



IEA Technology Collaboration Programme

COUNTRY REPORT Canada

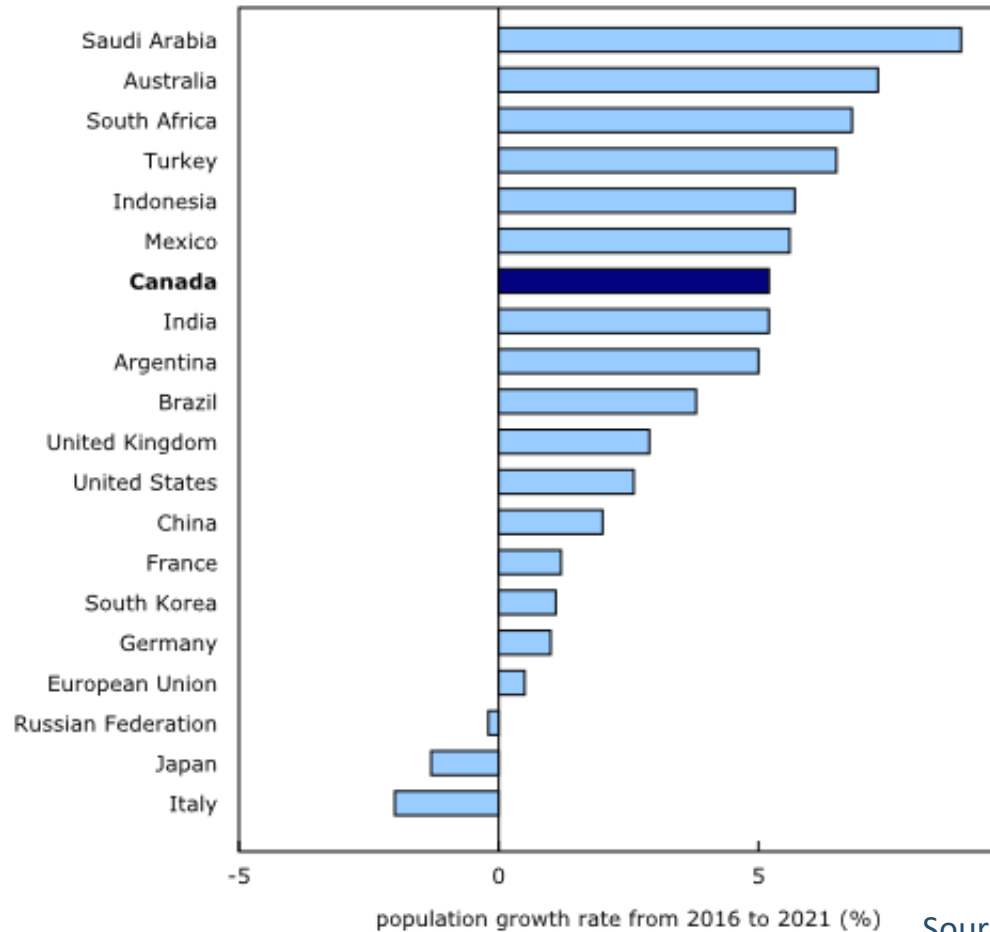
Darren Jang, P.Eng. (National Research Council Canada)

ES TCP XC 95, Vienna, Austria, 31 May 2023

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Country Specific Information

- **Population: 38M in 2021, projected to ~45M in 2043 (mainly from immigration)**



