Executive summary

Changing course:
a strategic approach to get Canada to net-zero

INSTITUT DE L'ÉNERGIE TROTTIER

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About the Trottier Energy Institute (IET)

The Institut de l'énergie Trottier (IET) was created in 2013 thanks to an exceptional donation from the Trottier Family Foundation to Polytechnique Montréal. Since then, it has been involved in every energy debate in the country. At the source of major collective reflections, the team mobilizes knowledge, analyzes data, popularizes issues and recommends fair and effective plans, simultaneously contributing to academic research and training. Its independence gives it the neutrality essential to the collaborative approach it advocates, facilitating work with the players most likely to advance the energy transition, while allowing it to be freely critical when relevant. As the initial 10-year mandate came to an end, the Trottier Family Foundation decided to renew its confidence in the IET and made a new donation. Given the scope of the IET's activities and its status as a key player, its mandate was extended. The team will thus be able to continue offering science-based advice and enriching societal dialogue in order to advance the way we produce, convert, distribute and use energy.

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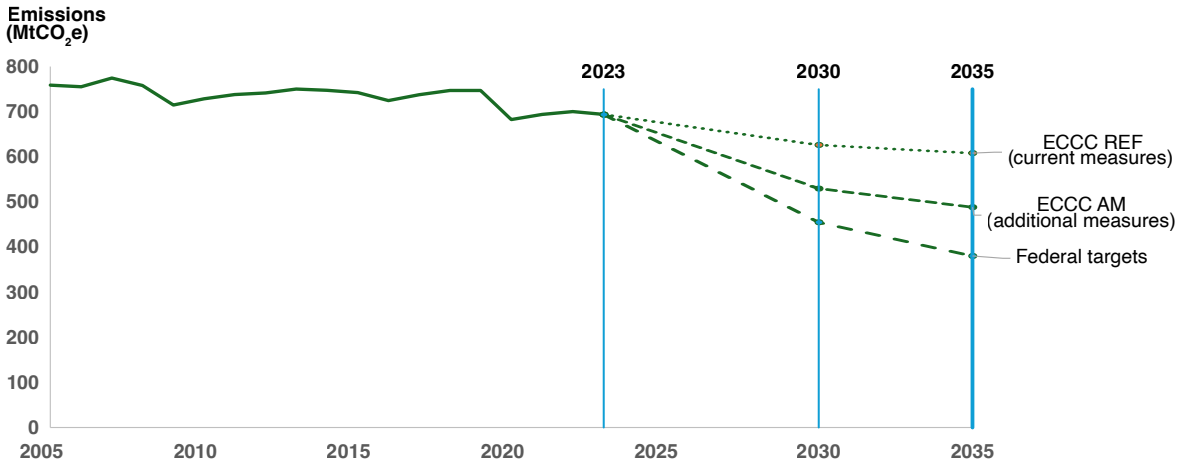
At present Canada is not on track to reach net-zero GHG emissions by mid-century.

Despite the climate policies introduced by the federal government since 2015, and optimistic assessments of Canada's 2022 Emissions Reduction Plan, a recent report from Environment and Climate Change Canada (ECCC) recognized a substantial gap remains between reductions anticipated from existing climate policies and the official 2030 and 2035 interim targets (Canada, 2025). This is consistent with the earlier assessment in the Institut de l'énergie Trottier's Canadian Energy Outlook (Langlois-Bertrand *et al.*, 2024). ECCC now forecasts an 18% GHG reduction rather than 40% for 2030, and 20% rather than the intended 50% for 2035 (Figure ES1), a projection that does not include the impact of the repeal of the consumer-facing carbon levy. According to ECCC, the adoption and full implementation of all other measures being considered by government (so called 'advanced measures') could partially close this gap by achieving a 30% GHG reduction by 2030 and 35% by 2035.

Without further significant action the country would therefore achieve less than half the targeted reductions. Considering the difficult political conjuncture, with turmoil over tariffs, the hostility of the current US administration to the energy transition and international climate regime (as well as the Canadian government's poor record of accurately anticipating future emissions trajectories), even these results are far from certain. In the meantime, many of Canada's OECD counterparts have managed to make greater progress. In contrast to Canada, European countries have decreased their emissions significantly since 1990. So, while every country faces its own unique challenges and conditions, a large number of states have succeeded in deploying strategies that allow sizeable reductions in emissions, compatible with the Paris Agreement objectives.

