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Decarbonizing Canada via 'Electrification'

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1. Introduction

Canada has committed to a net-zero economy by 2050,[1] which will help the country not only reduce its greenhouse gas emissions but also take advantage of the economic opportunities presented by the energy transition.

Environment and Climate Change Canada's *2030 Emissions Reduction Plan* outlines a clear plan on how several sectors including buildings, transportation and electricity can be decarbonized. It is evident that many sectors depend on electrification as a significant pathway to decarbonization. This means that a clean electricity grid will form the backbone of a net-zero economy.

The imperative for electrification and grid decarbonization also creates several opportunities for the members of Electro-Federation Canada (EFC) to contribute to Canada's net-zero commitment. Member companies participate in multiple ways to help in the decarbonization journey including demand reduction with energy-efficient products, efficient automation solutions, e-mobility support, and grid development and infrastructure. With around $80 billion of investment into decarbonization needed each year, but only $15 billion seen today, there is a substantial opportunity for EFC members to take part in a growing clean energy economy.

Given the services provided by the members of EFC, this paper examines the major decarbonization trends and key policy opportunities in three sectors: electricity, transportation (specifically electric vehicle charging), and buildings. In 2020, electricity (56 megatonnes (Mt)) accounted for 8% of Canada's total greenhouse gas (GHG) emissions, transport (159 Mt) 24%, and buildings (88 Mt) 13%.[2] Together, the three sectors account for 45% of Canada's GHG emissions and are crucial to reducing Canada's overall emissions.

This is a pivotal moment for all levels of government to collaborate on reducing emissions. With less than a decade to achieve steep carbon reductions, success hinges on the rigorous implementation of the necessary policies, programs, and regulations — aided by effective consultations with both industry and civil society.

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[1] Government of Canada, *Net-Zero Emissions by 2050*. https://www.canada.ca/en/services/environment/weather/climatechange/climate-plan/net-zero-emissions-2050.html

[2] Environment and Climate Change Canada, *National Inventory Report 1990-2020: Greenhouse Gas Sources and Sinks in Canada, Part III* (2022), 11. https://publications.gc.ca/site/eng/9.506002/publication.html

2. Decarbonization trends and opportunities

All three sectors — electricity, buildings, and transportation — have been undergoing fundamental shifts in terms of the technologies available, increasingly favourable economics, and rising interest from consumers. This section provides an overview of these trends and opportunities.

2.1 Electricity: Grid decarbonization and modernization

2.1.1 Context

Canada's electricity sector produces 56 Mt of emissions per year.[3] While emissions in the electricity sector have decreased in recent years — currently accounting for only 8% of Canada's emissions — as the retirement of coal facilities continues, current projections show that gas-fired generation will increase by 70% by 2050.[4] This growth in fossil fuel generation must be avoided and all emissions from electricity generation brought close to zero. International Energy Agency (IEA) analysis shows that to meet the Paris commitment of limiting the global temperature increase to 1.5°C, all developed economies must decarbonize their grids by 2035.

A net-zero grid is also essential for achieving economy-wide net-zero greenhouse gas emissions by 2050. In addition to reducing direct emissions from electricity generation, a net-zero grid will also facilitate emissions reductions in other sectors that rely on the grid, such as buildings and transportation.

The reliability of services in an increasingly decarbonized grid can be maintained by diversifying generation sources, deploying storage, investing in grid modernization, enabling demand-side management and energy efficiency, and constructing transmission interconnections between provinces. In fact, clean energy portfolios consisting of renewables, energy efficiency, demand response, and storage can provide

[3] *National Inventory Report 1990-2020: Part III*, 11.

[4] Canada Energy Regulator, *Canada's Energy Futures,* 2021 dataset. https://www.cer-rec.gc.ca/en/data-analysis/canada-energy-future/

the same reliability services as new thermal generation plants, but at lower costs.[5,6] These measures, because of their diverse, flexible, and distributed natures, also provide greater protection against large-scale disruptions.

In addition to the deployment of various technologies, maintaining grid reliability requires improved system planning and changes to how the grid is operated. For example, since the National Grid Electricity System Operator in the U.K. committed to being able to operate a zero-carbon grid by 2025, it has been identifying and implementing solutions — such as more accurate forecasting of wind and solar generation — that allow it to maintain the voltage and frequency of the electricity supply without depending on fossil fuels.[7]

2.1.2 Challenges and opportunities for supporting decarbonization

There are many pathways to a decarbonized grid, but three aspects are key. First, the supply of electricity will need to become cleaner with a rapid deployment of renewable energy and storage. Second, more distributed energy resources are needed, along with demand-side management (DSM) opportunities. Third, transmission and distribution system networks need to be updated to optimize performance of the above technologies.

Distributed energy resources include micro-generators like rooftop solar and localized energy storage, which can include integrating electric vehicle (EV) batteries for a household, business, or the grid. DSM programs can support technologies such as smart thermostats, appliances, and EV energy management systems (EVEMS) to help minimize emissions and costs to consumers by adjusting when they operate. DSM also includes energy efficiency upgrades.

Getting to a net-zero grid and supporting widespread electrification will require both physical electricity infrastructure upgrades and the mass deployment of electrical and automation devices. While changes of this magnitude present many challenges, they offer economic opportunities for the electrical products industry and benefits to

[5] J. Gorski and B. Jeyakumar, *Reliable, affordable: The economic case for scaling up clean energy portfolios* (Pembina Institute, 2019). https://www.pembina.org/pub/reliable-affordable-economic-case-scaling-clean-energy-portfolios

[6] J. Gorski and B. Jeyakumar, *Towards a Clean Atlantic Grid* (Pembina Institute, 2022). https://www.pembina.org/pub/towards-clean-atlantic-grid

[7] National Grid ESO, *The Road to Zero Carbon* (2021). https://www.nationalgrideso.com/future-energy/our-progress/road-zero-carbon/report

consumers. Not only will consumers have access to household renewable energy generation, but they will also be able to save money through energy efficiency and DSM, and benefit from the cheaper and more stable electricity rates that a clean energy portfolio offers.[8]

However, electricity market regulations stand in the way of clean energy solutions and electrification. There are inadequate incentives for utilities (generators and distributors) and consumers to change from the status quo. For example, provinces without net metering may limit the revenue that residential solar generators see from selling their electricity to the grid.[9]

Reforms to regulations — including the mandates of regulators — are essential to providing the right incentives to utilities and service providers to enable the mass public and private deployment of clean grid solutions, and unlock the economic, social, and environmental benefits they will bring. Regulatory reform can further help to minimize and equitably distribute the costs of the electricity grid's transformation.

Since electricity markets fall under provincial jurisdiction, each provincial government will need to direct their respective regulators to support these decarbonization trends. There may be a limited role for the federal government to convene and help establish standards across the country. The recommendations section will discuss these opportunities further.

2.2 Buildings: Energy efficiency and heat electrification

2.2.1 Context

Buildings are the integration hub for a decarbonized energy system and with 88 Mt of annual emissions, the buildings sector is the third-largest source of emissions in Canada and trending upward. In some cities, buildings contribute as much as two-thirds of the

[8] B. Jeyakumar, *Achieving a Net-Zero Canadian Electricity Grid by 2035* (Pembina Institute, 2022), 8. https://www.pembina.org/reports/achieving-a-net-zero-canadian-power-grid-by-2035.pdf

[9] B. Dronkers, S. Hastings-Simon, *Making electricity billing fair* (Pembina Institute, 2017). https://www.pembina.org/reports/microgeneration-briefing-note-final-june21.pdf

local emissions,[10] and assuming a replacement rate of 1-2% per year, we expect 2/3 to 3/4 of existing buildings will still be in operation by 2050.

There is a shift underway to deep energy and carbon emissions reductions to help mitigate climate change, adapt to impacts of a changing climate, improve the health and safety of indoor spaces, and improve the quality and affordability of homes. Water and space heating load remains the primary source of emissions in most of Canada, particularly as the electrical grid decarbonizes, and will remain so even as climate change increases demand for cooling. Peak demand in Canada remains during the coldest days of the year.

Resistance heating and heat pump solutions are available to replace carbon-intense 20th-century heating systems in Canada's diverse climate and application landscape. Some applications will require both technologies to meet comfort and efficiency goals, which is important for policymakers to recognize. Ventilation systems for existing buildings are also necessary for improving indoor air quality, removing risks of moisture and mold, and improving the health and comfort of the occupants.

Not surprisingly, plug loads are increasing and the market for building energy management systems is expanding beyond commercial and institutional spaces to homes and multi-unit residential buildings, opening opportunities for system controls and automation. Homeowners are also adding EV charging and solar photovoltaic systems, which can require electrical service upgrades at the building and/or neighbourhood scale, especially when also electrifying space and water heating.

