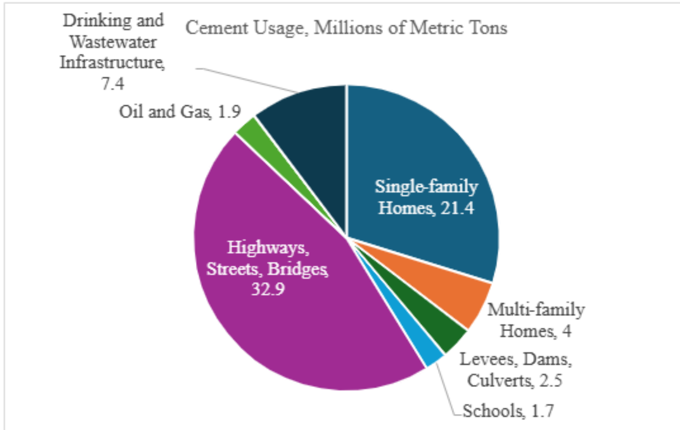

Figure 2: Examples of US cement usage across different applications.
Source: Portland Cement Association, https://www.cement.org/wp-content/uploads/2024/07/pca_unitedstates_one-sheet_05-31-24_v1.pdf

For example, Caltrans is updating material specifications to permit lower-EC alternatives, including broader use of Portland Limestone Cement (PLC) and supplementary cementitious materials (SCM). This approach integrates EC considerations directly into engineering specifications while maintaining structural performance standards. By embedding EPD reporting and low-carbon material allowances into procurement workflows, Caltrans demonstrates a hybrid model: disclosure-driven market conditioning paired with incremental specification reform. Given the scale of California's transportation program, these requirements have the potential to materially influence cement and asphalt supply chains statewide.

Across federal, state, and local levels, EC policy exhibits several consistent characteristics: (1) disclosure precedes performance thresholds, (2) procurement authority is a primary market lever, (3) standardization of EPD methodologies and reporting infrastructure is still evolving, and (4) coverage remains uneven, particularly in small commercial and residential markets. This evolving policy environment signals long-term regulatory direction, while simultaneously underscoring the need for harmonized measurement frameworks, stable funding mechanisms, and broader market coverage to achieve scalable emissions reductions. Convergence of procurement mandates, building code provisions, and agency-led disclosure programs suggests that EC is transitioning from voluntary green building practice to a normalized component of climate policy architecture.

Examples of Spillover Impacts from EC Procurement Specifications

One of the clearest early policy successes comes from Marin County, California, which adopted a reach code establishing cement quantity and GWP limits for concrete used in new construction in unincorporated areas of Marin County in 2023. The ordinance requires ready-mix concrete used in permitted projects to meet performance-based EC thresholds rather than prescribing specific mix designs, allowing suppliers flexibility in compliance while sending a clear market signal. The program is a midstream intervention that interfaced with concrete suppliers in the middle of the supply chain. It started with just nine prequalified mixes and more than tripled to over 30 prequalified mixes by 2025. Marin County is small and heavily rural, so the direct GHG tons are small in comparison to large urban environments. However, the increase in prequalified mixes shows a strong relative rate of growth and adoption. Marin County was among the first jurisdictions in California to mobilize EC reduction through the building code, building on the same regulatory logic that has historically driven EE gains. As such, Marin County stands as an early leader, demonstrating code feasibility and enforceability across a small but growing number of local jurisdictions.

Interviews conducted with Marin County staff reveal a critical—and often overlooked—mechanism by which this policy has delivered impact beyond its formal jurisdiction. Marin County directly controls permitting only in unincorporated areas, not within incorporated cities. However, the contractors and concrete suppliers working in unincorporated Marin County also operate extensively within the county's municipalities. As a result, many suppliers have chosen to standardize on lower-EC concrete mixes that comply with Marin County's ordinance as their default product offering, rather than maintaining separate inventories or processes for different jurisdictions. In practice, this has allowed a policy covering a limited market to reshape material availability and norms across a much larger market, effectively extending EC reductions into cities where no such requirement yet exists. This spillover effect highlights how well-designed local policy can catalyze MT even when formal regulatory authority is limited.

