Federal Buy Clean Policy for Construction Materials in the United States

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Abstract

The United States spends billions of dollars each year on government procurement towards the development of infrastructure like roads, bridges, etc. Green public procurement, known as Buy Clean in the U.S., is a policy tool that can leverage this large-scale purchasing power to help drive markets towards industrial decarbonization. This paper focuses on steel and cement as examples of the potential impact of Buy Clean on GHG emissions from construction products. 46% of total U.S. cement consumption in 2018 was for public construction projects, which led to the emission of 36 Mt CO_2. We estimate annual emissions reductions of 3.6 Mt CO_2 and 18 Mt $CO_2$from public cement procurement using low (10%) and transformative (50%) Buy Clean target scenarios, respectively. 18% of total U.S. steel consumption in 2018 was for public construction projects, which led to the emission of 21 Mt CO_2. We estimate annual emissions reductions of 2 Mt CO_2 and 10 Mt CO_2 from public steel procurement using low (10%) and transformative (50%) Buy Clean target scenarios, respectively. The reductions could increase by over two-fold for cement and five-fold for steel if spillover effects in the private sector are included. Current federal and state-level Buy Clean policies are surveyed and recommendations are made based on international best practice.

1. Introduction

When public entities leverage their large-scale purchasing power by buying goods and services with a lower carbon footprint, they help drive markets in the direction of sustainability, reduce the negative impacts of their use of goods, and produce positive environmental and social benefits (UNEP 2017). In 2018, the United States spent $110 billion in federal non-defense investments in physical capital that resulted in the development of infrastructure such as highways, bridges, and more (Campbell & Tawil 2019).

Green public procurement (GPP) is the process by which the public sector seeks to procure products and services with a reduced environmental impact. Many governments around the world have already recognized the value of GPP as a policy instrument to leverage public spending in large contracts to achieve green goals. Hasanbeigi et al. (2019) studied 30 such programs, 22 of which are in countries in Asia, Europe, North and South America, Africa, and Oceania, five case studies at the city and regional level, as well as GPP programs of three multi-lateral banks and the UN to promote sustainable production and consumption (Hasanbeigi, et al. 2019).

In the United States, 55% of GHG emissions attributed to public institutions are a result of government-purchased goods and products. There is little federal, state, or local regulatory framework to address these emissions, but several voluntary national programs (e.g., Leadership in Energy and Environmental Design (LEED) and Living Building Challenge) have evolved to strengthen the focus on embodied carbon reduction. The Buy Clean California Act may act as a model for states and cities considering embodied carbon policies (Simonen, Huang, & Huang, 2018).

In January 2021, President Biden issued Executive Order 14008 to consider additional regulatory steps the federal government can make to promote increased contractor attention on supply chain emissions. (White House 2021). In March 2021, the Climate Leadership and Environmental Action for our Nation's (CLEAN) Future Act was proposed to realize this goal.

The CLEAN Future Act is a comprehensive bill that proposes both sector-specific and economy-wide policies to achieve net-zero GHG emissions by 2050. In the industrial sector, the bill proposes to reduce embodied emissions in projects involving federal funds by increasing transparency of embodied emissions in construction products, establishing a Federal Buy Clean program, and creating a Climate Star program (E&C 2021). If passed, this bill would greatly increase public awareness of embodied emissions and promote the use of low-carbon materials.

In this paper, we focus on steel and cement as examples of the potential impact of Buy Clean on construction materials. The paper investigates the scale of public procurement of steel and cement in the U.S. and estimates the potential impact of Federal Buy Clean on GHG emissions. It also reviews current and proposed Buy Clean policies in the U.S. and makes recommendations for Federal Buy Clean based on international best practice.

2. Scale of government procurement of construction materials in the U.S.

Hasanbeigi and Khutal (2021) analyzed the scale of government procurement of carbon-intensive materials including steel, concrete, and cement for the development of infrastructure in the U.S. It analyzed the scale of federal funds provided to state and local governments for the development of physical capital, the amount of federal spending on imported and domestic materials for infrastructure projects, and specific states where federal funds are used to purchase significant amounts of materials for infrastructure projects.

The funding for transportation dominates the overall federal non-defense spending on physical capital, accounting for around 58% ($63.9 billion) of the total. Of the $63.9 billion in transportation funding, almost 92% ($58.8 billion) was issued through grants to state and local governments, whereas, the remaining 8% represented direct spending by the federal government. These grants to state and local governments concentrate on the development of highways, mass transportation, and airports (Campbell & Tawil, 2019).

In this section we quantify the scale of public procurement of steel and cement as examples of the potential impact of Buy Clean on construction materials.

2.1. Cement used in public construction and associated GHG emissions

The United States produced 86 million metric tonnes (Mt) of Portland cement and masonry cement in 2018. The United States is the 4th largest producer and consumer of cement in the world. Cement was produced at 96 plants in 34 states in 2018. Of those, 86 plants employed the dry kiln process, and 9 used the wet kiln process. Sales of cement in 2018 were around $12.7 billion. Texas, California, Missouri, Florida, Alabama, Michigan, and Pennsylvania have the highest cement production, in that order, and they account for about 60% of U.S. cement production (USGS 2020).

Total cement consumption in the U.S. was 98.5 Mt in 2018 (USGS 2020). From that, around 45 Mt was used in public construction projects, which is 46% of total cement used in the U.S. (PCA 2016). Table 1 shows the detailed breakdown of cement consumption by market segment in the U.S.