This failure is not only environmental: we are not moving rapidly enough to build the new economy that will be required for Canadian prosperity in the second half of the century.

Figure ES1 - Historical and projected GHG emissions according to different scenarios



Source: Canada (2025)
Note: the measures included in the current measures (REF) and additional measures (AM) scenarios are detailed in Canada (2024)

Many factors have contributed to limiting progress :

1. It was always going to be difficult to curtail emissions in a country with a resource-based economy, expanding oil and gas exports, widely varying regional energy political economies, decentralized political arrangements, and close economic integration with the United States.
2. Moreover, the interim (2030) abatement target adopted by the federal government in 2021 was not based on careful bottom-up analysis but on political expediency.
3. Despite its name, the **Emissions Reduction Plan was not a workable plan** that identified the concrete requirements for reducing emissions and then established gradual steps to achieve these. Rather it was an aspirational modelling exercise tweaked to show the desired outcome.
4. Policy development was excruciatingly slow (not aided by excessively complex pricing and compliance mechanisms that lacked transparency), and large amounts of political capital were wasted on initiatives that can contribute little to transitioning Canada's systems to net zero.

In this report we reexamine the challenge of decarbonizing Canada's economy by mid-century, consider the progress that has been made to date, and outline measures that can reorient efforts to make progress in key economic sectors. Before presenting our detailed analysis, it is beneficial to lay out our approach.

Adopting a more strategic stance

To decarbonize our economy over the next 25 years, the 'gap' between ambition and practical actions must be closed. This means adopting a more strategic approach that includes:

1. Shifting focus. Instead of worrying about short-term emission reduction targets we should **prioritize real-world changes that gradually transform our systems**, so emissions are essentially eliminated by mid-century. Tracking physical indicators (the installation of clean electricity generation, the number of buildings converted to electric heating) and measures of market transformation (percentage of EVs in total auto sales, relative costs of gas and electric heating) in these systems is more important than tabulating annual emissions reductions.
2. Recognizing that **climate policy is increasingly linked to economic development and industrial policy**. Renewable technologies (solar, EVs) are now being adopted by poorer countries to accelerate economic development, and nations are jostling to secure their place in low carbon production chains. For Canada net zero is about building an economy that can be competitive and prosper in a decarbonizing world. Support for clean electricity buildout, value-added transformation of natural resources (mining and processing critical minerals) and manufacture of low-carbon technologies (EVs, heat pumps, electrical system components, etc.), creates the foundation of future affluence, gives us tools to decarbonize our domestic economy, and can strengthen political coalitions favouring more vigorous action.
3. **Embracing asymmetrical decarbonization.** Sectors, provinces and regions will proceed down pathways, and at rates appropriate to their circumstances. Policies should be adapted to the phase of transition in different regions and sectors. Where solutions are ready, policy measures should accelerate mass deployment. Where solutions are not yet clear, policy can support R&D, experimentation, and measures to prepare eventual market transformation.
4. **Adopting a planning and implementation mind set:**
   - **a)** *Think first about what a net zero economy would look like.* How do we organize effective systems for moving goods, heating buildings, providing electricity, and so on, that do not result in net GHG emissions? Of course we cannot anticipate every detail. But we already know the basic structure of a net zero energy system.
   - **b)** Then ask *what sequence of changes in the physical world* is required to achieve this goal. This includes the buildout of infrastructure (power plants and EV charging stations), the adoption of new end-use technologies (EVs on the roads, heat pumps in buildings), and the development and eventual adoption of novel technologies (for heavy industry, net zero aviation, carbon removals, and so on).
   - **c)** *Examine the barriers to and enablers* of the desired transformation in each specific context (the sector, province or city) and adopt appropriate policy measures to secure the physical changes that construct the future economy. By working backwards from the desired system architecture, it is possible to plan the concrete steps required to build the new economy.
   - **d)** *Monitor progress*, through relevant indicators, and adapt to what is happening on the ground on an almost continuous basis.