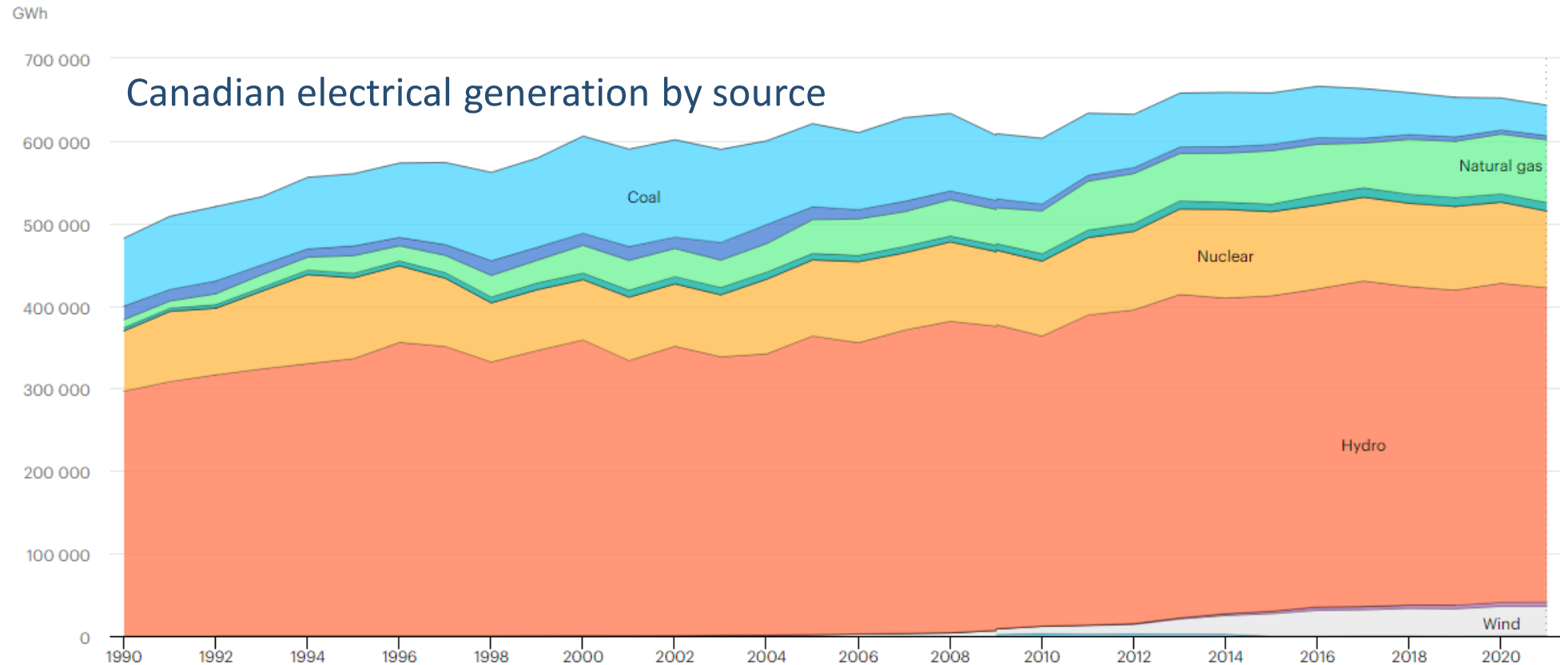
POPULATION GROWTH RATE FROM 2016 TO 2021



Source: Census of Population, 2016 and 2021 (3901).

Country Specific Information

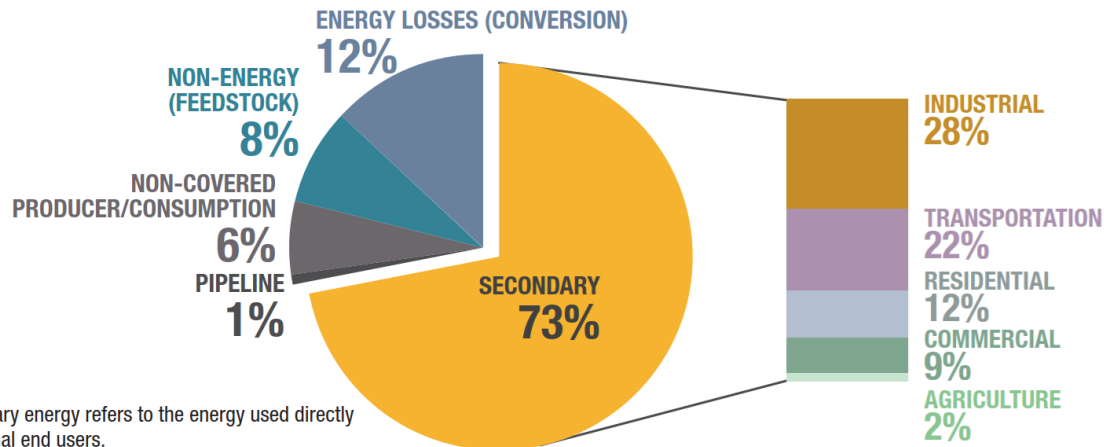
- **Primary Energy: 13,276 PJ; Secondary Energy: 9,683 PJ**
- **2,290 PJ (636 TWh) of electrical generation (2020), ~ 83% non-emitting**



