



# Scaling Buy Clean Policy

Strategies to Achieve Larger Embodied Carbon Reductions

November 2024



## About the Carbon Leadership Forum

The Carbon Leadership Forum accelerates the transformation of the building sector to radically reduce the greenhouse gas emissions attributed to materials (also known as embodied carbon) used in buildings and infrastructure. We research, educate, and foster cross-collaboration to bring the embodied carbon of buildings and infrastructure down to zero.

## Authors

The research team from the Carbon Leadership Forum (CLF) at the Life Cycle Lab at the University of Washington (UW) College of Built Environments:

- Jordan Palmeri, Senior Researcher, UW\*
- Brook Waldman, Low-Carbon Products Lead, CLF
- Kathrina Simonen, Professor, UW
- Meghan Lewis, Program Director, CLF

Author contributions: Writing — original draft: J.P.; Writing — review and editing: B.W., M.L., K.S., J.P.; Conceptualization: J.P., K.S.; Methodology: J.P., B.W.; Visualization: J.P., M.L.; Funding acquisition: K.S., M.L., J.P.

\*Jordan Palmeri is also a part-time Senior Manager of the Low Carbon Products team at the CLF. His contributions to this work were in his role as Senior Researcher at UW.

Competing interests statement: The Carbon Leadership Forum receives gifts from sponsors, including manufacturers and trade associations, which are listed here: <https://carbonleadershipforum.org/our-sponsors/>.

## Acknowledgments

The research team would like to thank Charlie Martin (BlueGreen Alliance) for his thoughtful and insightful reviews of a report draft. His feedback led to many improvements in the final version. We would like to thank Sea Change Foundation for supporting this research at the University of Washington.

The research and project began while the CLF was hosted at UW. After the CLF became an independent nonprofit in the spring of 2024, this project continued as a collaboration between UW and CLF staff. The UW team appreciates the CLF's commitment to disseminating this work broadly. The CLF team appreciates UW's continued technical support of the publication.

## Citation

Palmeri, J., Waldman, B., Simonen, K., Lewis, M. (2024). *Scaling Buy Clean Policy: Strategies to Achieve Larger Embodied Carbon Reductions*. Carbon Leadership Forum.

## Copyright

*Scaling Buy Clean Policy: Strategies to Achieve Larger Embodied Carbon Reductions* is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License.

Cover Image by [joffi from Pixabay](#).

# Contents

- Executive Summary ..... 3**
  - Why Scale Buy Clean? ..... 4
  - Strategies and Actions ..... 4
  - Complementary policies that build upon Buy Clean ..... 6
  - Conclusions ..... 6
- Introduction ..... 7**
  - Buy Clean Goals ..... 7
  - Status of Existing Buy Clean Policies ..... 9
  - Why Scale Buy Clean? ..... 10
- Scaling Strategies and Actions ..... 11**
  - Strategy 1: Establish Buy Clean policy in more jurisdictions ..... 11
  - Strategy 2: Expand the policy scope ..... 19
  - Strategy 3: Implement the policy more effectively ..... 21
- Complementary policies that build upon Buy Clean ..... 23**
- Prioritizing scaling strategies and actions ..... 29**
- Conclusions, limitations, and next steps ..... 32**
- References ..... 33**



## Executive Summary

Buy Clean is a procurement policy approach incorporating low-carbon requirements into government construction materials purchasing. One major goal of Buy Clean policies is to reduce the embodied carbon of construction materials, which refers to the greenhouse gas emissions generated by material production and use. Specifically, Buy Clean policies aim to drive down the emissions intensity of construction materials manufacturing through a combination of reporting, limits, and incentives. A key component of Buy Clean policy is reporting embodied carbon through environmental product declarations (EPDs), which are third-party verified labels that disclose the environmental impacts of a product.

This report presents actions to help advance and scale the impact of Buy Clean policies. These actions are targeted to achieve larger embodied carbon emissions reductions through any of the following strategies:

1. Establish Buy Clean policy in more jurisdictions
2. Expand the policy scope
3. Implement the policy more effectively

This report also presents Buy Clean as a foundational policy upon which others can be built. Buy Clean policy is expanding product-level embodied carbon disclosure through EPDs at unprecedented levels. This report highlights complementary policies that can build upon Buy Clean to create a multiplier effect to more rapidly decarbonize the industrial sector.

### Why Scale Buy Clean?

Buy Clean weaves together multiple policy priorities related to climate, labor, economic growth, and trade. In this report, scaling Buy Clean policy means **achieving larger embodied carbon reductions** during implementation. Reasons to scale this policy concept include but are not limited to:

- Normalizing the measurement and disclosure of embodied carbon at the product scale
- Providing a market and continued demand for lower carbon products
- Leveraging and expanding upon some initial policy successes – leading to larger embodied carbon reductions
- Providing foundational embodied carbon data (EPDs) upon which other policies can be built

### Strategies and Actions

This study presents three scaling strategies covering twenty five potential actions for increasing the embodied carbon reductions achieved by Buy Clean policies. These actions act as a menu of options for others to evaluate and prioritize to suit their own policy goals, focused on the following factors:

- **Embodied carbon impact:** *To what extent does the action reduce embodied carbon?*
- **Feasibility to implement:** *How easily could an organization implement the strategy?*

Many of the scaling strategies and actions presented in this report represent the lessons learned from Carbon Leadership Forum (CLF) and University of Washington (UW) staff directly supporting Buy Clean policy development and implementation efforts. The strategies also reflect what we've learned

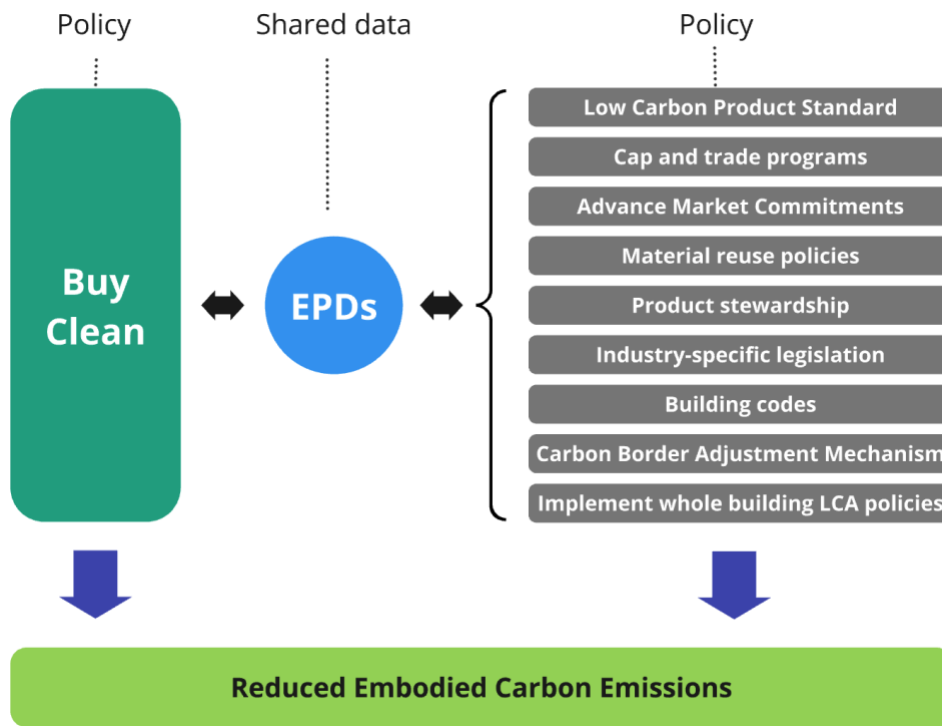
through targeted interviews with staff and stakeholders who support, develop, or implement Buy Clean policies. We reference several other publications in the field, especially for policies that can build upon Buy Clean to more rapidly decarbonize the industrial sector. We also propose a simple ranking and prioritization method to help jurisdictions evaluate which of these actions best suit their local needs. Table 1 describes the strategies and actions outlined in this report for scaling Buy Clean policy.

**Table 1: Scaling strategies and actions for Buy Clean policy.**

Strategy	Action
Establish Buy Clean policy in more jurisdictions	Measure and report embodied carbon using consumption-based GHG inventories
	Use both legislative and administrative policy pathways
	Focus new policies where construction activity is highest
	Prioritize materials by total reduction potential
	Provide resources to support new policies
	Increase the number and quality of EPDs available
	Highlight policy co-benefits
	Integrate Buy Clean into other sustainable procurement efforts
Expand the policy scope	Add more materials
	Add more pollutants
	Lower qualifying project thresholds
	Include total emissions targets instead of just efficiency-based targets
	Add incentives to policy structure
	Use a two-tiered approach to GWP limits
	Set reduction goals for future policy years based on science-based targets
Implement the policy more effectively	Establish a tracking system for EPDs and material quantities
	Provide staff education
	Actively track the indicators to measure policy effectiveness
	Provide preference or demand for more robust EPDs
	Establish a standard naming system for EPDs
	Set GWP limits faster
	Conduct pilot projects
	Use the EPA label for lower carbon products (once available)
	Share lessons learned and harmonize policies
	Review specifications and standards

## Complementary policies that build upon Buy Clean

The foundational embodied carbon data created by Buy Clean policies can create a *multiplier effect* – where other complementary policies build upon and utilize EPD data to achieve embodied carbon reductions. This multiplier effect is key to reducing the embodied carbon of construction materials at the scale and pace needed to address climate change. Figure 1 shows the additional policies covered in this report that could utilize EPD data and mutually reinforce the common policy goals of reducing embodied carbon emissions.



**Figure 1. Complementary policies that build upon Buy Clean.**

## Conclusions

Despite the young age of this policy, Buy Clean continues to be a strong focus of federal and state built environment policy in the United States. There are early signs that Buy Clean policies are making positive impacts toward reduced emissions and the twenty five actions presented in this report offer practical steps to expanding Buy Clean to new jurisdictions and improving existing policies. Additionally, we offer nine complementary policies that have the potential to create a multiplier effect – building upon Buy Clean policy and achieving greater embodied carbon reductions.

These strategies, actions, and complementary policies would benefit from socialization, discussion, and refinement with industry, NGO, and government partners. While Buy Clean policies alone cannot decarbonize the industrial sector, they provide an important market signal, prioritize and increase material transparency and disclosure, and act as a catalyst for complementary policies that utilize EPDs to achieve embodied carbon reductions.

## Introduction

Buy Clean is a procurement policy approach incorporating low-carbon requirements into government construction materials purchasing. One major goal of Buy Clean policies is to reduce the *embodied carbon* of construction materials, which refers to the greenhouse gas emissions generated by material production, use, and end of life. *Global warming potential* (GWP) is the metric we use to measure and track embodied carbon, which is reported in units of kgCO<sub>2</sub>e. Embodied carbon is reported through environmental product declarations (EPDs), which are like nutrition fact labels for building materials. EPDs are third-party-verified documents that report the environmental impacts of a product according to international standards.

