



# Lower Carbon Cement and Net-Zero Concrete

*Waste Management Association of BC*

*February 23, 2023*

**Concrete**  
building for life.



# Introduction



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# The voice of Canada's cement industry

Welcome to the Cement Association of Canada, the voice of Canada's cement industry. Together with our members and partners in the concrete sector, we're committed to making concrete a net-zero material of choice.

We're helping to build a better, greener future.

***"Canada's cement and concrete industry are leaders in the fight to stop climate change."*** – Adam Auer, President and CEO, CAC

[www.Cement.ca](http://www.Cement.ca)

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# Content

- **Climate Change**
- Cement Manufacturing Process
- Concrete
- Decarbonizing Cement and Concrete
- Portland Limestone Cement (PLC) and SCMs
- C&D Recycling – Concrete, Lower Carbon Fuels
- Thank you



# Climate Change



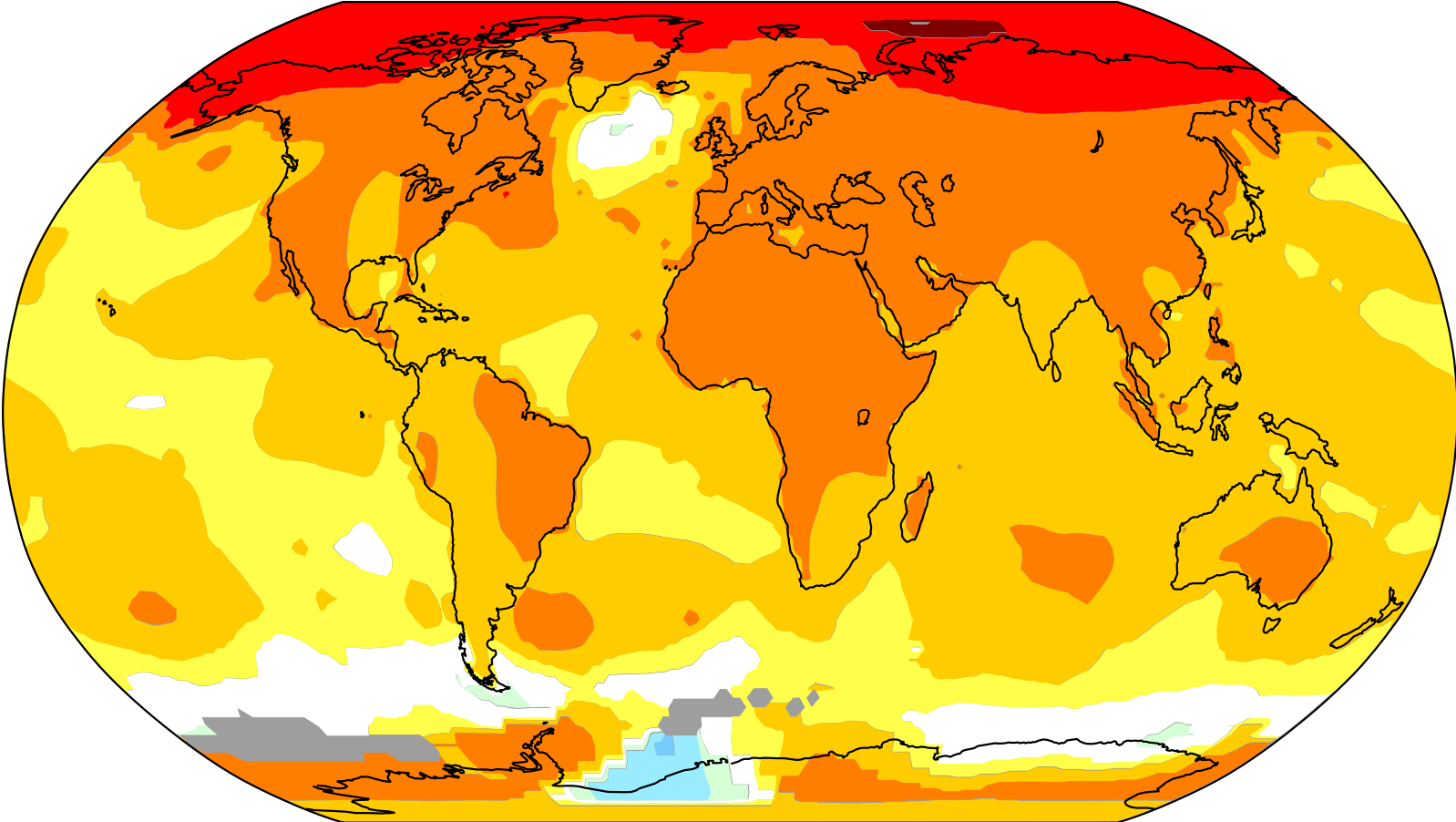
# Temperature change in the last 50 years

