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Advancing Buy Clean Policy in Canada

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Executive Summary

Canada spends billions of dollars each year on public procurement: the purchase of goods and services by public authorities such as government departments. In 2020, Canada spent approximately CA$ 278 billion on public procurement (by all levels of government). This large-scale purchasing power gives governments leverage in driving markets towards the development of low-carbon goods and services.

Green public procurement (GPP) is a policy instrument where public entities seek to procure goods with a reduced environmental impact throughout their lifecycle relative to similar goods that provide the same function. GPP adoption is increasing around the world as national governments, sub-national governments, and multilateral entities develop policies to reduce their carbon footprints and create new low-carbon markets. Whereas GPP covers a wide array of environmental impacts and goods, a Buy Clean policy specifically focuses on reducing the greenhouse gas (GHG) emissions associated with materials procured by the government. The initial focus is primarily on carbon-intensive construction materials such as cement and concrete, steel, aluminum, glass, etc.

In Canada, some elements of a Buy Clean policy are already in place. The federal Greening Government Strategy announced in 2017 established a goal of net-zero emissions by 2050, including the procurement of goods and services. The government aims to reduce embodied carbon by 30% starting in 2025 through the use of recycled and lower-carbon materials, material efficiency, and performance-based design standards, and conduct a whole building life-cycle analysis by 2025 for major projects. In service of this, the government is building a repository of reliable emissions data through the Low Carbon Assets through Life Cycle Assessment (LCA^2) initiative.

This report focuses on three energy- and carbon-intensive industries/products: cement, steel, and aluminum. Together, the three sectors account for around 20% of global CO_2 emissions. They are also covered by the United States proposed Buy Clean strategy, which is highly relevant due to the large volume of trade of these materials across the Canada-US border. In 2019, total cement, steel, and aluminum consumption in Canada were 9.5 million tonnes (Mt), 14.4 Mt, and 0.6 Mt, respectively. It should be noted that in the majority of cases, the government or its contractors do not purchase cement and instead purchase concrete (mainly ready-mix concrete) which is the final product used in construction projects. The values shown in this report include the cement used in concrete that is then used in construction projects.

We estimated the CO_2 emissions associated with cement, steel, and aluminum used in public construction projects and the potential impact of the Buy Clean policy to reduce those emissions. Public procurement of cement, steel, and aluminum in Canada accounted for approximately 2.3 Mt CO_2, 5.5 Mt CO_2, and 0.1 Mt CO_2 emissions in 2019, respectively. Figure ES1 shows the annual CO_2 emissions reduction potential resulting from Buy Clean for cement, steel, and aluminum in Canada in 2019. We also developed similar estimates for selected provinces in Canada (see chapter 3).

While Buy Clean has political support in Canada, the pace of implementation could be improved. Some of the challenges include consistent emissions reporting, establishing feasible quantitative limits on embodied carbon, highly decentralized procurement, lack of expertise and bandwidth, and a highly integrated North American market.

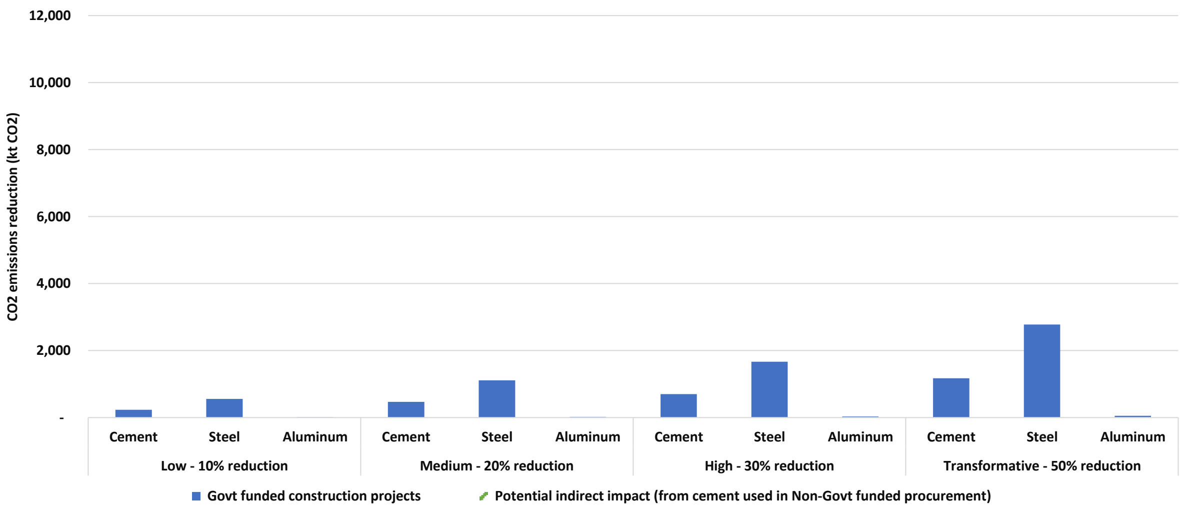

Figure ES1. Annual CO_2 emissions reduction potential resulted from Buy Clean for cement, steel, and aluminum in Canada in 2019

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

Applying learnings from international best practices, we make the following recommendations for a federal Buy Clean policy:

- Accelerate the creation of the life cycle emissions inventory. This is a crucial step to enable reliable reporting of emissions data and the use of environmental impact in bid evaluation. The government should identify complications that are slowing down the LCA[2] initiative and work to alleviate these issues.
- The federal government should examine international best practices and evaluate different models to promote or ensure uptake of Buy Clean at the sub-national level, including leveraging infrastructure transfer agreements; creating a mandatory federal backstop program similar to carbon pricing; developing robust federal programming; and encouraging provinces and municipalities to adopt Buy Clean through funds or incentives aimed to top-up spending on infrastructure investments that use low-carbon materials.
- Federal Buy Clean policy should move quickly to prevent fragmented Buy Clean policies across provinces and municipalities. It is easier to build a harmonized framework now than in a few years when more sub-national governments will have their own Buy Clean policies.
- Targets should use a two-tiered approach to promote innovation while maintaining feasibility. Targets should be performance-based, preferring whole-project over product-level analysis where possible. Standards should be adjusted at a regular interval to reflect changes in technology to continually incentivize innovation.
- Build a federal team to help national and sub-national agencies implement green procurement. This team should build expertise on embodied carbon, lifecycle analysis, and tender creation; publish online resources, and act as consultants to public agencies. This team could be a part of Natural Resources Canada (NRCan), with the online hub modeled after the Clean Growth Hub initiative shared by Innovation, Science, and Economic Development Canada (ISED) and NRCan.

- Invest in tools and capacity-building programs that can be used by sub-national governments and private entities that have low administrative capacity. Many provinces and cities with smaller bureaucracies do not have the time and resources to invest in training for Buy Clean procurement. This paired with the significant amount of procurement that happens at the sub-national level underscores the importance of the federal program investing in tools that automate and simplify the implementation of the Buy Clean policy.
- Build out a portfolio of policies that support industrial decarbonization. A carbon border adjustment mechanism (CBAM) can protect low-carbon manufacturers from competitors whose prices do not reflect negative environmental externalities. Carbon contracts-for-differences (CCfD) can remove uncertainty over future carbon prices. With Buy Clean creating a demand signal for low-carbon construction materials, loans and grants for manufacturers can close the loop by helping the supply side pay upfront costs for retrofitting and retraining.

Buy Clean can catalyze significant carbon emissions reductions in construction materials by acting as a signal of durable demand. This complements Canada's ongoing investments in industrial upgrading by closing the loop and demonstrating demand for the growing supply of low-carbon materials. Together, these policies can make Canadian manufacturers more globally competitive in the growing market of green construction materials. This is especially important and timely as other jurisdictions, including Canada's largest trade partner (the U.S.) and the European Union, adopt and strengthen their green public procurement policies. Canada should move quickly to maintain its low-carbon advantage to capture the domestic and international markets.

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Introduction

Global momentum for deep decarbonization of heavy industries such as steel, cement, aluminum, chemicals, etc. is growing. This is the next frontier in climate change mitigation, as these heavy industries are energy-intensive and typically rely on fossil fuel inputs, giving rise to significant CO_2 emissions. In addition, the demand for these materials is only expected to increase globally as many countries around the world continue to develop and industrialize. Therefore, there is growing awareness that emissions from heavy industry must be reduced sharply for the world to reach the target of the Paris Agreement: to limit global warming to "well below" 2 ℃. As the 9th largest world economy and the 9th largest GHG emitting country (WRI 2020), Canada can play an important role in achieving this target.

The products that governments procure for large infrastructure projects such as roads, buildings, and railways account for a large percentage of CO_2 emissions. These projects heavily use construction materials such as steel and cement. Energy efficiency and material substitution will play an important role in reducing emissions from these materials, but deep decarbonization will require investment in large-scale fuel switching, electrification, carbon capture, utilization, and storage (CCUS), and other transformative technologies.

For the last decade, public procurement expenditure as a percentage of gross domestic product (GDP) in Organization for Economic Cooperation and Development (OECD) countries has been around 12%. The COVID-19 pandemic led to an increase: procurement increased from 14% of GDP in 2019 to 15% of GDP in 2020 in 22 OECD-EU countries (OECD 2021). In Canada, public procurement amounted to about 27% of total government expenditure and slightly more than 13% of the national GDP in 2020 amounting to approximately CA$ 218 billion (OECD 2021). The total public spending (i.e., total expenditure by federal, provincial, territorial, and municipal governments) on infrastructure projects stood at about CA$ 61 billion, representing a large share (approx. 22%) of total public spending in Canada in 2020 (Infrastructure Canada, 2021).

When governments leverage their large-scale purchasing power by buying goods and services with lower environmental impact, they help drive markets towards sustainability, reduce the emissions footprint of their operations, and create new markets for innovative low-carbon products. Green public procurement is a policy mechanism that can facilitate this change.

The Treasury Board of Canada Secretariat defines green procurement as the process of "procuring goods and services with a reduced environmental impact. Environmental performance is considered along with other priorities such as price, availability, quality, and performance" (Treasury Board of Canada Secretariat 2019). Green public procurement is the process by which public authorities engage in green procurement. This has the effect of reducing the direct environmental impact of the government, while also creating a market signal to guarantee manufacturers of future demand for low-carbon materials. Whereas GPP covers a wide array of environmental impacts, Buy Clean is a policy that specifically focuses on embodied carbon or the greenhouse gas (GHG) emissions associated with the production, transportation, use, and disposal of materials.

This report focuses on three materials in particular: cement, steel, and aluminum. These three sectors combined account for around 20% of global CO_2 emissions (Hasanbeigi 2022, Hasanbeigi et al 2022, Hasanbeigi 2021). They are also covered by the United States proposed Buy Clean strategy, which is highly relevant due to the large volume of trade of these materials across the Canada-US border. The transition to net-zero is challenging for these hard-to-abate sectors. For example, in the case of cement, process-related CO_2 emissions from calcination (the process of thermal decomposition of limestone into quick lime and carbon dioxide in a kiln) account for over 50% of total CO_2 emissions. This means that conventional energy efficiency and fuel switching measures will not be enough to produce net-zero cement.

These three sectors are also relevant to public agencies as the materials (especially cement/concrete and steel) are heavily used in the construction of roads, buildings, and other public infrastructure. By putting limits on the embodied carbon in these materials and granting incentives to projects with low carbon footprints, the government can catalyze the growth of the low-carbon materials economy. Embodied carbon refers to the carbon emissions from the entire lifecycle of a product including extraction, processing, transportation, and end-of-life recycling or disposal.

Currently, Canada has a goal of reducing emissions from government operations by 40% below 2005 levels by 2025 and to net-zero emissions by 2050. The federal government has released a Greening Government Strategy. Part of this strategy is a transition to net-zero procurement: the government will disclose and reduce the embodied carbon in major construction projects and conduct a whole building life-cycle analysis. As of 2022, the implementation of Buy Clean is still in the disclosure and emissions data collection phase. Some sub-national governments also have their policies around green public procurement of construction materials. One highlighted in this report is the Embodied Carbon Strategy of the City of Vancouver which applies to public and private construction.

This report investigates the scale of public procurement of construction materials to evaluate the potential impact of a Buy Clean policy on greenhouse gas (GHG) emissions from cement, steel, and aluminum. We review existing national and sub-national policies related to embodied carbon. We identify common challenges to Buy Clean implementation, as well as challenges unique to Canada. We close by surveying international best practices and making recommendations.

2 Scale of Public Procurement of Construction Materials

The following subsections present the spending on various construction sectors[1] as well as the procurement of construction materials of interest by private and public sectors (i.e., Federal government, Provincial & territorial governments, and Municipal governments) in Canada. Total expenditure on construction sectors and procurement of construction materials is extracted from the Input-Output "use table" for 2018, which was the most recent year for which the data is available (Statistic Canada, 2020a). Total expenditure by the federal and provincial governments is estimated using the gross fixed capital formation (construction)[2] section of the use tables (Statistic Canada, 2020a). The descriptions of the construction sectors analyzed in this report can be found in Table 1 and the descriptions of construction materials of interest can be found in Table 2. It should be noted that later in the report for GHG impact analysis of Buy Clean, we only focus only on three carbon-intensive materials, i.e. cement, steel, and aluminum.

Table 1. Descriptions of construction sectors analyzed in this report (Statistics Canada, 2022b)

Construction sector	Description
Residential buildings	Housing structures
Non-residential buildings	Commercial buildings – Sports facilities, indoor recreational facilities, Airports, and other passenger facilities, communication buildings Institutional buildings – educational buildings, hospitals, nursing homes, old age homes, religious centers, museums, historic sites, libraries, public security facilities
Transportation engineering construction	Highways and road structures, bridges, tunnels, railway lines, runways
Oil and gas engineering construction	Oil and gas pipelines
Electric power engineering construction	Wind and solar power plants, steam production plants, nuclear production plants, hydraulic production plants, power transmission networks, power distribution networks
Communications engineering network	Cables and lines, Optical fiber, transmission support structures

1 Construction services are not included in this analysis.

2 Gross Fixed Capital Formation (GFCF) consists of producers' investment, deducting disposal, in fixed assets during a given period. Fixed assets are defined as economic resources that have some value or usefulness and that are owned by enterprises or individuals (e.g., machinery or building).

Table 2. Description of construction materials of interest (Statistics Canada, 2020a)

Construction materials	Construction materials sub-categories
Cement & concrete	Cement
	Ready-mixed concrete
	Concrete products
Iron and steel products	Iron and steel basic shapes and ferro-alloy products
	Iron and steel pipes and tubes (except castings)
	Cold-rolled iron or steel products
	Fabricated steel frames and other fabricated structural materials
Aluminum products	Bauxite and aluminum oxide
	Unwrought aluminum including alloys
	Basic and semi-finished products of aluminum and alloys
Wood products	Hardwood lumber
	Softwood lumber
	Wood chips
	Other sawmill products and treated wood products
	Veneer and plywood
	Wood trusses and engineered wood members
	Reconstituted wood products
	Wood windows and doors
	Wood containers and pallets
	Prefabricated wood and manufactured (mobile) buildings and components
	Wood products, N.E.C.
Glass and glass products	Glass (including automotive), glass products, and glass containers
	Waste and scrap of glass

Figure 1 presents the total private and public sector (federal, provincial/territorial, and local governments) expenditure on six construction sectors at the national level in 2018. The figure also highlights the difference in the shares of public spending between the construction sectors. The residential building construction is the leading construction sector in terms of total construction expenditure. The largest share of public spending (94% of total expenditure; CA$ 17 billion by provincial, territorial and municipal governments[3] and CA$1.6 billion in direct federal investment) is observed for the transportation engineering construction sector, whereas the most significant portion of federal spending (CA$10.7 billion by provincial, territorial and municipal governments and CA$10.6 billion direct federal investment) went to the construction of non-residential buildings in 2018 (Figure 1).

3 Provincial, territorial, and municipal funding consists of federally transferred funds as well as their own funds.

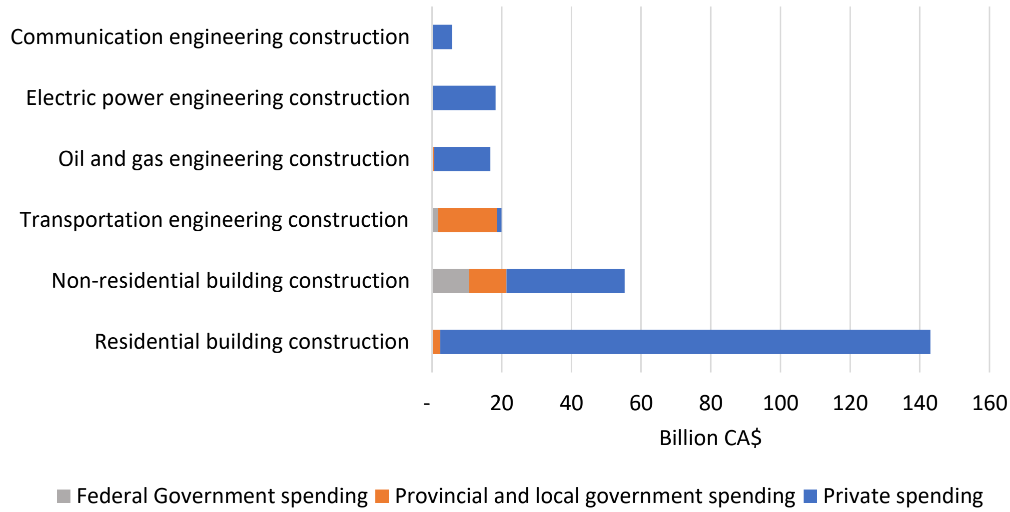

Figure 1. Total infrastructure spending on construction sectors at the national level in 2018 (Statistics Canada, 2020a).

Figure 2 presents the total private and public spending (by all levels of government) on the procurement of construction materials of interest at the national level. The total public spending on the procurement of construction materials of interest in 2018 amounted to CA$ 5 billion. Amongst the construction materials of interest, wood products were the most procured construction material at the national level, according to the 2018 "use table". However, the public procurement of wood products amounted to only 5% (i.e., CA$ 0.8 billion) of total expenditure on wood. The governments at all levels together spent the most on the procurement of cement and concrete (CA$ 2.3 billion), followed by iron and steel (CA$ 1.6 billion), equal to 32% and 29% of total expenditure on cement and steel, respectively.

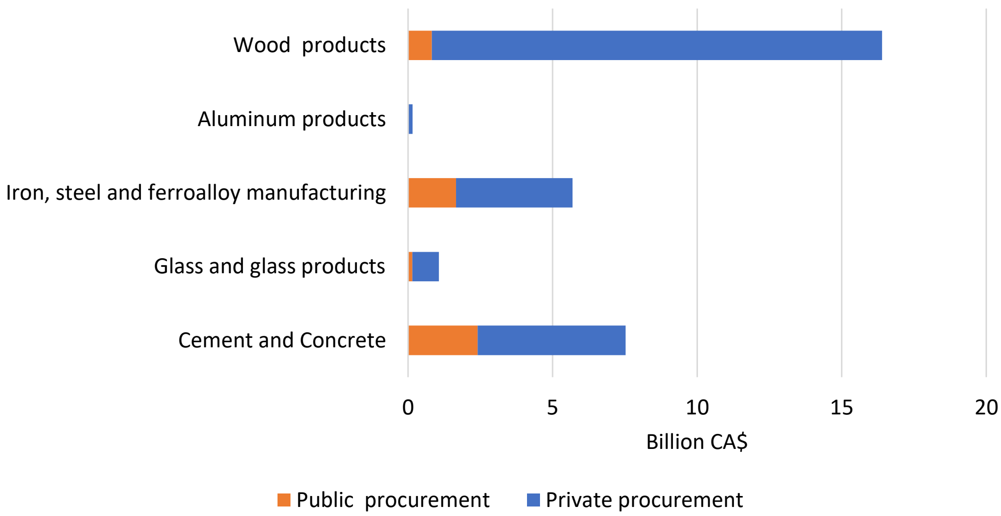

Figure 2. Total private and public construction materials of interest at the national level in 2018 (Estimated based on Statistics Canada, 2020a).

As a result of a relatively clean electricity system and higher share of natural gas in the fuel mix compared with many other countries, some of the construction materials sourced from within Canada such as steel and aluminum typically have a lower carbon intensity as compared to imported materials (Blue Green Canada, 2021). Thus, adopting Buy Clean

Policies could potentially result in the growth in the procurement of domestically sourced construction materials and, consequently, reduction of embodied carbon. On the other hand, some domestically produced construction materials have higher carbon intensity than imported materials. Adoption of decarbonization policies can add the so-called green premium to these products leading to carbon leakage: a situation where a company decides to move their production to a country with a more lenient climate policy, leading to no net change in greenhouse gas emissions. Buy Clean policies can circumvent this by creating a level playing field (Moran et al.,2018).

Table 3 presents the absolute value of total imports and total consumption of the construction materials of interest estimated based on the "supply tables" for the year 2018 (Statistics Canada, 2022). A vast majority of cement and concrete consumed in the Canadian economy is supplied domestically, resulting in cement and concrete being the least imported construction material of interest in terms of the absolute value of imports, amounting to only 6% of total cement and concrete consumed in Canada in 2018 (CA$ 1 billion). Iron and steel, on the other hand, with the total value of imports amounting to 31% of total steel consumption (CA$ 16 billion), is the most imported construction material of interest in 2018 in terms of the absolute value of imports. Wood products are amongst the most consumed construction materials. However, the total value of imports amounts to only 8% of total consumption in 2018. Aluminum and glass products are amongst the least consumed construction materials of interest, with the value of import of aluminum amounting to 38% of total aluminum consumption and the value of imported glass products amounting to 44% of total glass consumption in 2018.

Table 3. Total consumption and total imports of the construction materials of interest in 2018 (Statistic Canada, 2022)

Construction material	Total consumption (billion CA$)	Total imports (billion CA$)
Wood products	49	4
Aluminum	8	3
Iron and steel	50	16
Glass products	8	3
Cement and concrete	13	1

2.1. Scale of Federal Procurement

According to the statistics published by Statistics Canada, the total non-defense public infrastructure spending was CA$62.5 billion in 2018 (CA$ 61 billion in 2020; Statistics Canada, 2022). Total public infrastructure spending consists of expenditures by the federal, provincial, territorial, and municipal governments (see Figure 3). Provincial, territorial, and municipal governments' spending consist of federally transferred funds as well as their funds. Based on the analysis by the Parliamentary Budget Office, the federal government spent about 25% of the funds directly on federally owned assets, whereas the rest, 75% of the total infrastructure budget, constitutes transfers to provincial, territorial, and municipal governments in FY 2018-19 (PBO, 2022). Based on the aforementioned shares, the total infrastructure spending by the federal government in 2018 for Canada can be estimated at CA$10.8 billion, with CA$ 2.7 billion as direct spending and 8.1 billion as transfers to other levels of the government via programs like Investing in Canada Plan (IICP) among others (Figure 3).

