

INDUSTRY

Cement



10.2 CEMENT

Function	A binding agent in concrete (a mix of cement, aggregates and water) that is a basic construction material.
GHG emissions	10 Mt of CO ₂ e in 2024 (Process emissions about 60% , energy-use emissions about 30% , with the remainder from transport and operations). Approximately 1.5% of Canadian emissions.[61] ¹
Options for decarbonization	Decarbonization Pathways: Electrification, hydrogen, hybrid energy mix, CCUS. Bridge Pathways: Alternative fuels (biomass and waste). Niche Pathways: Alternative chemistries. Enabling Pathways: Supplementary cementitious materials, optimizing design, recycling.
Stage of transition	Emergence: Electrification, hydrogen, alternative chemistries. Emergence / diffusion: CCUS. Diffusion: Hybrid energy mix, alternative fuels (biomass and waste), supplementary cementitious materials, optimizing design, recycling.
Current obstacles:	Decarbonization technologies are capital intensive; some are immature, while others face regulatory policy barriers. Weak demand for low carbon cement and high building sector sensitivity to material prices; cumbersome codes and standards process slow to adopt innovations; competitiveness concerns.
Economic/social opportunities:	Job creation while developing and implementing new technologies, reduction in air pollution and associated health risks; climate adaptation/resilience applications.
Industrial policy/competitiveness	Cement production in Canada is dominated by multinational parent companies; international collaboration can accelerate decarbonization.
Priorities for action	Public investment in demonstration and commercial applications of viable low-carbon cement technologies; government procurement of low-carbon cement and support for material-efficient design; movement to performance-based codes and standards; research and development on novel technologies.
Longer-term issues	Alternative cement chemistries; alternative building materials.
Indicators of progress	Percent change in GHG emissions from cement manufacture; market penetration of low-carbon cement.

¹ All noted references can be found in the full Playbook document.

10.2.1 Current Status

Cement is manufactured by heating limestone, clay, and sand to form an intermediate product called clinker, which is then ground into cement. As the second-most consumed material globally after water,[373] cement acts as a binder in concrete—a fundamental construction material used across commercial and industrial buildings, housing, roads, schools, hospitals, dams, airports and ports.

Canada produces 13 to 14 million tonnes of cement per year.[374] With 16 domestic cement manufacturing plants (15 integrated, one grinding plant) that ship cement to more than 1,100 concrete facilities, the industry directly employed more than 27,000 people in Canada in 2023 (Figure 30), with a GDP of \$5.0 billion². [359,375] Cement production is concentrated in central and Western Canada, and financial impact is provided primarily by Ontario (34%), Alberta (21%), Quebec (17%), and British Columbia (14%), with exports going to the United States.[373]

Cement and Clinker Production in Canada

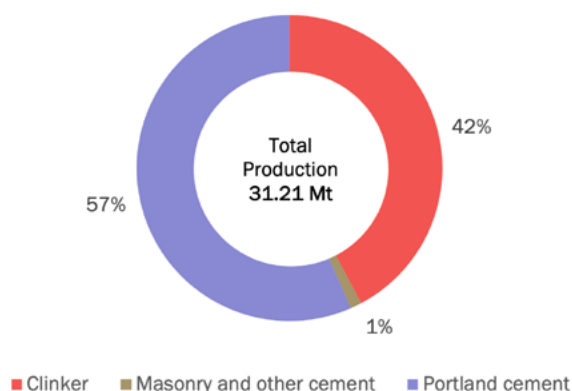


Figure 30. Cement and Clinker Production in Canada

Source: Annual Survey of Cement, production and exports – 2023 Dataset[376]

10.2.2 Nature of the Problem

The cement industry is energy, material, and emissions intensive. Historically, cement production in Canada relied primarily on coal and petroleum coke products (82%); electricity (13%); natural gas, liquid petroleum products and waste oil products (4%); and tire-derived fuels and other alternative energy sources (2%).[377] However, over the past decade there has been movement towards gas and alternative fuels as energy sources.

