

Canadian Energy Outlook 3rd edition

Report #3: Decarbonizing off-road transport

May 28th 2025

A decorative geometric pattern at the bottom of the slide, composed of various colored triangles and polygons in shades of green, blue, and orange, creating a modern, abstract background.

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Reviewing: Louis Beaumier

In this webinar

- Profile of off-road transport
- Challenges and opportunities across sectors

Presentation

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Host

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About the Institut de l'énergie Trottier



Created in 2013 with funding from the Trottier Family Foundation, support renewed in 2023

Mission

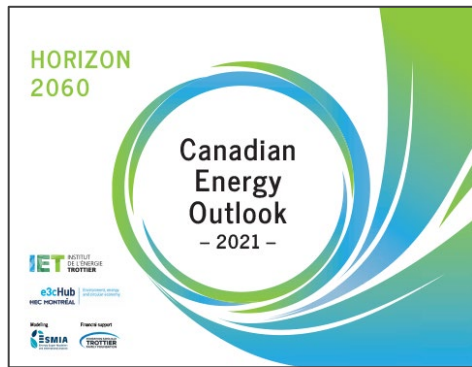
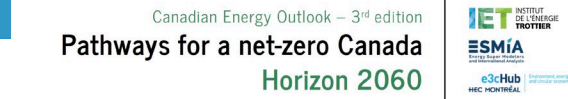
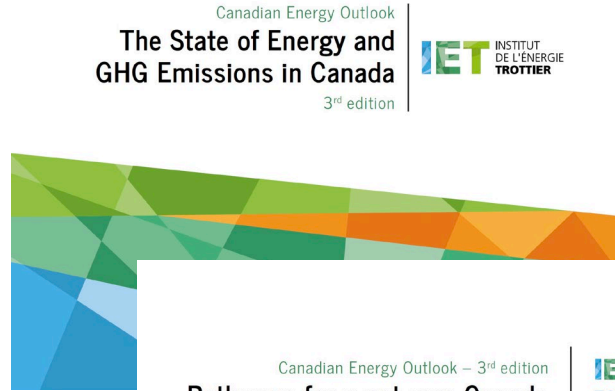
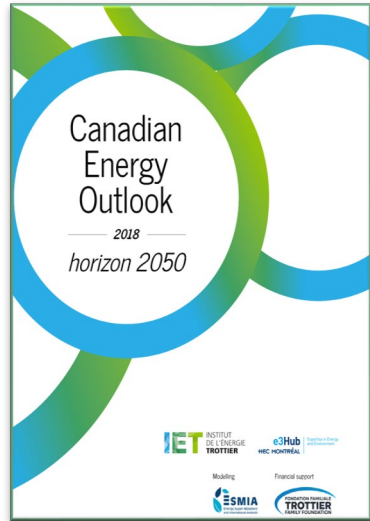
- The **academic training** of a new generation of engineers, scientists and innovators with a systemic and trans-disciplinary understanding of energy issues;
- The **research for sustainable** solutions for our energy future, while supporting knowledge generation and innovation in the energy sector to help face the coming decades challenges;
- The **dissemination of knowledge** on energy related topics, to fuel societal dialogue on energy issues.

