ACTION CANADA
Building Leadership for Canada's Future
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POSITIVE CHARGE

Maximizing Canada's Electric Vehicle Battery Repurposing and Recycling Ecosystem

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ABOUT ACTION CANADA

The Action Canada Fellowship is a 10-month public policy leadership training program delivered by the Public Policy Forum (PPF) and led by Action Canada alumni. The fellowship enhances emerging leaders' understanding of Canada and current and future public policy issues. Each year, Action Canada chooses a critical policy issue for Fellows to explore over the course of the program. Working in task forces, the Fellows engage with experts and stakeholders across the country to prepare a report identifying policy solutions with the aim of contributing to national dialogue on key challenges facing Canadians. This year's theme is sustainable transportation.

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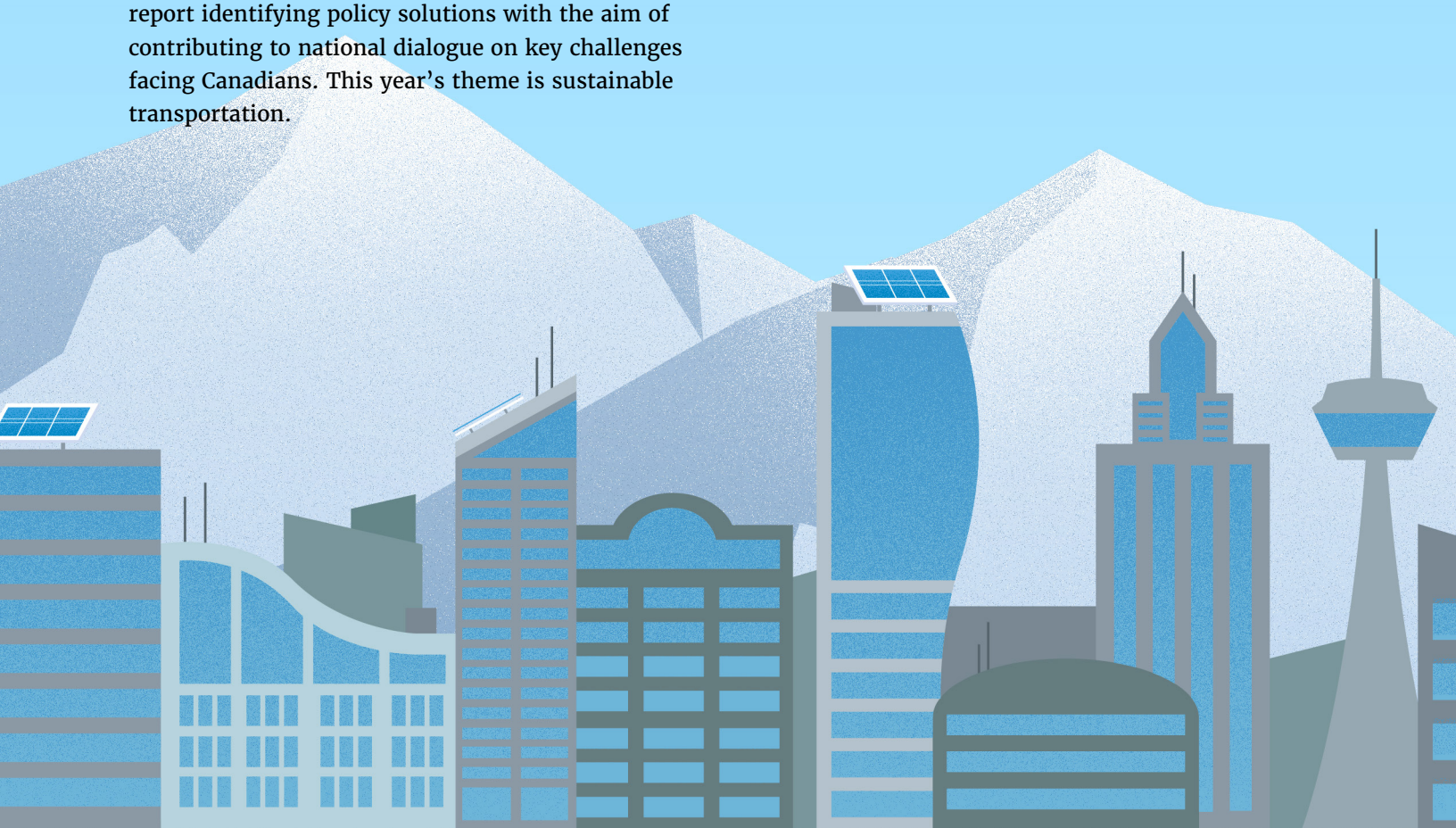

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EXECUTIVE SUMMARY

In the pursuit of a sustainable future, Canada's federal and provincial governments have invested billions in the electric vehicle (EV) transition to steer the nation toward a decarbonized transportation sector.

These investments have sparked a national conversation on the "upstream" aspects of the EV transition, from environmental concerns over the mining of critical minerals to the economic opportunities of domestic EV battery manufacturing. However, the "downstream" impacts of this transition remain uncharted. As the gears of progress turn and Canada seeks to maximize its return on investment in EV manufacturing, it is the opportune moment to prepare for the next stage: managing EV batteries at end-of-vehicle-life (EoVL).

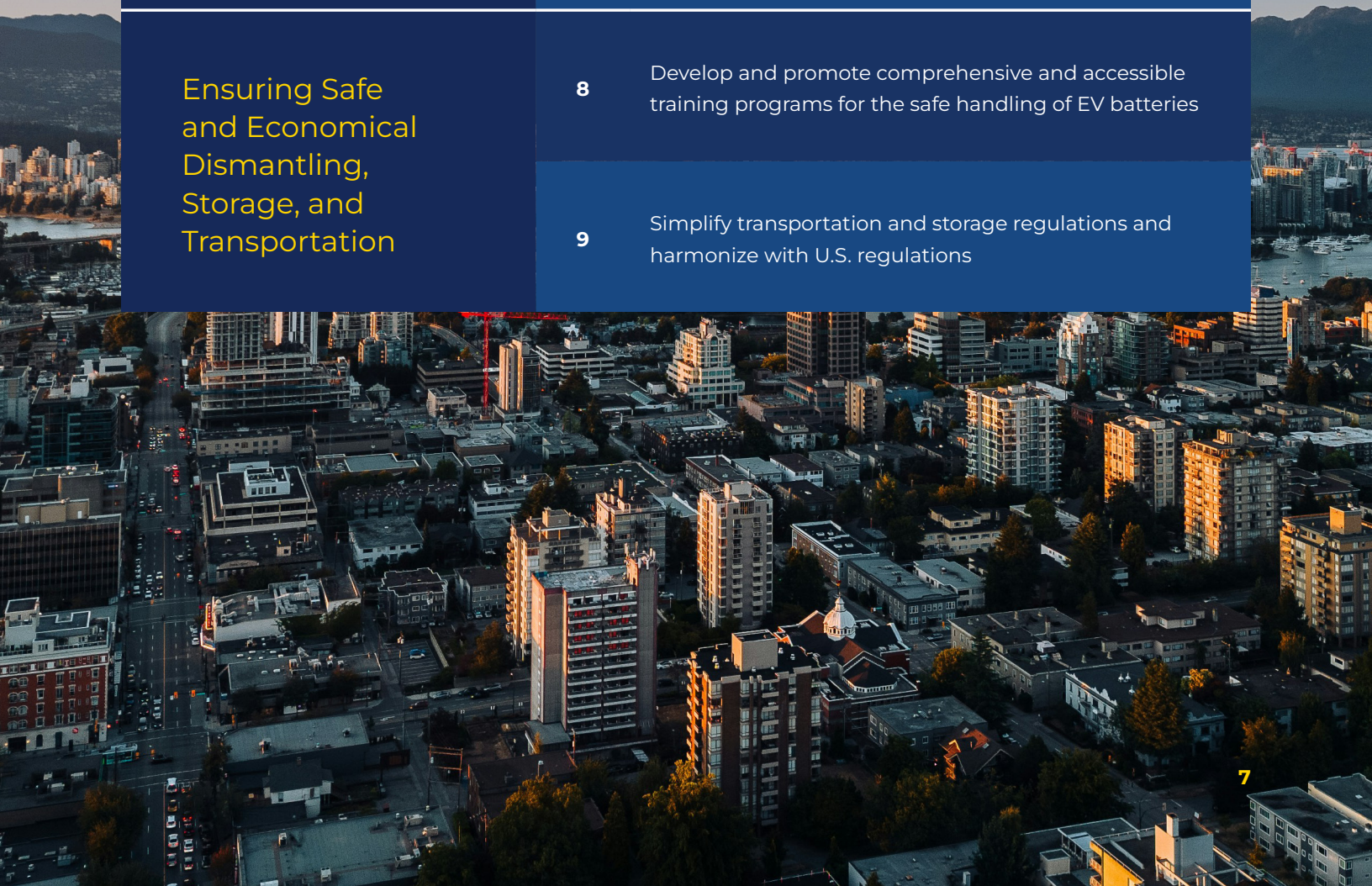
This report urges immediate action to ensure the safe and sustainable management of EV batteries at EoVL.

