Role of mineral processing, smelting and refining in Canada's critical minerals strategy – strengths, opportunities, weaknesses and threats

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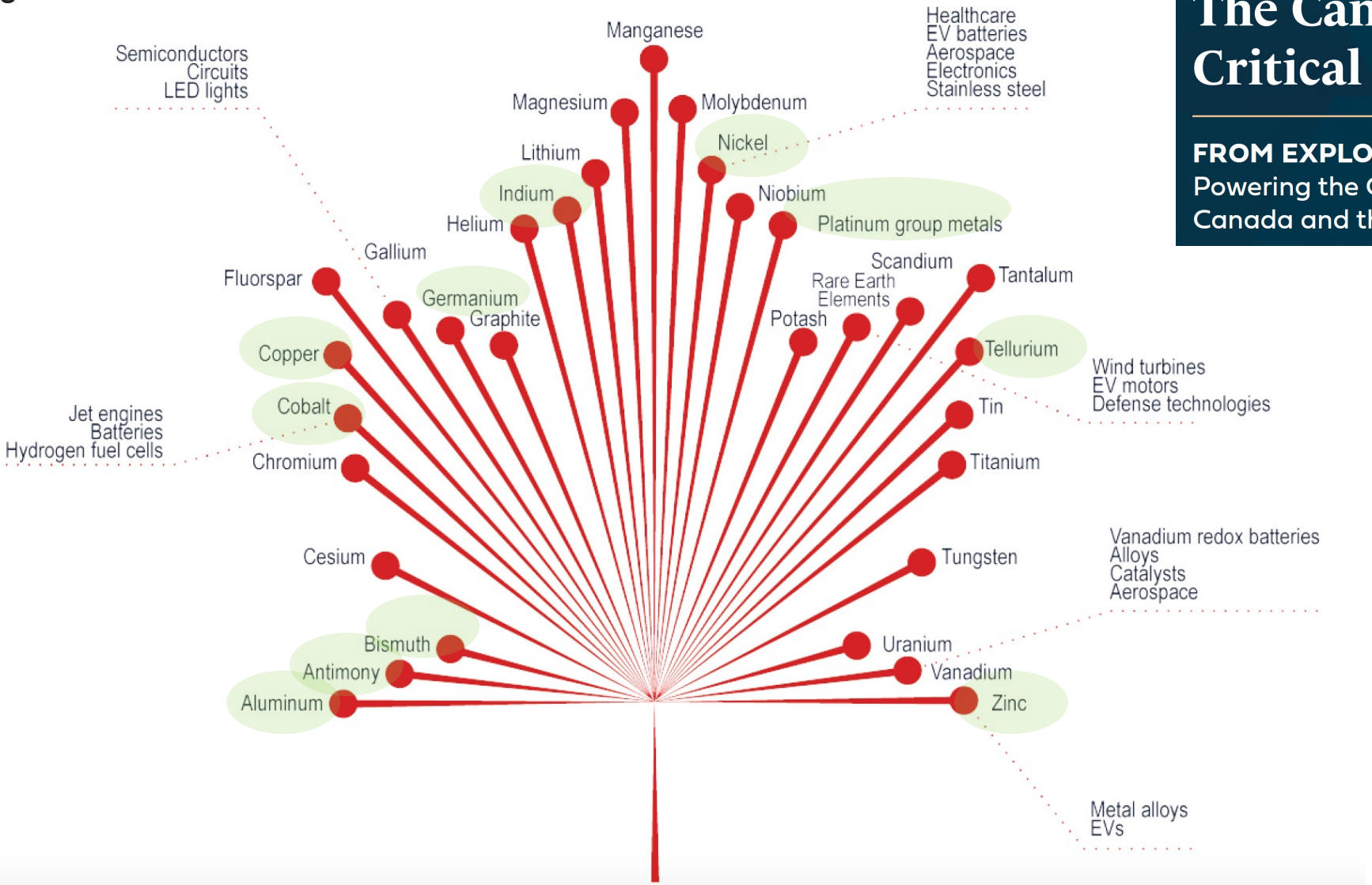
Introduction

- Canadian Critical Minerals Plan and base metals context
- Base metals industry structure in Canada and changes in last 20 years
  - Mining and mineral processing
  - Smelting and refining
  - Trade in intermediate and refined products
- Strengths, weaknesses, opportunities and threats
- New technologies and analogies for successfully renewing base metals smelting and refining in Canada

Figure 1: Canada's 31 Critical Minerals and Some of Their Uses



The Canadian Critical Minerals Strategy

FROM EXPLORATION TO RECYCLING:
Powering the Green and Digital Economy for Canada and the World

Focus for today:

- **Copper**
- **Nickel**
- **Zinc**
- **Associated companion metals/byproducts**
- **Aluminum as an analogy**

