# Pathways to net zero

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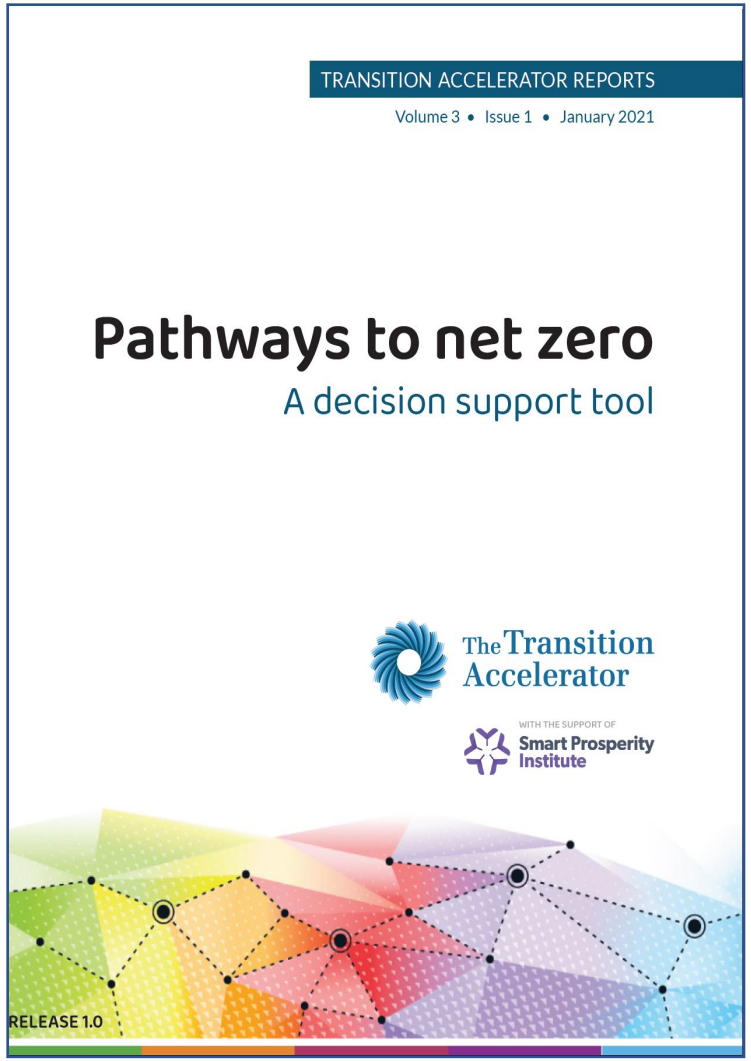
HEC Webinar: Pathways to Net Zero:
A Decision Support Tool

Tuesday, June 22, 2021



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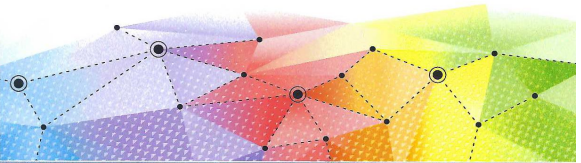
# Why did we prepare this report?

**Evaluate pathways options for Canada**

**A tool for those taking decisions related to net zero GHG emissions**

**Time to stop muddling along**

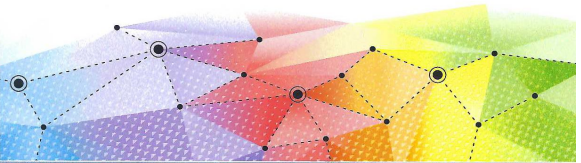


## What do we mean by ‘net zero’?

- 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



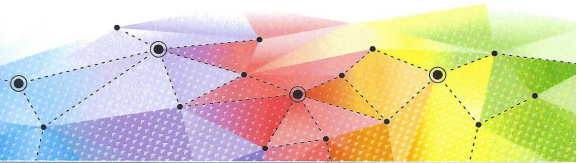
# What makes this report different?