The fast-evolving EV battery repurposing and recycling ecosystem holds immense potential for growth in Canada, promising environmental, economic, and energy security benefits. However, as this report details, the sector faces many technological, regulatory, and economic challenges.

Based on an extensive literature review and interviews with experts from industry, non-governmental organizations (NGOs), and academia, this report outlines nine recommendations to unlock Canada's ability to effectively and safely repurpose and recycle EV batteries. These recommendations call on all stakeholders to work together to scale, optimize, and develop Canada's EV battery repurposing and recycling sector.

RECOMMENDATIONS

Enabling Conditions and Building Capacity	1	Incentivize market conditions to support the battery repurposing and recycling sector in Canada
	2	Encourage battery-makers to design for circularity
	3	Accelerate Canadian research and development on battery repurposing and recycling technologies
Encouraging the Best Pathway for Batteries at End-of-Vehicle-Life	4	Implement a coordinated producer take-back approach to EoVL management of EV batteries
	5	Ensure that state of health assessments are standardized and easily accessible to consumers and actors within the EV battery ecosystem
	6	Establish an expert advisory group to co-develop guidelines to ensure proper pathways for EoVL batteries
	7	Introduce a Battery Passport System
Ensuring Safe and Economical Dismantling, Storage, and Transportation	8	Develop and promote comprehensive and accessible training programs for the safe handling of EV batteries
	9	Simplify transportation and storage regulations and harmonize with U.S. regulations



INTRODUCTION

The transition to electric vehicles (EVs) will result in a growing number of batteries[i] that reach their end-of-vehicle-life (EoVL)[ii] and need to be recycled or repurposed into secondary uses.

Although a critical mass of EoVL batteries will only emerge in the years following higher EV adoption rates, there is a window of opportunity now to craft policies that harness the battery repurposing and recycling sector's momentum and responsibly scale infrastructure to meet future demands for repurposing and recycling. There is currently no comprehensive, national policy regime in Canada that fully considers the economic, regulatory, environmental, and technical requirements for the effective management of EV battery waste.

Policies that promote circularity[iii]—including the effective, efficient, and safe repurposing and recycling of batteries and their critical minerals—help ensure the transition to EVs is economically and environmentally sustainable. This influences the speed of decarbonization, the supply of critical minerals, and the viability and environmental sustainability of Canada's multibillion-dollar investments in battery manufacturing. Simply put, Canada has a significant opportunity to demonstrate leadership and advance its goals on climate action, sustainable natural resource development, economic growth, and workforce development by developing a robust repurposing and recycling ecosystem for EV batteries.

The Government of Canada defines a zero-emission vehicle (ZEV) as battery-electric, plug-in hybrid electric, and hydrogen fuel cell vehicle, as they all can operate without a greenhouse gas emitting internal combustion engine. This report's use of the term "electric vehicle" includes both battery-electric and plug-in hybrid electric vehicles.

This report explores the national and international landscape of EV battery repurposing and recycling as well as the economic, regulatory, and technical challenges facing this sector. It asserts that Canada, as a key part of an integrated North American automotive market, should pursue a holistic policy framework that ensures EV batteries are managed sustainably when they reach EoVL, further establishing Canada's competitive presence in the EV battery ecosystem.

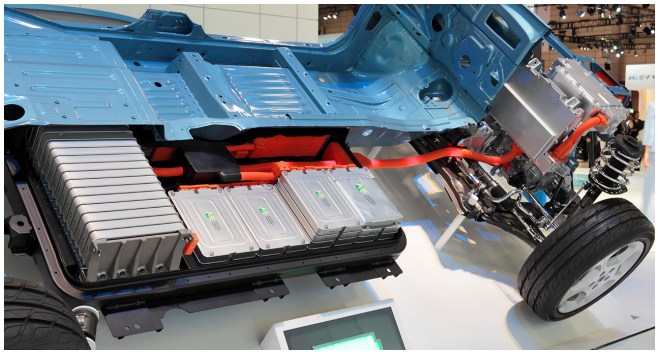


Photo: Nissan Leaf battery by H.Kashioka, CC-BY-SA-3.0

[i] In this report, EV battery refers to the battery pack inside an EV, which is a set of connected battery modules that perform as one entity. Battery modules are a group of battery cells, and one cell is a single rechargeable unit within a module.

[ii] End-of-vehicle-life (EoVL) describes a "battery pack whose life within a vehicle has come to an end and is ready for its journey along one of the pathways," including repair, remanufacturing, resale as is, repurpose, direct to recycling," while end-of-life (EoL) "refers to a battery pack whose entire useful life has come to an end and is ready for recycling" (CVMA & Call2Recycle. (2022). *Electric Vehicle Battery Management at End-of-Vehicle Life: A Primer for Canada*, p. 11).

[iii] Circularity is the principle of keeping a resource "in use" as long as possible and then seeking ways of reusing, regenerating, or recycling it so it can re-enter the supply chain instead of becoming waste.

1.1 - ELECTRIC VEHICLE TRANSITION

The transportation sector accounts for 25% of Canada's carbon emissions. Over 70% of transportation emissions come from passenger and freight vehicles,[1] meaning that an EV shift is crucial for the country's decarbonization efforts. The 2030 Emissions Reduction Plan sets a mandatory target of 100% zero-emission new light-duty cars and passenger truck sales by 2035. Further, in December 2023, the federal government announced the Electric Vehicle Availability Standard, requiring that ZEVs account for at least 20% of all light-duty vehicles sold starting in model year 2026, rising to 60% by 2030 and 100% by 2035.[2]

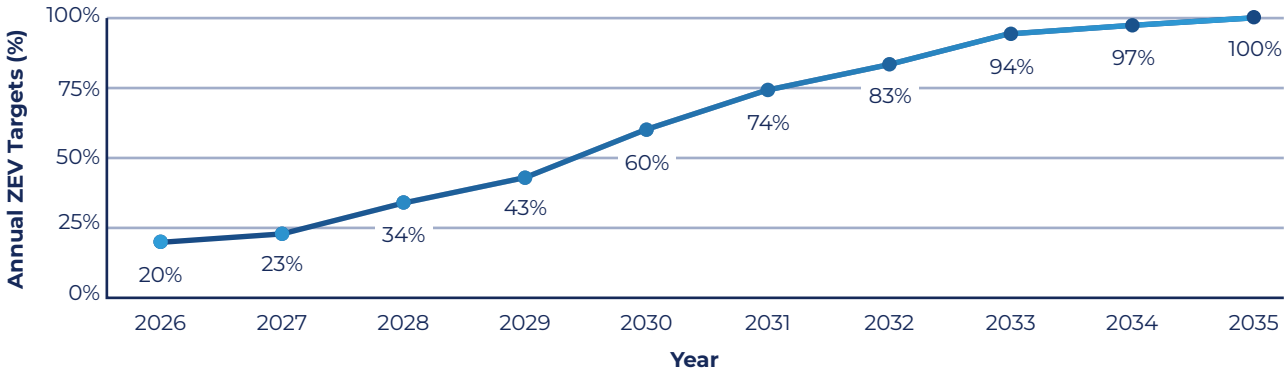


Figure 1 - Annual ZEV regulated sales targets[3]

In line with these targets—and in response to federal and provincial/territorial EV incentives[4]—the number of EVs in Canada is growing. While EVs only account for 1.4% of total vehicles registered in Canada—over 345,000 light-duty vehicles in 2022—EVs represented just over 10% of all *new* motor vehicle registrations in the first nine months of 2023.