**2020 to 2023**

**COVID-19**

**War in Ukraine**

**Climate Change**



2011-2021 average vs 1956-1976 baseline

-1.0   -0.5   -0.2   +0.2   +0.5   +1.0   +2.0   +4.0 °C

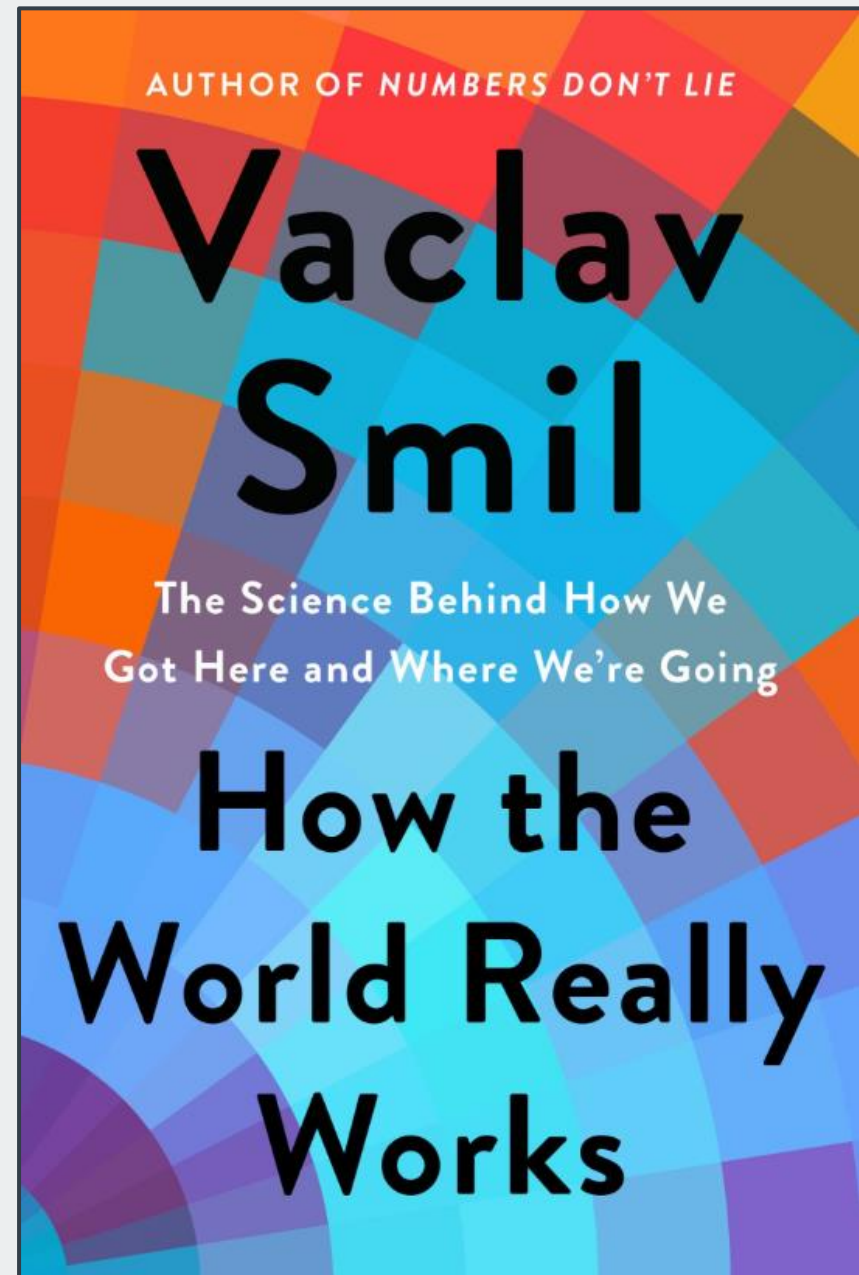


-1.8   -0.9   -0.4   +0.4   +0.9   +1.8   +3.6   +7.2



# Climate Change

*“...four pillars of modern civilization: cement, steel, plastics, and ammonia...”  
page 94*



\$17 eBook  
\$29 Amazon.ca



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# Cement and concrete industry in BC

## ■ Cement Manufacturing Plants

- Heidelberg / Lehigh, Delta and Lafarge, Richmond

## ■ Concrete Operations

- 135 “ready-mixed” concrete facilities throughout BC
- 17 precast concrete producers

## ■ Cement is a Strategic Local Asset

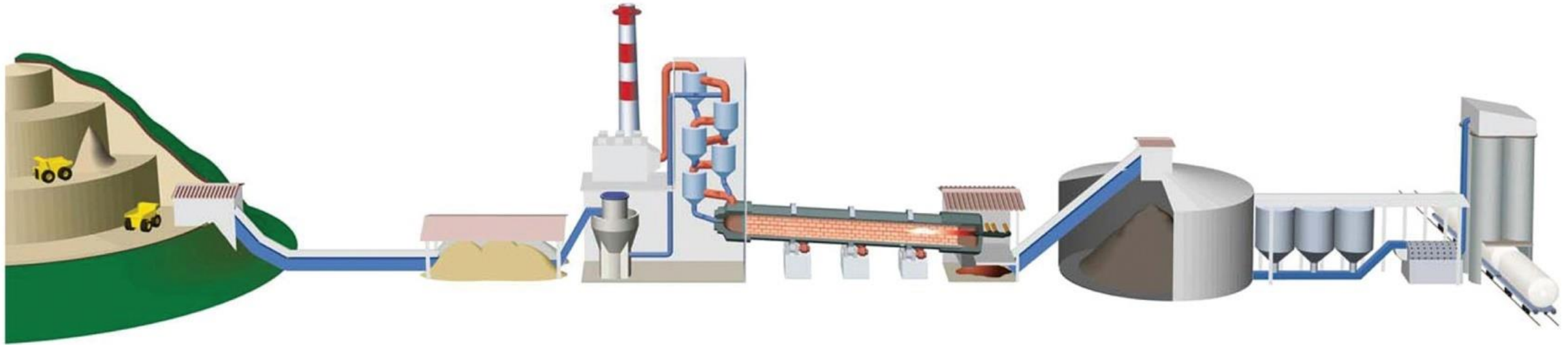
- Cement will continue to be required in all Metro Vancouver / BC infrastructure
- Want to see continued support for **locally produced cement and concrete** in housing, water & sewer utilities, public transportation, renewable energy, industry
- COVID-19 has highlighted the need for domestic manufacturing

## ■ Jobs and Investment

- **Supports more than 23,000 direct and indirect jobs in BC**
- **\$11 billion in direct, indirect and induced economic impact**



# How cement is made



## Quarrying

Limestone and small amounts of sand and clay are extracted, usually from a quarry located near the cement manufacturing plant.

## Raw Materials Preparation

The extracted materials are analyzed, blended with additional mineral components depending on the type of limestone available, and finely ground for further processing.

## Clinker Production

The materials are heated in a kiln reaching a temperature of 1,470°C. The heat transforms the materials into a molten product called clinker, which is then rapidly cooled.

## Cement Grinding and Distribution

The clinker is stored and then finely ground. Gypsum is added to control setting time, along with supplementary cementing materials, such as fly ash or slag, to obtain a fine powder called cement, with the desired properties of strength and chemical resistance.





