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Northern Confluence

Closing the Loop

B.C.'s role in recycling battery metals and minerals to power the electric vehicle revolution

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December 2021

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Recommended citation: Kim, Carolyn, Nikki Skuce, and Karen Tam Wu. *Closing the Loop: B.C.'s role in recycling battery metals and minerals to power the electric vehicle revolution*. The Pembina Institute, 2021.

ISBN 1-897390-54-8

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Additional copies of this publication may be downloaded from the Pembina Institute website, www.pembina.org.

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The Pembina Institute is a national non-partisan think tank that advocates for strong, effective policies to support Canada's clean energy transition. We employ multi-faceted and highly collaborative approaches to change. Producing credible, evidence-based research and analysis, we consult directly with organizations to design and implement clean energy solutions, and convene diverse sets of stakeholders to identify and move toward common solutions.

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About the Northern Confluence Initiative

The Northern Confluence Initiative is dedicated to conserving the salmon watersheds that sustain our communities, economies and shared futures. We are rooted in northwestern British Columbia and draw together perspectives from across the region. We focus on solutions. Together, we are working to improve land use decisions that respect Indigenous laws and rights and are based on sustainability principles. Northern Confluence is a project on MakeWay's shared platform.

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Acknowledgements

We would like to acknowledge the contributions of Dan Woynillowicz, Polaris Strategy + Insight, in support of the research and production of this report.

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Executive summary

The number of electric vehicles (EVs) hitting the road in British Columbia — and the rest of North America — is surging ahead, and sales growth is accelerating. Policies like B.C's zero-emission vehicle mandate coupled with growing consumer interest are driving a transition away from internal combustion engine vehicles and towards EVs, with B.C. leading North America in EV sales rates. In response, global automakers are rapidly pivoting their vehicle line-ups, and demand for the metals and minerals needed for EV batteries is projected to grow rapidly in the coming years.

Canada's federal and B.C. governments are trying to capitalize and position the country as a key materials source for the low-carbon transition, with the B.C. government "supporting innovative new ZEV technologies that could potentially put by-products of B.C. minerals and metals to good use, helping us transition to a low carbon economy and play a significant role in Canada's development of a national EV battery supply chain."

With EV batteries currently anticipated to have an average lifetime of eight to 15 years (based on current warranty timeframes and usage data), the first EVs to hit the road in North America are already reaching the end of their battery life. In light of this, B.C.'s role as an early adopter of EVs creates a significant economic and environmental opportunity: to secure a regional leadership role — and first-mover advantage — in recycling metals and minerals from EV batteries at end-of-life, closing the loop and minimizing the need for raw resource extraction.

The recycling and reuse of metals and minerals can and must play a key role in material supply and emission reductions for our transition to sustainable transportation. In September 2021, the B.C. government introduced an Extended Producer Responsibility Five Year Action Plan, which has been expanded to include products like hybrid and electric vehicle batteries and other battery types. Taking a phased approach, the provincial Recycling Regulation would consider hybrid and EV battery types in late 2023/early 2024, with programs becoming operational in 2026. By investing now in aggressive EV adoption, public transit infrastructure, and EV battery recycling capabilities, B.C. can be strategically positioned to be a leader in the low carbon future.

To capitalize upon this position, the government of B.C. should:

1. Assume a leadership role in engaging with neighbouring jurisdictions to ensure efficient and safe collection and transport of batteries for recycling purposes, including across borders.
2. Establish clear guidelines and an efficient review process for battery recycling facility permitting and land use.
3. Accelerate the timeline for implementing provincial regulations from 2026 to 2023 in order to address a growing stock of end-of-life batteries and position the province as a first-mover and regional leader.
4. Support pilot projects that explore solutions to various challenges, such as Quebec's support for a "battery passport" pilot to trace metals and minerals from mining and processing through to their use in batteries.
5. Work with the federal government to establish content targets for incorporating recycled metals and minerals into battery cells produced in Canada, closing the loop on the materials chain and spurring investment in recycling capacity.
6. Work with the federal government to establish battery labelling standards to ensure cell chemistry information can be used to simplify end-of-life recycling.

An electric vehicle boom

It wasn't long ago that electric vehicles (EVs) were considered niche. While Tesla generated headlines and sales most major automakers were, at best, only dabbling in EVs. But times have changed, and fast. According to the International Energy Agency, 18 of the world's top 20 vehicle manufacturers — accounting for about 90% of new car registrations in 2020 — have announced plans to increase their portfolio of electric models and rapidly scale up their production.[1] Worldwide there were about 370 electric car models available to choose from in 2020,[2] and automakers are slated to launch 400 new models by 2025.[3] And the pivot to electric isn't occurring only in light duty vehicles; four major truck manufacturers are indicating an all-electric future.[4]

In 2020, the COVID-19 pandemic led to a 6% drop in global car sales. But EV registrations grew by 43% with more than 3 million EVs hitting the road, with consumer spending on EVs topping US$120 billion.[5] While this success was largely driven by sales in the European Union and China, EV sales in North America held fairly steady, reaching 2% market share in the United States and 4% in Canada.[6] In British Columbia, zero-emission vehicle (ZEV)[7] sales grew to represent a continent-leading 9.4% of all light duty vehicle sales (Figure 1) and the total number of EVs on B.C. roads reached 54,469 (Figure 2).

[1] International Energy Agency, *Global EV Outlook 2021: Accelerating ambitions despite the pandemic* (2021), 5. https://www.iea.org/reports/global-ev-outlook-2021

[2] *Global EV Outlook 2021*, 23.

[3] McKinsey Centre for Future Mobility, *Electrifying the Bottom Line: How OEMs can boost EV profitability* (2021). https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/electrifying-the-bottom-line-how-oems-can-boost-ev-profitability

[4] *Global EV Outlook 2021,* 5.

[5] *Global EV Outlook 2021,* 5.

[6] *Global EV Outlook 2021,* 18.

[7] While the Zero-Emission Vehicles category includes fuel cell ZEVs, to date sales have been dominated by battery electric and plug-in hybrid electric vehicles.