IICP is one of the most significant programs with which the Government of Canada delivers funding to the communities. Investment in the infrastructure projects is made through targeted funding streams such as the Public Transit stream, Green Infrastructure stream, Community, Culture and Recreation stream, and Rural and Northern Communities stream. For the infrastructure projects funded through the funding streams mentioned above, the government of Canada shares the investment cost of up to 40% for municipal projects, 50% for provincial projects, 75% for territories and Indigenous partners, and up to 25% for private sector projects.

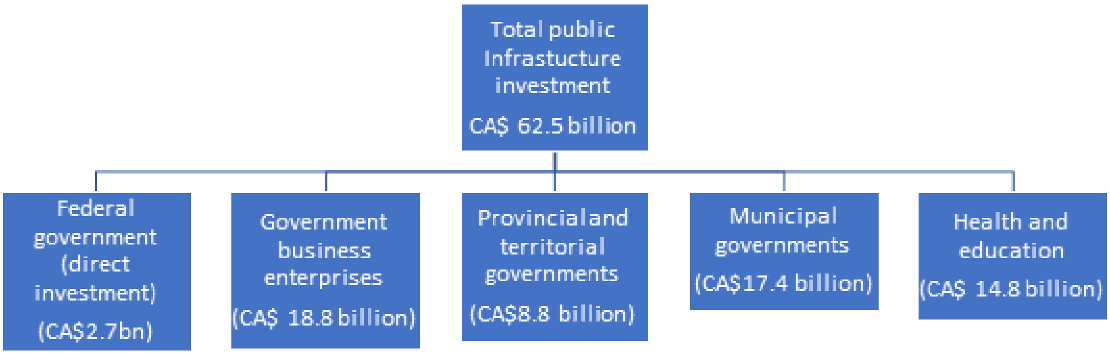

Figure 3. Infrastructure spending in Canada (Statistics Canada, 2022b)[4]

2.2. Scale of Provincial Procurement

The provincial governments receive grants from the federal government through transfer payment programs like Canada Health Transfer (CHT), Canada Social Transfer (CST), Investing In Canada Plan (IICP), Gas Tax Fund (GTF), Provincial-Territorial Base Fund, and Public Transit Fund, amongst other programs. Table 4 presents the transfers received by the provincial and territorial governments from the federal government in the year 2018 through major transfer programs.

The total expenditure on construction projects, along with the share of public spending (i.e., spending by all levels of government) for the construction sectors analyzed in this report for each province, are presented in Figure 4 below. Ontario is the leading province in terms of total amount spent as well as public spending (CA$ 14bn by all levels of government combined) for construction sectors (Table 1) analyzed in this report followed by Quebec (CA$ 9.8 billion by all levels of government), Alberta (CA$ 6.6 billion by all levels of government) and British Columbia (CA$ 5.8 billion by all levels of government). The maximum share of government spending on construction activities can be observed in the Northwest Territories (64%; CA$ 0.2 billion), Nunavut (48%; CA$ 0.17 billion), and Yukon (45%; CA$ 0.17 billion). However, this represents a relatively minor share of total infrastructure spending at the national level.

4 Statistics Canada classifies the Government business enterprises (GBE) as a public spending category. However, it is not classified as government spending jurisdiction in the Input-Output supply and use tables. Since the present analysis is based on the data from use tables, GBEs are not included in the analysis.

Table 4. Total transfers received by provinces and territories for infrastructure development in 2018 (Infrastructure Canada, 2021; Infrastructure Canada, 2022)

Provinces	Sum of Federal Contribution (Infrastructure Canada projects; million CA$)[1]	Gas tax municipal allocations (million CA$)[2]
Alberta	1,816	230
British Columbia	1,277	242
Ontario	1,131	819
Quebec	942	477
Manitoba	503	72
Yukon	140	17
Saskatchewan	140	62
Newfoundland and Labrador	84	23
Northwest Territories	59	17
Nova Scotia	50	58
New Brunswick	35	48
Nunavut	26	16
Prince Edward Island	7	17
Grand Total	6,210	2,095

[1] The column presents the sum of federal contributions to the projects approved under programs such as Smart Cities Challenge, Green Infrastructure Stream, Public Transit Infrastructure Fund, Clean Water and Wastewater Fund, and Provincial-Territorial Infrastructure Component.
[2] Gas tax funds guarantee annual transfer to municipal governments for public infrastructure projects.

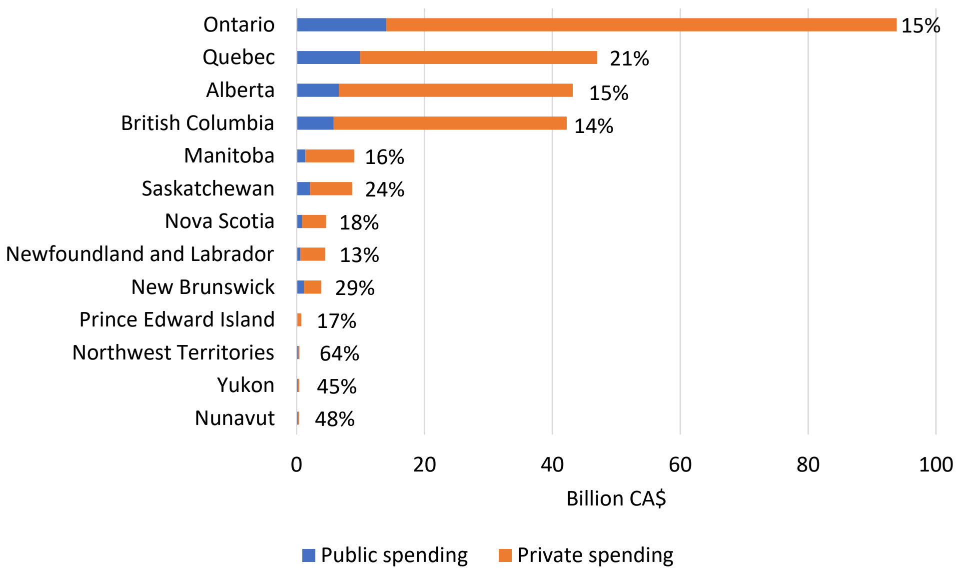

Figure 4. Total public and private sector spending on construction projects by each province in 2018 (percentages represent the share of public spending relative to the total spending by each province; Statistics Canada, 2020a).

The following subsections present the scales of public spending (by all levels of government) on various construction sectors and construction materials of interest for the provinces with the highest spending on construction activities in Canada in 2018.

2.2.1. Ontario

Figure 5 presents the total expenditure on construction projects by the private and public sectors (all levels of government) for various construction sectors analyzed in this report in the province of Ontario in 2018. The residential building construction sector leads in terms of overall total expenditure on construction activities. However, the share of public spending amounted to only 1% of residential building construction expenditure (CA$ 9.9 million in direct federal spending and CA$ 800 million by provincial, territorial and municipal government spending). The transportation construction sector leads in terms of public spending on construction, with the provincial, territorial and municipal governments being responsible for the vast majority of spending (CA$ 739 million in direct federal spending and CA$ 4.8 billion in provincial, territorial and municipal government spending). Oil and gas, electric power, and communications engineering construction sectors represented very small total investment with negligible shares of public spending.

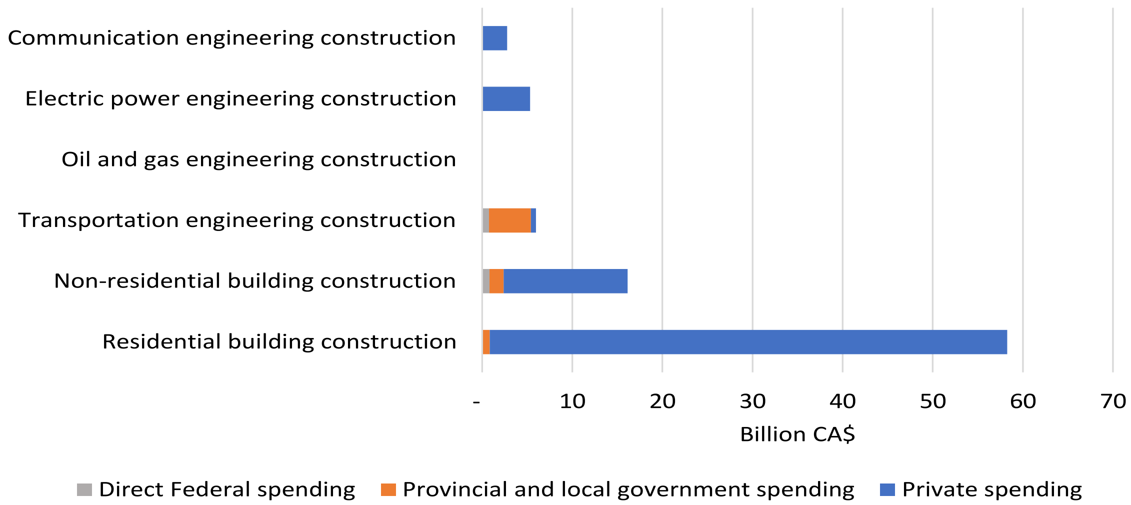

Figure 5. Total public and private sector spending on construction projects for various construction sectors in Ontario in 2018 (Statistics Canada, 2020a).

Total expenditure by the private and public sectors (by all levels of the government) on the procurement of construction materials of interest is presented in Figure 6 for the province of Ontario in 2018. Wood products were the most procured construction material in terms of total expenditure, with public spending representing only 4% of total procurement (CA$ 202 million). Cement and concrete (CA$ 989 million) along with iron and steel (CA$ 516 million) were the most procured construction materials in terms of public spending in Ontario in 2018. Aluminum and glass products were the least procured infrastructure materials of interest.

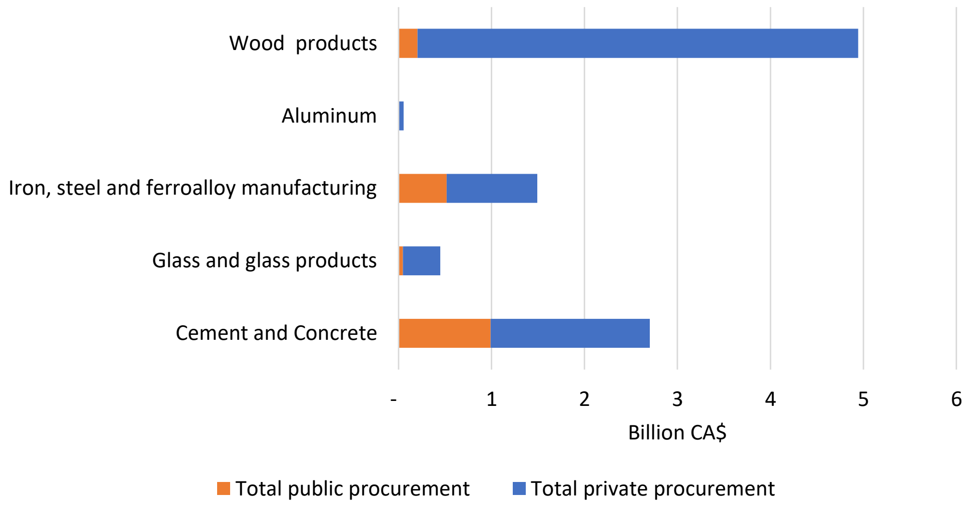

Figure 6. Total public and private sector spending on construction materials of interest in Ontario in 2018 (estimated based on Statistics Canada, 2020a).

2.2.2. Quebec

Figure 7 presents the total expenditure by the private and public sectors (all levels of government) on various construction activities in the province of Quebec in 2018. The residential building sector saw the maximum spending, with public spending being responsible for only 1% of the total (CA$ 8 million in direct federal spending and CA$341 million in provincial, territorial, and municipal spending). Most of the public spending went to the transportation engineering construction sector in Quebec in 2018, amounting to 95% (CA$ 889 million in direct federal spending and CA$ 3.7 billion by the provincial, territorial, and municipal governments) of total expenditure in the year 2018. Relatively smaller amounts of private and public funds were invested in the oil and gas, electric power, and communications engineering construction sectors, with no public funds invested in the oil and gas construction sector.

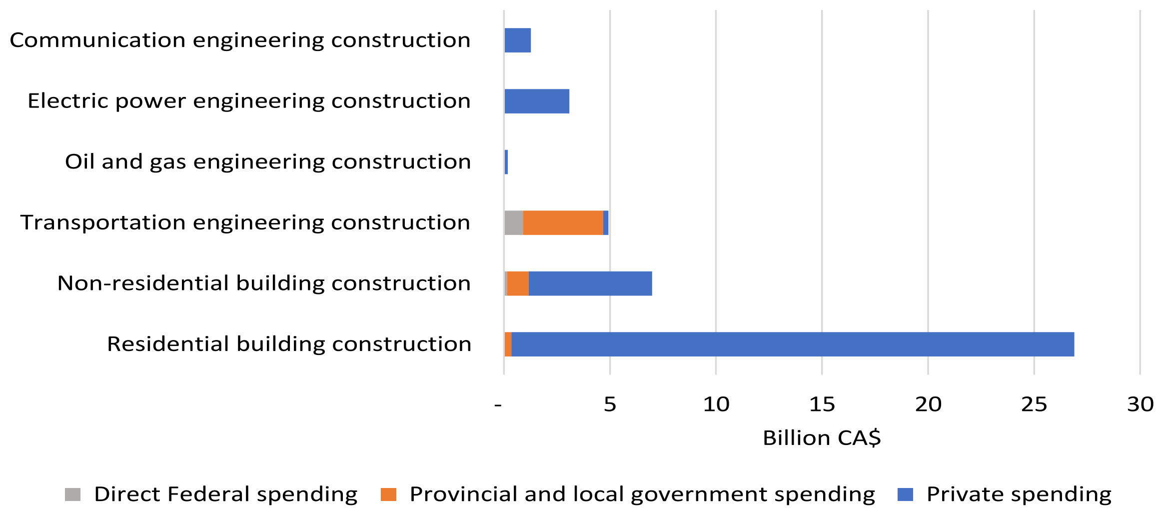

Figure 7. Total public and private sector spending on construction projects for various construction sectors in Quebec in 2018 (Statistics Canada, 2020a).

The total private and public (all levels of government) spending on the procurement of construction materials of interest in Quebec in 2018 is presented in Figure 8. Spending on wood products leads in terms of total expenditure. However, the share of public spending amounted to only 5% (CA$ 166million) of total expenditure for the procurement of wood products in 2018. The majority of public spending went for the procurement of cement and concrete (CA$ 465 million), followed by the procurement of iron and steel (CA$292 million). Glass and Aluminum were the least procured construction materials of interest.

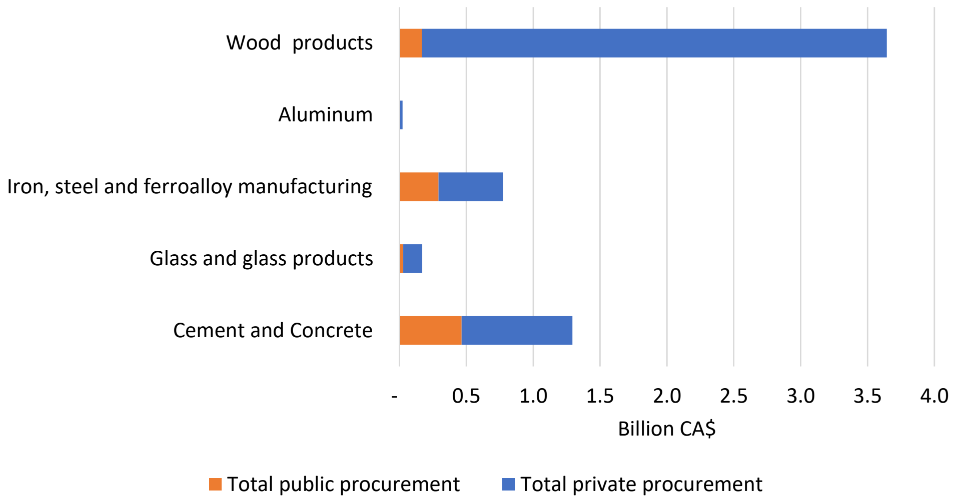

Figure 8. Total public and private sector spending on construction materials of interest in Quebec in 2018 (estimated based on Statistics Canada, 2020a).

2.2.3. British Columbia

The total expenditure by private and public sectors (all levels of government) on various construction activities in British Columbia in 2018 is shown in Figure 9. The residential building construction sector represents by far the largest share in terms of total expenditure on construction activities in the province of British Columbia. However, public spending amounts to only 2% of residential building construction expenditure (CA$ 1.2 million in direct federal spending and CA$ 518 million by the provincial, territorial, and municipal governments) of total expenditure. While the largest share of public spending in British Columbia in 2018 was observed for the transportation construction sector (95% of total expenditure; CA$ 7.4 million in direct federal spending and CA$ 2.1 billion by the provincial, territorial, and municipal governments), no public funds were invested in oil and gas construction projects, and only 1% of the total investment for electric power generation was represented by public spending. Relatively small private and public funds were invested in the communications engineering construction sector.

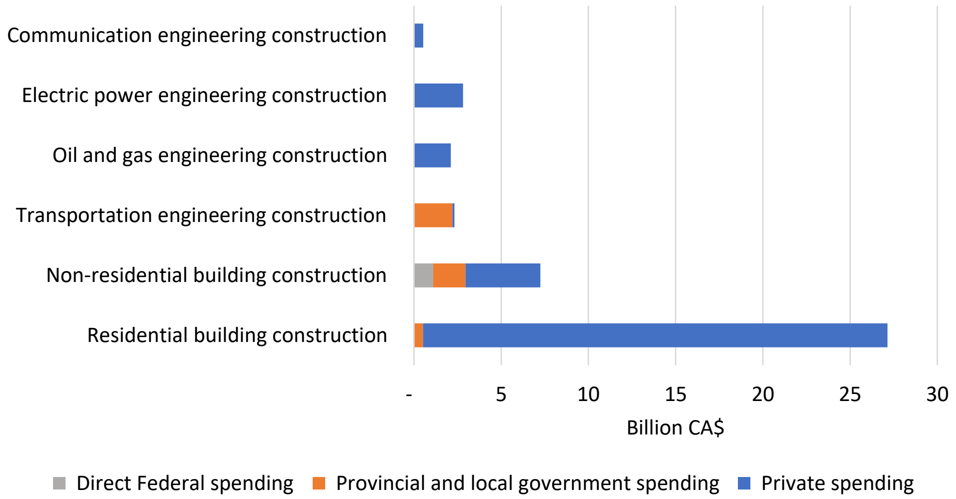

Figure 9. Total public and private sector spending on construction projects for various construction sectors in British Columbia in 2018 (Statistics Canada, 2020a).

Figure 10 shows the total private and public (by all levels of government) spending on the procurement of construction materials of interest in the province of British Columbia in 2018. Wood products were the most procured construction materials in terms of total expenditure, with the share of public spending amounting to 5% (CA$ 171 million) of total expenditure. However, in terms of public spending, cement and concrete (CA$ 301million; 22% of total expenditure) and iron and steel (CA$ 215million; 27% of total expenditure) were the most procured construction materials in British Columbia in 2018. Glass and Aluminum were the least procured construction materials.

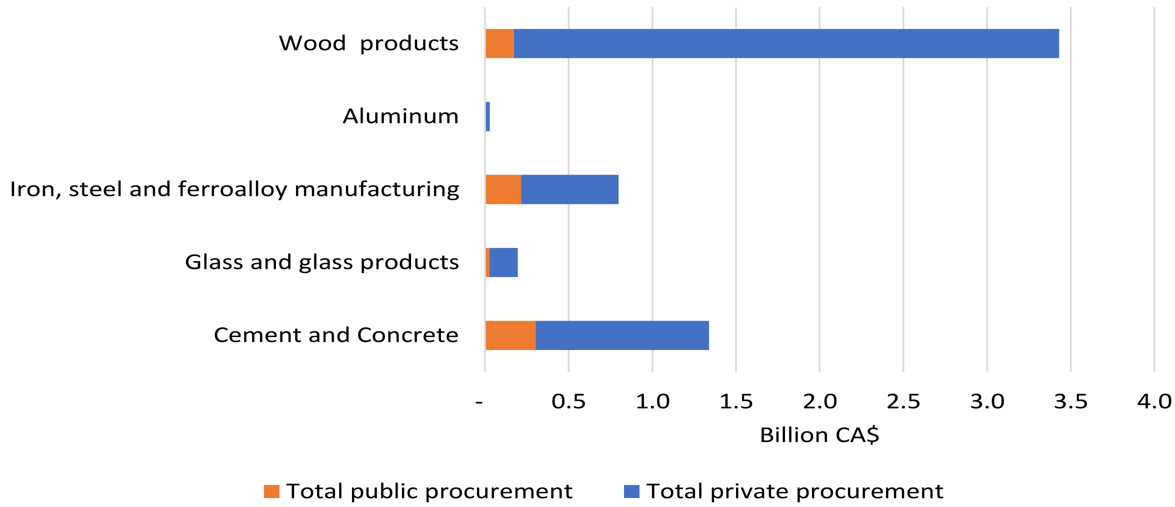

Figure 10. Total public and private sector spending on construction materials of interest in British Columbia in 2018 (estimated based on Statistics Canada, 2020a).

2.2.4. Alberta

The total private and public spending on construction sectors in the province of Alberta in 2018 is shown in Figure 11. A vast majority of funds in Alberta were spent on the construction sectors of residential buildings (CA$ 17 billion) and oil and gas infrastructure (CA$ 11.4 billion). However, the share of public spending amounted to only 1% of residential building construction expenditure (CA$ 1.7 million in direct federal spending and CA$ 239 million by provincial, territorial, and municipal governments) for residential buildings and spending on oil and gas entirely constitutes private sector funds. On the other hand, the infrastructure spending on the transport sector was dominated by public spending amounting to 97% of total expenditure (CA$0.7 million in direct federal spending and CA$3 billion by provincial, territorial, and municipal governments). While public spending in non-residential building construction amounted to 37% (CA$ 32 million in direct federal spending and CA$ 1 billion by provincial, territorial, and municipal governments) of total expenditure, the share of public spending in communication construction and electric power construction sector was 1% and 2% respectively.