Retrofitting lighting and building automation systems are increasingly seen as a means of helping to pay for deeper retrofits rather than as standalone actions. Whole-building retrofits ensure opportunities are not missed and benefits are maximized during major renovations. Ultimately, energy efficiency policies are projected to reduce overall household energy bills by 2050.[11]

[10] City of Calgary, *Calgary Climate Strategy*. https://www.calgary.ca/content/www/en/home/environment/climate/climate-strategy.html

[11] Clean Energy Canada, *Media Brief: What Does Net Zero Mean for Household Energy Prices*? (2022). https://cleanenergycanada.org/media-brief-what-does-net-zero-mean-for-household-energy-prices/

2.2.2 Challenges and opportunities for supporting decarbonization

The bulk of Canada's housing infrastructure is more than 30 years old. At our current retrofit pace (<1% each year, mostly not deep retrofits), it will take us well beyond 2050 to retrofit all residential, commercial, and public buildings. The Pembina Institute estimates that Canada needs to ramp up deep retrofits and fuel-switching to 4.5% of the existing building stock each year, or 600,000 homes and 750 million m^2 commercial space, from now until 2040.[12]

By our estimates, Canadian manufacturers, suppliers, designers, and builders are looking at a $400-billion opportunity to retrofit and decarbonize Canada's residential and commercial buildings between now and 2040.

However, the low cost of heating fuels in Canada, especially compared with other parts of the world, mean energy savings alone will not drive deep retrofits. We must look at the additional benefits from deep retrofits; this moment is one chance in a lifetime to make our homes not only more energy efficient, but also healthy, low carbon, affordable to heat, resilient to shocks such as storms, heatwaves, and earthquakes, and smart grid-integrated in a way that helps utilities better manage loads.

Canadians spend 90% of our lives indoors and the condition of our indoor spaces can impact our health. Indoor air can have as much or higher levels of pollution than outdoor air, and poor indoor air quality can:

- Lead to sick building syndrome
- Aggravate respiratory disease like asthma and allergies
- Intensify transmission of infectious diseases, like the flu or COVID-19
- Be particularly risky for the health of vulnerable populations such as the elderly, young children, and people living with chronic illness.

There are also real costs associated with ignoring the deep retrofits we need. At the simplest level, as buyers learn and grasp the risks of climate change, properties that are not ready for increasing intensity and frequency of extreme weather events will not be valued as highly as others. Impacts from extreme weather events result in expensive recovery costs. Climate change has increased home insurance rates on top of inflation – for example, through higher and insurance premiums and deductibles for sewer backups and overland floods. This makes insurance coverage less affordable and, in some cases,

[12] Canadian Climate Institute, *440 Megatonnes: Emissions Pathway Tracker*. https://dashboard.440megatonnes.ca/

unavailable, and insurers are starting to recommend that governments mandate risk disclosure. Finally, the federal carbon price is scheduled to grow to $170 by 2030.

The construction sector is innovating rapidly and converging around support for an "envelope-first" approach, largely thanks to the success of the Passive House movement and the follow-on effect of capacity building and supply chain growth. Still, when embodied carbon is factored into retrofit decisions, it can shift the design toward less insulation and larger-capacity HVAC systems. Innovations in building automation and control are also unlocking efficiencies and equipment synergies, and quickly flagging equipment issues. That said, one of Canada's biggest challenges is that the market is not ready for rapid scale-up of deep retrofits and high-performance new construction.

2.3 Transportation: Electric vehicle charging

2.3.1 Context

In 2020, transportation accounted for 24% of total GHG emissions in Canada, making the sector the second-largest source of overall emissions.[13] The majority of emissions stem from on-road passenger light-duty vehicles (LDVs) and freight medium- and heavy-duty vehicles (MHDVs). Due to a growing number of vehicles on the road and a preference for larger and heavier cars, emissions continue to rise. Between 1990 and 2020, emissions from passenger LDVs and MHDVs increased by 12% and 130%, respectively.[14] Driving down emissions from transportation is critical to achieve the Paris commitment of limiting the rise in global temperatures to 1.5°C, and the deployment of electric vehicles[15] has been identified as playing a central role. In all Canadian provinces, it is already less emissions-intensive to drive an EV both operationally and considering embedded carbon compared to non-hybrid fossil fuel vehicles.

According to the International Energy Agency, global electric passenger LDV sales more than doubled in 2021, reaching 6.6 million and representing nearly 10% of the total vehicle market.[16] Sales of electric MHDVs doubled over 2020 volumes, reaching a global sales share of 0.3% in 2021. Europe and China are leading the race, each representing

[13] *National Inventory Report 1990-2020: Part III*, 11.

[14] Government of Canada, *Greenhouse gas emissions*, 10.

[15] Electric vehicles include battery electric vehicles, plug-in hybrid vehicles, and hydrogen fuel cell vehicles.

[16] International Energy Agency, *Global Electric Vehicle Outlook* (2022), 4. https://www.iea.org/reports/global-ev-outlook-2022

the largest markets for electric MHDVs and with the market share of electric LDVs rising to 17% and 16% in 2021 in these regions, respectively.[17] Meanwhile, electric cars represented 5.5% of new vehicle sales in Canada in 2021.[18] For the Paris commitment to be met, almost all passenger LDV sales in developed economies will need to be electric by the early 2030s, with MHDV vehicles also transitioning, albeit at a slower pace.[19]

While Canada sits well below the global average for electric car sales, the need to scale up adoption to meet climate commitments is recognized by policymakers. Canada's 2030 Emission Reduction Plan[20] lays out a goal to develop a LDV sales mandate to achieve targets for 20% of new LDV sales to be electric by 2026, rising to 60% by 2030 and 100% by 2035, resulting in approximately 40% of all LDVs on the road in Canada being electric in 2035.[21] The freight sector is also being targeted, with the aim of reaching 35% of new MHDV sales being electric by 2030 and nearly 100% by 2040.

Achieving Canada's newly announced vehicle electrification targets will require significant expansion of vehicle charging infrastructure. Common locations for passenger electric car charging include owners' homes, workplaces, commute destinations (e.g., retail) and highway rest stops. A recent survey of Canadian electric car owners reveals, however, that charging behaviour is different for owners based on their type of residence. Compared to electric car owners who live in single-family homes, owners who live in multi-unit residential buildings (MURBs) rely significantly more on public charging infrastructure, with 42% of respondents indicating that more than half of their charging needs are met through using public charging stations.[22] This is significant given that most respondents feel that the number of public charging stations in Canada is currently insufficient. Furthermore, around 34% of all Canadians live in MURBs.[23]

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[17] IEA, *Global Electric Vehicle Outlook,* 16-17.

[18] IEA, *Global Electric Vehicle Outlook,* 61.

[19] International Energy Agency, *Net Zero by 2050* (2021), 134. https://www.iea.org/reports/net-zero-by-2050

[20] Environment and Climate Change Canada, *2030 Emissions Reduction Plan* (2022), 61. https://publications.gc.ca/site/eng/9.909338/publication.html

[21] Dunsky, *Canada's Public Charging Infrastructure Needs* (2022), A-1. https://www.nrcan.gc.ca/sites/nrcan/files/energy/cpcin/2022-ev-charging-assesment-report-eng.pdf

[22] Pollution Probe, *Assessment of the Consumer Electric Vehicle Charging Experience in Canada* (2022), 11. https://www.pollutionprobe.org/wp-content/uploads/2022/06/Pollution-Probe-.Consumer-EV-charging-Experience.pdf

[23] Statistics Canada, Type of Dwelling Reference Guide, Census of Population, 2021 (2022). https://www12.statcan.gc.ca/census-recensement/2021/ref/98-500/001/98-500-x2021001-eng.cfm

Dedicated deployment of charging infrastructure that meets the needs of different MHDVs is also needed in the electrification transition. Because currently available electric vehicle models tend to provide sufficient range to cover the daily distances serviced by most medium-duty vehicles (e.g., delivery trucks) and buses, these vehicles can satisfy most of their recharging needs by charging overnight at a private depot after the end of a shift. In contrast, some heavy-duty vehicles (e.g., long-haul tractor-trailers) travel extensive distances, requiring re-charging throughout their journey using publicly available charging stations.

2.3.2 Challenges and opportunities for supporting decarbonization

To support electric vehicle adoption in line with Canada's electrification targets, more charging infrastructure is needed. For the LDV sector, the number of public charging stations will need to reach around 52,000 by 2025, rising to between 747,000 and 830,000 stations in 2050.[24] Charging stations in MURBs will also need to increase substantially. Across the MHDV sector, preliminary estimates by the Pembina Institute (see Appendix Table 3) identify that the number of private chargers may need to rise from 12,000 (Level 2) and 4,000 (Level 3) in 2025 to 337,000 (Level 2) and 87,000 (Level 3) in 2050.[25] The number of public charging stations for MHDVs will need to increase from 2,000 in 2025 to 40,000 in 2050.[26] Supporting widespread deployment of charging infrastructure in Canada will require large-scale investments.

In addition to ensuring there is adequate funding available to support rollout of chargers in Canada, there is a critical need to ensure financing is equitable and capacity is built where a lack of knowledge and understanding on how to navigate the process of purchasing and installing charging infrastructure remains a barrier.[27] Many Canadians want to go electric but may not know where to start, and where dealerships are in many cases the first point of contact, sales teams can lack training and knowledge to inform

[24] Dunsky, *Canada's Public Charging Infrastructure Needs*, 22.