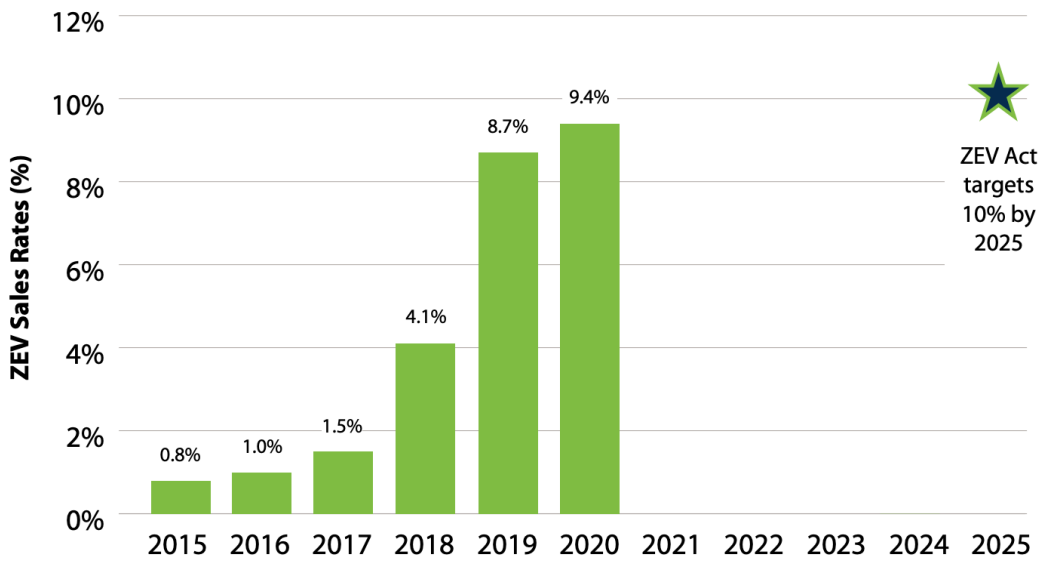

Figure 1. Light-duty ZEV sales in British Columbia

Source: Government of British Columbia[8]

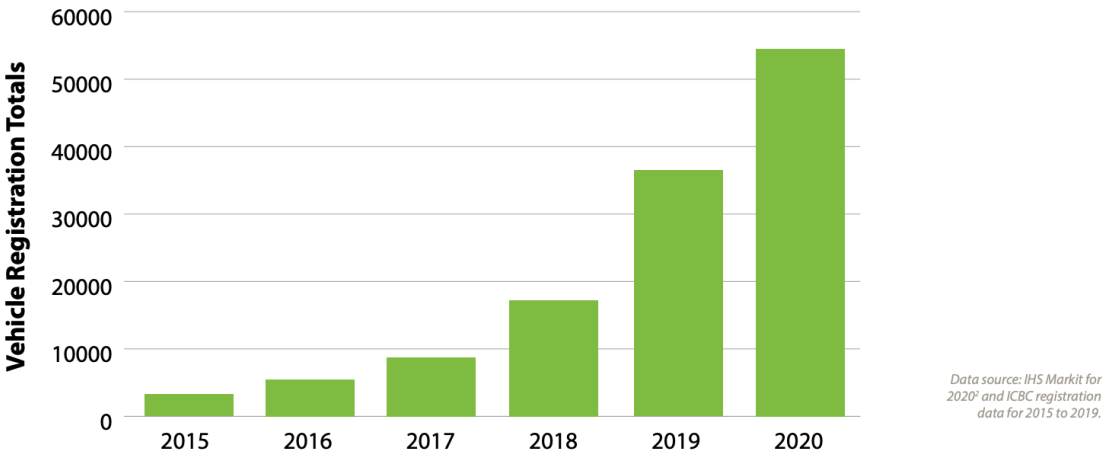

Figure 2. Light duty ZEV registrations in British Columbia

Source: Government of British Columbia[9]

[8] Government of British Columbia, *Zero Emission Vehicle Update 2020* (2021) , 4. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/2020_zero_emission_vehicle_update.pdf

Based on IHS Markit New Registration Data (Year End 2020) for the Province of British Columbia and IHS Markit's definition of Light Vehicles which excludes Medium and Heavy Trucks and vehicles greater than 8,500 GVW.

[9] *Zero Emission Vehicle Update 2020*, 3.

The B.C. government has actively encouraged consumer adoption of EVs to reduce greenhouse gas emissions from the transportation sector. It became the first jurisdiction in the world to legislate a 100% ZEV sales requirement in 2040, with interim targets in 2025 (10% of sales) and 2030 (30% of sales). However, given the rapid growth in sales — the 2025 10% sales requirement was nearly reached in 2020 — the B.C. government's updated climate plan, the CleanBC Roadmap to 2030 released in October 2021, signalled a more aggressive ZEV sales mandate of 26% in 2026, 90% in 2030 and 100% in 2035.[10] The Climate Solutions Council, which advises the government on climate change policy, estimates that to achieve 80–100% ZEV sales, the province would likely need over 200,000 new ZEVs sold in 2030 alone.[11] Even before this more aggressive plan, the B.C. government was projecting massive growth in the number of EVs on B.C. roads in the coming years, from over 50,000 in 2020 to 107,000 in 2025,[12] somewhere between 394,000[13] and 635,000[14] in 2030, and over 2.5 million in 2040.[15]

Beyond light-duty vehicles

B.C.'s interest in electrification of transportation extends beyond light duty vehicles, with the government encouraging consumer adoption of electric bicycles,[16] transit buses[17] and other medium- and heavy-duty vehicles.[18] The CleanBC Roadmap to 2030 has also laid out a plan to extend its ZEV mandate to medium and heavy-duty vehicles, to be developed in alignment with California.

[10] Government of British Columbia, *CleanBC Roadmap to 2030* (2021), 8. https://cleanbc.gov.bc.ca/

[11] B.C. Climate Solutions Council, Letter to Minister Heyman, July 9, 2021. https://www2.gov.bc.ca/assets/gov/environment/climate-change/advisory-council/letter_zevstandardadvice_07092021.pdf

[12] Government of British Columbia, *British Columbia Public Light-Duty Zero-Emission Vehicle Infrastructure Study* (2021), 11. https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/electricity-alternative-energy/transportation/bc_public_ld_zev_infrastructure_study_final_20210505.pdf

[13] *British Columbia Public Light-Duty Zero-Emission Vehicle Infrastructure Study*, 11.