# Lafarge, Richmond, BC



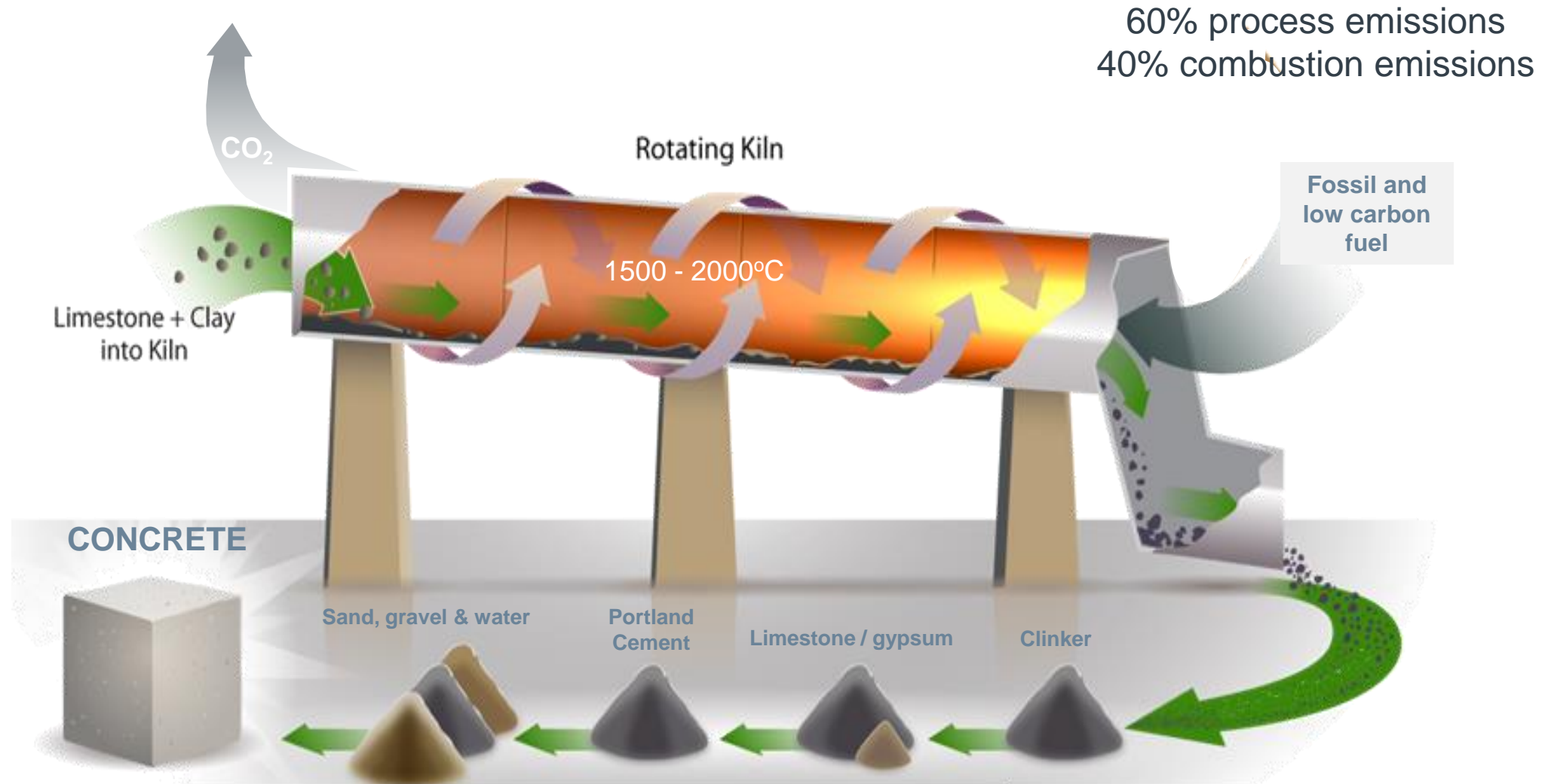


# Heidelberg / Lehigh, Delta, BC





# Cement and concrete production



# GHGs from cement production

- Cement production is energy intensive
- GHGs produced both from combustion and process
- Cement production is responsible for about 8% of worldwide GHG emissions
- In Canada, cement production accounts for about 1.5% of Canada's total GHG inventory
- Options to reduce GHG emissions:
  - Produce lower carbon intensity cement (e.g. PLC, blended cement)
  - Transition from fossil fuels (coal, natural gas) to lower carbon and biogenic fuels (e.g. urban woodwaste, wastewater biosolids)
  - capture CO<sub>2</sub> emissions, including irreducible process emissions
  - Use higher levels of supplementary cementitious materials (SCMs)
  - Use concrete effectively in construction
  - Maximize re-carbonation of concrete at end-of-life



# Cement Kiln





# Cement Kiln





# Raw Materials





# Limestone









# Fuel





# Burner





# Cement Chemistry

- The main constituents in cement powder are:
  - $3\text{CaO} \cdot \text{SiO}_2$  (*tri-calcium silicate*)
  - $2\text{CaO} \cdot \text{SiO}_2$  (*di-calcium silicate*)
  - $3\text{CaO} \cdot \text{Al}_2\text{O}_3$  (*tri-calcium aluminate*)
  - $4\text{CaO} \cdot \text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$  (*tetra-calcium aluminoferrite*)
- Abbreviations:  $C = \text{CaO}$ ,  $S = \text{SiO}_2$ ,  $A = \text{Al}_2\text{O}_3$ ,  $F = \text{Fe}_2\text{O}_3$ ,  $H = \text{H}_2\text{O}$
- The main constituents in cement:  $\text{C}_3\text{S}$ ,  $\text{C}_2\text{S}$ ,  $\text{C}_3\text{A}$ ,  $\text{C}_4\text{AF}$



# Cement Types

TYPE	10	20	30	40	50
<b>C<sub>3</sub>S</b>	53%	47%	<b>58%</b>	26%	43%
<b>C<sub>2</sub>S</b>	24%	32%	16%	<b>54%</b>	37%
<b>C<sub>3</sub>A</b>	8%	3%	8%	2%	2%
<b>C<sub>4</sub>AF</b>	8%	12%	8%	12%	10%
	<i>Most Common</i>	<i>Lower Heat</i>	<i>High Early Strength</i>	<i>Low Heat</i>	<i>Suphate Resisting</i>