[25] C. Kasteel, S. McBain, and C. Bhardwaj, *Towards Clean MHDVs* (Pembina Institute, 2022), 18. https://www.pembina.org/reports/towards-clean-mhdvs-recommendations.pdf

[26] Pembina Institute, *Towards Clean MHDVs*, 18.

[27] C. Kim and C. Smith, *Building a zero-emission goods-movement system: Opportunities to strengthen Canada's ZEV freight sector* (Pembina Institute, 2020). https://www.pembina.org/reports/building-a-zero-emission-goods-movement-system-report.pdf

consumers.[28,29] In addition, there is shortage of technicians with adequate training to install charging infrastructure.[30]

It is also prudent to consider the various contexts for EV charging. For example, to support Canadians without access to home charging, public charging stations should be strategically deployed in areas with high concentrations of MURB occupants. To support the electrification of long-haul trucks, high-power charging stations should be placed on highly utilized transport corridors. Special consideration is needed to understand the charging needs of northern, rural, and Indigenous communities.

There are other additional challenges that need to be overcome to support widespread uptake of electric vehicles in Canada. As adoption of electric vehicles grows, so will demand pressure on electricity grids, potentially affecting grid stability. To avoid bottlenecks in supplying enough power to support an electrified vehicle sector, grid upgrades may be needed. The International Energy Agency anticipates that grid upgrade needs may be low while electric vehicle penetration levels remain moderate (10-20% vehicle stock share), though beyond 2030 more significant upgrades may be required as adoption rapidly increases.[31] Rural regions with relatively weaker grids, plus cities leading in electric vehicle adoption, may first in line for upgrades.[32]

Charging heavy-duty vehicles will also be a source of stress to grids, as charging hubs on major transport corridors capable of charging several freight trucks at the same time will require connection capacity of more than 10 MW to a high-voltage line. Scaling up the use of smart charging should also be explored as a tool to alleviate grid impacts, though several challenges need to be addressed to enable this technology, including developing interoperability standards in Canada.[33] Interoperability standards are also a pre-condition for smart charging development, which can help alleviate stress to the grid through DSM.

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[28] M.K. Karwa, "Electric Vehicle Dealership Education & Training," *World Electric Vehicle Journal* 8 (2016), 3. https://www.mdpi.com/2032-6653/8/4/974

[29] Clean Energy Canada, *How Canada can design a truly effective zero-emission vehicle mandate* (2022), 15. https://cleanenergycanada.org/wp-content/uploads/2022/08/ZEV-Standard-Best-Practices-EN.pdf

[30] M. Yakub, "Curbing unsafe EV charger installations needs "carrot or stick" strategy, *Electric Autonomy Canada*, August 10, 2022. https://electricautonomy.ca/2022/08/10/unsafe-ev-charger-installations-canada/

[31] IEA, *Global Electric Vehicle Outlook,* 197-198.

[32] IEA, *Global Electric Vehicle Outlook,* 196-198.

[33] IEA, *Global Electric Vehicle Outlook,* 204-205.

3. Recommendations for policy and regulatory measures

Just as electrification is a wide-reaching tool for decarbonization, the policy and regulatory levers to enable deep electrification span many branches of government. The federal government has legislation, regulations, and mandates as mechanisms to set a national direction for electrification, funding for targeted programs to support a transition, and a convening role that can also be used to build capacities. The federal government can also influence the development of standards that will better enable electrification to scale rapidly across the country. Provincial governments have similar tools at their disposal, although they also uniquely set construction standards and the mandate of their electric utilities or regulators.

The section below includes a summary of our recommendations for key policy areas EFC should consider for advocacy. Appendix A includes a compilation of already announced policies and funding programs that provide further context to these recommendations, and which represent strategic opportunities that may be of interest to EFC and its membership.

3.1 General recommendations

There are a few key recommendations that impact all three sectors:

- **Federal funding needs to increase and be supplemented through additional sources**. As of 2022, the federal government is spending around $15 billion per year towards decarbonization. However, according to multiple analyses of net-zero pathways, around $80 billion per year needs to be invested across the Canadian economy. Further public and private funding is needed to reach Canada's greenhouse gas emission targets. It is also critical for Canada to invest in climate adaptation to improve the resilience of — and minimize the damages to — communities, businesses, and supply chains.
- **Funding programs and tax credits should be used to their best advantages.** A recurring issue with government funding programs is they generally require participants to apply for grants, which adds a burden to companies trying to decarbonize. These programs are also quickly subscribed to. In contrast, programs like tax credits or an economy-wide carbon tax are less onerous, more

evenly distributed across eligible participants, and less exposed to political and budgetary cycles. However, the design of incentive programs should be managed carefully so that they are not disadvantageous to small and medium-sized enterprises or households with lower income for whom cash flow is a major concern.

- **Harmonization of standards for the electricity, buildings, and transportation sectors is also needed.** In particular, as grid decarbonization and modernization progresses, there will be need for rapid installation of several types of key equipment and technologies. Ensuring that Canadian standards are harmonized nationally and aligned with international standards will help with diversifying supply chains and making the products more cost-effective. Standards can also help to integrate initiatives that cross sectors, minimizing resources needed and redundancies. For example, service upgrades to individual buildings can account for EV chargers and clean electric heat solutions together. Building upgrades can also trigger a costly neighbourhood-level upgrade; rate structure changes can more evenly distribute the costs of upgrades that bring shared benefits.

3.2 Electricity

3.2.1 Federal

- **Stringent Clean Electricity Regulation**. It is critical that the federal government develop a CER that delivers a credible net-zero grid in 2035. Interim targets, a strong emissions intensity limit, and minimal exemptions and loopholes are necessary to limit the amount of stranded unabated fossil assets and accelerate the deployment of clean energy sources and accompanying electrical goods and services.[34]
- **Clear carbon pricing**. The full carbon price — up to $170 per tonne by 2030 — must be applied to all emissions from electricity generation across Canada through zero-intensity benchmarks in industrial carbon pricing systems like the federal output-based pricing system or Ontario's Emissions Performance

[34] B. Jeyakumar, N. Schumacher, J. Wang, K. Singh, and A. Beattie, *Pembina Institute response to the proposed frame for the Clean Electricity Regulations* (Pembina Institute, 2022). https://www.pembina.org/reports/for-upload-aug2022-pembinaresponse-cerdraftframework.pdf

Standard. Such systems can provide strong policy certainty while protecting the competitiveness of Canadian businesses.[35]

- **Increased funding mechanisms** to support the deployment of clean energy and capacity-building across economic sectors, such as:[36]
  - $12 billion for further clean electricity infrastructure deployment funds
  - $4.8 billion for Indigenous, low-income, and vulnerable communities
  - $100 million for federal tax credit for personal investments into DERs
  - $100 million additional to the Smart Renewables and Electrification Pathways program for DERs and clean electric heating solutions
    - Funding programs for decarbonizing buildings must recognize that both electric heat pumps and resistance heating are critical technologies for helping Canadians meet climate goals within the diverse climate, physical application, and cost contexts they face.
- **Support the development of regional electricity transmission infrastructure**. Intra- and inter-provincial transmission are key components of the cheapest pathways to a net-zero grid,[37] but social, regulatory, and political barriers stand in the way of implementing these solutions — particularly for interties connecting provinces. The federal government must offer incentives and support collaboration among the provinces to overcome these barriers. Given the long development timelines for transmission infrastructure, these actions must begin immediately.

3.2.2 Provincial

- **Mandate electricity regulators and utilities to achieve net-zero by 2035.** Given a mandate, regulators and utilities can adjust their electricity markets' economic rules to reflect the nature of a modern grid and unlock innovative business models that will catalyze electrification. For example:
  - Full, not virtual, net metering can greatly shorten payback periods for DERs.
  - Ancillary services can better leverage the emissions arbitrage benefits of energy storage.

[35] J. Wang, *Amendments to Emissions Performance Standards in Ontario* (Pembina Institute, 2022). https://www.pembina.org/reports/2022-10-on-eps-amendments-response.pdf

[36] Green Budget Coalition, *Recommendations for Budget 2023* (2022). https://greenbudget.ca/recommendations.

[37] J. Gorski, B. Jeyakumar, and S. Williams, *Connecting provinces for clean electricity grids* (Pembina Institute, 2021), 4-5. https://www.pembina.org/reports/connecting-provinces-for-clean-electricity-grid.pdf

    - Performance Incentive Mechanisms can provide the right signals for utilities to invest in measures such as energy efficiency (including deploying electric heating solutions).
- **Update rate structures** to incentivize utilities to earn a return on non-wire solutions including DSM.
    - Policies could include time-of-use electricity pricing, allowing utilities to earn a return on the total of capital and operating expenses (Totex), and Performance Incentive Mechanisms could provide revenue-linked KPIs.[38]
    - Rate structure changes can also more evenly distribute the costs of infrastructure upgrades to everyone who benefits.
- **Invest in distribution system upgrades.** As electrification continues to grow and as consumers look for more ways to interact with the grid (for example through time-of-use pricing and production of rooftop solar energy), the distribution network will need to be upgraded.
- **Develop regional electricity interties**. Provinces can benefit substantially from interties, especially when a non-hydro province connects with a hydro-heavy one (Alberta–B.C., Saskatchewan–Manitoba, Ontario–Quebec, an Atlantic Loop). While Saskatchewan–Manitoba connections are growing, the Ontario government recently cancelled a transmission contract with Quebec and the Atlantic Loop is indefinitely stalled.