**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

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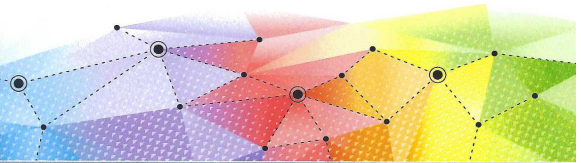
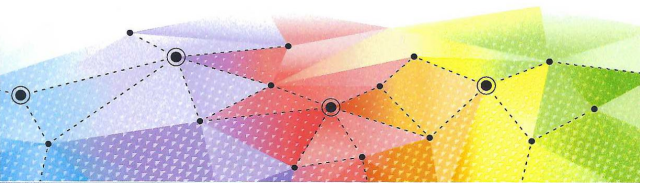
- Getting to net zero requires fundamental adjustment (transition) in **multiple systems** of social provisioning: not one transition but many
- Each system has distinct dynamics, obstacles and enabling factors for change - so the focus should be on sectors and regions
- Transition is not just about 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

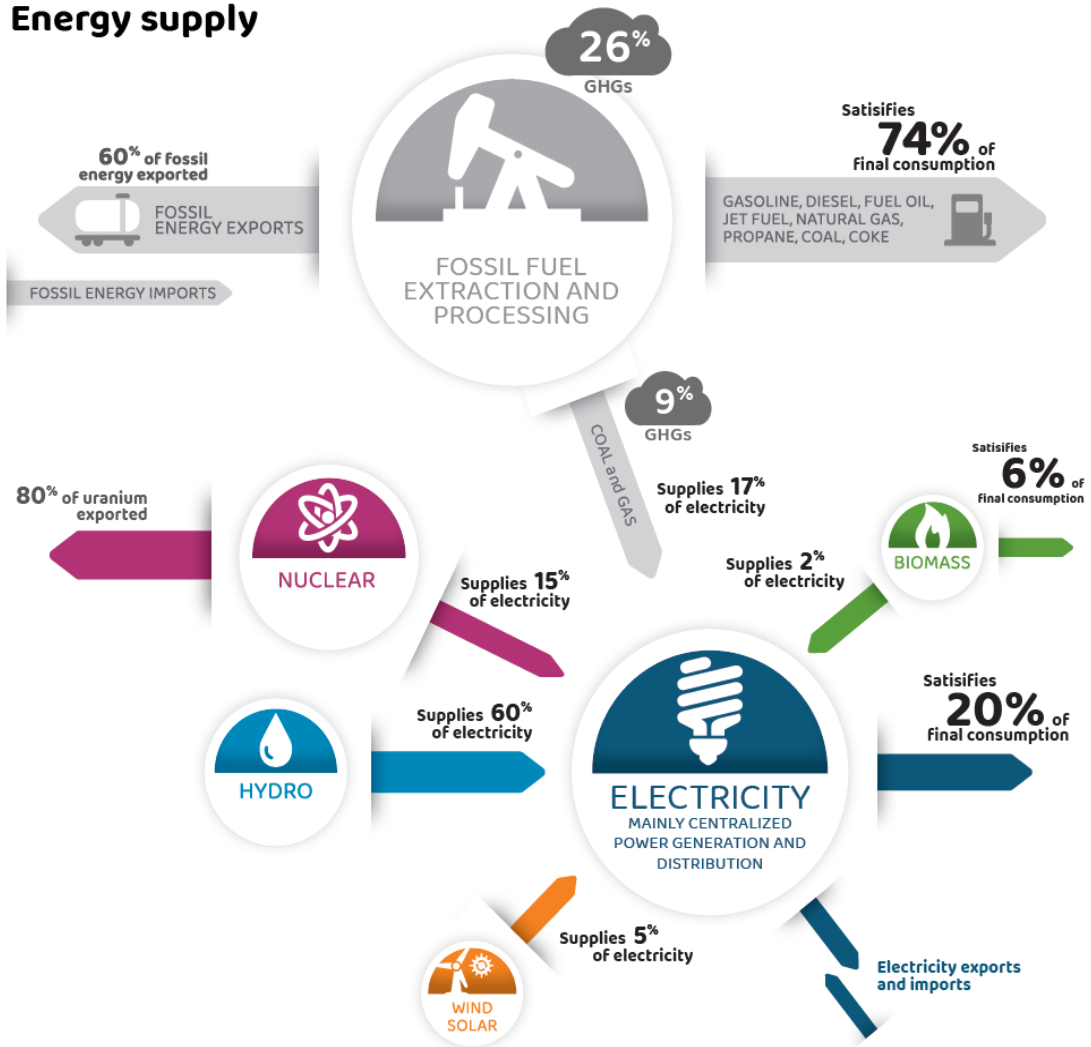
- What does our energy system look like today?
- What would a future net zero energy system look like?