Table 1. Cement consumption in the U.S. in 2018 (USGS 2020, PCA 2016)

Market	Cement use (kt)
Total cement consumption	98,500
Public construction	**45,136**
Building	2,520
Highways and streets	31,084
Public safety	195
Conservation	3,066
Sewage & Waste Disposal	4,698
Water Supply Systems	3,572

Note: 1) public construction values for 2018 are estimated based on 2016 values given by PCA (2016)
2) The values shown in the table include the cement used in concrete that is used in construction projects.

It should be noted that in the majority of cases, the government or its contractors do not purchase cement and instead purchase concrete, which is the final product used in construction projects. The values shown in this chapter include the cement used in concrete that is used in construction projects.

Figure 1 shows annual CO_2 emissions associated with cement used in the U.S. in 2018. We used the weighted average CO_2 intensity of cement produced in the U.S. and net imported cement to calculate annual CO_2 emissions associated with cement consumption. Around half of the annual CO_2 emissions linked with cement consumption are associated with public construction which was around 36 Mt CO_2 in 2018. Around 25% of total cement and concrete procured by the government in the U.S. is by means of federal funds with the remaining through state and local government funds (Hasanbeigi and Khutal 2021). Therefore, public procurement has significant leverage in incentivizing decarbonization of the cement production.

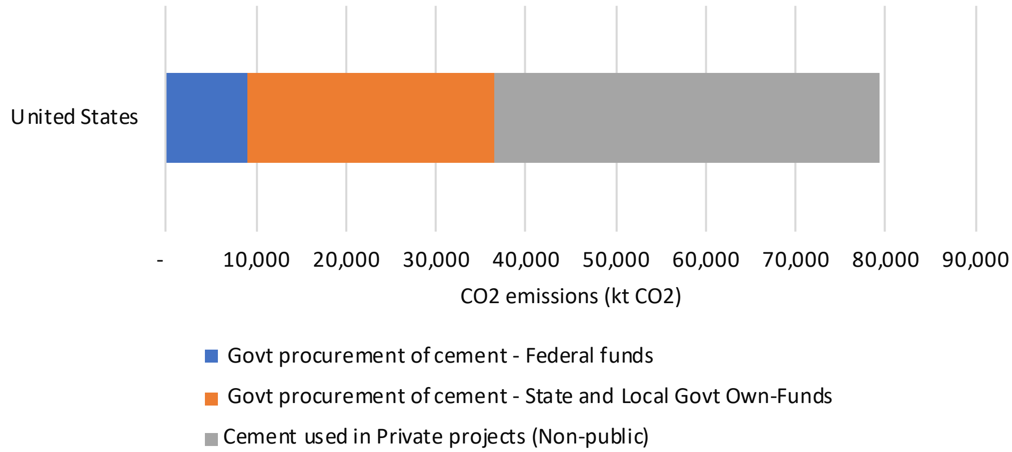


Figure 1. Annual CO_2 emissions associated with cement used in the U.S. in 2018

2.1. Steel used in public construction and associated GHG emissions

The U.S. steel industry produced 87 Mt of crude steel in 2018, of which 33% was produced by primary steelmaking plants using blast furnace-basic oxygen furnace (BF-BOF) and 67% was produced by the electric arc furnace (EAF) production route, which mainly uses steel scrap but can also use direct reduced iron (DRI). The U.S. also imported 32 Mt and exported 8 Mt of steel mill products in 2018. The United States is the 4th largest producer and consumer of steel in the world. The value of products produced by the U.S. iron and steel industry and ferrous foundries in the United States in 2018 was about $137 billion. The BF-BOF plants in the United States that produce pig iron and crude steel are operated by three companies that have integrated steel mills in nine locations. The EAF steel plants are owned by 51 companies producing crude steel at 99 minimills. BF-BOF and EAF steel plants together employed around 81,000 people, and iron and steel foundries employed an additional 64,000 people in the United States in 2018. Indiana accounted for 27% of total crude steel production, followed by Ohio (12%), Michigan (6%), and Pennsylvania (6%) (USGS 2020b).

Total steel consumption in the U.S. was 101 Mt in 2018. Around 43% of the steel used in the U.S. is for construction. The second-largest market segment is transportation, predominantly the automotive sector (USGS 2020b).

Based on the share of steel for construction from the total used in the U.S. (43%) (USGS 2020b) and the share of government spending as a proportion of total construction spending in the U.S. of 41% (US BEA 2020, Hasanbeigi and Khutal 2021), we estimated that around 18% of the total steel used in the U.S. is for public construction. Consequently, around 25% of the total steel used in the U.S. is for private construction. In addition, we estimated that around 27% of total steel procured by the government in the U.S. for construction uses federal funds, and the remaining uses state and local government-own funds (Hasanbeigi and Khutal 2021). It should be noted that the government procures other products that include steel such as vehicles, appliances, etc. These are not included in the estimates, which only focuses on steel used in construction.

Figure 2 shows annual CO_2 emissions associated with steel used in the U.S. in 2018. We used the weighted average CO_2 intensity of steel produced in the U.S. and net imported steel to calculate annual CO_2 emissions associated with steel consumption. Approximately 18% of the annual CO_2 emissions associated with steel used in the U.S. are associated with public construction, or about 21 Mt CO_2 in 2018. Therefore, government procurement has significant leverage in incentivizing decarbonization of the steel production.