# Cement Phase Diagram

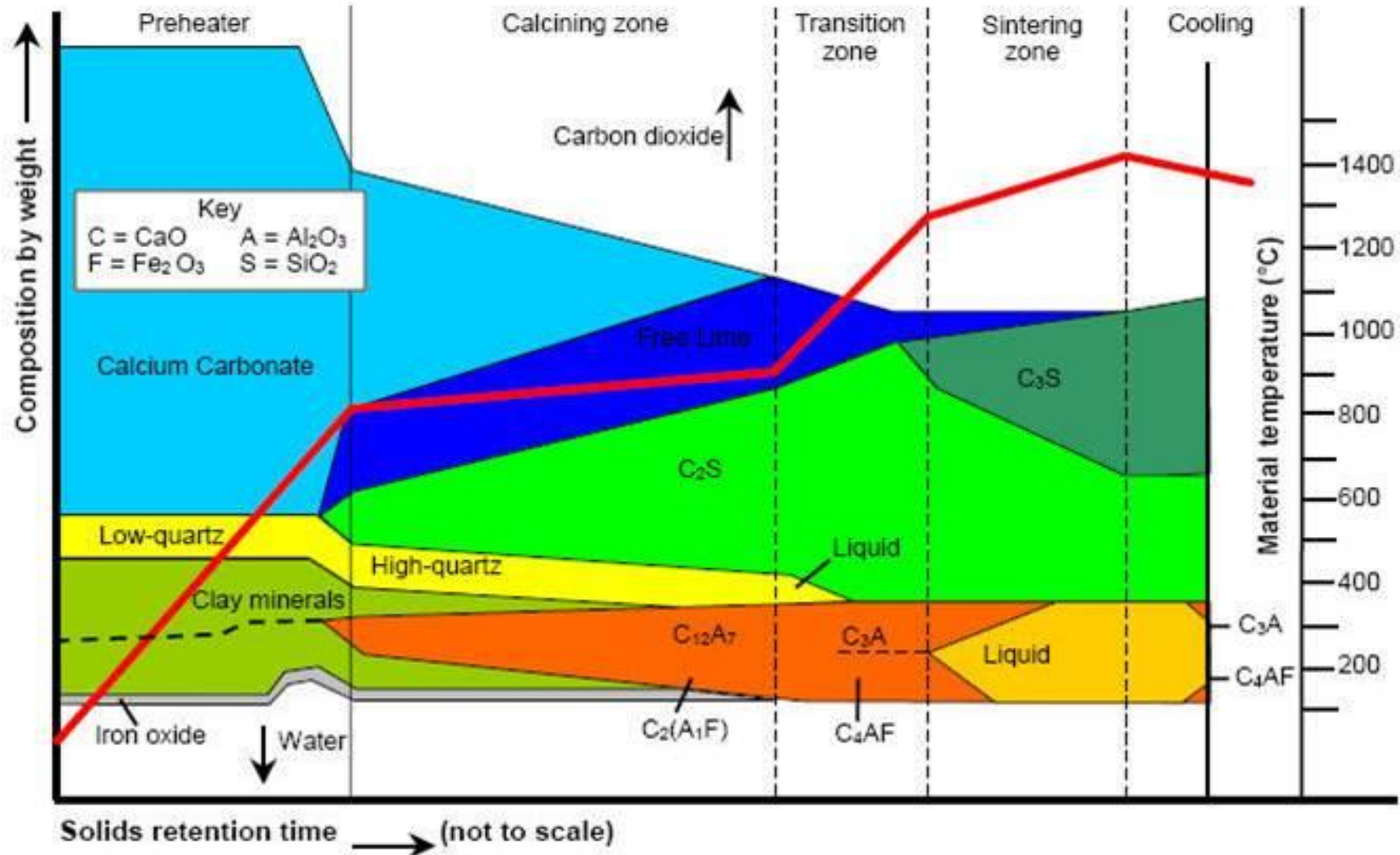


Figure 1-2 - Typical Pre-heater Kiln Processing System

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# Concrete



# Cement and concrete industry in BC

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- **Concrete Operations**

- 135 “ready-mixed” concrete facilities throughout BC
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- **Cement is a Strategic Local Asset**

- Cement will continue to be required in all Metro Vancouver / BC infrastructure
- Want to see continued support for **locally produced cement and concrete** in housing, water & sewer utilities, public transportation, renewable energy, industry
- COVID-19 has highlighted the need for domestic manufacturing