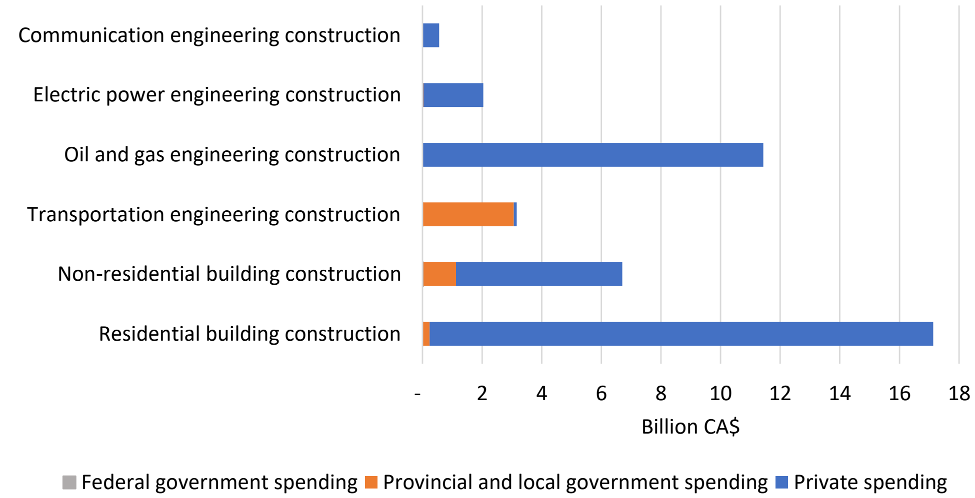

Figure 11. Total public and private sector spending on construction projects for various construction sectors in Alberta in 2018 (Statistics Canada, 2020a).

Figure 12 presents the total private and public (all levels of government) spending on the procurement of construction materials of interest in Alberta in 2018. Wood products were the most procured construction materials in terms of total expenditure, with public spending share on procurement amounting to 6% (CA$ 233 million). However, a large portion of public funds (federal, provincial, territorial and municipal together) was spent on the procurement of iron and steel (CA$ 391 million; 26% of total expenditure), followed by the procurement of cement and concrete (CA$ 324 million; 25% of total expenditure).

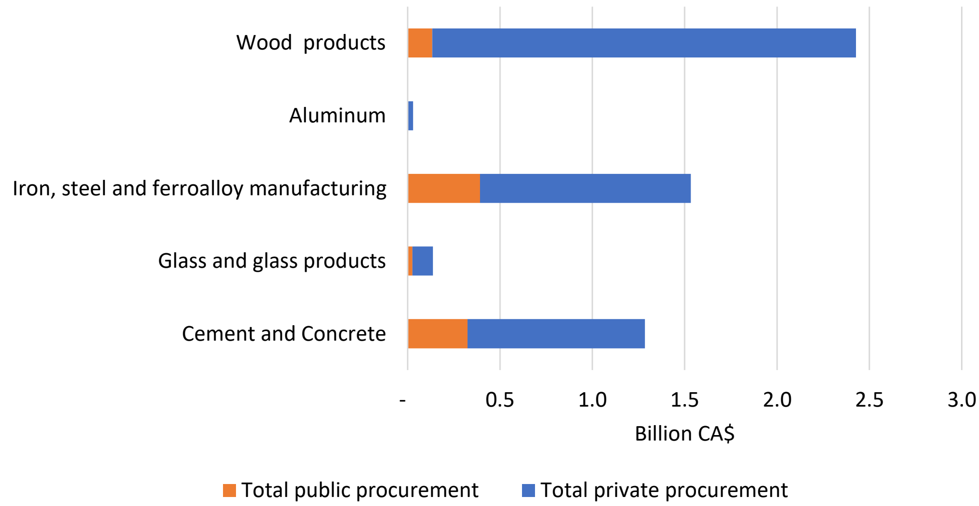

Figure 12. Total public and private sector spending on construction materials of interest in Alberta in 2018 (estimated based on Statistics Canada, 2020a).

2.3. Scale of Public and Private Procurement of Cement and Associated CO_2 Emissions

Canada produced 13.2 million metric tonnes (Mt) of cement in 2019 (USGS 2022a). Total cement consumption in Canada was around 9.5 Mt in 2019 (estimated from USGS 2022a and WITS 2022). From that, around 3 Mt was used in public-funded 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 (mainly ready-mix concrete and pre-cast 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 13 shows the total cement consumption in both public and private construction in selected provinces in Canada in 2019. Ontario has the highest cement consumption in Canada.

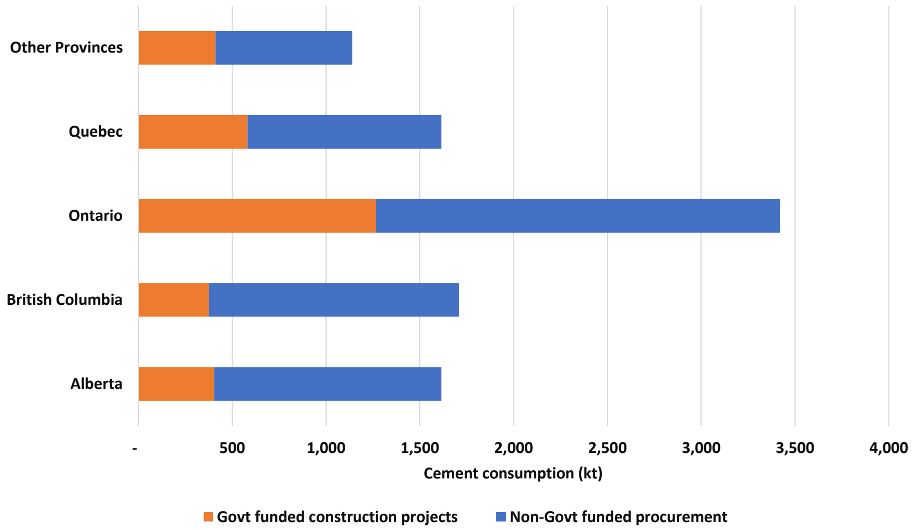

Figure 13. Total cement consumption in both public and private construction in selected provinces in Canada in 2019 (estimated based on Statistics Canada, 2020a).

Figure 14 shows annual CO_2 emissions associated with cement used in selected provinces in 2019. Since around 95% of the cement used in Canada is produced domestically, we used the CO_2 intensity of cement produced in Canada (771 kgCO_2/t cement (GoC 2019)[5]) to estimate annual CO_2 emissions associated with cement consumption. Around one-third of the annual CO_2 emissions linked with cement consumption in Canada are associated with public construction which was around 2.3 Mt CO_2 in 2019. Therefore, government procurement has significant leverage in incentivizing the decarbonization of cement production.

5 The source, Output Based Pricing Standards regulation in Canada, provides a benchmark of 95% of the national average equal to 733 kg CO_2/t cement which is 95% of 771 kg CO_2/t cement.

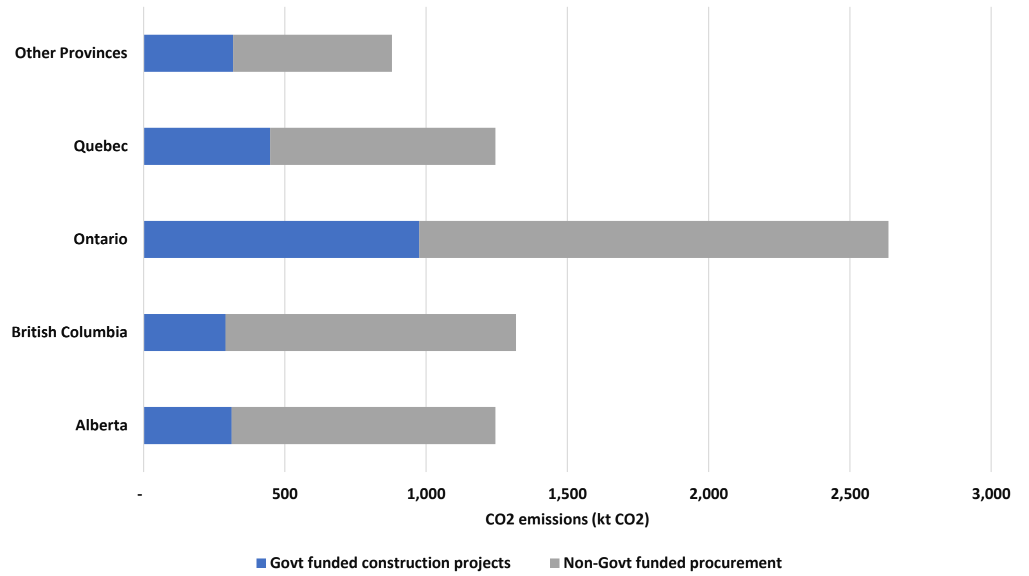

Figure 14. Annual CO_2 emissions associated with cement used in selected provinces in 2019.

2.4. Scale of Public and Private Procurement of Steel and Associated CO_2 Emissions

Canada produced 12.9 Mt of steel in 2019 and total steel consumption in Canada was around 14.4 Mt in that year (Worldsteel Association 2022). From that, around 4.2 Mt was used in Government-funded projects in Canada. Figure 15 shows the total steel procurement by both public and private sectors in selected provinces in Canada in 2019. Alberta and Ontario have the highest steel consumption in Canada. It should be noted that the government also procures other products that contain steel (e.g. vehicles, equipment, etc.). The values on the graphs for "Government-funded construction projects" only contain the steel procured for public construction. The "Non-Government-funded procurement" refers to the rest of the steel consumed in Canada other than those for public construction.

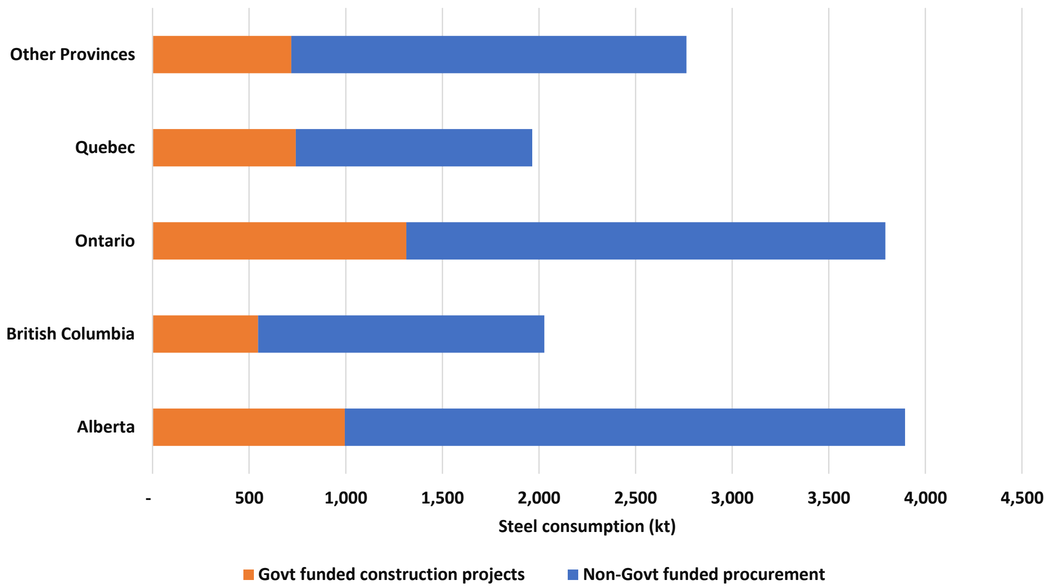

Figure 15. Public and private procurement of steel in selected provinces in Canada in 2019 (estimated based on Statistics Canada, 2020a).

Figure 16 shows annual CO_2 emissions associated with steel used in selected provinces in 2019. Because of the substantial import of steel in Canada, we used the weighted average CO_2 intensity of steel produced in Canada (1,155 kg CO_2/t steel) (both primary steel and electric arc furnace (EAF) steelmaking) and imported steel to calculate annual CO_2 emissions associated with steel consumption in Canada. Approximately, 29% of the annual CO_2 emissions linked with steel consumption are associated with Government-funded projects which were around 5.5 Mt CO_2 in 2019. Therefore, government procurement can be a strong driver of demand for low-carbon steel.

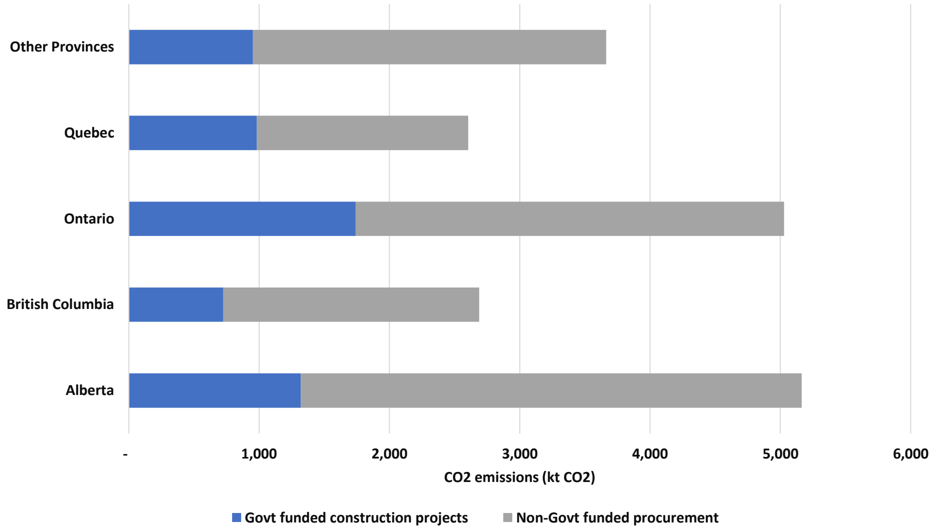

Figure 16. Annual CO_2 emissions associated with steel used in selected provinces in 2019.

2.5. Scale of Public and Private Procurement of Aluminum and Associated CO_2 Emissions

Canada produced 2.85 Mt of aluminum in 2019 (USGS 2022b). Total aluminum consumption in Canada was around 0.5 Mt in 2019 (estimated from USGS 2020b and Statistics Canada 2022c). From that, around 0.04 Mt was used in Government-funded projects in Canada. Figure 17 shows the total aluminum consumption by both public and private sectors in selected provinces in Canada in 2019. Ontario has the highest aluminum consumption in Canada.

It should be noted that the government also procures other products that contain aluminum (e.g. appliances, etc.). The values on the graphs for "Government-funded construction projects" only contain the aluminum procured for public construction. The "Non-Government-funded procurement" refers to the rest of the aluminum consumed in Canada other than those for public construction.

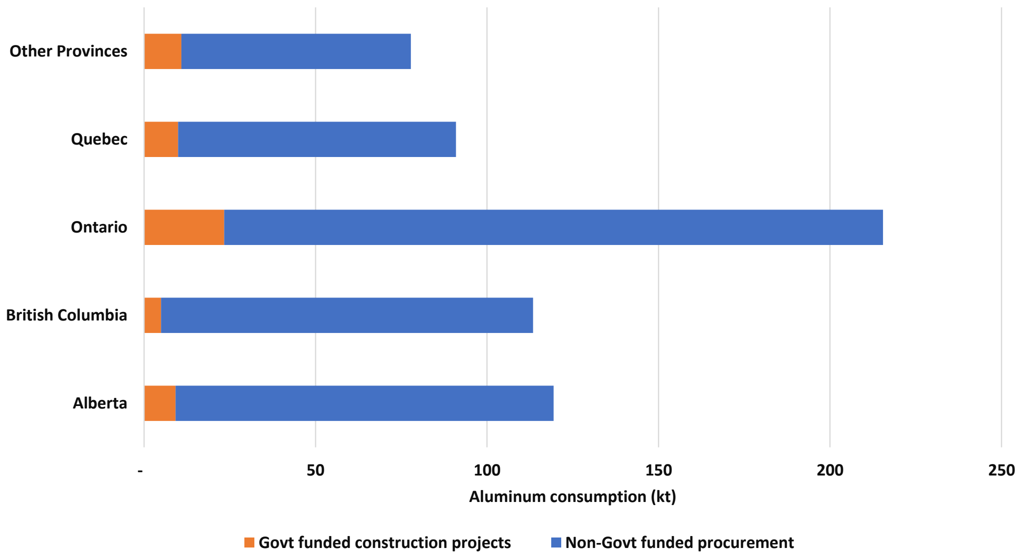

Figure 17. Public and private procurement of aluminum in selected provinces in Canada in 2019 (estimated based on Statistics Canada, 2020a).

Figure 18 shows annual CO_2 emissions associated with aluminum used in selected provinces in 2019. Because of the substantial import of aluminum in Canada, we used the weighted average CO_2 intensity of aluminum produced in Canada (1,211 kg CO_2/t aluminum) (includes both primary and secondary aluminum) and imported aluminum to calculate annual CO_2 emissions associated with aluminum consumption in Canada. Around 9% of the annual CO_2 emissions linked with aluminum consumption are associated with Government-funded projects which were around 0.1 Mt CO_2 in 2019. Relative to cement and steel, government procurement has smaller leverage in incentivizing demand for low-carbon aluminum.

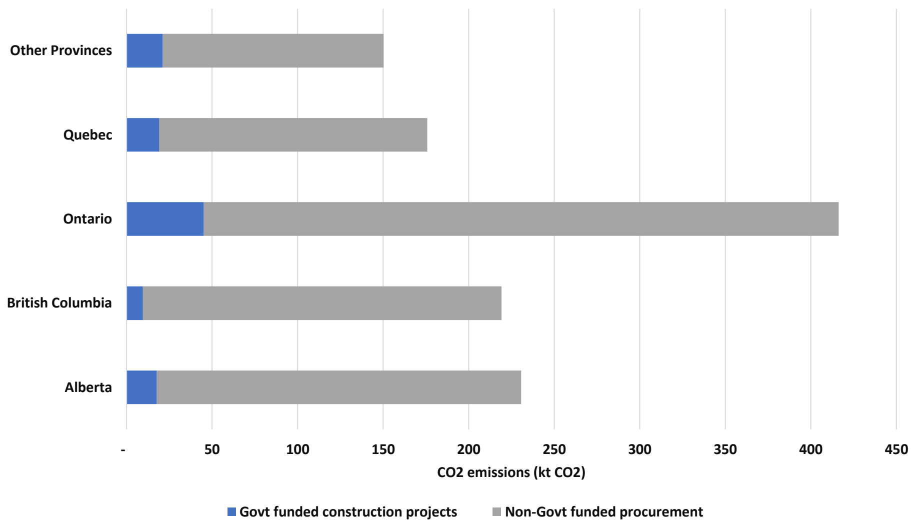

Figure 18. Annual CO_2 emissions associated with aluminum use in selected provinces in 2019.

3 Potential Impact of Buy Clean on CO_2 Emissions

In this section, we present the results of our analysis to estimate the potential impact of a Buy Clean policy on the CO_2 emissions associated with cement, steel, and aluminum used in Canada.

3.1. Potential Impact of Buy Clean on the Cement Industry's Emissions

To estimate the potential impact of Buy Clean on CO_2 emission associated with cement consumption in Canada, we developed several scenarios with various Buy Clean targets for CO_2 intensity of cement set by a Buy Clean policy (Table 5). Since only around 5% of cement consumption in Canada is imported cement, we used the average CO_2 emissions intensity of Canada's domestic cement industry as the baseline for the target setting for cement Buy Clean.

It should be noted that the Buy Clean intensity targets shown in the table below are industry-level targets and not for a specific cement product. In reality, a Buy Clean policy might set product-specific intensity targets rather than industry-level targets, like in California's Buy Clean program. However, because of the lack of information and the existence of 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 for cement.

Table 5. Buy Clean target scenarios for cement

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	-	771	This is the CO_2 emissions intensity of Canada's domestic cement industry since around 95% of the cement used in Canada is produced domestically.
Low	10%	694	Can be achieved by low effort in energy efficiency improvement, fuel switching to lower carbon fuels, and the use of supplementary cementitious materials (SCMs) instead of clinker.
Medium	20%	617	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%	540	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. Carbon capture and storage (CCS) can help to achieve it easily.
Transformative	50%	386	Will require CCUS to achieve this target. This stimulates innovation and the adoption of transformative technologies.

* The Buy Clean intensity targets shown in this table are industry-level targets and not for a specific product.

** More detailed information on potential actions for CO2 emissions reduction can be found at (IEA 2018, Bataille 2019, Hasanbeigi and Springer 2019c, Friedmann et al. 2019, Material Economics 2019, McKinsey & Company 2018, Sandalow et al. 2019).

Potential Activities for Emissions Reduction in the Cement Industry

In the cement industry, process-related CO_2 emissions from calcination accounted for over 50% of total CO_2 emissions. In other words, more than half of the CO_2 emissions from the cement industry are not associated with energy use. Therefore, deep decarbonization in the cement industry (Transformative scenario) cannot be achieved even by the best available energy-efficient technologies or fuel switching alone. Clinker substitution and CCUS are imperative to achieve deep decarbonization in the cement industry. Material efficiency and circular economy measures can help to reduce the carbon footprint of cement and concrete used on the demand side. Below we briefly discuss major decarbonization levers for the cement industry (IEA 2018, Bataille 2019, Hasanbeigi and Springer 2019, Friedmann et al. 2019, Material Economics 2019, McKinsey & Company 2018, Sandalow et al. 2019)

Energy efficiency: Many energy efficiency technologies are already ready to be deployed on a commercial scale. These include waste heat recovery (WHR) technologies, high-efficiency clinker cooling and grinding processes, the use of multistage preheater/precalciner kilns, strategic energy management, smart sensors, advanced analytics, etc.

Fuel switching: Switching away from coal and petroleum coke to lower-carbon fuels such as natural gas (as a transition fuel) or sustainable biomass that are available in large quantities and can be easily used in cement plants with current technology's main fuel switching option in the near term. In the long-term, zero-carbon fuels (e.g. green hydrogen, renewable natural gas, or electrification of process) should be considered.

Clinker substitution: All the fuel used and around 60% of the electricity used in a cement plant is consumed for clinker production (for raw material grinding, fuel preparation, and cement kiln). A higher clinker-to-cement ratio results in higher energy intensity per tonne of cement produced. Replacing clinker with supplementary cementitious materials (SCMs) such as fly ash, blast furnace slag, natural pozzolans, ground limestone, and calcined clay can help to significantly reduce CO_2 intensity per tonne of cement produced.

Carbon capture, utilization, and storage (CCUS): CCUS technologies are emerging for the cement industry that capture and compress CO_2 emissions and permanently store them underground or use the captured carbon to produce other materials. The carbon capture technologies are being piloted and demonstrated at several cement plants around the world including in Canada, while some carbon utilization technologies are fully commercialized and adopted on large scale such as the CarbonCure technology (developed in Canada).