Most carbon emissions are produced during clinker production: approximately 60% from process emissions associated with calcination, and 40% from fuel combustion to provide kiln heat.[378] As the dominant energy user, 90% of total energy consumption comes from clinker production while the remaining 10% of energy is used in activities related to fuel and raw material preparation, grinding of clinker, and the blending to produce finished cement.

In 2024, the cement industry emitted 10 Mt of CO₂e. This represents approximately 14% of heavy industry emissions and 1.5% of Canada's total emissions.[61] Of these, 7.3 Mt CO₂ (66%) are process emissions associated with clinker production and the remainder are energy-related.[186]

Cement production is highly capital intensive, requiring large upfront investments in facilities that are expected to operate for decades. In Canada, production is concentrated among six companies, most of which are multinational firms. As a result, the sectors are shaped not only by domestic conditions but also by competitive pressures in global markets, particularly from the U.S.[379]

² Chained (2017) Canadian dollars

10.2.3 Net-Zero Pathways

Shifting cement production towards net zero will require a variety of approaches. While energy and operational efficiencies can deliver incremental emission reductions, deeper structural changes are needed to address both energy-related and process emissions.[380] Recent sector analyses suggest that demand-side measures, such as material efficiency, increased reuse and recycling, and reduced over-specification (i.e., the practice of specifying concrete strength, cement content, or durability requirements beyond what the application requires, resulting in unnecessarily high cement use and associated emissions), could account for a significant share of cumulative emissions reductions through 2050. These measures would complement supply-side approaches such as fuel switching, additional binders, and CCUS.[381] Given the long operating lifetimes of cement kilns, decisions about major retrofits and reinvestment over the next one to two decades will be critical in determining whether the sector can align with net-zero trajectories. Key elements that can contribute to such a transformation include:

Net-zero energy: Replace fossil fuels burned in kilns to provide heat with renewable (or other net-zero) energy. Options include the use of biomass and waste-derived fuels, electrification, and hydrogen.[77] Waste and biomass are already used as partial substitutes for fossil fuels within the sector, but some waste streams have associated air pollution risks, and provincial policy barriers have limited their deployment in Canada relative to international best practice. To date, alternative fuels have included waste wood, paper, textiles, plastics, tires, and asphalt shingles. Moving to 100% alternative fuels in kilns presents additional technical and practical challenges, including maintaining a consistent fuel mix, the availability of fuel supply, managing life-cycle emissions, and addressing

air pollution. Electrification, with electrified kilns and pre-heating technologies, is technically plausible but has not been demonstrated at an industrial scale and would require substantial kiln redesign. Hydrogen is another potential alternative but would again require kiln redesign, as well as access to a reliable and affordable supply of low-carbon hydrogen.[77]

Low-carbon cements: Reducing the proportion of clinker in the final cement mix by adding supplementary cementitious materials (SCMs) can significantly reduce emissions. Blast furnace slag and coal fly ash are the most common SCMs used today, although supplies are being disrupted as decarbonization proceeds in other sectors; these could be replaced with recovered landfilled materials, recycled construction materials, unprocessed limestone, or calcined clay, amongst others. The Cement Association of Canada has a roadmap to increase SCMs and decrease clinker substantially in cement blends by 2050 (see Figure 31).[373] New SCMs are being actively researched, developed, and sourced, such as incorporating local calcined clays and limestone with clinker and gypsum, which can reduce process emissions by around 40%.[382]

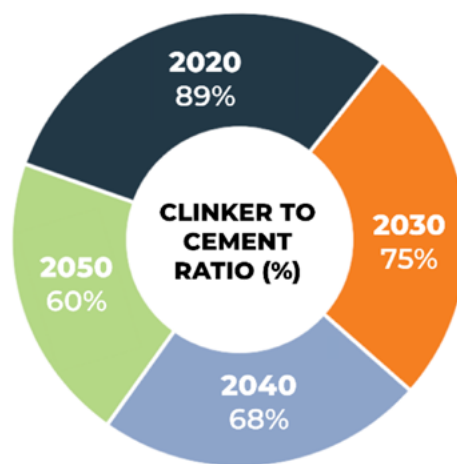


Figure 31. Canada, Clinker-cement ratio targets for decarbonizing production proposed by the Cement Association of Canada (2020-2050)

