Environnement et Changement climatique Canada
Environment and Climate Change Canada
Canada

Deep decarbonisation and Canada's Mid-Century Strategy

Open modelling platform for deep decarbonisation studies

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Summary

1. ECCC's Economic Analysis Directorate: Who we are

2. Deep Decarbonisation Efforts at ECCC
   - Canada's Mid Century Strategy
   - Electricity sector

1. Who we are

- Economic Analysis Directorate (EAD) provides economic support to the environmental agenda.

- The EAD is a directorate within ECCC's Strategy Policy Branch and is responsible for providing the analytical foundation for the development of environmental policies and regulations.

- The divisions within the Directorate are:
  - **Current Analysis and Economic Research**
  - **Regulatory Analysis and Valuation**
  - **Analysis and Modeling**
  - **Model Development and Quantitative Research**

Econmic Analysis Directorate (EAD)

- **Current Analysis and Economic Research;** responsible for conducting research and analysis on areas relevant to economic and environmental policy and engaging the academic community on issues relevant to the Government's environmental agenda.
- **Regulatory Analysis and Valuation;** responsible for undertaking cost-benefit analysis and valuation of ecological goods and services for the government environmental regulatory agenda.
- **Analysis and Modeling;** uses a bottom-up integrated energy, emissions and economy model to develop emissions projections and to analyze policies and measures aimed at reducing greenhouse gas emissions.
- **Model Development and Quantitative Research**; uses a suite of multi-region, multi-sector computable general equilibrium models (domestic and international) and integrated assessment models to support Canada's domestic and international policy agenda.

EAD activities support every stage of the development of policies and regulations

Policy and Regulations

- Policy development and regulatory drafting
  (work with provinces/territories and stakeholders to consider policy design/ stringency, draft regulations)
- Memorandum to Cabinet
  (obtain policy approval from Cabinet)
- Regulatory Impact Assessment Statement (RIAS)
  (public consultation on draft regulations through gazetting process, final regulations)

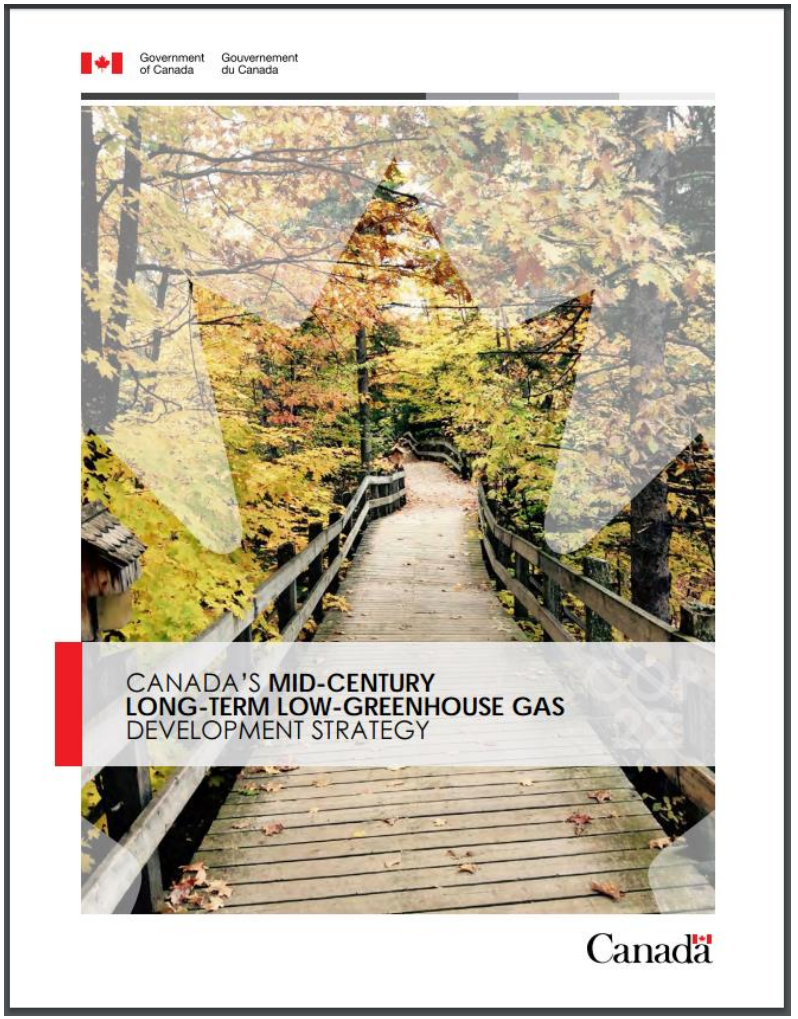
Economic Analysis

- Financial analysis
  (impacts on firms and sectors: profits, competitiveness)
- Macroeconomic analysis
  (national and sectoral impacts: GDP, employment, output, prices)
- Cost Benefit analysis
  (net welfare impact on society, environmental trade-off in economic terms)

2. Deep Decarbonisation: Canada's Mid-Century Report

- Article 4.19 of the Paris Agreement invites all countries to submit long-term low-greenhouse gas emissions development strategies [by 2020].

- Canada's report was submitted to the United Nations Framework Convention on Climate Change (UNFCCC) in November 2016.