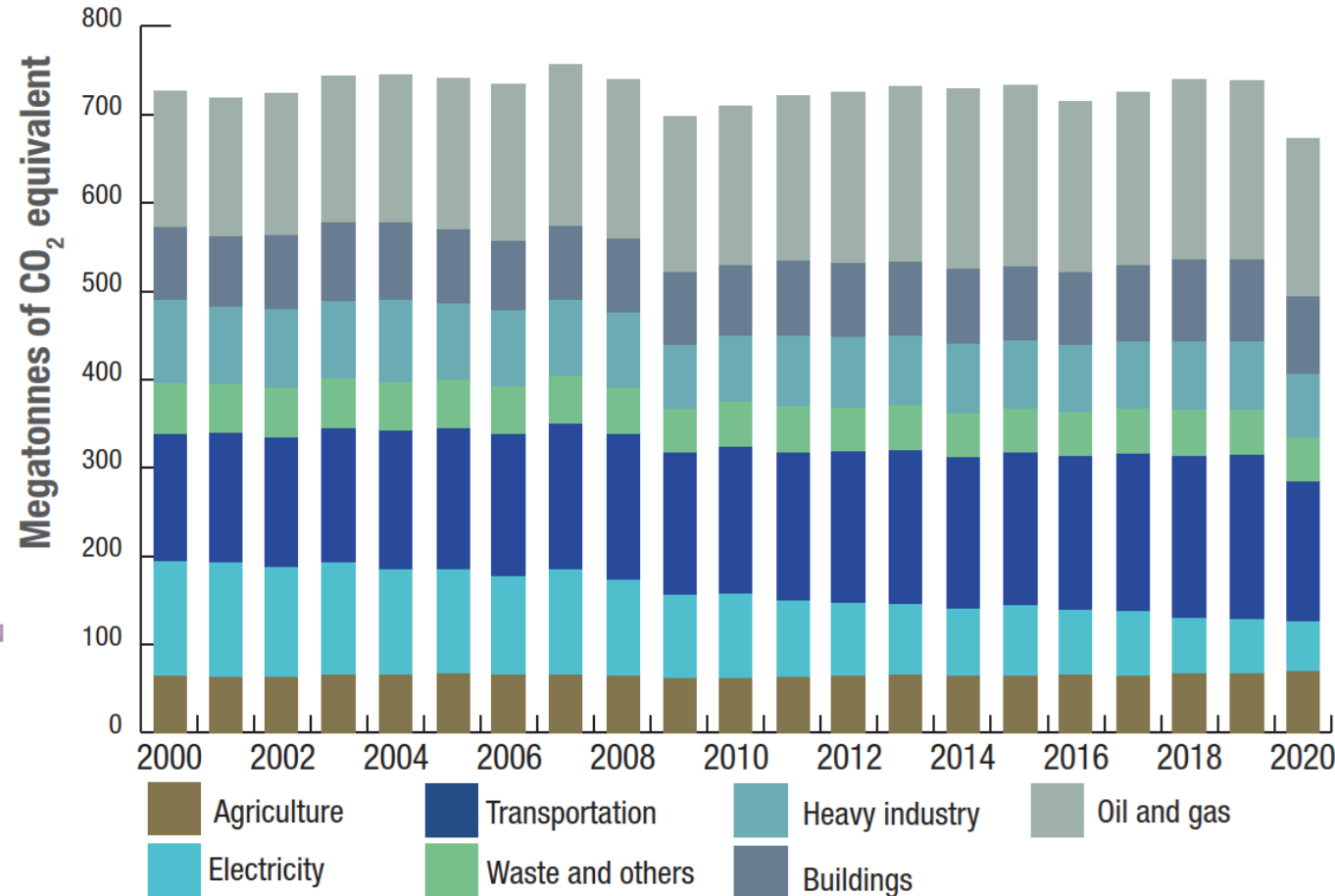
Country Specific Information

- While Canada’s electricity is relatively clean, national GHG emissions remain stubbornly high (per-capita basis).
- While oil GHG intensity *decreased* by 33% from 2000 to 2020, production increased by ~118%

PRIMARY AND SECONDARY ENERGY USE BY SECTOR, 2019



*Secondary energy refers to the energy used directly by the final end users.



RDD Information

- 2021 energy RD&D expenditure was **\$1.16B** (\$837M federal, \$325M provincial)

EXPENDITURES ON ENERGY RD&D BY TECHNOLOGY AREA (\$ MILLIONS)



Federal
(2020/2021)