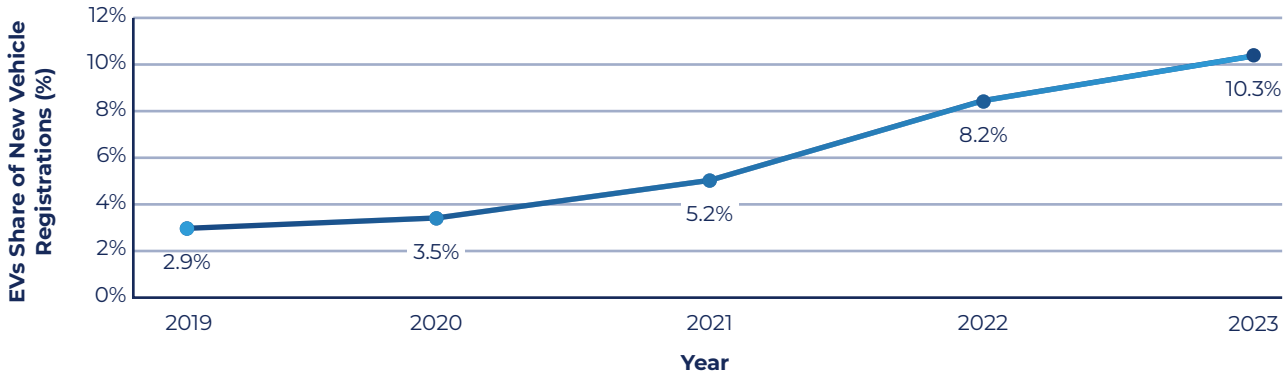


Figure 2 - EVs as a percentage of new motor vehicle registrations (Statistics Canada)[5, 6]

A battery is considered EoVL once it retains less than 80% of its charge.[7] When EV batteries are removed from the vehicle—due to damage or lifespan—the battery can be ***repurposed*** (for a different use or a non-vehicle "second-life application," such as energy storage), ***recycled*** (to recover and reuse source materials and minerals), or ***disposed*** of (via incineration or, in rare cases, landfills). Ensuring that EV batteries are appropriately managed at EoVL remains key to supporting the sustainability of EVs as a mode of transportation.

Figure 3 - Life cycle of EV batteries[8]

There are many benefits associated with proper management of EoVL batteries:

Reducing Greenhouse Gas Emissions and Environmental Harms of EV Batteries

Repurposing and recycling EoVL batteries supports decarbonization efforts and can mitigate some of their negative environmental impacts. Recycling critical minerals is less carbon intensive than mining new materials. While recycled critical minerals will not meet demand for a full EV transition, it can reduce demand for new minerals. It's estimated that recycling EV batteries could reduce demand for critical minerals by 3% globally in 2030, growing to 28% in 2050. Repurposed EV batteries can also be used as renewable energy storage systems that replace fossil-fuel-based systems. Overall, the proper management of EoVL batteries helps ensure the hazardous materials the batteries contain are diverted from landfills.

Growing a Green Economy

EV battery repurposing and recycling offers economic benefits, generating new jobs for highly skilled workers and GDP growth. Clean Energy Canada estimates that, by 2030, battery recycling could create over 3,200 jobs in Canada and add $281 million directly to the GDP. This doesn't consider the economic impact related to battery repurposing, which is a factor in the fast-growing renewable-energy storage market. As the EV transition accelerates beyond 2030, economic and workforce opportunities in the EoVL sector will keep growing.

Securing Domestic Supply Chains

Recycling or "urban mining" of EV batteries allows Canada to supplement its domestic supply of critical minerals for manufacturing, minimizing stress on the early battery value chain and decreasing reliance on international supply chains. This is significant, as a domestic supply of critical minerals supports Canada's energy security, reducing dependency on volatile critical mineral supply chains. Currently, China dominates the global supply chain, leaving Canada vulnerable to supply uncertainty and political posturing.

Photo: David Baillot/UC San Diego Jacobs School of Engineering

If EoVL batteries are managed poorly, Canada will not be well positioned to capitalize on these benefits.

1.2 - THE CURRENT EV BATTERY ECOSYSTEM IN CANADA

In 2023, the federal government, along with Ontario and Quebec, committed nearly $40 billion to incentivize global EV battery companies to establish manufacturing facilities in Canada.[iv] The Parliamentary Budget Officer estimates a further $5.8 billion in forgone corporate federal and provincial income tax due to these subsidies.[9]

	Volkswagen / PowerCo SE (St. Thomas, ON)	**Northvolt** (Saint-Basile-le-Grand and McMasterville, QC)	**NextStar Energy - LG Energy Solutions / Stellantis** (Windsor, ON)	**Total**
Construction	$1.2B	$2.7B	$1.0B	$4.9B
Production subsidies	$13.2B	$4.6B	$15.0B	$32.8B
Total	$14.4B	$7.3B	$16.0B	**$37.7B**

Figure 4 – Battery Manufacturing Investments[10]

These investments focus on the manufacturing or assembly of EV batteries. In contrast, there has been limited support for Canadian companies involved in battery repurposing or recycling. The most significant investment is from the Government of Quebec, which invested $22.5 million in Lithion Technologies, split between equity and grants.[11] RecycLiCo received $75,000 from the federal Industrial Research Assistance Program[12] and Moment Energy received $320,000 from the Government of British Columbia through a CleanBC program.[13] Budget 2023 announced a clean technology manufacturing refundable investment tax credit of 30% for the cost of equipment used to manufacture clean technologies or extract, process, or recycle critical minerals, which could provide additional support for the sector.[14]

Canada's operational EV battery recycling capacity is limited. Cirba Solutions in Trail, B.C., operates the only commercial lithium battery recycling plant that accepts EV batteries, though this facility also recycles household consumer lithium-ion batteries. Li-Cycle previously operated a commercial EV battery recycling facility in Kingston, Ontario, but paused operations in November 2023.[15] RecycLiCo has a demonstration plant in Vancouver, B.C. Lithion Technologies has a demonstration plant and is building a commercial critical minerals extraction facility in St-Bruno-de-Montarville, Quebec. They have plans to open a hydrometallurgical plant in 2026.[v] There are also companies in Canada, such as Glencore, that participate in EV battery recycling, though it is not their main focus.[vi]

[iv] This figure comprises $37.7 billion in construction and production subsidies, as noted in Figure 4, as well as $2.07 billion in battery materials processing and manufacturing, split across four sites in Bécancour and Granby, Quebec, and Loyalist Township, Ontario.

[v] Hydrometallury is an approach to battery recycling that uses acids to dissolve and extract the desired battery metals.

[vi] Glencore is exploring using excess smelting capacity to reclaim nickel and cobalt from EV batteries.

Similarly, the landscape for repurposing EV batteries is still emerging. Canadian companies like Moment Energy, EVB360, and Exro Technologies are leaders in this nascent industry, developing innovative technologies for second-life applications such as energy storage and grid optimization.