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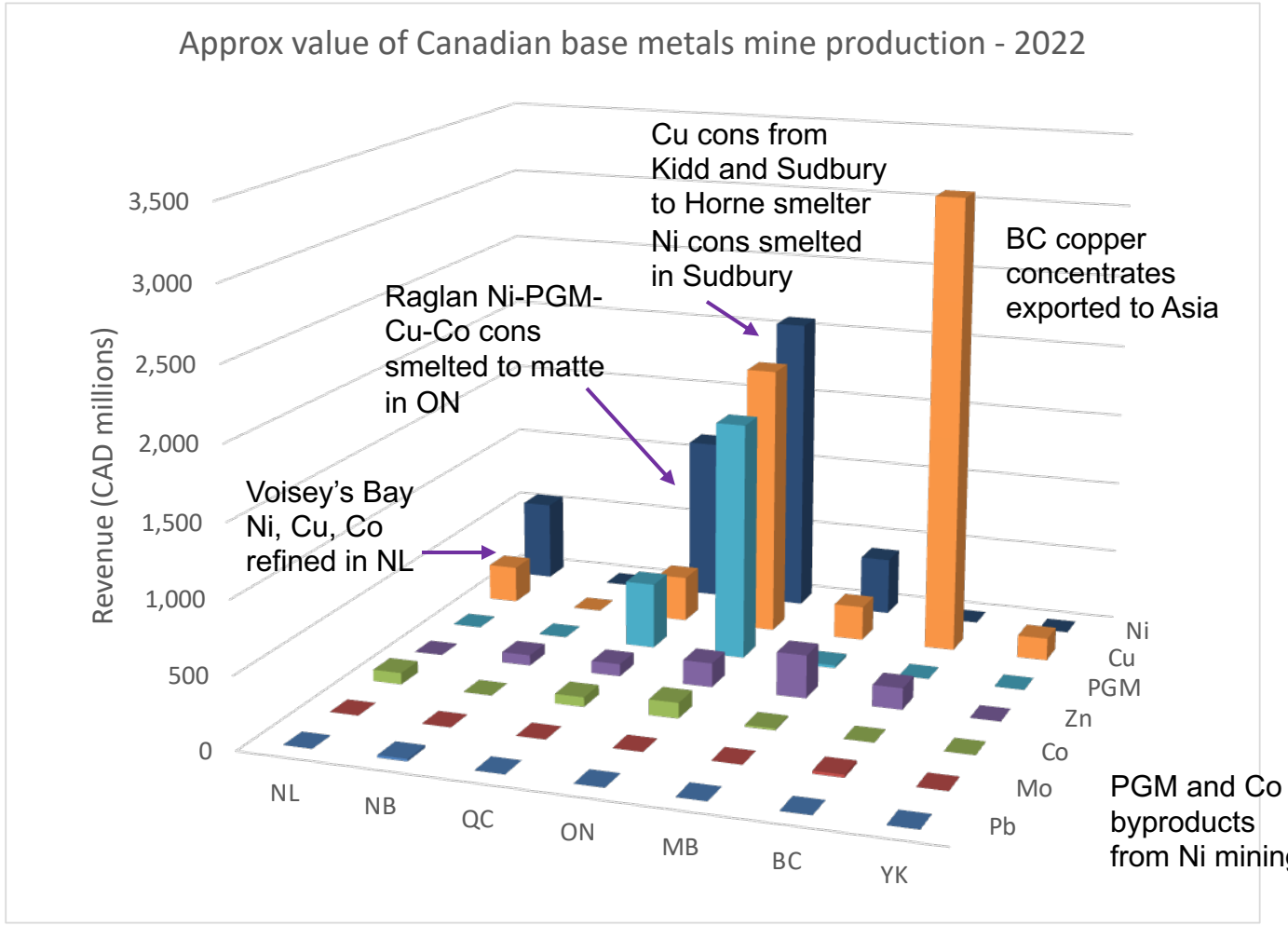
Canada Base Metals Mining



- Decline in all Canadian base metals mine production from 2002 to 2022, but most severe in Pb and Zn

Metal	2002	2022
Cobalt	5,093	3,063
Copper	600,200	510,782
Lead	97,000	8,247
Nickel	187,791	143,266
Zinc	891,924	208,147

Canada Base Metals Smelting & Refining

Feed from Cuba

Facility Name	Location	Company	Plant type	Primary	Product form	Co-products
Horne	Rouyn-Noranda, QC	Glencore	Smelter	Cu	Anode Cu	Au, Ag, H2SO4
CCR	Montreal, QC	Glencore	Refinery	Cu	Cathode Cu	Au, Ag, Te, Se, PGM
Sudbury INO	Falconbridge, ON	Glencore	Smelter	Ni	Ni matte	Cu, Co, PGM, H_2SO_4
Copper Cliff	Sudbury, ON	Vale	Smelter & refinery	Ni	Ni oxides, pellets, powders	Cu anode, Co and Au-Ag-PGM residues
Port Colborne	Port Colborne, ON	Vale	Refinery	Co	Electrolytic Co	Co, PGM
Long Harbour	Long Harbour, NF	Vale	Refinery	Ni	Ni cathode	Co, Cu
Fort Saskachewan	Fort Saskachewan, AB	Sherritt	Refinery	Ni	Electrolytic Ni	Co, $(NH_4)_2SO_4$
CEZinc	Valleyfield, QC	Glencore	Electrolytic refinery	Zn	Zn ingot	Cu cake, H_2SO_4
Trail	Trail, BC	Teck	Electrolytic refinery	Zn	Zn ingot	Cd, In, GeO_2, S, H_2SO_4, SO_2 (l), $(NH_4)_2SO_4$
Trail	Trail, BC	Teck	Smelter & refinery	Pb	Refined Pb ingot	Ag, Au, Bi, $NaSbO_3$, $Cu_3(AsO_4)_2$, $CuSO_4$, H_2SO_4