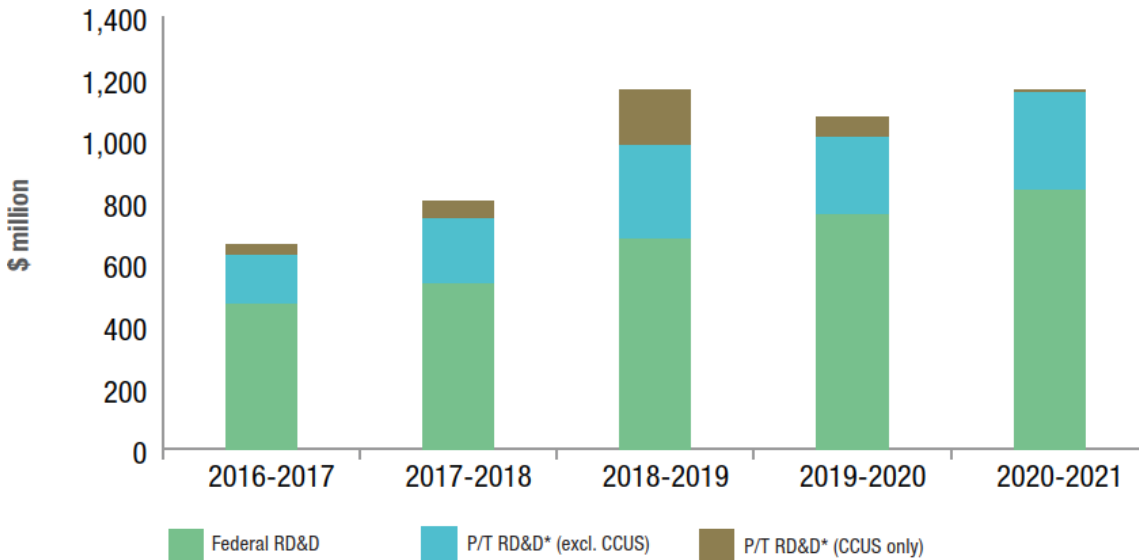


Provincial and territorial
(2020/2021)



Industry
(2020)

CANADIAN PUBLIC EXPENDITURES ON ENERGY RD&D



Hydrocarbons
(including CCUS)

Renewable and non-emitting energy**

Energy end use***

Total*

135

296

406

837

73

150

102

325

621

596

457

1,675

* Totals may not be exact due to rounding.

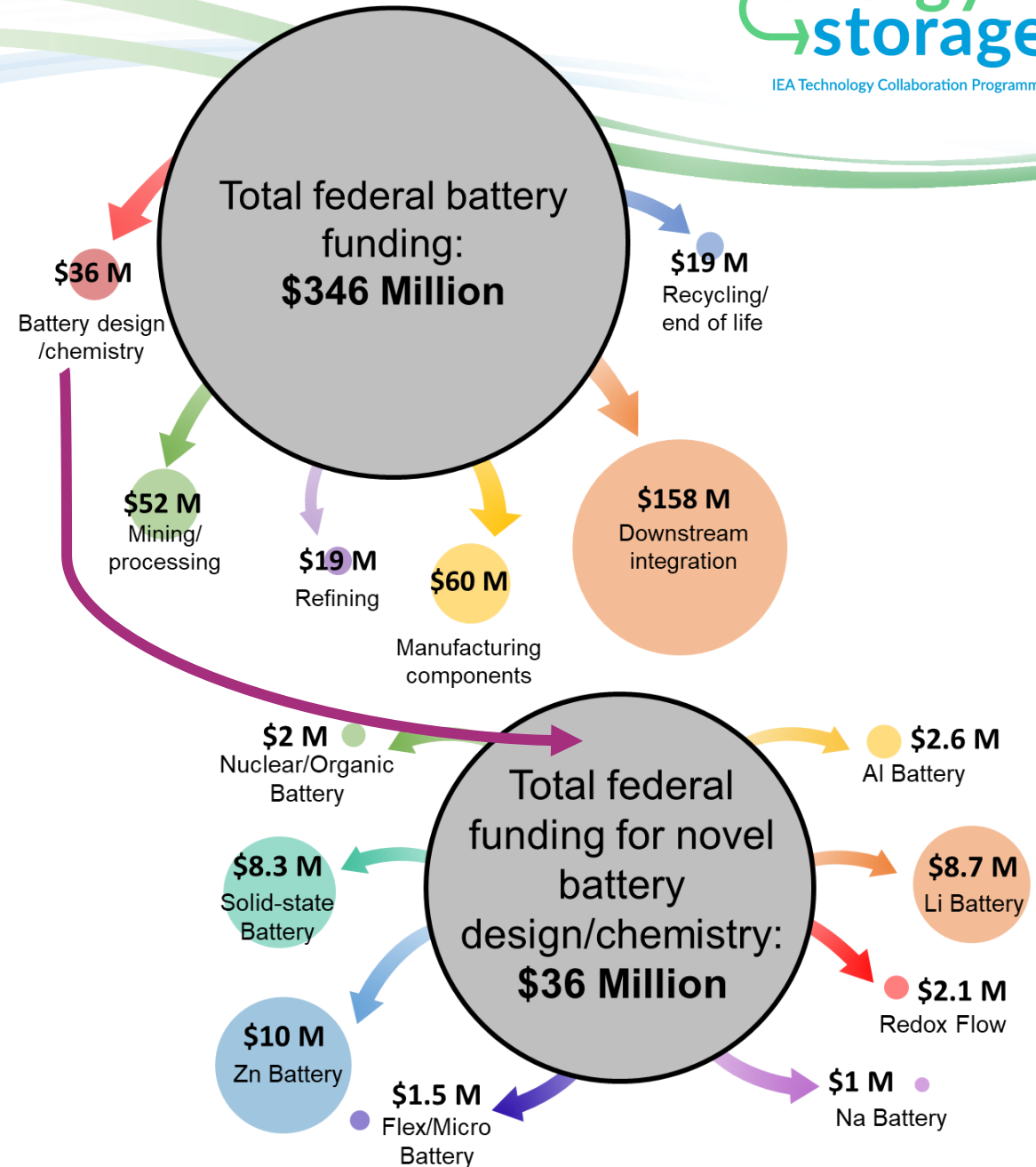
** Renewable and non-emitting energy includes renewable and nuclear energy.