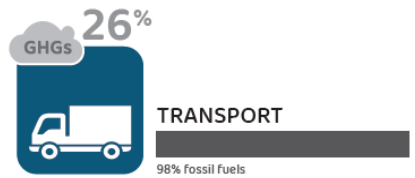
# SCHEMATIC OVERVIEW OF CANADA'S CURRENT ENERGY SYSTEM

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

## Energy supply

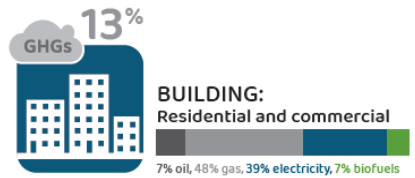



## Energy end use



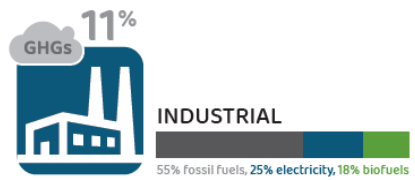

**TRANSPORT**

98% fossil fuels



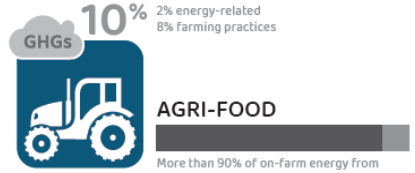

**BUILDING:**
Residential and commercial

7% oil, 48% gas, 39% electricity, 7% biofuels




**INDUSTRIAL**

55% fossil fuels, 25% electricity, 18% biofuels




