Pathways to net zero

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HEC Webinar: Pathways to Net Zero: A Decision Support Tool

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Why did we prepare this report?

Evaluate pathways options for Canada
A tool for those taking decisions related to net zero GHG emissions

Time to stop muddling along
What do we mean by ‘net zero’?
• Residual emissions balanced by removals

‘Net zero’ changes everything:
• No longer about incremental emissions reductions
• And in practice achieving ‘net zero’ means working to get as close to zero as possible in each sector
What makes this report different?

It is not a ‘modelling’ report
- We need qualitative assessment as well as modelling
- Deep dive into literature and consultation with experts

The two lenses we bring to bear on the issue:
- Transitions
- Energy system analysis
A transition lens

• Getting to net zero requires fundamental adjustment (transition) in **multiple systems** of social provisioning: not one transition but many

• Each system has distinct dynamics, obstacles and enabling factors for change - so the focus should be on sectors and regions

• Transition is not just about climate but about other problems, disruptions and transformative forces in each sector

• Transitions go through phases, so policy should be oriented appropriately, using multiple instruments

• Test for policy: not ‘does it achieve incremental low-cost emissions reductions?’ but ‘**does it accelerate system change?**’
An energy systems lens

- What does our energy system look like today?
- What would a future net zero energy system look like?
SCHEMATIC OVERVIEW OF CANADA’S CURRENT ENERGY SYSTEM

Secondary flows omitted for simplicity (for example: energy from waste)

**Energy supply**
- **60%** of fossil energy exported
- **26%** GHGs
- **26%** of GHGs satisfies final consumption
- **FOSSIL FUEL EXTRACTION AND PROCESSING**
  - GASOLINE, DIESEL, FUEL OIL, JET FUEL, NATURAL GAS, PROPANE, COAL, COKE
- **9%** GHGs
- **80%** of uranium exported
- **NUCLEAR**
  - Supplies 17% of electricity
  - Supplies 60% of electricity
- **ELECTRICITY MAINLY CENTRALIZED POWER GENERATION AND DISTRIBUTION**
  - Supplies 15% of electricity
  - Supplies 2% of electricity
  - Supplies 5% of electricity
- **HYDRO**
  - Supplies 60% of electricity
- **WIND SOLAR**
  - Supplies 5% of electricity

**Energy end use**
- **GHGs 26%**
  - **TRANSPORT**
    - 98% Fossil Fuels
  - **BUILDING: Residential and commercial**
    - 7% oil, 41% gas, 39% electricity, 1% biofuels
  - **INDUSTRIAL**
    - 65% fossil fuels, 25% electricity, 10% biofuels
  - **AGRI-FOOD**
    - 2% energy-related
    - 9% farming practices

Sector GHG emissions include process emissions. Emissions from waste and land use change are not shown.
Decarbonization tasks:

- decarbonize electricity generation and expand supply to eliminate fossil fuel end use;
- develop and deploy net zero fuels to replace fossil fuels in situations where electrification is difficult or expensive;
- enhance energy efficiency to reduce the need for net zero energy supply;
- address non-energy emissions (waste, industrial processes, agriculture);
- explore carbon removal to offset residual emissions
- ensure any remaining fossil fuel production or use is net zero.
Exploring pathways to net zero

**Pathways**: the character, magnitude, and sequence of changes in technologies, infrastructure, business models, societal practices, and policy or regulatory frameworks required to transform a system to respond to societal needs including net zero emission goals.

- Map scale and direction of change; identify obstacles and robust elements (technologies, investments, policies)
- Can help avoid ‘dead end’ pathways: wasted investment, effort and time.
- An example: Biofuels for light duty vehicles
Pathway assessments: system/sector reports

Each section:

Analysis of current circumstances, obstacles to change, disruptive currents, options for decarbonization, other system problems; priorities for action, longer term issues.