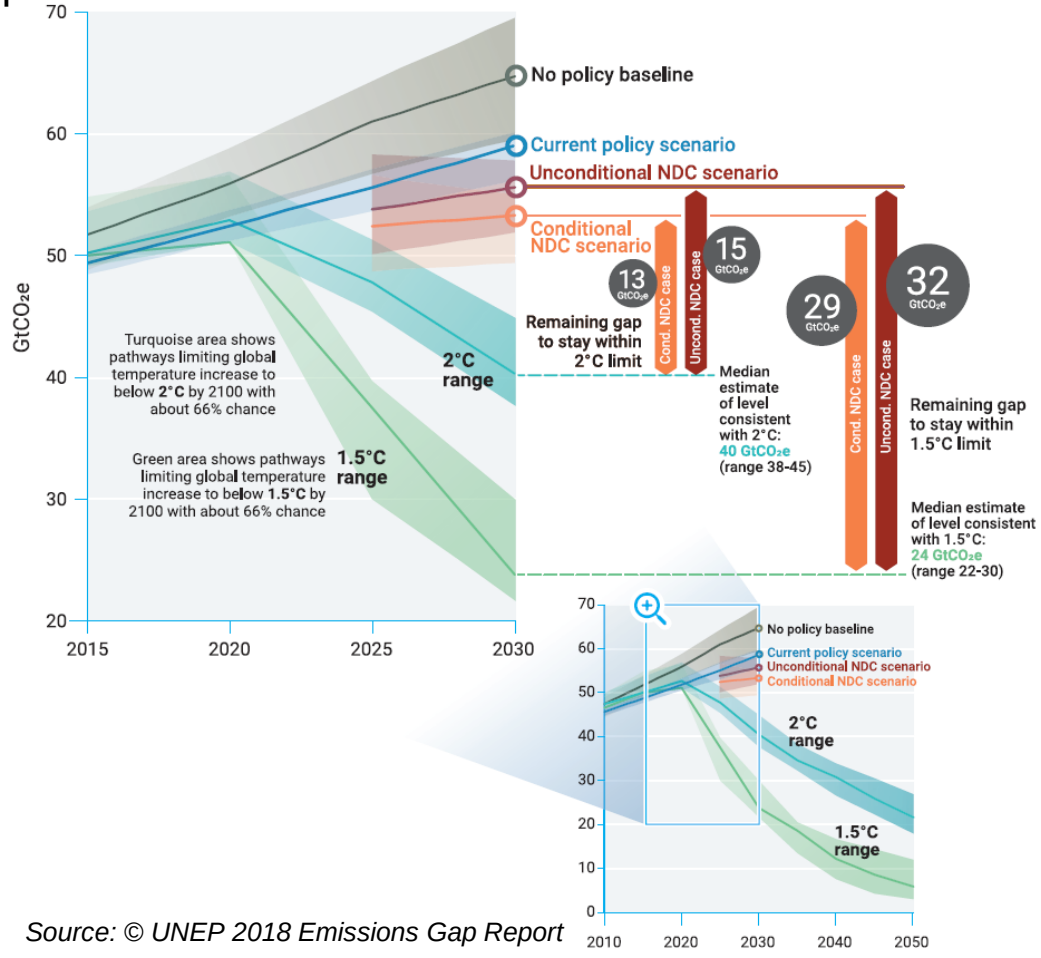


Magnitude of the Global Challenge

- Future warming scenarios released in 2018 by UNEP's *Emissions Gap Report* focused attention on limiting temperature increase.

COP 21Paris Agreement
Nov. 2015

"Holding the increase in the global average temperature to well below 2 ℃ above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 ℃ above pre-industrial levels"



Source: © UNEP 2018 Emissions Gap Report

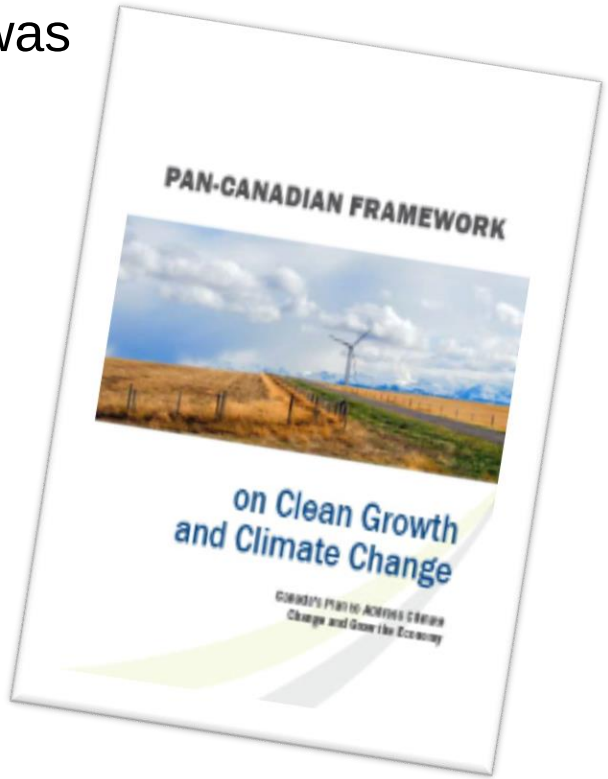
Importance of long-term thinking

Art 4.1 […] achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century

- Emphasizes the magnitude of the challenge
- Presents a vision and possible pathways
- Informs citizens, stakeholders, investors
- Provokes a conversation/mobilizes action
- Fosters better decisions that will (hopefully):
  - Avoid manifestations of climate change
  - Avoid misallocation of investments, infrastructure and stranded assets
  - Avoid Canadian innovators being left out of global opportunities that will arise from world-wide decarbonization