Canada lacks a national regulatory framework for batteries at EoVL. Some provinces have made efforts towards extended producer responsibility (EPR)—"an environmental policy approach in which a producer's responsibility for a product is extended to the post-consumer stage of its life cycle"[16]—with mixed results.[17] In 2021, B.C. expanded its five-year EPR action plan to include EV batteries as a product category, requiring producers to manage collection and recycling. While details are pending, the EPR action plan acknowledges the importance of repurposing EV batteries and notes a phased-in approach is preferable, with plans to operationalize EPR for EV batteries by 2026.[18]

Quebec sought to implement a provincial regulatory framework in 2021, proposing measures under the Environment Quality Act. These measures included improving the identification and traceability of EV batteries, the creation of a nonprofit to manage batteries at EoVL, and a prohibition on activities such as reselling EV batteries to be repurposed. It mandated batteries be removed from vehicles after 10 years, regardless of their performance—a measure that, among others,[19] received strong pushback for its arbitrary limit on a battery's lifespan.[20] In 2022, Quebec shifted to a voluntary EoVL battery management scheme funded by EV manufacturers, which became operational in June 2023. Under this scheme, an individual in possession of an EoVL battery must provide the battery to an authorized battery holder (e.g., automotive dismantler, automotive recycler, garage, dealership). The battery holder then contacts the service provider that has been identified by the vehicle manufacturer for complimentary collection.[vii] The program complements existing EV batteries collections done by manufacturers for warranty, recalls, or remanufacturing.

Photo: ICM

Lithion Technologies

Lithion Technologies, headquartered in Quebec, shred battery packs to produce a critical mineral concentrate known as "black mass." The black mass is processed through their patented hydrometallurgy technology to recover battery-grade lithium, cobalt, and nickel as well as graphite and manganese. Using this method, Lithion is able to recover over 95% of critical minerals from the batteries.

Photo: Moment Energy

Moment Energy

Based in Coquitlam, B.C., Moment Energy provides clean, affordable, and reliable battery energy storage systems (BESS) by repurposing EV batteries for second-life applications, extending battery life by seven-10 years. Their BESS can help reduce fossil fuel consumption in off-grid communities or better support grid infrastructure facing rising demands.

[vii] The program is a collaboration between vehicle manufacturers and Call2Recycle and includes an online platform to guide battery holders through the process.

EUROPEAN UNION

The European Union (EU) is a leader in regulations surrounding waste batteries. EU Reg. 2023/1542, implemented in 2023, applies to all "economic operators" and covers all types of batteries, including EVs.[viii] It contains targets for recycling critical minerals, establishes an EPR model, prohibits batteries being sent to landfills, and mandates EoVL battery retrieval at "no cost" to consumers.[21] The regulation also introduces a digital "battery passport" featuring information on the battery model, purpose, capacity, performance, durability, and chemistry.[22]

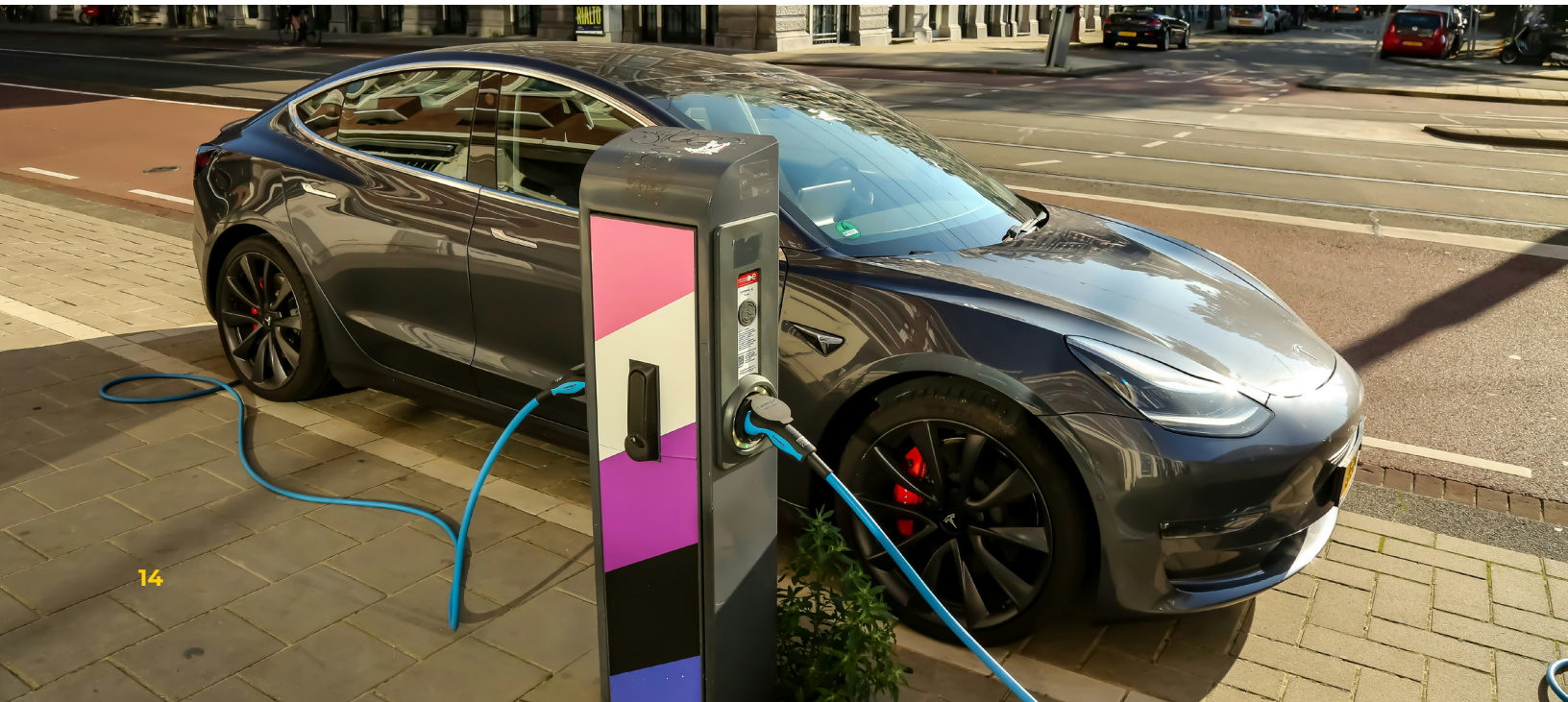
CHINA

China dominates lithium-ion battery recycling with three times the recycling capacity of all other nations[23] and more than half of the world's new patents in the area since 2001.[24] China's EPR plan launched in 2017 and outlines its path to scale up recycling.[25] Battery producers and importers, particularly original equipment manufacturers (OEMs), are responsible for establishing and operating recycling systems. Recycling facilities must obtain environmental permits and adhere to strict standards. China is additionally implementing an EV battery traceability system.[26]

UNITED STATES

The United States (U.S.) lags in EoVL battery regulations but leads in investments, notably through the Inflation Reduction Act (IRA). In July 2023, the U.S. Department of Energy allocated US$192 million for lithium-ion battery recycling.[27] Recent grants and loans include US$75 million to expand an Ohio battery recycling plant[28] and a US$2 billion loan for a battery materials campus in Nevada.[29] Li-Cycle, a Canadian company, received a US$375 million conditional loan commitment for its first commercial hydrometallurgical facility near Rochester, New York,[30] though the project is on hold due to escalating construction costs.[31] The IRA also outlines consumer tax credits of up to US$7,000 if a newly purchased EV meets annually increasing requirements for critical minerals in battery components. These credits aim to incentivize mineral extraction, mineral processing, mineral recycling, and materials repurposing within North America.[32]

[viii] The EU Battery Regulation builds on the previous EU battery framework, Directive 2006/66/EC ("the 2006 Battery Directive").