*** Energy end use includes energy efficiency related to transport, industry, and buildings & communities.

RDD Information

- **\$346M in targeted battery funding from 2017-2021**
- **Funding to Gov. labs, industry, RTOs**

Value Chain	Number of Agreements	Fraction of Agreements Numbers	Fraction of Funding	Total Funding (Millions)
Battery design/chemistry	150	27%	11%	\$ 36
Downstream integration/ancillary services	256	47%	46%	\$ 159
Manufacturing	24	4%	17%	\$ 60
Mining, processing	51	9%	15%	\$ 52
Recycling/end of life	35	6%	6%	\$ 19
Refining into advanced materials	33	6%	6%	\$ 19
Grand Total	549	100%	100%	\$ 346



Energy Storage Landscape

- Canada's ES landscape is diverse, spanning multiple technologies (Li-ion, compressed air, flow batteries, thermal energy) and applications (short and long duration ES developers and integrators)
- Sample of universities advancing ES:
 - Dalhousie University ([Clean Technologies Research Institute \(CTRI\)](#))
 - University of Toronto ([Electrification Hub \(utoronto.ca\)](#))
 - University of Calgary ([Calgary Advanced Energy Storage and Conversion Research Technologies \(CAESR-Tech\) Institutes](#))
 - University of British Columbia ([Department of Electrical and Computer Engineering](#))
 - Carleton University: ([Sustainable Building Energy Systems](#))
 - Simon Fraser University: ([NSERC CREATE HyTEM \(create-hytem.ca\)](#))
 - McGill University: ([McGill Centre for Innovation in Storage and Conversion of Energy - McGill University](#))
- Research and technology organizations:
 - CanmetENERGY - Ottawa: ([Residential thermal energy storage for renewable energy resources integration](#))
 - CanmetENERGY - Varennes: ([Smart Grid in Canada](#))
 - National Research Council Canada: ([Advanced Clean Energy program: Battery energy storage](#))
 - Hydro Quebec: ([Center of Excellence | Hydro-Québec](#))
- Associations:
 - [Energy Storage Canada](#)
 - [Canadian Renewable Energy Association](#)

- **Canada employs multiple policy tools to incentivize energy storage:**
 - Tax incentives
 - Strategic support for RD&D
 - Grants for technology demonstrations and financing for deployment
- **For example, a 15% tax credit for investments in non-emitting stationary ES systems, and a 30% tax credit for clean tech manufacturing, including grid-scale electrical ES. Canada's Infrastructure Bank will invest an additional \geq \$20B in clean electricity generation, transmission, and storage projects.**
 - [A Made-In-Canada Plan: Affordable Energy, Good Jobs, and a Growing Clean Economy \(Budget 2023\)](#)
- **Natural Resources Canada [Smart Renewables and Electrification Pathways Program](#)**
- **Natural Resources Canada [Smart Grid Program](#)**

Policies & Market

- From detailed projections of various 2050 net-zero scenarios, significant investments in ES is being planned nationally.
- Market-based electric systems (e.g. IESO) significantly investing in economic ES now.