There are multiple approaches to the use of information disclosed in an EPD, such as the GWP. Many policies use GWP limits as procurement criteria to reduce the embodied carbon impacts of their purchases. Others use incentives to provide purchasing preference for lower carbon materials or tax credits for materials that meet specific GWP thresholds.

The first Buy Clean procurement policy was introduced in the USA via the 2017 passage of the Buy Clean California Act (BCCA). Since then, multiple states, cities, regional authorities, and the USA federal government have enacted similar policies. Federal agencies are currently integrating billions of dollars dedicated to low-carbon construction materials into government spending via the Inflation Reduction Act (Office of the Federal Chief Sustainability Officer, 2023).

In the USA, policymakers and agencies have developed low-carbon material policies based on the policy's potential to reduce emissions, provide a market for lower-carbon materials, and leverage the purchasing power of federal, state, and local governments to help decarbonize the industrial sector. However, since these policies are relatively new, there's little understanding of the policies' effectiveness to reduce embodied carbon. As more jurisdictions consider and implement similar policies, it is important to take time to assess their effectiveness and impacts. A complementary report published by CLF – *Buy Clean Indicators: Approaches for Measuring Policy Effectiveness* (2024) – proposes a series of indicators and associated metrics that could be used to assess Buy Clean policy effectiveness to reduce embodied carbon emissions.

This report focuses on scaling the impact of Buy Clean policies by achieving larger embodied carbon reductions through strategies that establish Buy Clean policy in more jurisdictions, expand the policy scope, and implement the policy more effectively. The report also establishes Buy Clean as a foundational measurement and disclosure policy upon which other policies can be built.

## Buy Clean Goals

Buy Clean weaves together multiple policy priorities to address goals related to climate change, labor, economic growth, trade, and others (BGA, 2022). This report focuses on scaling the climate goal of Buy Clean – to reduce the embodied carbon of the government-procured construction materials – while acknowledging strategies that build upon complementary policy goals.

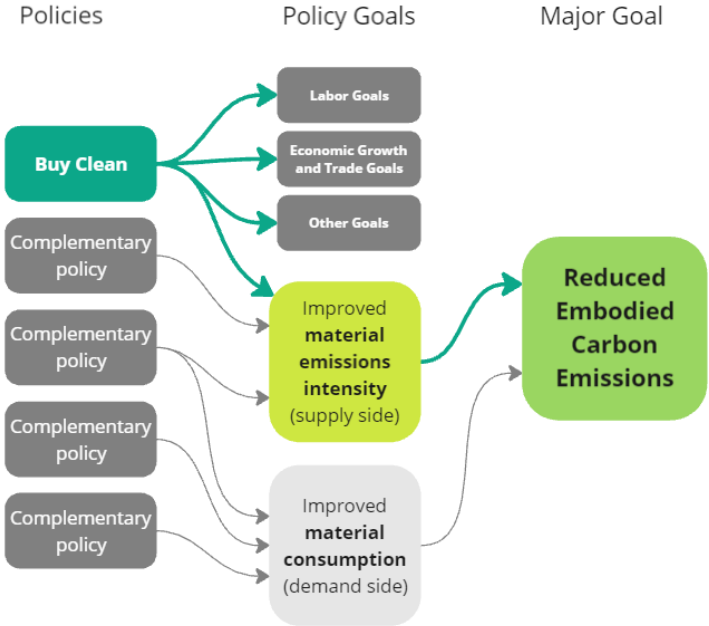
The embodied carbon of construction materials refers to the greenhouse gas (GHG) emissions generated from their production (the focus of this report) as well as their transportation, installation, maintenance, and disposal. Building and infrastructure material embodied carbon is a significant

contributor to climate change, responsible for roughly 17% of annual global GHG emissions (Lambert and Lewis, 2024), but often undercounted in GHG accounting (Hasanbeigi and Springer, 2018).

Total embodied carbon emissions are a function of two major variables: (a) *material emissions intensity* — the emissions associated with producing a given unit of construction material; and (b) *material quantity* — the amount of material produced and consumed. Emissions intensity is a *supply-side* issue, as it is a function of a product’s manufacturing processes and supply chain. Quantity is a *demand-side* issue, as it is a function of agency and owner choices in the design of buildings and infrastructure and the ultimate choice to purchase materials.

Many complementary policies and programs aim to address one or both major variables. Buy Clean predominantly focuses on the first variable in this equation — its primary **policy goal** is to *improve material emissions intensity* (i.e., to reduce the per-unit embodied emissions of materials). Most Buy Clean policies set global warming potential (GWP) limits. These limits, such as BCCA’s limit of 890 kg CO<sub>2</sub>e *per metric ton* of rebar (DGS, 2024), act on a per-unit basis to drive down emissions intensity. Other policies and programs aim to address another key variable in the embodied carbon equation — *material quantities* — and are discussed in this paper as scaling strategies.

Figure 2 illustrates this concept of a set of complementary programs, all aimed towards reducing embodied carbon emissions, where Buy Clean is one policy in that set.

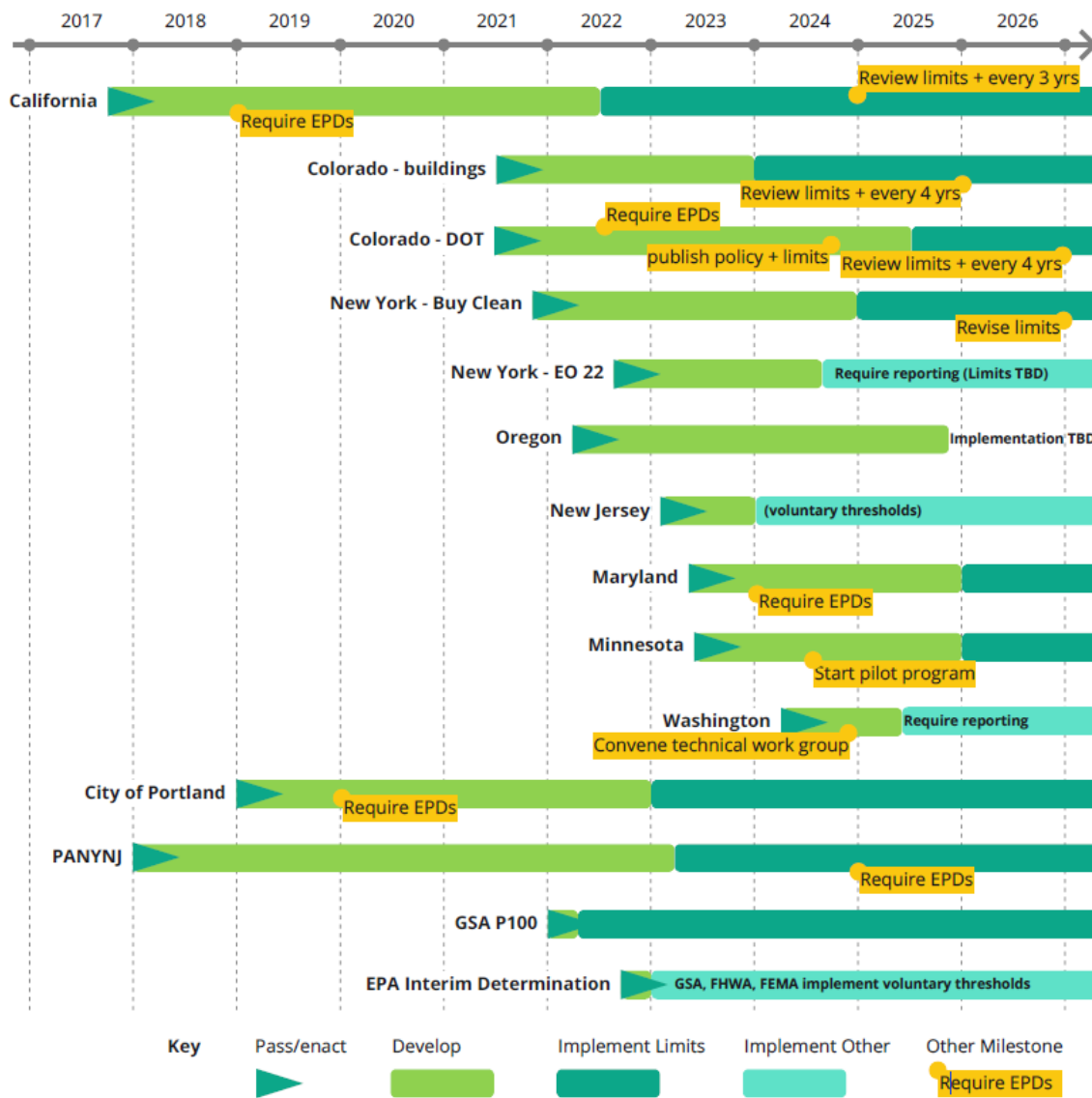


**Figure 2. Buy Clean policy goals in context.** Buy Clean — which aims at bringing down material emissions intensity — is one policy type in a broader portfolio of policies that share the goal of reducing embodied carbon emissions. Buy Clean also has other goals besides reducing carbon emissions that are outside of this report’s scope.

**Status of Existing Buy Clean Policies**

In this section, we provide a brief status update of Buy Clean policies in the United States. Figure 3 includes a status update for fourteen federal, state, and local policies and programs. For a more

extensive summary of existing Buy Clean policies, refer to CLF’s factsheet [Buy Clean Policies: Overview and Implementation](#) (2024) and the associated [spreadsheet](#) containing policy details.



**Figure 3. Buy Clean policy timelines.** For the EPA Interim Determination, the GSA, FHWA, and FEMA are each implementing separate voluntary thresholds (on separate timelines) in accordance with this determination. Thus there is some overlap between development and implementation.

Despite the immaturity of Buy Clean policy in the United States, there are early signs that Buy Clean policies are making positive impacts toward reduced emissions. These early signs include but are not limited to:

- An increase in the number of EPDs available over time, as well as an increase in tools to simplify or automate EPD production for manufacturers

- An **increase in EPD accessibility** through freely accessible tools and tracking platforms, such as the EC3 tool
- Movement towards more **specific data requirements in EPDs** through active Product Category Rules (PCR) committees that have been responsive to public procurement requests and demands
- **Increased participation in open standards development**, like ACLCA's recent invitation for non-members to provide input to their [PCR Open Standard](#) through a monthly advisory group
- An **increase in LCA knowledge and educational efforts** for government staff. CLF has conducted embodied carbon training for Federal, State, and local governments. The U.S. Climate Alliance (USCA) convenes monthly Federal and State Buy Clean partnership meetings, which facilitate information sharing. And the FHWA is increasing their educational efforts through its sustainable pavements program and state-specific EPD training to their Climate Challenge grant recipients and additionally through webinars.
- Increased attention and funding (through the Inflation Reduction Act (IRA)) to support **robust and abundant EPD generation** and a consumer-facing EPA labeling program for low-carbon materials
- The **commercialization of new low-carbon practices** and the creation of new coalitions, like the [Decarbonized Cement and Concrete Alliance](#).

For further discussion of potential indicators for tracking the impact of Buy Clean, see CLF's *Buy Clean Indicators: Approaches for Measuring Policy Effectiveness* report (2024).