Some of our recent projects

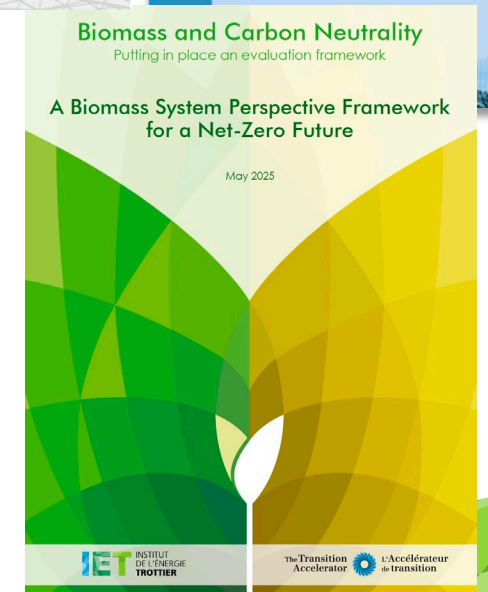
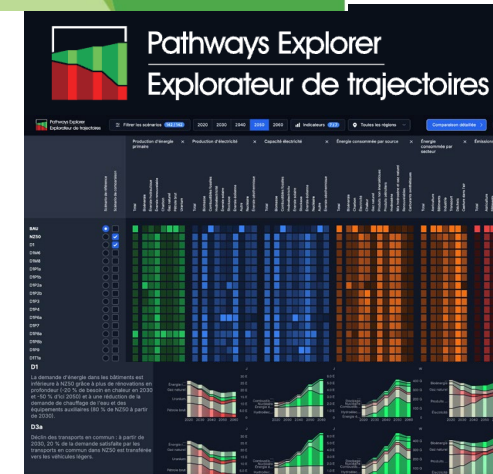
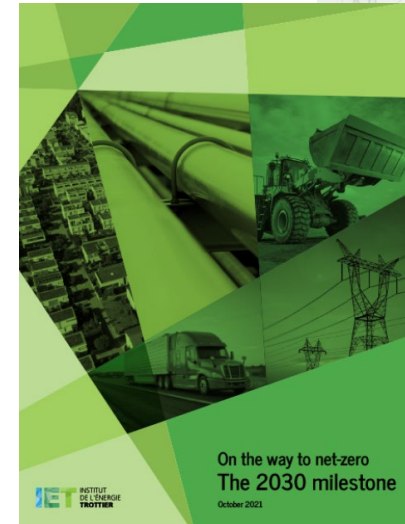
- Development of an **evaluation grid for biomass projects** in the context of a carbon-neutral Canada
- **Managing peak electricity demand** and **improving resilience** in an increasingly electrified world.
- Co-direct, with IESVic and the University of Calgary, the **Energy Modeling Hub**, a pan-Canadian organization that develops, maintains and makes available energy models, and brings together public decision-makers and the energy modeling community.

Work from the IET on decarbonization

Three editions of the Canadian Energy Outlook



Other reports on strategic issues



Definition and objectives

Several variations in the definition of the off-road “ sector ”. For this report:

- Mobile or portable equipment, which includes machinery but also vehicles not registered to be used on public roads
- Category that is present across all industry sectors, in residential and recreational services, in agriculture, in forestry and in commercial and institutional operations, including airports and public administration

Objectives:

- Non exhaustive overview of several challenges and opportunities for the decarbonization of off-road transport
- Development of an assessment grid for solutions to explore
- Frame of discussion for a workshop with stakeholders and experts later in 2025

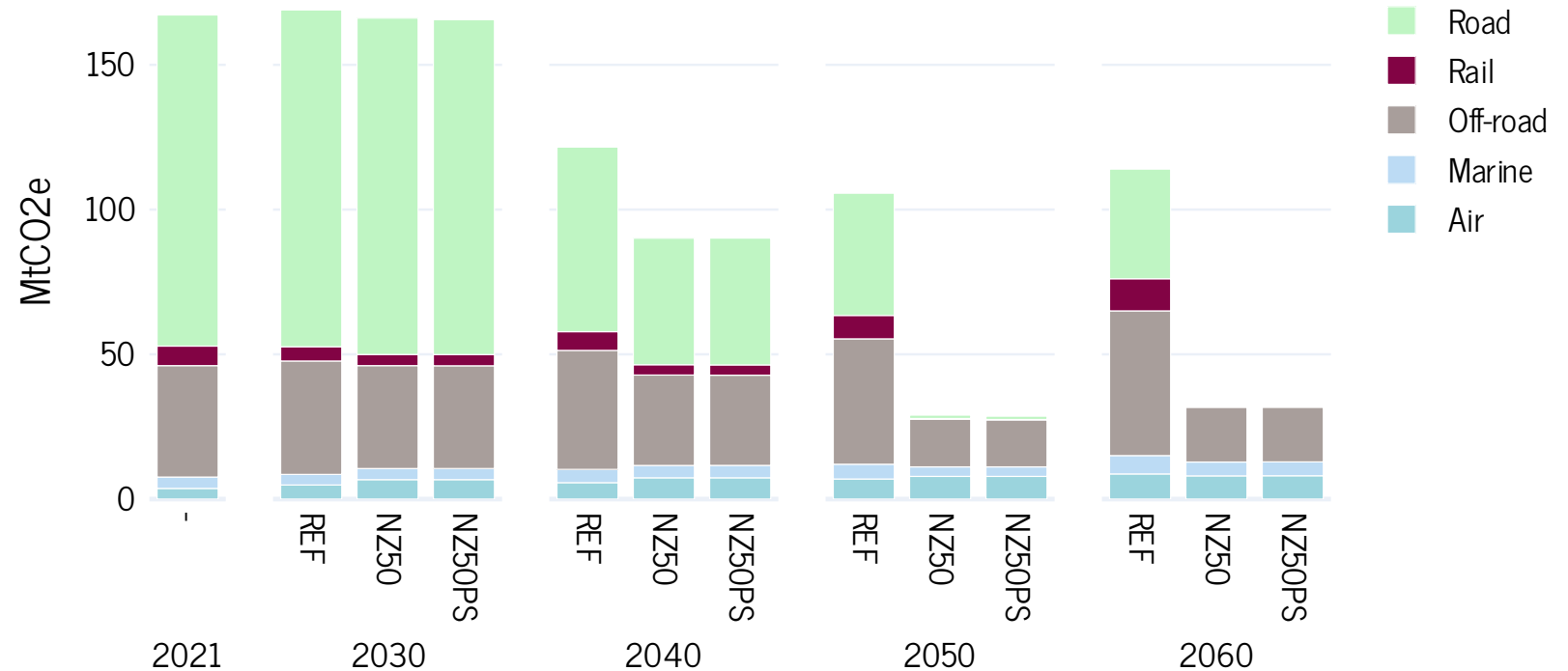
We extend special thanks to ECCC for help in the initial phase of this project.