A comparable pattern has emerged through Buy Clean procurement policies, particularly at the state level. BCCA, which sets EC disclosure and performance requirements for construction materials purchased for public infrastructure, has been widely cited as influencing private-sector material supply chains well beyond covered public projects. Analyses by the Carbon Leadership Forum (CLF) and Rocky Mountain Institute (RMI) document how manufacturers and suppliers, once required to produce EPDs and meet GWP thresholds for public contracts, often apply those same lower-EC products across their broader portfolios to avoid duplicative production lines (Carbon Leadership Forum n.d.b.)(RMI n.d.). In effect, procurement policy aimed at a subset of projects has helped normalize transparency, data availability, and lower-EC materials throughout the market. As with Marin County's reach code, these examples illustrate how policy-driven demand aggregation can overcome information and coordination failures that voluntary action alone has struggled to address.

Examples of Potential EC Pathways in California

As highlighted by California, which has had decades of success through upstream, midstream, and downstream EE programs, there are opportunities to leverage existing EE programmatic strategies, approaches, and capabilities through agencies such as the California Energy Commission (CEC), which can step in to fill gaps. Despite first movers like Marin County showing early success and state-level leadership through CALGreen and BCCA initiatives, there is still much work to be done. Though Marin County has been successful, it operated at the local level, while CALGreen and BCCA are statewide but are limited to public and large commercial buildings. BCCA also does not cover concrete, which is a major contributor to EC.

Table 1: Summary of EC Activities, Successes, and Gaps

EC Activity	Successes	Gaps
Procurement Standards	● Positive Spillover impacts (e.g., Marin County) ● Growing low-EC product availability ● Increasing demand for low-EC materials	● Non-uniform standards across jurisdictions and materials ● Limited enforcement ● Lack of project cost transparency
Disclosure Requirements	● Increased EC market awareness	● Standardization of EPD methodologies and reporting is still evolving
Building Codes	● Increasing number of jurisdictions incorporating EC into codes ● Standards are developing (e.g., RESNET 1550, ASHRAE/ICC Standard 240P)	● Limited enforcement mechanisms ● Limited number of applicable building types
Legislative Bills	● Increasing awareness and support of EC	● Some push back due to affordability concerns
Incentive Programs	● Mostly non-financing incentives (e.g., tax credits, C-PACE)	● Progressive reforms limited to a few states (e.g., MA, NM)

Source: Energy Solutions

Stakeholder interviews revealed that compliance is difficult and enforcement is inconsistent under BCCA. Looking forward, state entities such as the CEC and the Building Standards Commission (BSC) have a role to play in tracking and monitoring progress and in providing actionable insights to the California Air Resources Board (CARB), the lead agency for EC in California. For example, these entities can help CARB by:

- Sharing available data on building performance levels and/or EC requirements (where available) to inform CARB's creation of EC baseline standards for targeted building materials
- Assessing any indirect consequences of the EC regulations on building design, operational energy use, or material transportation
- Recommending improvements to the regulatory requirements to support enforcement and compliance, minimize compliance costs, and maximize GHG reductions.

In certain ways, the CEC has already started on a similar pathway with the creation of a statewide Building Performance Standard (BPS) approach that could address these concerns on an operational carbon basis. If the CEC incorporated EC considerations as part of BPS assessments, a more holistic carbon impact might be achieved. Harmonizing embodied and operational carbon emissions within BPS could include:

- Developing policy and market actions with established legislative deadlines that fully consider agency strategies—BPS strategy in the case of the CEC, and EC strategy in the case of CARB—to outline next steps
- Engaging similar market actors while highlighting potential synergies with existing EE and building decarbonization programs
- Providing market-facing education about the timing and urgency for addressing EC. This grows in urgency if certain penalties are imposed on building owners or operators for failure to meet local guidelines or codes.