[14] BC Hydro, *BC Hydro's Electrification Plan: A clean future powered by water* (2021) , 11. https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/electrification/Electrification-Plan.pdf

[15] *British Columbia Public Light-Duty Zero-Emission Vehicle Infrastructure Study*, 11.

[16] Government of British Columbia, "E-bike incentive to benefit users, environment," media release, July 6, 2021. https://news.gov.bc.ca/releases/2021FIN0045-001313

[17] BC Transit, "BC Transit's Low Carbon Fleet Program supports provincial targets to reduce greenhouse gas emissions," media release, July 29, 2019. https://www.bctransit.com/victoria/news?nid=1529705248190

[18] Government of British Columbia, "CleanBC Specialty Use Vehicle Incentive." https://suvibc.ca/

Surging demand for battery minerals and metals

As the demand for EVs and energy storage grows — in B.C., Canada and North America — so too will the demand for the metals needed for the batteries that power them. The batteries used in EVs are composed of battery cells contained in battery modules combined in a battery pack. The battery cells contain a number of minerals in the active cathode material (e.g. lithium, nickel, cobalt and manganese), the anode (e.g. graphite), and the current collector (e.g. copper) (Figure 3).

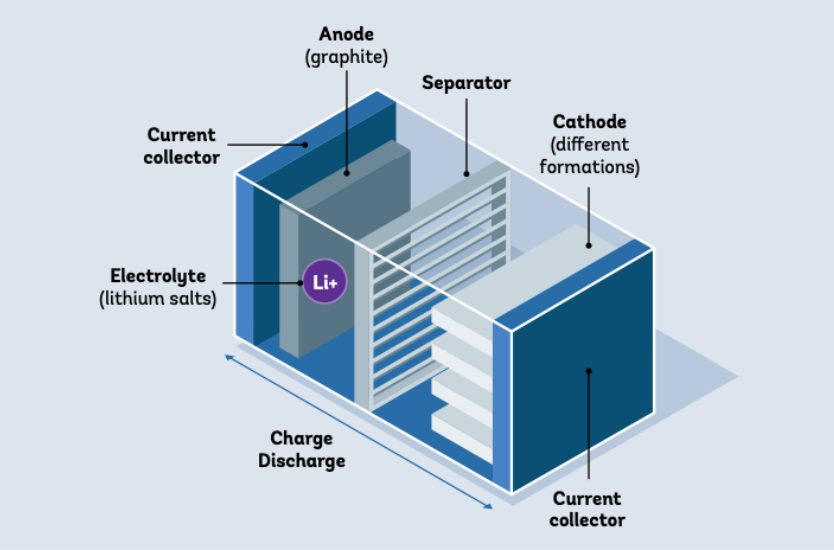

Illustration adapted from the World Bank's Minerals for Climate Action Infographic, https://www.worldbank.org/en/news/infographic/2019/02/26/climate-smart-mining.

Figure 3. Lithium-ion battery schematic

Figure source: World Bank[19]

The need for each mineral varies considerably depending on the cathode and anode chemistries (Table 1), with numerous chemistries still competing for EV supremacy. Consequently, projections for future mineral and metal demand for batteries — and

[19] The World Bank Group, *Minerals for Climate Action: The Mineral Intensity of the Clean Energy Transition* (2020), 60. https://pubdocs.worldbank.org/en/961711588875536384/Minerals-for-Climate-Action-The-Mineral-Intensity-of-the-Clean-Energy-Transition.pdf

their end-of-life recycling processes — are fraught with uncertainty.[20] For example, nickel manganese cobalt oxide (NMC) 111 batteries require about eight times more cobalt than nickel cobalt aluminium oxide (NCA+) batteries, but only half the nickel. Meanwhile, lithium iron phosphate (LFP) batteries do not require nickel, cobalt or manganese, but compared to NCM batteries, LFP batteries require approximately 50% more copper.[21]

Table 1. Lithium-ion battery sub-technologies

Cathode	Anode	Electrolyte
Nickel manganese cobalt (NMC) oxide Nickel cobalt aluminum (NCA) oxide Lithium cobalt oxide (LCO) Lithium manganese oxide (LMO) Lithium iron phosphate (LFP)	Graphite	Lithium salt

Data source: International Energy Agency[22]

In assessing the critical mineral requirements for clean energy technologies, the International Energy Agency rated the relative importance of copper, cobalt, nickel, lithium and rare earth elements as "high" for use in EV batteries.[23] So while there remains some uncertainty around which battery chemistry might ultimately dominate, it is likely that a variety of chemistries will be used, albeit to varying degrees. As a result, there will be significant and growing demand for a wide range of metals (Figure 4).

[20] International Energy Agency, *The Role of Critical Minerals in Clean Energy Transitions* (2021), 8. https://www.iea.org/reports/the-role-of-critical-minerals-in-clean-energy-transitions.

[21] *The Role of Critical Minerals in Clean Energy Transitions*, 88.

[22] *The Role of Critical Minerals in Clean Energy Transitions,* 90.

[23] *The Role of Critical Minerals in Clean Energy Transitions,* 45.

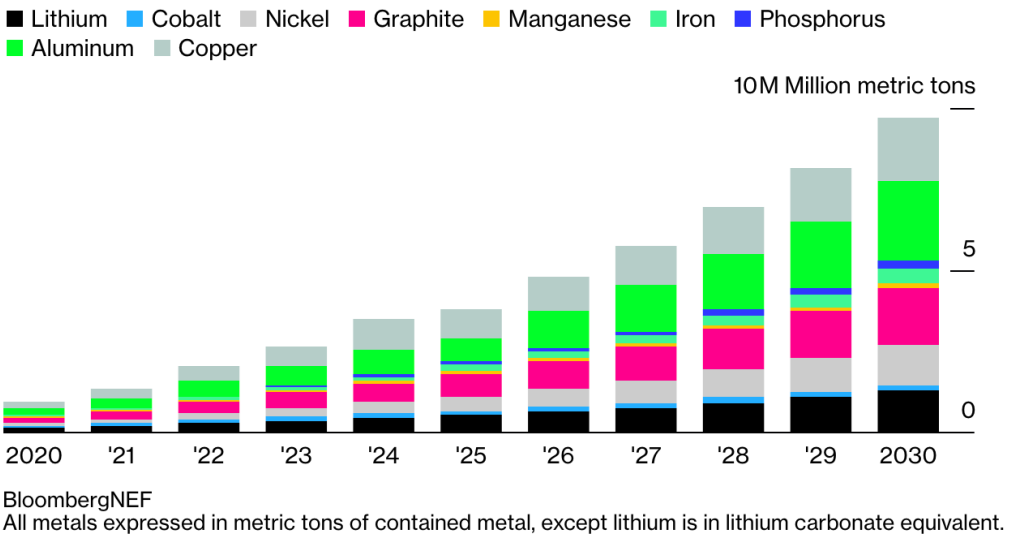

Figure 4. Demand forecast for metals used in EV batteries

Source: Bloomberg[24]