Pan-Canadian Framework on Clean Growth and Climate Change

- Dec. 2016 – ***Pan-Canadian Framework on Clean Growth and Climate Change*** (PCF) was adopted
  - 2030 horizon
  - Puts Canada on a path to meet or exceed its 2030 emissions target
  - Four main pillars:
    1. pricing carbon pollution;
    2. complementary measures;
    3. measures to adapt and build resilience; and
    4. actions to accelerate innovation, support clean technology, and create jobs.
- Canada's Mid-Century Strategy (MCS) was developed alongside this process



Highlights of Canada's Strategy

- Presented pathways consistent with net emissions falling by 80% by 2050 relative to 2005 levels.
- Intended to illustrate the magnitude of the challenge, requiring very deep emissions cuts from every sector by mid-century
- Informed by independent and internal expert analysis, and identifies key objectives and challenges for a transition to a low-GHG economy.
- Not policy prescriptive. It is meant to start the conversation about how Canada will achieve a low-carbon economy.
- Concludes that Canada is well placed to benefit from the economic opportunities of moving to a low-carbon global economy.

Models used in Canada's MCS

Internal

- GCAM (Global Change Assessment Model)
  - A dynamic-recursive model with technology-rich representations of the economy, energy sector, land use and water linked to a climate model.

- Multi-Sector, Multi-Region Computable General Equilibrium (CGE) Model
  - A model exploring macroeconomic implications by linking the energy and emissions insights from GCAM.

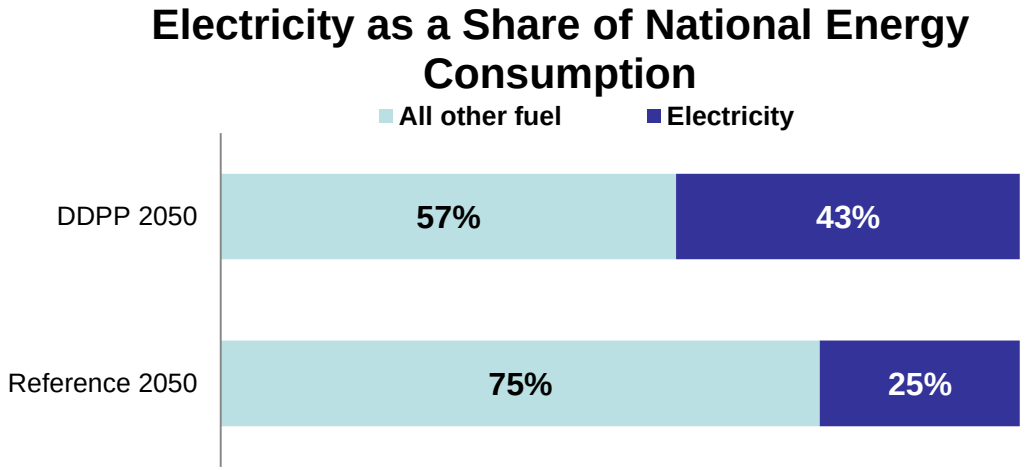
Models used in Canada's MCS

External

- Deep Decarbonization Pathways Project (DDPP)
  - A model capturing changes in energy, process on fugitive emissions, linked to regionally and sectorally disaggregated macroeconomic model to capture changes in GDP, economic structure, employment and trade.
- Trottier Energy Future Project
  - A comprehensive engineering analysis of Canada's future energy systems, with the goal of achieving an 80 per cent reduction in GHGs by 2050, relative to 1990 levels.
  - Examined 11 different scenarios for Canada to achieve different levels of GHG reductions by 2050 using one optimisation model and one simulation model that integrate energy and economic systems with different sets of strategies to achieve reductions at a minimum cost.