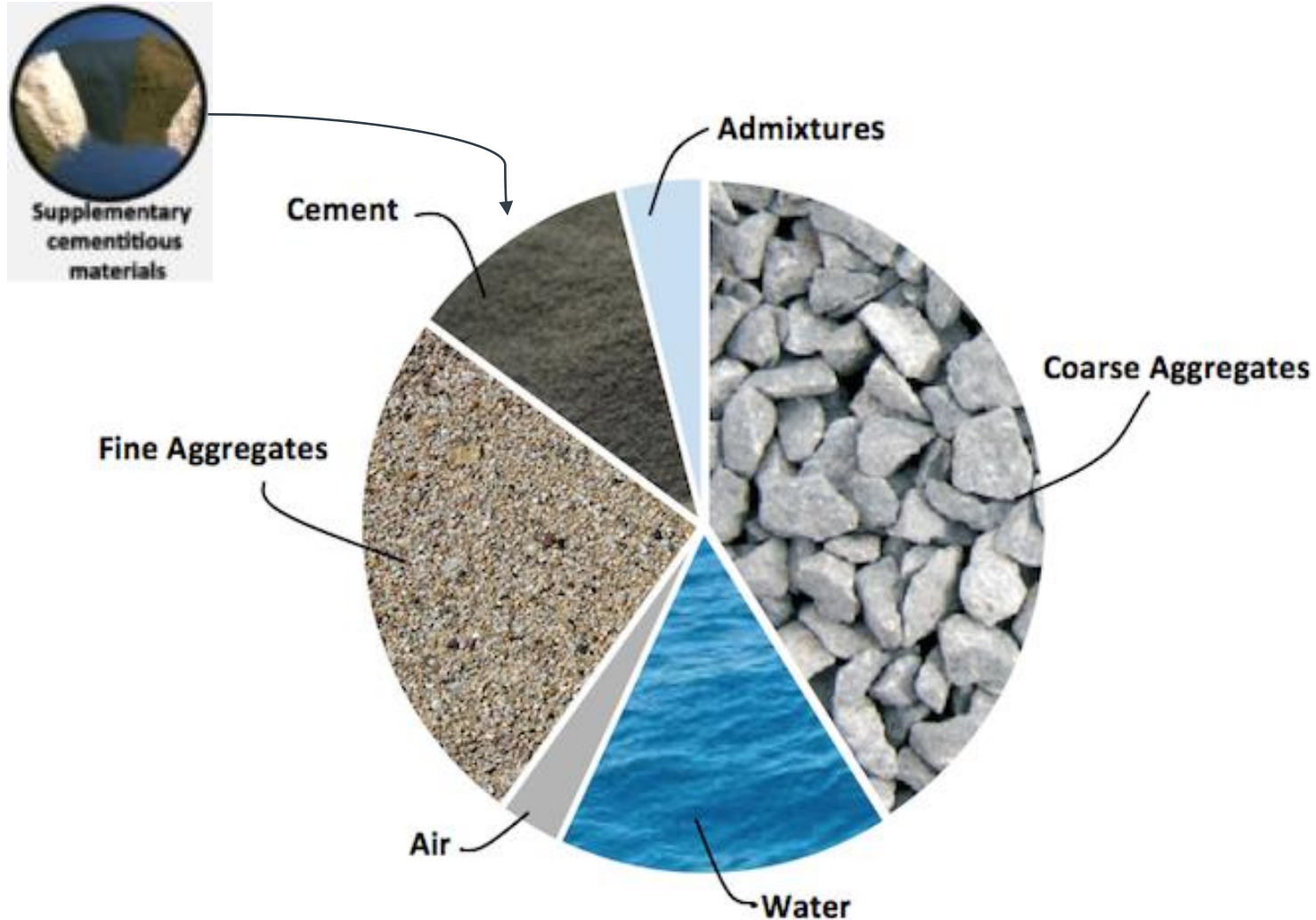
- **Jobs and Investment**

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# Concrete

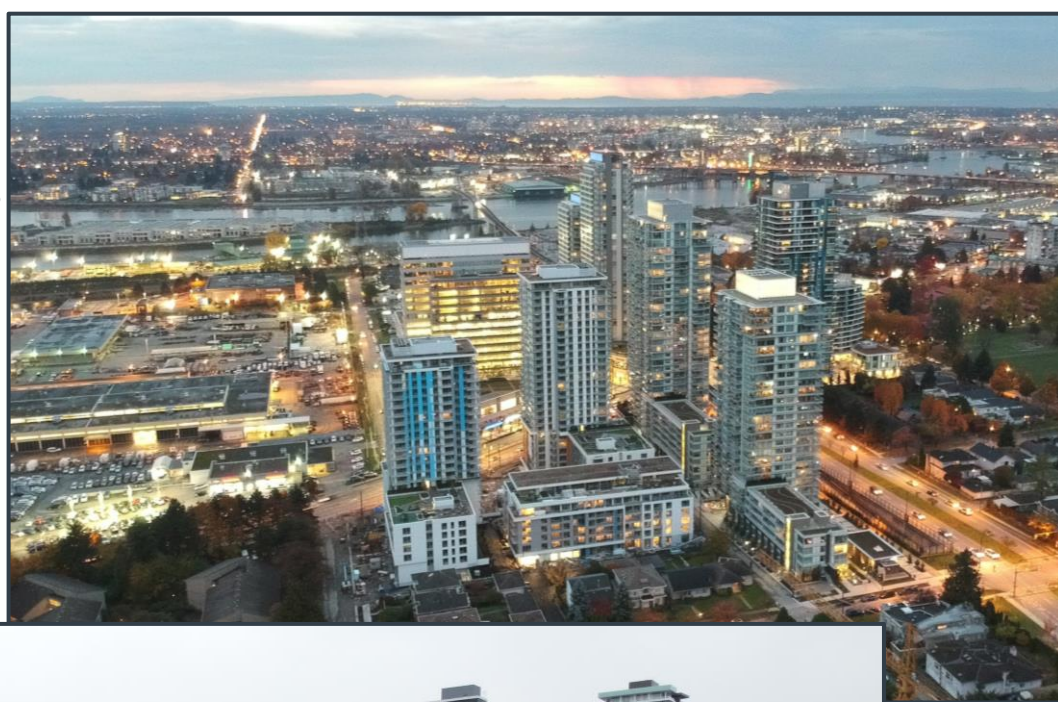


- 7-15% cement is added to water, sand and gravel
- but cement comprises 60% to 80% of the carbon footprint of concrete

# Concrete as an important building material

- All construction requires concrete
- Twice as much concrete is used than all other materials combined
- over **20 billion tonnes / 8 billion m<sup>3</sup> of concrete** produced globally each year
- using 4 billion tonnes of cement
- Second most consumed material in the world, **second only to water**
- Concrete is inherently a local material

Marine Gateway, Vancouver



Brentwood, Burnaby









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# Our challenge is reducing GHGs in the cement, concrete and construction industry

- **Net-Zero Carbon Concrete Action Plan and the “5-Cs”:**  
*Clinker, Cement, Concrete, Construction, re-Carbonation*
- **Key areas to reduce GHG emissions:**
  - Produce **lower carbon intensity cement** (e.g. PLC, blended cement)
  - Transition from fossil fuels (coal, natural gas) to **lower carbon and biogenic fuels** (e.g. urban woodwaste, wastewater biosolids)
  - **capture CO<sub>2</sub> emissions**, including irreducible process emissions
  - Use higher levels of supplementary cementitious materials (**SCMs**)
  - **Use concrete effectively** in construction
  - Maximize **re-carbonation of concrete at end-of-life**



# Canadian Cement Industry Partnering with Federal & Provincial Governments to Lower Carbon Footprint

- 1. *Canada's Cement Industry and the Government of Canada have partnered to establish Canada as a global leader in low-carbon cement and to achieve net-zero carbon concrete.***
- 2. *A reduction of 15 Megatonnes of GHGs needs to be achieved by 2030. On-going additional reductions of 4 Megatonnes a year.***
- 3. *We are proud partners of an Industry-Government Working Group that includes the NRC, the SCC, and ISED\* that are working together on broad adoption of Green Procurement Rules with the Treasury Board of Canada Secretariat.***