Potential pathways for EC to become harmonized with EE policies and approaches include:

- Development of an EC avoided cost calculator (ACC) to allow non-energy benefits (NEBs) of low-EC building materials to be quantified and accounted for in EE programs. Similar steps were taken to quantify NEBs through the Refrigerant Avoided Cost Calculator (RACC), which enables EE programs to incorporate GHG benefits from low-GWP refrigerants.[2]
- New construction programs like California Energy Design Assistance (CEDA) intentionally targeting and interfacing with decision-makers who impact the operational energy use of a building. These are some of the same decision-makers who impact the EC of that same building.

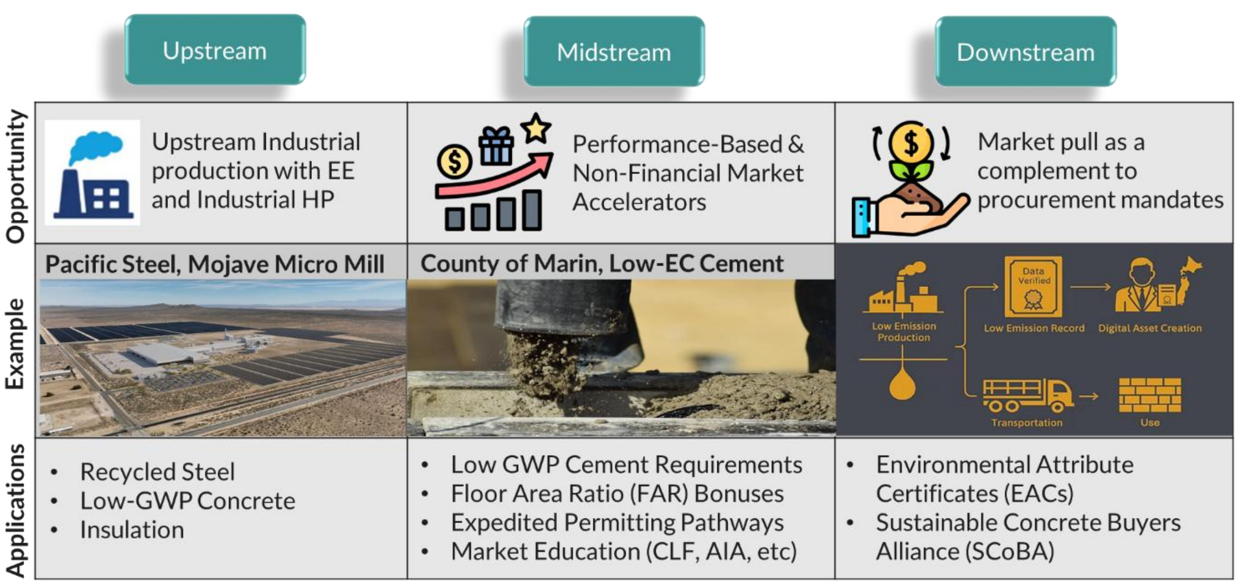

Figure 3: Example of EC upstream, midstream, and downstream approaches.
Source: Energy Solutions

[2] https://www.etcc-ca.com/sites/default/files/u2292/etcc_refrigerant_policy_slides_june_2022.pdf

Specific EC Programmatic Considerations

Reducing EC at scale requires policy and program designs that align interventions with where decisions are made along the value chain. State-level climate policy already uses this approach effectively in other domains (e.g., clean fuels, appliances, and electricity), combining **downstream** demand signals, **midstream** market coordination, and **upstream** production support. The same approach is well suited to EC in buildings—particularly given evidence from RMI and other sources that meaningful GHG reductions can be achieved through low-or no-cost material substitutions when interventions are correctly targeted (Jungclaus 2021).

Production Support, Financing, and Supply-Side Readiness – Upstream

For developing markets, upstream approaches with manufacturers to achieve societally beneficial product designs typically magnify the benefits of ratepayer investments because they target funding at critical product manufacturing points, where changes in product design, manufacturing, or other considerations impact the product before it enters the supply chain. In a similar fashion, upstream approaches with lower-EC building product manufacturers could reduce EC content with related market transformational impacts.