The Potential Impact of Buy Clean on Cement Emissions

Using the annual CO_2 emissions associated with cement consumed in Canada from the previous chapter and the targets set in Table 5, we estimated the annual CO_2 emissions reduction potential resulting from Buy Clean for cement in Canada and selected provinces in 2019 (Figure 19-23).

The potential indirect impact assumes that changes in Canadian cement plants to reduce CO_2 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 less clear; therefore, it is shown by striped bars on the charts.
Under the Low scenario for Buy Clean target for cement, an annual emissions reduction of 0.2

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 0.7 Mt CO_2 and 1.2 Mt CO_2 under High and Transformative scenarios, respectively. The potential CO_2 emissions reduction impact of Buy Clean for cement would be more than triple if we consider the potential indirect impact from the cement sold to non-public construction and assume the changes that cement plants make for CO_2 emissions reduction applies to all cement they produce.

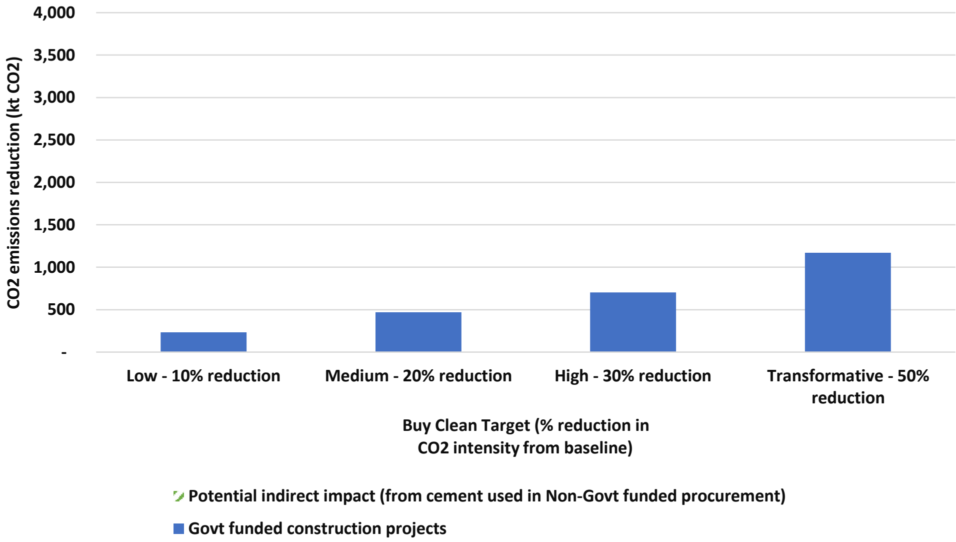

Figure 19. Annual CO_2 emissions reduction potential resulted from Buy Clean for cement in Canada in 2019.

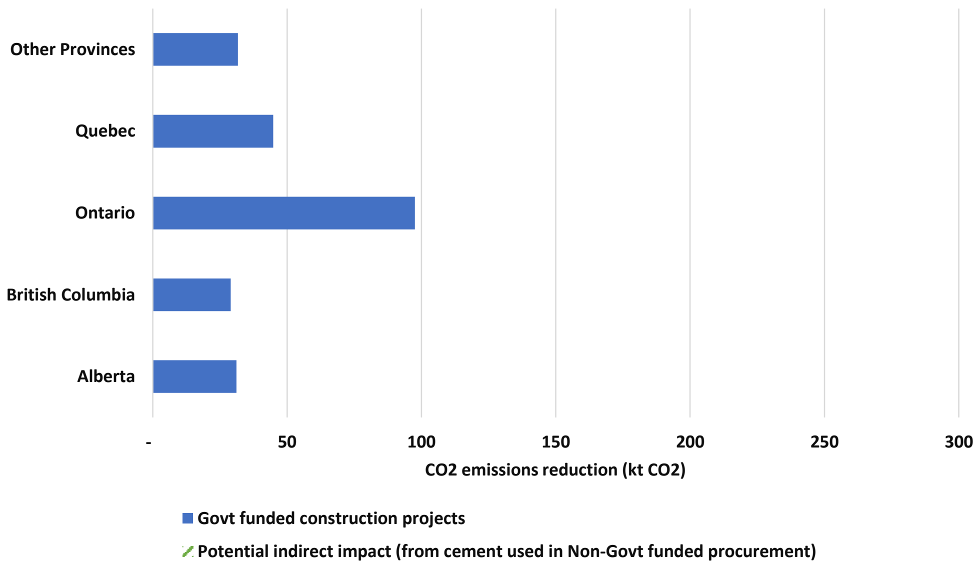

Figure 20. Annual CO_2 emissions reduction potential resulted from Buy Clean for cement in the selected provinces in 2019 – Low Scenario (10% reduction in CO_2 intensity).

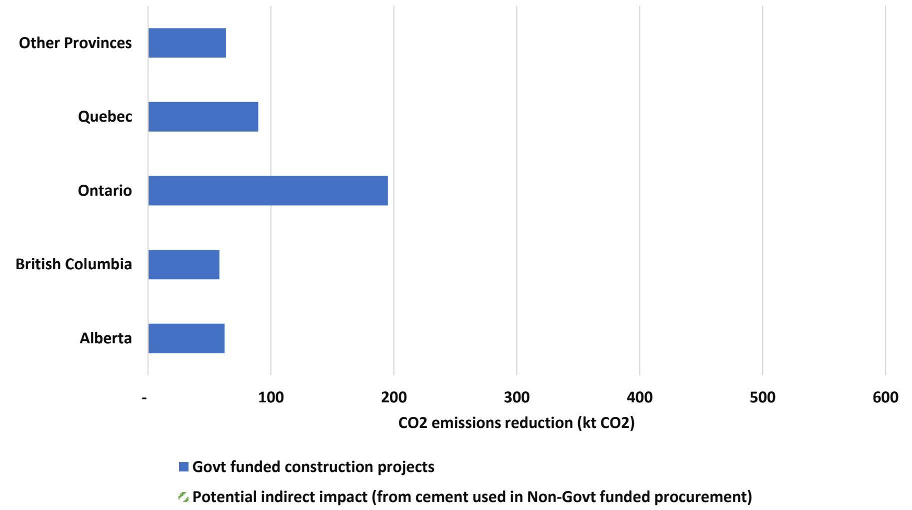

Figure 21. Annual CO_2 emissions reduction potential resulted from Buy Clean for cement in the selected provinces in 2019 –Medium Scenario (20% reduction in CO_2 intensity).

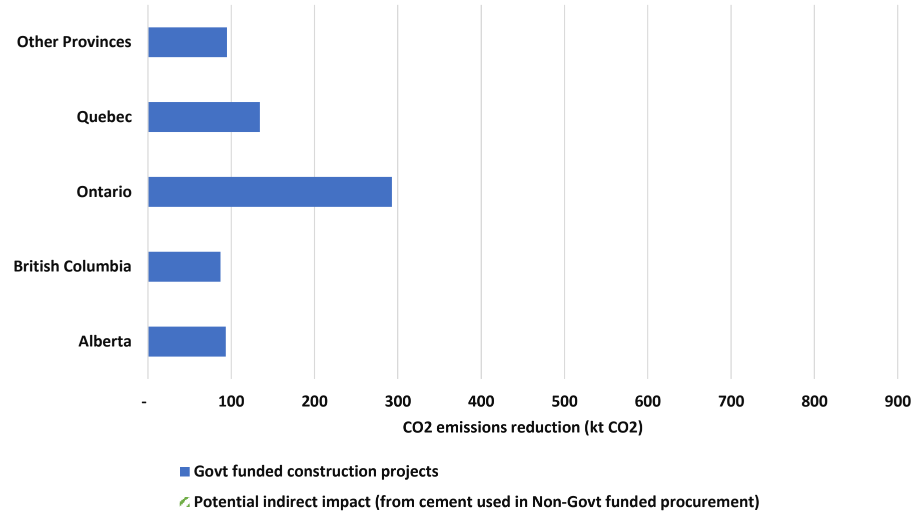

Figure 22. Annual CO_2 emissions reduction potential resulted from Buy Clean for cement in the selected provinces in 2019 – High Scenario (30% reduction in CO_2 intensity).

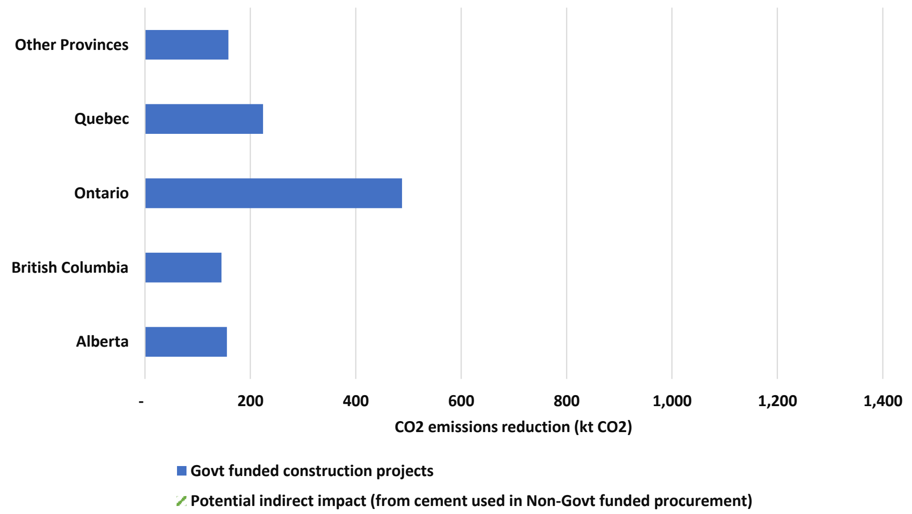

Figure 23. Annual CO_2 emissions reduction potential resulted from Buy Clean for cement in the selected provinces in 2019 – Transformative Scenario (50% reduction in CO_2 intensity).

Figure 24 shows that Ontario has the highest annual CO_2 emissions reduction potential from Buy Clean for both public and private procurement of cement in Canada. While Quebec ranks second for CO_2 emissions reduction potential from Buy Clean for public procurement, British Columbia ranks second for CO_2 emissions reduction potential from Buy Clean for private procurement of cement. This is because of differences in the level of public vs private procurement of cement in each province.

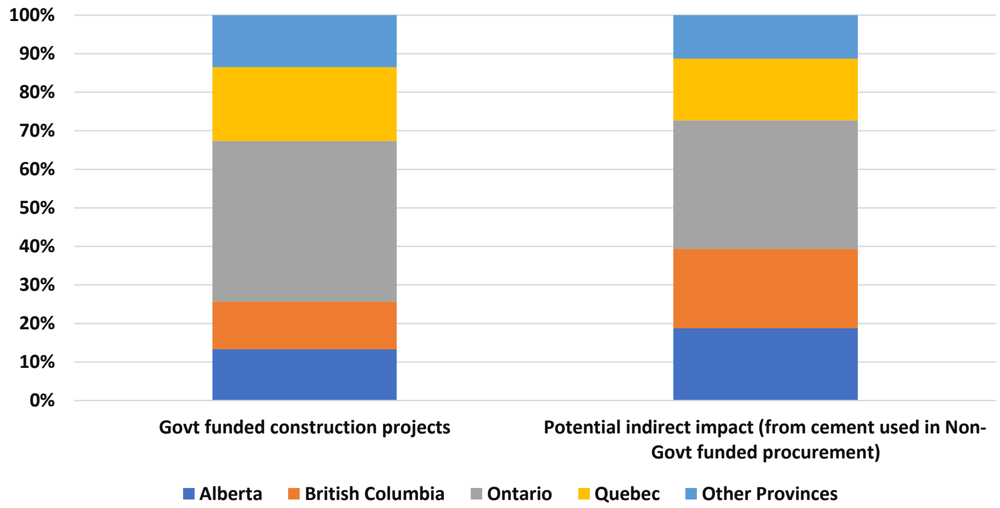

Figure 24. Share of provinces from total annual CO_2 emissions reduction potential resulted from Buy Clean for cement in 2019.

3.2. Potential Impact of Buy Clean on the Steel Industry's Emissions

Similarly, to estimate the potential impact of Buy Clean on CO2 emissions associated with steel consumed in Canada, we developed several scenarios with various Buy Clean targets for CO2 intensity of steel set by a Buy Clean policy (Table 6). Since the amount of steel (in tonnes) imported into Canada accounts for around 64% of the amount of steel consumed in Canada (Worldsteel 2022), we used the weighted average CO2 emissions intensity of the Canadian steel industry (both primary and EAF steelmaking) and the imported steel as the baseline for target setting for steel Buy Clean. Around 42% of the steel imported into Canada is from the US. Canada also exports around 60% of its steel production (SAC 2022).

It should be noted that when primary steelmaking by blast furnace and basic oxygen furnace (BF-BOF) and secondary steelmaking by electric arc furnace (EAF) in Canada are compared separately to those in the US and other countries, Canada has a lower CO_2 emissions intensity (Hasanbeigi 2022). However, since the share of EAF steelmaking in Canada is only around 40% compared to 70% in the US, the overall steel industry CO_2 emissions intensity in Canada is higher than in the US and a few other trading partners such as Mexico and Turkey, which have a higher share of EAF steel production (See Appendix 4 for more detail on CO_2 intensity of steel in different countries).

Like the cement targets above, Buy Clean intensity targets shown in the table below are industry-level targets and not for a specific steel product. A Buy Clean policy is likely to set product-specific intensity targets rather than industry-level targets. However, because of the lack of information and the existence of so many different steel 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 steel.

Table 6. 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	-	1,326	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 Canada imports steel from are above this threshold except U.S., Turkey, and Mexico. These 3 countries accounted for 49% of Canada's steel imports in 2019.
Low	10%	1,193	The Canadian steel industry currently meets this intensity threshold. Most countries that Canada imports steel from are above this threshold except U.S., Turkey, and Mexico because these countries have a large share of EAF steel production.
Medium	20%	1,061	The Canadian steel industry intensity currently sits right above this intensity threshold. Improvements in energy efficiency and fuel switching from coal and coke to natural gas or other lower-carbon fuels will help the Canadian steel industry to meet this intensity threshold. Increasing the share of EAF in Canada from 39% to 47% can also help to meet this threshold. All the countries that Canada imports steel from are above this intensity threshold except U.S., Turkey, and Mexico.
High	30%	928	Improvements in energy efficiency and fuel switching from coal and coke to natural gas or other lower-carbon fuels will help the Canadian steel industry to meet this intensity threshold. Increasing the share of EAF in Canada from 39% to 59% can also help to meet this threshold. All the countries that Canada imports steel from are above this intensity threshold.
Transformative	50%	663	Substantial switch to EAF steelmaking, maximizing energy efficiency and a substantial amount of fuel switching from fossil fuel to lower carbon fuels, and adoption of transformative technologies such as green hydrogen- DRI ironmaking or CCUS in BF-BOF plants will help the Canadian steel industry to meet this threshold.

* The Buy Clean intensity targets shown in this table are industry-level targets and not for a specific steel product. See Appendix 4 for more detail on the CO_2 intensity of steel in different countries.

** More detailed information on potential actions for CO2 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).

BF: blast furnace; BOF: basic oxygen furnace; EAF: electric arc furnace; DRI: direct reduced iron; CCUS: carbon capture, utilization, and storage.

Potential Activities for Emissions Reduction in the Steel Industry

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 the adoption of transformative technologies. Material efficiency and circular economy measures can help to reduce the carbon footprint of steel used on the demand side. Below we briefly discuss these major decarbonization levers for the steel industry (IEA 2020, Bataille 2019, Friedmann et al. 2019, Material Economics 2019, McKinsey & Company 2018, Sandalow et al. 2019, ETC 2018).

Energy efficiency: There is a variety of energy efficiency technologies that are already ready to be deployed on a commercial scale in the steel industry. Technologies such as waste heat recovery for different processes, coke dry quenching (CDQ), Top-Pressure Recovery Turbine Plant (TRT), and many others are commercially available for deployment. Also, cutting-edge technologies could assist with energy management systems, drawing from smart manufacturing and the Internet of Things; such technologies include predictive maintenance and machine learning or digital twins to improve process control.

Fuel switching and electrification: Several fuels can replace coal or coke as a reducing agent in the smelting process. These alternative fuels include natural gas, biomass, biogas, and on a longer time horizon, hydrogen. Globally, the main pathway to the electrification of the steel industry is increasing the use of EAF steel production. In Canada, around 40% of the steel is already produced by EAFs and at least two new EAF plants are under development, but there is still an opportunity for increased use of EAF technology. Another major pathway to electrification is the use of transformative steelmaking technologies such as the ones discussed below. Several different process heating pathways in steel production could be decarbonized by switching to low-carbon electricity. Reheating furnaces could be electrified, and electric induction furnaces could be scaled up. Ladle and tundish heating could be switched to resistance, infrared, or plasma heating.

The provincial and federal governments in Canada are already investing hundreds of millions of dollars in Ontario to replace blast furnace-basic oxygen furnace (BF-BOF) steelmaking with electric arc furnace (EAF) steelmaking. This will help to lower the average CO_2 intensity of steel production in Canada in the coming years.

CCUS: Carbon capture, utilization, and storage (CCUS) could decarbonize different routes of steel production, such as top-gas recycling in blast furnaces with CCUS, DRI with post-combustion CCUS, and oxygen-rich smelt reduction with CCUS, etc. These production pathways vary greatly in their commercialization status, with blast furnace CCUS being at the pilot stage, DRI with CCUS in the development stage, and smelting reduction CCUS in the pilot stage. The main challenges for CCUS technologies are achieving further reductions in costs and improving operational efficiencies. The captured CO_2 emissions from iron and steel production can be permanently stored underground (dependant on geology), or used for chemicals or fuel production.

Transformative technologies: These technologies help to produce steel with a substantially lower carbon footprint. Two of such transformative technologies are the use of hydrogen that is produced from renewable energy (electrolysis) instead of natural gas in direct reduced iron (DRI) production (HYBRIT 2022) and the electrolysis of iron ore (Boston Metal 2022). A few full industrial-scale hydrogen DRI plants are being planned or built around the world. Currently, the DRI process requires higher quality iron ore which may have limited availability in certain parts of the world. However, applied R&D is already on the way to using lower quality iron ore in DRI ironmaking. More R&D, pilots, and demonstrations are needed for the wide-scale commercialization of these technologies. It should be noted that all the Buy Clean targets assumed in this study for the steel industry (Table 6) can be achieved without the adoption of transformative technologies. However, the adoption of green hydrogen-DRI ironmaking or CCUS might be needed for the Transformative scenario.

The Potential Impact of Buy Clean Steel

Using the annual CO_2 emissions associated with steel used in Canada presented in the previous chapter and the targets set in Table 6, we estimated the annual CO_2 emissions reduction potential resulting from Buy Clean for steel in Canada both at the national and provincial level in 2019 (Figure 25-29).

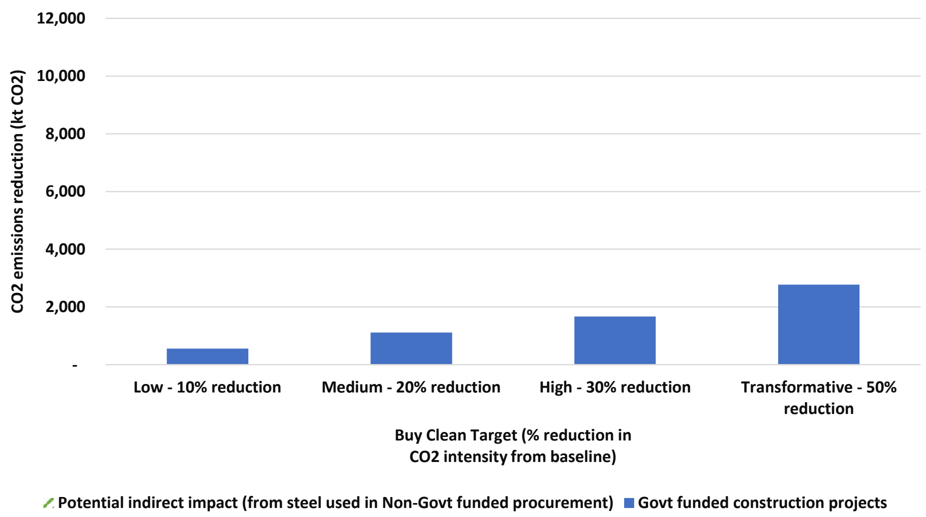

Figure 25. Annual CO_2 emissions reduction potential resulted from Buy Clean for steel in Canada in 2019.

Under the Low scenario for Buy Clean target for steel, an annual emissions reduction of 0.5 Mt CO_2 can be achieved directly from public procurement of steel. This direct annual CO_2 emissions reduction potential would increase to 1.7 Mt CO_2 and 2.8 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 three-fold if we consider the potential indirect impact from the steel sold to non-public funded projects if we assume the changes that steel plants make for CO_2 emissions reduction applies to all steel they produced for market.

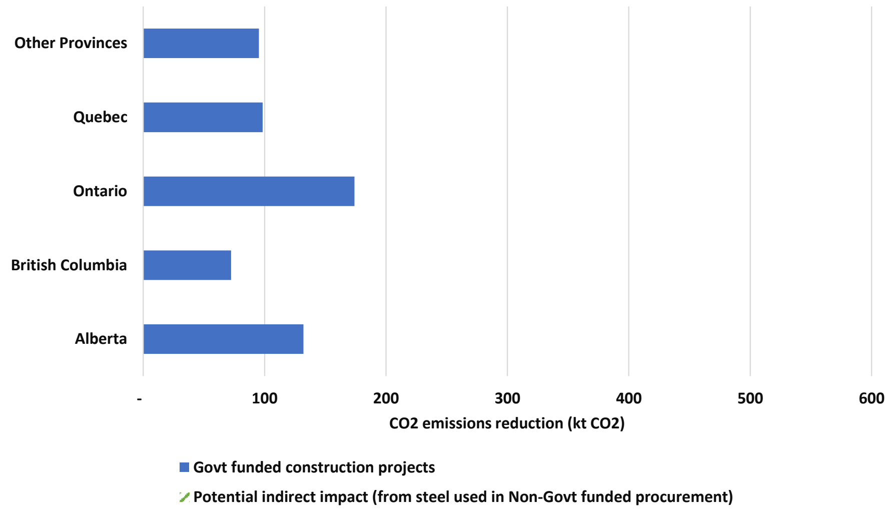

Figure 26. Annual CO_2 emissions reduction potential resulted from Buy Clean for steel in the selected provinces in 2019 – Low Scenario (10% reduction in CO_2 intensity).