5. **Supporting the new rather than punishing the old.** Society will not primarily abandon fossil fuel resources because supply has been politically constrained but because demand has been eroded by superior renewable technologies and electric end-uses with higher performance, that are convenient, safer, and ultimately cheaper. So the policy emphasis should be on rolling out the new, with a strategy to drive costs and prices down while demonstrating the benefits of new technologies, rather than penalizing the old. As fossil fuel dependence is eroded on the demand side, the balance of forces between old and new energy systems, and the political calculus, will change and the transition can accelerate. But targeting fossil energy producers directly (when oil remains the country's largest export earner and several province's economies are based on the petroleum industry) is politically challenging.
6. **Paying attention to prices.** In the short term, prices are largely given, but over time they are influenced by investment. Learning rates (the price fall with doubling of deployment), economies of scale and regulations can dramatically transform relative costs. Thus, the purchase price of solar panels has dropped by 90% over the past decade. Policy can help drive down the price of new technologies by encouraging uptake through procurement, training, strategic production or consumption subsidies, regulations and other mechanisms. Carbon pricing acts in the other direction, by raising the costs for fossil fuel-based options. But, as we have seen, measures that raise prices are likely to meet political resistance, and people resent an imposed loss (for example, through taxes) more than an advantage conferred to others (for example, through subsidies). More generally in navigating the energy transition governments must take care to avoid a sudden rise in energy prices (for example electricity rates), or concentrated losses imposed on a particular industry, occupational group or region, for they can spark a backlash that can derail plans for years. They must also ensure that policies drive structural changes that lower the price of the desired technologies and services.

Reaching net-zero: how to achieve transformative outcomes

As we show in this report, what all this means in sectoral terms is:

For electricity:

- Steadily and rapidly expand non-emitting grids (especially wind and solar generation, storage and transmission) to meet the growing need for electricity as other sectors (transport, building heating, industry) decarbonize
- Gradually phase out any remaining coal-fired generation and unmitigated gas generation
- Implement strategies to mitigate the short and medium-term challenges of rapid electrification in different grids across the country, for instance seasonal peak exacerbation as well as distribution- and transmission-level short-term capacity constraints

For transport:

- Accelerate the uptake of light and medium duty electric vehicles
- Continue R&D and experimentation with heavy-duty road vehicles (and off-road vehicles), with battery electric and hydrogen fuels cells as the most promising options
- Build out high-speed rail in major inter-city transport corridors and extend electrified public transit systems
- Continue R&D and experimentation with net zero options for rail, marine and aviation

For buildings:

- Stop building new residential and commercial structures with gas-fired heating
- Systematically retrofit existing buildings with low carbon heating systems (mainly with air source heat pumps, but in some circumstances other net-zero options may be practical).
- Encourage energy efficiency improvements for new and old buildings to reduce clean energy supplies that will be required in a net zero world.

For industry:

- Electrify mechanical operations and low-temperature heat in industry
- Gradually convert high-temperature heat provision to electricity, hydrogen or biofuels
- Progressively address process emissions, timing lumpy investment with cycles of capital renewal

For oil and gas:

- Ensure industry lowers production emissions with the goal of achieving net zero for the sector by mid-century. How quickly emissions can be brought down depends on political decisions and the speed with which the Canadian and global economy decarbonizes.

But these goals can only be met by implementing the general principles underpinning the strategic approach outlined above. To inform this discussion, we propose a closer look at sectors to illustrate what this might look like.

Designing a strategic approach

Developing a strategic approach to meet these components of a prosperous net-zero Canada requires a focus on structural transformations that can enable the realization of these goals. It also requires seizing on the considerable opportunities to enhance productivity and the competitiveness of Canada's economy through these transformations.

To illustrate how this can be achieved, in Section 3 of the report we focus on three sectors and propose an assessment of needs and a strategy to address them: buildings, road transport, and industry. We also provide an overview of the challenges facing other sectors, to be analysed in more detail in a subsequent report. Our proposed sector strategies aim to transform markets and reduce prices, thereby facilitating and accelerating the transition to low-emission services. In so doing, each strategy follows similar principles for approaching the design and implementation of decarbonization measures.

The framework covers:

1. *What net-zero transformation looks like:* what are **the key elements of an improved system** that can provide services in the sector and that does not result in net GHG emissions?
2. *Which physical changes are needed to get there:* what are the **essential material components** required to achieve such a system transformation, and at what pace?
3. *How to overcome key barriers:* what are the **foreseeable obstacles** that must be removed, in as many relevant locations around the country as possible, to facilitate the necessary changes? What measures (coordination efforts among key stakeholders, regulations, policies, etc.) can be enablers to support the deployment of the transformative pathway?
4. *Capturing economic benefits:* **what strategic economic interests** for Canada can be realized through the successful deployment of the strategy?

Each strategy is then summarized in a table with the main objectives and action items for the short term (a year), medium term (1-5 years) and longer term (5-25) years.