## Why Scale Buy Clean?

At its core, Buy Clean is a procurement approach to reducing the carbon intensity of one's purchases. This report largely focuses on the public sector Buy Clean policy, but the concept can be applied to any purchase of construction materials. In fact, this policy concept has been incentivized in the private market for over 10 years through the LEED green building rating system and for about 8 years through public policies like Buy Clean California. Reasons to scale this policy concept include but are not limited to:

- Normalizing the measurement and disclosure of embodied carbon at the product scale
- Providing a market and continued demand for lower carbon products
- Leveraging and expanding upon some initial policy successes – leading to larger embodied carbon reductions
- Providing foundational embodied carbon data upon which other policies can be built

The focus on public sector Buy Clean policy has the potential to rapidly decarbonize the industrial sector due to the large influence of government purchases of concrete, cement, steel, glass, and asphalt. Federal agency programs are also enhancing the ability to have reliable, accessible, and comparable EPDs for building products through their grant and labeling programs. Federal and State programs are advancing key components of the life cycle assessment (LCA) ecosystem – the standards, data, tools, and stakeholders that support the measurement and reporting of embodied carbon. The LCA ecosystem is needed to support policies targeting GHG reductions in the built environment. Fundamentally, we can't manage what we don't measure, and Buy Clean policies are advancing reliable measurement using EPDs.

This foundational EPD data plays an important role for industrial decarbonization. EPDs provide a supply-side view of production hot spots for targeting reduction strategies and a demand-side view of the carbon impacts of building material purchases. This foundational embodied carbon data can create a *multiplier effect* – where other complementary policies build upon and utilize EPD data to achieve embodied carbon reductions. The section titled “Complementary policies that build upon Buy Clean” describes some of the policies that can be built upon the embodied carbon data created through Buy Clean. This multiplier effect is key to reducing the embodied carbon of construction materials at the scale and pace needed to address climate change.

# Scaling Strategies and Actions

Many of the scaling strategies and actions presented in this report represent the lessons learned from CLF staff directly supporting Buy Clean policy development and implementation efforts. The actions also reflect what we've learned through targeted interviews with staff and stakeholders who support, develop, or implement Buy Clean policies. We reference several other publications in the field, but this report does not rely on a detailed literature review of strategies and actions for scaling procurement policies.

For this report, scaling a Buy Clean policy means **achieving larger embodied carbon reductions** through any of the following strategies:

1. Establish Buy Clean policy in more jurisdictions
2. Expand the policy scope
3. Implement the policy more effectively

## Strategy 1: Establish Buy Clean policy in more jurisdictions

This section highlights nine actions that can help establish additional Buy Clean policies beyond the current ones. This includes actions that increase the likelihood of passing new policies (e.g., “Highlight policy co-benefits”) and how to prioritize the location and material scope of new policies for the biggest impact (e.g., “Focus on large spending”), among other approaches.

### 1. Measure and report embodied carbon using consumption-based GHG inventories

The measurement, reporting, and understanding of embodied carbon impacts within a jurisdiction can help establish Buy Clean policies in new locations. Most state and local GHG inventories are production-based inventories that don't clearly identify embodied carbon emissions that occur outside the physical boundary of the jurisdiction conducting the inventory. Focusing solely on production-based inventories creates an incomplete picture of the embodied carbon of construction within a specific geography.

Consumption-based greenhouse gas emissions inventories, however, can measure the embodied carbon emissions of buildings and infrastructure regardless of where the materials are produced. The State of Oregon has produced a [Consumption-Based Emissions Inventory](#) that shows the embodied carbon of construction materials and transportation contributes to 8% of all statewide emissions. EPA has begun working on an approach to creating Consumption-based GHG Inventories for States using a US EEIO approach. The EPA recently released state-based [US Environmentally-Extended Input-Output \(USEEIO\)](#) models, which can aid state efforts.

Measuring embodied carbon impacts using consumption-based GHG inventories can highlight the emissions and help drive resources, policies, and programs dedicated to reducing those emissions. Often, climate action plans are key determinants for focusing resources on specific programs and actions. In fact, EPA's recent [Climate Pollution Reduction Grants](#) represent a 5 billion dollar Inflation Reduction Act (IRA) investment in climate action at state, local, and tribal governments. These grants require a GHG inventory that identifies priority measures and an estimate of reduction potential for each program measure pursued through the grant.

## 2. Use both legislative and administrative policy pathways

There are legislative and administrative pathways to establish Buy Clean policy in federal, state, and local governments. Both pathways can be effective for policy development and implementation. While there are pros and cons for each pathway, scaling Buy Clean policy impacts need not focus on a single policy pathway. Instead, the focus should be on establishing new policies and not the pathway by which they are established. In some cases, both pathways can be pursued. Finding program leadership and staff champions is an important part of either policy pathway. Table 2 provides an overview of the pros and cons of each Buy Clean policy pathway.

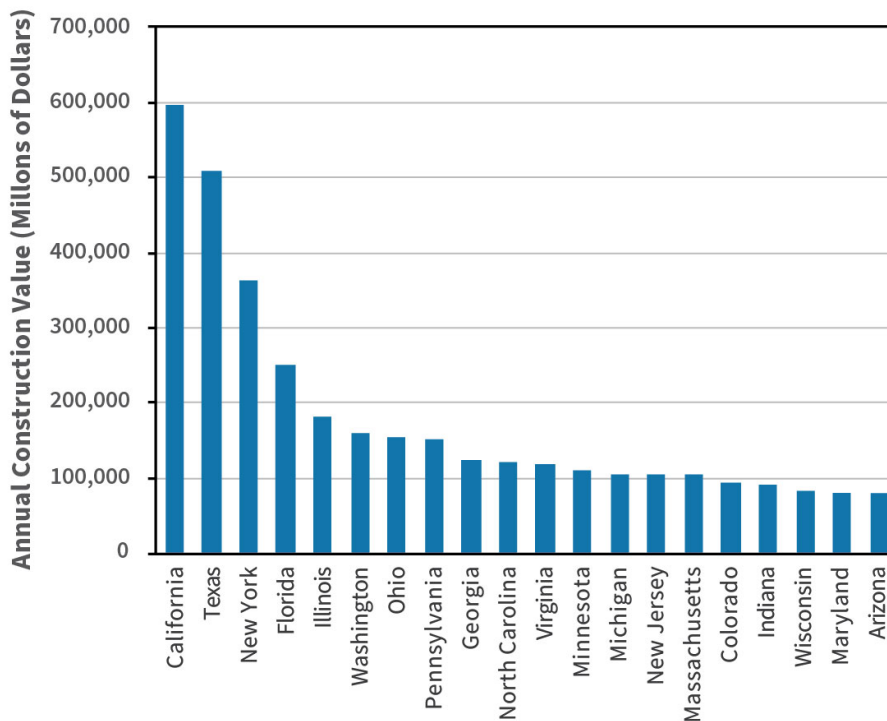
Table 2: Buy Clean policy pathway pros and cons.

	Buy Clean - legislative pathway	Buy Clean - administrative pathway
<b>Pros</b>	<ul style="list-style-type: none"> <li>• New funding and staffing for program development and implementation is more likely</li> <li>• Leverage connections to other procurement efforts, like Buy Fair labor conditions reporting</li> <li>• Shows support from publicly elected and accountable officials</li> <li>• Becomes an agency program regardless of leadership politics</li> <li>• Opportunity for public input</li> </ul>	<ul style="list-style-type: none"> <li>• Simpler and faster to develop initially - often needs approval from a single top administrator instead of an entire elected body</li> <li>• Flexibility can be greater and not subject to rulemaking and/or procedural hurdles</li> <li>• Can integrate into public building sustainable building standards (if applicable)</li> </ul>
<b>Cons</b>	<ul style="list-style-type: none"> <li>• Slow to pass - often takes many years to pass state legislatures</li> <li>• Needs invested and educated legislative champion (sponsor)</li> </ul>	<ul style="list-style-type: none"> <li>• Subject to changing leadership and political priorities</li> <li>• Less likely to have dedicated program funding</li> <li>• May have less opportunity for public input</li> </ul>

## 3. Focus new policies where construction activity is highest

Generally, increased construction spending correlates with increased embodied carbon. One simple strategy for targeting future locations for new Buy Clean policies is to focus policy development where public construction activity is highest. Figure 4 shows the twenty most active states ranked by value of public construction spending.

### Annual Value of State and Local Construction Put in Place by State, 2006-2022



**Figure 4. Annual value of state and local construction (2006-2022, in millions of dollars).** Data source: US Census Bureau’s “[Historical Value Put in Place](#)” data

Governments procure about 46% of cement used in the U.S. and 18% of steel purchased in the U.S. (Hasanbeigi et al., 2021). Federal procurement comprises approximately 11.5% of all cement consumed in the US and 5% of all steel, with the remainder of government procurement attributed to state and local purchasing (Hasanbeigi et al., 2021). Given these high values, making Federal Buy Clean a permanent policy is another action to pursue. Currently, Federal Buy Clean policy is driven by Federal Executive Orders and Inflation Reduction Act incentive funding. New legislation would likely be required to make Federal Buy Clean a permanent program.

#### 4. Prioritize materials by total reduction potential

In each jurisdiction, it’s possible to prioritize the eligible materials in a Buy Clean policy using the four steps outlined below. Prioritizing materials by impact keeps the number of materials limited to those that have the most reduction potential and also has the potential to reduce the politics associated with passing the policy. Put simply, managing input from four prioritized industries is much simpler than twelve. Jurisdictions should consider prioritizing by:

1. Total consumption of the product type
2. Average embodied carbon intensity
3. Range in embodied carbon intensity

4. State of industry
  - a. To what extent are current best practices being used
  - b. To what extent are there opportunities for innovation

Reduction potential is a function of how much the material contributes to overall embodied carbon emissions (which is itself a function of total consumption (item #1 on the list above) and average EC intensity (item #2)) and the potential to reduce the EC intensity (which relates to both the current range of available products (item #3) and the state of the industry (item #4) in terms of the feasibility or likelihood of future intensity reductions). One example of this strategy at work is the State of Colorado’s prioritization of precast concrete for EPD collection and GWP limit setting. The cost and quantities of precast items were found to be impactful based on 5 years of historical bid item data and therefore, the Colorado Department of Transportation (CDOT) determined EPDs should be collected for them. While the industry was not ready to provide EPDs in 2022, CDOT worked with stakeholders to bring them up to speed and EPDs have been required for precast since July of 2023.

## 5. Provide resources to support new policies

Based on CLF staff experience supporting staff and legislators directly on the development of numerous Buy Clean policies, Table 3 below outlines some resources that could help any legislative effort pass more informed and effective Buy Clean policies.