Key findings: Electrification

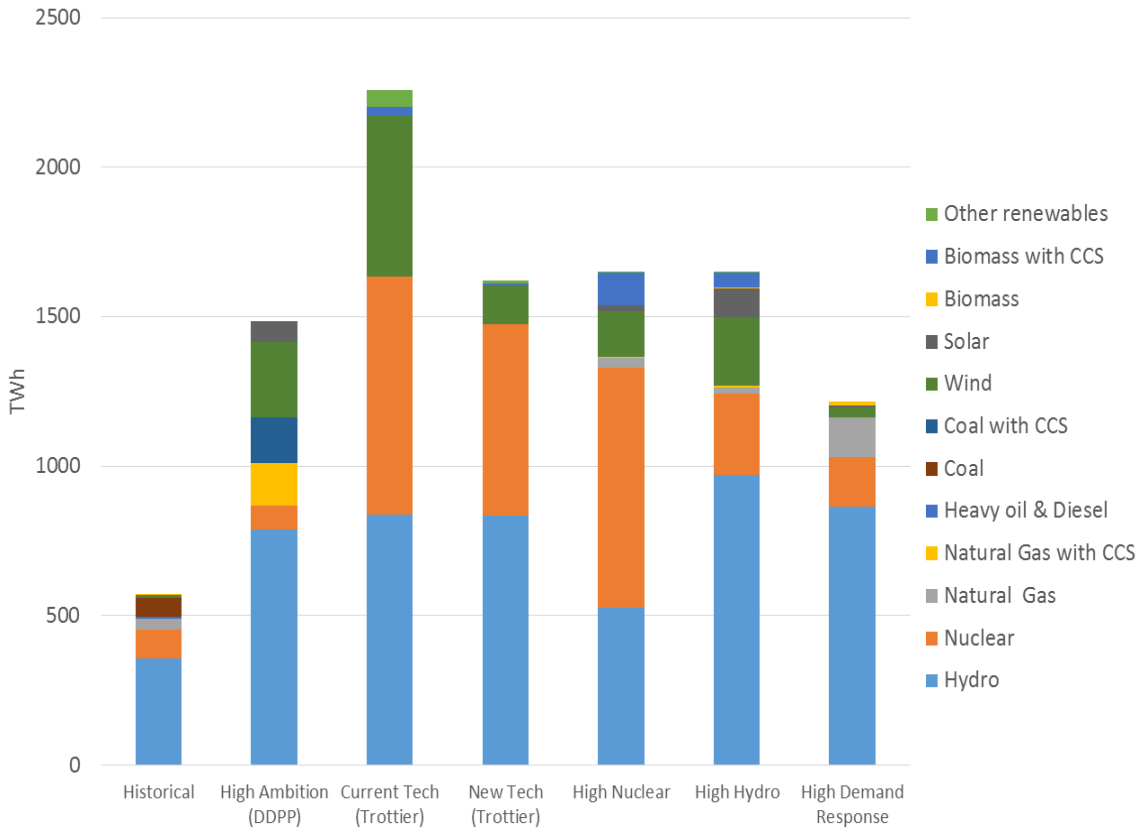
- Electrification is an essential component.
- Clean electricity can fulfill future power requirements, switching away from refined petroleum products, natural gas, and other fossil fuels.
- Electrification is often accompanied by efficiency gains, especially in the transportation sector, although the electrification of home heating can foster efficiency loss.
- Under a low-carbon future, Canada's electricity demand is expected to increase substantially by 2050.



Source: Bataille, C. et al. *Pathways to deep decarbonization in Canada*.

Key findings: Non-GHG-Emitting Electricity Generation

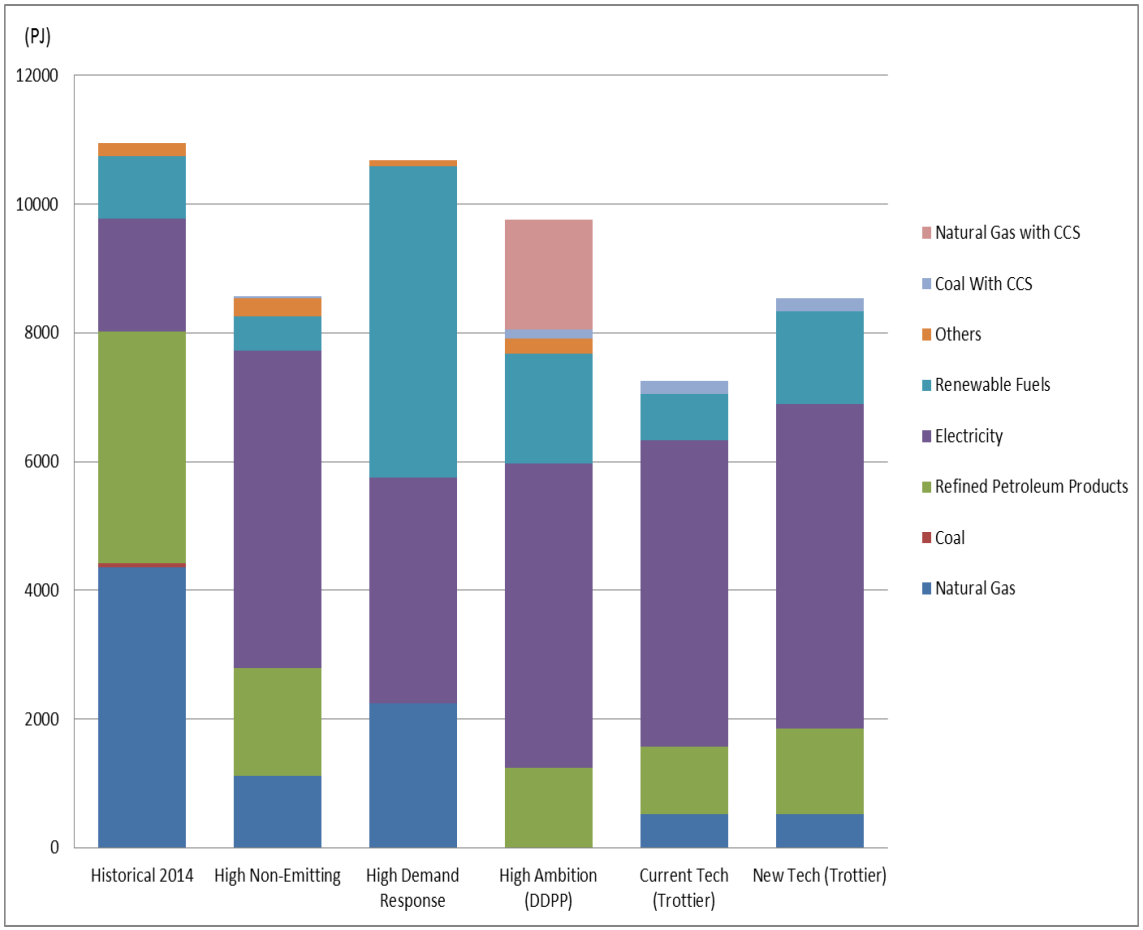
- Electricity generation to approach 100% non-GHG-emitting by 2050.
- Electricity generation in Canada is already more than 80% non-emitting, with a trend towards non-emitting generation expected to continue.
- Declining cost of renewable electricity such as wind and solar
- Future electricity generation mix will differ from jurisdiction to jurisdiction.