A summarized version of these strategies, containing example action items, is provided in Tables ES1, ES2 and ES3 of this document.

NOTE

For this report, we accept the government's 2035 targets (with the sectoral split consistent with the 2030 additional measures modelling run) as a reference point for discussion and to highlight the gap between stated ambition and anticipated system transformation (and emissions reduction) over the coming decade. This does not necessarily imply that we believe the 2030 or 2035 targets were well chosen, or that the sectoral contributions to emission reduction should be those implied in the 'additional measures' scenario, or indeed that these contributions will remain constant over time. Indeed, everything we know about market transformation suggests the process is not linear, but takes place slowly at first, then accelerates, and then slows again. And these changes will not be aligned across different across sectors and regions, so their relative contribution to emission reductions will vary at different points in time.

The real goal here is an essentially decarbonized economy by mid-century. And this will require transformative measures along the lines discussed in the sections below over the next 20-30 years. Whether one thinks that the target for a particular sector is too stringent or not sufficiently stringent; and whether a specified degree of market transformation is achieved in 2031, 2035, or 2039, the same general sequence of changes discussed below, and reductions on something like the same scale, will be required for any feasible plan to reach net zero by mid-century. If change is to be slower in earlier years, then it will have to be more rapid in subsequent periods as technologies mature, prices fall, and infrastructure is built up. So the basic steps outlined in the sectoral strategies below remain the same whether we dig in our heels next year or continue to defer action. Of course, the window for Canada to seize opportunities in international net-zero supply chains may close as other countries pursue more vigorous action.

With this set of measures in mind, we build a tentative timeline for these transformations (Figure ES2).

Figure ES2 - Timeline of high-level elements in national strategy

Objectives	2025	2030	2035	2040	2045	2050
No gas installed in new residential and commercial buildings	Deploy		Complete			
Retrofits eliminate gas in existing residential and commercial buildings	Deploy					Complete
Electrify light-duty vehicle fleet	Deploy				Complete	
Make heavy-duty fleet net-zero	R&D and demo		Deploy			Complete
Decarbonize low-temperature heat in industry	Deploy			Complete		
Decarbonize high-temperature heat in industry	Deploy					Complete
Commercial-scale CCS & negative emission technologies	Pilots	Deploy				Complete
Decarbonize industrial processes	R&D and demo		Deploy			Complete

Note: The latter stages in this timeline are contingent, on some aspects, to international progress; they might be accelerated or delayed by a few years.

Table ES1 - Decarbonization strategy for buildings: objectives and action items (excerpts from full report)

RESIDENTIAL BUILDINGS	Short term (1-12 months)	Medium term (1-5 years)	Long term (5-25 years)
Objectives	Send a clear signal that Canada is aiming for more than half of residential buildings to be equipped with heat pumps within a decade and zero-emission systems to be a requirement of new buildings	Expand a heat pump service and supply industry by ensuring a market in all regions of the country; start reducing prices	By 2040: Achieve electrification of space heating in 80% of existing residential buildings; create a robust and export-competitive service and supply chain industry for heat pumps; deploy building-related peak management strategies for electricity grids in all provinces
Example action items	Map out capacity bottlenecks in electricity distribution grids that require urgent attention for short-term deployment of heat pumps and begin planning and execution of upgrades	Support the development of efficient supply chains for heat pump parts and devices in all provinces (local suppliers, repair expertise, etc.)	
COMMERCIAL BUILDINGS	**Short term (1-12 months)**	**Medium term (1-5 years)**	**Long term (5-25 years)**
Objectives	Send a clear signal that heat pumps will be made to dominate new space heating system installations in all types of MCI buildings by 2030.	High performance heat pumps and heat-pump-based commercial HVAC systems are available at the lowest possible costs across the country	By 2045: Achieve decarbonization of MCI buildings in all provinces; create a robust and export-competitive service and supply chain industry; deploy MCI building-related peak management strategies in all provinces
Example action items	Identify and reduce regulatory barriers to the use, maintenance and repair of heat pumps in large buildings and start process to lift them	Deploy a strategy to develop a supply and service industry for the various technologies adapted to the various segments, with support for increasing their competitiveness	

Table ES2 - Decarbonization strategy for road transport: objectives and action items (excerpts from full report)