These forecasts for significantly growing demand for the metals and minerals found in clean energy technologies, including EV batteries, is now driving a commodities "supercycle"[25] (a supercycle is generally defined as a sustained period of expansion, typically resulting from robust growth in demand). According to Wood Mackenzie's *Accelerated Energy Transition-2 (AET-2)* model scenario — which is consistent with limiting the rise in global temperatures to 2°C — clean energy technologies will require 360 million tonnes (Mt) of aluminium, 90 Mt of copper, and 30 Mt of nickel over just the next 20 years.[26]

According to BloombergNEF's, Canada ranks fourth amongst the top 25 nations for mining in the EV battery supply chain (Figure 5).

[24] Annie Lee and Ed Spence, "Metals Behind EV Revolution to Resume Volatile Rally – Again," *Bloomberg,* January 14, 2021. https://www.bloomberg.com/news/articles/2021-01-15/metals-behind-ev-revolution-to-resume-volatile-rally-again?sref=KqJz5d6B

[25] Wood Mackenzie, "Next commodities supercycle will be driven by global energy transition," July 15, 2021. https://www.woodmac.com/press-releases/next-commodities-supercycle-will-be-driven-by-global-energy-transition/

[26] "Next commodities supercycle will be driven by global energy transition."

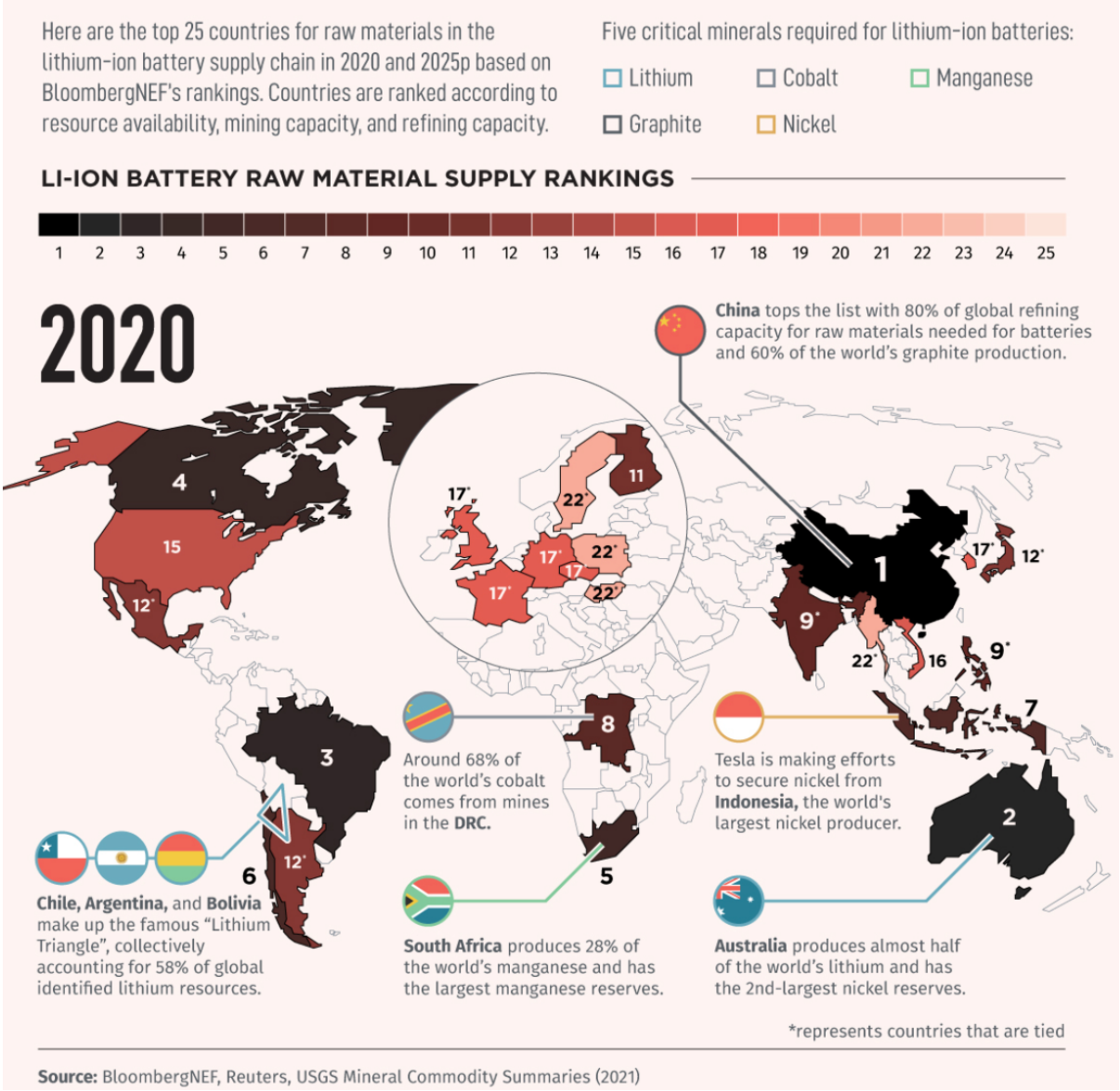

Figure 5. Top 25 nations for raw materials in the EV battery supply chain

Source: Visual Capitalist[27]

The Canadian federal and B.C. governments are trying to capitalize and position the country as a key materials source for the low carbon transition. The federal government has described Canada as having a "mines to mobility" advantage as "the only nation in the western hemisphere with an abundance of cobalt, graphite, lithium and nickel, the