Upstream interventions address the reality that EC is strongly influenced by how materials are produced, not just how they are specified. Upstream EC reductions are often achievable through material specifications within existing production capacity, such as changing the type of clinker used in manufacturing cement to a lower-EC option or including renewable generation with steel production as Pacific Steel Group has done in their new Mojave Micro Mill (Pacific Steel). While incremental improvements in the manufacturing of building materials can add up to significant differences in their EC content, accomplishing total decarbonization of building materials can require long-term capital investment for some low-EC building materials.

At the federal level, US Department of Energy grants that fund the testing and validation of innovative decarbonized manufacturing processes play a significant role in addressing upstream EC emissions. Few other sources can provide the requisite financing for large capital projects with uncertain payoffs, which are characteristic of new lower-EC production. At the state level, tools such as production tax credits, loan guarantees, and green financing mechanisms (e.g., C-PACE) can reduce the risk for manufacturers investing in lower-carbon production pathways (Bukauskas). These approaches are especially relevant for materials like cement and steel, where emissions are concentrated upstream and where market demand alone may not justify early investment without policy support.

An important state-level measure demonstrated successfully in Massachusetts was a grant program that covered the cost of EPD development for concrete suppliers. Establishing an industry-standard EPD can typically cost between $3,000 to $5,000 on average for a concrete supplier, which is prohibitively expensive for a small, independent business. The Mass Save program provided up to $3,000 in grants to partially or completely offset this cost, dramatically increasing the number of concrete suppliers in the state with compliant EPDs.

For state-level policymakers and utilities, there is an unexplored upstream pathway to mitigate EC alongside of industrial decarbonization processes: harmonizing EC and industrial EE programs to drive upstream MT. Each industrial product has its own distinct manufacturing process, and there is no "one size fits all" approach. However, by working with upstream manufacturers of products such as concrete, steel, glass, and insulation and by identifying opportunities to reduce operational as well as EC in the development of industrial products, total carbon reductions can be assessed and pursued. While a number of innovative pilots have highlighted successful upstream interventions, none have had the appropriate scale and mandate to convert these successes into true MT. An upstream EC MT program such as this would have the complementary benefits of promoting EE in industry, driving long-term industrial decarbonization, and, in the future, reducing GHG reduction in the manufacturing of low-EC building materials. This may also improve local air quality given that industrial manufacturing facilities are often located in or near disadvantaged communities.

Importantly, upstream support should be coordinated with downstream and midstream signals to achieve market scale. This aligns with the CEC's California Building Energy Action Plan which called for interagency coordination for EC. Financing low-EC production in the absence of clear demand risks stranded assets; conversely, demand signals without supply-side readiness can drive cost premiums. A value-chain-aligned program design minimizes both risks.

Performance-Based Incentives and Non-Financial Market Accelerators – Midstream

Midstream interventions target the design, permitting, and development phase, where material choices are finalized and project risk is priced. In addition to programs that focus on low-to-no-cost industrial processes to reduce GHG in buildings (e.g., Strategic Energy Management), there are other non-financial mechanisms that can also influence decision-makers into adopting low-EC building materials. Two low-cost, potentially high-impact approaches include:

- **Floor Area Ratio (FAR) bonuses** tied to demonstrated EC reductions. By allowing additional buildable area in exchange for meeting low-EC thresholds, jurisdictions can align climate outcomes with developer economics, creating a powerful incentive that operates entirely outside traditional rebate structures.
- **Expedited permitting pathways** for projects that meet defined EC performance criteria. Interviews with builders and developers indicate that time savings—including reduced carrying costs and faster project delivery—can be as valuable as direct financial incentives, especially in high-cost urban markets.

Beyond permitting tools, education delivered through existing touchpoints is a critical midstream strategy. Some architects, engineers, and contractors already engage with EE, building decarbonization, and code-support programs. Integrating EC guidance into these same channels—rather than creating parallel structures—can significantly lower transaction costs and accelerate adoption. Many lower-EC material substitutions are not pursued simply because project teams do not realize they are feasible at low cost (Okada 2025).