3.3 Buildings

Historic and existing incentive programs continue to support incremental building performance improvements, which risks missing the net-zero emissions targets set for 2050. The Canada Green Building Strategy instead presents an opportunity to eliminate energy poverty, make homes and buildings safe and healthy, and adapt construction and retrofits to be resilient to a changing climate. The strategy aims to drive down energy demand and carbon emissions in a once-in-a-lifetime opportunity for charting a path to decarbonize our aging housing infrastructure.

By advocating for the key recommendations listed below, EFC members will help voice watershed policy recommendations, driving demand and opening markets for members and for others in the building sector working toward the same low-carbon goal:

[38] E. He, *Transforming the Utility Business Model* (Pembina Institute, 2022). https://www.pembina.org/pub/transforming-utility-business-model

- **Model building and retrofit codes** need to be aligned with a net-zero emissions goal and adopted wholesale by provinces and territories, which will codify requirements for low carbon heating systems, highly efficient electrical equipment, and smart controls.
- **10 to 20 times more investment** is needed from federal and provincial governments to decarbonize Canada's existing buildings through electrification of space and water heating systems and reduction of heating energy demand through deep envelope retrofits (in the range of $277 billion starting now and continuing to 2040).[39]
- **Incentive and rebate programs** must be tied to the net-zero emissions target to discourage standalone energy efficiency measures and exclude like-for-like replacement of fossil fuel-burning equipment. This will also stimulate supply chain and skill growth in industries that support electrification.
- **Efficiency acts** need to not only drive energy efficiency but also fuel-switching away from fossil fuels towards low-carbon space and water heating systems, such as heat pumps and resistance heating.
- **A comprehensive national deep retrofit market development strategy** is needed to remove barriers to scaling up demand for these solutions and simultaneously open markets and compress costs.
- **Industry standards** such as equipment certification are needed, to facilitate rapid adoption of net-zero aligned innovations (e.g., without the long expensive process of re-certifying for safety).
- **Regulatory reviews** of electric equipment, such as lighting, should be taken as opportunities to reduce carbon and improve energy efficiency.
- **Support communities** responsible for enforcing new regulations to ensure compliance in the field.
- **Electricity and natural gas energy resource plans** need to be developed together and combined to clarify the future energy mix in buildings under a decarbonization path and to help electric equipment providers plan for future demand growth.
- **Demand-side management regulations** need to be refined to align with climate targets and energy plans. Electrical utility DSM programs also need to include transportation end-uses in their planning, including strategies to reduce demand such as made feasible by Electro-Federation Canada members who are driving down energy demand.

[39] M. Kennedy and T. P. Frappé-Sénéclauze, *Canada's Renovation Wave: A Plan for Jobs and Climate* (Pembina Institute, 2021). https://www.pembina.org/pub/canadas-renovation-wave

To facilitate this transition, the Pembina institute and others across Canada are proposing the $200 million Retrofit Accelerator fund support a network of trusted independent deep retrofit market development teams. These teams would have a clear mandate and agency to build volume through pre-packaged systems with business consortiums and pass on distributor price savings. We summarize the conditions of success in Figure 1 below.

Figure 1. Critical conditions for a successful market development program

3.4 Transportation

3.4.1 Federal

Significant investments from the public and private sector will be necessary to meet the challenge of the zero emissions transition. Estimates by Dunsky Energy Consultants find that the cost of building out a charging network to support Canada's electrification targets for LDVs will be approximately $20 billion over the next three decades.[40] The Pembina Institute estimates that the total cost of charging infrastructure for MHDVs will be about $300 million to $500 million in 2025, rising to about $7 billion to $13

[40] Dunsky, *Canada's Public Charging Infrastructure Needs* (2022), 24.

billion by 2050 (see Appendix Table 3) . Key recommendations to meet this challenge include:

- **Develop a long-term plan to support the EV charger buildout.**
  - The existing Zero Emission Vehicle Infrastructure Program (ZEVIP) is currently offering $680 million and is set to end in 2027; there is a need for ongoing evaluation of the adequacy of the program over time.
- **Develop a national infrastructure deployment plan** covering all regions and aligned with vehicle electrification targets.
  - The plan should consider charging access for all Canadians and identify solutions based on the needs of different vehicle use cases (e.g., more public chargers in high-density communities or transport corridors).
- **Develop interoperability standards** to address a current lack of integration across charge point providers, which creates a confusing and burdensome experience for users.
  - Such standards would harmonize the process of locating, utilizing, and paying for charging services across different providers, which is critical in creating a seamless experience that instills confidence in electric vehicles. In developing such standards, Canada should ensure that they address cybersecurity and data accessibility.[41]
  - Canada can extract best practices from the National Electric Vehicle Infrastructure Program (NEVI) established through the U.S. Infrastructure Investment and Jobs Act.[42] NEVI will provide funding to states to deploy fast charging stations along designated corridors, and the Federal Highway Administration has proposed minimum standards and requirements for funded projects and seeks to finalize the rulemaking expeditiously.[43]
- **Significantly expand current outreach initiatives and fund the development of new training programs,** such as through the Zero Emission Vehicle Awareness (ZEVAI) Initiative.
  - Special consideration should be placed on reaching underrepresented groups and disadvantaged communities.

[41] IEA, *Global EV Outlook* (2022), 205.

[42] California Energy Commission, "National Electric Vehicle Infrastructure Program." https://www.energy.ca.gov/programs-and-topics/programs/national-electric-vehicle-infrastructure-program-nevi

[43] Federal Register, "National Electric Vehicle Infrastructure Formula Program- A proposed Rule by the Federal Highway Administration on 06/22/2022." https://www.federalregister.gov/documents/2022/06/22/2022-12704/national-electric-vehicle-infrastructure-formula-program

    - In addition, new workforce training programs should be developed to ensure technicians, electricians and other key members of Canada's labour force have the skills to respond to an evolving labour market.
- **Establish electric vehicle charging requirements in National Model Building and Electrical Codes.**
    - Electric Mobility Canada suggests that all new residential parking spots be required to be "EV-ready" and 20% to 40% of new non-residential parking spots include basic electrical infrastructure for charging.[44]
- **Develop and implement a Zero Emission Vehicle Mandate for both the LDV and MHDV sectors.**
    - Not only will this regulation grow the availability of ZEV models across the country, but it will play a strong role in signalling market certainty. This will help de-risk investment in charging infrastructure and associated supply chains.

3.4.2 Provincial and territorial

- Provinces and territories without subsidies in place should **develop programs to provide support for installing chargers**. Best practices can be adopted from other leading jurisdictions — such as British Columbia, which offers a rebate of up to $3,000 for MURBs to create an EV-ready plan, and additional funding to cover installation costs of up to $600 per parking stall.
- Provinces and territories without subsidies should **establish purchase incentive programs for electric light-duty vehicles and SUVs**. Program design best practices can be adopted from British Columbia and Quebec, which offer a rebate of $4,000 and $7,000, respectively. Notably, British Columbia's rebate incorporates equity considerations by offering different levels of support based on individual income.
- Work closely with local colleges and institutions to **develop and fund training and skills programs for electric vehicles and associated charging infrastructure**. Provinces can also support technician training by updating the vehicle mechanic curriculum to include training for electric vehicle mechanics.[45]

[44] Electric Mobility Canada, *National EV Infrastructure Deployment Plan*. https://2030evactionplan.ca/policy/national-ev-infrastructure-deployment-plan/#section-1-accordion-item-3

[45] Electric Mobility Canada, *Domestic EV Jobs and Manufacturing Capacity*. https://2030evactionplan.ca/policy/domestic-ev-jobs-and-manufacturing-capacity/#section-1-accordion-item-3

- **Adopt "right to charge" legislation** to enable the build-out of charging infrastructure in MURBs. Best practices can be adopted from jurisdictions leading the implementation of "right to charge" laws, including California, Colorado, Florida, Hawaii, and Oregon.[46]
- **Establish cross-jurisdictional collaboration** to facilitate a coordinated approach to the build-out of Canada's charging network, ensuring that stations are placed along key connective transport corridors. Collaboration could come through taskforces that focus on addressing specific challenges in the transition to electric vehicles.

[46] NESCAUM, *Right to Charge Laws* (2019), 11. https://www.nescaum.org/documents/ev-right-to-charge.pdf/

Appendix A. Current policies and programs

The section below includes an overview of already legislated or announced energy transformation policies in Canada in the three major sectors described above. These current policies and funding programs may be of interest to EFC members and provide further context for our recommendations.