A detailed assessment of pathway elements that may contribute to systemic change
5.2.1 **Sector**: Light-duty vehicles

<table>
<thead>
<tr>
<th>Function</th>
<th>Mobility for work, shopping, social activities, recreation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GHG emissions</td>
<td>13% of Canadian emissions (54% of transportation emissions), plus the emissions generated in the oil and gas sector to produce this gasoline</td>
</tr>
<tr>
<td>Options for decarbonization</td>
<td>Electric vehicles; hydrogen fuel cell vehicles</td>
</tr>
<tr>
<td>Stage of transition</td>
<td>Electric vehicles: early diffusion phase; Fuel cell emergence</td>
</tr>
<tr>
<td>Nature of the problem today</td>
<td>Up-front costs of zero-emission vehicles; limited charging/refuelling infrastructure; resistance by established manufacturers (supply)</td>
</tr>
<tr>
<td>Other systemic issues</td>
<td>Air and noise pollution, costs of ownership, traffic congestion, car-dependent land-use patterns</td>
</tr>
<tr>
<td>Opportunities and concerns</td>
<td>For users: reductions in fuel costs, reduced maintenance, reduced total cost of ownership, enhanced vehicle performance. For communities: reduced air pollution. Economic development: business opportunities in the EV value chain; being prepared for vehicle connectivity and automation. Risks: decline in existing Canadian auto sector if sufficient investment in EV value chain fails to materialize</td>
</tr>
<tr>
<td>Priorities for action</td>
<td>Subsidies for EV purchases; infrastructure investment for charging; government fleet and procurement standards; zero-emission vehicle standards; gasoline/diesel phase-out date; measures to ensure charging at multi-unit residential buildings; building code adjustments; Strategic intervention to build out supply chain for zero-emission transport manufacture</td>
</tr>
<tr>
<td>Longer-term issues</td>
<td>Managing grid integration; complementary technologies, smart charging, vehicle to grid, advanced materials; integration with other approaches including: active mobility, public transit, mobility as a service and connected and autonomous vehicles</td>
</tr>
<tr>
<td>Indicators of progress</td>
<td>Percent of zero emission vehicle sales; infrastructure build out; value-added in zero emission vehicle production</td>
</tr>
</tbody>
</table>
Evaluation criteria

**Credible**
- Maturity
- Economic viability
- Social acceptability

**Capable**
- Fit for purpose
- Net zero potential

**Compelling**
- To critical stakeholders
- Other costs and benefits
- Economic development opportunities
# ASSESSMENT TABLE: Light-duty vehicles

<table>
<thead>
<tr>
<th></th>
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<th>Capable</th>
<th>Compelling</th>
<th>Priority approach</th>
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<td>Maturity</td>
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<td><strong>Electric Vehicle</strong></td>
<td></td>
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<tr>
<td>Battery electric</td>
<td>Early maturity but with plenty of room for development in batteries and power trains to improve functionality and cost.</td>
<td>Purchase cost still higher than ICE vehicles but improving, in some cases. Lifetime ownership costs already lower.</td>
<td>No particular concerns</td>
<td>Yes. Continuous improvement in range. Some concerns over operation in extreme weather.</td>
</tr>
<tr>
<td>Plug in hybrid electric</td>
<td>Early maturity with some development potential</td>
<td>Purchase cost higher than ICE vehicles. Two power trains mean less maintenance gains than battery electric.</td>
<td>No particular concerns</td>
<td>Yes. Range concerns eased by gasoline auxiliary motor.</td>
</tr>
<tr>
<td><strong>Hydrogen Fuel Cell</strong></td>
<td>Late development phase. Light-duty vehicle design not yet stabilized. Hydrogen distribution network virtually non-existent.</td>
<td>Low at present. Vehicle purchase cost higher and distribution of hydrogen very expensive and currently impractical for light duty vehicles.</td>
<td>Some concerns over safety of hydrogen fueling</td>
<td>Yes. Good power and range.</td>
</tr>
<tr>
<td><strong>Ethanol</strong></td>
<td>Mature</td>
<td>No vehicles cost premium. Fuel more expensive than gasoline, but frequently mandated.</td>
<td>Yes, widely practiced</td>
<td>Yes, slightly reduces distance level. Blends not compatible with net zero emissions or with a transitional role because full ethanol endpoint is not viable (see below).</td>
</tr>
</tbody>
</table>
Priorities for key sectors

**POWER**
- **13% of Canadian emissions**
- Early Diffusion
- Multiple low carbon generation options. Will assume transport and other loads as decarbonization progresses.
- **Actions:** Priorities differ by province: Phase out coal, integrate renewables and other net zero sources; improve system capacity to deliver reliable, affordable net zero electricity (grid interties, storage, demand management).