Feeds from USA, Peru

Feeds from South America

Primarily Canadian feed
Canadian and imported feed
Primarily imported feed

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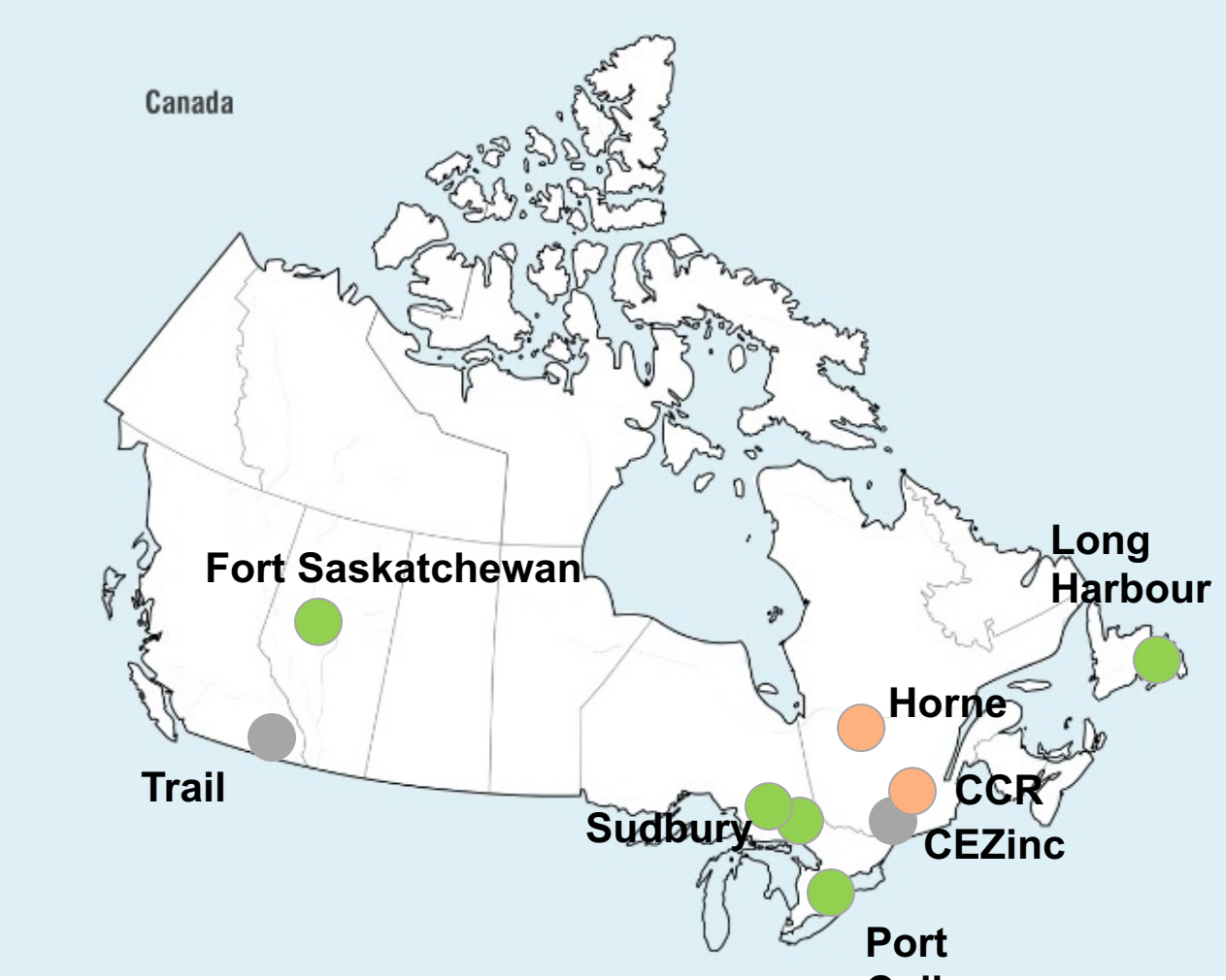
Base Metals Smelter and Refinery Locations 2022



- Several smelters located inland due to proximity to legacy mines
- Becomes a limitation as transition to treating external concentrates

Smelter Closures

- **Stream of Cu, Ni, Zn and Pb smelting/refining closures since 2002**
  - **Challenges: emissions controls (SO_2), reduced access to feed stocks due to mine closures, high transport costs (for acid out, custom concentrates in)**
  - **One new refinery: Long Harbour, Ni, Cu, Co, mandated in province processing**