CHALLENGES

2.1 - ECONOMIC CHALLENGES

Substantial U.S. investment in EV battery repurposing and recycling creates strong incentives for Canadian-based companies to expand south of the border, benefiting from a larger market and attractive government support. However, this poses challenges for Canada, including an outflow of intellectual property and skilled jobs, reduced product availability for consumers seeking repurposed batteries, and a manufacturing supply chain relying more on foreign sources, even for recycled critical minerals.

While the governments of Canada, Ontario, and Quebec have made substantial investments to attract foreign companies for EV battery manufacturing and assembly, a similar effort is needed for EV battery repurposing and recycling. Failing to develop domestic infrastructure and technical expertise in these areas is a missed opportunity for Canada to maximize its return on investment in battery manufacturing, while ceding other high-value aspects of the supply chain to other jurisdictions.

2.2 - REGULATORY CHALLENGES

Canada's regulatory ecosystem is not optimized for EV battery repurposing and recycling. Without a comprehensive framework, how to manage batteries at EoVL is unclear, handled on a case-by-case basis, and left vulnerable to market forces.[33] A battery's EoVL scenario is primarily driven by resale value,[34] posing the risk that damaged, small, or low-value-material batteries that are less cost-effective to recycle might not be managed sustainably. Relying on economic drivers without a comprehensive framework could compromise environmental and safety considerations.[35] Additionally, while OEMs are responsible for EV batteries under warranty (typically 8–10 years), battery lifespan often extends closer to 12–15 years, leaving the consumer to manage their EoVL battery.[36] This situation can lead to confusion, unexpected costs, and unsustainable disposal practices.[37]

Another regulatory framework challenge is that waste management, under which recycling and EPR programs operate, is primarily within provincial/territorial jurisdiction. This may lead to a patchwork of EoVL battery regulations emerging, rather than a common national approach. This risk is evident given B.C.'s EPR plan and Quebec's choice of a voluntary recovery program.

With respect to interprovincial or international transportation, EoVL batteries are subject to federal Transportation of Dangerous Goods Regulations and Cross-border Movement of Hazardous Waste and Hazardous Recyclable Material Regulations. However, for storage and intraprovincial transportation, provincial/territorial regulations also apply.[ix] These jurisdictional differences can cause confusion and discourage battery shipping,[38] particularly when they further drive up transportation costs (already a significant portion of the total cost for EoVL battery management).[39] Current regulations group EV batteries with other lithium-ion or nickel metal hydride batteries, failing to recognize their unique qualities and design.[40] Additionally, transportation regulations are not fully harmonized within North America, making transport more complex, time consuming, and expensive.

[ix] These include rules on documentation, packaging, staff training/certification, import/export permits, and reporting.

2.3 - TECHNICAL CHALLENGES

Efficiently repurposing and recycling EoVL batteries can be challenging, due to the technical complexity and variability in design. EV batteries are not standardized, often differing on component choices that range from the battery management system (BMS) to module sizing.[41] Furthermore, many battery packs are not designed for ease of disassembly, making recycling efforts time- and cost-intensive[42] and creating safety hazards for technicians. While standardizing battery designs could impede innovation and impact manufacturing costs, the merits of designing for circularity should not be overlooked.

The unique chemistries of EV batteries, along with their various material compositions, pose another challenge for EoVL management, increasing the cost and complexity of recycling. For repurposing, certain battery chemistries are more suited for second-life applications and particular BMS's are easier to reprogram. For example, BMW i3 batteries were designed for repurposing as energy storage units and are well suited to operate appliances and entertainment devices.[43] Conversely, the Tesla Model Y has a structural battery pack that cannot be deconstructed into serviceable modules.[44] Furthermore, it uses a BMS with proprietary communication standards, making it extremely difficult to test, grade, and repurpose it into a second-life application.

Disassembly is further complicated by insufficient information on battery chemistry, operational history, and state of health (SoH). SoH assessments are essential for informed decision-making—not only about recycling but for consumers concerned with vehicle performance and for businesses seeking a stable supply of reused batteries. While several diagnostic methods can be used to access this information, there is no standardized "battery health assessment" that is easily accessible.[45] This SoH information vacuum impedes optimized recycling and reuse pathways for EoVL batteries.

Finally, new technology poses challenges for skilled labour. EV batteries are evolving quickly, demanding continuous education for individuals who work within and outside of the battery ecosystem (e.g., firefighters and first responders).[46] Hands-on training may require specialized facilities, and safety concerns can arise due to hazardous materials in the batteries. The scarcity of standardized certification programs will further complicate reskilling and upskilling efforts as the demand for recycling and repurposing grows.[x]

Photo: Renault Group

The Renault ZOE: a battery design success story

Designed with consideration of second-life applications, ZOE battery packs are being repurposed for grid storage across the EU. On the island of Belle-Île-en-Mer, ZOE batteries were repurposed to store solar power for the local school. This means the school can use clean electricity day or night, and it also makes the batteries last at least five years longer.

[x] Some EV service technician training programs and courses have been created, such as the Electric Drive Vehicle Technician program at St. Clair College in Windsor, Ontario, or the Electric Vehicle Technology and Service course at BCIT in B.C. It is not clear whether the curricula in these programs focuses on batteries at EoVL.

POLICY RECOMMENDATIONS

To fully embrace EV battery circularity, Canada must establish a robust repurposing and recycling sector with the capacity to properly manage EoVL batteries. All levels of government should support and regulate this rapidly evolving sector without stifling innovation or causing unintended consequences. Engagement from industry, researchers, and non-governmental stakeholders will be crucial.

As an overarching policy objective, governments should seek to ensure the sustainable management of EV batteries at EoVL. While the market is anticipated to manage most EoVL batteries, due to their economic value, it is crucial to establish policy guardrails within which market forces operate. This framework should be established now to manage expected future growth of batteries at EoVL.

Policy objectives that guide this report include:

- Canada should have an economically viable repurposing and recycling industry, powered by domestic technology and talent, that maximizes the value of a circular supply chain
- Roles and responsibilities for EoVL EV battery management in Canada are clear, with adequate and accurate information that informs the best pathway for each battery
- EoVL batteries should be safely removed, stored, and transported in accordance with regulations that consider the unique characteristics of EV batteries and are handled by a well-trained workforce

Recommendations have been grouped into interventions that address: i) enabling conditions and building capacity for the sector; ii) EoVL decision-making pathways; and iii) dismantling, storage, and transportation.

3.1 - ENABLING CONDITIONS AND BUILDING CAPACITY

RECOMMENDATION 1: Incentivize market conditions to support the battery repurposing and recycling sector in Canada

All levels of government should aim to maximize the economic and environmental benefits of Canada's nascent battery manufacturing industry, which is largely owned by foreign multinational companies. This can be achieved by fostering favourable market conditions for domestic EV battery repurposing and recycling. To achieve this goal, a comprehensive set of incentives, including direct investment, consumer subsidies, and the clarification of tax credit program eligibility, is recommended.

Specifically, repurposing and recycling companies may need subsidies and grants in the early stages of the EV transition, when the supply of recyclable material is heavily reliant on production scrap. Repayable grant programs, where repayment schedules trigger once company's achieve certain revenue targets, could help grow capacity and improve viability of the sector early on. Provincial and territorial governments can support the market for repurposed EV batteries by working with electricity providers to integrate distributed energy resources into electricity systems, including grid applications of stationary EV batteries.

As EVs become the standard choice of vehicle for consumers, governments are expected to phase out consumer subsidies.[47] As the supply of recycled critical minerals grows, it is recommended that these blanket subsidies be replaced with specific subsidies for the purchase of EVs with batteries that contain a certain percentage of recycled materials.[xi] Over time, the threshold of recycled material that qualifies for the subsidy could increase.