Source: Cement Association of Canada, 2023. Canada's cement and concrete industry action plan to net zero.[373]

More fundamentally, novel clinker chemistries could replace traditional limestone-derived clinker—a number of such chemistries, with varying emission intensities, are currently being explored. One option is alkali/geo-polymer-based-cement, which could reduce emissions by 70% compared to conventional clinkers using widely available minerals.[77] Magnesium silicate or ultramafic cements could eliminate emissions entirely or even achieve carbon negative results, but these remain in the early development phase and material availability and cost may limit their potential contribution.[373]

Carbon capture, utilization and storage

(CCUS): Capture of CO₂ from process emissions, and perhaps also from fuel combustion, could play an important role in the solution mix.[382,383] Captured CO₂ can be permanently sequestered in geological formations or used in other industrial processes. Some approaches are already being deployed on a small scale, such as injecting CO₂ into wet concrete, where it can both strengthen the building material and store carbon within the finished structure. Internationally, multiple full-scale CCUS projects in the cement sector are now moving into funded demonstration and early commercial deployment. These include operational and advanced projects at European cement plants, such as Heidelberg Materials' Brevik facility in Norway, as well as proposed large-scale applications under development in Canada, including at Heidelberg's Edmonton plant.[384,385] In addition, it may also be possible to accelerate the natural carbonation of concrete as it ages, by exposing crushed concrete to air or concentrated CO₂ streams, for example, to

reduce the lifecycle GHG emissions of cement and concrete. However, the viability of CCUS at scale depends not only on capture technologies but also on the availability of shared CO₂ transport and long-term storage infrastructure.

Demand reduction: Cement use can be minimized by improving the design of structures to require less new cement and concrete, and to employ more recycled construction material. Concrete can also be replaced by other materials that have lower emissions profiles, such as timber, the use of which can yield significantly lower emissions than concrete in similar applications.[386] New forms of wood construction, including cross-laminated timber, could compete with concrete in low- to mid-rise construction, but have yet to be widely adopted. Research is ongoing into a variety of net-zero (or in some case net-negative) building technologies. Demand can also be reduced by extending the service life of existing structures through adaptive reuse and retrofit, delaying the need for new cement- and concrete-intensive construction.[381]

Cost remains a key challenge for deep decarbonization, particularly for a low-margin product such as cement. Cement is often cited as one of the most difficult and potentially expensive industrial sectors to decarbonize.[382] Some analyses suggest costs could double, which would translate to roughly a 30% increase in the cost of concrete. However, experience with past cost estimates for meeting other environmental objectives and the possibilities for significant technological advances suggest this may be an overstatement.

Competitiveness Implications

Canada's cement plants are not owned by domestic firms competing in a national market; they are facilities within multinational portfolios, and the question that determines their future is whether those multinationals direct their next generation of decarbonization capital here or elsewhere. That contest is already underway: these same firms are advancing fully funded CCUS-equipped cement facilities in Europe and evaluating large-scale investments in the United States. With kiln assets built to last decades, the reinvestment decisions made over the next 10 to 15 years will determine which facilities become low-carbon flagships and which do not. Canada has relevant advantages: geological CO₂ storage, emerging transport infrastructure, the potential to anchor demand through public procurement. But those advantages only matter if they are in place before capital decisions are locked in.



10.2.4 Priorities for Action

There is no single pathway to decarbonize the cement industry. Demand for low-carbon cement remains limited, and wider adoption of lower-carbon cements may require adjustments in construction techniques and building codes, as alternative cement compositions can differ in setting times or structural characteristics.[387]

Despite these challenges, decarbonizing cement is critical and can complement other sectoral transitions in buildings, heavy industry, and rollout of CCS technologies and the hydrogen economy.