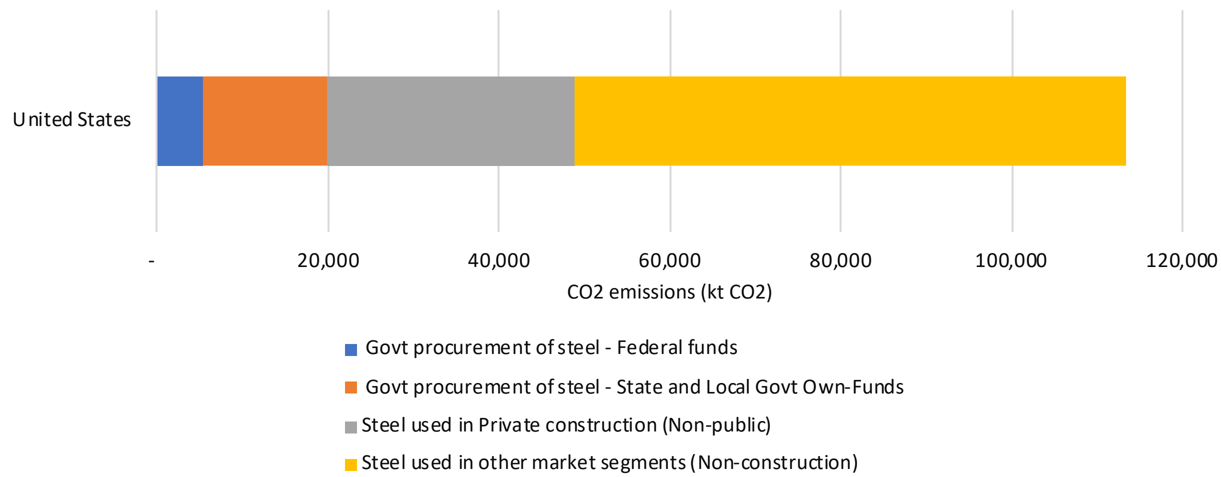


Figure 2. Annual CO_2 emissions associated with steel used in the U.S. in 2018

3. Potential impact of Federal Buy Clean on industrial GHG emissions

In this section, we present the results of our analysis to estimate the potential impact of federal Buy Clean on the GHG emissions associated with cement used in the U.S.

3.1. Potential impact of Federal Buy Clean on cement industry emissions

To estimate the potential impact of Buy Clean on GHG emissions associated with cement use in the U.S., we developed several scenarios with various Buy Clean targets for CO_2 intensity of cement set by a Buy Clean policy (Table 2). It should be noted that the Buy Clean intensity targets shown in the table are industry-level targets and not for a specific cement product. In reality, a Buy Clean policy is more likely to set product-specific intensity targets rather than industry-level targets like in California’s Buy Clean Act (DGS 2021). However, because of the lack of information and also the existence of so many different cement (and concrete) products, it is not possible to do such industry-level impact estimation using product-level targets. Therefore, we used industry-level intensity targets to show the potential impact of Buy Clean cement.

Table 2. Buy Clean target scenarios for the cement industry

Buy Clean Target	% reduction in cement CO_2 intensity from baseline	Cement CO_2 intensity ($kgCO_2$/t cement)*	Potential actions for CO_2 emissions reduction**
Baseline	-	806	This is the weighted average of CO_2 intensity for both domestic and imported portland cement. The assumed clinker to cement ratio for both domestic and imported cement is 0.9.
Starter	5%	766	Can be achieved by small effort in energy efficiency improvement, fuel switching to lower carbon fuels, and a small addition of supplementary cementitious materials (SCMs) instead of clinker
Low	10%	725	Can be achieved by low effort in energy efficiency improvement, fuel switching to lower carbon fuels, and the addition of SCMs instead of clinker
Medium	20%	645	Can be achieved by maximizing energy efficiency improvement, more aggressive fuel switching to lower carbon fuels, and higher use of SCMs instead of clinker
High	30%	564	Can be achieved by maximizing energy efficiency improvement, substantial phase-out of coal and pet coke and switching to lower carbon fuels, and substantially higher use of SCMs instead of clinker. CCS can help to achieve it easily
Transformative	50%	403	Will require CCS to achieve this target. This stimulates innovation and adoption of transformative technologies

* The Buy Clean intensity targets show in this table are industry-level targets and not for a specific product.
** More detailed information on potential actions for CO_2 emissions reduction can be found at (IEA 2018, Bataille 2019, Hasanbeigi and Springer 2019b, Friedmann et al. 2019, Material Economics 2019, McKinsey & Company 2018, Sandalow et al. 2019).