2% energy-related
8% farming practices

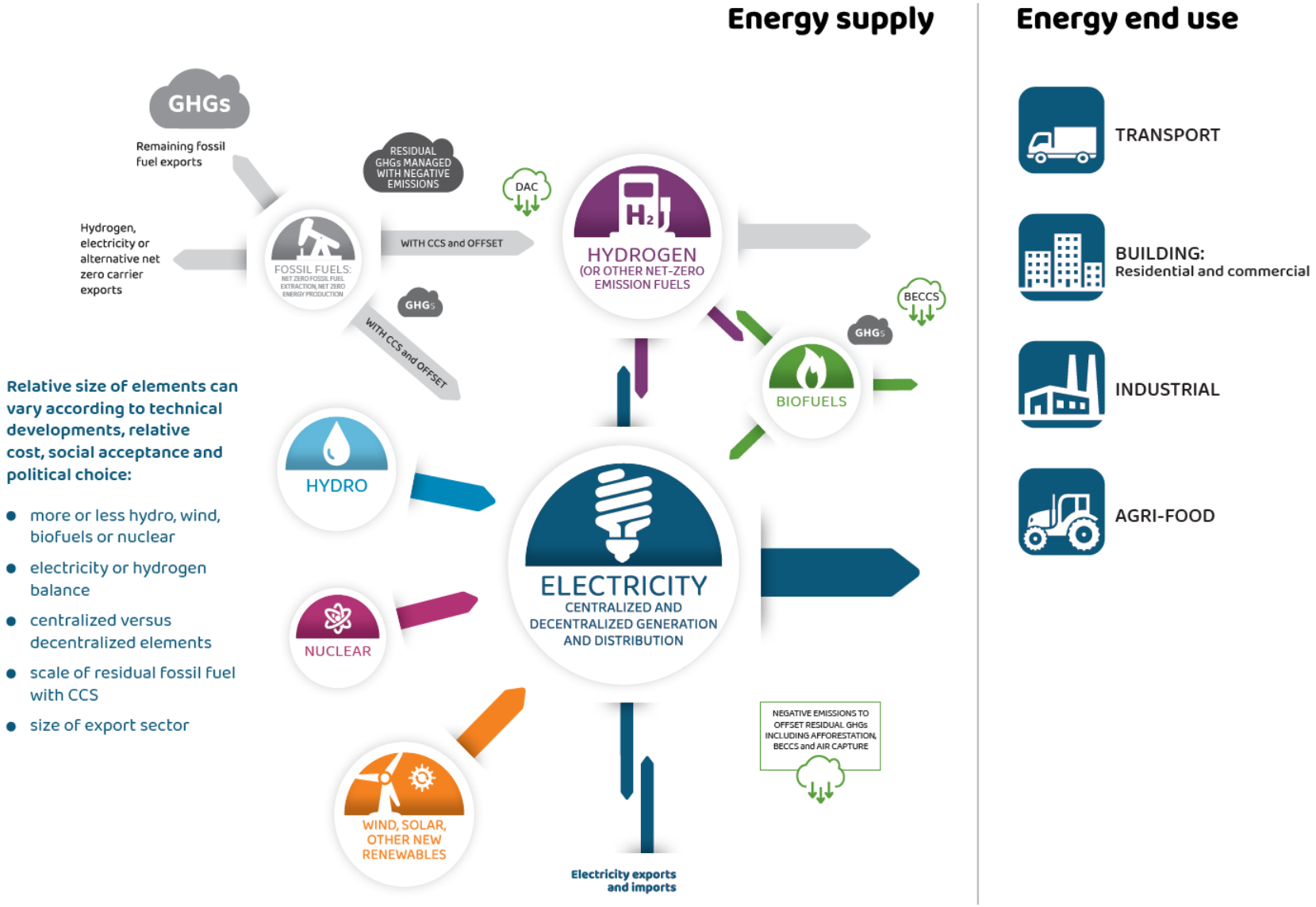
**AGRI-FOOD**

More than 90% of on-farm energy from fossil fuels

Sector GHG emissions include process emissions.
Emissions from waste and land use change not shown.

# SCHEMATIC VISION OF A NET ZERO GHG EMISSIONS ENERGY SYSTEM

Energy and energy-related emissions only. Secondary flows (e.g. clean energy flows to fossil sector) and some technologically feasible processes omitted for simplicity (e.g. synthetic hydrocarbons)