The following resources could support passing more informed and effective Buy Clean policies:

- **Model policy language:** State-level legislation may benefit from model policy, which acts as a starting place for legislative language. Developing model policy language may include a review of existing language and recommendations based on best practices for maximizing policy outcomes.
- **Standard definitions for common LCA terms:** Vetted definitions of common life cycle assessment (LCA) terms would provide more clarity for LCA-based policies like Buy Clean. The American Center for Life Cycle Assessment (ACLCA) is developing a definitions document as of November 2024 and plans to publish it soon.
- **Cost impacts:** The cost impacts of acquiring EPDs for manufacturers are well understood and cause little to no increase in product price for the consumers. This knowledge is based on interviews and anecdotes from government staff, project teams, and manufacturers. Additionally, a recent review of CDOT’s pricing by FHWA staff revealed no significant difference in price of select materials before and after their requirement to submit EPDs (w/o GWP limits) (Carrion, 2023).

However, in some cases, the cost of manufacturing lower-carbon products can have an impact on price. A 2021 RMI study showed that concrete, steel, rebar, glazing, and finish materials have reduction potentials between 3-30% with no to low-cost premium. The exception was glazing which had a 10% cost premium (Jungclaus et al., 2021). The City of Portland has reported an approximate 5% increase in product prices for some concrete products that meet their GWP limits. The cost and price implications of utilizing lower-carbon materials are not well understood. As environmental performance increasingly becomes a matter of competition, inadequate supply could lead to price increases. Interviews and email communication revealed that it’s complicated to draw a direct correlation between lower

carbon products and increases in cost/price. Material costs fluctuate often due to supply chain constraints, inflation, and labor costs, which makes it difficult to correlate the exact cause of cost/price impacts. A more comprehensive study of cost/price impacts would help inform decision-makers and future policy.

Finally, it's important to recognize the difference between "cost" and "price". The manufacturer's cost to produce some lower carbon materials may be equal to average materials, but the price charged by the manufacturer is a function of market demand and profit margins.

- **Project case studies:** More well-documented project case studies to demonstrate successful procurement and installation of lower-carbon materials would help increase education and awareness of strategies for implementing Buy Clean strategies. Examples of existing case studies are City of Portland's [Pilot Project Case Study Reports](#) and GSA's [2024 Program updates](#), which provide brief updates on their targeted lower-carbon material purchases using IRA funding. The State of Oregon has also published a couple of useful case studies on [residential](#) and [commercial building projects](#).

More case studies are needed to show that low-carbon material procurement and installations are possible in today's market in a variety of geographic locations. In many geographies, private building projects exist that exemplify lower carbon material procurement using EPDs, but are not featured in case studies due to confidentiality issues and/or time and resource constraints by the project teams working on these buildings. Policymakers can be more motivated to act when presented with successful examples of feasible policy implementation.

- **Policy scale evaluations:** Very few policy-scale evaluations exist to better understand the reduction potential of LCA-based policies like Buy Clean. CLF published an [Embodied Carbon Policy Reduction Calculator](#) report that includes a simple evaluation tool for assessing the impact of embodied carbon reduction policies. The report features a Buy Clean policy evaluation scenario focused on public purchases of concrete (Benke et al., 2022).

Better Buy Clean policy reduction models (with more materials, scenarios, and geographies) and post-implementation policy evaluations could help assess emissions reductions achieved by Buy Clean policies.

- **RFP and Contract specifications for agency contracts:** A 2022 Buy Clean Buy Fair pilot study for Washington State identified that model RFP and contract specifications would help both the development and implementation of Buy Clean policy in Washington (Huang et al., 2022). All jurisdictions would benefit from these model specifications as a starting place for Buy Clean implementation. While establishing model specifications does not directly help pass new policies, it may help reduce the fiscal impact of policy by providing a resource that doesn't have to be developed from scratch.
- **Government staff training:** Buy Clean policy currently relies on EPDs and in some cases, specific results reported within EPDs. EPDs are relatively new product labels and many procurement professionals and/or government staff project managers are not familiar with them. In some cases, EPDs can be confusing and misunderstood. Training of government

staff either managing or implementing Buy Clean programs is essential for successful understanding and implementation of Buy Clean policy.

- **Industry position statements or papers:** Successful Buy Clean policy implementation requires input and cooperation by affected industries. This can be time consuming, technically challenging, and a low priority for some industries. Direct work with industries to profile their scope of North American manufacturing, range of products available, range of associated EPD results, and considerations in requiring EPDs and setting GWP limits would help support policy development and implementation in more jurisdictions.

One example of a position paper that meets some of these criteria is the [Buy Clean Guidance for Structural Steel Products](#) published by AISC.

## 6. Increase the number and quality of EPDs available

EPDs are an essential part of Buy Clean policy. As described in CLF's *Buy Clean Indicators: Approaches for Measuring Policy Effectiveness* (2024) report, a rise in EPDs is one of many indicators for a successful Buy Clean policy. An increase in EPDs can be the result of a Buy Clean policy as well as a precursor to getting a Buy Clean policy adopted. For that reason, increasing the number of EPDs available could be both an indicator of a successful policy and a strategy for scaling Buy Clean impact, in that the increase might help pave the way for additional Buy Clean policies being adopted.

For example, the City of Portland's Buy Clean concrete policy was enabled by a wide availability of concrete EPDs that were already on the market. Those same EPDs helped enable a state-wide Buy Clean policy that was supported by the concrete and asphalt industries since they were already familiar with EPDs, had many on the market, and were aware of strategies to lower the carbon impacts of their materials.

There are many strategies for increasing the number of EPDs on the market that include but are not limited to:

- Providing grants for the creation of EPDs. Oregon and Massachusetts have done this for concrete and at the time of this report, EPA [recently selected](#) 38 businesses, universities and nonprofit organizations serving all 50 states to receive \$160M in funding for fiscal year 2024 to increase the supply and robustness of construction material EPDs.
- Requiring or incentivizing private and/or public projects to pursue points in rating systems that require EPDs (e.g., LEED, Envision)
- Requiring EPD publication via complementary environmental regulations.

Given the range of how concentrated or distributed different industries are, what constitutes a “large” number of EPDs depends on the product type. For example, there are relatively few North American flat glass manufacturing facilities (~ approximately 20), so a “large” number of North American flat glass product EPDs would likely be anywhere in the double digits. On the other hand, there are thousands of North American concrete producers, each that produces multiple mixes, and plants that each serve a relatively small region. Therefore, a “large” number of concrete EPDs would be determined by region (e.g., urban metro area) and could easily be hundreds or thousands in a given region.

In addition to *quantity*, a successful Buy Clean policy requires a collection of EPDs of robust enough *quality* that they can be accurately compared against a limit or similar target/threshold. This means, for example, that the EPDs cover functionally equivalent products and that the methods and data used to create the EPDs are equivalent.

To promote more robust EPDs, government agencies and their supporting partners could:

- Serve on PCR committees to improve PCR requirements that support EPD comparability. (For example, State and Federal agency representatives currently sit on the North American steel and concrete PCR committees.)
- Incorporate EPD requirements into Buy Clean policies that support more robust, comparable EPDs. For example, policies could incent or require the use of product and facility-specific EPDs. Product and facility-specific EPDs measure the impacts of one product from one manufacturing facility and are the most useful for tracking the embodied carbon of procurement. EPDs can also disclose the percentage of supply chain-specific data. While there is not yet consensus in the LCA community on a precise definition for “supply-chain-specific EPDs,” the general idea is that EPDs that rely on more specific data, particularly related to upstream suppliers, are more accurate.
- Incentivize or require participation in the industry average EPDs for each product type. Industry average EPDs are important tools for benchmarking, target setting, and tracking a sector’s carbon intensity reductions.
- Implement the “Roadmap” to advance product LCA and EPDs for policy outlined in CLF’s *Advancing the LCA Data Ecosystem for Policy* report (2023), which includes:
  - Increasing EPD availability and accessibility
  - Strengthening PCRs and PCR development process
  - Creating and adopting North American PCR harmonization requirements
  - Increasing access to public EPD generator tools
  - Increasing availability of industry data for setting policy emissions thresholds

## 7. Highlight policy co-benefits

The potential to reduce carbon emissions is not always the most effective selling point for passing new policies. Combining the bill scope and/or messaging with other complementary policy co-benefits can be helpful when establishing new Buy Clean policies.

The [Federal Executive Order 14057](#), which includes provisions for the Federal Buy Clean Program, promotes American manufactured items to help “combat the climate crisis; help American businesses compete in strategic industries; create and sustain well-paying union jobs that allow workers to thrive; maximize the use of American goods, products, materials, and services; and promote a secure, just, and equitable future for all Americans” (The White House, 2021).

Many Buy Clean policies are also promoted to advance American manufacturing competitiveness. The BlueGreen Alliance promotes that “[a]ny strategy to reduce industrial sector emissions must also boost the important economic benefits of domestic manufacturing and enhance international competitiveness. One such policy tool is Buy Clean...” (BGA, 2022). Buy Clean has the potential to reward companies producing cleaner goods while incentivizing fellow domestic competitors to follow suit.

Buy Clean policies have the potential co-benefits associated with buying local and supporting American-made goods, workforce development, and lower pollution for fence line communities. Hasanbeigi et al. (2021) highlighted the potential to boost American manufacturing competitiveness by stating that “Buy Clean could help American manufacturing become more competitive in a growing global market of green construction products; maintain the domestic competitive advantage of energy-intensive, trade-exposed industries; reduce the price of green products; and induce green innovation.”

## 8. Integrate Buy Clean into other sustainable procurement standards

If a jurisdiction already has an existing sustainable procurement effort in place, one avenue for establishing new Buy Clean requirements is to fold those into the already-existing program, rather than creating a new policy from scratch. There are strong sustainable procurement programs at the local and state government levels that could incorporate Buy Clean requirements directly into their efforts. The Sustainable Purchasing Leadership Council (SPLC) is a member-based organization that promotes coordination and collaboration on sustainable procurement initiatives.

The recent SPLC [2023 Sustainable Procurement Snapshot Report](#) cites that 80% of their member organizations prioritize more sustainable purchases for construction and renovation services (SPLC, 2023). There’s growing interest in the procurement space for addressing embodied carbon as demonstrated in a number of featured sessions in [SPLCs 2023 Summit](#).

Strategic partnership with organizations like SPLC, who already have a strong presence and audience with procurement professionals is an action for scaling Buy Clean’s impact.

## Strategy 2: Expand the policy scope

Expanding the scope of the Buy Clean policy can allow more materials or projects to qualify and include strategies beyond manufacturing efficiency like the reuse of buildings and materials. Policies can also set future GWP targets/limits ahead of time to provide a roadmap to meet their reduction targets. This section highlights seven potential actions for expanding the scope of Buy Clean.

### 1. Add more materials

Most existing policies focus on only a few high-impact materials. A phased approach can include other materials over time as the EPD market matures for other construction materials. Although adding more materials to a Buy Clean policy can add complexity to getting the policy passed, it also provides a more inclusive and equitable approach to basic material disclosure practices.

### 2. Add more pollutants

Current Buy Clean policy is focused on measuring, disclosing, and reducing GHG emissions through the use of EPDs. However, EPDs report on many more environmental impact categories that affect air, water, and land quality. Some of these impact categories are global (GWP, ozone depletion) and some are local/regional (smog, eutrophication, acidification). Adding additional pollutants and/or impact categories to Buy Clean policy has the potential to raise awareness with different interest

groups, expand the policy scope, and provide a potential pathway for increasing the policy's effectiveness in reducing GHG emissions and other pollutants.