Potential activities for emissions reduction

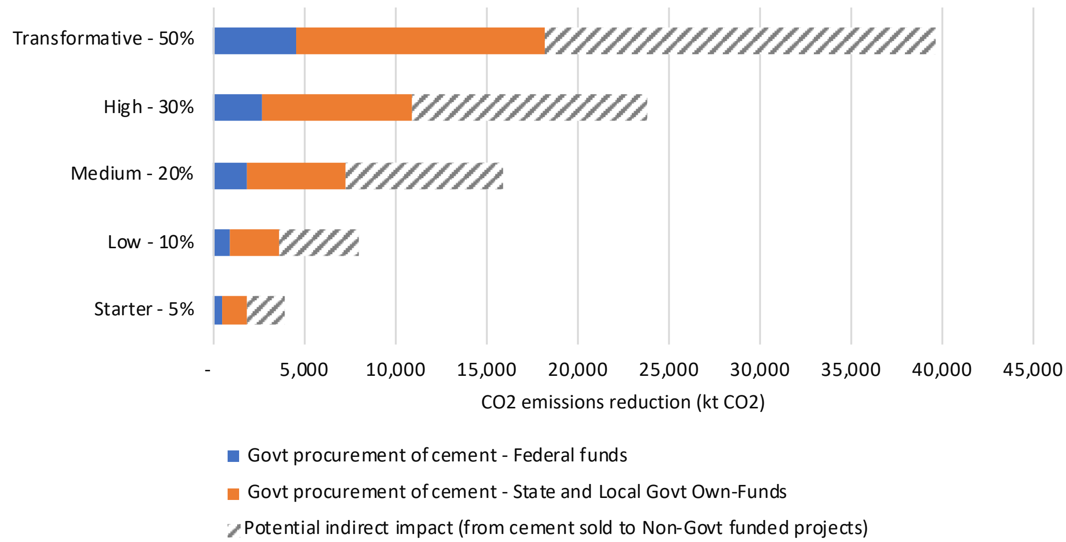
In the U.S. cement industry, process-related CO_2 emissions from calcination accounted for over 50% of total CO_2 emissions (Hasanbeigi and Springer 2019b). As the majority of CO_2 emissions from the U.S. cement industry are not associated with energy use, deep decarbonization cannot be achieved by energy efficiency or fuel switching alone. Clinker substitution and CCUS are imperative to achieve the transformative decarbonization scenario in the cement industry. Material efficiency and circular economy measures can help to reduce the carbon footprint of cement and concrete use on the demand side.

Potential impact of Buy Clean cement

Using the annual CO_2 emissions associated with cement used in the U.S. presented in the previous chapter and the targets set in Table 2, we estimated the annual CO_2 emissions reduction potential resulted from Buy Clean for cement in the U.S. in 2018 (Figure 3).

Potential indirect impact assumes that changes in U.S. cement plants to reduce GHG emissions would impact the CO_2 intensity of all cement produced and sold even to non-government funded projects. The scale of such indirect impact is unknown; therefore, it’s shown by striped bars on the charts.

Under the Low scenario for Buy Clean target for cement, annual emissions reduction of 3.6 Mt CO_2 can be achieved directly from government procurement of cement for construction. This direct annual CO_2 emissions reduction potential would increase to 11 Mt CO_2 and 18 Mt CO_2 under High and Transformative scenarios, respectively. The potential CO_2 emissions reduction impact of Buy Clean for cement would more than double if we consider the potential indirect impact from the cement sold to non-public construction if we assume the changes that cement plants make for CO_2 emissions reduction applies to all cement they produce.



Note: Potential indirect impact assumes that changes in U.S. cement plants to reduce GHG emissions would impact the CO_2 intensity of all cement produced and sold even to non-government funded projects.

Figure 3. Annual CO_2 emissions reduction potential resulted from Buy Clean for cement in the U.S. in 2018

3.2. Potential impact of federal Buy Clean on steel industry emissions

Similarly, to estimate the potential impact of Buy Clean on GHG emission associated with steel used in the U.S., we developed several scenarios with various Buy Clean targets for CO_2 intensity of steel set by a Buy Clean policy (Table 3). The Buy Clean intensity targets shown in Table 3 are industry-level targets and not for a specific steel product.

Potential activities for emissions reduction

The major decarbonization levers that can help to reduce GHG emissions from the steel industry are energy efficiency, fuel switching to low/no-carbon fuels and electrification, CCUS, and adoption of transformative technologies. Globally, the main pathway to electrification of the steel industry is the use of EAF steel production. In the United States, around 70% of the steel is already produced by EAFs and limited opportunity remains for increased use of EAF technology. Innovations such as the use of green hydrogen in DRI production and the electrolysis of iron ore may be needed for the transformative scenario. Material efficiency and circular economy measures can help to reduce the carbon footprint of steel use on the demand side.

Table 3. Buy Clean target scenarios for the steel industry

Buy Clean Target	% reduction in steel CO_2 intensity from baseline	Steel CO_2 intensity ($kgCO_2/t$ crude steel) *	Notes and potential actions for CO_2 emissions reduction **
Baseline	-	1,124	This is the weighted average of CO_2 intensity for both domestic and imported steel which includes both EAF and BF-BOF. Most countries that the U.S. imports steel from are above this threshold.
Starter	5%	1,068	U.S. steel industry currently meets this intensity threshold. All of the countries that the U.S. imports steel from except Canada, Mexico and Spain (only account for 30% of the U.S. import combined) are above this intensity threshold.
Low	10%	1,012	U.S. steel industry currently meets this intensity threshold. All of the countries that the U.S. imports steel from except Mexico and Spain (only account for 12% of the U.S. import combined) are above this intensity threshold
Medium	20%	899	Improvement in energy efficiency and a small amount of fuel switching from coal and coke to natural gas or other lower-carbon fuels will help the U.S. steel industry to meet this intensity threshold. All the countries that the U.S. imports steel from except Spain (only account for 1% of the U.S. import) are above this intensity threshold.
High	30%	787	A larger improvement in energy efficiency and fuel switching from coal and coke to lower carbon fuels will help the U.S. steel industry to meet this threshold. All of the countries that the U.S. imports steel from are above this intensity threshold.
Transformative	50%	562	Maximizing in energy efficiency and a substantial amount of fuel switching from fossil fuel to lower carbon fuels and adoption of CCUS in BF-BOF plants will help the U.S. steel industry to meet this threshold.