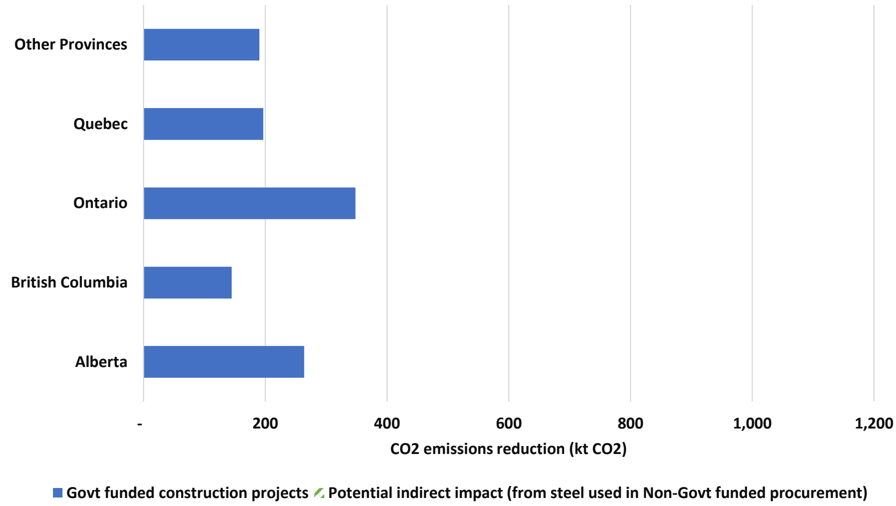

Figure 27. Annual CO_2 emissions reduction potential resulted from Buy Clean for steel in the selected provinces in 2019 –Medium Scenario (20% reduction in CO_2 intensity).

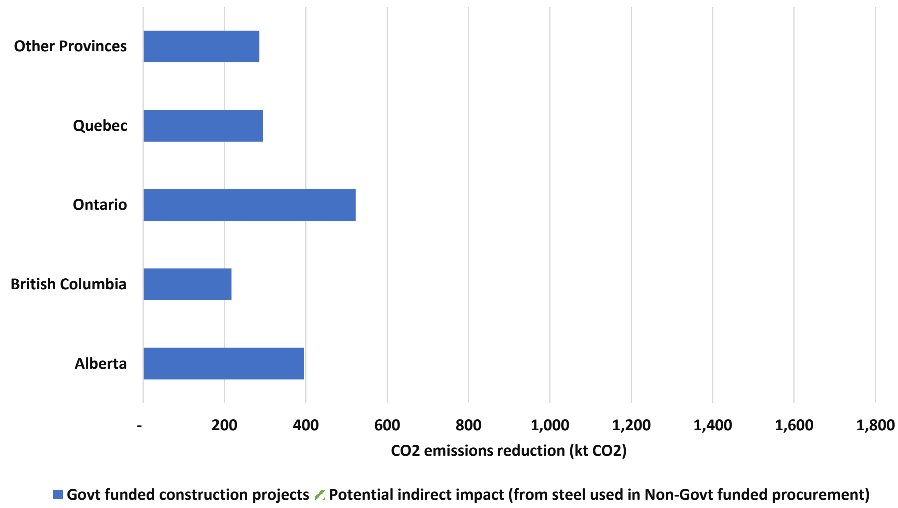

Figure 28. Annual CO_2 emissions reduction potential resulted from Buy Clean for steel in the selected provinces in 2019 – High Scenario (30% reduction in CO_2 intensity).

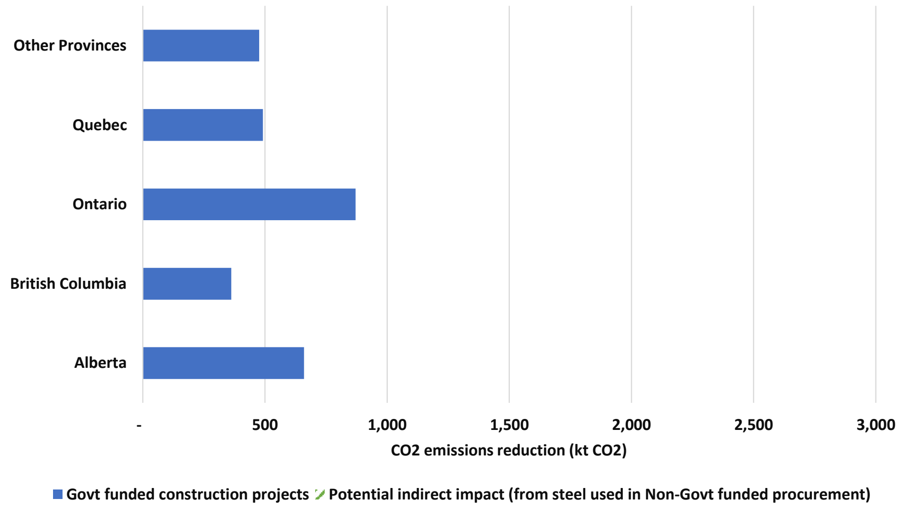

Figure 29. Annual CO_2 emissions reduction potential resulted from Buy Clean for steel in the selected provinces in 2019 – Transformative Scenario (50% reduction in CO_2 intensity).

Figure 30 shows that Ontario has the highest annual CO_2 emissions reduction potential from Buy Clean for public procurement of steel in Canada, whereas Alberta ranks first for CO_2 emissions reduction potential from Buy Clean for private procurement of steel.

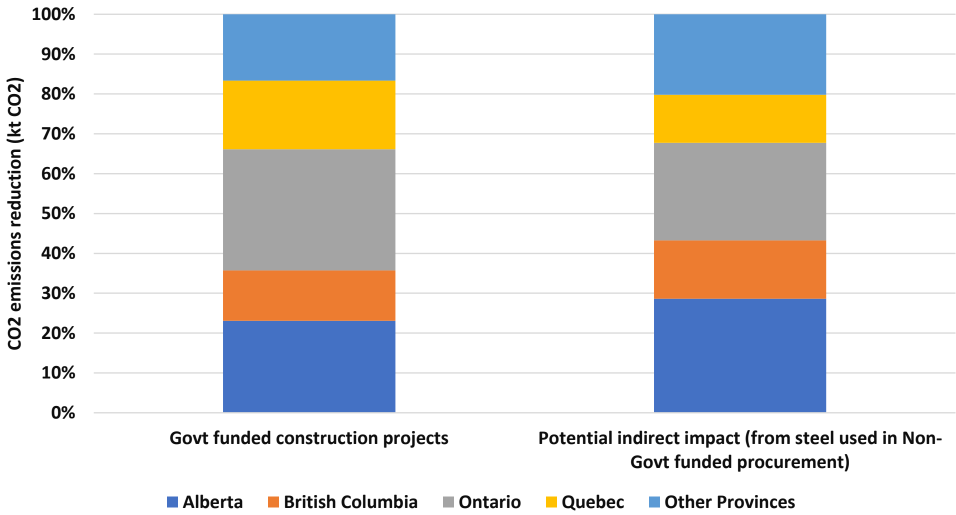

Figure 30. Share of provinces from total annual CO_2 emissions reduction potential resulted from Buy Clean for steel in 2019.

3.3. Potential Impact of Buy Clean on the Aluminum Industry's Emissions

To estimate the potential impact of Buy Clean on CO_2 emission associated with aluminum used in Canada, we used the same scenario definitions for Buy Clean targets for CO_2 intensity of aluminum set by a Buy Clean policy (Table 7). Since the amount of aluminum imported in Canada accounts for 30% of the amount of aluminum consumed in Canada, we used the weighted average CO_2 emissions intensity of the Canadian aluminum industry and the imported aluminum as the baseline for the target setting for steel Buy Clean. Around 60% of the aluminum imported to Canada is from the U.S. Canada also exports around 90% of its aluminum production (Statistics Canada 2022c). Like the cement and steel section, the Buy Clean intensity targets shown in the table below are industry-level targets and not for a specific aluminum product.

The primary aluminum production in Canada has one of the lowest CO_2 intensities (1,260 kg-CO_2/t aluminum) in the world primarily because all its aluminum plants are located in Quebec and British Columbia with near-zero carbon electricity generation from hydropower (Hasanbeigi et al. 2022). However, it should be noted that around 45% of imported aluminum and half of domestic aluminum consumption is secondary aluminum produced from aluminum scrap (Aluminum Association of Canada, 2022). Secondary aluminum production has substantially lower energy and carbon intensity (90% - 95% lower) compared to primary aluminum production. Therefore, in this analysis, to establish a Baseline for aluminum consumed in Canada, we used the weighted average of CO_2 intensity for both domestic and imported aluminum which includes both primary and secondary aluminum (Table 7). See Appendix 4 for more detail on the CO_2 intensity of primary aluminum in different countries.

Because of the very low CO_2 intensity of primary aluminum production, Canada's domestic aluminum production meets all the intensity targets proposed in Table 7 except the Transformative target. Canada's aluminum industry already uses near zero-carbon electricity, so there is limited improvement opportunity there. Improvement in energy efficiency and fuel switching in the production of alumina (an intermediate product in aluminum production) can help to further reduce domestic aluminum CO_2 intensity. Increasing the share of secondary aluminum production and consumption in Canada can substantially help to achieve the Transformative CO_2 intensity threshold as well. Currently, only around 6% of total aluminum production in Canada is secondary aluminum while in the US (Canada's number one aluminum trading partner) around 78% of total aluminum production is secondary aluminum.

Table 7. Buy Clean target scenarios for aluminum

Buy Clean Target	% reduction in aluminum CO_2 intensity from baseline	Aluminum CO_2 intensity (kgCO_2/t aluminum)*	Notes and potential actions for CO_2 emissions reduction
Baseline	-	1,932	This is the weighted average of CO_2 intensity for both domestic and imported aluminum which includes both primary and secondary aluminum. Only Canada and one of its trading partners (Iceland, 10% of import) meet this intensity threshold.
Low	10%	1,739	Only Canada meets this intensity threshold. None of the countries Canada is importing aluminum from meet this intensity threshold.
Medium	20%	1,546	Only Canada meets this intensity thresh-old.
High	30%	1,352	Only Canada meets this intensity threshold.
Transformative	50%	966	Canada's domestic aluminum production is above this CO_2 intensity threshold. Potential decarbonization actions to reduce the carbon intensity to meet the Transformative target threshold are discussed in the section below this table.

* The Buy Clean intensity targets shown in this table are industry-level targets and not for a specific product. See Appendix 4 for more detail on the CO_2 intensity of primary aluminum in different countries.

Potential Activities for Emissions Reduction in the Aluminum Industry

The most important measure to decarbonize the primary aluminum industry is the decarbonization of the electricity used in aluminum production. This is because the majority of energy used in primary aluminum production is electricity used in aluminum smelters. As mentioned above, Canada's aluminum plants are in Quebec and British Columbia with near-zero carbon electricity generation from hydropower. Therefore, there is limited opportunity to further reduce electricity-related emissions. Energy efficiency and switching to low/no-carbon fuels for alumina production can further reduce the primary aluminum production CO_2 intensity in Canada (Hasanbeigi et al. 2022, WEF 2020, IAI 2021, Reinsch and Benson 2022, Kortes and van Dril 2019).

Regarding secondary aluminum, there is substantial potential in Canada to increase the production of secondary aluminum, thereby reducing the weighted average CO_2 intensity of total aluminum production in Canada. Even though energy use and emissions of secondary aluminum are substantially lower than the primary aluminum, still there is potential to reduce them by improving energy efficiency and switching to low/no-carbon fuel or electrification secondary aluminum production furnaces.

The Potential Impact of Buy Clean Aluminum

Using the annual CO_2 emissions associated with aluminum used in Canada and the targets set in Table 7, we estimated the annual CO_2 emissions reduction potential resulting from Buy Clean for aluminum in Canada and selected provinces in 2019 (Figure 31-35).

Under the Low scenario for Buy Clean target for aluminum, an annual emissions reduction of 11 kt CO_2 can be achieved from public procurement of aluminum. This direct annual CO_2 emissions reduction potential would increase to 32 kt CO_2 and 54 kt CO_2 under High and Transformative scenarios, respectively. The share of CO_2 emissions reduction potential from a Buy Clean for public procurement is small because of the low share of public procurement from total aluminum consumed in Canada. The potential CO_2 emissions reduction impact of Buy Clean for aluminum would increase substantially if we consider the potential indirect impact from the aluminum sold for the non-public project and if we assume the changes that the aluminum industry makes for CO_2 emissions reduction applies to all aluminum produced.

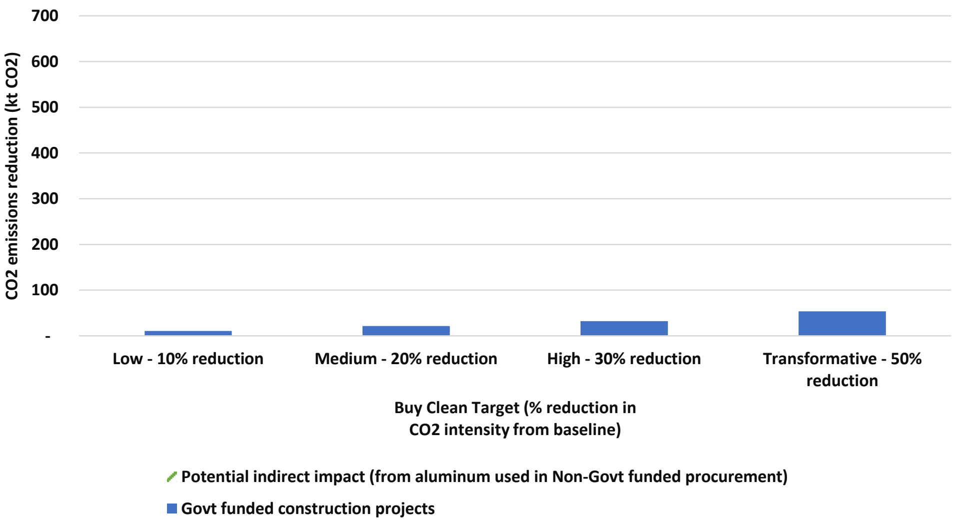

Figure 31. Annual CO_2 emissions reduction potential resulted from Buy Clean for aluminum in Canada in 2019.

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

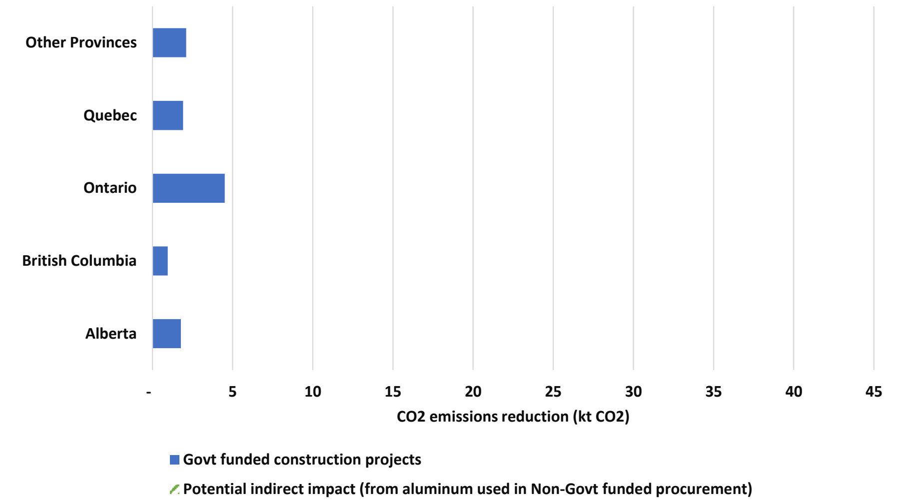

Figure 32. Annual CO_2 emissions reduction potential resulted from Buy Clean for aluminum in the selected provinces in 2019 – Low Scenario (10% reduction in CO_2 intensity).

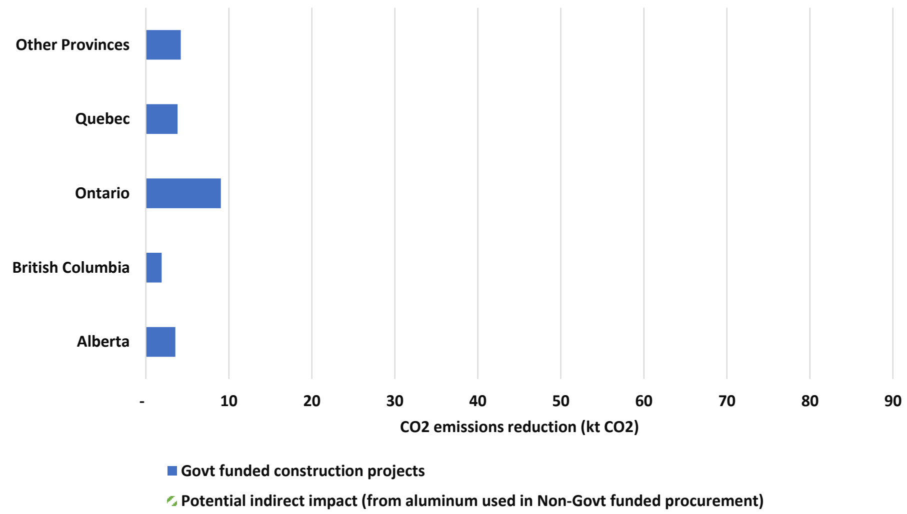

Figure 33. Annual CO_2 emissions reduction potential resulted from Buy Clean for aluminum in the selected provinces in 2019 –Medium Scenario (20% reduction in CO_2 intensity).

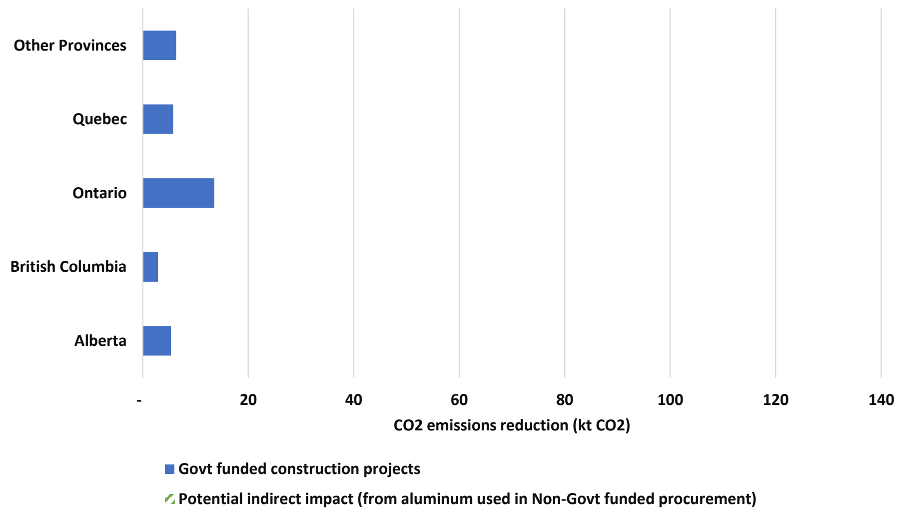

Figure 34. Annual CO_2 emissions reduction potential resulted from Buy Clean for aluminum in the selected provinces in 2019 – High Scenario (30% reduction in CO_2 intensity).

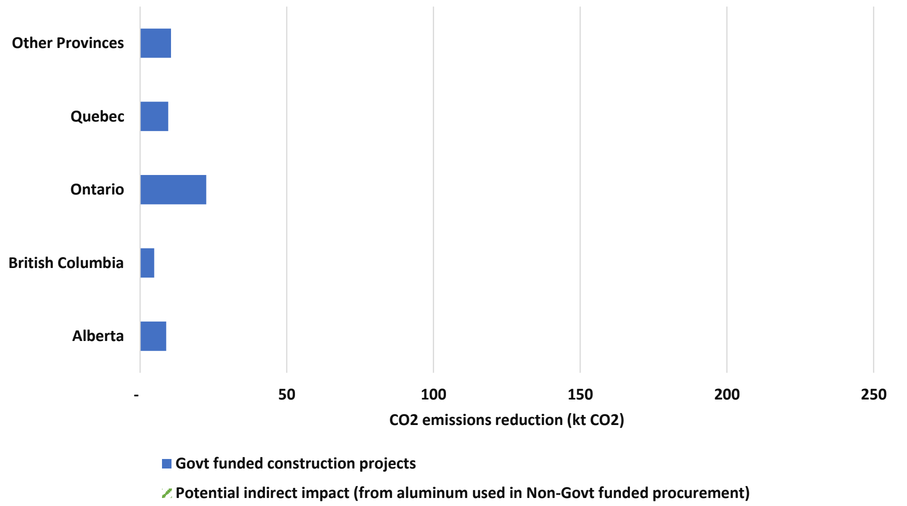

Figure 35. Annual CO_2 emissions reduction potential resulted from Buy Clean for aluminum in the selected provinces in 2019 – Transformative Scenario (50% reduction in CO_2 intensity).

Figure 36 shows that Ontario has the highest annual CO_2 emissions reduction potential from Buy Clean for both public and private procurement of aluminum in Canada. While Quebec ranks second for CO_2 emissions reduction potential from Buy Clean for public procurement of aluminum, Alberta ranks second for CO_2 emissions reduction potential from Buy Clean for private procurement of aluminum.

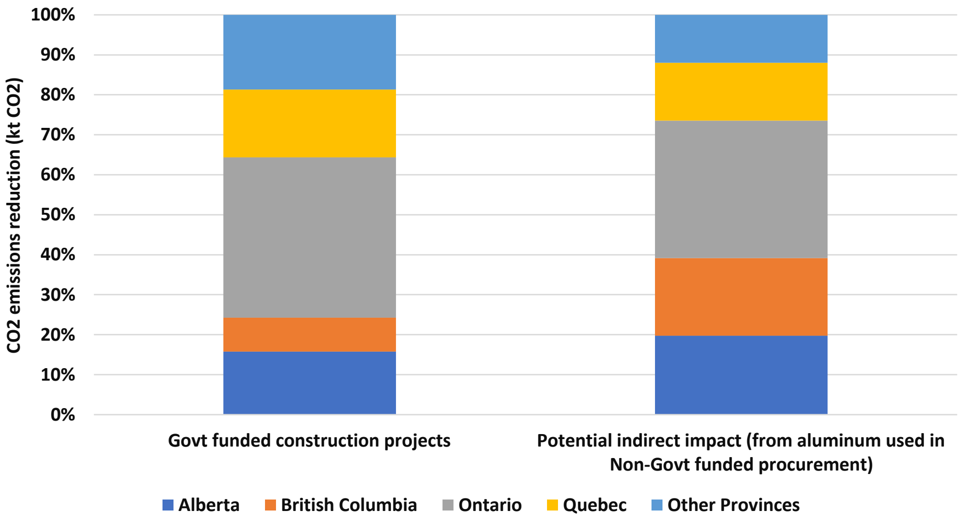

Figure 36. Share of provinces from total annual CO_2 emissions reduction potential resulted from Buy Clean for aluminum in 2019.