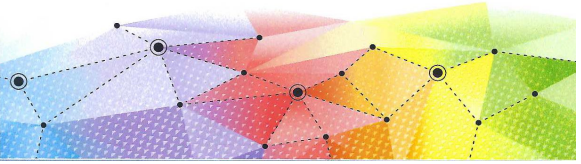

## Decarbonization tasks:

- 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

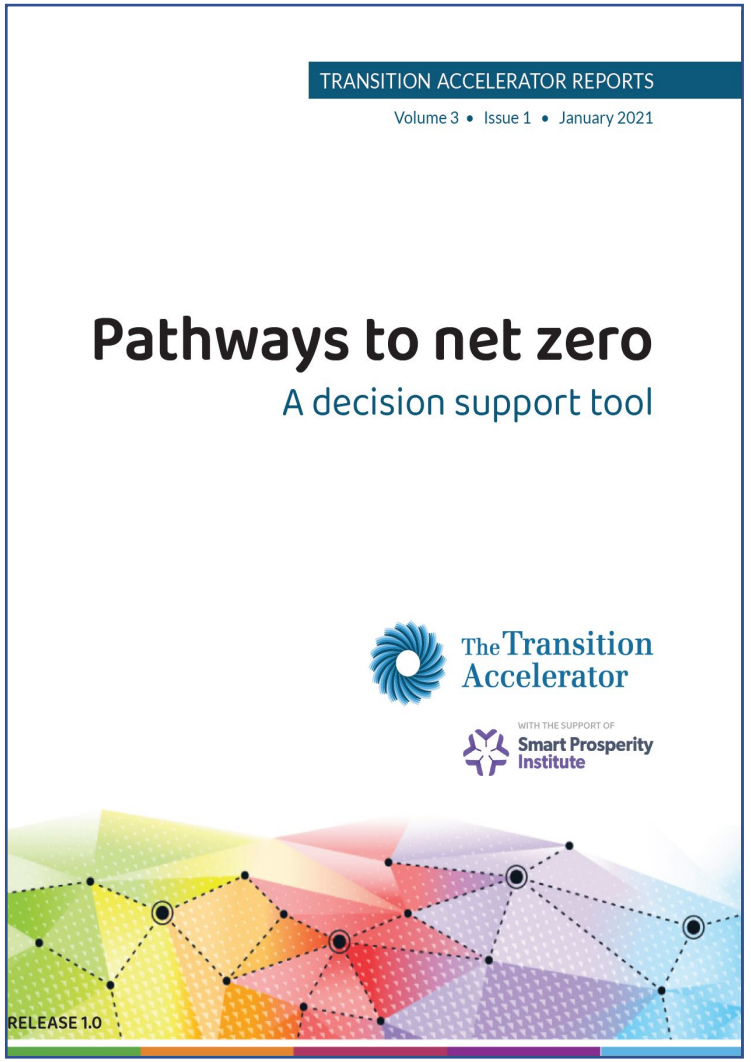


# Pathway assessments: system/ sector reports

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

| | |
|---|---|
| **Function** | Mobility for work, shopping, social activities, recreation |
| **GHG emissions** | 13% of Canadian emissions (54% of transportation emissions), plus the emissions generated in the oil and gas sector to produce this gasoline |
| **Options for decarbonization** | Electric vehicles; hydrogen fuel cell vehicles |
| **Stage of transition** | Electric vehicles: early diffusion phase; Fuel cell: emergence |
| **Nature of the problem today** | Up-front costs of zero-emission vehicles; limited charging/refuelling infrastructure; resistance by established manufacturers (supply) |
| **Other systemic issues** | Air and noise pollution, costs of ownership, traffic congestion, car-dependent land-use patterns |
| **Opportunities and concerns** | For users: reductions in fuel costs, reduced maintenance, reduced total cost of ownership, enhanced vehicle performance. For communities: reduced air pollution.<br><br>Economic development: business opportunities in the EV value chain; being prepared for vehicle connectivity and automation<br><br>Risks: decline in existing Canadian auto sector if sufficient investment in EV value chain fails to materialize |
| **Priorities for action** | 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 |
| **Longer-term issues** | 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 |
| **Indicators of progress** | Percent of zero emission vehicle sales; infrastructure build out; value-added in zero emission vehicle production |

# Evaluation criteria

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*Credible*

- Maturity
- Economic viability
- Social acceptability

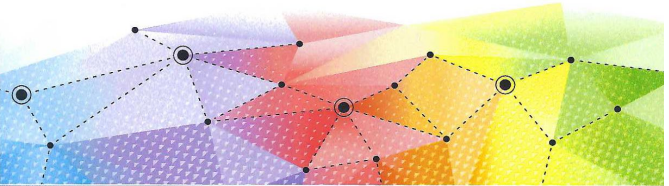
*Capable*

- Fit for purpose
- Net zero potential

  Part of that future, or a necessary step to net zero, or a change accelerant

*Compelling*

- To critical stakeholders
- Other costs and benefits
- Economic development opportunities



| Fails to meet criteria | Not promising | Meets in some respects | Potentially meets criteria | Meets criteria |
|---|---|---|---|---|