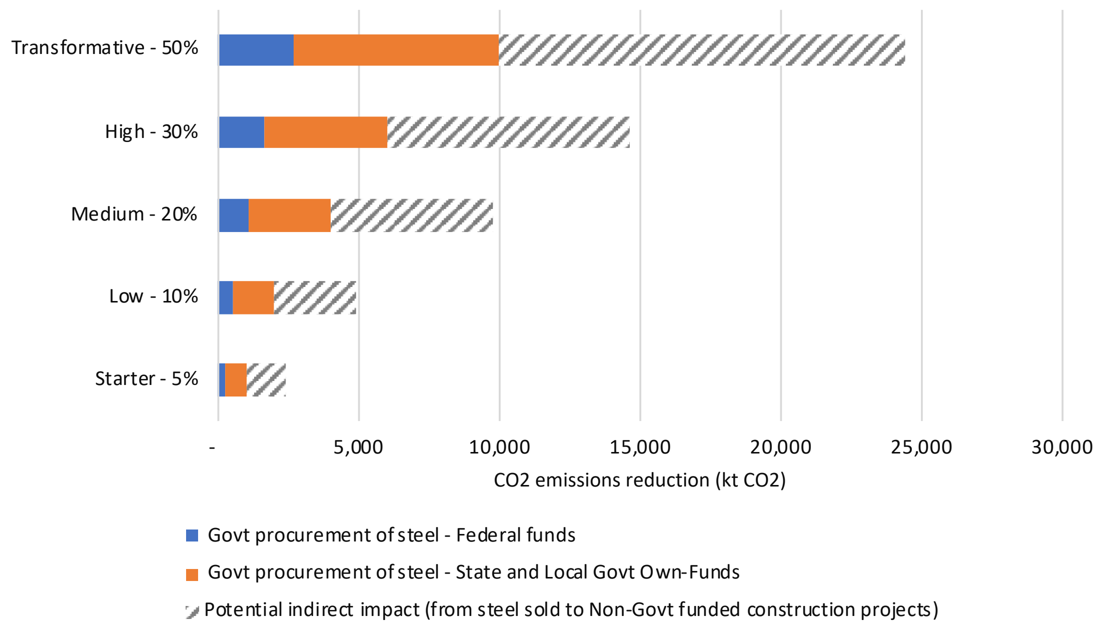
* The Buy Clean intensity targets show in this table are industry-level targets and not for a specific steel product.
** More detailed information on potential actions for CO_2 emissions reduction can be found at (IEA 2020, Bataille 2019, Friedmann et al. 2019, Material Economics 2019, McKinsey & Company 2018, Sandalow et al. 2019, ETC 2018).

Potential impact of Buy Clean steel

Using the annual CO_2 emissions associated with steel used in the U.S. and the targets set in Table 3, we estimated the annual CO_2 emissions reduction potential resulted from Buy Clean for steel in the U.S. in 2018 (Figure 4).

Potential indirect impact assumption for the steel industry is different from that of the cement industry. It assumes that changes in U.S. steel plants to reduce GHG emissions would impact the CO_2 intensity of all steel produced and sold to non-public *construction* projects (not all other steel applications). The scale of such indirect impact is unknown; therefore, it's shown by striped bars on the charts.

Under the Low scenario for Buy Clean target for steel, annual emissions reduction of 2 Mt CO_2 can be achieved directly from government procurement of steel for construction. This direct annual CO_2 emissions reduction potential would increase to 6 Mt CO_2 and 10 Mt CO_2 under High and Transformative scenarios, respectively. The potential CO_2 emissions reduction impact of Buy Clean for steel could increase by over five-fold if we consider the potential indirect impact from the steel sold to non-public *construction* projects if we assume the changes that steel plants make for CO_2 emissions reduction applies to all steel produced for construction market. The impact would be even greater if spillover effects lower the carbon intensity of steel produced for non-construction market segments as well.



Note: Potential indirect impact assumes that changes in U.S. steel plants to reduce GHG emissions would impact the CO_2 intensity of all steel produced and sold to non-public construction projects (not all other steel applications).

Figure 4. Annual CO_2 emissions reduction potential resulted from Buy Clean for steel in the U.S. in 2018

5. Current and proposed Buy Clean policies in the U.S.

In January 2021, President Biden issued Executive Order 14008 to consider additional regulatory steps the federal government can make to promote increased contractor attention on supply chain emissions (White House 2021). In March 2021, the Climate Leadership and Environmental Action for our Nation's (CLEAN) Future Act was introduced to realize this goal.

The CLEAN Future Act is a comprehensive bill from the House Energy and Commerce Committee that proposes both sector-specific and economy-wide policies to achieve net-zero GHG emissions by 2050. In the industrial sector, the bill proposes to reduce embodied emissions in projects involving federal funds by increasing transparency of embodied emissions in construction products, establishing a federal Buy Clean program, and creating a Climate Star program (E&C 2021).