Off-road transport's role in net-zero pathways

GHG Emissions - Transport

- Transport sector is the main source of remaining emissions in 2050 in net-zero scenarios
- Off-road becomes the main source of transport emissions over time, whether reaching net-zero or not
- Source of emissions largely neglected in both analysis and public policy



Broad variety of equipment and services

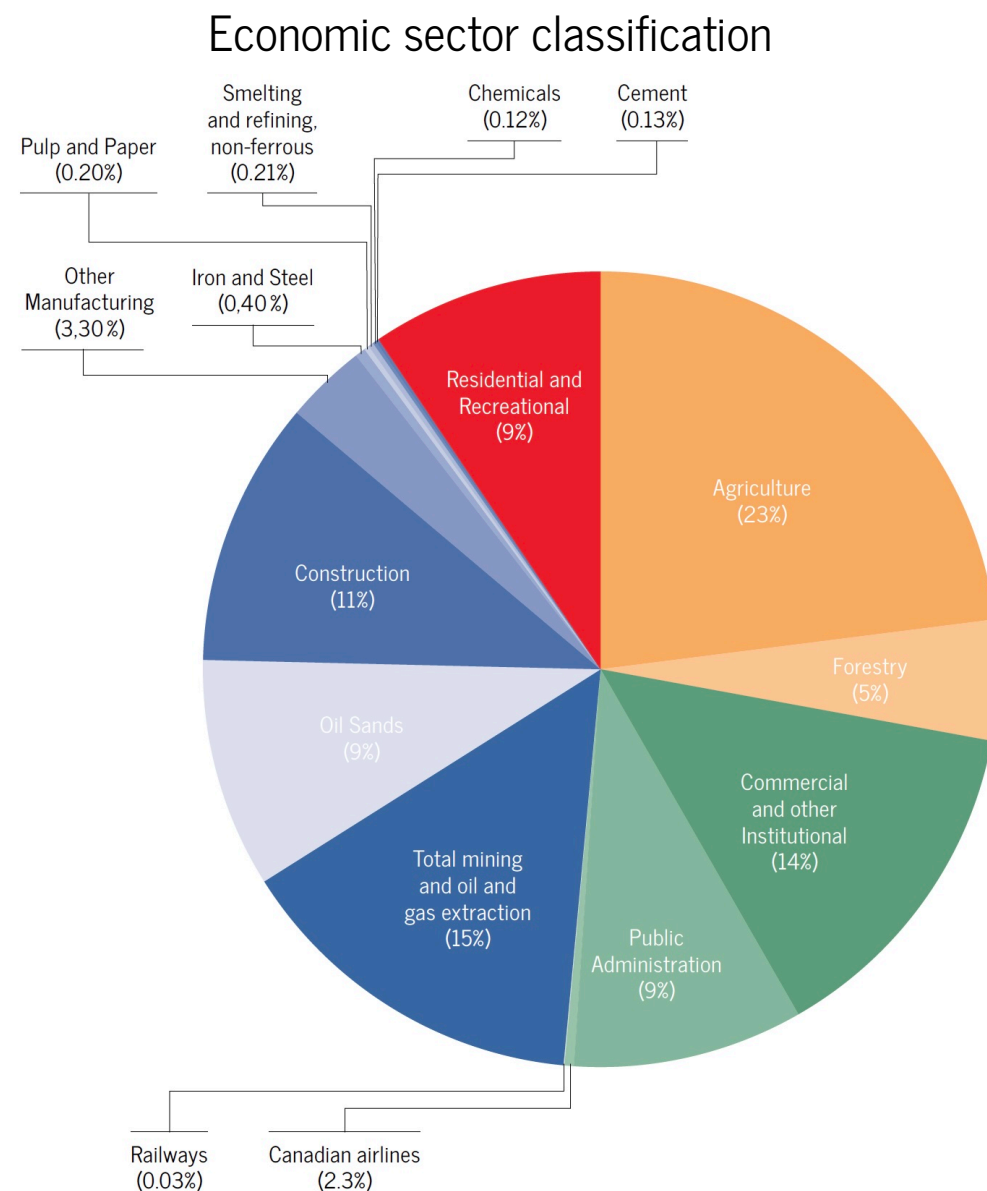
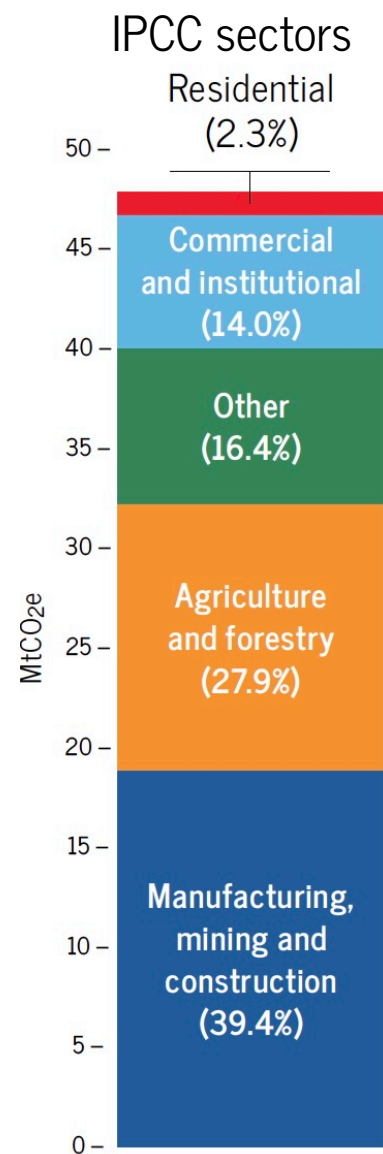
Numerous types of equipment and vehicles depending on the sector:

- Agriculture (tractors, mowers, balers)
- Forestry (shredders, chain saws)
- Commercial and institutional (generators, pressure washers)
- Public administration (compressors, turf equipment)
- Mining and oil&gas industry (drill rigs, rubber tire loaders)
- Construction (concrete saws, paving equipment)
- Steel and cement (forklifts, sweepers)
- Residential and recreational (all-terrain vehicles, leaf blowers)
- ...



Categorizing off-road transport GHG emissions

- Very different depending on the use of the economic sector classification or the IPCC classification



Overview of challenges and opportunities

Overview of sectors based on existing literature, on past work and conversations with various experts.

Five questions are used to structure the overview:

- What is the potential for electricity-based technologies to decarbonize off-road in each sector?
 - What is the commercial availability of the low-carbon equipment needed?
 - How much of a change in practices would be required to adopt the decarbonized technologies or alternative, low-carbon operation modes?
 - How dependent is Canada on foreign actors for these decarbonization efforts?
 - Overall, what are some of the key challenges of implementing solutions to decarbonize off-road in the sector?
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Mining and oil and gas extraction

Key points:

- Operational requirements are a strong constraint
- Electrification brings several advantages in underground mining
- No dominant technology yet available for low-carbon vehicles in surface mining
- More info necessary for the oil and gas sector's specific conditions