4 Potential Socio-economic impacts of Buy Clean

4.1. Overall Economic and Employment Impact

According to a scenario analysis conducted by the International Institute for Sustainable Development (IISD), implementation of GPP in Canada could stimulate the demand for domestic steel and result in the generation of approximately 400 new jobs and almost a billion dollars in revenues in the steel industry by 2035 as compared to the business-as-usual scenario (IISD, 2019). This section presents a summary of the impacts of climate policies, including green procurement policies, on economic growth and jobs.

Based on the evidence from the impact analysis of green construction policy (i.e., construction standards) in the U.S., over nine years (2000-2008), the adoption of green construction[6] helped generate US$ 173 billion in GDP (USGBC, 2015). Many studies analyzing the impact of climate policies on employment estimate that climate policies will lead to the creation of new employment opportunities accompanied by a significant shift in employment patterns resulting in the redistribution of jobs. As a result of policies like green procurement, the demand for green products will increase, thus, resulting in job growth in "green" sectors of the economy but a reduction in the jobs in "brown" sectors of the economy (OECD, 2017).

Climate policy like green construction was successful in stimulating the demand for low-carbon construction materials in the U.S. and consequently contributed significantly towards economic gains in terms of GDP, jobs, and labor earnings with a net direct impact of US$ 85.4 billion and an indirect impact of US$ 98.3 billion in 2015 (USGBC, 2015). According to estimates by the US Green Building Council, the green construction market in the U.S. directly contributed to the creation of about 1.1 million jobs, and about US$ 74.6 billion in wages can be attributed to the green construction industry.

6 Green construction refers to green building standards such as Leadership in Energy and Environmental Design (LEED).

The adoption of GPP in South Korea resulted in the growth of the domestic market for green products. According to the impact analysis of GPP implemented by South Korea, the growth of the domestic green products market resulted in economic benefits of US$ 45.5 billion and 12,143 new jobs between 2005 and 2017 (UNEP, 2019).

Table 8 presents the total direct and indirect jobs supported by the manufacturing industries for construction materials of interest in Canada along with the provinces where these jobs are predominantly located. Buy Clean policy prioritizes the procurement of low-carbon construction materials. This could lead to an increase in jobs because Canada-produced construction materials often have lower embodied emissions today compared to imported materials. For example, aluminum produced in Canada has significantly lower embodied carbon than imported aluminum. If Buy Clean policy set ambitious quantitative limits on embodied carbon of aluminum, 60% of the market currently served by imports would likely be dominated by domestic production. These effects will eventually lead to economic growth, especially in the provinces of Quebec, Ontario, British Columbia, and Alberta.

Table 8. Employment is supported by the manufacturing of construction materials of interest (BlueGreen Canada, 2021)

Construction materials	Total Jobs	Direct jobs	Indirect jobs	Location
Steel	123,000	23,000	100,000	Ontario, Quebec, Saskatchewan, Alberta, Manitoba
Aluminum	31,000	10,000	21,000	Quebec and British Columbia
Cement	158,000	N.A.	N.A.	Ontario, Quebec, British Columbia, Alberta, Nova Scotia

4.2. Buy Clean and Canadian Manufacturing Competitiveness

Buy Clean could bolster Canadian competitiveness among global manufacturers and induce innovation. As more countries commit to carbon neutrality, policies requiring industrial inputs to meet low-carbon standards are soon to follow. The European Union is well on its way to putting in place a Carbon Border Adjustment Mechanism (CBAM). The CBAM is an environmental trade policy that consists of charges on imports and sometimes rebates on exports related to embodied carbon in traded products. The EU CBAM will initially apply to imports of the following goods: cement, iron and steel, aluminum, fertilizers, and electricity (European Commission 2021). The United States and other countries are also working to put in place their CBAM for carbon-intensive products such as cement, steel, aluminum, fertilizer, etc. (Sheldon Whitehouse 2022). It should be noted that Canada has a domestic carbon pricing mechanism and the carbon price that Canadian manufacturers pay in Canada would be taken into account by the EU or other carbon adjustment mechanisms.

For Canadian firms to remain competitive, they must develop low-carbon products. Buy Clean can encourage this development and open markets in the global economy. Beyond maintaining existing competitiveness, Buy Clean can encourage development in the emerging market of low-carbon construction products. There is increasing international demand for green construction products and manufacturing processes (Allied Market

Research 2022). The global solar photovoltaic (PV) market, valued at over $160 billion in 2019, is an example of how valuable these markets can become (Fortune Business Insights 2020). Chinese companies that entered the PV market in the early 2000s now account for more than half of all PVs produced in the world (Jarsulic 2021). No country has dominated green construction products yet. The government can use its purchasing power to encourage Canadian companies to capture this opportunity.

Buy Clean can also protect energy-intensive, trade-exposed industries that produce materials such as cement, steel, and aluminum from offshoring, therefore protecting Canadian jobs. Policies such as carbon pricing or direct regulation of domestic facility emissions can lead to a competitive disadvantage if imports are not subject to the same measures. By focusing on market creation, Buy Clean promotes low-carbon development while allowing Canadian manufacturing companies to retain domestic advantages such as lower transportation costs, easier access to markets, and thereby securing Canadian jobs.

Public procurement for large infrastructure projects can have a significant effect on the market by stimulating demand. Buy Clean can bolster manufacturing competitiveness by increasing demand for green products, which leads to two outcomes. The first is reducing costs in the long run. This may be through economies of scale: as the market increases in size, the cost of production can fall as firms can invest in more efficient and low-carbon processes, benefit from bulk orders, and spread fixed costs over a larger amount of goods. Costs can also be reduced as firms become more specialized and develop low-carbon production practices. Another long-run outcome is reduced prices through increased competition. An increase in demand for green products encourages new suppliers to enter the green market, raising supply and lowering the price of green products in the long run (Krupnick 2020).

Increased competition in the market can stimulate innovation. A large body of literature examines public procurement as a key element of demand-oriented innovation policy. Elder and Georghiou (2007) note that innovation often entails high learning and switching costs, which prevents suppliers from investing in the research and development required for innovation. Private corporations may be hesitant to make large initial investments even when the profitability of a new product is reasonably clear due to their inability to capture all the benefits of innovations (Jarsulic 2021). This is certainly the case for manufacturing and construction materials suppliers, where the upfront cost of upgrading facilities can be very high.

Green public procurement programs establish demand certainty and build confidence in the existence of future markets for low-carbon materials, which enables suppliers to justify high switching costs. Unlike R&D subsidies, state demand induces not only proof-of-concept technological innovation, but also manufacturing innovation and commercialization of new technologies (Elder and Georghiou 2007). In the solar industry, government subsidies for solar power adoption in Japan and Germany helped to spur innovation. New entrants and increased competition to meet rising demand led to technical and manufacturing innovation that allowed the cost of solar to fall dramatically and become competitive with fossil fuel-generated electricity (Jarsulic 2021). One study of manufacturing firms in the European Union, Switzerland, and the United States has shown that firms were more likely to adopt innovative green technologies after receiving public procurement funds (Ghisetti 2017).

Buy Clean may also lead to several positive spillover effects. Measurement protocols and certification programs need to be established before green procurement as procuring agencies need to be able to evaluate options. Standardizing this information and making it publicly accessible allows private businesses and consumers to distinguish low-carbon products from alternatives (Krupnick 2020). These programs can promote private demand for green products, which may have even larger market impacts than public purchases for some materials such as steel and aluminum.

Another positive indirect effect is workforce development. As more domestic suppliers enter the green materials market, local workforces develop expertise in green manufacturing processes. This provides the industry with skilled workers with process knowledge of green manufacturing who can move between firms leading to the diffusion of new standards. A study of local governments in California showed that green building procurement policies led to increased private-sector adoption of LEED certification in those jurisdictions and neighboring areas (Simcoe and Toffel 2014). The authors also found that public procurement stimulated investment in green building expertise, as measured by the number of LEED-accredited professionals. They suggested that these professionals were a key transmission mechanism for geographic spillover effects.

Buy Clean could help Canadian 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.

5 Current and Proposed Buy Clean Policies in Canada

Federal

Canada has a nationwide target of net-zero emissions by 2050 (Government of Canada 2022a). In 2017, the federal government released the Greening Government Strategy. This effort is led by the Treasury Board of Canada Secretariat. It establishes commitments to reduce emissions from government operations to 40% below 2005 levels by 2025, and from operations and procurement to net zero by 2050 (Treasury Board of Canada Secretariat 2017). One such commitment is to integrate sustainability and life-cycle assessment principles into the procurement of goods and services. For structural construction materials, the government will:

- Disclose the embodied carbon in major construction projects by 2022, based on carbon intensity or life-cycle analysis,
- Reduce embodied carbon by 30% starting in 2025 through the use of recycled and lower-carbon materials, material efficiency, and performance-based design standards,
- Conduct whole building life-cycle analysis by 2025 for major projects

To achieve these goals, an inventory of material-specific emissions data is needed. To this end, the National Research Council has begun the Low-Carbon Assets Through Life Cycle Assessment (LCA^2) initiative. This initiative will produce a centralized low-carbon inventory, and a database of input and output flows for water, energy, raw materials, etc. This inventory can then be used to conduct life-cycle analysis (LCA), whereby the flows for a specific product are compiled to produce an environmental product declaration (EPD). LCA^2 will also produce LCA guidelines, low-carbon benchmarks, a framework for a total cost of ownership estimation, and enhanced tools to implement this framework (National Research Council 2019).

Another related initiative is the Greening Government Fund, which provides funding to federal departments to reduce greenhouse gas emissions in their operations. One of the projects that have received funding is Buyers for Climate Action. This project will bring together a coalition of large governments across Canada, including British Columbia and Quebec, and the cities of Montreal, Toronto, and Vancouver, to create a green buyers group (Government of Canada 2022b). Banding together gives procurement officials more market influence, which can lead to accelerated emissions disclosure and low-carbon innovation in areas such as net zero buildings and low-carbon construction materials.

While not directly affecting procurement, supporting policies including the industrial carbon price, Net Zero Accelerator Initiative, and federal budget spending also influence industrial transformation. Since 2019, every provincial or territorial jurisdiction in Canada has had a price on carbon emissions. In 2022, the minimum federal benchmark price is CA$50 per tonne of CO_2. It will increase annually at a rate of CA$15 per year from 2023 to 2030, to reach CA$170 per tonne in 2030 (Government of Canada 2021). Provinces and territories can design their pricing system as long as it meets minimum national standards. For example, British Columbia has had a carbon price in place since 2008; in 2022 the carbon price was on-par with the federal backstop at CA$50 per tonne of CO_2 (Government of British Columbia 2022a). Meanwhile, Quebec has implemented a cap-and-trade system that is linked to the Western Climate Initiative, allowing trading between the regions (Ministry of the Environment and the Fight Against Climate Change 2021). While Canada's carbon pricing schedule seems ambitious, it is limited in its efficacy due to heavy exemptions to a few sectors including steel and cement. Exemptions allow emitters to only pay the carbon price for the non-exempt share of their emissions, effectively lowering the true price these companies must pay.

The Strategic Innovation Fund's Net Zero Accelerator (NZA) initiative aims to target key high-emitting industrial sectors across the country to drive industrial transition and greenhouse gas emission reductions. The initiative will provide up to CA$8 billion in support of the adoption of carbon capture, utilization, and storage (CCUS) technology, energy efficiency retrofits, electrification of processes and equipment, and targeting fossil fuel use (Government of Canada 2022d).

The 2022 federal budget proposed to provide CA$150 million over five years to Natural Resources Canada to develop a Green Buildings Strategy. This strategy will include initiatives to drive building code reform; accelerate the adoption and implementation of performance-based national building codes; and promote the use of lower carbon construction materials. The budget also proposed to provide CA$183.2 million over seven years to the National Research Council to conduct research and development on innovative construction materials and to revitalize national housing and building standards to encourage low-carbon construction (Government of Canada 2022c).

Ontario

Ontario has a target of reducing greenhouse gas emissions by 30% below 2005 levels by 2030 (Environmental Registry of Ontario 2022). While the Made-in-Ontario Environment Plan mentions consideration of climate change when purchasing goods and services across the government, there are no guidelines on how to weigh these considerations against other factors such as cost. There is no dedicated Buy Clean policy with quantitative limits on embodied carbon. The concentration of steel and cement plants in Ontario makes its policy context highly relevant: a lack of measures to decarbonize these plants can have an outsized impact on Canada's overall emissions.

Although Ontario does not have an embodied carbon policy, it is investing in industrial transformation. As shown in Figure 37, the three biggest industrial emitters of CO_2 in Ontario are all steel plants. In February 2022, Ontario announced it would contribute up to CA$500 million in loans and grants to the ArcelorMittal Dofasco plant in Hamilton, adding to the CA$400 million federal investment announced in 2021 (CBC News 2022a). This investment will be used to convert blast furnace-basic oxygen furnace (BF-BOF) technology into electric arc furnace (EAF) technology, which produces significantly lower emissions. This plant is Canada's largest flat-rolled steel producer and Hamilton's largest private-sector employer (CBC News 2022b). The Ontario government has stated that this investment will help bolster the auto sector, making the province a "global innovation hub for the car of the future" (Ontario Newsroom 2022). The provincial and federal governments are also investing in coal-to-electricity transformation at Algoma Steel, providing 60 million and 420 million respectively (Ontario Newsroom 2021, CBC News 2021). These investments to create a greater supply of low-carbon materials would be well balanced by a durable demand signal in the form of a Buy Clean policy.

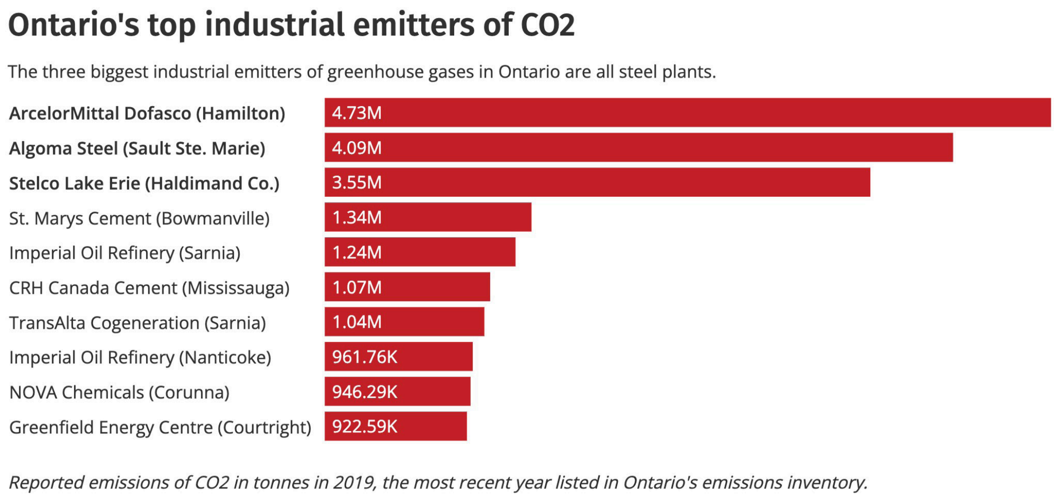

Figure 37. Top industrial emitters of CO_2 in Ontario. (Source: CBC News 2022a).

Quebec

In May 2022, Quebec passed an act to promote Quebec-sourced and responsible public procurement. Bill 12 aims to use public purchasing as a vector of influence to reduce the carbon footprint of goods and services and fight climate change. Beyond reducing embodied carbon, it also aims to increase the representation of Indigenous businesses and encourage the participation of people facing labor market barriers. This bill gives procurement officers the ability to waive traditional “lowest compliant bidder” rules to promote sustainable development. This may include the use of tools such as life-cycle analysis, granting a premium to enterprises that go beyond environmental standards, or issuing invitations to tender to acquire a prototype. The bill does not include any quantitative goals for the reduction of embodied carbon (National Assembly of Quebec 2022).

Separately, Quebec has a climate policy framework called the 2030 Plan for a Green Economy. This plan was created to help the province achieve its goal of reducing emissions by 37.5% relative to 1990 by 2030. The projected reductions will be driven primarily by price signals from a cap-and-trade system. Public procurement could play a significant role in helping the province achieve these targets (Government of Quebec 2022).

British Columbia

British Columbia has committed to reducing greenhouse gas emissions by 16% below 2007 levels by 2025, 40% by 2030, 60% by 2040, and 80% by 2050 (Government of British Columbia 2022b). One of the pathways to achieve this target will be low-carbon building materials. The CleanBC Roadmap to 2030 states that B.C. will develop a Low Carbon Building Materials Strategy by 2023 that includes a holistic approach to decarbonizing buildings. The initial phase will focus on developing embodied carbon targets for public sector buildings by 2030 (Government of British Columbia 2021).

Vancouver

The City of Vancouver declared a climate emergency in 2019 and developed its Climate Emergency Response report in the same year. In the report, Vancouver set a target of being carbon neutral before 2050. One of the objectives is to reduce carbon pollution from building materials and construction practices in all new private and public buildings by 40% compared to a 2018 baseline. There is an even more ambitious target of a 50% reduction for all new city-owned buildings (City of Vancouver 2020).

To achieve this target, the report includes an embodied carbon strategy. The strategy contains four actions: policy and regulation, removing barriers and providing incentives, building capacity, and complementary actions such as coordination with other cities. In the first action, the city changed the regulation to require a low-carbon transformation. Since 2017, the city has required rezoning applications to include estimated carbon pollution associated with their materials and construction. There is a proposal underway to require a reduction of at least 20% relative to a 2018 baseline to be effective in 2025 (City of Vancouver 2022). These requirements specify embodied carbon reduction but leave implementation decisions to developers and designers, allowing them to choose the solutions that are most appropriate for their specific project.

Toronto

The City of Toronto's Transform TO Net Zero Climate Strategy sets a goal of net zero greenhouse gas emissions by 2040. To support this goal, the fourth version of the Toronto Green Standard (TGS) came into effect on May 1, 2022, for new development applications. The standard requires all buildings constructed on or after 2030 to be near-zero emissions (City of Toronto 2022).

TGS consists of three tiers of performance measures with supporting guidelines based on the type of building: Tier 1 is mandatory for approval, and Tier 2 and 3 are higher-level voluntary standards associated with financial incentives verified post-construction. For non-residential developments such as City agency facilities, Tier 1 requires a Material Emissions Assessment that identifies low-carbon material alternatives for use in the project or a whole building life cycle assessment of the building's structure and envelope that demonstrates a minimum of 20% embodied carbon reduction compared to a baseline building. Tier 2 requires conducting a life-cycle assessment to calculate the total embodied carbon for lifecycle stages A1-A5 (from raw material production to building installation). Tier 3 requires a full life-cycle assessment for life-cycle stages A1-A5, B1-B5, and C1-C4 (from material production to building demolition and disposal). TGS is expected to be updated with performance requirements for embodied emissions in materials such as concrete, steel, and insulation in 2023 (City of Toronto 2022).

Langford

The City of Langford has adopted a low-carbon concrete policy. As of June 1, 2022, all concrete supplied to City-owned projects and private construction greater than 50 cubic meters requires the use of post-industrial carbon dioxide mineralization technology, or an equivalent that offers concrete with lower embodied carbon. This technology injects captured carbon into fresh concrete, producing the dual benefit of using less cement and sequestering CO_2. The primary supplier will be Butler Concrete and Aggregate Ltd, a supplier based in British Columbia that uses carbon mineralization technology by CarbonCure, a manufacturer of carbon removal and utilization technology based in Nova Scotia (City of Langford 2022).

6 Challenges and Policy Recommendations

6.1 Challenges to Implementing Buy Clean in Canada

There are several challenges shared by all countries seeking to implement green public procurement policy. These include emissions reporting standards, data availability, setting targets, and closing carbon loopholes. Beyond these, there are a set of challenges to implementation that are unique to Canada. These include a highly decentralized public procurement apparatus, limited market size, high integration with the US market, and limited bandwidth for implementation.

Common Challenges to Green Public Procurement Policy

The first set of challenges is around establishing common emissions reporting standards. Emissions reporting standards are required to compare products to one another in terms of environmental impact. This requires selecting one format of reporting, typically an environmental product declaration (EPD), and defining the system boundaries (i.e. which stages of production should be counted). Another challenge is ensuring the emissions data used to produce EPDs are reliable and comprehensive. In some cases, data is unavailable if one segment of the supply chain does not report its emissions. Reliability of data can be especially difficult if some stages of production happen outside of Canada, as regulators cannot always verify the accuracy of reported values.

A second challenge is setting feasible yet ambitious targets for emissions reduction. The targets must be ambitious to incentivize low-carbon innovation without being infeasible, which could harm domestic competitiveness. As a result, developing targets requires an iterative process of engagement with the industry and stakeholders. Experts in currently available technology and future feasibility may include academics, industry associations, and other researchers.

A third common challenge is closing the carbon loophole. The carbon loophole refers to the embodied emissions associated with goods that are traded across borders. If an imported good is not subject to climate policy in its country of origin, it may have higher embodied emissions that are not accounted for by the domestic policy. There are two potentially harmful outcomes if the green procurement policy does not address the carbon loophole from the outset. The first is that manufacturers may avoid low-carbon innovation by selling to another nation with no embodied emissions policy. The second is a potential loss of market share to imported materials. If domestic manufacturers invest in R&D and facilities transformation to reduce emissions, their costs may go up. This could lead to a competitive disadvantage relative to imported materials which do not face these costs. For green public procurement to successfully drive innovation, it must be paired with policies that address the carbon loophole (Moran et al. 2018).

Decentralized Procurement

Canada has a highly decentralized bureaucracy when it comes to public procurement. In 2019, federal spending accounted for less than 12% of public procurement, compared to 43% in the United States and 66% in the United Kingdom. By this metric, Canada has the second-most decentralized public spending of all OECD countries (OECD 2021). When most government procurement spending occurs at the provincial, territorial and municipal level, the impact of federal Buy Clean will be limited (i.e. lower than the potential mitigated emissions shown in section 3).