To increase embodied emissions transparency, the CLEAN Future Act charges the Environmental Protection Agency (EPA) with designating a single product category rule for each product made primarily of eligible materials and creating a publicly accessible National Environmental Product Declaration Database for all covered products. The initial list of eligible materials will consist of aluminum, iron, steel, concrete, and cement. The bill also directs the EPA and Department of Energy (DOE) to establish Buy Clean standards for federally funded infrastructure projects to steadily reduce emissions from construction materials and products. It also directs the EPA and DOE to establish a Climate Star Program, a voluntary labeling program to identify and promote products with significantly lower embodied emissions that comparable products (E&C 2021).

5.1 State-level Buy Clean programs

Buy Clean California

In October 2017, California passed Assembly Bill (AB) 262, the Buy Clean California Act, a new law requiring state-funded building projects to consider the global warming potential (GWP) of certain construction materials during procurement. The bill had two components: manufacturers of eligible materials had to submit facility-specific EPDs, and eligible materials had to demonstrate GWP below the product-specific compliance limits defined by the California Department of General Services (DGS), which regulates policy implementation. The eligible materials include structural steel, concrete reinforcing steel, flat glass, and mineral wool insulation. In January 2021, the DGS published maximum acceptable GWP limits for each product category based on the industry average GWP for each material. The maximum acceptable GWP will be reviewed every three years for downward adjustment. Beginning July 1, 2021, awarding authorities will be required to verify GWP compliance for all eligible materials (DGS 2021).

Buy Clean and Buy Fair Washington

Several existing laws and executive orders require Washington state agencies to increase environmentally preferred purchasing. This includes reducing the purchase of products containing persistent toxic chemicals, requiring at least 30% of new vehicles purchased to be clean-fuel vehicles, and green building criteria such as LEED certification on new state-funded facilities (Washington State Department of Ecology 2021).

The Buy Clean and Buy Fair Washington Act (HB 1033) was introduced in Washington state's 2021 legislative session to establish embodied emissions reporting. The bill will require state-funded construction projects larger than 25,000 square feet to submit EPDs for structural concrete, reinforcing steel, structural steel, and engineered wood products. The bill also directs the University of Washington College of Built Environment to create a publicly accessible database of the collected data with projects anonymized. The bill differs from the Buy Clean California Act in that it requires EPDs to be supply chain-specific and includes consideration of working conditions such as average hourly wage and share of employees covered by a collective bargaining agreement. Supply chain-specific EPDs differ from the facility-specific EPDs required by California as they must include all processes that contribute to 80% or more of a product's cradle-to-gate environmental impacts (Washington State Legislature 2021).

Buy Clean Minnesota

In 2019, the Buy Clean Minnesota Act (HF 2203) was introduced to incorporate embodied emissions into public procurement decisions. It proposed to establish a maximum acceptable GWP at the industry average for each category of eligible materials. The eligible materials list consisted of carbon steel rebar, flat glass, mineral wood board insulation, structural steel, cement, structural timber, solar panels, refrigerants, aluminum, gypsum, and concrete (State of Minnesota Legislature 2019).

Buy Clean New York & New Jersey

New York and New Jersey governments are the single largest purchasers of concrete in their respective states (OpenAir 2021). A new piece of legislature called the Low Embodied Carbon Concrete Leadership Act (LECCLA) leverages this buying power to promote low carbon concrete development. LECCLA will require state agencies to factor climate impact into the procurement of concrete. It will increase competition between concrete suppliers by asking suppliers to supply EPDs with their bids for state-funded projects. A discounting rate not exceeding 5% will be applied based on the GWP: a lower GWP will lead to a higher discount rate, making the bid more competitive. An additional discount not exceeding 3% will be applied for bids incorporating carbon capture, utilization, and storage (CCUS) technology (New York State Senate 2020). This policy differs from the Buy Clean programs of other states in that it uses price discounting as a bid incentive without establishing a maximum acceptable GWP limit.

6. Recommendations for Federal Buy Clean for construction materials based on international best practice

6.1. International best practices

Many governments around the world have already recognized the value of green public procurement as a policy instrument and are leveraging public spending to achieve green goals. Hasanbeigi et al. (2019) studied 30 such programs and identified the GPP program in The Netherlands as one of the world's best examples, especially related to GHG emissions reduction from construction materials including steel and cement. Other GPP best practices are found in South Korea and the European Union. A brief explanation of GPP in these countries are presented below:

A. **Netherlands**: The Netherlands' most significant success in GPP is a result of its robust planning tools and approach, nationally enforced policy, specific guidelines for GPP set by The Directorate-General for Public Works and Water Management (Dutch: Rijkswaterstaat), publicly available data for monitoring, government bodies specifically designed to enforce and evaluate policies, and annual reevaluation of goals. The program uses a software called DuboCalc to calculate life cycle environmental impacts for proposed designs and generate an environmental cost indicator (ECI). The tool is publicly available and can be used by governmental and non-governmental entities. This type of whole-project assessment allows for cross-industry comparison as the onus is on the bidder to consider trade-offs between cost, embodied emissions, and durability of materials. Bids must meet a maximum allowable ECI and additional reductions in emissions are monetized as a discount applied to the quoted price. The Netherlands also has a voluntary CO_2 Performance Ladder scheme that certifies companies and projects on a level scale of 1 to 5. Proposals with higher CO_2 Performance Ladder levels have further discounts applied. The specifications for the levels increase over time, encouraging the companies at the highest levels to continue to innovate. PIANOo, the Dutch public procurement expertise center, exists to support procurers in adopting these new practices and accelerate the uptake of GPP standards.