Key findings: The portfolio of energy consumption shifts to low emitting alternatives

- Low carbon or renewable fuels an alternative to traditional fossil fuels (e.g., renewable natural gas).
- Carbon capture and storage (CCS) apparent in the DDPP scenario.
- Traditional coal phased-out, traditional natural gas significantly reduced.
- Electricity share increases.

Total Energy Consumption by End Use Fuel (2050)



Key findings: Areas critical to achieving mid-century goals

- **Energy efficiency** and demand side management
  - International Energy Agency estimates that 38% of required global reductions associated with a 2°C pathway could be met via energy efficiency improvements.
- Abatement of **non-carbon dioxide** greenhouse gases
  - Methane –to reduce emissions by 40-45% below 2012 by 2025
  - HFCs - Montreal Protocol amendment (Oct 15, 2016)
  - Black Carbon mitigation from transport and coal-fired electricity
- **Sequestration** potential from Canada's forests and lands .
- **Innovation**, a scale up of RD&D investment, and private sector investment is a key element in the equation.

Collaboration *with provinces and territories, Indigenous peoples, municipalities, business and other stakeholders is fundamentally important to a successful transition.*

Overall Experience

- Extremely valuable process
- Started a conversation with stakeholders that was long overdue in Canada
- Stakeholders were engaged, but timelines were tight so the discussion continues
- Highlighted areas where similar conclusions had been drawn in our internal and external scenarios
  - 100% non-emitting electricity,
  - electrification of transportation and heating/cooling
- Highlighted areas where divergent scenarios exist
  - Decarbonization of heavy industry (CCS/renewables)

Next Steps

- The MCS was submitted on the premise that the report's content will continue to be updated and adjusted as Canada advances on the implementation of its low carbon development pathway
- We would like to update the MCS as low-GHG technologies and national circumstances continue to evolve.
- Longer-term decarbonisation will be achieved through a series of shorter-term implementation strategies, currently the PCF.
- Long-term decarbonization thinking needs to be incorporated in every day government and business planning

Ongoing Work on MCS: Potential Areas of Focus

Chapter	Discussion / Deep dives / additional modelling
Electricity	-Transition of skills (coal phase out) and training required for electricity expansion. -Modelling wind and solar.
Circular Economy	-Potential related GHG-Emissions reductions and its challenges in Canada. -Policies traditionally related to the topic and ways to build capacity in Canada.
Negative Emissions Technologies	-Different NET (BECCS, DAC), scalability and their potential impact.

Ongoing Work on MCS: Potential Areas of Focus

Chapter	Discussion / Deep dives / additional modelling
Agriculture and Land Use	-Animal options and innovations. -Soil carbon content mitigation. -Land/farm management. -Bioproducts.
Transportation	-Developments in freight transportation and aviation. -Further analysis of EVs -Current policies or incentives that are encouraging the high purchases in EVs in leading countries.
Cities	-Current challenges (e.g. funding, buildings, transit) and what should be considered as opportunities (e.g. retrofit, building permits, conversion of transit).

Interest in the platform

- Input for MCS
- Modelling scenarios (inclusion of renewables)
- Future electricity demand (e.g. energy efficiency projections)
- Costs for certain technologies (e.g. decarbonisation of heavy industry)
- Sources of modelling data
- Comparing results to ECCC models

Conclusion

- EAD provides economic lenses in support of the environment agenda.
- Mid-Century Strategy work is ongoing, including stakeholder and expert engagement.
- ECCC has a long history of engaging with the academic community to incorporate the latest research findings into its policy and regulatory work.
- This platform is a significant opportunity for further cooperation

ANNEX

You can read Canada's full Mid-Century Strategy at:

http://unfccc.int/focus/long-term_strategies/items/9971.php

Mid Century Report, 2016 highlights

Chapter	Key messages
Electricity	-Existing electricity generation is over 80% non-GHG emitting (hydro and nuclear). -Expanding electrification with renewables in other sectors (e.g. transportation, buildings, industrial process) is an opportunity to further decarbonise.
Transportation	-Greater uptake and broad use of electric vehicles will require more widespread acceptance of the technology. -Freight is challenging sector but there are solutions that show potential towards deeper emissions reductions.
Buildings	-Over one third of homes already use clean electricity. -Natural gas and electrification serve important roles. -Retrofitting existing buildings will be necessary to address the inefficient building stock.
Industry	-National circumstances represent challenges for decarbonisation. -Electrification of industrial operations offers emissions reduction potential. -Innovation is important to reduce emissions in a sector that has challenges.

Mid Century Report, 2016 highlights

Chapter	Key messages
Forests	-Canada has significant potential for long-term forest-based GHG mitigation given its vast managed forest land. -Mitigation can involve either reducing or avoiding emissions, or enhancing carbon sequestration. -Emission reductions is also possible with changes in how forests are managed, greater domestic use of long-lived wood products, greater use of bioenergy from waste wood and afforestation.
Agriculture	-Emissions result mostly from biological processes rather than energy use. -Technological innovations and sustainable land management practices will ensure that agricultural soils remain a net carbon sink over the long-term. -Promoting the adoption of existing and emerging technologies and management practices could increase efficiency and reduce emissions from crop and livestock systems.
Waste	-Effective management strategies, focusing on waste prevention and diversion, can bring deep cuts in direct and indirect waste related emissions. -Consider behavioral change away from wasteful consumption patterns and shift the responsibility for end-of-life management of products from consumers to producers. -Progress in landfill gas capture and flaring technologies could further reduce emissions.
Clean technology	-Private and government sectors should work together to identify strategies for reducing deployment costs and barriers to adoption. -Further investments in RD&D and innovation, combined with market mechanisms such as carbon pricing, will support Canada's competitiveness. -Providing a clear and predictable signal for long-term investments and disclosing climate-related information will allow the market to better anticipate the transition to a low-carbon future.