Lastly, technology-agnostic innovation pathways exist. A key example is the prize competition structure. Prize competitions offer a flexible, low-risk mechanism to accelerate EC market development by rewarding demonstrated performance rather than prescribing specific technologies or pathways. Importantly, prize competitions function as a market-conditioning tool—driving data generation, education, and early adoption—while preserving optionality and avoiding the cost and enforcement challenges associated with premature mandates.

Market-Pull as a Complement to Procurement Mandates – Downstream

Downstream interventions for EC are most effective when they extend beyond compliance-oriented procurement mandates and actively create market pull. While procurement mandates (e.g., Buy Clean–style requirements) remain a critical policy tool, they are not, in themselves, programs. Their primary function is to set minimum performance expectations. Market-pull mechanisms, by contrast, are designed to aggregate voluntary demand, de-risk investment, and accelerate supply-side transformation ahead of, or alongside of, formal regulation.

A clear example of this approach is the Sustainable Concrete Buyers Alliance (SCoBA), led by the Center for Green Market Activation (GMA) and RMI (GCCA n.d.). SCoBA pools demand from large private and institutional buyers such as Amazon and Meta to collectively procure environmental attribute certificates (EACs) associated with low-EC cement and concrete. Rather than requiring physical delivery of low-EC material to a specific project, SCoBA uses a book-and-claim model that separates the environmental attribute from the physical product, allowing buyers to send a credible demand signal while enabling producers to invest in lower-carbon production at scale.

From a programmatic perspective, this model is particularly well suited to EC because early market barriers are not primarily technological, but financial and contractual. Cement and concrete producers face high capital costs and long asset lifetimes, and they require confidence in future demand before committing to new processes, fuels, or binders. By aggregating buyers and standardizing demand through EACs, SCoBA creates a forward market signal that complements public procurement mandates without requiring immediate changes to building codes or procurement rules.

Importantly, SCoBA is explicitly modeled on the Sustainable Aviation Buyers Alliance (SABA), which has successfully mobilized corporate demand for sustainable aviation fuel (SAF) using a similar book-and-claim framework (Fly Saba Conservation Foundation n.d.). However, the aviation sector's experience also highlights the need for careful integration between market-pull mechanisms and public policy. Recent analysis by the International Air Transport Association (IATA) shows that SAF mandates introduced without sufficient market safeguards led to sharply increased costs due to compliance fees, undermining the efficiency of the decarbonization effort and eroding industry support (IATA 2025). IATA has emphasized that mandates introduced ahead of mature market conditions can unintentionally raise costs and slow adoption if not paired with transparent accounting, robust registries, and protections against market power abuse.

The lesson for EC policy is not that market pull mechanisms should be avoided, but that voluntary buyer alliances, EAC systems, and procurement mandates must be deliberately aligned. Market pull initiatives like SCoBA can play a critical pre-compliance role by accelerating supply readiness and cost reductions. At the same time, policymakers must ensure that any future regulatory integration:

- Clearly defines how EAC-based claims interact with compliance obligations
- Avoids double counting between voluntary and regulated markets
- Preserves cost containment and transparency as demand scales.

When designed in coordination, procurement mandates establish the floor, while market-pull mechanisms raise the ceiling—together enabling faster, lower-cost reductions in EC than either approach could achieve alone.

Conclusions and Path Forward

This paper reviews how EC is a critical and underutilized strategy for achieving near-term emissions reductions in the building sector. While technical pathways for lower-EC materials already exist, adoption remains limited by gaps in data, market familiarity, and coordinated policy signals. Moving from isolated pilots to durable impact will require aligning policy, procurement, and market education around a shared understanding of value.

Closing Market Gaps Through Data

A central constraint on EC action is the limited availability and diversity of EPDs. Incomplete coverage—particularly among regional producers and alternative material pathways—limits benchmarking, policy design, and informed material selection. As discussed earlier, this challenge is especially visible in California, where upstream and midstream considerations like BCCA and related policies depend on product-specific EPDs, yet downstream stakeholders still report difficulty finding qualifying low-EC building materials. At the same time, Massachusetts and New Mexico offer useful examples of how policies can help close this gap; both states proposed grant support programs for EPD development to help manufacturers offset the cost of producing compliant EPDs while expanding the number of suppliers able to participate. Expanding EPD availability and improving consistency across product categories should therefore be a near-term policy priority, both to strengthen current procurement and code efforts and to make lower-EC material selection more practical at scale.