Name	Location	Company	Opened	Closed	Plant type	Primary	Product form	Co-products
Gaspe	Gaspe, QC	Noranda	1955	2002	Smelter	Cu	Anode Cu	H_2SO_4
Copper Cliff	Sudbury, ON	Vale	1930	2005	Refinery	Cu	Cathode Cu	
Kidd Cu	Timmins, ON	Xstrata	1980	2010	Smelter & refinery	Cu	Anode Cu	H_2SO_4
Kidd Zn	Timmins, ON	Xstrata	1980	2010	Electrolytic refinery	Zn	Zn ingot	In, H_2SO_4
Flin Flon	Flin Flon, MB	Hudbay	1930	2010	Smelter & refinery	Cu	Anode Cu	
Thompson	Thompson, MB	Vale	1961	2018	Smelter & refinery	Ni	Ni cathode	
Brunswick	Belledune, NB	Glencore	1966	2019	Smelter & refinery	Pb	Refined Pb ingot	Ag, Bi, Sb, Cu
Flin Flon	Flin Flon, MB	Hudbay	1993	2022	Electrolytic refinery	Zn	Zn ingot	

Decline in Refined Metal Production

- **Decline in refined base metal production has followed mine and smelter closures and increased import reliance for copper and zinc concentrates for remaining plants**

	2002	2022
Refined Copper	495,000	310,000
Refined Lead (primary)	170,000	56,000
Refined Zinc	793,000	535,000
Refined Nickel	144,000	125,000
Cobalt metal	4,300	2,400

Approximate refined production from both Canadian and imported sources

SO_2 Emissions Abatement vs. Closure

https://worldfoto.photoshelter.com/image/I0000amJw.ZOQjsg

https://www.worldatlas.com/articles/the-tallest-smokestacks-in-canada.html

https://digitalcollections.thechpf.com/index.php/Detail/objects/10501

https://en.wikipedia.org/wiki/Inco_Superstack#/media/File:Sudbury_sunset.JPG

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Base Metals and their Companions

Base metal	Lead and Zinc	Copper	Nickel
Major economic companions (revenue paid to mine)		Gold	
			Platinum group
	Silver		
		Cobalt	
		Molybdenum	Copper
		Uranium	
Minor economic companions (generally not paid to mine, revenue to refinery if recovered)	Copper	Zinc	Silver
	Gold	Lead	Gold
	Germanium	Bismuth	
	Indium	Nickel	
	Bismuth	Selenium	
	Antimony	Tellurium	
	Cadmium		
Deleterious (mine penalized)	Arsenic		
	Mercury		

Key:

Critical Mineral

- Indicative relationships. Companions are ore dependent.
- Minor companions - smelter and refinery configuration and environmental regulations determine whether penalty or revenue source.
- Without smelting and refining, value from critical mineral companions not realized

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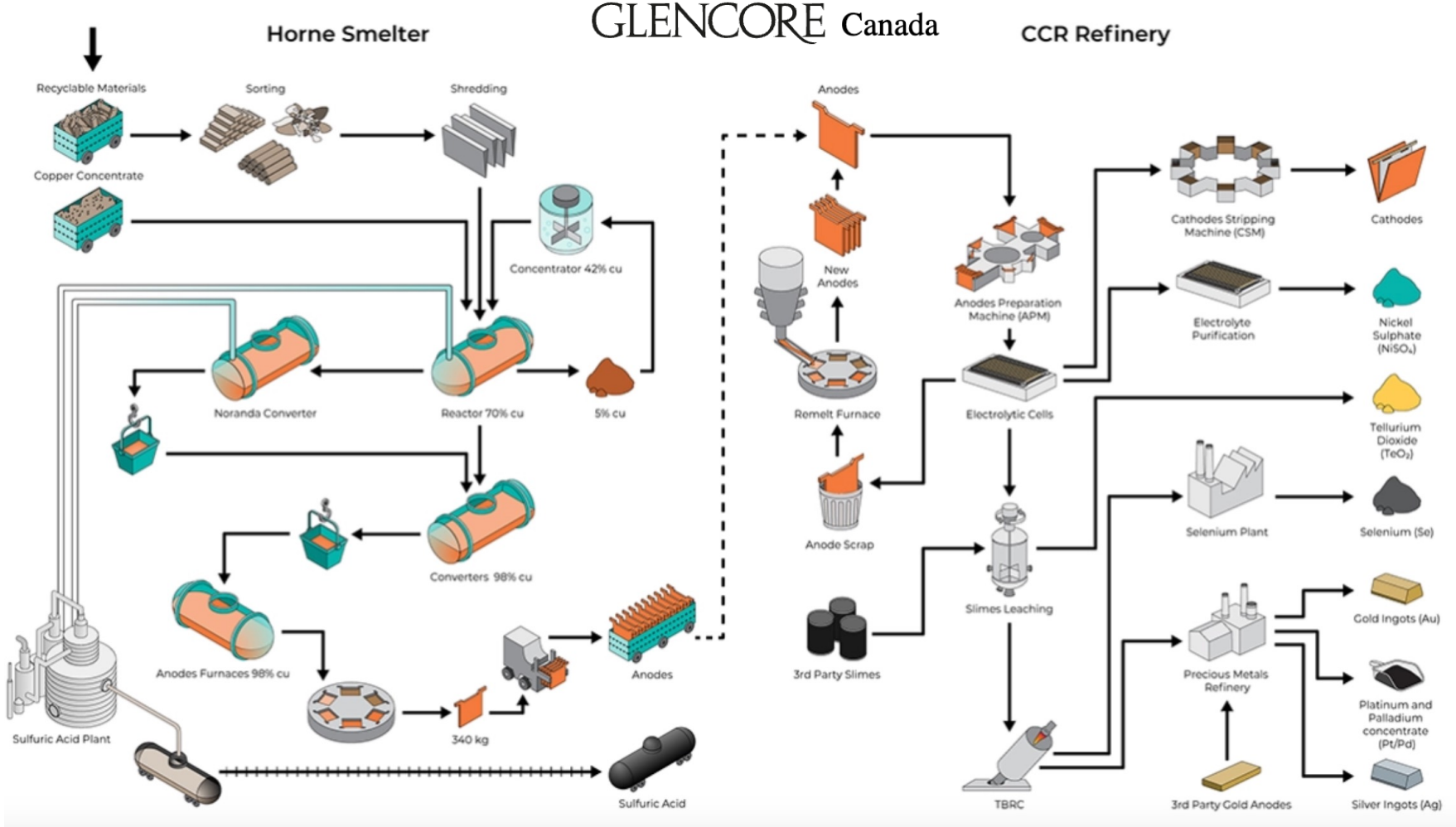
Horne and CCR: the Canadian Cu Value Chain