Internal Modelling of Pathways

- **1st scenario - High Nuclear**, based on nuclear electricity production
- **2nd scenario - High Hydro**, relying on a mix of hydro and wind
- Both of these used the **Global Change Assessment Model (GCAM)** a dynamic-recursive model with technology-rich representations of the economy, energy sector, land use and water linked to a climate model.
- **3rd scenario - High Demand Response**, explored macroeconomic implications by linking the energy and emission insights from GCAM to our own in-house **Multi-Sector, Multi-Region computable general equilibrium (CGE) model.**
- External modelling results (e.g., Deep Decarbonisation Pathways Project) were showcased and illustrated against the in-house results allowing for a comparison across models (identification of common trends and divergences)

Modelling of Pathways (external)

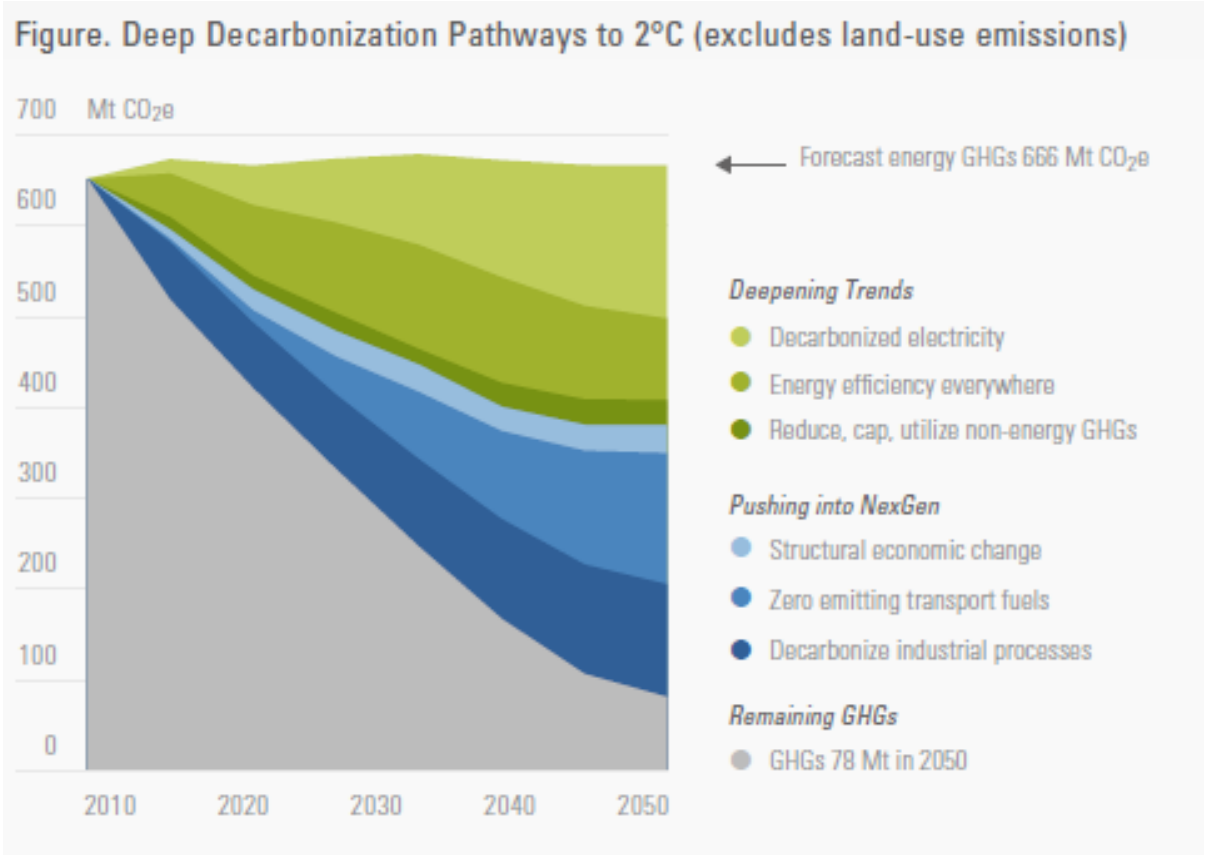
MCS relied on scenarios from publications including:

- Deep Decarbonization Pathways Project (DDPP)- 2015 Canadian study
  - The DDPP is a global collaboration of energy research teams charting practical pathways to deeply reducing greenhouse gas emissions in their own countries.
  - The study employed a highly detailed, behaviourally realistic technology stock turnover model (CIMS) to capture changes in energy, process on fugitive emissions, linked to regionally and sectorally disaggregated macroeconomic model (RGEEM) to capture changes in GDP, economic structure, employment and trade. Emissions reductions in both models were driven by a policy package of performance based technology regulations and hybrid (i.e., general tax and cap and trade) carbon pricing.