Finally, it is recommended that EV battery repurposing and recycling technologies be explicitly listed as an eligible activity for the refundable clean technology manufacturing tax credit. This would demonstrate that the federal government recognizes the opportunity to use repurposed EV batteries as a form of clean energy and the importance of EV battery recycling as a major potential source for recycled critical minerals.

[xi] The United States' Inflation Reduction Act (IRA) includes a clean vehicle tax credit for consumers purchasing a vehicle where applicable critical minerals have been mined in countries with which the United States has a free trade agreement or have been recycled in North America.

RECOMMENDATION 2: Encourage battery-makers to design for circularity

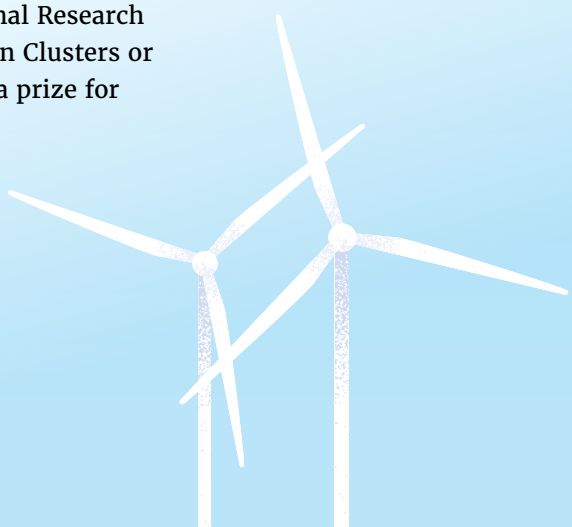
Encouraging stakeholders to design for circularity is a key component of a sustainable and economically viable battery ecosystem.[48] Circular design effectively balances disassembly, reusability, and recycling requirements with performance and lifespan. Instead of regulation, a collaborative approach is recommended in which governments and OEMs develop reporting requirements that track the disassembly or remanufacturing metrics of EV battery packs. OEMs would commit to annual non-public reporting to the government on improvements in this domain. While it is not recommended this information be made public, due to the potential inclusion of proprietary information, reporting would offer insights on the progress of circular design practices and could inform future policy decisions.

It should be noted, however, that EV batteries are mainly designed outside of Canada. For this reason, it is important that Canada work with the international community to promote this approach. This could be achieved by expanding Canada's relationship with international partners working to cultivate circularity in the battery ecosystem, such as the Global Battery Alliance (GBA). Furthermore, domestic post-secondary institutions and engineering associations should collaborate to integrate circular economy design principles into training programs.

RECOMMENDATION 3: Accelerate Canadian research and development (R&D) on battery repurposing and recycling technologies

Industry, government, and academia must work together to build Canadian expertise in EV battery repurposing and recycling. With world class R&D facilities at the University of Toronto, Dalhousie University, and the University of Windsor[49] and Hydro-Québec's Center of Excellence in Transportation Electrification and Energy Storage holding key patents for lithium-iron-phosphate cathodes and solid-state batteries,[50] further investment in R&D on repurposing and recycling is a logical next step that would position Canada as a global leader in battery innovation.

Areas of focus could include improving access to sectoral data, exploring technological improvements that lower costs, or supporting the development of new breakthrough technologies. It is recommended that the government establish a co-funded research consortium with industry and academics. This could be led by the National Research Council and modelled on existing programs such as the Global Innovation Clusters or Challenge programs. The government should also consider establishing a prize for innovation.



3.2 - ENCOURAGING THE BEST PATHWAY FOR BATTERIES AT END-OF-VEHICLE-LIFE

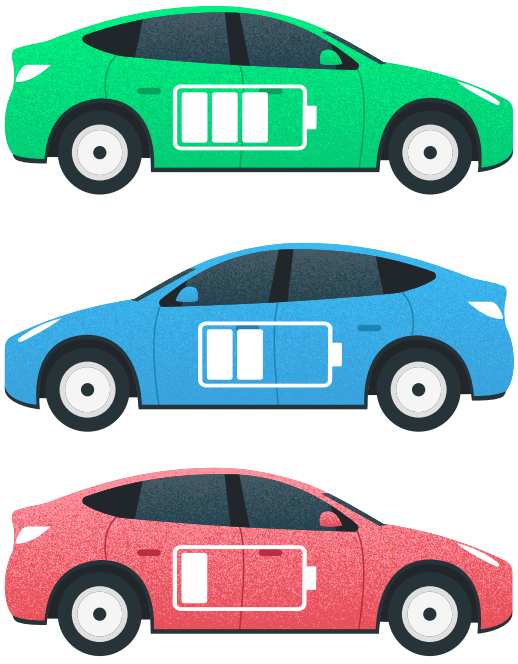
RECOMMENDATION 4: Implement a coordinated producer take-back approach to EoVL management of EV batteries

The most common framework with respect to EoVL batteries is EPR, where producers are responsible for the battery beyond its use in the vehicle. It is recommended that Canada initially adopt a "light touch" backstop approach to EPR. This approach allows EV battery recycling and repurposing markets to operate freely, while requiring OEMs to sustainably collect and manage unwanted batteries at no cost to the consumer. Regulations should outline expected efforts from OEMs, including timelines for collection and assessment protocols for the battery. This backstop approach should be periodically evaluated to determine whether more stringent regulations are needed.

EPR regimes are regulated by provinces and territories in Canada, but it is recommended that governments work together to ensure one common approach across the country and provide clarity and coherence for consumers, OEMs, and recycling/repurposing industry. The 2009 Canada-Wide Action Plan for Extended Producer Responsibility,[51] which sought to create a harmonized approach to EPR with coordinated policies and commitments for action, can be used as a model.

RECOMMENDATION 5: Ensure that state of health assessments are standardized and easily accessible to consumers and actors within the EV battery ecosystem

Information about a battery's SoH is critical to help stakeholders understand the battery's value and determine the best option for it—repair, repurpose, or recycle. It is recommended that Canada align with the EU regulations concerning SoH for batteries and waste batteries.[52] This means that battery owners, or any other third party acting on their behalf, should be able to easily determine the SoH and expected lifetime of the batteries at any time from the data stored in the BMS. Furthermore, efforts should be made by the automotive industry to improve the standardization of data to ensure better comparability of SoH between different types of EVs.



RECOMMENDATION 6: Establish an expert advisory group to co-develop guidelines to ensure proper pathways for EoVL batteries

As the demand for critical minerals grows, market forces may prematurely drive the recycling of EoVL batteries over repurposing. It is recommended that an expert advisory group with representatives from industry (OEMs, repurposing, recycling, auto dismantlers), academia, and NGOs co-develop guidelines to help identify the appropriate pathway for EoVL batteries, in line with the best and highest use of EV batteries, which would prioritize repurposing before recycling when possible. Guidelines should suggest pathways for different battery grades and types, partnered with recommended pathways determined by a standardized SoH assessment (e.g., batteries at more than 50% SoH should be repurposed). These guidelines should consider extenuating circumstances, such as battery damage, that might change the trajectory of the battery irrespective of SOH assessment. Once established, a public awareness campaign should promote the guidelines to ensure Canadians are familiar with considerations for EoVL batteries. Compliance with guidelines should be monitored over time, and the federal government should evaluate if firmer regulations are required if the market unnecessarily prioritizes recycling over repurposing.

RECOMMENDATION 7: Introduce a battery passport system

Consumers and businesses need accurate information about battery composition to make appropriate decisions at EoVL. "Battery passports" include information on the battery model, purpose, capacity, performance, durability, and chemistry. They are made available only to authorized handlers. They support secondary markets by increasing consumers' confidence in the safety and performance of a remanufactured or repurposed battery. Battery passports have widespread support, including from industry, with the GBA launching a proof of concept in January 2023.[53] The EU's battery passport system could be a model for Canada, and the use of such a system across North America will be important, given the integrated automotive market.