* For explanation of criteria see Box B, page 22

# ASSESSMENT TABLE: **Light-duty vehicles**

| | Credible | | | Capable | | Compelling | | | Priority approach |
|---|---|---|---|---|---|---|---|---|---|
| | Maturity | Economic viability | Social acceptability | Fit for purpose | Net-zero pathway potential | To critical stakeholders | Related costs and benefits | Economic development opportunities | |
| **Electric Vehicle** | | | | | | | | | |
| **Battery electric** | Early maturity but with plenty of room for development in batteries and power trains to improve functionality and cost. | Purchase cost still higher than ICE vehicles but improving; in some cases, lifetime ownership costs already lower. | No particular concerns | Yes. Continuous improvement in range. Some concerns over operation in extreme weather. | Yes. Full net zero dependent on decarbonizing grid electricity and decarbonizing supply chain (net zero lifecycle vehicles). | Compelling to emerging producers.<br>Considerable residual opposition from incumbents including dealerships | Improved driving, lower maintenance costs, no air pollution, noise reductions. Prepared for connected and autonomous technologies.<br>Environmental risks associated with battery production and disposal, and safety | Potential jobs in supply chain: mining (lithium, cobalt, copper, etc.), material processing, battery production, auto assembly, research, design, ancillary industries.<br>Links to connected and autonomous vehicle development | High.<br>Potentially part of net zero emission world |
| **Plug in hybrid electric** | Early maturity with some development potential | Purchase cost higher than ICE vehicles. Two power trains mean less maintenance gains than battery electric. | No particular concerns | Yes. Range concerns eased by gasoline auxiliary motor. | Not compatible with net zero because of gasoline engine but can help accustom consumers to EVs and weaken dominance of ICE vehicles | Appealing to consumers who want to go electric, but need reassurance on range and reliability | Improved driving, reduced air pollution.<br>GHG emissions Environmental risks associated with battery production and disposal. | Some potential jobs in supply chain (see for battery electric above). But widely seen as intermediate/transitory technology. | Medium<br>Can facilitate transition to battery electric |
| **Hydrogen Fuel Cell** | | | | | | | | | |
| | Late development phase. Light duty vehicle design not yet stabilized.<br>Hydrogen distribution network virtually non-existent. | Low at present. Vehicle purchase cost higher and distribution of hydrogen very expensive and currently impractical for light duty vehicles. | Some concerns over safety of hydrogen fueling | Yes. Good power and range. | Yes. Full net zero dependent on decarbonized hydrogen production for renewable, nuclear or methane with CCS and offsets. | Most stakeholders now backing battery electric for light duty vehicles. Some support in specific markets (Japan, California). May have potential for fleet vehicles because of centralized fueling model | Improved driving, lower maintenance costs, no air pollution, noise reductions. | Potential jobs in manufacturing and building out hydrogen economy. | Medium/high<br>Potentially part of net zero world. But less compelling for this use today than battery electric |
| **Ethanol** | | | | | | | | | |
| **Blended with gasoline** | Mature | No vehicles cost premium. Fuel more expensive than gasoline. But frequently mandated. | Yes, widely practiced | Yes. slightly reduces octane level. | **Blends not compatible with net zero emissions or with a transitional role because full ethanol endpoint is not viable (see below)** | Appealing to some producers and those seeking symbolic emissions reductions | Does not eliminate air pollution.<br>Potential land use problems.<br>GHG reductions depend on proportion of blend, bio feed stock source and energy inputs. | Not in a net zero economy | **Not a priority** |

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# Priorities for key sectors

## POWER

**9%** OF CANADIAN EMISSIONS

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

**13%** OF CANADIAN EMISSIONS

EARLY 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.