A.1 Federal policies and funding

A.1.1 Electricity

A.1.1.1 Regulations, standards, and mandates

Two major regulatory mechanisms are driving the progress towards a clean electricity sector in Canada:

- **Clean Electricity Regulation**: Environment and Climate Change Canada is developing this regulation with the goal of achieving a net-zero emissions grid by 2035. It is an emissions intensity standard for greenhouse gas emissions for every unit of electricity produced (tCO_2e/MWh) that will apply to all fossil fuel power plants. It is critical that these regulations set interim standards before 2035, ensure that all facilities meet the final standard by 2035, and that any residual emissions are negated with credible offsets.
- **Carbon pricing**: The federal output-based pricing system for GHG emissions from industrial sectors will be updated to align with the Clean Electricity Regulation. This update must ensure that all emissions in the electricity sector face a full carbon price. The federal government should also evaluate the equivalency of provincial carbon pricing systems with the same stringency.

  Carbon pricing systems should consider the impact on the international competitiveness of Canadian industries. Canada should continue working internationally to support more U.S. states and other nations to adopt carbon pricing, including by introducing carbon border adjustment mechanisms.

Additionally, the federal government is convening regional roundtables to incentivize the buildout of interprovincial transmission lines. This infrastructure will enable grid flexibility, allowing a larger build-out of clean energy generation and enhancing the resilience of the electricity grid.

A.1.1.2 Funding

Since 2020, the federal government's Healthy Environment and Healthy Economy commitments and the 2030 Emissions Reduction Plan have committed around $2 billion for electrification in areas where EFC's membership operate.

Funding has been allocated through four main streams:

- Smart Renewables and Electrification Pathways — $1.5 billion ($600 million top-up in 2022)
- Green Infrastructure grants — $300 million
- Funding for rural and remote communities — $300 million
- Clean electricity projects pre-development activities — $250 million

These programs have been delivered through Natural Resources Canada and support the growth of future grid technologies in Canada. While these programs have already fully allocated their funds and are not expected to grow significantly for a few years, Canada has also announced an investment tax credit (ITC) for the capital costs of clean technologies.

October's Fall Economic Statement announced more details about the ITC, including that it will cover 30% of capital costs, will become available on the day of Budget 2023, cost $6.7 billion over five years, and run until at least 2032. Eligible technologies include clean electricity generation, energy storage, low-carbon heating equipment, and industrial zero-emission vehicles. The Department of Finance has signalled they will consult with stakeholders regarding further eligible equipment. Like the American Inflation Reduction Act's ITCs, this ITC is expected to draw in significant private investment.

Still, Canada needs to step up its investment in the electricity sector by an order of magnitude. The U.S. investments through the Inflation Reduction Act provide a good template for the level of investment needed in various clean electricity solutions. Specifically in Canada, a clean grid requires further investments in energy storage, transmission infrastructure and grid modernization (including smart meters, non-wire alternatives etc.). As an example, the Green Budget Coalition has asked for Budget 2023

to include **$17.8 billion over five years** beyond what has been announced to date (see Section 3.2.1).

Notably, the federal government has also been using the Canada Infrastructure Bank and Economic Development Canada to draw in private investment. In the 2022 Fall Economic Statement, they also announced the Canada Growth Fund, which takes an equity stake in or gives loans to decarbonization activities. Unlike other programs, it explicitly expects a return on investment.

Given that electricity is a provincial jurisdiction in Canada, provinces will play a significant role in decarbonizing the grid; however, the federal government can support the provinces by funding and enabling capacity-building of provincial agencies and regulators. This can be done by ensuring there are mechanisms and platforms to share best practices and lessons learnt among provinces and from other jurisdictions outside Canada.

A.1.2 Buildings

A.1.2.1 Regulations, standards, and mandates

The primary tools driving adoption of low-carbon heating systems are energy efficiency acts and equipment regulations that trigger adoption of heat pumps switching to refrigerants with low or zero global warming potentials. To accelerate building decarbonization and meet the interim goal of 37% emissions reduction from 2005 levels by 2030, Budget 2022 committed $150 million to develop the Canada Green Buildings Strategy.[47] The path to decarbonizing Canada's homes and buildings and making sure they are ready for the coming impacts of climate change is illustrated in Figure 2.

[47] Natural Resources Canada, "The Canada Green Buildings Strategy." https://www.rncanengagenrcan.ca/en/collections/canada-green-buildings-strategy. Accessed 24 Oct. 2022.

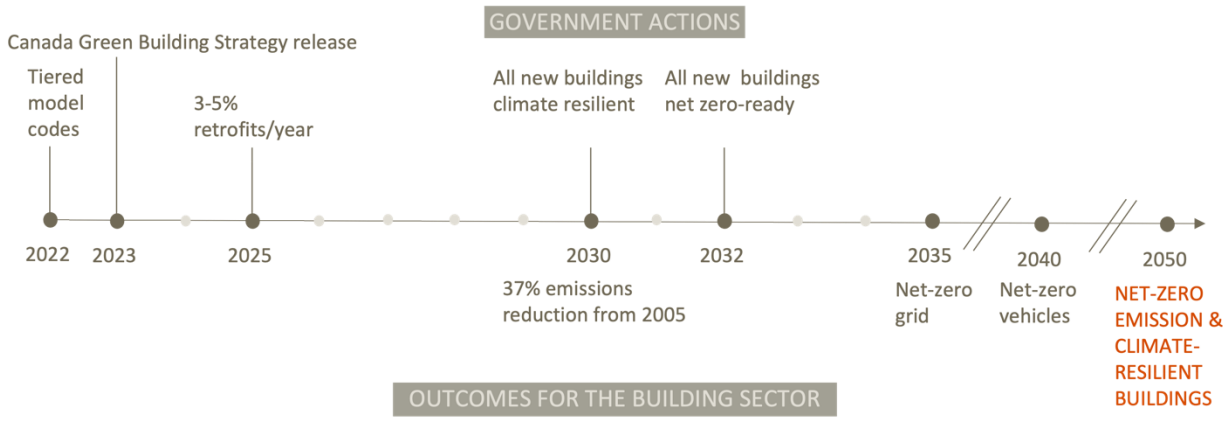

Figure 2. Path to net-zero buildings

In the early stages of developing the Canada Green Buildings Strategy, six action areas have been identified as necessary to transform the market and policy environment. Of those six, the three most directly relevant to Canada's manufacturing and supply sector are:

- **Mandating change** through advancing model building codes to increase energy efficiency when making alterations to existing buildings and to increase climate resiliency in the built environment; developing performance-based regulatory standards and incentive frameworks (e.g., working with partners to set phased timelines for ending the installation of new oil or natural gas heating systems such as those introduced by the City of Vancouver and New York City)
- **Growing Canada's advantage** by building domestic supply of low-carbon and climate-resilient, high-performance technologies, building materials, and construction practices (e.g., prefabrication)
- **Training and incentivizing the future workforce** through Launching a Clean Jobs Training Centre and expanding training funding for the Union Training and Innovation Program for the Red Seal trades,[48] which are vital to the low-carbon, climate-resilient buildings workforce. Five years of funding was announced in the 2022 Fall Economic Statement committing $250 million to launch a new Sustainable Jobs Training Centre and Secretariat.[49]

[48] Employment and Social Development Canada, "About the Skilled Trades and Apprenticeship program (Red Seal Program)." https://www.canada.ca/en/employment-social-development/programs/skilled-trades-apprenticeships.html

[49] Department of Finance Canada, "Fall Economic Statement 2022." https://www.budget.gc.ca/fes-eea/2022/home-accueil-en.html

NRCan already provides direct training to the construction industry through the Local Energy Efficiency Partnerships (LEEP) program.[50] LEEP aims to accelerate energy-efficient construction by enabling builders to reduce their time and risk in trying innovations that can help them build higher-performance homes better, faster and more affordably. LEEP events are delivered through partnerships with Local Home Building Associations and BC Housing in B.C. NRCan also helps homeowners seeking service providers licensed to deliver its EnerGuide Rating System, ENERGY STAR® for New Homes and R-2000 initiatives through its online directory.

A.1.2.2 Funding

To drive consumer demand for high-performance homes and retrofits, the Canada Greener Homes Initiative[51] provides grants and a loan for home evaluations and for retrofits. The eligible retrofits include home insulation, windows and doors, air sealing, and mechanical and renewable energy systems (both a pre- and post-retrofit EnerGuide evaluation are required). Through this initiative, homeowners can apply for:

- Grants from $125 to $5,000 for eligible home retrofits
- Up to $600 toward the total costs of pre- and post-retrofit EnerGuide evaluations
- Interest-free loans of up to $40,000, with a repayment term of 10 years to pay for major home retrofits

CMHC also has several funding programs to support the priority areas laid out in the National Housing Strategy,[52] some of which are:

- Affordable Housing Innovation Fund: Loans, forgivable loans, contributions, and financing options that support housing innovation such as new innovative technologies
- Funding for Indigenous housing construction and renovation on and off reserve
- Innovation and research funding opportunities to promote excellence in housing innovation and research, including the NHS Demonstrations Initiative for demonstrating innovative practices, technologies, programs, policies, and strategies

[50] Natural Resources Canada, "Local Energy Efficiency Partnerships (LEEP)." https://www.nrcan.gc.ca/energy-efficiency/homes/local-energy-efficiency-partnerships-leep/17338

[51] Natural Resources Canada, "Canada Greener Homes Grant." https://www.nrcan.gc.ca/energy-efficiency/homes/canada-greener-homes-grant/23441

[52] CMHC, "National Housing Strategy: What is the strategy?" https://www.cmhc-schl.gc.ca/en/nhs/guidepage-strategy

For large residential, commercial, and industrial buildings the Canada Infrastructure Bank Building Retrofits Initiative supports public and privately-owned green infrastructure by investing in large-scale retrofit projects to bring in private capital where investment from the private sector has traditionally been limited due to the uncertain nature of expected cost savings. The initiative is open to applicants through three different approaches:

1. Direct investment loans,
2. Participation and agency agreement with first ranking mortgage lenders, or
3. Privately-owned special purpose vehicles such as available through Energy Service Companies (ESCO), third-party investors, commercial property assessed clean energy (C-PACE), on-bill financing program administrators, etc.