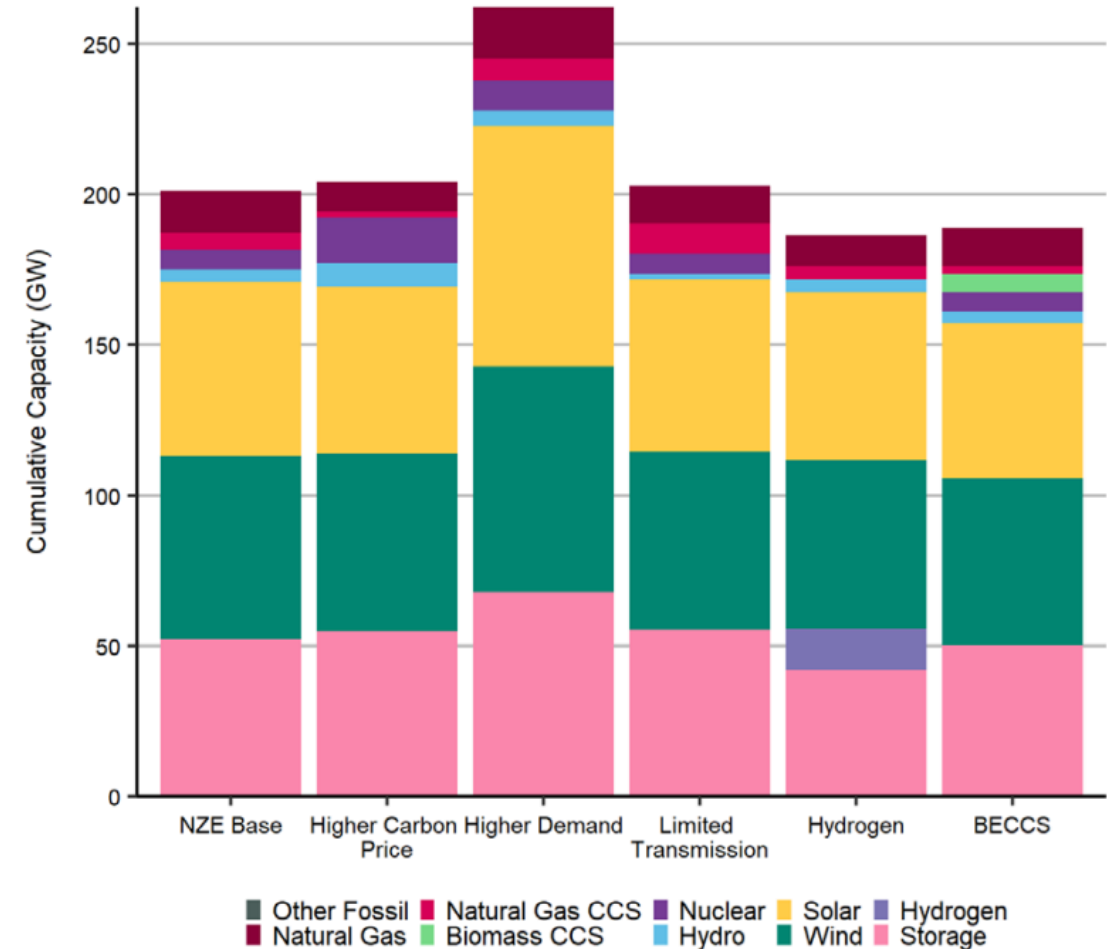
Procurement Mechanism	Procurement Target (MW)	Storage (MW)	Natural Gas (MW)	Other**
Same Technology Upgrades	300	No limit	Up to 300	No limit
Expedited Long-Term 1	1,500	~900	Up to 600	No limit
Long-Term 1*	2,200	~1,600	Up to 600	No limit
Total by 2027	4,000	~2,500	Up to 1,500	-

* Exact targets to be confirmed

** Non-emitting resources including hybrids and biofuels

Source: "Resource Eligibility Interim Report" Ontario IESO, 7-Oct-2022

Cumulative New Capacity Additions by 2050 in Different Scenarios



Policies & Market

- Federal investments in \$20B worth of battery + EV projects since 2020 from just the Strategic Innovation Fund alone