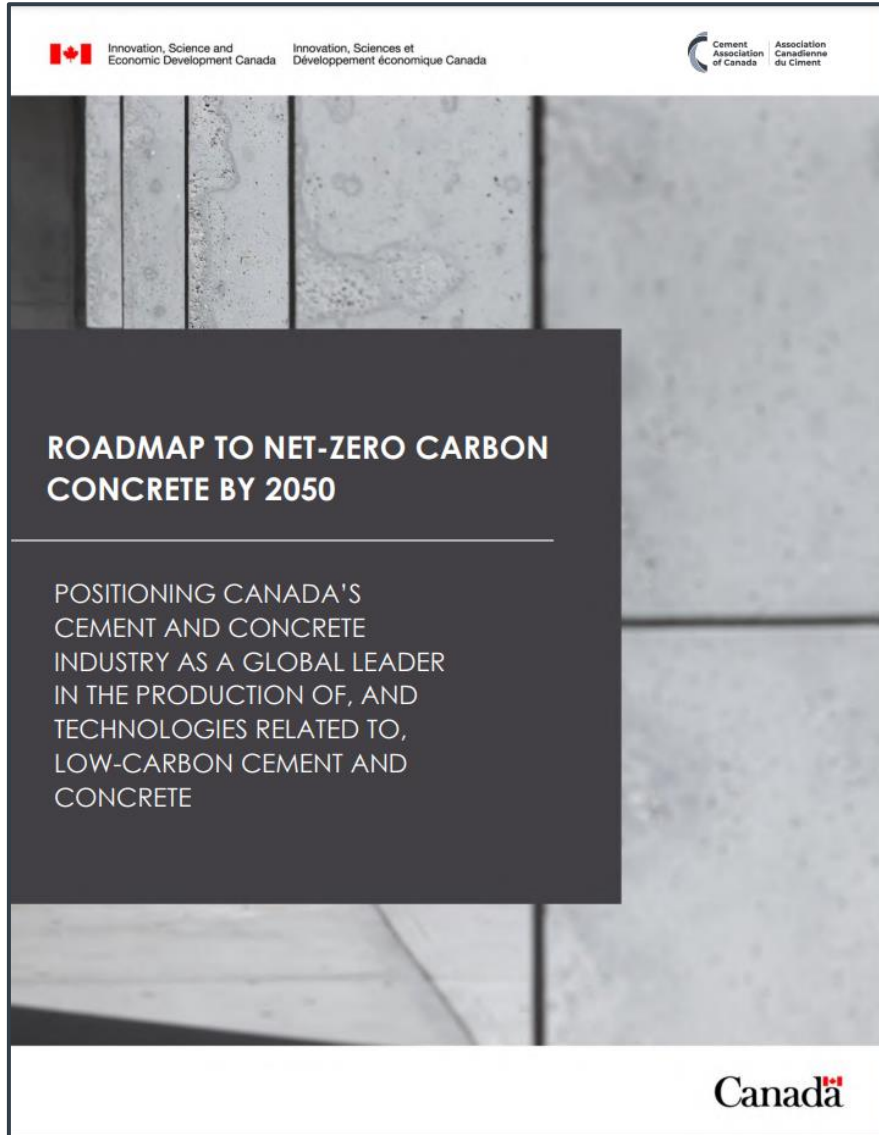
*\*NRC – Natural Resources Canada*

*SCC – Standards Council of Canada*

*ISED – Innovation, Science and Economic Development*



# ISED Roadmap to Net-zero Carbon Concrete



## Roadmap to Net-zero Carbon Concrete by 2050

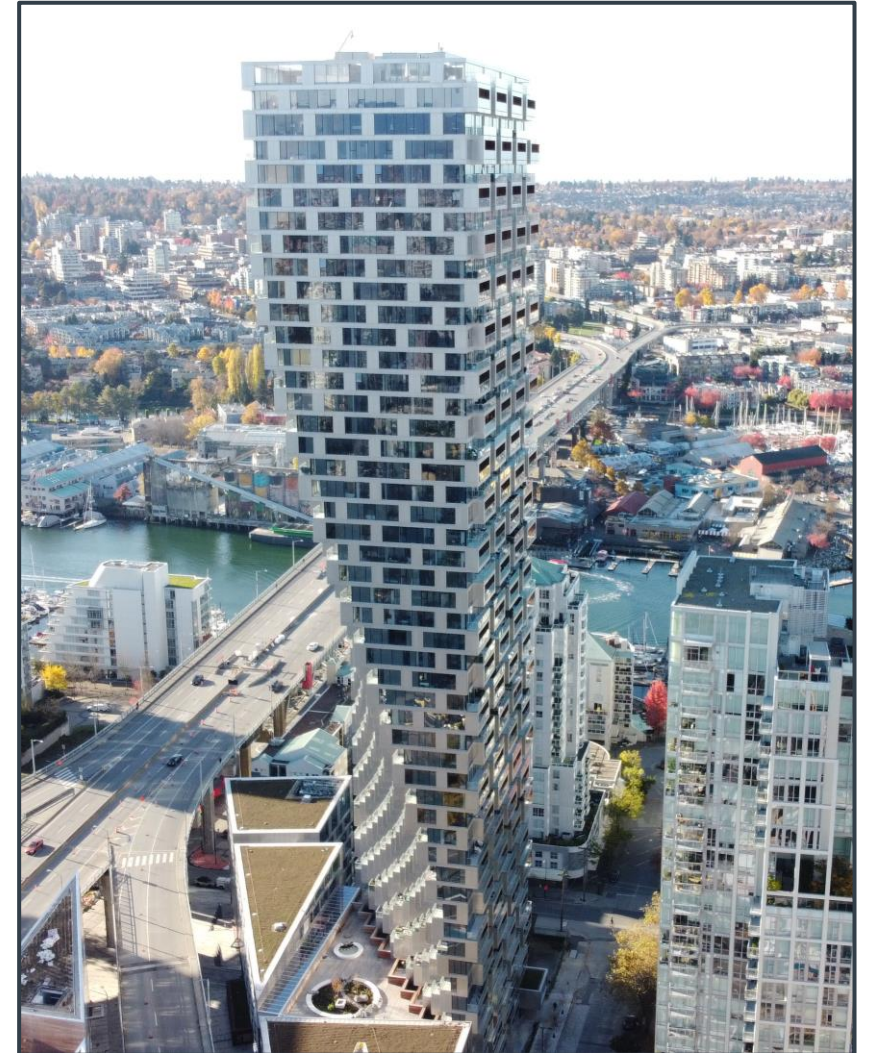
- co-led by Federal Ministry of Innovation, Science and Economic Development (ISED) and the Cement Association of Canada
- working group includes representatives from the federal government, the Canadian cement and concrete industry, and relevant environmental experts
- announced on Wednesday November 9, 2022 at Burnco site in Saskatoon  
*François-Philippe Champagne, Minister of ISED*  
*Marie Glenn, Board Chair, Cement Association of Canada*  
*Adam Auer, President and CEO, Cement Association of Canada*  
*Tom Zeis, CEO, Burnco Rock Products*

<https://ised-isde.canada.ca/site/clean-growth-hub/en/roadmap-net-zero-carbon-concrete-2050>

- ISED announcement is the start of a more detailed Roadmap implementation process across industry

# Canadian Net-Zero Carbon Concrete

- *Collaborative process across the industry, with Concrete BC Board, staff and member volunteers on 5 working groups:*
  1. *Clinker (e.g. lower carbon raw materials)*
  2. *Cement (e.g. higher substitution)*
  3. *Concrete (e.g. SCMs)*
  4. *Construction (e.g. additional optimization)*
  5. *Carbonation*
- *Development of draft roadmap underway*
- *Release of the Net-Zero Concrete Action Plan*





# Resilience, Durability and Longevity



Europe Hotel, Vancouver

## Repurpose existing structures

- Built in 1908-09
- Restored and converted to affordable housing in 1983

Build structures to a much higher standard of **durability, resilience, and longevity**



CN Tower, built in 1975  
Life expectancy over 300 years

# Decarbonizing CEMENT?

- **80% of the industry's greenhouse gas (GHG) emissions originate from cement production**
  - *additional clinker substitution (e.g. higher limestone PLCs, blended cements, novel SCMs)*
  - *lower carbon fuels instead of coal and natural gas (e.g. waste derived biogenic fuels, green hydrogen, etc.)*
  - decarbonated raw materials
- **but ~60% of those cement emissions are generated from process/chemical calcination emissions**
  - carbon capture, utilization and storage (CCUS)
    - access to significant funding and tax credits to support private sector investment



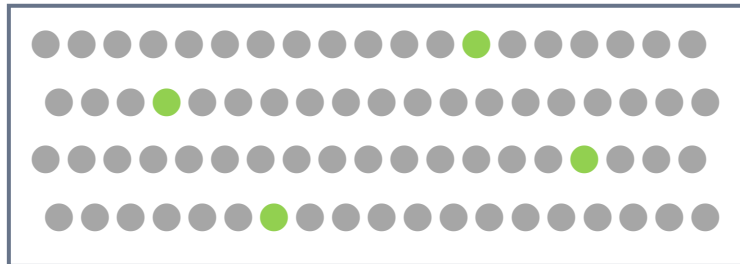
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# Portland-Limestone Cement (PLC)

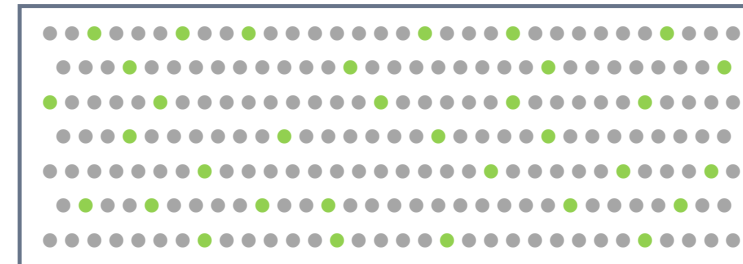
- PLC is made by inter-grinding clinker with up to **15% limestone**, while regular cement contains 5% limestone
- PLC is a finer ground product than regular cement
- Reduces the embodied carbon of cement by up to 10%