The federal government provides research and development supports for construction and manufacturing innovation through the National Green Infrastructure Energy Efficient Buildings Program.[53] In the 2022 budget, it also extended the 50% corporate and business tax rate for zero-emission tech manufacturers to include air-source heat pump manufacturers. This was followed up in the 2022 Fall Economic Statement with a $6.7 billion investment in clean tech over five years through tax credits for low-carbon systems, including renewable energy, energy storage, heat pumps, zero emissions vehicles, and others.

A.1.3 Transportation

A.1.3.1 Regulations, standards, and mandates

There are a series of regulations and policy measures advancing electrification of Canada's on-road transportation sector, most notably:

- **ZEV sales mandate:** Government of Canada is in the process of developing a light-duty vehicle sales mandate, which will set increasing requirements toward achieving 100% ZEV sales by 2035. Interim targets will require that 20% of new LDV sales are ZEVs by 2026, rising to 60% by 2030. Commitments have also been made to develop a sales mandate for MHDV sales to be 100% ZEVs by 2040 with interim sales requirements for the mid-2020s and 2030. Sales requirements for the MHDV sector may vary for different vehicle categories, based on feasibility.
- **Clean Fuel Regulation:** The Clean Fuel Regulation requires liquid fossil fuel suppliers to reduce the carbon intensity of fuels produced and sold for use in

[53] Natural Resources Canada, "Energy Efficient Buildings RD&D." https://www.nrcan.gc.ca/netzerobuildings

Canada, with reduction requirements starting at 3.5 gCO2e/MJ in 2023, rising by 1.5 gCO2e/MJ each year to reach a reduction of 14 gCO2e/MJ in 2030. The regulation establishes a credit market where regulated parties can create or buy credits to meet reduction requirements. Charging network operators can generate credits through public and residential electric vehicle charging sites, and charging site hosts will also receive credits for private and commercial charging. This system will enable the build out of infrastructure at a subsidized cost and reduce the total cost of ownership of electrified fleets.

- **Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations:** This regulation aims to reduce greenhouse gas emissions from light-duty vehicles by requiring automakers to meet fleet-wide average CO_2e emission targets. The stringency of the passenger vehicle CO_2e emission target values will increase by 1.5% for model year (MY) 2021/2022, 10% for MY 2022/2023, 5% for MY 2023/2024 and 6.6% for MY 2025/2026. The regulation provides a credit multiplier for electric vehicles for calculation of fleet-average CO_2e values, thus incentivizing their sale.
- **Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations:** Phase 2 of this regulation aims to reduce greenhouse gas emissions from the heavy-duty vehicle sector by 5-27% in 2027 (variation depends on vehicle category and weight) relative to 2017. Companies obtain credits when the CO_2 emissions of their fleet is lower than the standard, which can be used to offset a future deficit where the standard was not met. The regulation provides a credit multiplier for electric vehicles, thus incentivizing their sale.

A.1.3.2 Funding

The Government of Canada has put forth funding for a series of programs to support widespread uptake of electric vehicle adoption, most notably:

- **The Zero Emission Vehicle Infrastructure Program:** This $680 million initiative ending in 2027, seeks to address the lack of charging and refuelling stations across Canada. The program targets infrastructure in public places, workplaces, MURBs, and commercial and public fleets sites, where funding is dispersed through cost-sharing contribution agreements for eligible projects.
- **Electric Vehicle Infrastructure Demonstration Program:** This program seeks to accelerate the demonstration and commercialization of innovative charging and hydrogen refueling infrastructure, with a funding eligibility requirement that projects have a technology readiness level of at least 5 from the onset of the project and achieve a readiness level of 8 by completion.

- **Incentives for Zero-Emission Vehicles Program:** Targeting the light-duty vehicle market, this program provides purchase incentives on eligible zero-emission vehicles, up to $5,000. It will continue to provide funding until March 31, 2025. The program has a remaining $192 million budgeted, as of September 30, 2022.
- **Incentives for Medium- and Heavy-Duty Zero-Emission Vehicles Program:** As of July 11, 2022, incentives of up to $200,000 are available for the purchase or lease of eligible vehicles. A total of $547.5 million is available for four years, or until funding is exhausted.
- **Zero Emission Vehicle Awareness Initiative:** This initiative aims to support education and capacity-building projects to increase awareness, knowledge and confidence in electric vehicles and associated charging infrastructure. A recent call for project proposals to support projects for the light-duty vehicle sector was completed, and a forthcoming call for projects is scheduled for the medium- and heavy-duty vehicle sector.

A.2 Provincial policies and regulations

A.2.1 Electricity

A.2.1.1 Regulations, standards, and mandates

Electricity regulations were written for the grid that existed, but whose paradigm has significantly shifted. Provinces with more clean energy currently offer lower electricity prices, which also draws economic activity like manufacturing. Across sectors, there are many opportunities for provinces to invest in decarbonization. By initiating regulatory reform, provinces can also reshape utilities into decarbonization leaders that provide affordable and flexible electricity for its consumers.

DERs and DSM technologies are growing to meet consumers' demands across the country. However, markets do not incentivize these new mechanisms, stifling their adoption. Electricity regulators need to be able to recognize, for example, the value an energy storage site provides to grid flexibility and improved building and occupant resilience. They need to enable distributed generators to sell electricity back to the grid fairly. Flexibility of dispatch is the most important aspect now rather than the magnitude of baseload.

- **Rate structures need to be updated** to incentivize consumer behaviour that contributes to a more flexible and cleaner grid. This includes introducing

mechanisms such as time-of-use pricing,[54] differentiated rates for electric vehicle charging,[55] full net metering (instead of net billing), and mechanisms that reward fuel-switching to electric heating systems and carrying out deep energy efficiency upgrades. While some programs exist, regulatory reform could change the utility business model and capture incentives for deploying efficiency measures. In particular, Alberta is now the only jurisdiction in North America that does not support DSM efforts by utilities.[56]

- To support end-use electrification and grid modernization, **billions need to be invested in transmission and distribution infrastructure upgrades**. These costs are currently passed on to electric utilities' rate bases. In some cases, ratepayers may not be able to see the benefits of the rate increases. In some cases, households least able to reduce their energy use will face the entire bill. Utilities frequently use this argument to oppose net metering for DERs, but multiple studies have shown that net metering provides net benefits from helping to avoid other infrastructure upgrades and reducing demand peaks in a grid.[57] There are many opportunities to ensure a future grid is cost-effective, equitable, and flexible.
- At a high level, **provincial electricity regulators need to be modernized and given the mandate to support decarbonization**. Most regulators have a narrow mandate focused on reliability and affordability. This limits their actions and their incentive to innovate in ways that optimize costs and emissions reductions while maintaining reliability. They need to have additional mandates for sustainability to help the electricity industry meet net-zero commitments and to reform their regulatory mechanisms.
- **Provinces need to build cooperation with their neighbours and the federal government**. While regional interties provide large opportunities for improving grid flexibility and resilience, few efforts have been made to overcome the political barriers to building interties. The Atlantic Loop project proposed has

[54] Rocky Mountain Institute, *A Review of Alternative Rate Designs: Industry Experience With Time-Based and Demand Charge Rates for Mass-Market Customers* (2016). https://rmi.org/wp-content/uploads/2017/04/A-Review-of-Alternative-Rate-Designs-2016.pdf

[55] E. Jarratt, "Ultra-low overnight electricity rates could save Ontario EV drivers up to $90 a year: Ontario Energy Board report," *Electric Autonomy Canada*, 12 April 2022. https://electricautonomy.ca/2022/04/12/ultra-low-electricity-rates-ontario/

[56] Efficiency Canada, *The Canadian Energy Efficiency Scorecard: Provinces and Territories* (2022). https://www.scorecard.efficiencycanada.org/energy-efficiency-alberta

[57] M. Muro and D. Saha, *Rooftop solar: Net metering is a net benefit* (Brookings, 2016). https://www.brookings.edu/research/rooftop-solar-net-metering-is-a-net-benefit/

been paused, and Ontario recently chose to not renew their electricity trade agreement with Quebec, which limits Ontario grid's flexibility and ability to procure clean electricity.