Commercial, publ. admin. and other institutional

Key points:

- Complexity due to the very broad variety of vehicle and equipment types, and few catalogues available
- Public admin. and municipalities: : several pilot projects and developments for electric vehicles (public work, park maintenance), but the greater requirements for resilience make electrification more difficult for some operations
- Municipalities: essential to encourage information sharing as currently done (C40, zero-emission zones elsewhere in the world, vehicle testing, etc.)
- Little information available for decarbonization initiatives in the commercial sector, although some equipment are often a large share of the total needs (forklifts, for instance): additional benefits are also often important for operations inside buildings



Construction

Key points:

- Challenges for electrification are more linked to site conditions than to vehicle type
- Low-carbon equipment availability is very limited: urgent to develop catalogues and launch pilot test projects
- Operating hours are often shorter than in other sectors, opening the door for a larger role for electrification



Forestry

Key points:

- Several regional particularities, including in the actors involved (property of vehicles, regional roads near wind farms, etc.)
- On-site large equipment often require a mobile energy supply
- Electrification's role for transport around sites can be increased depending on the topography of the surrounding area (use of regenerative breaking, in particular)
- For transport vehicles, challenges are closely aligned with those of log transport
- Available vehicles mostly European, with standardization and regulatory issues



Agriculture

Key points:

- Similarity to challenges in forestry: decarbonization options depend site location and surrounding areas
- Regional and local particularities for options to prioritize: grid accessibility, sustainable liquid fuel production
- Long hours of operation for vehicles during some parts of the year adding to logistical challenges facing electrification (for some equipment)



Residential and recreational

Key points:

- More important availability of electricity-based equipment and operation duration allows for a rapid decarbonization for many of these services with the right incentives/regulation
- Side-benefits are important in residential sectors (noise and pollution reduction)
- Decarbonization of recreational equipment facing challenges in isolated areas (long range needed in cold weather), making a uniform approach unlikely/undesirable



Conclusions

Despite numerous specificities across services and sectors, a number of cross-cutting issues can help with the design of decarbonization policies:

- Is a non-emitting replacement technology providing workable conditions for the service offered readily available?
- Does the use of non-emitting equipment often involve additional constraints and requirements?
- Does the alternative energy sources to propel off-road equipment require significant additional infrastructure?

The report presents an assessment grid allowing for a comparative evaluation of solutions.



Assessment grid for decarbonization solutions

Sector	Example application/technology	Technology/model availability	Needs for new infrastructure or modifications	Induced security impact/resilience requirements	Noise reduction benefit	Other pollutant reduction benefit
Agriculture	BEV ⁸ on-farm tractors (small to medium size)	Some models available but limited deployment	Substantial, especially for remote areas	Long hours and continuous days of operation during crunch periods	Unlikely to be determinant	Important from the replacement of diesel
Mining	BEV underground haulers	Available but limited deployment	Substantial in terms of charging equipment but additional power needs typically low for sites that are already electrified	Not negligible but some flexibility available in typical sites	High	Reduced need for ventilation underground
Construction	BEV large equipment on site in urban settings	Some models available but limited deployment	Several options to deploy charging, including direct grid connection	Hours of operation may allow for smaller logistical changes due to charging needs	High, especially in existing residential neighbourhoods, although noise remains substantial during operation	High
Public administration	BEV municipal garbage collection	Some models available from partnerships	Important, necessitate careful logistical planning of charging sites	Important, but predictable	Very high	High
Residential	Electrified lawn equipment	High	Accommodated by existing installations	None	Not negligible, but noise remains substantial during operation	High, including the elimination of the need to store petroleum products

Assessment grid: examples

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Development of a strategic approach

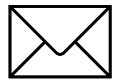
Once a more comprehensive grid has been developed: design a strategic approach using a stepwise learning process. The steps of this approach should follow four higher-level principles:

- Maximize electrification where possible
 - Explore other low-carbon energy sources based on potential co-benefits and nearby infrastructure availability
 - Anticipate information gathering needs for technologies and share this information with relevant actors and stakeholders
 - Launch pilot projects to test options, chosen and designed to maximize the potential for learning and to spill over into other sectors where decarbonization options face similar challenges
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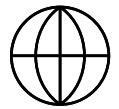
Q & A



Thank you!



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<https://iet.polymtl.ca/en/energy-outlook>