[27] Visual Capitalist, "Ranked: Top 25 nations producing battery metals for the EV supply chain." https://www.mining.com/web/ranked-top-25-nations-producing-battery-metals-for-the-ev-supply-chain/

minerals needed to make next-generation electric batteries."[28] The rising price of nickel has led to a resurgence of mining exploration, especially for nickel and cobalt.[29]

Similarly, the B.C. provincial government is "supporting innovative new ZEV technologies that could potentially put by-products of B.C. minerals and metals to good use, helping us transition to a low carbon economy and play a significant role in Canada's development of a national EV battery supply chain."[30] Similarly, the Mining Association of Canada notes "B.C. has some of the lowest greenhouse-gas emissions-intensive mines and smelters in the world, providing the minerals and metals the world needs for a low-carbon future."[31] The B.C. government has invested $736 million to extend power transmission lines into the northern part of the province to support mineral development,[32] and both levels of government have created permanent tax incentives for mineral exploration.[33]

[28] Navdeep Bains, "Mining gives Canada a competitive advantage in electric vehicle market," *Policy Options*, September 17, 2020. https://policyoptions.irpp.org/magazines/september-2020/mining-gives-canada-a-competitive-advantage-in-electric-vehicle-market/

[29] Association for Mineral Exploration British Columbia, "BC's Green Mineral Potential in a Low Carbon Future," February 20, 2019. https://amebc.ca/bcs-green-mineral-potential-in-a-low-carbon-future/

[30] University of Victoria, "Materials innovation driving next-gen EV batteries," June 22, 2021. https://www.uvic.ca/news/topics/2021+next-gen-batteries+media-release

[31] Resource Works, "Digging for the future: The world is electrifying. And it's looking to BC to supply the metals and minerals it needs," July 2, 2021. https://www.resourceworks.com/digging-for-the-future

[32] Bloomberg Business News Network, "Why the future is bright for nickel exploration," February 16, 2021. https://www.bnnbloomberg.ca/why-the-future-is-bright-for-nickel-exploration-1.1562606

[33] Mining.com, "BC exploration tax credits made permanent," January 28, 2019. https://www.mining.com/bc-exploration-tax-credits-made-permanent/

Canada's movement towards more responsible mining

B.C.'s reputation as a responsible mining jurisdiction is not without criticism. The province had one of the largest environmental mining disasters in Canadian history when the Mount Polley tailings waste dam breached in 2014.[34] Indigenous peoples[35], community groups[36] and transboundary States[37] have all expressed ongoing concerns about B.C. mining practices.

At the same time, several large purchasers in the automotive, tech, building and jewellery sectors are increasing pressure for more responsible mining in order to clean up their supply chains.[38] Various standards have been developed to try to create accountability in the mining sector, such as the Initiative for Responsible Mining Assurance (IRMA),[39] Responsible Steel,[40] and the Responsible Jewellery Council.[41] Some vehicle manufacturers are beginning to do the same, including Tesla and Porsche.[42] Investors are also becoming

[34] Government of British Columbia, "Mount Polley Mine Tailing Dam Breach." https://www2.gov.bc.ca/gov/content/environment/air-land-water/spills-environmental-emergencies/spill-incidents/past-spill-incidents/mt-polley

[35] See First Nations Energy and Mining Council, "Resources: Mining and Mineral Exploration." http://fnemc.ca/resources/mining-and-mineral-exploration/; Tsihlqotin National Government, "Gibraltar Mine." https://www.tsilhqotin.ca/gibraltar/; Odette Auger, "Nuxalk Nation issues eviction notice to mining company operating on unceded territory," *Toronto Star,* August 18, 2021. https://www.thestar.com/news/canada/2021/08/18/nuxalk-nation-issues-eviction-notice-to-mining-company-operating-on-unceded-territory.html; Bradley Jones, "Ktunaxa Nation: Teck's $60-million fine is step to "acknowledging the harm" caused by mining operations," *My East Kootenay Now,* March 26, 2021. https://www.myeastkootenaynow.com/15463/ktunaxa-nation-tecks-60-million-fine-is-step-to-acknowledging-the-harm-caused-by-mining-operations/

[36] BC Mining Law Reform Network. https://reformbcmining.ca

[37] United States Senate, Multistate delegation letter to Premier Horgan, June 13, 2019. Available at https://www.salmonbeyondborders.org/uploads/3/9/0/1/39018435/06.13.2019_multistate_delegation_letter_to_premier_horgan.pdf

[38] IRMA, "Climate Change and the Push for More Mining," webinar, September 25, 2020). https://vimeo.com/462750060

[39] IRMA, "Certification." https://responsiblemining.net/what-we-do/certification/

[40] Responsible Steel, "Certification." https://www.responsiblesteel.org/certification/

[41] Responsible Jewellery, "Standards." https://www.responsiblejewellery.com/standards/

[42] Sustainable Brands. "Porsche, Tesla Partner with Materials Suppliers to Increase Sustainability of EV Batteries." July 26, 2021. https://sustainablebrands.com/read/supply-chain/porsche-tesla-partner-with-materials-suppliers-to-increase-sustainability-of-ev-batteries

more demanding of environmental, social and governance (ESG) performance measures, and disclosures around both climate and tailings risks in the mining sector.[43]

B.C. made some reforms after Mount Polley but needs to do more if it is to position itself as a responsible mining jurisdiction.[44] Gaps must be addressed to ensure that any new mining operations align with the province's climate targets and obligations under the Declaration for the Rights of Indigenous Peoples Act,[45] and that all mines have better financial assurances, and waste and water management and practices. Moving forward, the B.C. government will need to ensure rigorous environmental assessment and world-class monitoring and enforcement of environmental standards in the mining sector. This must include full participation and joint decision-making with Indigenous communities in accordance with DRIPA, and continuous performance improvement to ensure B.C. produces the lowest carbon, and ultimately net-zero, metals and minerals.