**CARS**
- **9% of Canadian emissions**
- Diffusion
- Innovation stabilized around electric vehicles for personal cars and light trucks. Critical to break fossil energy dependence in transport.
- **Actions:** Accelerate EV adoption and build value chain for manufacture of zero emission vehicles. Invest in charging infrastructure. Zero emission vehicle standard. Fix phaseout goal for gasoline cars.

**OIL & GAS**
- **26% of Canadian emissions**
- Emergence
- Approaches to net zero fossil fuel production and net zero energy production from fossil resources are immature. Traditional production wind down necessary for net zero.
- **Actions:** Dramatically improve energy efficiency and emissions profile of existing oil and gas extraction. R&D and infrastructure for zero emission fuels production (hydrogen or electricity), geothermal energy, and materials. Scale back all investment in the sector not geared to an ultra-low emission future.

**CEMENT**
- **1.5% of Canadian emissions**
- Emergence
- No single pathway has emerged. Fossil energy can be replaced by electricity, hydrogen, or biofuels. Process emissions can be addressed by CCS or changing cement chemistries. Novel building materials could reduce cement demand.
- **Actions:** R&D and demonstration projects to address energy and process emissions. Changes to procurement and building codes to establish market for low carbon cement.

**BUILDINGS**
- **13% of Canadian emissions**
- Early Diffusion
- Advanced building approaches and electric heating mature. ‘Green gas’ options immature. Systematic retrofit of existing structures is critical.
- **Actions:** More stringent codes for new builds; regulatory standards to drive improvement in existing buildings; public procurement to support sector transformation; pilot mass retrofit approaches; develop mechanisms to mobilize private capital for retrofits.

**HEAVY TRUCKS**
- **9% of Canadian emissions**
- Emergence
- Heavy vehicle options require further development to enter market at scale.
- **Actions:** Vehicle development R&D, trials at scale, infrastructure investment, low carbon hydrogen production, zero emission vehicle mandate, public procurement, support for fleet conversions.

**MINING**
- **1% of Canadian emissions**
- Emergence
- Electric and hydrogen fuel cell equipment; on-site renewable electricity generation; advances in processing technologies and efficiency; recycle metals and reduce use.
- **Actions:** Support for advanced ore movement and processing technologies. Electrification of operations. Develop low emission mining to service expanded material needs of net zero societies.

**AGRI-FOOD**
- **10% of Canadian emissions**
- Emergence
- Approaches to address emissions from animal agriculture and nitrogen fertilizer use are in development. Sustainable farming and food system models remain immature in this diverse sector.
- **Actions:** Research, trials and promotion of alternative crop regimes and technologies to reduce nitrogen fertilizer use, improve manure management and reduce enteric emissions. Encourage production and consumption of alternative proteins. Decarbonize on farm energy use.
Figure 16. Progress of low carbon transition.

Adapted from Victor, Geels and Sharpe, 2019
Critical messages

Stop muddling along.
Think about system transitions to net zero: not just short- or medium-term reductions
Focus on places we can accelerate system change **now:**

- Electrification of transport
- Fully decarbonize electricity
- Get to work on buildings

Drive down Fossil Fuel production emissions

Develop options for less ‘mature’ sectors
- Some industrial sectors, heavy transport, agri-food
Going forward

We are continuing to extend and deepen the analysis:

- Sectors, policy profiles, ‘score cards’, updates

We know the analysis is incomplete and there are areas where we may be mistaken

Our goal is to encourage dialogue and we welcome your feedback

Thank you