- Integrated Cu smelter and refinery in Quebec
- Smelter opened 1927 to treat concentrates from Horne mine, closed 1976
- Horne now treats Canadian and imported concentrates and recycled materials
- Precious and critical minerals byproducts core to business model
- CCR cathode feeds downstream Cu semi manufacturing

Horne capacity 250,000 t/y Cu

CCR capacity 325,000 t/y Cu

https://www.glencore.ca/en/ccr/ce-que-nous-faisons/du-concentre-au-produit-fini

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Horne Smelter – Future in the Balance

Horne Smelter says it will follow Quebec's 5-year arsenic emissions target, but it wants financial aid

Reduction will take technological overhaul costing $502M, says Glencore

Verity Stevenson · CBC News · Posted: Aug 18, 2022 10:54 AM PDT | Last Updated: August 18, 2022

https://www.cbc.ca/news/canada/montreal/horne-502-million-to-reduce-emissions-1.6555056

- Complex smelter transformation and emissions reduction control project that is looking to incorporate new smelting technology
- Incorporates expanded buffer zone between smelter and town
- Analogous to other smelter transformations, e.g. Port Pirie, South Australia

VELOX
OPÉRER LE CHANGEMENT

Neighbours to be relocated as Glencore's Horne smelter grapples with meeting emissions targets

Canada's only operating copper smelter, Horne, belonging to Glencore (LSE: GLEN) in Rouyn-Noranda, Que., is facing increased scrutiny as it aspires to [...]

By Marilyn Scales • March 20, 2023 • At 2:25 pm •

https://www.canadianminingjournal.com/news/neighbours-to-be-relocated-as-glencores-horne-smelter-grapples-with-meeting-emissions-targets/

https://www.newswire.ca/news-releases/air-emissions-reduction-the-horne-smelter-unveils-its-plan-to-reach-the-15-ng-m3-target-of-arsenic-in-the-air-within-5-years-887554040.html