[43] Earthworks, "Investor Pressure and the Global Tailings Review." https://earthworks.org/campaigns/preventing-mine-waste-disasters/investor-pressure-and-the-global-tailings-review/

[44] First Nations Energy and Mining Council, *Mount Polley Disaster: Six Years Later is B.C. Any Safer?* (2020. http://fnemc.ca/wp-content/uploads/2015/07/Mt.-Polley-Disaster-Is-BC-Any-Safer-July-29.pdf

The Mount Polley Expert Panel report contained recommendations, many yet to be implemented (such as mandating safety in tailings design and reducing B.C's tailings facility inventory by half): Independent Expert Engineering Investigation and Review Panel, R*eport on Mount Polley Tailings Storage Facility Breach* (2015), 139. https://www.mountpolleyreviewpanel.ca/final-report

[45] For example, see CBC News. "Gitxaała First Nation sues B.C. government over automatic granting of mineral rights." October 27, 2021. https://www.cbc.ca/news/canada/british-columbia/gitxaala-first-nation-bc-mineral-rights-1.6227758

EV battery waste: challenge and opportunity

While more mining around the world will be required to meet soaring global demand for battery metals and minerals, extraction of raw resources is not the only possible or needed source of supply. When EV batteries reach the end of their useful life they are not just a waste stream to be disposed of, but can be a critical and growing source of metal and mineral supply — closing the loop and minimizing, to the greatest extent possible, the need for new mining and the associated environmental impacts.

> *"…you can either get your lithium and your nickel and the various constituents of the battery from rocks, or from batteries. It's much better to get them from batteries."*
>
> *— Elon Musk, CEO, Tesla*[46]

With EV batteries currently anticipated to have an average lifetime of eight to 15 years (based on current warranty timeframes and usage data),[47] the first EVs to hit the road in North America are already reaching the end of their battery life. While there are opportunities and applications where these batteries can be re-used — a so-called "second life" — at some point they will enter the waste stream and will need to be properly managed.[48] It is at this stage that it's possible to close the loop, and support the establishment of a more circular economy.

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[46] Bloomberg, "China's Next EV Advantage Is a Mountain of Retired Batteries," October 25, 2021. https://www.bloomberg.com/news/newsletters/2021-10-25/china-ev-battery-life-cycle-is-coming-full-circle-with-recycling?sref=KqJz5d6B

[47] E. Dominish, N. Florin, R. Wakefield-Rann, *Reducing new mining for electric vehicle battery metals: responsible sourcing through demand reduction strategies and recycling*, prepared for Earthworks by the Institute for Sustainable Futures, University of Technology Sydney (2021). https://earthworks.org/publications/recycle-dont-mine/

[48] EV batteries pose several environmental, health and safety risks if their end-of-life isn't properly regulated and managed. For example, lithium-ion batteries contain several toxic and/or flammable materials, posing safety risks (fire and explosion, soil and groundwater contamination) should they find their way into municipal solid waste streams. Alexandre Beaudet, François Larouche, Kamyab Amouzegar, Patrick Bouchard and Karim Zaghib, "Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials," *Sustainability* 12, (2020). https://doi.org/10.3390/su12145837

> *"We have maybe 20 years before all the vehicles become electric. The actual supply chain will not withstand the transition without recyclable materials."*
> *— Asmae Mokrini, National Research Council*[49]

In addition, recycling EV batteries offers an important opportunity to lower their life cycle carbon footprint. At least 30–50% of life cycle emissions from EVs arise from mineral extraction and battery manufacturing.[50] Recycling them at end-of-life and re-using the recovered metals and minerals — thus avoiding virgin extraction and refining — has been estimated to reduce life cycle emissions by up to 51%[51] and save as much as 20 times the energy relative to mining new, raw materials.[52] Recycled feedstock could also help reduce the cost of EV batteries, and hence the cost of EVs, with the use of recycled materials estimated to reduce total battery pack costs by up to 30%.[53]

Beyond the need to address a waste stream, recycling EV batteries could provide a critical source of metals and minerals to sustain the electrification of mobility and the associated greenhouse gas emission reductions. Fortunately, metals "do not disappear when they are used…they retain their intrinsic properties throughout the recycling process. They can be used repeatedly, while maintaining their quality and functionality."[54] A recent study by the Institute for Sustainable Futures at the University of Technology Sydney found that recycling could reduce primary demand (relative to total demand in 2040), by approximately 25% for lithium, 35% for cobalt and nickel and 55% for copper, significantly reducing the scale of new mining required.[55]

Currently, less than 5% of EV batteries are recycled worldwide, because it's a far more complicated process than recycling old household batteries.[56] Before they can be recycled, EV batteries must be discharged, stabilised, and then dismantled to at least the module level, so that cell components can be separated into different material streams. There are two common processes for recycling lithium-ion batteries:

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[49] Nathaniel Basen, "Can Ontario boost EV battery recycling before it's too late?" *TVO*, April 22, 2021. https://www.tvo.org/article/can-ontario-boost-ev-battery-recycling-before-its-too-late

[50] Beaudet, "Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials."

[51] Beaudet, "Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials."

[52] Canada's Mines Ministers, *The Canadian Minerals And Metals Plan* (2019), 24. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/CMMP/CMMP_The_Plan-EN.pdf

[53] Beaudet, "Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials."

[54] *The Canadian Minerals And Metals Plan,* 24,

[55] *Reducing new mining for electric vehicle battery metals.*

[56] "Can Ontario boost EV battery recycling before it's too late?"

hydrometallurgical, which uses a liquid solution to extract metals; or pyrometallurgical, which uses fire.

Given the early stages of battery recycling in most parts of the world, the economics remain challenging. According to the McKinsey Centre for Future Mobility, "The residual value of batteries currently remains negative, forcing Original Equipment Manufacturers to set up provisions for their disposal, which will cost USD 1,000 to 2,000 per battery. And while companies in the battery space have just begun to form partnerships and set up pilot plants that could lead to a second life and/or recycling ecosystem for batteries and, eventually, increase the lifetime value of the EV battery, disposal costs will continue to be a hurdle for the coming years."[57] That said, if end-of-life batteries can be harvested for metals and minerals rather than treated as a waste stream, then the economics will shift from cost to benefit. Capitalizing upon this opportunity, the global EV battery recycling industry is expected to grow significantly, generating billions of dollars in revenue, tax income, and jobs.[58] This provides added impetus for governments to encourage and support EV battery recycling within their jurisdictions, and there are lively discussions in Canada — especially in Quebec[59] — about the possibility of attracting more investments in this area.[60]

> *"With the battery sector, we aim at developing a real circular economy model. From the sustainable extraction of minerals to battery recycling, we want to use cutting edge technologies to develop a sustainable electric mobility industry, with the lowest carbon footprint."*
>
> *—Pierre Fitzgibbon, Quebec Minister of Economy and Innovation*[61]

[57] *Electrifying the Bottom Line.*

[58] Beaudet, "Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials."