It can be difficult to build the political momentum to pass Buy Clean policy across all jurisdictions. If select provinces and local governments create their own Buy Clean programs, it can be challenging to harmonize standards across regions after the fact, especially as procurement processes can vary widely between agencies. This can be highly costly if manufacturers need to adjust to a different set of standards and policy frameworks for each jurisdiction. If one province has more ambitious embodied carbon standards than its neighbors, the efficacy of this policy instrument can be weakened by a carbon loophole between provinces where heavy polluters sell to the locale with the least regulation. A high degree of decentralization adds significant complexity to Buy Clean: Canada may benefit from modeling Buy Clean off the European Union's GPP model, rather than a policy from a highly centralized nation.

Market Size

The Canadian economy is less than one-twelfth the size of the US economy (World Bank 2022). Unlike similarly sized European economies, it is distributed across a vast land mass. A small, sparse market can lead firms to have a lower appetite for risk, especially if upfront investment costs are high. Whereas interest in low-carbon materials from the private procurement industry may constitute a sufficiently large market to drive innovation in larger economies, the Canadian economy requires a strong demand signal from public procurement.

Highly Integrated North American Market

The markets for construction materials are highly integrated across North America. Trade with the United States is especially high due to geographic proximity. In 2021, 99% of Canadian cement and concrete exports were to the U.S. and 44% of imports were from the U.S. (Stats Canada 2022). Trade-exposed industries must consider the implications of policy on both sides of the border: the country of destination and the country of origin.

In the United States, President Biden signed an Executive Order that called for a Buy Clean initiative for low-carbon materials in 2021. In August of 2022, the Inflation Reduction Act was signed into law. It allocates over US$250 million to support the development, standardization, transparency, and reporting criteria for EPDs; US$100 million to support the development of a low-embodied carbon label for construction materials; and US$5 billion to purchase low-carbon materials for the construction of federal buildings, roads, bridges, and homes (117th Congress 2022). On top of the federal Buy Clean policy, a sub-national green procurement policy has also been passed. In 2021, 17.4% and 15.2% of cement exports to the U.S. went to Washington and New York, respectively.

In Washington, the Buy Clean and Buy Fair Washington Act goes beyond embodied carbon to also require public procurement to consider prevailing wage and apprenticeship requirements. It failed to pass in the 2022 legislative session, but a version of it may return in the 2023 session. The New York State Low Embodied Carbon Concrete Leadership Act was signed into law in 2022, creating an advisory group to set minimum standards for low-carbon concrete procured by the state (New York State Senate 2022). For Canadian manufacturers to stay competitive in these markets, they will need to build capacity in emissions reporting and reduce the embodied emissions in their products.

In Canada, the Buy Clean policy must be crafted with trade exposure in mind. Low-carbon standards must be applied equally to domestically produced and imported materials. Embodied carbon reporting standards should be harmonized with trade partners to ensure that materials can move easily across borders without the additional overhead of adhering to different emissions standards.

Uneven Distribution of Production

As shown in Figure 38, the production of construction materials, in particular steel and aluminum, are unevenly distributed across the country. By volume produced, steel manufacturing is primarily concentrated in Ontario and Quebec. Aluminum is almost entirely concentrated in Quebec. Cement and concrete are more distributed with cement manufacturing in almost every province across the country. However, Ontario and Quebec account for 57% of cement manufacturing (BlueGreen 2021).

This distribution means that policy in a few provinces may have an outsized influence on the total industrial emissions of the country. It is critical for Quebec and Ontario to build policies that incentivize industrial transformation.

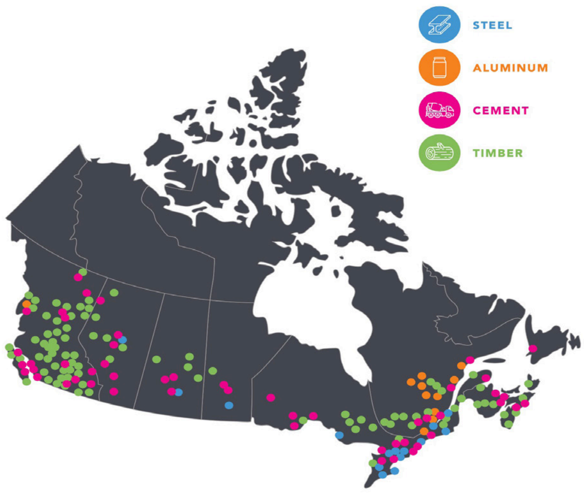

Figure 38. Distribution of production of construction materials across Canada. (BlueGreen 2021).

Lack of Expertise and Bandwidth

Developing expertise in green procurement is a challenge shared by all countries. Procuring officials need to learn about embodied emissions, EPDs, lifecycle analysis, and new frameworks for bid evaluation. In Canada, this is exacerbated by the problem of bandwidth. In federal agencies and select sub-national agencies, such as those in Ontario, Quebec, and Vancouver, there may be sufficient budget and staffing to support building in-house expertise in green procurement. However, in smaller provinces and municipalities with fewer procurement agents, there will be a lack of bandwidth to learn about green procurement practices. This is especially problematic due to the significant scale of procurement that occurs below the federal level within Canada.

6.2 Policy Recommendations

6.2.1 International best practice

Many governments around the world have already recognized the value of green public procurement as a policy instrument and are leveraging the money they invest in large contracts to achieve environmental goals. Hasanbeigi et al. (2019) studied 30 such programs, 22 of which were in countries in Asia, Europe, North and South America, Africa, and Oceania, five case studies at the city and regional level, and three GPP programs at multi-lateral banks and the UN. Based on this study, they identified the GPP program in The Netherlands as one of the world's best for the reduction of emissions from construction materials (cement, steel, etc). Below is a summary of international best practices in the GPP programs studied:

A. **Netherlands**: The Dutch GPP program has two kinds of environmental criteria: minimum requirements, quality criteria, and preference-based, or performance criteria. Tenders that do not meet quality criteria are disqualified from consideration. Performance criteria do not disqualify bids. Rather, they give preference to green materials during the Most Economically Advantageous Tender (MEAT) evaluation. The Dutch GPP program uses software called DuboCalc. DuboCalc is a life-cycle analysis-based tool that calculates the environmental impact of proposed designs based on the materials to be used. It calculates 11 environmental impact parameters and combines them into a single value, the Environmental Cost Indicator (ECI). Bids must meet a maximum allowable ECI and additional reductions in emissions are monetized as a discount applied to the quoted price. 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: rather than prescribing technical details, it places the onus on the bidder to consider trade-offs between cost, embodied emissions, and durability of materials.

   The Dutch public procurement expertise center, PIANOo, supports procurement officials in adopting green procurement practices. It maintains a website with information about current GPP targets set by Rijkswaterstaat. It also maintains an online tool for building tender documents with environmental criteria. This simplifies the process for procurement officials and bidders alike.

B. **European Union:** The European Commission has created a set of common GPP criteria which is the basis for GPP in member states. The criteria are divided into selection criteria, technical specifications, award criteria, and contract performance clauses. For each set of criteria, there are two levels: core criteria, which are designed for ease of use while reducing key environmental concerns, and comprehensive criteria, which are more ambitious requirements for agencies that want to go further in supporting environmental and innovation goals.

The European Union supports the use of project-level analysis in GPP criteria based on a point system. Points can be awarded based on the improvement of life cycle assessment (LCA) performance in comparison with business as usual or competing designs. A weighting system is applied to combine various LCA indicators including global warming potential (GWP), depletion potential of the stratospheric ozone layer (ODP), and acidification potential of soil and water (AP) into an overall score. In the absence of an LCA, the GWP from a carbon footprint (CF) assessment can be used. In the absence of both, points can be calculated from proxy data such as the reduction of CO_2 equivalent emissions from the transportation of materials and recycling of demolition waste (European Commission 2022).

C. **California, United States:** The State of California was the first state to pass the Buy Clean policy in the United States. The Buy Clean California Act requires state-funded projects to consider the global warming potential (GWP) of a set of construction materials during procurement. Covered materials include structural steel, concrete reinforcing steel, flat glass, and mineral wool insulation. An amendment to include concrete in this list is underway.

These laws were introduced in two stages. In the first stage, which lasted three years, manufacturers of eligible materials were required to submit facility-specific EPDs in their bids. Using these EPDs, the Department of General Services determined maximum acceptable GWP limits for each product category. These were set at the industry average for each material. In the second stage, beginning July 1, 2022, compliance with GWP limits will be required to be awarded a state-funded project. The maximum acceptable GWP limits are shown in Table 9. The department must review the maximum threshold for each material every three years. They may adjust the number downward to reflect industry improvements. However, the threshold should not be adjusted upward for any materials (California Department of General Services 2022).

Table 9. The maximum acceptable GWP limits in California Buy Clean (California Department of General Services 2022)

Eligible material	**Maximum acceptable GWP limit (unfabricated)***
Hot-rolled structural steel sections	1.01 MT CO_2 eq./MT
Hollow structural sections	1.71 MT CO_2 eq./MT
Steel plate	1.49 MT CO_2 eq./MT
Concrete reinforcing steel	0.89 MT CO_2 eq./MT
Flat glass	1.43 MT CO_2 eq./MT
Light-density mineral wool board insulation	3.33 kg CO_2 eq./1 m^2
Heavy-density mineral wool board insulation	8.16 kg CO_2 eq./1 m^2

D. **South Korea:** South Korea is a frontrunner in the use of electronic procurement systems and platforms for GPP implementation. In 2002, they created a fully integrated procurement system called the Korea Online E-Procurement System (KONEPS) which manages registration, creation of procurement requests, tendering, contracting, payments, and monitoring. In 2017, KONEPS had over 52,000 public users and 373,000 supplying companies, representing 71% of the total government procurement volume.

   In 2007, South Korea set up a Green Product Information Platform (GPIP) to facilitate reporting of green purchases. Records from over 30,000 public organizations are collected. This enables estimation of the impact of GPP on country-wide environmental impacts. The CO_2 emission reduction is calculated by comparing the environmental impact of eco-labeled products with conventional products (UNEP 2017).

6.2.2 Recommendations

Based on a review of international best practices in green public procurement policy, we propose the following recommendations.

- **Accelerate development of emissions reporting standards and industry-wide EPDs.** Reliable data is central to the successful implementation of Buy Clean. Embodied emissions reporting must be rooted in accurate, supply-chain-specific data. To compare products against one another and prior years' products, this data must be reported in a clear and standardized format. These are key building blocks for Buy Clean. Canada has already invested in building a centralized, publicly accessible life-cycle inventory database through the Low Carbon Assets through Life Cycle Assessment (LCA^2) initiative. Given the central role of this data in the Buy Clean policy, these efforts should be prioritized higher through additional resources. From the perspective of sequencing, this is the first step in Buy Clean; without life cycle emissions data, it is impossible to set quantitative embodied emission limits. Therefore, it is the highest priority task at present.

- **Buy Clean should evaluate international best practices to find novel ways to encourage the adoption of Buy Clean at subnational levels including** infrastructure transfer agreements; a federal backstop; and incentives for infrastructure investments that use low-carbon materials. Due to the highly decentralized nature of public procurement, Canada's Buy Clean program must be designed with sub-national governments in mind.

  Canada may benefit from replicating the EU GPP criteria. The EU GPP core criteria establish a common baseline: countries without the administrative capacity to invest in creating targets can use the core criteria as is while more ambitious countries can extend the framework to establish even more ambitious targets. This creates the conditions for policy experimentation as countries find the best GPP implementation for their specific governance context. Similarly, the federal government in Canada could lay the groundwork by creating a common set of embodied carbon reduction targets. This could replicate the policy framework behind the carbon price: the federal standards serve as a backstop for provinces such as Ontario that do not have their own embodied carbon policies. This significantly reduces the administrative burden of program setup for sub-national agencies. Provinces and municipalities should be able to experiment with even more ambitious targets; this experimentation in different provinces may lead to novel programs that can then be incorporated into federal Buy Clean.

Operationally, this might look like conditions attached to federal transfer payments. For example, the first set of requirements may be that all bids are submitted with product-level EPDs for eligible materials including steel, cement (concrete), and aluminum. If some provinces or municipalities have more strict Buy Clean policies, they may require materials with embodied carbon under some maximum value. This would be permissible. However, no projects funded by federal transfers can be contracted to bidders that have not submitted EPDs. To support sub-national governments to purchase low-carbon materials or adopt Buy Clean policies, the federal government could provide additional financial incentives (e.g. the US Inflation Reduction Act includes a 2% incentive to cover the incremental costs of using low-carbon materials in federal transportation projects).

- **Get ahead of subnational Buy Clean policies to avoid fragmentation.** Local governments are already making moves to design their own Buy Clean policies. Federal Buy Clean should move quickly to establish common reporting standards to ensure harmonization across regions. This will significantly simplify the bidding process for suppliers and avoid repeated work: it is unnecessary for each city to conduct a unique study to identify reasonable limits on embodied carbon for every product class.

- **Use a two-tiered approach to promote innovation while maintaining feasibility.** Procurement programs that only set a minimum environmental standard may reinforce current best practices and eliminate negligent actors from the competition. However, they do not lead to breakthrough innovation. Conversely, GPP targets that are too ambitious may be infeasible, potentially harming the competitiveness of the domestic industry. A two-tiered system like the EU GPP criteria can achieve both: the minimum criteria can be set at the industry average to ensure it is realistic while a second tier can be set at the 90^{th} percentile to reward innovative low-carbon materials. In practice, this ambitious tier can be applied to a percentage of public procurements. For example, the policy can require 10% of total public procurement to meet the higher, ambitious standards. It is then up to the procuring agency which projects they choose to apply the higher standards. Alternatively, the first tier can be a required minimum standard while the ambitious tier is rewarded through a discount applied to the project price, giving these projects a competitive advantage.
- **Prefer performance-based standards over prescriptive standards.** Taking learnings from the Dutch green public procurement program, Buy Clean standards should use whole-project life-cycle assessment over product-level standards where possible. This allows for comparison across materials: rather than prescribing technical details, this gives the bidder the flexibility to consider trade-offs between cost, embodied emissions, and durability of materials.

- **Ratchet up standards over time.** As technological advancements are made over time, Buy Clean targets should be adjusted to reflect new industry capabilities. This ensures that Buy Clean continues to promote green development and innovation. Maximum GWP standards can be lowered at two- or three-year intervals. The Carbon Leadership Forum proposes two models for the rate of change. The first is a percentage reduction using the initial value as a baseline to reach nationally determined contributions, such as zero carbon by 2050. The second is to reduce the value based on the new industry average such that the maximum GWP continuously reflects the 80^{th} percentile of industry performance. Figure 39 shows how these pathways would change the GWP limit over time.

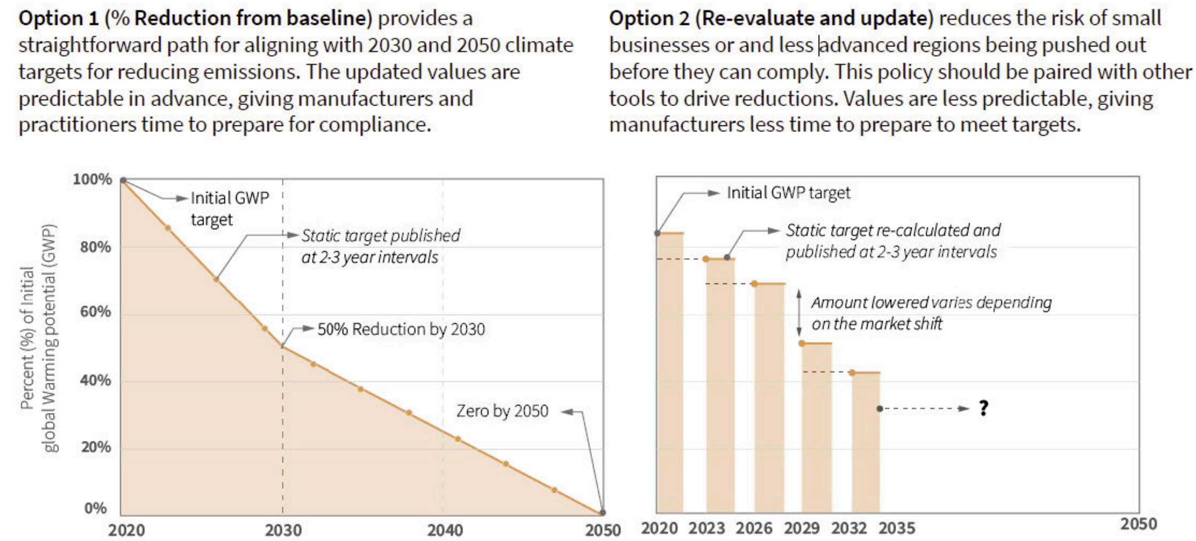

Figure 39. Two options for reducing maximum global warming potential (GWP) limits over time (Carbon Leadership Forum 2020).

- **Invest in programs to build capacity.** The use of EPDs and whole-project life cycle analysis will require a change in long-standing construction and procurement practices. It will take training for engineers to become familiar with the appropriate use of new materials, for construction workers to update processes such as concrete curing, and for procurement officers to adapt to evaluation criteria that go beyond the least cost. Federal Buy Clean should invest in creating training materials and programs to build this capacity. It would be valuable to create a team to assist sub-national governments and private entities in the implementation of green procurement, similar to the support offered by PIANOo in the Netherlands. This team could build expertise on embodied carbon, lifecycle analysis, and tender creation; this could translate into online resources and acting as consultants to other public agencies. This team could be a part of NRCan, with the online hub modeled after the Clean Growth Hub initiative shared by ISED and NRCan.

- **Create tools that can automate and simplify the implementation of the Buy Clean policy.** Many provinces and cities with smaller bureaucracies do not have the time and resources to invest in green procurement. The federal government should invest in software tools that simplify creating tender documents with environmental criteria, evaluating bids that reward emissions reductions, and monitoring during construction. Creating this suite of tools simplifies the implementation of Buy Clean, making it easier for procurement officials at all levels of government to prioritize environmental objectives. If the tools are open-sourced, they may even be adopted by the private sector. An example of this is the Dutch DuboCalc: an LCA-based tool developed by the Rijkswaterstaat (Department of Public Works of the Dutch Ministry of Infrastructure and the Environment) to calculate and compare the environmental impact of procurement. This tool is open to the public and can be used by the private sector as well as the public sector, lowering the barrier to the adoption of green procurement practices economy-wide.

- **Protection against offshoring through a carbon border adjustment mechanism (CBAM).** For trade-exposed industries where public procurement is not a significant portion of the total market share, it may not be economical for manufacturers to invest in retrofitting or adopt sustainable practices. This is because companies that invest in low-carbon technology may need to charge a price premium on their products causing consumers to search for cheaper options abroad. To mitigate these risks, assurances should be made that action will be taken to prevent emissions leakage in the private sector if necessary. This may be in the form of a carbon border adjustment mechanism (CBAM). The details of this measure are complex as they should be harmonized with major trade partners and complement the carbon price.

- **Close the uncertainty gap in the carbon price.** While the federal government has stated that the carbon price will rise to CA$170 per tonne by 2030, there is uncertainty due to the potential for future governments to change course. Private sector actors hesitate to take on this risk. Closing the certainty gap will give private actors the confidence to invest in low-carbon innovation. This can be done through carbon contracts-for-differences (CCfD), which removes uncertainty over future carbon prices by having the government take on the risk: if the future price falls short of the agreed-upon contract, the government pays the difference. This has been proposed in the Emissions Reduction Plan and should be implemented to incentivize private investment in decarbonization.

- **Continue to invest in industrial transformation.** The federal government should provide loans, grants, and financial support programs to help manufacturers pay the upfront costs required for retrofitting industrial facilities, building new facilities, and retraining workforces.

7 Conclusions

Public procurement accounts for a significant share of the Canadian economy. In 2020, public procurement represented about 27% of total government expenditure and slightly more than 13% of national GDP. Out of total public procurement spending (i.e., total expenditure by federal, provincial, territorial, and municipal governments), approximately 22% of expenditure goes towards infrastructure projects such as roads and buildings. These heavily utilize energy-intensive materials including cement and concrete, steel, and aluminum.

We also estimated the scale of embodied emissions associated with this public spending. Public procurement of cement, steel, and aluminum across all levels of government in Canada accounted for approximately 2.3 Mt CO_2, 5.5 Mt CO_2, and 0.1 Mt CO_2 emissions in 2019, respectively.

More and more governments are using their purchasing power to drive the industry towards more sustainable products and materials through green public procurement. Canada has already committed to reducing emissions from government emissions through the Greening Government Strategy. Specifically, the federal government will reduce embodied carbon by 30% starting in 2025 through the use of recycled and lower-carbon materials, material efficiency, and performance-based design standards, and conduct a whole building life-cycle analysis by 2025 for major projects. Using scenarios for emissions reduction targets, we estimated the impact of the Buy Clean policy at all levels of government on emissions. Table 10 shows the annual CO_2 emissions reduction potential resulting from Buy Clean for cement, steel, and aluminum in Canada in 2019.

Table 10. Annual CO_2 emissions reduction potential from Buy Clean for cement, steel, and aluminum in Canada in 2019 (in kt CO_2).

	Cement		Steel		Aluminum	
Buy Clean Target	Govt funded construction projects	Potential indirect impact (from cement used in non-Govt funded procurement)	Govt funded construction projects	Potential indirect impact (from steel used in non-Govt f unded procurement)	Govt funded construction projects	Potential indirect impact (from aluminum used in non-Govt funded pro-curement)
Low - 10% reduction	234	498	555	1,359	11	108
Medium - 20% reduction	469	996	1,111	2,719	21	217
High - 30% reduction	703	1,494	1,666	4,078	32	325
Transformative - 50% reduction	1,172	2,490	2,776	6,797	54	542

We find that Buy Clean would be beneficial for Canadian businesses. This is because the electricity grids of Ontario and Quebec, where much of the steel and aluminum are produced, are already low carbon, especially relative to developing countries. In addition, Canada uses a substantial amount of natural gas in its heavy industries as opposed to coal which is the primary fuel used in most other countries. As a result, the CO_2 intensity of aluminum and steel produced in Canada is already lower than the weighted average CO_2 intensity of imported aluminum and steel (See Appendix 4 for more detail on the CO_2 intensity of steel and aluminum in different countries). However, implementation and adoption of green procurement have been slow due to a lack of bandwidth. Canada should invest in accelerating the LCA[2] Initiative's effort to create an emissions inventory, create a set of common targets similar to the EU's common GPP criteria, build or adopt tools to simplify the adoption, and create a team within NRCan to help other public agencies adapt to new practices on embodied carbon.

Green public procurement can catalyze significant carbon emissions reductions in construction materials by acting as a signal of durable demand. This will make Canadian manufacturers more globally competitive as other countries including the United States and much of Europe adopt their green procurement policies. Canada should move quickly to maintain its low-carbon advantage to capture the domestic and international markets. Based on a review of international best practices in green public procurement policy, we have proposed several concrete recommendations to advance the Buy Clean policy in Canada.