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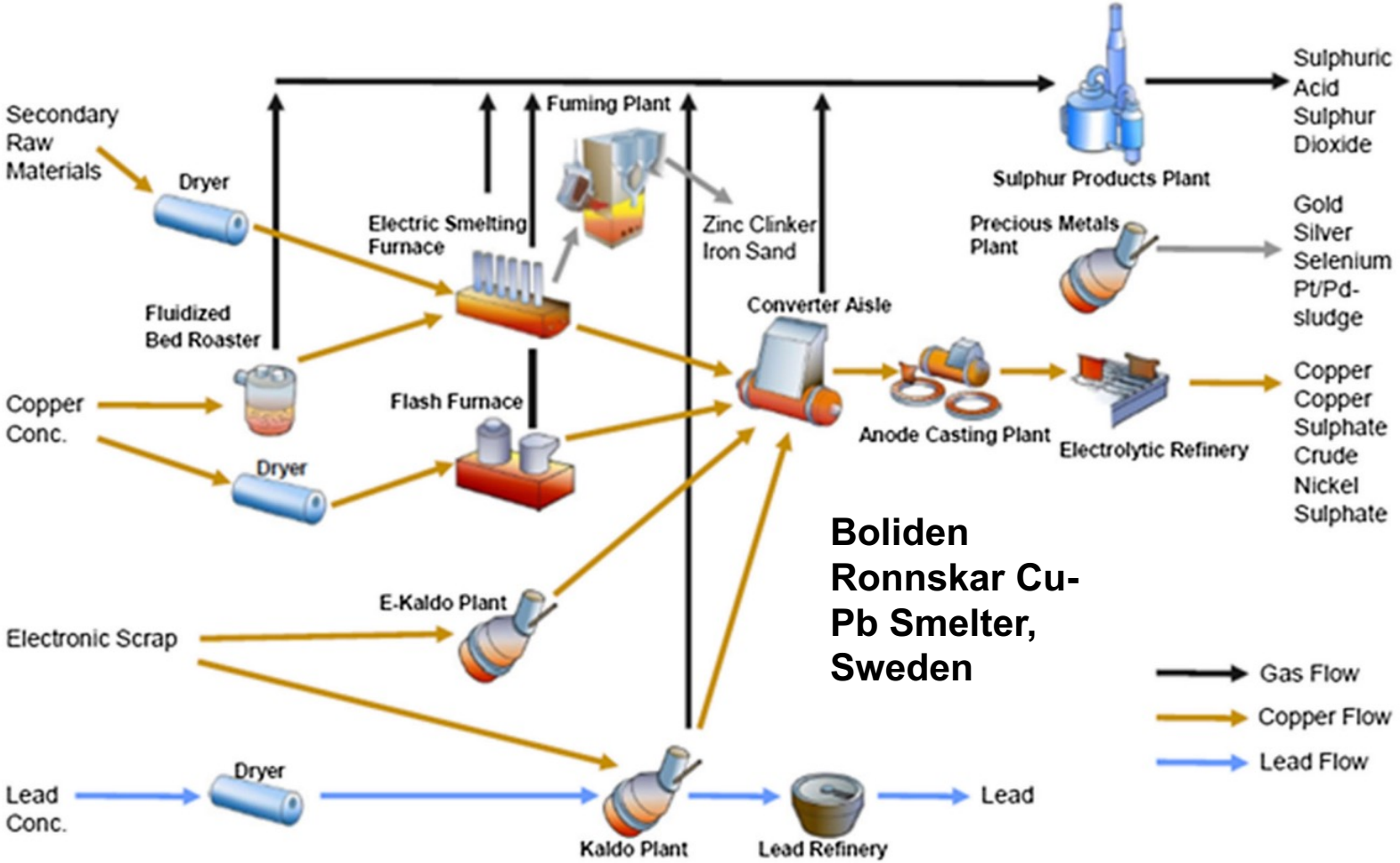
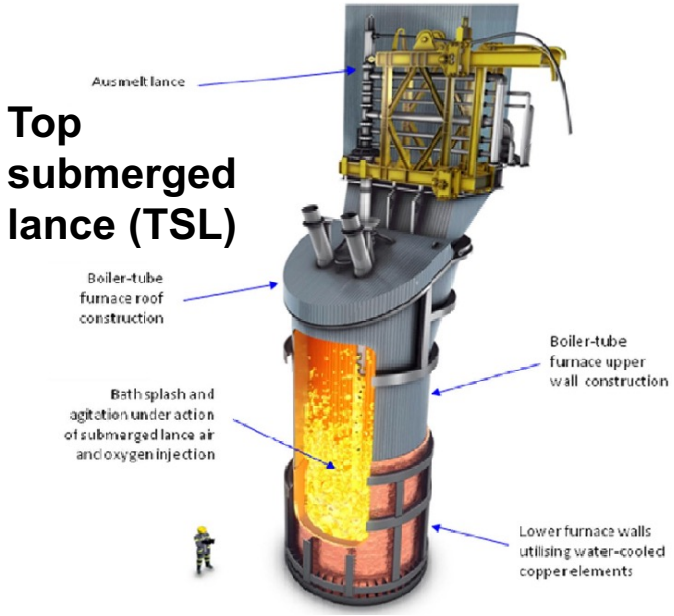
Strengths	Weaknesses
Stable economy	Cu, Pb and Zn mining, smelting and refining has been in decline for over 20 years. Where Canada was once a major player, it is now diminished and ability to recover companion critical minerals is diminished.
Proximity to US market	Limited use of newer smelter technologies (e.g. top-submerged lance)
Large, long life nickel sulphide resource base	Assets dominated by global multinationals with limited allegiance to Canada (e.g. Glencore, Vale)
Cheap hydroelectric power in BC, QC	History of production disruption due to industrial action, esp. in Ontario
Vertically integrated producers in Ni, Co and Cu (esp. Vale and Glencore)	Slow permitting and high costs of environmental compliance
Most smelters now comply with stringent emissions standards after significant investments in pollution controls (sulphuric acid plants)	Several plants are remote from customers, long transport distances to markets/from suppliers
Long range, high quality research capability at National Research Centre with strong focus on battery materials	Sulphuric acid markets are significant distance away from existing smelters.
Perceived as responsible supplier	Aging demographics of workforce in plants.
Opportunities	**Threats**
Synergies for developing lithium ion battery materials supply chains - Li, Ni, Co, graphite	Massive expansion of Indonesian nickel supply including Class 1 from new HPAL plants (making MHP - mixed hydroxide precipitate)
Stronger trade agreements with ally countries on trading and processing intermediate products	Loss of research, consulting and engineering base, esp. to support pyrometallurgy
Green metals - sustainable supply chain - ethical primary sourcing and expanded recycling (esp. for Ni, Cu and Co from BC, ON, QC, NL)	Volatility in sulphuric acid prices due to variations in S supply and demand can significantly threaten by-product revenue
Future treatment of Ni-Cu-PGM concentrates from Mid-West USA (MN, MI)	Failure to successfully complete emissions controls and transformation of Horne smelter leads to collapse of Canadian refined copper and downstream manfacturing sector
Expansion of fertilizer and chemical industries to provide large and stable market for by-product sulphuric acid.	Social resistence to industrial development to renew and grow smelting and refining capacity for base metals