B. **South Korea**: South Korea is a global leader in the use of digitized procurement systems for GPP implementation and monitoring. The Korean Online E-Procurement System (KONEPS) manages the entire procurement process including registration, tendering, contracting, payments, and monitoring. It is linked to the Green Product Information Platform which aggregates green procurement data from different agencies for reporting to the central monitoring body, the Korea Environmental Industry and Technology Institute (KEITI). Through these systems, all purchases are automatically monitored by KEITI without the need for institutions to report them manually. KEITI uses the aggregated data to compute the total reduction of GHG emissions from green procurement using LCA data. South Korea is also one of the only countries that offers a fiscal incentive for GPP implementation. Local governments with high performance in GPP adoption are reward with a larger budget and public institutions receive a performance bonus (UNEP 2019).

C. **European Union:** The European Commission established a common set of GPP criteria that is especially relevant to the United States given the federalist system. The voluntary criteria is split into two levels: a set of core criteria designed for easy application of GPP and a set of comprehensive criteria that encompasses more ambitious requirements. The criteria encourages use of LCA and EPDs while providing guidelines for evaluation when these tools are absent.

6.2. Adoptable best practices for U.S. federal Buy Clean

Below we list some of the key aspects of international best practices of Buy Clean that can be adopted in the U.S. for successful design and implementation of Federal Buy Clean.

- Criteria designed at the national level and implemented at the national, state, and local levels. The process of developing feasible yet ambitious Buy Clean standards requires consultation with technical experts, industry stakeholders, and consideration of complex environmental and social factors. The federal government has the resources to take on this task and produce a set of standards that can be reused by each state. This is similar to the EU model where the European Commission creates a shared set of GPP criteria that all EU countries can use.
- Establish standardized reporting and evaluation. Standardized reporting could entail mandatory life cycle analysis for entire project bids and/or use of environmental product declaration (EPD) for materials and products. Eco-labeling schemes could be expanded

beyond the energy sector. The standards for bid evaluation should be flexible to be used across different materials and account for the heterogeneity of products within an industry. Whole-project environmental analysis can enable cross-industry comparison and ensure that substitute materials are not given unfair advantages.

- Create digital tools to support GPP implementation. As seen in South Korea, digital systems can streamline the procurement process and increase accuracy of monitoring efforts. Digital tools like the Dutch DuboCalc software can also simplify bid evaluation by computing bids' environmental impact programmatically. The database of EPDs and all tools can be made public to enable adoption in the private sector.
- Establish programs and funds to help companies, especially small and medium-sized enterprises (SMEs), adopt these new practices. LCA can be an expensive and complex process, especially for capital-constrained SMEs that lack expertise in conducting environmental assessments. The U.S. could establish loans and grants to help SMEs offset upfront costs for contracting EPD professionals, retrofitting industrial facilities, and retraining workforces. An office could be established to provide information on sustainable procurement and help suppliers adopt new guidelines, similar to PIANOo in the Netherlands.
- Policy elements that promote innovation. Procurement programs that only set a minimum environmental standard may reinforce current best practices and eliminate negligent actors from the competition. However, it does not necessarily lead to innovation. A two-tiered system like the one used in the Netherlands may remedy this concern: a minimum standard is required for bidders to be considered while further improvements are rewarded through a discount applied to the project price, giving these projects a competitive advantage.
- Increase standards over time to account for technological improvements and encourage continued emissions reduction. As new technology and efficient manufacturing processes become more widespread, GPP standards should be raised to account for this. A model of this is the CO_2 Performance Ladder program in the Netherlands which raises its standards over time, encouraging the entire industry to continue to innovate.

7. Conclusions

In this paper, we quantified the scale and emissions impact of federal, state, and local government procurement of steel and cement in the United States. Total steel consumption in the U.S. was 101 Mt in 2018. 18%, or about 18 Mt, went towards public construction. This produced an estimated 21 Mt CO_2 emissions. Total cement consumption in the U.S. was 98.5 Mt in 2018. 46%, or about 45 Mt, went towards public construction. An estimated 36 Mt CO_2 emissions were produced by publicly-funded cement consumption.

We also quantified the annual CO_2 emissions reduction potential for five target scenarios. Under a Low scenario of 10% reduction in steel CO_2 intensity, Buy Clean can achieve an annual emissions reduction of 2 Mt CO_2 from direct public procurement of steel for construction. This emissions reduction potential would increase to 6 Mt CO_2 and 10 Mt CO_2 under the High and Transformative scenarios, respectively. The potential CO_2 emissions reduction impact would increase more than five-fold if we consider the potential indirect impact on steel sold to non-public construction, and even greater if we include the spillover effects into non-construction market segments.

Under a Low scenario of 10% reduction in cement CO_2 intensity, Buy Clean can achieve an annual emissions reduction of 3.6 Mt CO_2 from direct public procurement of cement for construction. This emissions reduction potential would increase to 11 Mt CO_2 and 18 Mt CO_2 under the High and Transformative scenarios, respectively. The potential CO_2 emissions reduction impact would more than double if we consider the potential indirect impact on cement sold to non-public construction, assuming the changes that cement plants make for CO_2 emissions reduction applies to all cement they produce.