A.2.1.2 Funding

Natural Resources Canada maintains a directory of funding programs from government and other parties.[58] However, most provincial funding programs are directed towards energy efficiency and are otherwise limited. Some examples of existing funding programs include:

- DERs (including rooftop solar)
  - Property Assessed Clean Energy programs — these help to drive the adoption of rooftop solar, not just building renovations, by reducing the upfront capital costs to homeowners or commercial building owners. Ontario, Alberta, and Nova Scotia currently have legislation that enable PACE programs.
  - Ontario IESO Grid Innovation Fund[59]
- Net-zero-ready building codes include provisions for easy installation of rooftop solar
- Utility-level renewables support, including net-zero government and utility renewables procurement commitments
  - For example, Alberta's Renewable Electricity Program procured some of North America's cheapest electricity and has generated a net profit to the government of $160 million[60]

A.2.2 Buildings

A.2.2.1 Regulations, standards, and mandates

Efficiency acts in B.C., Manitoba, Ontario, and Quebec, combined with provincial equipment regulations, are driving fuel-switching. Regulatory reviews, such as the

[58] Natural Resources Canada, "*Main Directory of Energy Efficiency and Alternative Energy Programs in Canada*." https://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/policy_e/programs.cfm

[59] IESO, "Distributed Energy Resources." https://www.ieso.ca/en/Learn/Ontario-Electricity-Grid/Distributed-Energy-Resources

[60] S. Hastings-Simon, A. Leach, B. Shaffer, and T. Weis, "An Alberta Wind Energy Windfall," *Energy and Environmental Policy Trends*, 15 no. 1 (2022). https://journalhosting.ucalgary.ca/index.php/sppp/article/view/76259

review Quebec is undertaking to remove mercury from equipment, also present opportunities to introduce carbon reduction and energy efficiency requirements.

For new construction, tiered performance-based energy codes developed in B.C. and the 2020 model National Building Code and National Energy Code for Buildings now offer new compliance paths with energy performance tiers. Tiered energy performance codes provide a framework for achieving higher levels of energy efficiency in new buildings and major renovations, with the top tier meeting net-zero emissions ready standards. They offer provinces, territories, and local governments more flexibility in code adoption and implementation while also offering all building sector stakeholders regulatory certainty and an anchor by which to develop a long-term strategy to cut energy waste and decarbonize the buildings sector. Despite those benefits, only B.C. has adopted a tiered code — the B.C. Energy Step Code — which the province is working to harmonize with the tiered national model codes to facilitate adoption and allows municipalities to adopt higher Steps. Ontario adopted only Tier 1 of the 2022 national model codes, holding its energy requirements at 2017 levels until 2027 when the Ontario Building Code will next be updated.

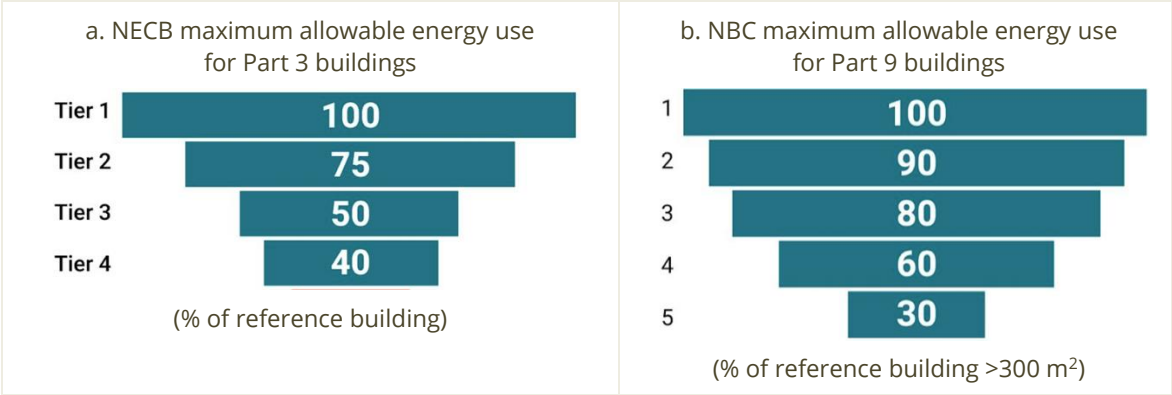

Figure 3. Energy code maximum allowable energy use for buildings by tier

Source: Efficiency Canada[61]

In parallel with energy reductions, carbon emissions caps are being mandated at both the utility and building scales. For example, B.C. is implementing a GHG emissions cap for natural gas utilities. By 2030, natural gas utilities will be restricted to emitting no more than 6 Mt of CO_2e per year, a reduction of approximately 47% from 2007 levels. The cap is performance based, meaning the utilities determine the best strategy to meet it (e.g., using renewable fuels), and the regulator (the B.C. Utility Commission) will

[61] Efficiency Canada, *Tiered Energy Codes Best Practices for Code Compliance* (2020) , 7, 8. https://www.efficiencycanada.org/wp-content/uploads/2020/09/Tiered-Energy-Code-Best-Practices-for-Code-Compliance.pdf

review the plans and investments to make sure they align with the emissions cap. In parallel, all new space and water heating equipment sold after 2030 for installation in B.C. must be at least 100% efficient, which favours electric baseboards and heat pumps. Performance-based, this combination of policies opens the field to innovation, including hybrid and highly efficient natural gas heat pumps fueled with renewable natural gas.[62]

At the building scale, under the City of Vancouver's Zero Emissions Buildings Plan[63] new buildings built as of 2030 must have zero-emission space and water heating systems. For existing buildings, Vancouver is phasing in carbon pollution reporting requirements for large commercial (starting 2024) and multi-unit residential buildings (starting 2025) and GHG intensity limits will come into effect in 2027. Vancouver is also introducing embodied carbon reporting requirements for Part 3 buildings as of July 2023 and reduction requirements as of January 2025. Metro Vancouver is also developing greenhouse gas performance requirements for existing large buildings and homes. These requirements will use energy benchmarking and labelling, harmonized with provincial regulatory requirements. Metro Vancouver also works with the B.C. government to improve compliance with the province's Ozone Depleting Substances and other Halocarbons Regulation, to help safely reduce refrigerant leaks.[64]

Several Ontario cities also have building performance standards (e.g., Toronto Green Standard[65]), but Ontario's *Bill-23 More Homes Built Faster Act, 2022* overrides council-approved sustainable design standards. This decision reverses processes established to reduce energy and emissions and exposes new homeowners to high energy costs and carbon prices. With the Ontario Building Code adoption of Tier 1 only, Ontario municipalities rely heavily on building performance standards; Bill 23 hobbles their progress.

Utility regulations also need updating to help drive energy efficiency programs and support fuel-switching using the full range of electric heat solutions available to

[62] Government of British Columbia, *CleanBC: Roadmap to 2030* (2021). https://www2.gov.bc.ca/assets/gov/environment/climate-change/action/cleanbc/cleanbc_roadmap_to_2030.pdf

[63] City of Vancouver, "Zero Emissions Buildings." https://vancouver.ca/green-vancouver/zero-emissions-buildings.aspx

[64] Metro Vancouver, "Buildings: A Pathway to Zero Emissions and Resilient Buildings," *Climate 2050 Roadmap* (2021), 52. http://www.metrovancouver.org/services/air-quality/climate-action/climate2050/Climate2050Docs/Climate2050BuildingsRoadmap_Final_October2021_old.pdf

[65] City of Toronto, "Toronto Green Standard Version 4." https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/toronto-green-standard-version-4/

Canadians (e.g., phasing out incentives for natural gas equipment[66]). Electricity and gas energy plans also need to be combined to better clarify the future energy mix in buildings under a decarbonization path, such as the roles of renewable gases, distributed energy generation, and demand response technology. DSM regulations need to be refined to align with provincial and federal climate targets and energy plans (e.g., service upgrade policies and rate structures need to be designed to remove barriers to building electrification[67]) and incorporate transportation end-uses in their planning, including strategies to reduce demand. More generally, standards for the electricity, buildings and transportation sectors need to be harmonized.

A.2.2.2 Funding

We estimate the renovation wave needed to decarbonize existing buildings will require an incremental investment of about $400 billion over the next 20 years. This will require significant investments from government, and a paradigm shift in how we structure funding programs. Current rates of energy retrofits vary across Canada, but hover around 1% of stock per year. The renovation wave would see the retrofit rate more than quadruple, to 4 to 5% per year.

We estimate the public portion of the investments needed to meet these objectives at about $10 to $15 billion per year, every year between now and 2040 (or until appropriate regulatory drivers are in place). Utility, federal, and provincial incentives announced or in place today offer a cumulative $2 billion annually, leaving a funding gap of approximately $8-13 billion per year. Table 1 summarizes the projected annual renovation rate, carbon reductions and investment needed.