*Regular Portland Cement*



● = *ground clinker, precursor to cement*  
● = ***limestone (5%)***

*Portland-Limestone Cement*



• = *finely ground clinker*  
• = ***finely ground limestone (15%)***

# Portland-Limestone Cement (PLC)

- PLC produces concrete with the same durability and performance
- Code-approved and available across Canada
- **Could reduce 1 million tonnes of GHG per year across Canada**
- Benefits additive to carbon reductions from using SCMs like flyash, slag and silica fume
- GHG reduction potential of up to 10% for PLC and over 30% when used with other SCMs



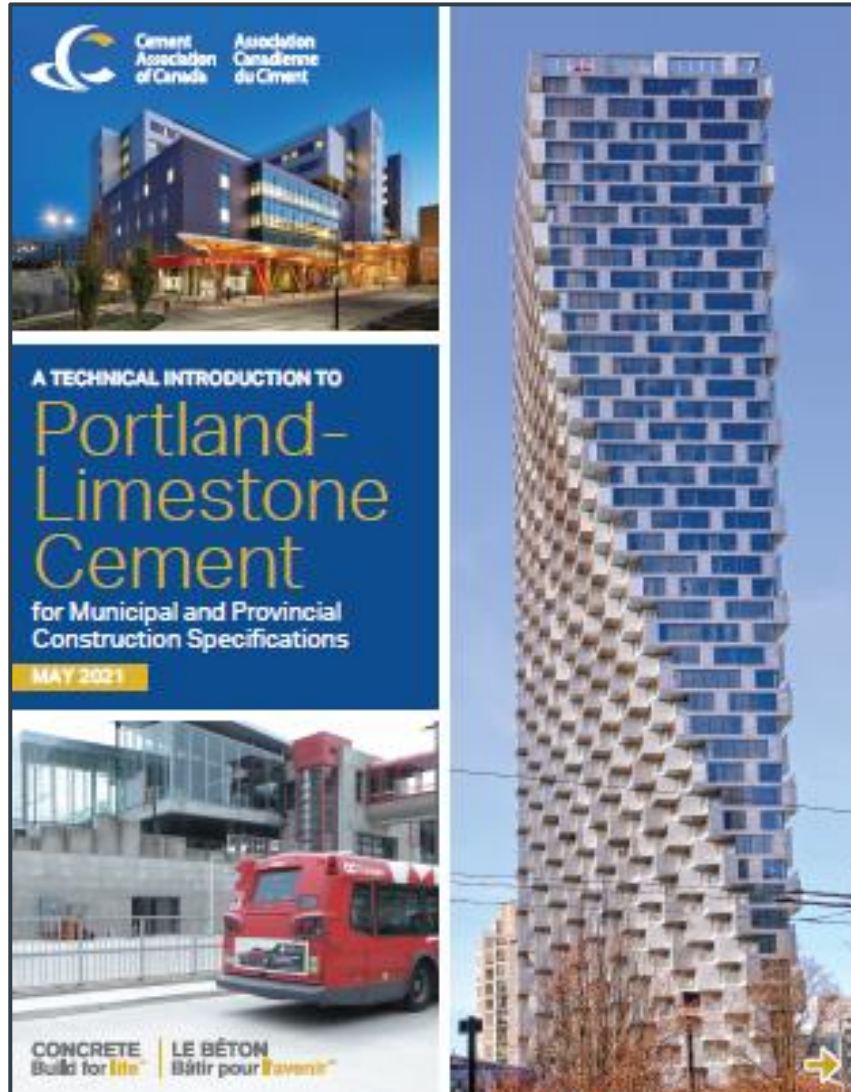


# Supplementary Cementitious Materials (SCMs)

- SCMs reduce the cement and clinker content of a concrete mix
- SCMs include **waste flyash** (from coal-fired power generation), **slag** from steel production, and **silica fume** from industrial processes
- The blending or inter-grinding of cement or Portland-limestone cement with up to three SCMs can produce a **blended cement**
- In general, mixtures perform in a manner that can be predicted by knowing the characteristics of the individual ingredients
- Benefits of concrete with SCMs include **improved properties, lower cost and avoided GHG emissions**



# A Technical Introduction to PLC, May 2021



Cement Association of Canada / Association Canadienne du Ciment Portland-limestone Cement Technical Summary | 1

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CONCRETE | LE BÉTON Build for life | Bâtir pour l'avenir

No charge  
from CAC



# Decarbonizing CONCRETE?

- **Procurement**
  - Support and education at Federal, Provincial and Municipal agencies to update procurement policies e.g. “Buy Clean”, “Materials Innovation Hub”, outcomes-based procurement practices, etc.
- **Codes and Standards**
  - Move towards Performance Based Codes, Standards and specifications (e.g. instead of minimum cement requirements, maximum SCMs, etc)
  - Changes to National Master Specifications
  - Standards Council of Canada (SCC) operates under ISED
- **Innovation and Funding**
  - Research and development (National Research Council of Canada also under ISED) and related R&D funding opportunities for the industry
    - harvesting, processing and use of impounded flyash
    - mineralization technologies
    - etc.
  - Support in accessing funding programs across government