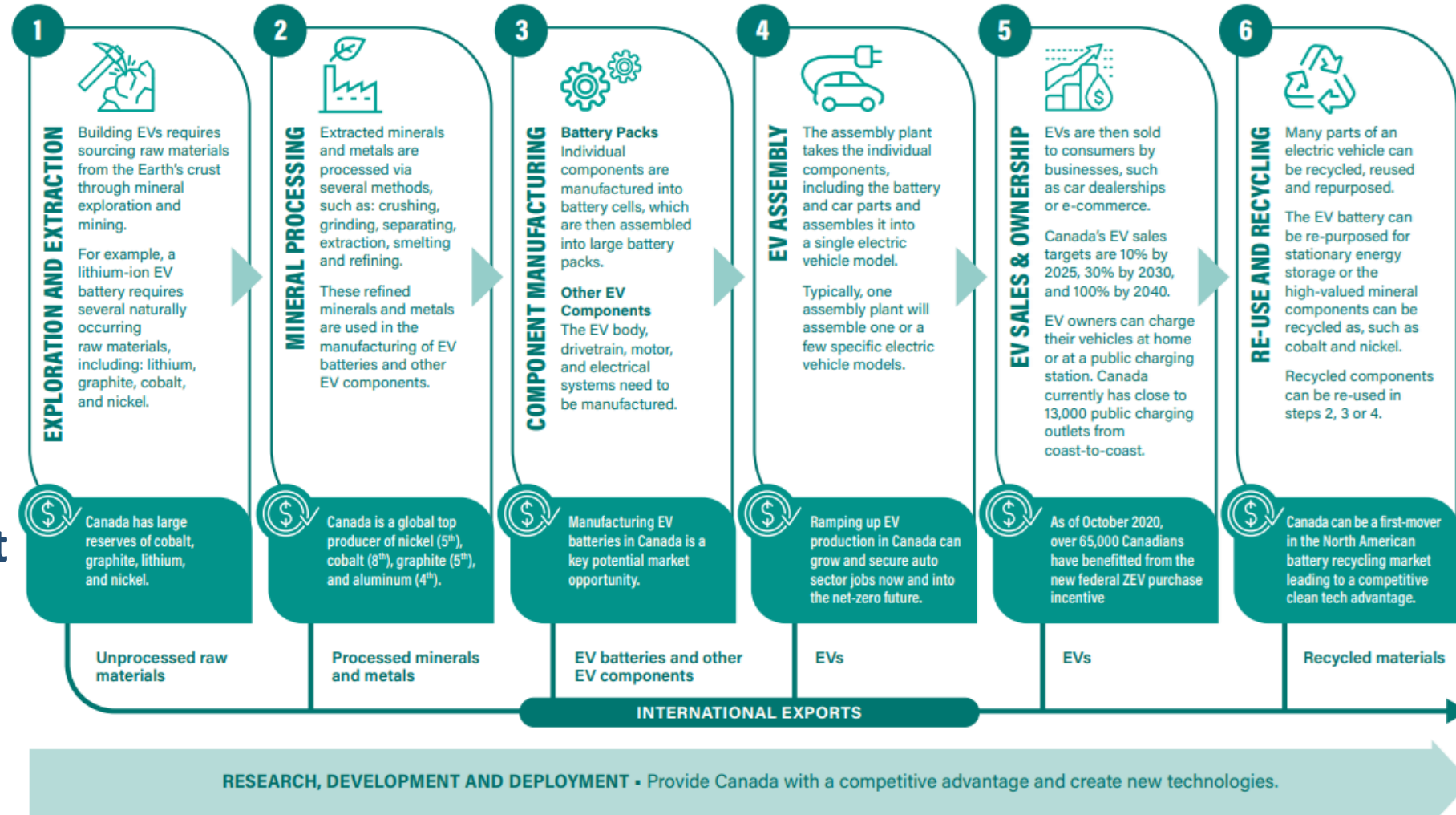
Investments Across the Battery Value Chain

<p>Ford</p> <p>Investing \$1.8 billion to produce Vs in Canada</p> 	<p>GM Canada</p> <p>Investing \$1 billion to transform CAMI Ingersoll plant to EV commercial van plant</p> 	<p>THE LION ELECTRIC CO</p> <p>A manufacturer of all electric medium and heavy duty vehicles invests \$285 million for a battery manufacturing plant and innovation centre in QC</p> 
<p>Electra Battery Materials</p> <p>North America's first cobalt refinery for battery metals announces plans to develop a second cobalt processing facility in Canada in Quebec</p> 	<p>Vale</p> <p>Concluded a prefeasibility study to produce nickel sulfate in Bécancour, QC</p> 	<p>NanoOne</p> <p>NanoOne acquires Johnson Matthey Battery Materials, enters into a joint production agreement with BASF for CAM and announces \$10 million strategic investment agreement with Rio Tinto</p> 
<p>LGES and Stellantis</p> <p>JV for over \$5 billion EV battery plant in Windsor, Ontario</p> 	<p>GM/POSCO</p> <p>\$500 million joint venture to produce cathode active materials in Bécancour, QC</p> 	<p>BASF</p> <p>purchase of land in Bécancour for a future cathode active materials production</p> 
<p>Stellantis</p> <p>\$3.6 billion to retool Brampton and Windsor plants to produce EVs & fund Windsor Automotive Research and Development Centre</p> 	<p>Umicore</p> <p>\$1.5 billion for cathode active material and precursor cathode active materials production in Ontario</p> 	<p>Honda</p> <p>to invest nearly \$1.4 billion to retool its manufacturing operations in Alliston, Ont., to launch the next generation of hybrid-electric vehicles.</p> 