[59] Quebec's draft regulations for recycling electric vehicle battery waste have garnered some criticism, and are likely to evolve before being finalized (for example, see Jeff Dahn, "Quebec risks a critical circular economy misstep with proposed EV battery recycling plan," *Electric Autonomy,* October 29, 2021. http://electricautonomy.ca/2021/10/29/jeff-dahn-quebec-ev-battery-recycling/). As Canada's first provincial regulations, they are likely to serve as an early model for other provinces.

[60] Beaudet, "Key Challenges and Opportunities for Recycling Electric Vehicle Battery Materials."

[61] Propulsion Quebec, "*Propulsion Québec releases a new study on extended producer responsibility for end-of-life electric vehicle battery management,"* November 17, 2020. https://propulsionquebec.com/en/2020/11/17/propulsion-quebec-releases-a-new-study-on-extended-producer-responsibility-for-end-of-life-electric-vehicle-battery-management/

The state of battery recycling

While Canada is home to several EV battery recyclers — Retriev Technologies in B.C., Li-Cycle in Ontario and Lithion in Quebec[62] — the country lags behind innovation and investment efforts in the United States, such as the ReCell Centre launched by the U.S Department of Energy[63] and the Biden Administration's emphasis on battery recycling as a key part of its broader EV plan.[64]

> In the U.S, battery recycling efforts are beginning to ramp up, including Redwood Materials, a Nevada-based privately held recycling firm that has signed a deal to recycle scrap and battery parts from a Tennessee-based contractor for Nissan Motor Co's Leaf EV, and Tesla's development of a battery recycling system at its Nevada Gigafactory.[65]

While Canada's National Research Council has a battery recycling research initiative of its own, it falls short American efforts,[66] and federal and provincial government efforts appear more oriented towards mining battery metals than recycling them.

Numerous hurdles will need to be overcome if EV battery recycling is to scale up and deliver economic and environmental benefits, including:[67]

- In most countries, including Canada, there are no comprehensive systems that dictate and guide the material collection processes at a national level.
- Specific regulations or guidelines to oversee discharging, disassembling and storing spent batteries are similarly lacking.
- Specified safety measures for the handling and transport of end-of-life EV batteries are needed.

As a result of these hurdles, battery recycling capacity is only in its infancy, and is policy-driven, not market-driven. At present, global battery recycling capacity is about

[62] "Can Ontario boost EV battery recycling before it's too late?"

[63] "Can Ontario boost EV battery recycling before it's too late?"

[64] Reuters, "Biden's electric vehicle plan includes battery recycling push," June 4, 2021. https://www.reuters.com/business/autos-transportation/exclusive-bidens-electric-vehicle-plan-includes-battery-recycling-push-2021-06-04/

[65] "Biden's electric vehicle plan includes battery recycling push."

[66] "Can Ontario boost EV battery recycling before it's too late?"

[67] *The Role of Critical Minerals in Clean Energy Transitions*, 185.

180 kilotonnes per year (kt/yr), and China is home to almost 50% of this capacity.[68] Thanks to plans to further increase its recycling capacity, China is all but certain to remain the largest recycler, but European countries are also scaling up, as are both the United States and Canada (Figure 7).

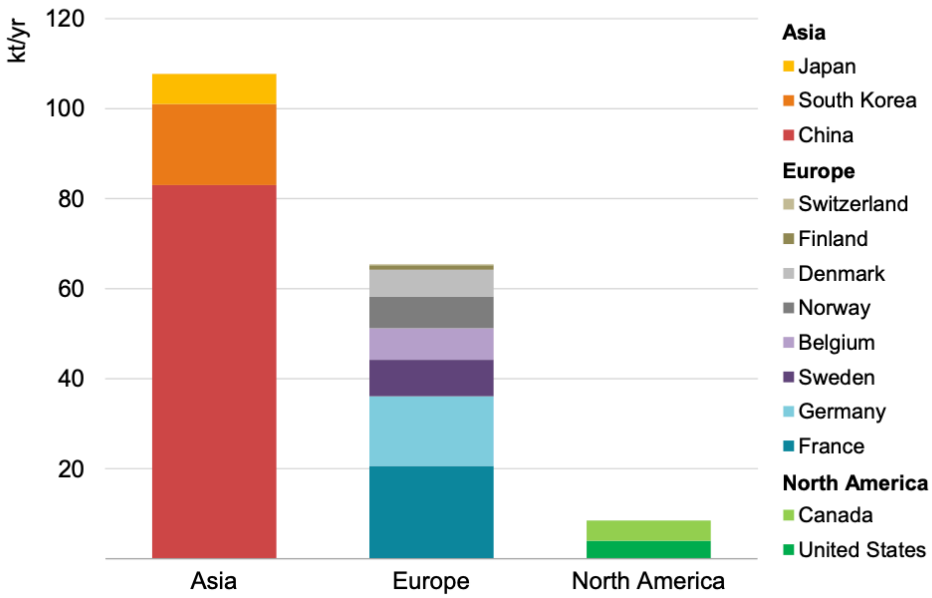

Figure 6. Lithium-ion battery recycling capacity to come online by 2021, existing and announced

Source: International Energy Agency[69]

China's early leadership in lithium-ion battery recycling was not just a response to a rapidly growing stockpile of end-of-life batteries, but also the result of early and deliberate policy leadership. China established a policy framework in 2018 to push battery producers to establish collection and recycling activities, with guidelines encouraging the standardization of battery design, production and verification, as well as repairing and repackaging for second life utilization.[70]

In the European Union, efforts are underway to establish global standards for environmentally and socially responsible batteries, with revisions to the EU 2006 Battery Directive proposed in December 2020 for mandatory collection and recycling of automotive EV batteries.[71] In the United States, California established the Lithium-ion

[68] *The Role of Critical Minerals in Clean Energy Transitions*, 183.

[69] *The Role of Critical Minerals in Clean Energy Transitions*, 184.