Recent developments in federal and state Buy Clean legislature are promising. The federal CLEAN Future Act proposed in March 2021 would increase transparency of embodied emissions and establish Buy Clean standards to reduce emissions from construction materials used in projects that receive federal funding. At the state level, California remains the only state with a Buy Clean bill passed in 2017. Washington, Minnesota, Oregon, Colorado, New York, and New Jersey all have similar Buy Clean bills proposed in legislature.

From international best practices, we make the following recommendations for :

- Criteria designed at the national level and implemented at the national, state, and local levels.
- Establish standardized reporting and evaluation including the use of EPDs.
- Create digital tools to support Buy Clean implementation.
- Establish programs and funds to help businesses adopt these new practices.
- Include policy elements that promote innovation such as price discounting for bids that go above and beyond the minimum requirements.
- Increase standards over time to account for technological improvements and encourage continued emissions reduction.

Federal Buy Clean can lead to significant carbon emissions reductions in the production of construction products such as steel, cement, and concrete. It can help drive markets towards greater sustainability, induce innovation, and lead to positive spillover effects in the non-construction and private sectors.

References

Bataille, Chris. 2019. “Low and Zero Emissions in the Steel and Cement Industries: Barriers, Technologies, and Policies.” OECD Green Growth and Sustainable Development Forum.

Campbell, S., & Tawil, N. (2019). Federal Investment, 1962 to 2018. Congressional Budget Office.

E&C (Committee on Energy and Commerce). 2021. Climate Leadership and Environmental Action for our Nation’s Future Act. https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/CFA%20Bill%20Text%202021.pdf

DGS (California Department of General Services). 2021. Buy Clean California Act. Available at https://www.dgs.ca.gov/PD/Resources/Page-Content/Procurement-Division-Resources-List-Folder/Buy-Clean-California-Act

ETC (Energy Transitions Commission). 2018. "Mission Possible: Achieving Net-Zero Carbon Emissions From Harder-to-Abate Sectors by Mid-Century"

Friedmann, J., Fan, Z., and Tang, K. 2019. "Low-Carbon Heat Solutions for Heavy Industry: Sources, Options, and Costs Today." Columbia University Center on Global Energy Policy.

Hasanbeigi, A. and Khutal, H. 2021. Scale of Government Procurement of Carbon-Intensive Materials in the United States. Global Efficiency Intelligence, LLC.

Hasanbeigi, A. and Springer, C. 2019a. How Clean is the U.S. Steel Industry? An International Benchmarking of Energy and CO2 Intensities. Global Efficiency Intelligence, LLC.

Hasanbeigi, A. and Springer, C. 2019b. Deep decarbonization roadmap for California's Cement Industry. Global Efficiency Intelligence, LLC.

Hasanbeigi, A., Becque, R., & Springer, C. 2019. Curbing Carbon from Consumption: The Role of Green Public Procurement. Global Efficiency Intelligence, LLC.

IEA (International Energy Agency). 2020. Iron and steel technology roadmap.

IEA (International Energy Agency). 2018. "Technology Roadmap: Low-Carbon Transition in the Cement Industry."

Material Economics, 2019. Industrial Transformation 2050 – Pathways to Net-Zero Emissions from EU Heavy Industry

McKinsey & Company. 2018. "Decarbonization of Industrial Sectors: The Next Frontier."

New York State Senate. 2020. Senate Bill S8965: The New York State Low Embodied Carbon Concrete Leadership Act. https://www.nysenate.gov/legislation/bills/2019/s8965

OpenAir 2021. The New York and New Jersey Low Embodied Carbon Concrete Leadership Act. https://openaircollective.cc/leccla

PCA (Portland Cement Association). 2016. U.S. cement industry annual yearbook 2016.

Sandalow, D., Friedmann, J., Aines, R., McCormick, C., McCoy, S., and Stolaroff J. 2019. "Industrial Heat Decarbonization Roadmap." Innovation for Cool Earth Forum.

State of Minnesota Legislature 2019. Buy Clean Minnesota Act. https://trackbill.com/bill/minnesota-house-file-2203-buy-clean-minnesota-act-created/1719218/

UNEP (UN Environment Programme). 2019. Green Public Procurement in the Republic of Korea: A Decade of Progress and Lessons Learned. https://www.oneplanetnetwork.org/resource/green-public-procurement-republic-korea-decade-progress-and-lessons-learned-0

U.S. BEA. 2020. Data Files - Use Tables - 2012: 405 Industries. Retrieved from Input-Output Accounts Data: https://www.bea.gov/industry/input-output-accounts-data

USGS. 2020. Mineral Commodity Summaries - Cement.

USGS. 2020b. Mineral Commodity Summaries - Steel.

Washington State Department of Ecology 2021. Environmentally preferable purchasing laws, rules & directives. https://ecology.wa.gov/Waste-Toxics/Reducing-recycling-waste/Environmentally-preferable-purchasing

Washington State Legislature 2021. Buy clean and buy fair Washington act. http://lawfilesext.leg.wa.gov/biennium/2021-22/Pdf/Bills/House%20Bills/1103.pdf?q=20210328090744

White House 2021. Executive Order on Tackling the Climate Crisis at Home and Abroad. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/