New Smelting Technology



Boliden Ronnskar Cu-Pb Smelter, Sweden



Top submerged lance (TSL)

Look to developments in Europe, Australia and USA using newer smelter furnace technologies and multi-metal flowsheets

https://link.springer.com/article/10.1007/s40831-018-0157-5

Aurubis doubles U.S. investment in multimetal recycling facility

https://www.aurubis.com/en/richmond/aurubis-doubles-u-s--investment-in-multimetal-recycling-facility

Augusta, GA | Tuesday, December 20, 2022

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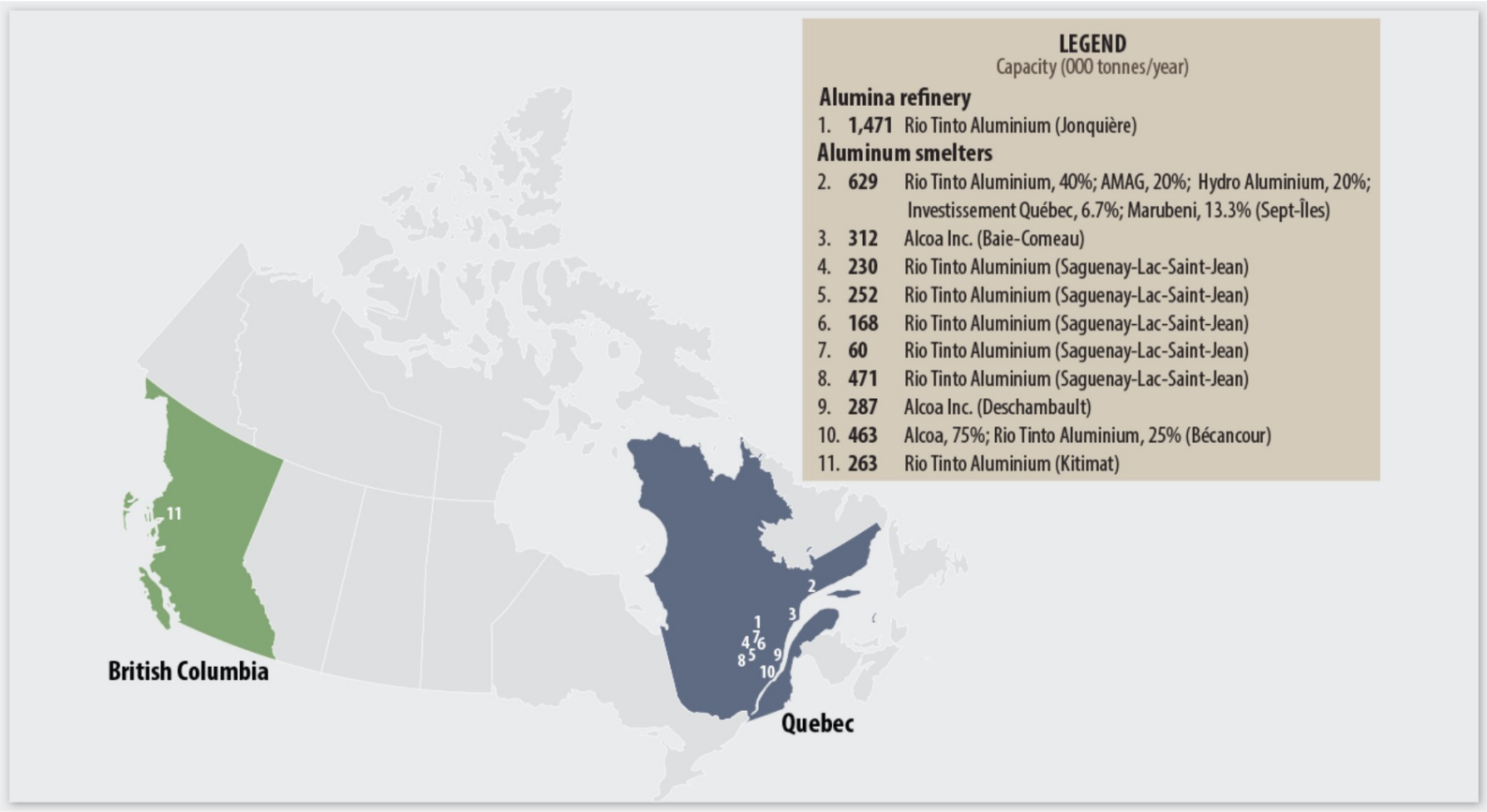
Can we learn from Quebec Aluminum Sector?