LIGHT-DUTY VEHICLES	Short term (1-12 months)	Medium term (1-5 years)	Long term (5-25 years)
Objectives	Confirm alignment with rest of G7 (all but USA) to impose that all new light duty vehicles must be net-zero by 2035 (with potential exceptions for remote areas)	Promote the emergence of Canadian players for parts, charging stations, and increase local manufacturing from foreign companies	By 2035: Use the advance on ZEV mandate to position Canada as highly competitive for some subsectors on zero-emission light-duty vehicles, while giving access to low-cost vehicles to Canadians
Example action items	Link ZEV compliance to industrial policy	Promote development and implementation of policies for recycling/reusing used EV batteries	
HEAVY-DUTY VEHICLES - LOCAL	**Short term (1-12 months)**	**Medium term (1-5 years)**	**Long term (5-25 years)**
Objectives	Set horizon for zero emissions heavy duty vehicles for local uses (trips of <200-300 km) for 2035/2040, in line with other countries.	Advance on the deployment of ZEV in this category; structure a strong Canadian ecosystem (manufacturing, service)	By 2035-2040: All new vehicles are zero-emission for this sector which supports the creation of a robust and export-competitive service and supply chain industry
Example action items	Identify barriers and advantages for each segment: availability, charging infrastructure, price, presence of competing providers	Adopt strategic, predictable and sustained procurement and subsidies to lower cost	
LONG-DISTANCE FREIGHT	**Short term (1-12 months)**	**Medium term (1-5 years)**	**Long term (5-25 years)**
Objectives	Set a 2040-2045 horizon for zero-emission long-distance freight (> 400 km per day) to start orienting investments and deployment	Start deployment of ZE long-range freight demonstration lines; structure Canadian manufacturing, assembly and service industry	By 2040-2045: All new vehicles are zero-emission for this sector which supports the creation of a robust and export-competitive service and supply chain industry
Example action items	Develop strategic procurement planning to support Canadian providers	Create regulatory sand-boxes to facilitate pilot projects	

Table ES3 - Decarbonization strategy for industry: objectives and action items (excerpts from full report)

LOW-TEMPERATURE HEAT	Short term (1-12 months)	Medium term (1-5 years)	Long term (5-25 years)
Objectives	Send a clear signal that low-temperature heat will have to be decarbonized across manufacturing and industrial sectors by 2040; launch a deployment strategy	Create a service and supply industry by ensuring a market; aim at reducing risks and prices	By 2040: Achieve decarbonization of low-temperature heat across all industrial and manufacturing sectors; create a robust and export-competitive service and supply chain industry
Example action items	Identify first-adoption sectors (such as agro-food industry) based on the existence of regional clusters, electric capacity, and support industry	Implement programs to favour the deployment of a service industry, including lowering prices and accelerating deployments	
HIGH-TEMPERATURE HEAT	**Short term (1-12 months)**	**Medium term (1-5 years)**	**Long term (5-25 years)**
Objectives	Send a clear signal that high-temperature heat will have to be decarbonized by 2050; launch a research and pilot strategy	Identify technologies for a large fraction of the needs; start strategic deployment	By 2050: Achieve decarbonization of high-temperature heat across all industrial and manufacturing sectors; create a robust and export-competitive service and supply chain industry for certain high-temperature technologies and sectors
Example action items	Identify regulatory barriers to the use of high-temp low-carbon solutions and start process to lift them	Design a strategy to develop a supply and service industry for the various technologies, with support for increasing their competitiveness	
CCS	**Short term (1-12 months)**	**Medium term (1-5 years)**	**Long term (5-25 years)**
Objectives	Send a clear signal that Canada aims to be a central actor in large-scale CCS: both innovation and deployment	Through successful large-scale pilot projects, start the deployment of industrial CCS sites across Canada, led by Canadian businesses	By 2050: Bring Canada and other nations to net-zero with the support of CCS; having made Canada one of the two or three world leaders in this field
Example action items	Set up programs to support large-scale pilot projects integrated with a real-life large-scale deployment (not only oil and gas)	Develop and implement a strategy to strengthen Canadian industry supporting the CCS technologies and increase its competitiveness	
PROCESSES	**Short term (1-12 months)**	**Medium term (1-5 years)**	**Long term (5-25 years)**
Objectives	Signal clearly that Canada understands the economic benefits of supporting the decarbonization of processes	Become a world-leader in the development and test of a few critical technologies for processes	By 2050: Ensure that Canadian Industrial processes are fully decarbonized
Example action items	Develop a specific blueprint to decarbonize processes in industry, first through processes change, second through CCS	Support large-scale pilot projects linked to full-scale deployment in Canada	