[70] *Global EV Outlook 2021*, 61.

[71] *Global EV Outlook 2021*, 62.

Car Battery Recycling Advisory Group, tasking it with developing policy recommendations for the end-of-life reuse and recycle of batteries by March 2022.[72]

According to the International Energy Agency, best practices for policymakers tasked with managing and regulating EV battery recycling include:[73]

- enabling the efficient collection and transport of end-of-life batteries
- product design and labelling requirements to help streamline the recycling process
- harmonizing regulations on international movement of batteries (which will be important in the Canadian context, as regional recycling is more likely to include north-south market integration with the U.S versus east-west across Canada).

While Canada's Minerals And Metals Plan recommends that "federal, provincial and territorial governments and industry should study Canada's recycling and reprocessing capacity and capabilities to determine how they can support sustainability and competitiveness,"[74] there is no evidence of this coordinated effort, nor has a comprehensive policy framework — critical to ensuring efficient and effective recycling — been established (federally or in any individual province). Encouragingly, efforts to convene stakeholders along the full EV battery supply chain have extended to end-of-use recycling,[75] recognizing that "Cross-industry collaboration, public-private partnerships, transparency and traceability, and recycling regulatory and incentive measures are warranted to ensure batteries are designed for recyclability, collected upon end-of-use, and ultimately recycled."[76]

> *"Facilitating recycling and reuse is a vital part of the low-carbon transition, but policy measures will need to incentivize action in this area while promoting awareness of the economic and environmental challenges associated with the processes of recycling. Future increases in recycling rates can play an important role in mitigating increases in demand for raw*

[72] California Environmental Protection Agency, "Lithium-ion Car Battery Recycling Group." https://calepa.ca.gov/lithium-ion-car-battery-recycling-advisory-group/

[73] *The Role of Critical Minerals in Clean Energy Transitions*, 186.

[74] *The Canadian Minerals And Metals Plan,* 21.

[75] Clean Energy Canada, *Turning talk into action: Building Canada's battery supply chain* (2021) , 14. https://cleanenergycanada.org/wp-content/uploads/2021/05/Turning-Talk-into-Action_Building-Canadas-Battery-Supply-Chain.pdf

[76] International Council on Clean Transportation, *How Technology, Recycling, and Policy Can Mitigate Supply Risks to the Long-Term Transition to Zero-Emission Vehicles* (2020), ii. http://www.zevalliance.org/wp-content/uploads/2020/12/zev-supply-risks-dec2020.pdf

> *materials, as can reuse of components for energy storage technologies, such as lithium-ion batteries."*
>
> *— The World Bank Group*[77]

Extended Producer Responsibility (EPR) is an approach to recycling that requires producers, such as manufacturers, distributors, and retailers, to take responsibility for the life cycle of the products they sell, including collection and recycling.[78]

In September 2021, the B.C. government announced that EV batteries will become eligible for province-wide recycling by way of inclusion in the Recycling Regulation[79] and the Extended Producer Responsibility (EPR) strategy, which is part of a five-year plan to advance recycling in the province.[80] The EPR Five-Year Action Plan will see changes phased in to give producers time to set up the necessary systems; however, the government acknowledges the need for timely action and has committed to accelerating proposed timelines where possible.[81] Under B.C.'s EPR strategy, producers are responsible for implementing, funding and managing recycling programs, with the product's complexity informing the phase-in timeline, to ensure adequate time to establish comprehensive management systems, and to submit EPR program plans to the Ministry of Environment and Climate Change Strategy for approval.[82] However, EV batteries won't be added to the regulation until late 2024, and EPR programs won't be operational until 2026.[83]

[77] *Minerals for Climate Action*, 14.

[78] Government of British Columbia, "Extended Producer Responsibility." https://www2.gov.bc.ca/gov/content/environment/waste-management/recycling/extended-producer-responsibility

[79] Government of British Columbia, "Recycling Regulation amendments and initiatives." https://www2.gov.bc.ca/gov/content/environment/waste-management/recycling/extended-producer-responsibility/recycling-regulation

[80] Government of British Columbia, "Province taking action to recycle more products," media release, September 10, 2021. https://news.gov.bc.ca/releases/2021ENV0052-001767

[81] "Province taking action to recycle more products."

[82] Government of British Columbia, *Advancing Recycling in B.C.: Extended Producer Responsibility Five-Year Action Plan 2021-2026* (2021), 4. https://www2.gov.bc.ca/assets/gov/environment/waste-management/recycling/recycle/extended_producer_five_year_action_plan.pdf

[83] *Advancing Recycling in B.C.: Extended Producer Responsibility Five-Year Action Plan*, 10.

Recommendations

The recycling and reuse of metals and minerals can and must play a key role in material supply and emission reductions for our transition to sustainable transportation. With investments now in aggressive EV adoption, public transit infrastructure, and EV battery recycling capabilities, B.C. can be strategically positioned to be a leader in the low-carbon future.

As an early leader in EV adoption, B.C. will see growing demand for end-of-life recycling, which offers the province the opportunity to also emerge as an early regional leader in battery recycling in the Pacific Northwest, and capture the associated economic benefits.

To capitalize upon this opportunity the government of B.C. should:

1. Assume a leadership role in engaging with neighbouring jurisdictions to ensure efficient and safe collection and transport of batteries for recycling purposes, including across borders.
2. Establish clear guidelines and an efficient review process for battery recycling facility permitting and land use.
3. Accelerate the timeline for implementing provincial regulations from 2026 to 2023 in order to address a growing stock of end-of-life batteries and position the province as a first-mover and regional leader.
4. Support pilot projects that explore solutions to various challenges, such as Quebec's support for a "battery passport" pilot to trace metals and minerals from mining and processing through to their use in batteries.[84]
5. Work with the federal government to establish content targets for incorporating recycled metals and minerals into battery cells produced in Canada, closing the loop on the materials chain and spurring investment in recycling capacity.
6. Work with the federal government to establish battery labelling standards to ensure cell chemistry information can be used to simplify end-of-life recycling.

[84] Shane Lasley, "Quebec invests in battery metals tracing," *Metal Tech News*, November 25, 2020. https://www.metaltechnews.com/story/2020/11/25/mining-tech/quebec-invests-in-battery-metals-tracing/396.html