3.3 - ENSURING SAFE AND ECONOMICAL DISMANTLING, STORAGE, AND TRANSPORTATION

RECOMMENDATION 8: Develop and promote comprehensive and accessible training programs for the safe handling of EV batteries

Handling EV batteries poses safety risks due to their high-voltage nature and their hazardous content. While there are EV service technician training programs,[xii] and some certification standards for EV battery repurposing facilities,[xiii] gaps in knowledge and training remain, particularly for dismantlers, recyclers, first responders, and others outside of formal service technician contexts.

Governments should collaborate with key stakeholders, including the Automotive Recyclers of Canada, the Canadian Council of Directors of Apprenticeship, and workers' compensation boards, to identify knowledge gaps and promote training opportunities. Additionally, it is recommended that governments jointly fund a small-scale reskilling grant for EV battery handling, discharging, removal, and recycling. Existing guides and online training programs[xiv] should be supplemented with a comprehensive, in-person curriculum—routinely updated to reflect evolving technology innovations—to ensure safe discharging and handling.

RECOMMENDATION 9: Simplify transportation and storage regulations and harmonize with U.S. regulations

Canada's small market and vast geography requires transporting EoVL batteries far distances for repurposing or recycling. Regulations should be streamlined and aligned between jurisdictions to avoid unnecessary costs or delays, without compromising safety. It is recommended that transportation regulations be developed specifically for EV batteries. Further, transportation and storage regulations should differentiate between uncompromised, intact EoVL batteries and those that are damaged or defective. Lastly, regulations should be harmonized with U.S. Department of Transportation regulations to avoid a regulatory patchwork that creates inefficiencies that further increase transportation costs.[54]

[xii] Automotive Service Technicians are a Red Seal Trade, and training programs are aware of the need for expertise in EV safety: https://www.red-seal.ca/eng/trades/autoservtech/2016rs.4s_.4v.2rv.3.2w.shtml#a4

[xiii] The Standards Council of Canada (SCC) upholds ANSI/CAN/UL 1974, a standard through which facilities can be certified in the sorting and grading of EV batteries for repurposing.

[xiv] The Automotive Recyclers of Canada (ARC) lists a variety of EV-dismantling resources on their website and has partnered with B.C.-based EVfriendly to offer an online consumer education and certification program to auto recyclers nationwide. See https://www.evfriendly.ca/news/evfriendly-is-going-national/

CONCLUSION

The wheels of Canada's EV transition are in motion. Canada has invested significantly in EV infrastructure to support decarbonization and economic growth. As the nation continues to establish itself as a significant global player in the EV revolution, attention must shift quickly towards capacity-building for the management of EoVL batteries.

Repurposing and recycling EV batteries is not only environmentally sound but commercially viable if economic, regulatory, and technical challenges are addressed through proactive policy planning.

Establishing Canada's competitive presence in the global EV battery ecosystem has been a collaborative effort between governments, industry, academia, and other critical stakeholders. These efforts to engage in meaningful partnerships should continue if the nation intends to develop a coordinated strategy on EV battery recycling and repurposing. The success of the country's green transition will be influenced by an EV battery's pathway at EoVL. Canada must act now to make a positive charge forward and position itself strategically for sustainable growth and prosperity.

REFERENCES

1 Environment and Climate Change Canada. (2022). *2030 Emissions Reduction Plan: Canada's Next Steps for Clean Air and a Strong Economy*, p. 53.

2 Environment and Climate Change Canada. (2023). *Canada's Electric Vehicle Availability Standard (regulated targets for zero-emission vehicles)*.

3 Ibid.

4 Finlayson, J. & Graham, K. (2023). *A Review of Electric Vehicle Consumer Subsidies in Canada*. Fraser Institute.

5 Statistics Canada. Table 23-10-0308-01 *Vehicle registrations, by type of vehicle and fuel type*.

6 Statistics Canada. Table 20-10-0024-01 *New motor vehicle registrations, quarterly*.

7 Kelleher, M., et al. (2022). *Circularity and Recycling of Lithium-Ion Batteries for Electric Vehicles — Standardization and Safety Requirements, CSA Group*, p. 8.

8 Kendall, A., Dayemo, K., Helal, N., Iskakov, G., Pares, F., Slattery, M., & Fulton, L. (2023). *Electric Vehicle Lithium-ion Batteries in Lower-and Middle-income Countries: Life Cycle Impacts and Issues. UC Davis Institute of Transportation Studies*, p. 5.

9 Giswold, J. & Dong, M. (2023, November 17). *Costing Support for EV Battery Manufacturing*. Office of the Parliamentary Budget Officer.

10 Ibid.

11 Lithion. (2022). *Lithion Recycling Receives $22.5 million in Funding from the Québec Government*.

12 Government of Canada. Grants and Contributions. https://search.open.canada.ca/grants/?sort=agreement_start_date+desc&search_text=recyclico&page=1

13 Government of British Columbia. (2022). *CleanBC supports B.C. company to repurpose old EV batteries*.

14 Environment and Climate Change Canada. (2023). *Minister Guilbeault highlights the big five new Clean Investment Tax Credits in Budget 2023 to support sustainable made-in-Canada clean economy*.

15 Li-Cycle. (2023). *Ontario Spoke*.

16 OECD. (2023). *New Aspects of EPR: Extending producer responsibility to additional product groups and challenges throughout the product lifecycle*.

17 Winfield, M., Myers, J., & Sooch, S. (2023). *Post-Consumer Management of End-of-Life Electric Vehicle Batteries: A Comparative Study of Regulatory Regimes in Canada, the U.S. and European Union*.

18 Ministry of Environment and Climate Change Strategy. (2021). *Advancing Recycling in B.C.: Extended Producer Responsibility Five-Year Action Plan 2021-2026*.

19 Electric Mobility Canada. (2021, November 2). *Extended Producer Responsibility regulation proposal by the government of Québec - 7 Electric Mobility Canada Battery working group recommendations*. [White paper].

20 Dahn, J. (2021, October 29). Québec Risks a Critical Circular Economy Misstep with Proposed EV Battery Recycling Plan. *Electric Autonomy Canada*.

21 European Union. (2020, December 10). *Questions and Answers on Sustainable Batteries Regulation*.

22 Batteries European Partnership Association. (2023 August 31). *Batteries Regulation Brief Overview*.

23 Baum, Z. J., Bird, R. E., Yu, X., & Ma, J. (2022). Lithium-ion battery recycling- overview of techniques and trends. *ACS Energy Lett.*, 7(2), pp. 712–719

24 Lin, X., Wang, X., Liu, G., & Zhang, G. (2023). *Recycling of Power Lithium-ion batteries: Technology, equipment, and policies*. Wiley-VCH. p. 109

25 California Environmental Protection Agency. (2022 March 16). *Lithium-ion Car Battery Recycling Advisory Group Final Report*. [White paper].

26 Wei, L., Wang, C., & Li, Y. (2022). *Governance strategies for end-of-life electric vehicle battery recycling in China: A Tripartite Evolutionary game analysis*. Frontiers in Environmental Science, p. 10.

27 U.S. Department of Energy. (2023). *Biden-Harris Administration Announces $192 Million to Advance Battery Recycling Technology*.

28 Cirba Solutions. (2022). *Cirba Solutions Awarded $75M in DOE Grant Funding*.

29 U.S. Department of Energy. (2023). *LPO Offers Conditional Commitment to Redwood Materials to Produce Critical Electric Vehicle Battery Components From Recycled Materials*.

30 Li-Cycle. (2023). *Li-Cycle Receives Conditional Commitment for $375 Million Loan from the U.S. Department of Energy ATVM Program*.

31 Voloschuk, C. (2023). *Li-Cycle Q3 report provides update on paused Rochester Hub project*. Recycling Today.

32 U.S. Treasury Department. (2023). *Treasury Releases Proposed Guidance on New Clean Vehicle Credit to Lower Costs for Consumers, Build U.S. Industrial Base, Strengthen Supply Chains*.