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Appendices

Appendix 1. Methodology to Estimate the Scale of Procurement

The analysis presented in chapter 2 is based on the Use table from the input-output tables published by Statistics Canada for the entire country as well as for the provinces (Statistics Canada, 2020). Use tables provide the relationship between the consumers (industries presented in columns) and the producers (commodities presented in rows). Use tables are generally divided into intermediate use (commodity used by other industries) and final consumption (i.e., gross capital formation or exports) (Statistics Canada, 2018).

Total expenditure by the government on construction sectors was identified using the Gross Fixed Capital Formation (construction) section of the use table. The gross fixed capital formation section provides the expenditure by various government jurisdictions (Health, Education, Other federal government, other provincial government, other municipal government, etc.) on the various construction sectors (see Table 1 for descriptions). The economic value of investments made by the construction sectors for the procurement of construction materials (see Table 2 for construction materials) is extracted from the intermediate consumption section of the use table.

The share of government spending was estimated for each construction sector by comparing the government spending with the total expenditure on respective construction sectors. The government spending for each construction material of interest was estimated by assuming that the government spending represents the same share estimated in the previous step for the material procurement within each construction sector (e.g., government spending for non-residential buildings represents 39% of total expenditure. Government spending on construction materials was estimated by assuming a government share of 39% for all construction materials procured for non-residential building construction). A similar procedure is followed for the estimation of the scale of procurement at the level of provinces.
To distinguish between direct federal funding and funding by provincial, territorial and municipal governments on construction projects, based on the definitions of jurisdiction, construction spending for education (CMEC) and healthcare infrastructure was assumed to be part of provincial, territorial and municipal government spending (The Commonwealth Fund, 2020) and only “Other federal government services (except defense)” are assumed to be direct federal funding.

Appendix 2. The Scale of Provincial Procurement for other Provinces

Appendix 2 presents the scale of procurement of all construction materials of interest for all provinces. Figures A1 to A5 present the total procurement of construction materials by public and private sectors for all provinces in 2018. Provinces of Ontario, Quebec, Alberta, and British Columbia represent the majority of spending on the procurement of all construction materials of interest. The share of public spending is highest for the procurement of iron and steel across all provinces followed by public spending on cement and concrete. Shares of public spending on wood products are lowest across all provinces in 2018.

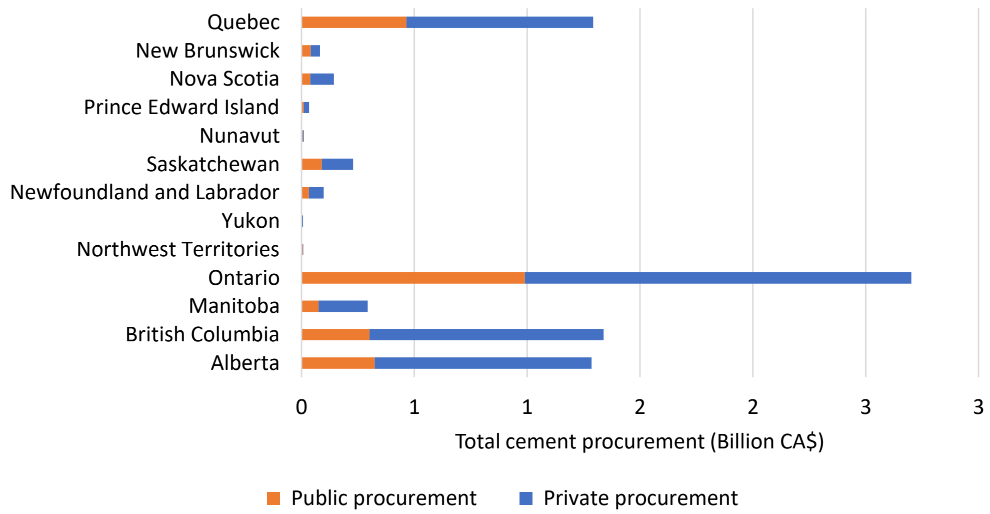

Figure A1. Total public and private spending on procurement of cement by the provinces in 2018 .

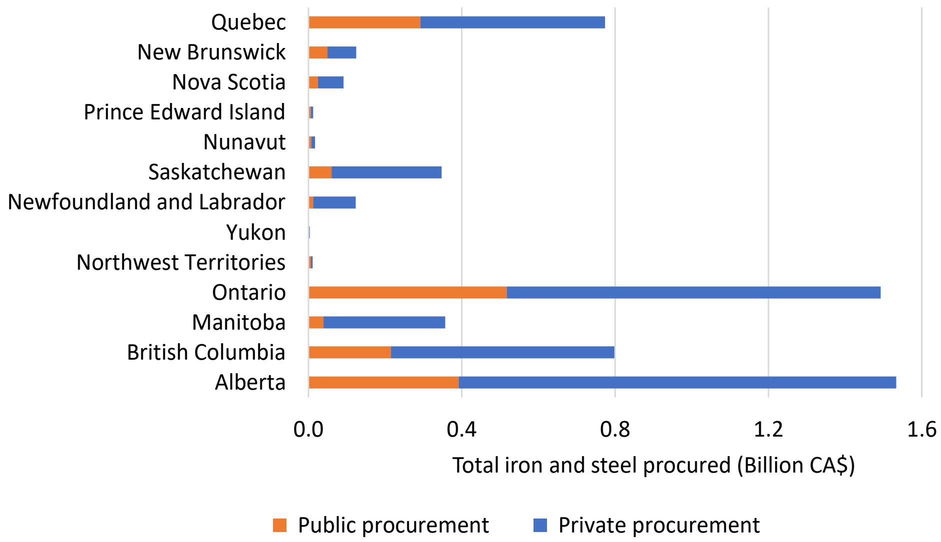

Figure A2. Total public and private spending on procurement of iron and steel by the provinces in 2018.

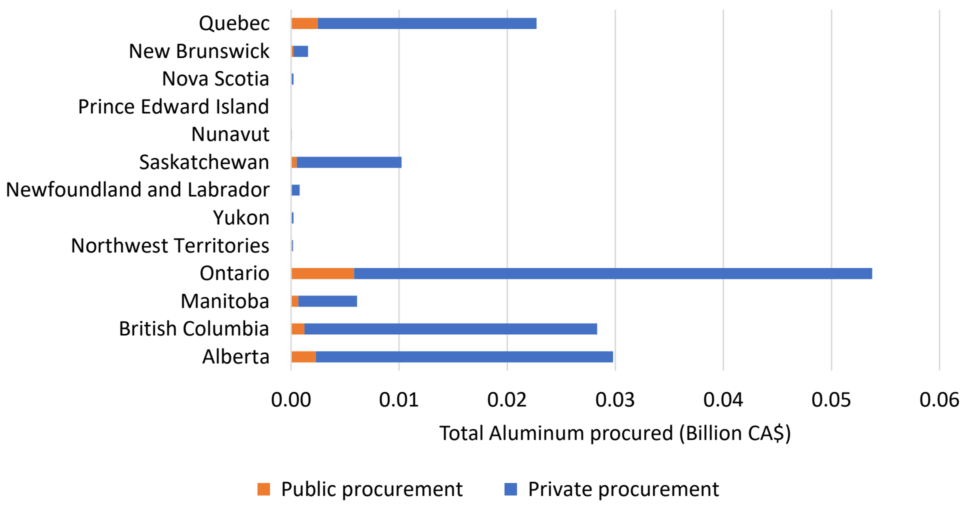

Figure A3. Total public and private spending on procurement of Aluminum by the provinces in 2018.

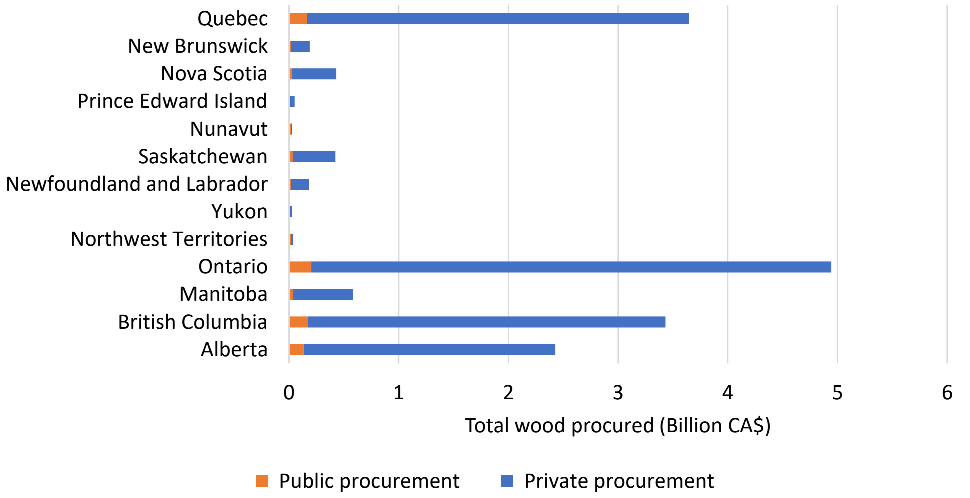

Figure A4. Total public and private spending on procurement of wood products by the provinces in 2018.

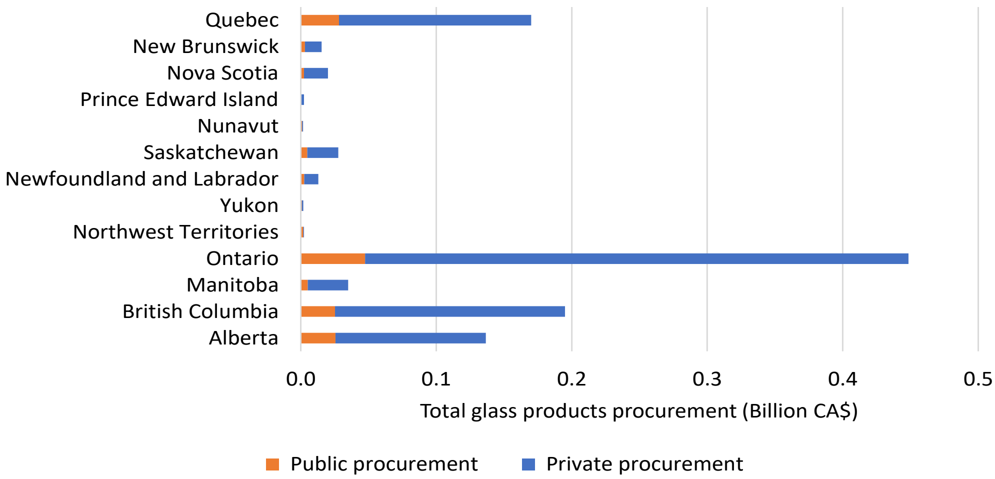

Figure A5. Total public and private spending on procurement of glass by the provinces in 2018 .

Appendix 3. Shares of Material Procurement for Construction Sectors

Table A1. Spending on the procurement of construction materials of interest relative to total construction spending for construction sectors (estimated as % of total construction-related spending based on Statistics Canada, 2020a)

	Residential building construction	Non-residential building construction	Transportation engineering construction	Oil and gas engineering construction	Electric power engineering construction	Communication engineering construction
Canada	14%	9%	14%	7%	6%	3%
Alberta	17%	12%	15%	3%	6%	2%
British Columbia	16%	11%	14%	4%	6%	3%
Manitoba	16%	9%	12%	9%	13%	2%
Newfoundland and Labrador	14%	13%	10%	0%	3%	2%
Northwest Territories	22%	15%	2%	3%	4%	5%
Nunavut	15%	20%	7%	0%	5%	2%
Ontario	11%	7%	21%	12%	6%	2%
Quebec	16%	9%	10%	13%	4%	3%
Saskatchewan	15%	9%	9%	4%	4%	6%
Yukon	17%	7%	2%	54%	2%	0%
New BrunSwick	12%	11%	9%	8%	7%	6%
Nova Scotia	17%	15%	4%	10%	8%	1%
Prince Edward Island	15%	12%	16%	10%	0%	3%

Appendix 4. Comparison of CO_2 Intensity of Steel and Aluminum Production in Canada and other Countries

The following subsections show the results of international benchmarking of the CO2 emissions intensities in the steel industry and aluminum industry in major steel and aluminum producing countries. These are from our previous studies published in Hasanbeigi (2022) and Hasanbeigi et al (2022). Please see these reports fa or a more detailed explanation of benchmarking analysis and results.

Appendix 4.1. Steel Industry's CO_2 Intensity Benchmarking

Benchmarking the Total Steel Industry's CO_2 Emissions Intensities

The ranking of the CO_2 emissions intensity of the steel industry among the countries studied is presented in Figure A.6. Italy, U.S., and Turkey have the lowest, and Ukraine, India, and China have the highest CO_2 emissions intensity.

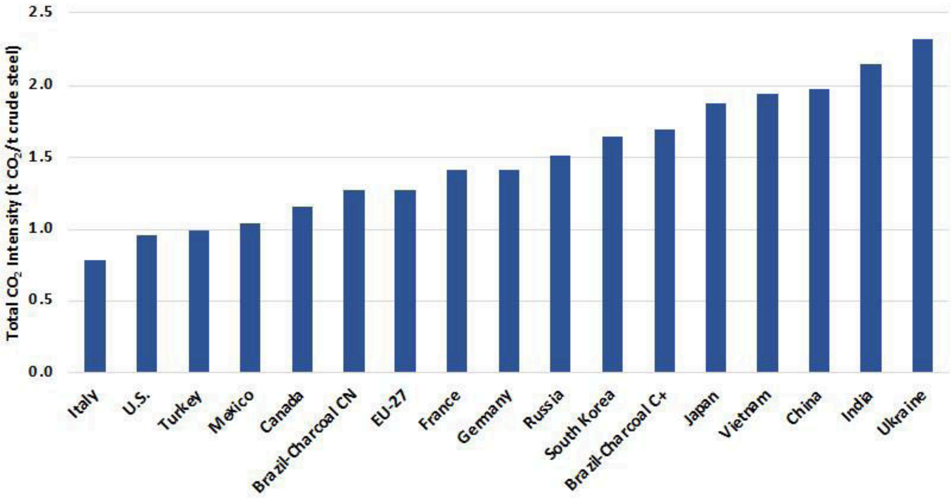

Figure A.6. Total CO_2 emissions intensity of the steel industry in 2019 (Hasanbeigi 2022).

Note: Brazil-Charcoal CN refers to when charcoal is considered carbon neutral. Brazil-Charcoal C+ refers to when charcoal is not considered carbon neutral because of questions and concerns regarding the sustainability of biomass used in the steel industry in Brazil. See methodology in the Appendix for more information.

Benchmarking BF-BOF Steel Production's CO_2 Emissions Intensities

Figure A.7 shows the CO_2 intensity of BF-BOF steel production in different countries in 2019. Canada has the second lowest CO_2 intensity for primary steel production.

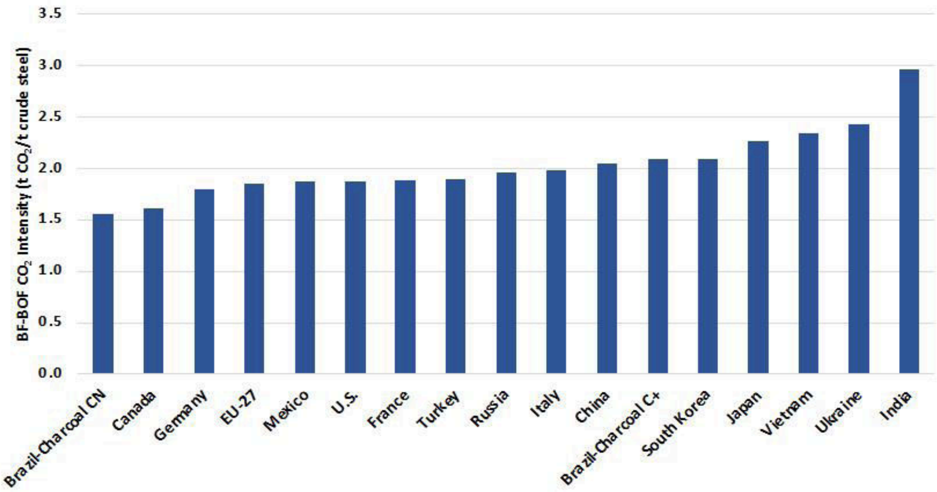

Figure A.7. The CO_2 intensity of BF-BOF steel production in 2019 (Hasanbeigi 2022).

Note: Brazil-Charcoal CN refers to when charcoal is considered carbon neutral. Brazil-Charcoal C+ refers to when charcoal is not considered carbon neutral because of questions and concerns regarding the sustainability of biomass used in the steel industry in Brazil. See methodology in the Appendix for more information.

Benchmarking EAF Steel Production's CO_2 Emissions Intensities

Figure A.8 shows the CO_2 intensity of EAF steel production. Brazil and France have the lowest and India and China have the highest CO_2 intensity of EAF steel production. Canada has the third lowest CO_2 intensity for primary steel production.

A key reason why the CO_2 intensity of EAF steel production in India, China, and Mexico are significantly higher than that in other countries is the type of feedstock used in EAF in these countries. In most countries, steel scrap is the primary feedstock for EAF. In India and Mexico, however, a substantial amount of DRI (around 50% in India and 40% in Mexico) is used as feedstock in EAFs. In China, instead of DRI, a significant amount of pig iron (around 50% of EAF feedstock), which is produced via blast furnace, is used as feedstock in EAFs. Both DRI and pig iron production are highly energy-intensive processes, which result in higher energy and CO_2 intensity of EAF steel production when used as feedstock in EAFs. Vietnam's high CO_2 intensity of EAF steelmaking can be mainly attributed to its very high electricity grid CO_2 emissions factor. Another important factor that influences the CO_2 intensity of EAF steel production is the electricity grid CO_2 emissions factor (Hasanbeigi 20222).

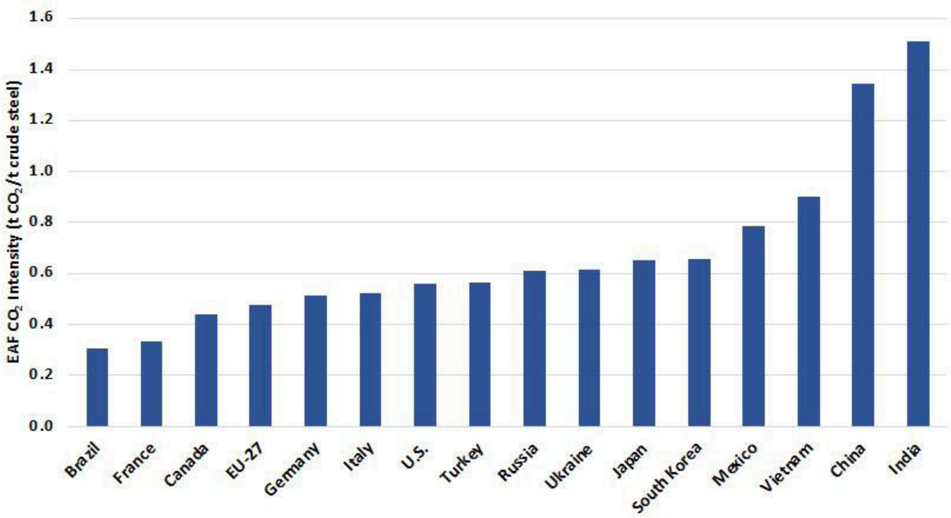

Figure A.8. The CO_2 intensity of EAF steel production in 2019 (Hasanbeigi 2022).

Appendix 4.2. The Primary Aluminum Industry's CO_2 Intensity Benchmarking

Figure A.9 shows the energy-related CO_2 emissions intensities for primary aluminum production in the different countries/regions, based on the system boundary of the alumina production and electrolysis phases (Hasanbeigi et al. 2022). Our results show that India, China, and Australia have the highest, and Iceland, Norway, and Canada have the lowest energy-related CO_2 emissions intensities among the countries/region studied. Among several reasons, this is primarily because of the emissions factors of electricity used to produce aluminum in these countries (mainly in the electrolysis process). It should be noted that all aluminum plants in Canada are located in Quebec and British Columbia, which have extremely low-carbon electricity generation. While in our previous study (Hasanbeigi et al. 2022) we did consider a large share of zero-carbon hydropower for electricity used in the Canadian aluminum industry, if only the carbon emissions factor of electricity generated in Quebec and British Columbia, where aluminum plants are located, are considered, then the CO_2 emissions intensity for aluminum production would be around 1.3 t CO2/t aluminum.

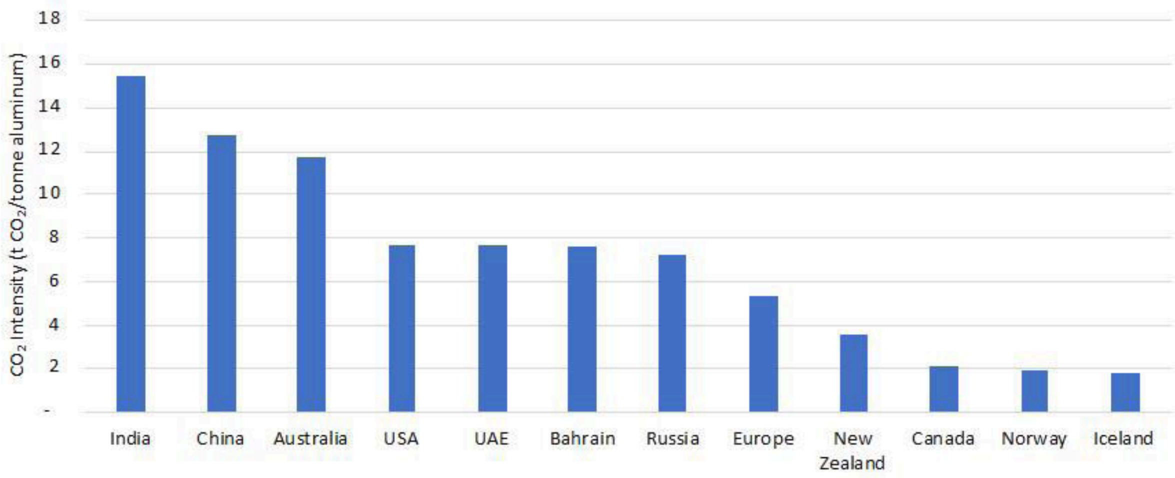

Figure A.9. The energy-related CO_2 intensity of primary aluminum production in 2019 (Hasanbeigi et al. 2022).

Note: Both smelters and alumina production processes are included. The CO_2 emissions from both electricity and fuel use are included.