Governments should encourage R&D and support large-scale demonstration and early commercial deployment of technologies that address both energy-related and process emissions. These include options such as

electric, hydrogen, and biofuel heating; CCS applications; and novel cement chemistry.

Policy levers such as carbon pricing, performance-focused building codes, and public procurement can help create demand for lower-carbon cement. In particular, ensuring that codes and standards can keep pace with innovation by moving from prescriptive, material-specific requirements toward performance-based standards can enable the deployment of new and alternative low-carbon materials while maintaining safety and durability. [381] Additional measures to improve building design to reduce material usage, discourage landfill of construction waste, and encourage recycling of building materials can further lower system-wide emissions. Given that the cement industry is dominated by a small number of large multinational firms, international coordination—particularly on R&D, demonstration, and financing—can accelerate change.[388]

Criteria Status

- Fails to meet criteria
- Meets in some respect
- Not promising
- Potentially meets criteria
- Meets criteria

10.2.5 Cement Pathways Table

Not promising Potentially meets criteria Meets criteria			ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS		ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
 Heat											
Alternative Fuels (biomass and waste)	Bridge Pathway Limited by biomass and waste availability.	Deploy Support supply chain buildout and connection of kilns to waste or biomass sources.	Reduces kiln heating and energy emissions. Reduction depends on fuel carbon intensities. Fuel substitution typically isn't 100%.	Depends on the fuel sources and availability but can be less expensive than other solutions as it leverages existing assets.	Can create niche economic clusters and rural jobs tied to biomass/waste supply chains. Production of low-carbon construction material.	Commercial and used globally. Full-scale plants in Canada. Very high rates of substitution are difficult to achieve.	Strong fit. Alternative fuels can often be integrated with existing burners and fuel handling. High substitution complicates operations.	Conditionally suitable as reliable local supply chains are needed to ensure consistent supply of alternative fuels.	Mixed acceptance. Depends on whether waste-derived fuels are perceived as incineration and on air and water emissions.	High relevance for cement operators and provinces. One of the most deployable near-term levers for kiln heat. Appears in major cement facilities in Canada.	Co-benefits include waste diversion. Concerns around air pollutants and lifecycle. Uncertainty if biomass/waste is not sustainably sourced.
Electrification	Potential Decarbonization Pathway Could fully eliminate kiln energy emissions if used with decarbonized electricity.	Incubate Fund R&D.	Eliminates kiln heating and energy emissions with decarbonized electricity. Must be combined with efforts to manage process emissions.	Economics are uncertain and depend on availability of affordable low-carbon electricity. Requires major retrofits.	Production of low-carbon construction material.	Large scale prototypes underway globally, research and development occurring mostly abroad.	Requires substantial process redesign. Easier for greenfield sites.	Requires very high-capacity electrical interconnections which may require grid infrastructure upgrades.	Generally positive with visible reduction in fossil fuel combustion.	Interest where low-carbon electricity is available and there are strong carbon commitments. Some pilot projects in Canada.	Reduction in air pollution. Large electricity requirement, so there may be competition for low-carbon electricity.
Hydrogen	Potential Decarbonization Pathway Could fully eliminate kiln energy emissions if used with net-zero hydrogen.	Incubate Fund Canadian demonstrations and pilots. Support buildout of hydrogen supply chain and infrastructure or co-location of production with cement kilns.	Can reduce combustion-related CO₂ when hydrogen is low-carbon.	Depends on availability of affordable low-carbon hydrogen.	Strategic opportunity with regional hydrogen and cement production hubs. Production of low-carbon construction material.	Global commercial-scale demonstrations have occurred. Still in research and development.	Conditionally applicable for kiln heat with fuel system modifications. High substitutions not tested. Evidence indicates it is applicable without major retrofit.	Requires establishment of low-carbon hydrogen supply chain and infrastructure.	Generally acceptable, but there can be some concern around the safety of hydrogen.	Interest where hydrogen sources may become available.	Reduced air pollution. Higher system complexity.

PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS	ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
				ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
Hybrid Energy Mix (combination of alternative fuels, electrification and/or hydrogen)	<i>Potential Decarbonization Pathway</i> Could either serve as a decarbonization, enabling, or niche pathway depending on market development. Must be combined with process emissions management.	Incubate Fund Canadian demonstrations and pilots. Develop guidance on optimizing fuel choice for regional advantages.	 Can significantly reduce kiln heat emissions assuming input energy sources have low carbon intensities and fossil fuels are eventually eliminated from the energy mixture.	 Allows for adjustment to lowest-cost and most available mix. Operational costs rise with multiple systems.	 Depends on the fuel types chosen. Can contribute to broader industrial electrification or hydrogen strategies, but does not necessarily achieve economies of scale.	 Global commercial-scale demonstrations have occurred with hydrogen and alternative fuels. Many mixes still in R&D.	 Retrofitting can be incremental and work well in brownfield sites. Facility changes will depend on the energy types selected.	 Infrastructure and supply chain is dependent on the energy sources chosen. Multiple supply chains provide flexibility but also increase complexity of coordination.	 Issues will depend on energy blend chosen, but should be generally accepted.	 Relevance is high as research, piloting, and demonstration have typically occurred with hybrid strategies (partial integration of one or more of the identified heating pathways).	 Depends on hybrid mix, but may lower burden on infrastructure and maintenance schedules. Expedited progress if facilities can substitute new energy types in partial amounts.
 Low Carbon Cement											
Alternative Chemistries	<i>Potential Niche Pathway</i> Can lower clinker production emissions and energy requirements but contingent on commercialization.	Incubate Fund R&D.	 Can lower energy and process emissions associated with clinker production (lower firing temperatures, clinker blending requirements, or direct emissions). Reduction depends on chemistry used.	 Vary with chemistry and availability of feedstocks. Estimated costs are currently higher than incumbents.	 Develop new mineral and cement precursor supply chains with export potential. Some chemistries may have improved structural or chemical properties.	 Alternative chemistries are at different levels of R&D. More research needed to determine which chemistries are suitable for which cement applications.	 Some chemistries may fit well into existing production processes while others may require different firing temperatures and curing times. Development of standards and regulations is required.	 Supply chains are immature for materials needed for new chemistries. Domestic sourcing may be available for some materials while others may need established international sourcing.	 Affordability of materials, particularly as it applies to housing, will be a concern. Some skepticism may occur around use of new materials.	 Interest is rising with Canadian stakeholders. Likely to be caution around adopting materials with fundamentally different chemistries in construction.	 Benefits will depend on the alternative. Could be cement with improved properties.

PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS	ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
				ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
Carbon Capture Utilization and Storage	<i>Potential Decarbonization Pathway</i> Can be used to manage either energy or process-related emissions.	Enable Support buildout of CO ₂ infrastructure in regions with geological storage and projects that incorporate utilization of capture carbon.	Without radical change to cement chemistries, essential to get to net zero.	Potentially viable pending policy, funding tools, etc.	Strong opportunity to be an anchor tenant for the CCUS industry.	Multiple projects leading to full scale are under construction in Canada. Globally advanced projects are also underway.	Feasible with high emissions capture for both energy and process emissions. Requires additional operational expertise, space, and energy. Can be added during retrofit schedules.	Needs CO ₂ pipelines and storage access. Hub models and permitting capacity are constraints. Some regions with natural storage are better positioned.	Some concerns regarding CO ₂ leakage from storage.	Investment from multiple Canadian companies, active research environment.	Links to broader applications including hydrogen production. Captured CO ₂ can be injected into concrete for strengthening. Extra burden on electrical infrastructure and capacity.
Supplementary Cementitious Materials (SCMs)	<i>Enabling Pathway</i> Recognized broadly as a strategy for reducing clinker use and associated emissions.	Deploy Support scaling for commercial SCMs and R&D for new SCMs. Build out supply chains that align SCM production with Canada's natural resource endowment. Accelerate regulatory changes.	Significantly reduces clinker use and associated emissions. Near-term lever while other technologies develop. Cannot reach net zero alone as clinker emissions are not eliminated with incumbent cement chemistries.	Economics depend on the material. New materials may and need support as supply chains scale.	Opportunity to build new supply chains for SCMs, repurpose local industrial waste. Align Canada's natural resource endowment clustering mining with cement.	Varies according to the SCM. Many have high maturity but as those are exhausted, more novel options will need R&D to mature.	Little change required. SCMs are incorporated at the mixing stage. Curing times may need adjustments and standards and regulations will need to be developed.	Scaling alternative SCMs may require new processing facilities, quarries, and logistics.	No particular issues. Proof of sustainability performance with environmental product declarations will improve optics.	Very high relevance, used today broadly across industry today. Seen as an essential near-term decarbonization lever by many stakeholders.	Benefits will depend on the SCM. Could improve cement properties. Industrial waste diverted from landfills.