### **3. Lower qualifying project thresholds**

Phase in lower qualifying project thresholds (i.e., the minimum physical size or cost of the project that determines if the project is subject to the policy requirements) if: (i) the current policy scope is being effectively implemented or (ii) significant quantities (by cost or weight) of materials consumed are not subject to the policy.

### **4. Include total emissions targets instead of just efficiency-based targets**

Buy Clean policies often have GWP limits per unit of material production, which offers a good measure of manufacturing efficiency. However, total GHG emissions matter too. In fact, in the context of global climate change, total emissions are really all that matters. Including total emissions targets for construction-related emissions within a jurisdiction can help develop and prioritize building and material reuse policies. Total emissions caps and reductions can be critical steps to decarbonize the built environment since they focus on material emissions intensities and material quantities for a more complete picture of total embodied carbon impacts.

### **5. Add incentives to policy structure**

Only two Buy Clean-type policies currently provide an incentive structure for purchasing lower-carbon materials. First, the New Jersey Buy Clean policy – a voluntary incentive-based policy also referred to as the Low Embodied Carbon Concrete Leadership Act (LECCLA) – provides a tax credit of up to 8% of contract cost for the companies that supply the ready mix concrete below an established GWP threshold.

Second, the Federal IRA funding for lower carbon material purchases provides a different type of incentive. For example, during GSA's Buy Clean pilot projects, they gave contractors with concrete, steel, glass, and asphalt materials that have EPDs in the best 20% of a product type, a perfect score for technical evaluation, meaning those contractors got all available points for 15% of the total evaluation, giving them a huge leg up against competing bids. GSA's bid scoring evaluates a number of factors - including carbon - that allow them to prioritize lower carbon over lowest cost.

Like GSA, many public procurement systems have scoring criteria that allow them to balance a variety of product attributes and performance characteristics. Utilizing this scoring system to prefer lower carbon products is a sound and underutilized strategy. For low-bid environments, there can also be price allowances provided for products meeting specific criteria. For example, Oregon's procurement laws ([ORS 279.570](#)) provide a preference for recycled materials and allow for a 5% price increase for products that meet their definition of including recycled content. This same concept can be applied to products that have EPDs compliant with a specific GWP threshold. In fact, a similar concept was initially incorporated into New York State's Buy Clean Concrete law but was removed through legislative negotiations before being passed.

Finally, it's important to note that a Buy Clean policy with GWP limits coupled with incentives to purchase the lowest carbon products that meet specifications may be able to significantly drive

innovation and speed the adoption of industry best practices. Put simply, financial incentives can help drive innovation and faster decarbonization.

## 6. Use a two-tiered approach to GWP limits

As described in Dell (2020), a policy with a two-tiered approach would: “set an eligibility threshold for participation in public projects that requires the use of current best practices and introduce a second, much more stringent, threshold that applies only to a small portion of projects or material quantity. This second threshold would reserve a portion of the public purchasing to commercialize practices that are better than any currently available practices. It would function very much like Renewable Portfolio Standard (RPS) policies did prior to 2010: providing guaranteed, bankable lead markets that could justify significant private-sector investment in at-the-time relatively high-cost technologies.”

## 7. Set reduction goals for future policy years based on science-based targets

All of the GWP limits set by Buy Clean policies in the United States are based on a combination of the jurisdiction's current procurement practices and the availability of lower carbon materials in their local market. As a starting point, this makes sense. While many policies include a regular review of limits (e.g. every 3 years), there is also value in projecting GWP targets for future years.

To meet the scale and pace of carbon reductions needed to address climate change, policies should also consider setting future science-based targets. Science-based targets give a jurisdiction or company a clearly defined path to reduce greenhouse gas emissions in line with limiting global warming to 1.5°C. They define how much and how quickly a government or business must reduce its emissions to be in line with the Paris Agreement goals (SBTi, 2024). Science-based targets align policy measures with the goals the policies set out to achieve, and also provide a roadmap and vision for the contractors and material suppliers that serve public procurement projects. Setting future targets can help prepare contractors and industry and may also spur innovation to meet those future GWP targets.

The recent RMI report titled [Buy Clean and Beyond](#) proposed material-specific reduction targets for nine different building materials between now and 2050 (Esau et al., 2023). Additionally, the [Science Based Targets](#) initiative (SBTi) is another pathway for informing material/sector-specific targets for climate actions. Although this effort is focused on corporate climate action, their pathways, and target to decarbonize certain industries (cement, steel, aluminum) and sectors (buildings) can be informative and helpful in setting reduction goals for Buy Clean policies.

## Strategy 3: Implement the policy more effectively

The ten actions outlined in this section would support more effective implementation of existing Buy Clean policies as a strategy to scale the impact. In some cases, there have been very long policy development and implementation timelines for some of the first Buy Clean policies in North America. Many of the actions outlined in this section build on the lessons learned from implementing these first policies.

## **1. Establish a tracking system for EPDs and material quantities**

Tracking systems that include material quantities and GWP impacts are essential for measuring the effectiveness of Buy Clean policies. Agencies tend to have different material procurement tracking systems. There's no one-size-fits-all approach, but external services like Building Transparency's Embodied Carbon in Construction Calculator (EC3) tool can track material quantities, EPDs for procured materials, and provide agency-specific login and secure server hosting.

## **2. Provide staff education**

The Washington State Buy Clean Buy Fair legislative report identified education (government staff, contractors, and manufacturers) as a critical component of an effective Buy Clean implementation. Interviews with jurisdictions implementing Buy Clean have also revealed a continued need for LCA-based education for government staff. Government staff should understand what EPDs are, why they are important, and how compliance with the Buy Clean policy is achieved.

## **3. Actively track indicators to measure policy effectiveness**

Integrate the tracking and measurement of the indicators recommended in CLF's *Buy Clean Indicators: Approaches for Measuring Policy Effectiveness* (2024).

## **4. Provide preference and demand for more robust EPDs**

More robust EPDs have higher data quality requirements and more accurately represent the product being evaluated. More robust EPDs also have a larger percentage of supply chain-specific data. More accurate results mean better comparison with other products, better tracking, and more confidence in carbon reductions achieved. For example, requiring product and facility-specific EPDs, which represent a single product from a single manufacturing facility, are required in Buy Clean California and Buy Clean and Buy Fair Washington. This ensures that the EPDs are representative of the actual product being purchased rather than an average value across multiple facilities from one manufacturer or an industry average EPD that combines multiple manufacturers of a single product into one production-weighted average EPD.

## **5. Establish a standard naming system for EPDs**

EPDs would benefit from a standardized naming system that creates a unique identifier in the EPD name and clearly identifies the product type (e.g. - 4000 psi concrete). The unique identifier helps control EPD versioning and also helps match an installed material EPD with the submitted EPD from an earlier point in project bidding or proposals. This has been particularly important for transportation agencies in their development of EPD programs. A clearly described "product type" is also important to facilitate digitally matching material quantities from whole building LCA models to EPDs for those materials. For example, a concrete mix number utilized as an EPD name helps contribute to a unique identifier but it doesn't help to facilitate a standardized naming convention to identify the product type (e.g. - 4000psi ready mix concrete).

## 6. Set GWP limits faster

Interviews with the City of Portland and the Port Authority of New York and New Jersey (PANYNJ) demonstrated that both jurisdictions looked back at many years of procurement data to help benchmark their past carbon impacts of concrete purchases. Even without EPDs from past mix purchases, it's possible to get an approximation of the EPD results using industry average GWP intensities combined with materials quantities from the mix design.

This allowed both jurisdictions to establish GWP limits representing realistic and incremental reductions in GWP impact per cubic yard of concrete purchased. This approach can speed up the establishment of limits and thereby accelerate carbon reductions achieved from the policy.

## 7. Conduct pilot projects

For some field-cured materials like ready-mix concrete or asphalt, lower carbon mixes have implications for curing times and methods of construction and finishing. The contractors installing lower carbon materials need to be familiar with any differences in curing or installation techniques to contribute towards a successful policy implementation. Pilot projects serve multiple functions including but not limited to:

- Testing the durability of new materials or mix designs
- Testing and refining construction and finishing techniques
- Training contractors in new techniques
- Development of best practices
- Product constructibility and/or performance feedback for the manufacturers

Additionally, construction site mock ups in collaboration with the general contractor, design team, and supplier are highly encouraged as a way to test the material and prepare for the full installation.

## 8. Use the EPA label for lower-carbon products (once available)

In 2024, the EPA will start developing a low-carbon material labeling system for building products. This program was identified and funded through the Inflation Reduction Act ([Section 60116](#)). Much like EPA's "Energy Star" or "Water Sense" labels, this future label could be required in Buy Clean procurement programs - simplifying implementation and compliance. EPA will base this label on the results of EPDs. EPA released [Implementation Approach for the US EPA Label Program for Low Embodied Carbon Construction Materials](#) in August 2024 and hosted a webinar and public comment period in February of 2024. EPDs can be difficult to understand for certain audiences, and simplifying the results of an EPD into a more consumer-friendly label could greatly enhance the standardization, utilization, and ultimate carbon reductions achieved through procurement policies like Buy Clean.

## 9. Share lessons learned and harmonize policies

With a growing number of Buy Clean policies, sharing lessons learned and harmonizing policies (where appropriate) can support better policy implementation and outcomes. Partnerships like the [Federal State Buy Clean Partnership](#) play important roles in sharing data, successes and failures, and lessons learned between local, state, and federal governments. Harmonizing across policies can help make implementation more effective through aligned reporting requirements, PCR standards, EPD

databases, GWP limits (for non-regional materials), and data storage approaches. See CLF's *Advancing the LCA Data Ecosystem in Policy* (2023) report for a more comprehensive approach to harmonization for product-level policy.

## **10. Review specifications and standards**

Project-level specifications (buildings or infrastructure) can be used to collect EPDs and set GWP limits. These same specifications can be barriers to achieving GWP limits for certain materials like concrete that may have more prescriptive criteria like cement minimums. Generally, a shift to performance-based specifications can facilitate lower carbon outcomes. For the purposes of this report, this scaling action is focused on a review of specifications and standards used in construction material purchases for implementing agencies. The review should include barriers in existing specifications and opportunities to reference other lower carbon materials and project standards in development (as of November 2024) such as ACI 323 Low-carbon Concrete Code and the ASHRAE/ICC Standard 240P – Quantification of Life Cycle Greenhouse Gas Emissions of Buildings.

## Complementary policies that build upon Buy Clean

Buy Clean is a foundational policy upon which others can be built. EPD development and disclosure are core elements of Buy Clean policies. The increase of EPDs on the market provides an unprecedented level of product-level embodied carbon reporting that has never existed before. This information is useful beyond the procurement lens of Buy Clean policies. In fact, other policies that use EPDs as compliance or reporting instruments to reduce embodied carbon can be mutually reinforcing and help scale the impact of Buy Clean policies.

The nine policies below all have potential uses for EPDs, build upon Buy Clean, and can create a multiplier effect to address embodied carbon reduction.