[66] C. Kasteel and T.-P. Frappé-Sénéclauze, *Regulating Gas in B.C. to Achieve 2030 and 2050 Climate Goals* (Pembina Institute, 2022). https://www.pembina.org/pub/regulating-gas-bc-achieve-2030-and-2050-climate-goals

[67] T. Billy and T.-P. Frappé-Sénéclauze, *Actions Needed to Electrify British Columbia's Buildings* (Pembina Institute, 2022), 8. https://www.pembina.org/pub/actions-needed-electrify-british-columbias-buildings

Table 1. Proposed retrofit rate and estimated carbon impact and needed investment, by province

	# of buildings retrofitted per year			Carbon reductions (% below 2017 by 2050)	Total Investment ($ billion/year)		
	Detached homes	Attached homes	Apartments		Residential	Commercial	TOTAL
CANADA	**339,800**	**70,700**	**188,200**	**89%**	**$14.60**	**$6.30**	**$20.90**
BC	40,400	10,200	27,700	95%	$1.90	$0.90	$2.80
AB	42,800	7,600	13,100	70%	$1.60	$0.90	$2.50
SK	13,500	1,200	3,300	78%	$0.50	$0.20	$0.70
MB	13,800	1,300	5,100	99%	$0.50	$0.20	$0.80
ON	128,300	33,900	64,700	99%	$5.60	$2.40	$8.00
QC	70,900	13,500	66,500	98%	$3.50	$1.20	$4.70
NB	9,700	800	2,300	99%	$0.30	$0.10	$0.50
NS	11,500	1,200	3,800	86%	$0.40	$0.20	$0.60
PE	1,800	200	500	100%	$0.10	$0.00	$0.10
NL	7,100	900	1,300	98%	$0.20	$0.10	$0.30

Sub-nationally, incentives are offered through utility DSM programs, directly by the province, and by many municipalities. NRCan hosts the Main Directory of Energy Efficiency and Alternative Energy, which aggregates programs that are searchable by province or territory. Incentive programs can otherwise be found through sites such as CleanBC's Better Homes and Better Buildings. Based on 2019 utility, provincial, and federal funding commitments, we estimate an annual national funding gap of $9.8 billion, which is broken down by province in Table 2.

Table 2. Funding gap, by province ($ billion/year)

	Projected retrofit investment needed		Baseline federal and provincial investment			Funding gap
	Estimated cost of retrofits per year	Estimate of Incentives needed per year	Utility programs (2019)	Provincial programs (2019)	Federal commitment	(Incentive needed minus baseline investment)
Canada	20.9	12.3	0.84	0.23	1.4	**9.8**
BC	2.8	1.6	0.18	0.03	0.11	**1.3**
AB	2.5	1.5	-	0.04	0.11	**1.4**
SK	0.67	0.4	0.01	-	0.11	**0.30**
MB	0.75	0.4	0.06	-	0.11	**0.30**
ON	8.0	4.8	0.42	-	0.22	**4.1**
QC	4.7	2.7	0.08	0.17	0.11	**2.3**
NB	0.46	0.30	0.03	-	0.11	**0.10**
NS	0.59	0.30	0.06	-	0.11	**0.20**
PE	0.09	0.06	0.01	-	0.11	**-0.07**
NL	0.33	0.20	0.02	-	0.11	**0.06**

Examples of utility programs that support decarbonization of the building sector, include BC Hydro's electrification plan[68] and FortisBC's clean growth pathway to 2050.[69] BC Hydro's Community Energy Manager program funds a municipal staff role designing and implementing community energy programs. Similarly, FortisBC funds a Community Energy Specialist that works with the CEM on natural gas-focused projects.

In terms of direct consumer incentives, BC Hydro also provides incentives for fuel-switching space and water heating and FortisBC provides building envelope and equipment upgrades (under the CleanBC conditions outlined above, closing the door on natural gas furnaces and boilers). FortisBC is also participating in the Pembina Institute's Reframed Initiative as part of its deep retrofit pilot project and investing in increasing renewable natural gas supply.

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

[69] FortisBC, *Clean growth pathway to 2050* (2022). https://www.cdn.fortisbc.com/libraries/docs/default-source/about-us-documents/clean-growth-pathway-brochure.pdf

A.2.3 Transportation

A.2.3.1 Regulations, standards, and mandates

There is a patchwork of regulations and policy measures to advance vehicle electrification across Canadian provinces. Historically, British Columbia and Quebec have led in the implementation of regulations, and it is within these provinces that adoption is the highest in the country. Regulations that have helped put B.C. and Quebec at the forefront include:

- **ZEV sales mandate:** British Columbia's Zero-Emission Vehicles Act was implemented in May 2019 and based on a recent update requires automakers to have new zero-emission light-duty vehicle sales and leases reach 26% of sales by 2026, 90% by 2030 and 100% by 2035. Quebec implemented its Zero-Emission Vehicles Act in 2016 and requires light-duty zero-emission vehicle sales to reach 26% of sales in 2026 and 65% in 2030.
- **Low Carbon Fuel Requirement:** British Columbia's Low Carbon Fuel Requirement sets carbon intensity targets for fuel suppliers that decline annually. The regulation aims to achieve a 20% reduction in the fuel carbon intensity by 2030. Operators of electric vehicle charging sites can generate credit revenue through the regulation, thereby incentivizing the deployment of infrastructure and lowering the total cost of ownership for electric vehicles in the province.

A.2.3.2 Funding

Some provinces and territories have funding in place to support electric vehicle purchases and the purchase and installation of charging equipment.

- **Zero-Emission Vehicle Purchase Incentives:** Provinces and territories that currently offer rebates on the purchase of an eligible light-duty electric vehicles include British Columbia ($4,000), Quebec ($7,000), New Brunswick ($5,000), Nova Scotia ($3,000), PEI ($5,000), Newfoundland and Labrador ($2,500), Yukon ($5,000) and Northwest Territories ($5,00).[70] These incentives can be stacked with the federal subsidy. Both British Columbia and Quebec also offer rebates on the purchase of electric medium- and heavy-duty vehicles through the Specialty-Use Vehicle Incentive Program (B.C.) and Programme Écocamionnage (Quebec).

[70] The rebate amounts described reflect the maximum purchase subsidy value in a given province or territory.

- **Charging Infrastructure Incentives:** Both British Columbia and Quebec have dedicated programs to support the deployment of electric vehicle charging infrastructure. The CleanBC Go Electric program offers rebates for Level 2 stations at a rate of 75% of total costs up to a maximum of $50,000 per applicant. Other provinces have announced investments in public charging stations, including $91 million in Ontario for chargers at highway rest stops and $1 million in Newfoundland to build out stations across the Trans-Canada.

Appendix B. Supporting numbers

B.1 Investments required for a net-zero economy

Estimates for the costs required to decarbonize the economy rely on modelling estimates that vary by institution and scenario. Despite inherent uncertainties in future forecasts and model assumptions, net-zero modelling studies are useful in providing some insight into cost-effective and robust pathways to deep emission reductions.

At a global level, an IPCC report in 2018 estimated that around 2.5% of global GDP needs to already be dedicated yearly towards energy system decarbonization investments,[71] with a larger portion taken by highly industrialized economies like Canada's. Applied only linearly, 2.5% of Canada's 2021 GDP PPP ($2.5 trillion in 2022 dollars[72]) represents $62.5 billion.

An RBC study for Canadian decarbonization estimated $80 billion of public and private investment is needed each year by 2050 — with at least $35 billion by 2030.[73] Their most recent estimate of Canadian spending is between $10 and 20 billion.

[71] IPCC, "Summary for Policymakers," *Special Report on 1.5°C* (2018), 22. https://doi.org/10.1017/9781009157940.001

[72] Statistics Canada, "Table 36-10-0222-01 Gross domestic product, expenditure-based, provincial and territorial, annual (x 1,000,000)." https://doi.org/10.25318/3610022201-eng

[73] C. Leach, "Financing Greener Growth: The fall economic statement needs to accelerate green investment," *RBC Economics Special Reports,* November 1, 2022. https://thoughtleadership.rbc.com/financing-greener-growth-the-fall-economic-statement-needs-to-accelerate-green-investment/

B.2 MHDV electrification

Table 3. Charging infrastructure cost under the Pembina Institute's policy scenario to reach MHDV electrification targets

Charger type	Charging infrastructure costs ($millions)					
	2025	2030	2035	2040	2045	2050
Low estimates						
Private depot chargers-Level 2	48	210	577	840	1,129	1,349
Private depot chargers-Level 3	115	588	1,039	1,753	2,593	2,625
Public chargers (Level 3)	144	732	1,294	2,182	3,227	3,267
Total	**308**	**1,530**	**2,911**	**4,776**	**6,950**	**7,241**
High estimates						
Private depot chargers-Level 2	1,823	790	2,165	3,150	4,235	5,061
Private depot chargers-Level 3	192	980	1,733	2,922	4,322	4,375
Public chargers (Level 3)	180	915	1,617	2,728	4,034	4,083
Total	**555**	**2,685**	**5,515**	**8,800**	**12,591**	**13,519**

Source: Pembina Institute[74]

Table 4. Number of EV charging stations required under the Pembina Institute's policy scenario to reach MHDV electrification targets

Charger type	Stations required					
	2025	2030	2035	2040	2045	2050
Private depot chargers (Level 2)	12,180	52,680	144,380	210,000	282,310	337,400
Private depot chargers (Level 3)	3,850	19,600	34,650	58,450	86,450	87,500
Public chargers (Level 3+)	1,800	9,150	16,170	27,280	40,340	40,830

[74] Pembina Institute, *Towards Clean MHDVs*, 19.