## 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.

## 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.

## 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

## 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.

## 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.

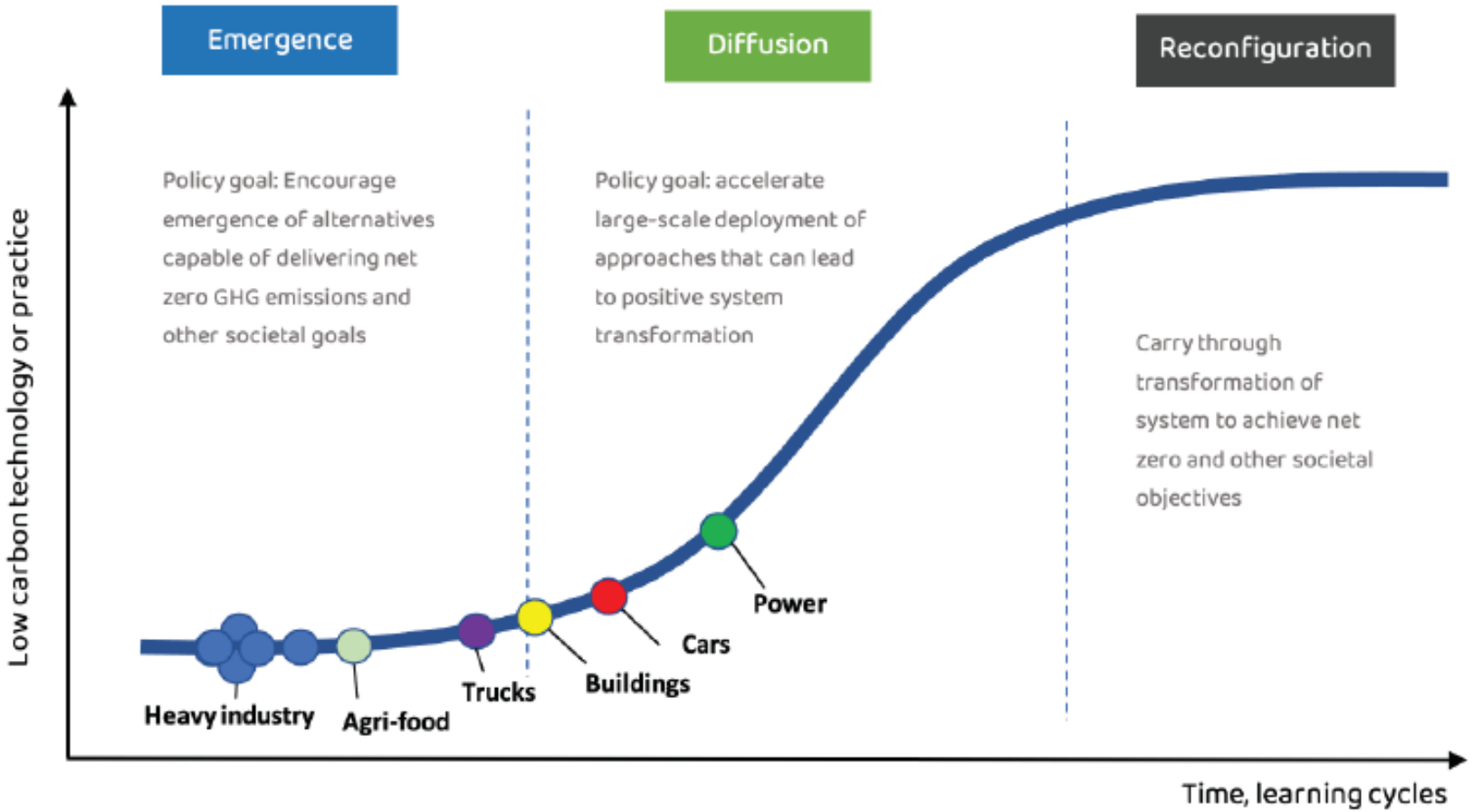



**Figure 16.** Progress of low carbon transition.

Adapted from Victor, Geels and Sharpe, 2019 [81]

# Critical messages

Stop muddling along.

Think about system transitions to net zero: not just short- or medium-term reductions

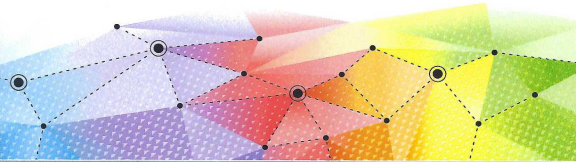
Focus on places we can accelerate system change **now**:

- 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

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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