### Low Carbon Product Standard

A low-carbon product standard (LCPS) is a regulatory policy that can be applied to the manufacturers of building products within a state, region, or country. The policy sets an emissions intensity benchmark that decreases over time — effectively regulating the efficient production of building materials. An LCPS policy regulates production efficiency but does not put a total cap on emissions within a geography.

Companies selling or importing the products covered by the policy must comply with the standard. Companies either receive or surrender credits based on the emissions intensity of their product relative to the established benchmark. Credits can also be bought or sold - providing a financial incentive to continue emissions reductions. The standard established by this policy works best alongside other policies, such as investment in research and development, additional financial incentives, technical assistance and procurement policies like Buy Clean (Fransen et al, 2021).

The key to emissions reductions for the policy is lowering the emissions intensity over time. The policy prevents leakage (companies shifting production to non-regulated geographies) by applying it to imports as well. The direct connection to Buy Clean is that EPDs can be used as information sources for both policies. For LCPS, EPDs can be used to establish the baseline emissions intensity metric and serve as the compliance instrument.

This policy approach has already been successfully utilized in the fuels market through a Low Carbon Fuel Standard (LCFS), which is currently being implemented in California, Oregon, Washington, and across all of Canada. Research indicates that the “LCFS policies in California, Oregon, and British Columbia have each helped to reduce GHG emissions to date, and forward-looking modeling indicates that a strong LCFS can play an additive role in a policy mix seeking deep GHG mitigation...” (Axsen & Wolinetz, 2023).

An LCPS has strong potential to complement a Buy Clean policy and co-utilize EPDs. Finally, in California, Senate Bill 43 allows the California Air Resources Board (CARB) to establish an embodied carbon trading system - effectively paving the way for the first potential U.S.-based policy (California Legislative Information, 2023). California was also the first to establish a low-carbon fuel standard.

## Cap and trade programs

In a cap-and-trade system, the government sets an emissions cap and issues emission allowances consistent with that cap. Emitters covered by the program, which are typically defined by an annual emissions threshold, must hold allowances for every ton of greenhouse gas they emit. Companies may buy and sell allowances, and this market establishes an emissions price (C2ES, 2024). The key component to carbon reductions is the issuance of fewer allowances over time (the cap gets smaller). Many emission-intensive trade-exposed industries (i.e., cement) get issued free allowances or don't have to comply with the cap at all - instead providing plans to follow the best available emissions technology practices.

The nexus with Buy Clean policies would be a simple requirement to publish EPDs as a means to compare the efficiency of plant-specific production practices with industry average practices. Implementing this simple reporting requirement into a Cap and Trade policy connects supply-side regulations with demand-side reporting. Making these connections may help advance the policy goals of reducing embodied carbon faster than what would have otherwise happened alone. Finally, one limitation of cap and trade policies is that they can only focus on the facilities physically located within a given jurisdiction - creating the potential for leakage and lacking regulation on imported products.

## Advance Market Commitments (AMCs)

An "Advance Market Commitment" is a binding contract, typically offered by a government or other financial entity, used to guarantee a viable initial market for a product once it is successfully developed. Generally, AMCs are used in circumstances where the cost of developing a new product is too high to be worthwhile for the private sector without a guarantee of a certain quantity of purchases in advance. The key to AMC's success is that private markets take on the R&D cost to develop a product, while the government provides an assurance of a sufficient initial market to enable a potential return on investment even before an organic market develops" (Ho & Taylor, 2021).

AMCs have been highly successful in the vaccine industry. "Climate change, similar to vaccines, is an ideal area for the USG to use AMCs, namely because the true cost of climate change is not reflected in today's market prices for such products. Furthermore, by selling these AMCs as 'First for America to achieve X before the end of the decade,' these are much more relatable technology goals for the American public." (Ho & Taylor, 2021).

There's already momentum in the private sector to use AMCs to decarbonize certain sectors. The [First Mover's Coalition](#) has assembled a wide variety of partners to make lower carbon procurement commitments. Although there are some governmental members (including the United States), most of the commitments are being made by private companies. However, governments are paying attention and the US Dept of Energy recently listed the utilization of AMCs as one of its top 3 strategies for decarbonizing the cement sector (Goldman et al., 2023).

AMCs are a promising way to scale the impacts of Buy Clean policy and leverage future government procurement opportunities to influence technology innovation in building materials industries. Although AMCs don't create immediate carbon reductions, coupled with Buy Clean policies, they can be a complementary longer-term strategy.

## Material reuse policies

The [EPA's interim determination](#) states that “The EPA has determined that salvaged and reused materials and products from onsite and/or within the project region qualify under the requirements of sections 60503 and 60506, if your agency provides an estimate of the avoided embodied greenhouse-gas emissions based on the typical newly manufactured alternative the materials/products are replacing.” EPA is also interested in developing EPDs for salvaged material as indicated in their recent \$160 million grant announcement to increase the quantity and quality of EPDs on the market. If EPDs are successfully developed for salvage products, there could be a significant uptick in demand for salvaged materials if their GWP impacts are significantly lower than newly produced products (which is likely). While the GWP reduction potential at the material scale may be high for this complementary policy, its ability to scale is limited based on material supply, storage, and labor to deconstruct instead of demolish buildings.

At the current time, the policy structure for material reuse is unclear. Potential policy designs for public procurement include requirements to use a certain percentage (by mass, volume, or dollar value) of salvaged materials (with EPDs) for publicly constructed projects. Similar approaches exist in green building rating systems right now but none of them include the use of salvaged materials that have EPDs. This is a developing policy field and will be more defined once a more robust market exists for salvaged and reused materials that have EPDs.

## Product stewardship

“Product stewardship is the act of minimizing the health, safety, environmental, and social impacts of a product and its packaging throughout all lifecycle stages, while also maximizing economic benefits. The manufacturer, or producer, of the product, has the greatest ability to minimize adverse impacts, but other stakeholders, such as suppliers, retailers, and consumers, also play a role. Stewardship can be either voluntary or required by law” (PSI, 2024).

Virtually all product stewardship programs today focus on extended producer responsibility (EPR). “Extended producer responsibility (EPR) is a mandatory type of product stewardship required by law. It includes, at a minimum, the requirement that the manufacturer’s responsibility for its product extends to post-consumer management of that product and its packaging. There are two related features of EPR policy: (1) shifting financial and management responsibility, with government oversight, upstream to the manufacturer and away from the public sector; and (2) providing incentives to manufacturers to incorporate environmental considerations into the design of their products and packaging. EPR levels the playing field among competitors and incentivizes environmentally conscious design” ([PSI, 2023](#)).

EPR programs exist across the United States today and are typically passed as state-by-state legislation and focus on products like batteries, mattresses, pharmaceuticals, paint, electronics, and carpets. Governments provide performance standards for the programs and coalitions of manufacturers typically implement the end-of-life collection and management program for these products. A key piece of the product stewardship concept is reducing impacts at every stage in the lifecycle of products. However, virtually all programs in the United States exclusively focus on end-of-life collection instead of reducing the upstream manufacturing impacts of the products.

The State of Oregon passed the Plastic and Pollution Reduction Act in 2021, which established a product stewardship program for a variety of manufacturers of certain types of packaging. Uniquely, this program also incorporated “eco modulation” fees which allowed the manufacturer to demonstrate (through life cycle assessment) that they’ve reduced the manufacturing impacts of their product, allowing them to lower fees for the end-of-life management of their products and packaging ([Oregon DEQ, 2023](#)).

In a recent interview with Resource Recycling, Reid Lifset (founding editor of the Journal of Industrial Ecology) is quoted saying, “I’m a great fan of what Oregon is doing because first of all, to my knowledge, I don’t think there’s any other government in the world that’s actually requiring LCAs in conjunction with eco-modulation. The European Union talks a lot about having life cycle-based policy, but they actually don’t do it as far as I can tell. Oregon is also avoiding a nasty mistake, which is setting the actual quantitative targets for eco-modulation on the basis of the outcome of an LCA. Doing so would run into some serious methodological problems. It’s a mistake to conduct an LCA, and if the result is that the emission reduction from the policy is five times bigger than business as usual, decide to make the fees five times bigger. LCA doesn’t provide the precision that warrants that. . . . Oregon instead is doing something smart, they’re working to get people used to thinking about issues on a life cycle basis through the use of LCA. They are avoiding the use of LCAs as a formula for regulation, but instead using it to get people to pay attention to the environmental dimensions of our policies and goals. I think that’s exactly right. It’s really innovative, difficult and very impressive” ([Hefernan, 2023](#))

Using the “eco modulation” fees connected to third-party review LCAs (or EPDs) has the potential to accelerate embodied carbon reduction through economic incentives to reduce the production-related impacts of a building material. This policy concept is in its infancy in the United States with only the State of Oregon attempting to use a downstream end of life regulation to affect upstream production impacts. A recent paper by Lifset et al ([2023](#)) describes the history, features, challenges, and opportunities of this policy concept. Future research is warranted to explore the reduction potential of this policy individually and the scaling potential when paired with a Buy Clean policy focused on building materials.

## Industry-specific legislation

[California SB 596](#) (2021) requires the state board to develop a comprehensive strategy for the state’s cement sector to achieve net-zero emissions of greenhouse gasses associated with cement used within the state as soon as possible, but no later than December 31, 2045. The bill would require the state board, in developing this comprehensive strategy, to define a metric for greenhouse gas intensity and evaluate data, as provided, to establish a baseline from which to measure greenhouse gas intensity reductions, coordinate and consult with other state agencies, prioritize actions that leverage state and federal incentives, and evaluate measures to support market demand and financial incentives to encourage the production and use of cement with low greenhouse gas intensity, among other actions.

EPDs can serve as the metric to establish a baseline and measure interim and final reductions for legislation like this. The nexus with Buy Clean would be the use of an EPD to set a baseline and measure compliance with a target. The policies could be complementary and mutually reinforcing to address both supply- and demand-side decarbonization strategies.

## Building codes

EPD requirements are a part of CALGreen, ASHRAE 189.1/IgCC, the Denver Green Code, and Marin County’s building code. In most of these cases, a specific set of materials are identified, GWP limits are established, and then EPDs are the compliance instruments for meeting the GWP limits. In the ASHRAE/IgCC code, the code remains material agnostic and simply requires thirty EPDs from not less than twenty different building products, which together must equal 25% of total product costs. The CALGreen code EPD compliance pathway requires EPDs for structural steel, rebar steel, flat glass, mineral wool insulation, and ready-mix concrete. The product GWP has to be less than 175% of the industry average GWP (as reported in the industry-average EPD) in each respective category with more stringent tiers available for jurisdictions to adopt. Projects complying with CALGreen may choose to pursue two other paths that require building reuse or reductions demonstrated with a whole building LCA.

Building code policies are an attractive complement to public Buy Clean policies because they cover private sector construction, regulate the entire market, and have been a proven pathway for increased energy efficiency in buildings (USDOE, 2023). And like energy, there isn’t a single policy pathway that alone can accomplish the reduction goals needed to meet our climate change reduction targets. For example, energy is regulated at the utility-scale, building scale, product scale, and through cap and trade programs at the state level. The embodied carbon of building materials needs a similar multipronged approach to accomplish some of the same gains we’ve seen in energy efficiency through building codes.