Canadian refinery and smelters estimated capacity and production, 2021



Heavy concentration of aluminum smelting in Quebec, accompanied by one large alumina refinery

https://natural-resources.canada.ca/our-natural-resources/minerals-mining/minerals-metals-facts/aluminum-facts/20510

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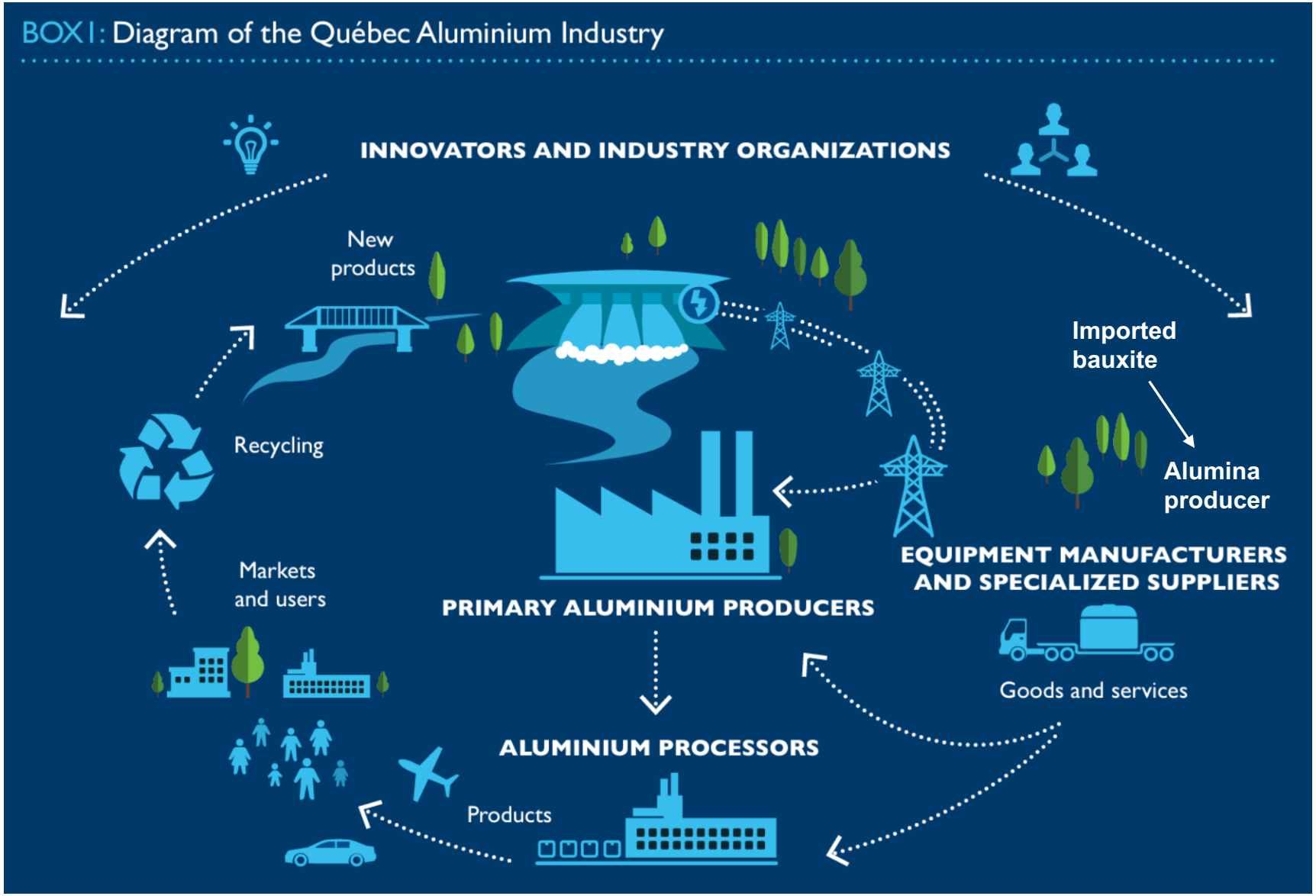

Self-supporting industrial and economic ecosystem

https://www.investquebec.com/documents/int/publications/strategie_aluminium_en.pdf

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World Leading Aluminum Smelting Industry

- Quebec aluminum hub in Saguenay-Lac-Saint-Jean
- Low C smelting technology
  - Rio Tinto AP60 technology – Complexe Jonquière smelter expansion and retirement of Arvida Smelter - C$1.4 B investment including C$150 M support from Quebec Government
  - Rio Tinto led consortium - Elysis zero carbon aluminum smelting
- Aluminum sector is strongly supported by the 2015-2025 Québec Aluminum Development Strategy
- Provides a model for other initiatives, e.g. Quebec's Battery Strategy – hub around Bécancour including GM-Vale Ni sulphate plant

Conclusions

- Smelting and refining of Cu, Ni and Zn and their companion critical minerals have been in decline in Canada for 20 years due to drops in mine supply, tightening emissions requirements and high costs
- Smelting and refining are key links in the battery and EV value chains that Canada is now trying to develop
- Investment in technology and emissions control is essential for competitiveness and social support
- Successful aluminum industry hub in Quebec provides a model for successful renewal and growth for base metals smelting and refining
- We need to get on with it!

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Questions?

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