Modelling of Pathways (external)

Relied on scenarios from publications including:

Deep Decarbonization Pathways Project (DDPP)- 2015 Canadian study



Source: © The Institute for Sustainable Development and International Relations (IDDRI)

Modelling of Pathways (external)

- Trottier Energy Future Project
  - The Trottier Energy Futures Project is a comprehensive engineering analysis of Canada's future energy systems, with the goal of achieving an 80 per cent reduction in GHGs by 2050, relative to 1990 levels.
  - The project looked at 11 different scenarios for Canada to achieve different levels of GHG reductions by 2050 using one optimisation model and one simulation model that integrate energy and economic systems with different sets of strategies to achieve reductions at a minimum cost.

Modelling of Pathways (new report)

- Trottier 2018 Canadian Energy Outlook

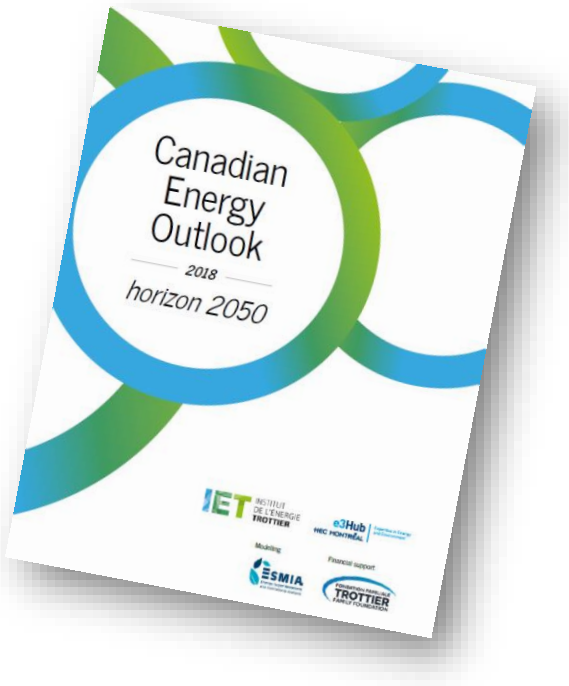


Figure 4.1 – Final energy consumption by source

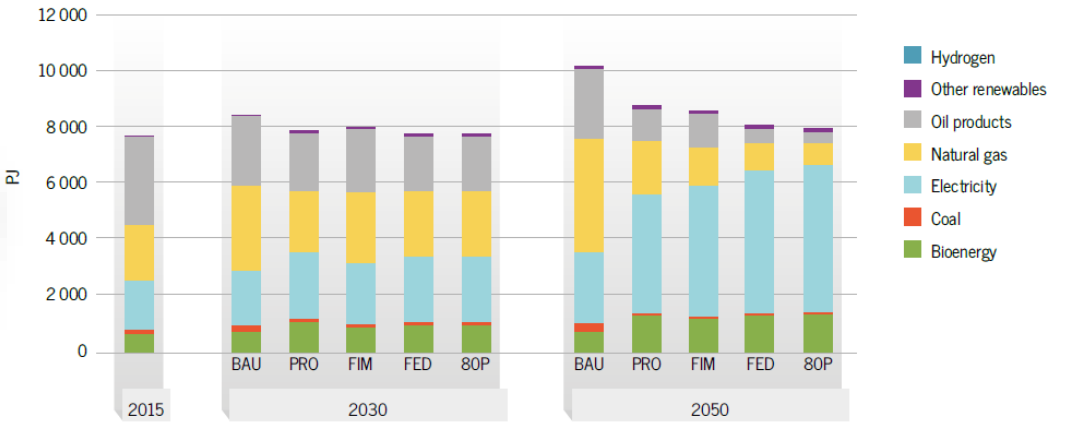
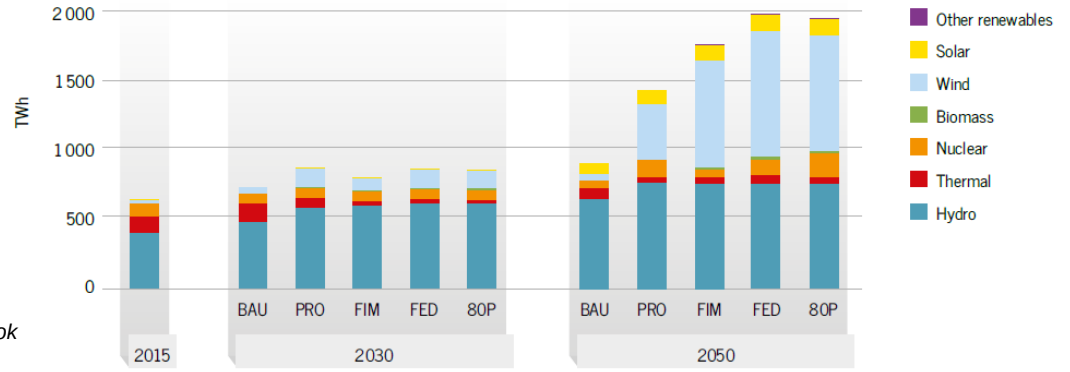


Figure 4.2 – Electricity generated by source



Source: © Trottier Institute 2018 Canadian Energy Outlook

Modelling of Pathways (internal)

- **Global Change Assessment Model (GCAM)** - An integrated assessment model, was used as primary modelling tool to simulate the sectoral impacts of a range of policies and emission targets
- GCAM is a dynamic-recursive model with technology-rich representations of the economy, energy sector, land use and water linked to a climate model.
- GCAM can be used to simulate scenarios, policies, and emission targets from various sources including the IPCC
- Macroeconomic implications were explored by linking the energy and emission insights from GCAM to our own in-house multi-sector, multi-region computable general equilibrium model (EC-MSMR).
- EC-MSMR is multi-sector and multi-regional and has the ability to capture interactions between consumers and economic sectors within Canada and globally.