33 Propulsion Québec. (2020). *Study of Extended Producer Responsibility for Electric Vehicle Lithium-Ion Batteries in Québec*. [White paper], p. 52.

34 Ibid, p. 39.

35 Ibid, p. 74.

36 Canadian Standards Association. (2022). *Circularity and Recycling of Lithium-Ion Batteries for Electric Vehicles — Standardization and Safety Requirements*, p. 6.

37 Canadian Vehicle Manufacturers' Association and Call2Recycle Canada. (2022). *Electric Vehicle Battery Management at End-of-Vehicle Life*, p. 57.

38 Canadian Standards Association. (2022). *Circularity and Recycling of Lithium-Ion Batteries for Electric Vehicles — Standardization and Safety Requirements*, p. 25.

39 CVMA and Call2Recycle Canada. (2022). *Electric Vehicle Battery Management at End-of-Vehicle Life*, p. 31 & 59.

40 Ibid, pp. 30-31.

41 Kelleher et al. (2022). *Circularity and Recycling of Lithium-Ion Batteries for Electric Vehicles—Standardization and Safety Requirements*. Canadian Standards Association.

42 California Environmental Protection Agency. (2022 March 16). *Lithium-ion Car Battery Recycling Advisory Group Final Report*, p. 59.

43 Greentech Media. (2016 June). *BMW is Turning Used i3 batteries into home energy storage units*.

44 Business Insider. (2023, September 4). *Tesla's Model Y Battery has "zero repairability" so a minor collision can junk the car.*

45 Canadian Vehicle Manufacturers' Association and Call2Recycle Canada. (2022). *Electric Vehicle Battery Management at End-of-Vehicle Life*, pp. 37-43.

46 Kelleher, M., et al. (2022). *Circularity and Recycling of Lithium-Ion Batteries for Electric Vehicles — Standardization and Safety Requirements, CSA Group*, pp. 19-20.

47 Reuters. *Germany to end e-vehicle subsidy programme*. (2023 December 16).

48 Global Battery Alliance. (2021). *A Framework for the Safe and Efficient Global Movement of Batteries*. World Economic Forum.

49 Clean Energy Canada. (2021 May). *Turning Talk into Action: Building Canada's Battery Supply Chain Report*, p. 13.

50 Ibid.

51 Canadian Council of Ministers of the Environment. (2009). *Canada-Wide Action Plan for Extended Producer Responsibility*.

52 Office Journal of the European Union. (2023 July 7), REGULATION (EU) 2023/1542 concerning batteries and waste batteries, amending Directive 2008/98/EC and Regulation (EU) 2019/1020 and repealing Directive 2006/66/EC.

53 Global Battery Alliance, GBA. (n.d.) *Battery passport.*

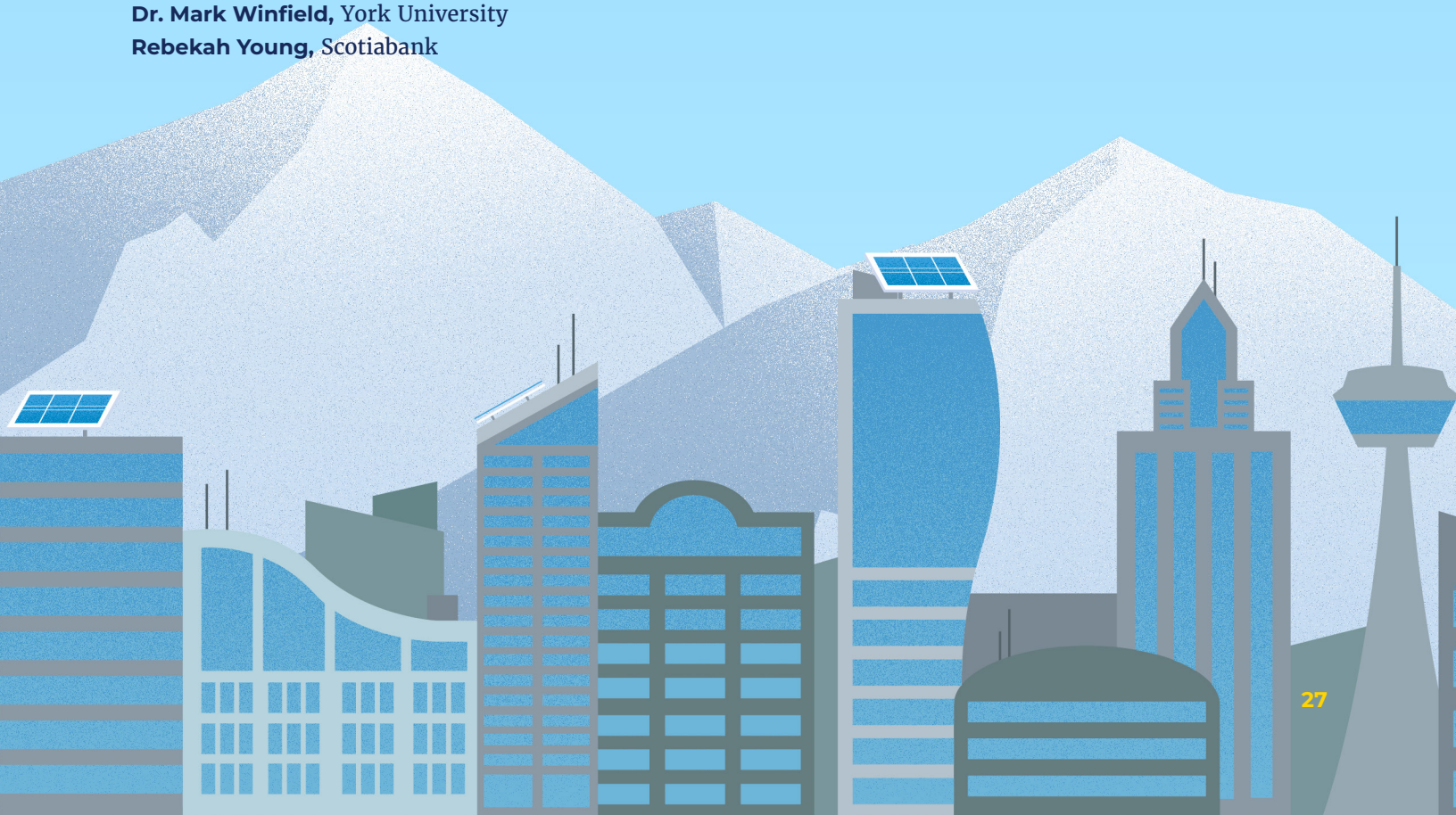
54 CVMA & Call2Recycle Canada. (2022). *Electric Vehicle Battery Management at End-of-Vehicle Life*, pp. 74-75.

APPENDIX A: INTERVIEWEES

Below is a list of individuals interviewed as part of our research. We thank each of them for their time and valuable insights.

In alphabetical order

Isaac Barkhouse, Victory Advanced Technologies Inc.
Dr. Catherine Beaudry, Polytechnique Montréal
Jesika Briones, EV Norte Consulting
Edward Chiang, Moment Energy
Steven Chung, ReJoule
Isabel Cyr, Lithion Technologies
Dr. Jeff Dahn, Dalhousie University
Steve Fletcher, Automotive Recyclers of Canada
Brad Griffin, Simon Fraser University
Dr. Narayan C. Kar, University of Windsor
Brian Kingston, Canadian Vehicle Manufacturers' Association (CVMA)
Arthur Kong, Next Generation Manufacturing Canada (NGen)
Joanna Kyriazis, Clean Energy Canada
Louise Levesque, Electric Mobility Canada
Dr. Shoshanna Saxe, University of Toronto
David Shea, Kraken Robotics
Dr. Lukas Swan, Dalhousie University
Dr. Edwin Tam, University of Windsor
Dr. Mark Winfield, York University
Rebekah Young, Scotiabank



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