VALUE CHAIN: ELECTRIC VEHICLES

- Major investments in EV supply chain equally benefits other ES markets
- Aggregation of EV fleets for grid services being demonstrated and market reforms under development



Case Study 1



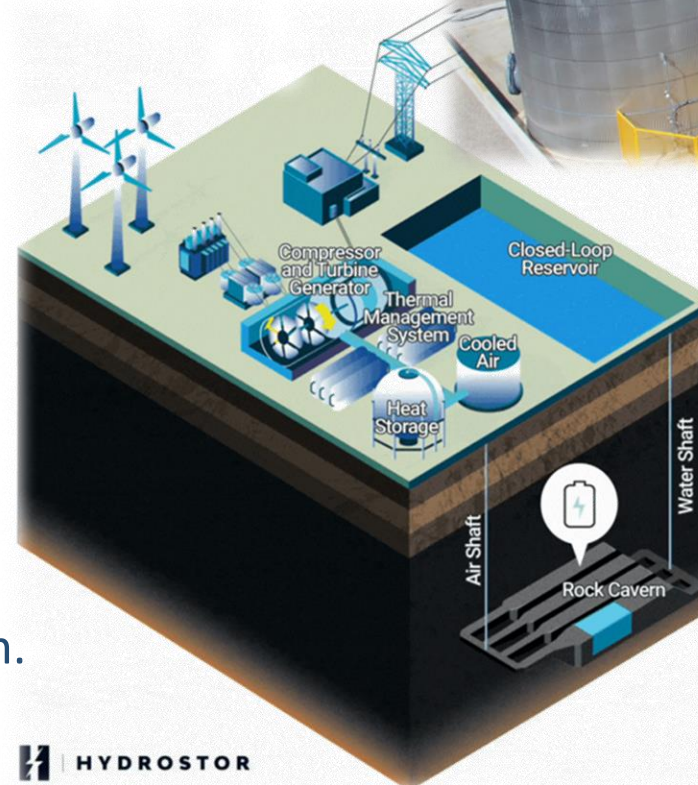
- Invinity Energy Systems
- Canada's largest vanadium flow battery:
3 MW / 8.4 MWh
- Delivered April 2023 to Chappice Lake, AB;
integrated with 21 MWp PV
- Order fulfilled with 38 Invinity
VS3 batteries
- Generating clean energy on demand to
serve the daily needs of more than 7,000
Albertans



Case Study 2



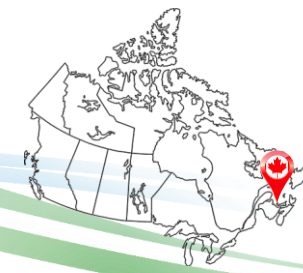
- Hydrostor: Global Long Duration Energy Storage Developer
- World's first commercial Advanced-CAES project
1.75 MW / 10 MWh
- Commissioned 2019 in Goderich, ON, contracted to Ontario's IESO providing:
 - Peaking capacity
 - Ancillary services
 - Merchant market participation
- A-CAES integrates compressed air, underground caverns, and water. Provides highly scalable, flexibly sited, low impact, and low cost ES. Flooding cavern during discharge maintains discharge pressure, and system is up to 1/20th the area/volume of an equivalently sized pumped hydro system.



Animation of A-CAES
available via QR code:



Case Study 3



- Wind Energy Institute of Canada ([WEICan](#)); Tignish, PEI
- 111.5 kW / 223 kWh Tesla PowerPack 2 (Li-ion)
 - Firming PV capacity
 - Limiting ramp rates
 - Providing regulation & VAR support
- 10MW wind, 109kW PV
~40 GWh renewable energy/yr
- Seasonal climate: -27°C to + 32°C
Operating Range: -30°C to + 40°C
- ES system used to develop deep learning surrogate model:
<https://doi.org/10.1109/GridEdge54130.2023.10102751>



Other Relevant Information

Reference publications

- Natural Resources Canada [Energy Fact Book 2022-2023 \(publications.gc.ca\)](https://publications.gc.ca)
- Canadian Climate Institute [Canadas-Net-Zero-Future \(climatechoices.ca\)](https://climatechoices.ca)
- Canada Energy Regulator [Canada's Energy Future 2021 \(cer-rec.gc.ca\)](https://cer-rec.gc.ca)
- Natural Resources Canada [Critical-minerals-strategy \(canada.ca\)](https://canada.ca)
- Navius Research [A study on the energy storage market in Canada \(2021\)](#)



IEA Technology Collaboration Programme

The Energy Storage TCP

*Country reports are an informative contribution of the ExCo delegates of the ES TCP member countries.
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