There are many ways to reduce embodied carbon through building code including but not limited to using fewer materials (e.g., advanced framing techniques designed to optimize framing lumber use and reduce waste during construction), lower carbon refrigerants, building smaller structures, requiring efficiently made buildings product via EPD requirements, and having whole building performance targets for design professionals. For the purposes of this report, CLF focuses only on policies that rely on EPDs. A recent RMI study has shown that reliance on EPDs for material sourcing can yield significant carbon savings for little to no incremental costs (Jungclaus et al., 2021). EPD requirements are an impactful and logical place to start for building code regulations since they are plentiful, third-party verified, and informative in the selection of lower carbon materials.

## Carbon Border Adjustment Mechanism

Carbon border adjustment mechanisms (CBAM) are policies designed to place a fee on imported goods that reflect the embodied carbon in those goods. Currently, the European Union is the only region of the world with a CBAM policy. Initial reporting for imported goods began in January 2024 and covers cement, iron and steel, aluminum, fertilizers, electricity and hydrogen. “The gradual introduction of the CBAM is aligned with the phase-out of the allocation of free allowances under the EU Emissions Trading System (ETS) to support the decarbonisation of EU industry” ([EU, 2023](#)). Overall, this policy is specifically designed to prevent “leakage” - the movement of an emissions-intensive industry from a highly regulated country to a less regulated country.

In the EU, the “CBAM proposal would require that imported goods face charges and requirements similar to those that would be applied if the imported product was produced domestically. At present, domestic producers of carbon-intensive goods in the EU must purchase allowances for each metric

ton of carbon dioxide emitted” ([Brauch et al., 2021](#)). The basic concept is that since EU-based manufacturers are subject to a carbon cap regulation (that includes a price on carbon), other imported goods are held to the same standard of emissions control as EU-based manufacturing - preventing leakage and incentivizing decarbonization across the entire EU market.

The design of the measurement system for CBAM policies is vitally important to ensuring fair pricing of imported goods, prevention of leakage, and incentives to reduce the carbon intensity of covered products. In the EU system, “companies have two options when calculating the amount of carbon in their imports. The default method assumes the emissions per tonne of an import to be equal to the average emissions per tonne of the worst 10% of emitters among EU producers of the same product. Alternatively, importers can calculate actual emissions using prescribed formulas, considering any carbon price paid in the country of origin. This approach supports companies with Environmental Product Declarations (EPDs) or Product Carbon Footprints (PCFs)” ([One Click LCA, 2023](#))

Since this is a new policy, it’s not entirely clear how well EPD calculation methods will align with the prescribed formulas published by the EU. Additional research is needed to explore how a CBAM could directly or indirectly utilize EPDs and act as a complementary policy to Buy Clean.

What is clear, however, is that there’s interest in the United States in CBAM policies. A recent Third Way article notes that “Manufacturers in the US tend to be much less carbon-intensive than those in countries like China, India, and Russia. So, by imposing a fee on more carbon-intensive imports, a CBAM makes these products more expensive and incentivizes the purchase of lower emissions goods, like those produced in the US. A lot depends on how the policy is designed. But the evidence is clear: a CBAM can give certain domestic manufacturers a major boost while incentivizing producers around the world to slash emissions in order to access more of the global marketplace” ([Third Way, 2023](#)).

## **Implement whole building LCA policies**

Whole building life cycle assessment (WBLCA) policies are complementary to Buy Clean policies. Buy Clean policies operate at the product scale and drive demand and competition for decarbonization in each material industry. Generally, EPDs push manufacturers to invest in clean manufacturing and contractors to procure low-carbon materials. EPDs can capture strategies like fuel switching, plant energy efficiency, and the creation of novel materials and products. In contrast, WBLCA policies operate at the building scale pushing architects and engineers to design a lower carbon building. WBLCA captures strategies like using less materials (through structural material optimization and other efficiency strategies), material substitution, and building and material reuse. Increasingly, WBLCA tools are utilizing EPDs as information sources in their databases. Thus, increasing the quantity and quality of EPDs through Buy Clean policies can help support better-informed decision making at the building scale.

WBLCA policies are becoming more common in North America and already exist in many countries in Europe and across the European Union through the EU Energy Performance of Buildings Directive (EPBD) Recast. For more information on current policies and basic guidance on developing new policies, refer to CLF’s recently published [Building-Scale Embodied Carbon Performance Requirements](#) (2024) factsheet.

## Prioritizing scaling strategies and actions

This study outlined twenty five potential scaling strategies and actions for increasing the carbon reductions achieved by Buy Clean policies and highlighted nine complementary and mutually reinforcing policies for embodied carbon reduction. These actions and additional policies act as a “menu of options” for others to evaluate and prioritize to suit their own policy goals. The authors developed a simple approach one could use to prioritize scaling strategies focused on the following two factors:

- **GWP impact:** *To what extent does the action or policy reduce GWP emissions?*
- **Feasibility to implement:** *How easily could an organization implement the action or policy?*

One could assess each action or policy against each factor with a simple Likert (1-5) scale quantitative score (where 1 = least and 5 = most). For each action or policy, the scores are then multiplied to create a single score, and the actions can be ranked.

Below are a few examples of how one could implement this proposed system.

- **Scaling action: Focus new policies where construction activity is highest** (example score:  $5 \times 2 = 10$ )
  - **GWP impact = 5:** More construction leads to higher embodied carbon impacts. Focusing new Buy Clean policy development in cities and states with greater levels of public construction spending has the potential to yield higher carbon reductions. Figure 3 suggests that states like Texas, Florida, Illinois, and Washington are good target states for new policy.
  - **Feasibility to implement = 2:** State-level Buy Clean policy competes with other legislative priorities in any given year. In states like Washington, which has already passed a cap and invest program, there may be more legislative bandwidth to address embodied carbon. In fact, WA did pass Buy Clean legislation in March of 2024. In States like Texas, Florida, and Illinois finding companion issues (jobs, American competitiveness, etc...) may serve as helpful pathways for passing Buy Clean policies. Additionally, as learned in Oregon, a city-focused program can help pave the way for a broader statewide program.
- **Scaling action: Prioritize materials by total reduction potential** (example score:  $3 \times 5 = 15$ )
  - **GWP impact = 3:** Buy Clean policies should focus on the materials that offer the most reduction potential. Prioritizing the materials by impact keeps the number of materials limited to those that have the most reduction potential and also has the potential to reduce the politics associated with passing the policy. Consider prioritizing by:
    - Total consumption of the product type
    - Average embodied carbon intensity
    - Range in embodied carbon intensity
    - State of industry
      - To what extent are current best practices being used

- To what extent are there opportunities for innovation

In each jurisdiction, it's possible to prioritize the eligible materials in a Buy Clean policy using the four steps outlined below. Reduction potential is a function of how much the material contributes to overall embodied carbon emissions (which is itself a function of total consumption (item #1 on the list above) and average EC intensity (item #2)) and the potential to reduce the EC intensity (which relates to both the current range of available products (item #3) and the state of the industry (item #4) in terms of the feasibility or likelihood of future intensity reductions).

- **Feasibility to implement = 5:** At a jurisdictional level, this strategy is feasible to implement if material procurement quantities are readily available. Combining these quantities with industry average GWP impacts (e.g. - CLF baselines) can provide a snapshot of material procurement impacts for construction (similar to an approach to conduct an agency Scope 3 GHG inventory).

At the scale of the United States, it's also possible to conduct this analysis - starting with total GHG impacts of domestic building material manufacturing. Applying the steps outlined above, one could assess near-term and long-term carbon reduction potential. The recent [US DOE Commercial Liftoff Report on Industrial Decarbonization](#) offers a starting place for this analysis.

- **Scaling action: Add incentives for ultra-low EC products to policy structure** (example score:  $5 \times 4 = 20$ )
  - **GWP impact = 5:** Adding incentives to prioritize the purchase of ultra-low embodied carbon products to the Buy Clean policy structure can greatly enhance the impact of this otherwise incremental policy. Incentives such as bid price credits can drive innovation to be the lowest carbon product on the market instead of just meeting the GWP limit.
  - **Feasibility to implement = 4:** This can be relatively easy to implement - even in competitive low-bid environments. For example, GSA provides extra points for the lowest carbon products in a multicriteria bid system which gives those low carbon products a significant advantage over other products.
- **Scaling action: Low Carbon Product Standard** (example score:  $5 \times 2 = 10$ )
  - **GWP impact = 5:** A low-carbon product standard is a regulatory policy that can be applied to the manufacturers of building products within a state, region, or country. The policy sets an emissions intensity benchmark that decreases over time - effectively regulating the efficient production of building materials. Companies selling or importing the products covered by the policy must comply with the standard. Companies either receive or surrender credits based on the emissions intensity of their product relative to the established benchmark. Credits can also be bought or sold - providing a financial incentive to continue emissions reductions. Although tradable credits can be valuable, they are not a necessary feature of clean product standards (Dell, 2020). The standard established by this policy works best alongside other policies, such as investment in research and development,

additional financial incentives, technical assistance, and procurement policies like Buy Clean (Fransen et al, 2021).

This is a proven policy mechanism that has the ability to decrease the production intensity impacts of locally produced and imported building materials. The policy structure can be built upon information reported in EPDs, which makes it a complementary policy capable of its own carbon reductions and complementary scaling potential for Buy Clean policies. This policy has already proved to be effective for clean fuels programs in California, Washington, Oregon, and British Columbia.

- **Feasibility to implement = 2:** This program would need dedicated government staff for both development and implementation, which does translate to a fiscal impact for implementing agencies. However, it's feasible to implement and has already been done for clean fuels. The cement and steel sectors are the two most viable industrial sectors to apply this policy since their emissions are easier to measure and can be assessed at a well-defined point in the supply chain (Dell, 2020). Additionally, the ability to trade market credits in this program makes short-term compliance easier, which may support implementation feasibility.

## Conclusions, limitations, and next steps

Despite the young age of this policy, Buy Clean continues to be a strong focus of federal and state built environment policy in the United States. There are early signs that Buy Clean policies are making positive impacts toward reduced emissions and this report presents a menu of options for scaling the effectiveness of Buy Clean policy in achieving carbon reductions. The twenty five actions presented in this report offer practical steps to expanding Buy Clean to new jurisdictions and improving existing policies. Additionally, we offer nine complementary and mutually reinforcing policies to address both supply- and demand-side decarbonization strategies. All of these complementary policies are linked to product-level embodied carbon disclosures (via EPDs) that are fundamental elements of Buy Clean policy.

Buy Clean is striving for direct reductions where implemented and acting as a foundational policy upon which others can be built. It has the potential to create a multiplier effect of embodied carbon reductions through the fundamental disclosure (via EPDs) of product-level embodied carbon and the multitude of different policies that can utilize that data.