Modelling of Pathways (internal)

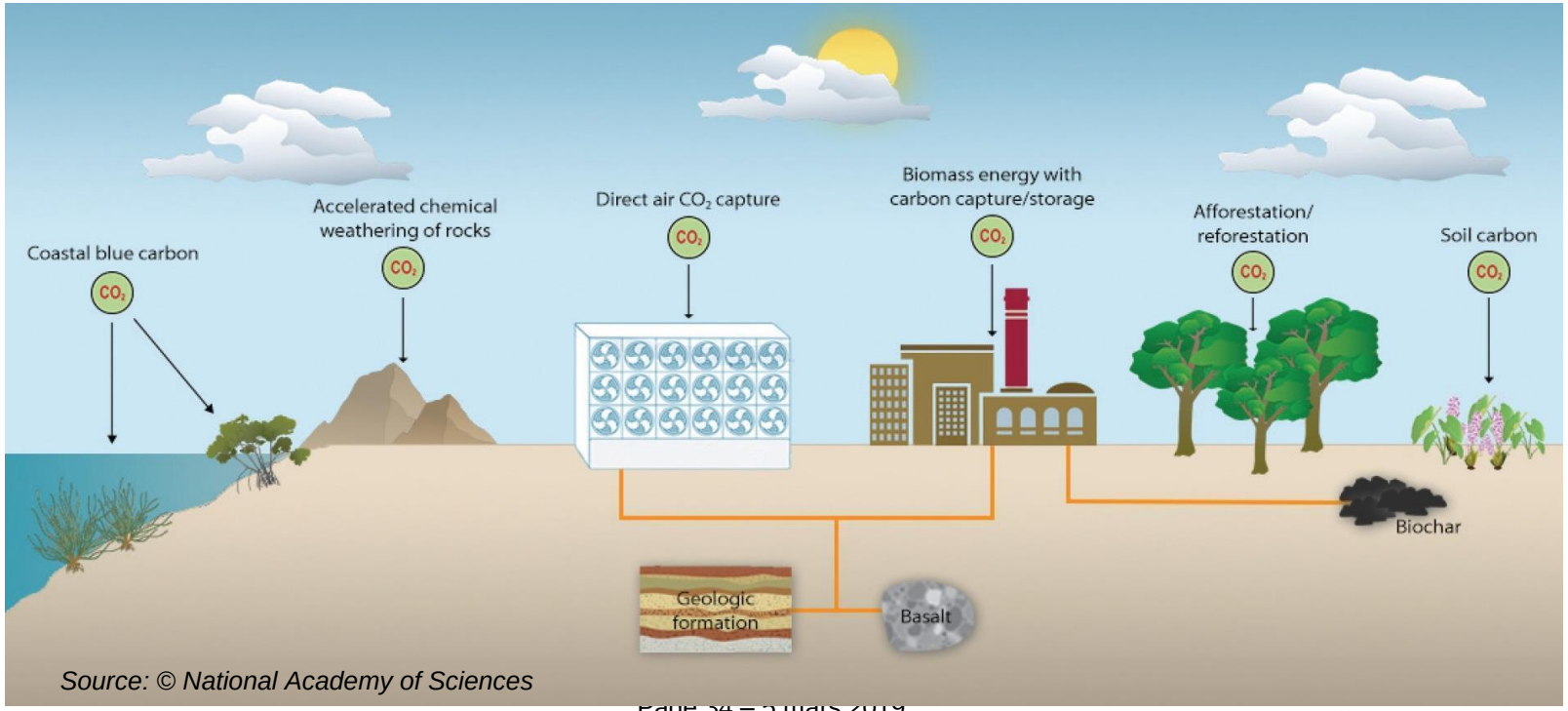
- Assumptions were discussed with our Mexican and American partners, and aligned as appropriate
- EC-MSMR assumptions
  - A carbon constraint/budget equal to 80% below the 2005 level by 2050 is imposed and the model then finds the least-cost solution to meet this target based on projected costs
- GCAM assumptions
  - Electrification of building and transportation sectors
  - Carbon tax imposed on all industrial sectors
  - Hydroelectric power to be exploited to the fullest extent
  - Cumulative land-use change emissions during 2005-2050 matched between GCAM and information from Canadian Forest Service
  - International – Countries achieve INDC and continue ambition

Negative emission technologies?

- Would compensate for challenging areas and further drive reductions

Examples include:

- Afforestation/reforestation
- Direct air capture
- Bio-energy CCS
- Soil carbon sequestration
- Blue carbon



Source: © National Academy of Sciences

Innovation is needed

"Much of the transformation can be achieved with existing technology, but innovation….will be fundamental to the transition." (MCS, pg.75)

Innovation will:

- ease the burden/cost of transition;
- open up global opportunities to innovators; and
- create clean growth and employment.

7 Mission Innovation Challenge areas:

- Funding
- Off-grid access to electricity
- Carbon capture
- Sustainable biofuels
- Clean energy materials
- Converting sunlight to storable solar fuel
- Affordable heating and cooling of buildings