Market Education and Baseline Development

In parallel, market education remains essential. Many designers, builders, and permitting authorities lack familiarity with EPDs, whole-building lifecycle assessments, and low-cost EC reductions that meet performance and code requirements. As discussed earlier, one advantage of integrating EC into existing EE and code-support infrastructure is that the relevant market actors are already being reached through those often highly scalable upstream and midstream channels. For example, programs such as CEDA and the California Code Readiness Program already engage architects, engineers, and other decision-makers who shape building specifications and compliance pathways. Expanding those touchpoints to include EC guidance could normalize EC considerations without creating entirely new delivery systems.

As data availability improves, credible baseline metrics must be established. Baselines enable performance-based policy, support fair comparison, and allow progress tracking over time. Caltrans' disclosure-first strategy is building a statewide dataset of cradle-to-gate GWP values for high-volume materials, creating the kind of empirical foundation needed for future benchmarking and specification reform. Similarly, BCCA and Marin County's low-carbon concrete rules demonstrate that once benchmarks and thresholds are clearly defined, they can begin to shape supplier behavior and product availability. For these reasons, baseline metrics should be material-specific, regionally informed, and designed to evolve as markets advance.

Coalition Building and Value Definition

Durable progress will depend on broad stakeholder engagement. Earlier examples in this paper suggest that coalition-based approaches can help overcome the coordination problems that often stall EC adoption. In the private and institutional market, SCoBA, a potentially potent downstream delivery channel, shows how aggregated demand can create a credible forward signal for lower-EC cement and concrete by aligning buyers around shared metrics and procurement objectives. In the public sector, policies such as Buy Clean California and Marin County's low-carbon concrete rules show that when benchmarks and expectations are clearly defined, suppliers and contractors can begin to standardize around lower-EC offerings. Together, these examples suggest that coalitions—whether market-led or policy-driven—can help move EC from a niche concern to a mainstream market expectation by coordinating demand, data, and implementation practices.

Equally important is clarifying EC's value proposition. Beyond emissions reductions, EC strategies support supply-chain resilience, innovation, and long-term cost stability. The Marin County example is instructive here: as described earlier, some suppliers appear to have standardized lower-EC mixes across a broader service area rather than maintaining separate products for Marin County alone, suggesting that clearly signaled EC requirements can simplify offerings and improve market readiness beyond the jurisdiction that acts first. Framing EC within a **total carbon** perspective—integrating both embodied and operational emissions—also helps connect EC to the broader climate logic already familiar from EE and building decarbonization policy, enabling better lifecycle decision-making and avoiding unintended tradeoffs.

Buildings as Long-Term Climate Assets

Finally, EC policy creates an opportunity to reconceptualize buildings as adaptive, long-lived assets rather than one-time emissions sources. Earlier examples in this paper suggest that this framing is not just conceptual, but practical. Local programs in places such as Los Angeles and Phoenix already illustrate how adaptive reuse can avoid the carbon costs associated with demolition and new material production, while still supporting building renewal and community development. Similarly, Marin County's low-carbon concrete rules show how policy aimed at a specific stage of construction can influence broader market practices over time, reinforcing the idea that building-related decisions can generate durable carbon benefits beyond a single project. Integrating lifecycle assessment with adaptive reuse, lower-EC material selection, and circular design strategies can therefore extend building lifespans while avoiding unnecessary upfront emissions. In this framing, buildings become a resilient resource—capable of delivering sustained environmental and societal value.

Taken together, these pathways point to a clear call to action: align data infrastructure, policy design, and market education to transform EC from an emerging consideration into a scalable climate solution while also exploring interventions to animate the market toward low-EC materials. Doing so positions the building sector not as a persistent emissions challenge, but as a central part of the net-zero transition.

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