Since a formal evaluation of the direct effectiveness of Buy Clean policies has not been completed, the authors propose a simple method for prioritizing these policies to best suit the needs of different geographies and policy types. These strategies, actions, and complementary policies would benefit from socialization, discussion, and refinement with industry, NGO, and government partners.

As Buy Clean policies continue to expand and more agencies have experience with implementation, policy evaluation will also help refine the options presented in this report. *Buy Clean Indicators: Approaches for Measuring Policy Effectiveness* report (2024) provides a set of indicators for supporting this type of policy evaluation moving forward.

Continued support for Buy Clean policies will help maintain and strengthen this foundational demand-side policy focused on industrial decarbonization and environmental impact disclosure through EPDs. While Buy Clean policies alone cannot decarbonize industry, they provide an important market signal, prioritize and increase material transparency and disclosure, and act as a catalyst for complementary policies that utilize EPDs.

## References

- Axsen, J., & Wolinetz, M. (2023). What does a low-carbon fuel standard contribute to a policy mix? An interdisciplinary review of evidence and research gaps. *Transport Policy*, 133, 54–63. <https://doi.org/10.1016/j.tranpol.2023.01.008>
- Benke, B., Lewis, M., Carlisle, S., Huang, M., & Simonen, K. (2022). *Developing an Embodied Carbon Policy Reduction Calculator*. Carbon Leadership Forum (CLF). <https://carbonleadershipforum.org/policy-reduction-calculator/>
- BlueGreen Alliance (BGA). (2022). *Buy Clean: A Tool to Create Good Jobs, Cut Pollution, and Renew American Manufacturing*. [https://www.bluegreenalliance.org/wp-content/uploads/2022/09/Buy-Clean-White-Paper-22- v3\\_91222.pdf](https://www.bluegreenalliance.org/wp-content/uploads/2022/09/Buy-Clean-White-Paper-22- v3_91222.pdf)
- Brauch, M., Arnold, J., Klonsky, E., Everard, F. (2021). *Event Highlights: Carbon Border Adjustments in the EU, the U.S., and Beyond*. Columbia Center on Sustainable Investment. <https://ccsi.columbia.edu/sites/default/files/content/docs/ccsi-eu-cbam-border-carbon-adjustment-event.pdf>
- Building Transparency. (2023). *Embodied carbon in construction calculator (EC3) tool* [web-based database and tool]. <https://buildingtransparency.org/ec3>
- Carrion, M. (2023). Personal communication. December 26, 2023.
- California Legislative Information. (2023). “AB-43 Greenhouse gas emissions: building materials: embodied carbon trading system.” [https://leginfo.ca.gov/faces/billTextClient.xhtml?bill\\_id=202320240AB43](https://leginfo.ca.gov/faces/billTextClient.xhtml?bill_id=202320240AB43)
- Center for Climate and Energy Solutions (C2ES). (2024). “Cap and Trade Basics” [webpage]. <https://www.c2es.org/content/cap-and-trade-basics/#:~:text=In%20a%20cap%2Dand%2Dtrade,market%20establishes%20an%20emissions%20price.>
- Dell, R. (2020). *Build Clean: Industrial Policy for Climate Justice*. ClimateWorks. <https://www.climateworks.org/report/build-clean-industrial-policy-for-climate-and-justice/>
- Department of General Services (DGS). (2024). Buy Clean California Act. State of California. <https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act#:~:text=The%20Buy%20Clean%20California%20Act,limit%20for%20four%20eligible%20materials>
- Esau, R., Tilak, A., Usry, C., & Olgyay, V. (2023). *Buy Clean and Beyond: A Guide to Reaching Net-Zero Embodied Carbon in State-Owned Building Projects*. RMI. <https://rmi.org/insight/guide-to-road-mapping-state-owned-building-projects-to-reach-net-zero-embodied-carbon/>

- European Commission (EU). (2023). “Carbon Border Adjustment Mechanism” [webpage]. [https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism\\_en#guidance](https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism_en#guidance)
- Fransen, T., Lebling, K., Weyl, D., & Kennedy, K. (2021). *Toward a Tradable Low-Carbon Cement Standard: Policy Design Considerations for the United States*. World Resources Institute. <https://www.wri.org/research/toward-tradable-low-carbon-cement-standard-policy-design-considerations-united-states>
- Goldman, S., Majsztzik, P., Sgro Rojas, I., Gavvalapalli, M., Gaikwad, R., Feric, T., Visconti, K., & McMurtry, B. (2023). *Pathways to Commercial Liftoff: Low-Carbon Cement*. U.S. Department of Energy. <https://liftoff.energy.gov/wp-content/uploads/2023/09/20230918-Pathways-to-Commercial-Liftoff-Cement.pdf>
- Hasanbeigi, A. & Springer, C. (2018). The Carbon Loophole in Climate Policy: Quantifying the Embodied Carbon in Traded Products. <https://www.climateworks.org/wp-content/uploads/2018/09/Carbon-Loophole-in-Climate-Policy-Final.pdf>
- Hasanbeigi, A., Shi, D., & Khutal, H. (2021). *Federal Buy Clean for Cement and Steel: Policy Design And Impact On Industrial Emissions And Competitiveness*. Global Efficiency Intelligence. <https://www.globalefficiencyintel.com/federal-buy-clean-for-cement-and-steel>
- Hefernan, M. (2024). *The evolution of eco-modulation to drive eco-design*. Resource Recycling. <https://resource-recycling.com/recycling/2023/08/02/the-evolution-of-eco-modulation-to-drive-eco-design/#:~:text=In%20the%20context%20of%20packaging,or%20making%20packaging%20easily%20recyclable.>
- Ho, A. & Taylor, J. (2021). *Using Advance Market Commitments for Public Purpose Technology Development*. Harvard Kennedy School Belfer Center for Science and International Affairs. <https://www.belfercenter.org/publication/using-advance-market-commitments-public-purpose-technology-development>
- Huang, M., Lewis, M., Escarcega, P., Escarcega, E., Torres, M., Waterstrat, H., Kinder-Pyle, I., & Simonen, K. (2022). *Buy Clean Buy Fair Washington Project: Final Report*. Carbon Leadership Forum and Washington State Department of Commerce. <https://carbonleadershipforum.org/bcbf-project/>
- Jungclaus, M., Esau, R., Olgyay, V., Rempher, A. (2021). “Reducing Embodied Carbon in Buildings: Low-Cost, High-Value Opportunities”, RMI. <https://rmi.org/insight/reducing-embodied-carbon-in-buildings?submitted=ecrpfgerbh>
- Lambert, M. and Lewis, M. (2024). *Embodied Carbon 101*. Carbon Leadership Forum. <https://carbonleadershipforum.org/embodied-carbon-101-v2/>
- Lewis, M., Waldman, B., Carlisle, S., Benke, B., & Simonen, K. (2023). *Advancing the LCA Ecosystem A Policy-Focused Roadmap for Reducing Embodied Carbon*. Carbon Leadership Forum. <https://carbonleadershipforum.org/advancing-lca-ecosystem/>

- Lewis, M., Benke, B., Carlisle, S., Lambert, M. (2024). *Building-Scale Embodied Carbon Performance Requirements*. Carbon Leadership Forum. <https://carbonleadershipforum.org/building-ec-performance-regs/>
- Liefset, R., Kalimo, H., Jukka, A., Kautto, P., Miettinen, M. (2023). *Restoring the incentives for eco-design in extended producer responsibility: The challenges for eco-modulation*. Waste Management. <https://www.sciencedirect.com/science/article/abs/pii/S0956053X2300380X?via%3Dihub>
- Office of the Federal Chief Sustainability Officer. (2023). “Federal Buy Clean Initiative” [webpage]. Executive office of the President of the United States. <https://www.sustainability.gov/buyclean/>
- Product Stewardship Institute (PSI). (2024). “What is extended producer responsibility (EPR)?” [webpage]. <https://productstewardship.us/what-is-epr/>
- One Click LCA. (2024). “The European Carbon Border Adjustment Mechanism (CBAM)” [webpage]. <https://oneclicklca.com/en/resources/articles/european-carbon-border-adjustment-mechanism>
- Oregon Department of Environmental Quality (DEQ). (2023). “Concrete” [webpage]. State of Oregon. <https://www.oregon.gov/deq/mm/production/pages/concrete.aspx>
- Oregon Department of Environmental Quality (DEQ). (2024). “Plastic Pollution and Recycling Modernization Act” [webpage]. State of Oregon. <https://www.oregon.gov/deq/recycling/pages/modernizing-oregons-recycling-system.aspx>
- Science Based Targets Initiative (SBTi). (2024). “FAQ” [webpage]. <https://sciencebasedtargets.org/faqs#what-are-science-based-targets>
- Sustainable Purchasing Leadership Council (SPLC). (2023). *2023 Sustainable Procurement Snapshot Report*. <https://www.sustainablepurchasing.org/events/2023-sustainable-procurement-snapshot-report->
- The White House. (2021). *Executive Order on Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability*. <https://www.whitehouse.gov/briefing-room/presidential-actions/2021/12/08/executive-order-on-catalyzing-clean-energy-industries-and-jobs-through-federal-sustainability/>
- Third Way. (2023). “A US CBAM: A Win for US Manufacturing” [webpage]. <https://www.thirdway.org/memo/a-us-cbam-a-win-for-us-manufacturing>
- U.S. Environmental Protection Agency (USEPA). (2022). “Interim Determination on Low-Carbon Materials under IRA.” [https://www.epa.gov/system/files/documents/2023-01/2022.12.22%20Interim%20Determination%20on%20Low%20Carbon%20Materials%20under%20IRA%2060503%20and%2060506\\_508.pdf](https://www.epa.gov/system/files/documents/2023-01/2022.12.22%20Interim%20Determination%20on%20Low%20Carbon%20Materials%20under%20IRA%2060503%20and%2060506_508.pdf)
- U.S. Department of Energy (USDOE). (2023). *Pathways to Commercial Liftoff: Industrial Decarbonization*. [https://liftoff.energy.gov/wp-content/uploads/2023/10/LIFTOFF\\_DOE\\_Industrial-Decarbonization\\_v8.pdf](https://liftoff.energy.gov/wp-content/uploads/2023/10/LIFTOFF_DOE_Industrial-Decarbonization_v8.pdf)

U.S. Department of Energy (USDOE). (2023). “DOE Building Energy Codes Program Infographics” [webpage]. <https://www.energycodes.gov/infographics>

Waldman, B., Palmeri, J., Simonen, K., and Lewis, M. (2024). *Buy Clean Indicators: Approaches for Measuring Policy Effectiveness*. Carbon Leadership Forum.

Waldman, B., Hyatt, A., Carlisle, S., Palmeri, J., & Simonen, K. (2023). *2023 Carbon Leadership Forum Material Baselines Baseline Report v2*. Carbon Leadership Forum.  
<https://carbonleadershipforum.org/clf-material-baselines-2023/>

Waldman, B., Lewis, M., Palmeri, J. (2024). *Buy Clean Policies: Overview and Implementation*. Carbon Leadership Forum. <https://carbonleadershipforum.org/buy-clean-policies-overview/>