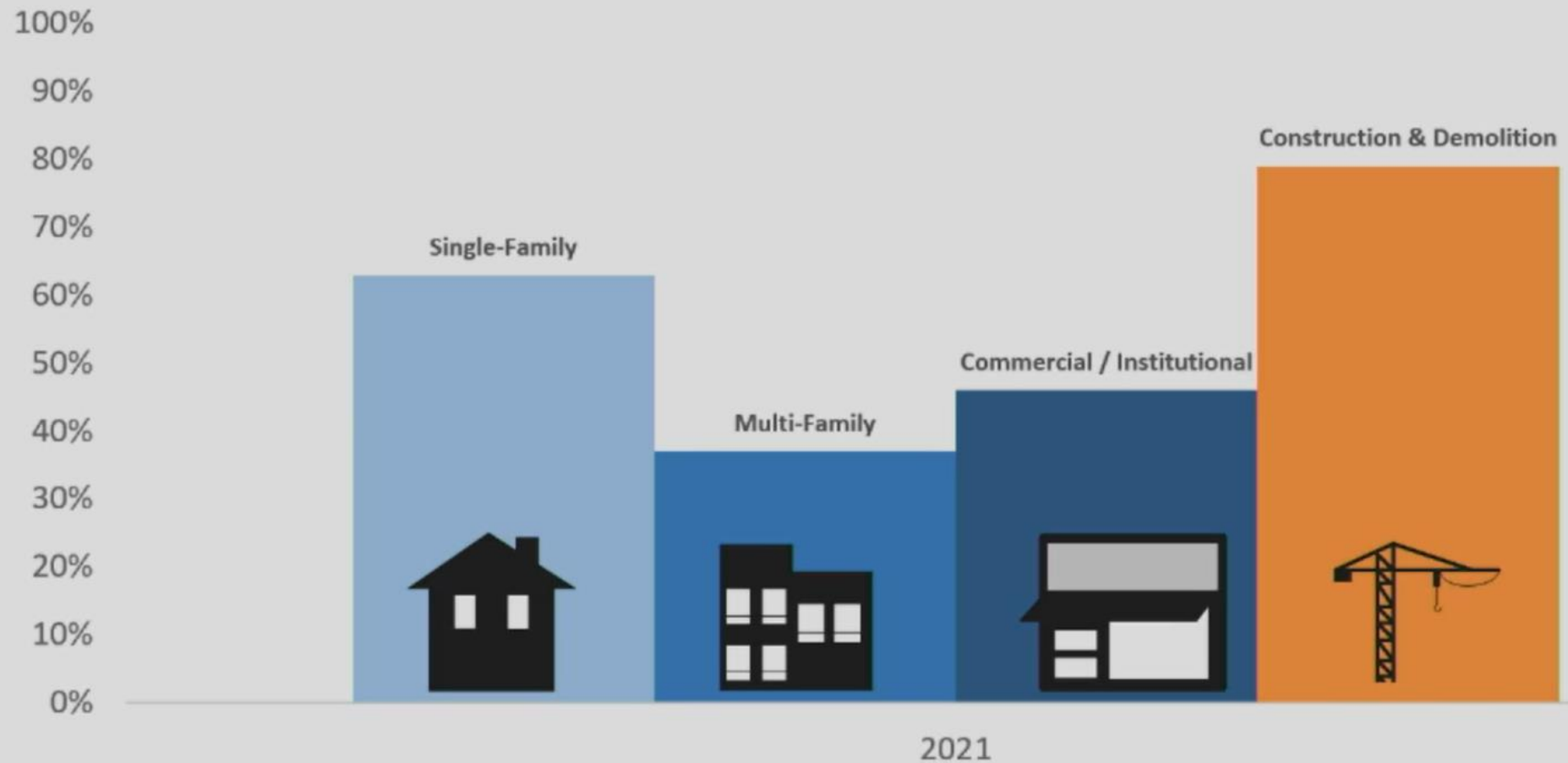


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# REGIONAL RECYCLING RATES BY SECTOR

Shown in percentages



Source: Metro Vancouver Zero Waste Committee – January 9, 2023



# 2021 SUMMARY

Source: Metro Vancouver Zero Waste Committee – January 9, 2023

WASTE SECTOR		DISPOSED (tonnes)			RECYCLED (tonnes)			RECYCLING RATE (%)			
		2019	2020	2021	2019	2020	2021	2019	2020	2021	% change (2020-2021)
Residential	tonnes	488,218	509,038	510,337	571,961	631,627	601,509	54%	55%	54%	-1%
	tonnes/capita	0.18	0.18	0.18	0.21	0.23	0.21				
Single Family	tonnes	254,516	269,485	266,999	439,730	485,419	455,723	63%	64%	63%	-1%
Multi-Family	tonnes	233,702	239,554	243,337	132,231	146,208	145,786	36%	38%	37%	-1%
Commercial/ Institutional	tonnes	385,073	354,268	372,861	289,764	278,507	316,406	43%	44%	46%	2%
	tonnes/capita	0.14	0.13	0.13	0.11	0.10	0.11				
Construction & Demolition	tonnes	425,713	382,007	371,972	1,329,696	1,350,904	1,433,933	76%	78%	79%	1%
<b>Total</b>	tonnes	1,299,005	1,245,314	1,255,169	2,191,421	2,261,038	2,351,848	63%	64%	65%	1%



# C&D Recycling



**Ken Carrusca**  
@KenCarrusca

Staff from @MetroVancouver presenting report on recycling

Shows 866,363 tonnes of concrete recycled

yes concrete is “heavy” (ie dense)

but its recycling rate is very high, in the 95 to 97 % range

Q: Where can the region improve?

A: Wood, with ~ 100,000 tonnes landfilled

2019	2020	2021
239,711	295,300	295,300
12,423	12,952	13,858
825,896	802,701	866,363
11,600	11,650	11,213
255,263	313,830	328,065
55,718	57,267	49,786
62,904	56,782	63,533
22,213	20,406	21,292
55,708	73,636	73,369
15,006	7,001	-
38,275	44,587	43,849
487	639	691
22,241	22,068	21,328
161,420	152,487	161,309
412,556	389,732	401,890
<b>2,191,421</b>	<b>2,261,038</b>	<b>2,351,848</b>

- Increased const material recyclin
- Increase yard & commercial/inst decrease in resi
- Decreased glass corresponding to November 2021

Materials Type Recycled (tonnes)	2019	2020	2021
Asphalt	239,711	295,300	295,300
Batteries	12,423	12,952	13,858
Concrete	825,896	802,701	866,363
Electronic & Electrical Equipment	11,600	11,650	11,213
Paper/Paper Products	255,263	313,830	328,065
Glass	55,718	57,267	49,786
Gypsum	62,904	56,782	63,533
Household Hazardous Waste	22,213	20,406	21,292
Metal	55,708	73,636	73,369
Other/Mixed	15,006	7,001	-
Plastic	38,275	44,587	43,849
Textiles	487	639	691
Tires	22,241	22,068	21,328
Wood	161,420	152,487	161,309
Yard & Food	412,556	389,732	401,890
<b>Total</b>	<b>2,191,421</b>	<b>2,261,038</b>	<b>2,351,848</b>

Source: Metro Vancouver Zero Waste Committee – January 9, 2023

# Lower carbon fuels

- Making cement is an energy-intensive process
- Cement production requires temperatures of 1300 to 1400 °C
- Combustion emissions are from 30 to 40% of total emissions
  
- Conventional fuels include coal, and natural gas
- Alternative fuels include end-of-life automotive tires
- Lower carbon fuels include non-recyclable urban woodwaste, and other biomass, wastewater biosolids
- Emerging fuels include renewable natural gas and hydrogen
  
- Strong focus on transitioning to lower carbon, waste-based fuels
- Can reduce costs and lower GHG emissions











**Urban woodwaste from residential demolition, Vancouver**



# Lower carbon fuels

- Can reduce costs and lower GHG emissions
- No post combustion residue, since ash by-products are irreversibly bound and form part of the final cement product
- **3Ts of combustion** – Time, Temperature and Turbulence are very easily achieved in a large volume, high-temperature cement kiln
- Process control systems ensure stability of combustion process
- Continuous emissions monitoring systems (CEMS) monitor environmental performance





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