			ALIGNMENT WITH CARBON NEUTRALITY	Economic		Technical			Social		
PATHWAY ELEMENTS	ROLE IN NET-ZERO SYSTEM	SIGNAL TO DECISION-MAKERS		ECONOMIC VIABILITY	ECONOMIC DEVELOPMENT OPPORTUNITY	MATURITY	OPERATIONAL FIT	INFRA-STRUCTURE AND SUPPLY CHAIN SUITABILITY	SOCIAL ACCEPTABILITY	RELEVANCE TO STAKEHOLDERS	RELATED BENEFITS AND COSTS
 Optimizing Material Use and Lifespan											
Optimizing Design	Enabling Pathway Near-term solution to reduce lifecycle emissions by lowering clinker demand.	Deploy Update standards to include new materials and design practices. Provide best practices for material choice. Support scaling of mass timber supply chains.	 Material efficiency and reduced over-specification save costs and emissions. Complements supply-side measures.	 Can reduce overall project costs by lowering material use, avoiding unnecessary margins beyond calculated factors of safety, extending asset lifetimes with longer-lasting materials, and using lower-cost materials.	 Grows sustainable building sector expertise and domestic advanced wood products. Adds high-value services and products to exports rather than just raw material.	 Material-efficient design and substitution are well-established practices. Mass timber and hybrid wood-concrete systems are commercial but broader adoption is uneven.	 Some training or reskilling is needed to broadly implement sustainable design practices and materials. Codes and standards may need to be updated.	 Established supply chains. Some expansion will be needed to scale mass timber products.	 Generally well accepted as framed as innovation and climate leadership. Some concerns with fire safety.	 High relevance to many stakeholders up and down the supply chain. Increasing demand for optimized design as a cost-saving measure. Greening government strategy.	 Reduces waste, lowers lifecycle costs. Support for building out the forestry sector and manufacturing.
Recycling	Enabling Pathway Recycled concrete as substitute for aggregates, replaces primary materials but does not target larger clinker emissions.	Deploy Scale recycling infrastructure. Support R&D focused on incorporating recycled concrete as SCMs.	 Compliments other pathways by replacing primary materials required as aggregates in concrete. Repurposes otherwise wasted materials.	 Often good economics, especially when landfill tipping fees are high. Provides local source of aggregates.	 Moderate local job creation at concrete recycling facilities.	 Widely practiced in Canada primarily for roads. More development is needed to reuse fines and aggregates.	 Requires crushing and sorting facilities. No changes to cement plants. Effective when planned into demolitions.	 Recycling infrastructure is uneven across regions. Transport distances can be cost prohibitive, especially in rural areas.	 Concrete recycling is well understood, practiced today, and socially accepted.	 Highly relevant to some stakeholders including waste management in municipalities, and green infrastructure.	 Reduces landfill burden. Lowers lifecycle emissions from quarrying. Benefits strongest when transport distances are low.