

Exploring the Impacts of Carbon Pricing on Canada's Electricity Sector

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Supplemental material

S1: Modelling assumptions

We used the following set of assumptions to incorporate carbon pricing mechanisms within an optimization framework, given available data:

- Since the carbon price level is not introduced, based on the historical approach of the Government of Canada, a 10 dollar per tonne CO₂e (\$/tCO₂e) increase in carbon price is assumed beyond 2030.
- The benchmark for diesel in NB is set based on federal benchmarks due to the lack of other data.
- There is a free emissions allowance in NS that enables NS power to emit 5.1 MtCO₂e in 2022 free of carbon cost, modelled using a scenario based on the two-stage modelling framework in Figure 1.
- In NL, benchmarks are based on a historical approach or sectoral benchmarks. Historical emissions data are unavailable for NL, as are sectoral benchmarks. As such, NL benchmarks were assumed to be the same as federal benchmarks.
- All benchmarks approach zero from 2035 onward.
- For provinces with CCAT systems, we assume the carbon allowance price is the same as the federal carbon price, and we limit provincial emissions based on the respective carbon reduction goals (i.e., zero by 2050 for NS and QC).
- Fossil fuel combustion for electricity generation produces three distinct GHGs: carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O), with different residence times and heat-trapping potentials. The total emissions of these three GHG emissions are aggregated using the carbon dioxide equivalent (CO₂e) measure, which is the equivalent amount of CO₂ that will result in an equivalent warming effect over a specified timeframe, typically 100 years [17].
- We have selected the most salient policies affecting the electricity sector. Other sector-specific policies (ZEV mandates, LCFS etc.) may also affect the electricity sector emissions but were excluded from the study to maintain the manageable scope.

S2: Costs

Figure S1 depicts a breakdown of modelled electricity system expenditures on operation, maintenance, and investment during the study period in the PCP scenario. In the short-term, by 2025, no major investments in new generation are required, while between 2025 and 2030, a significant increase investment in new generation is needed as coal is phased out and capacity reaches its end-of-life retirement. By 2030, gas-fired units (mostly gas CCS) are the cost-optimal option to replace phased-out generation. However, after 2030, almost all new investments are in non-emitting generation sources. A large investment of 13 billion dollars in non-emitting generation and storage capacity occurs in the 2035-2040 period. Operation and maintenance (O&M) costs will increase from 16 billion dollars in 2025 to 21 billion dollars by 2050.

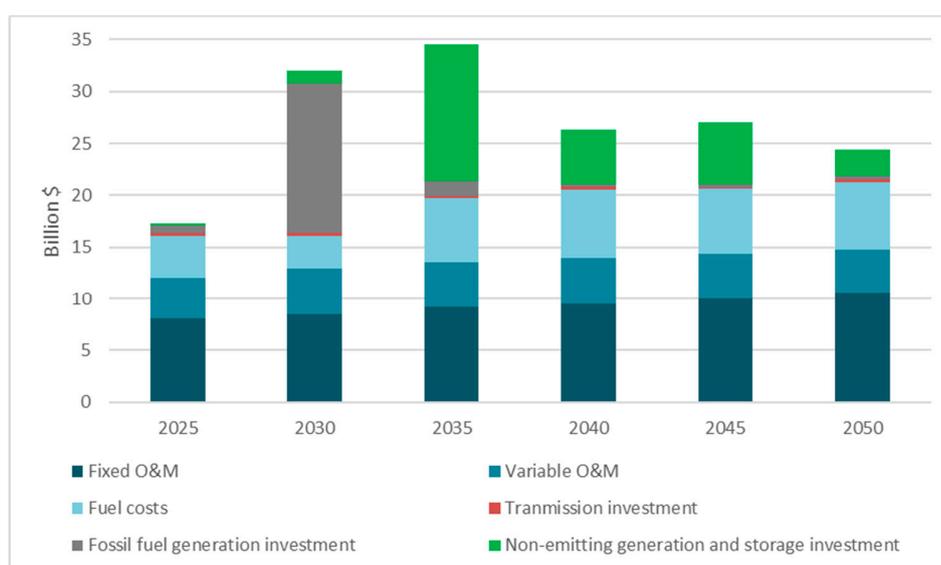


Figure S1: Breakdown of modelled national electricity system costs in the PCP scenario

A provincial breakdown of modelled total costs for the six modelled years is depicted in Figure S2. In all provinces, significant investments in non-emitting sources and storage are cost-optimal except for NB and AB, for which the model selects fossil fuel generation over non-emitting sources. Significant coal- and diesel-fired capacity in these provinces will be phased out by 2030 and will need to be replaced. As wind and solar costs have not reduced sufficiently for these sources to replace all retired units before 2030, and the emissions benchmark for gas is high enough to minimize the carbon price impact on gas CC (and even provides emissions credits for gas CCS units), the model selects a combination of gas CCS and gas CC to meet demand.

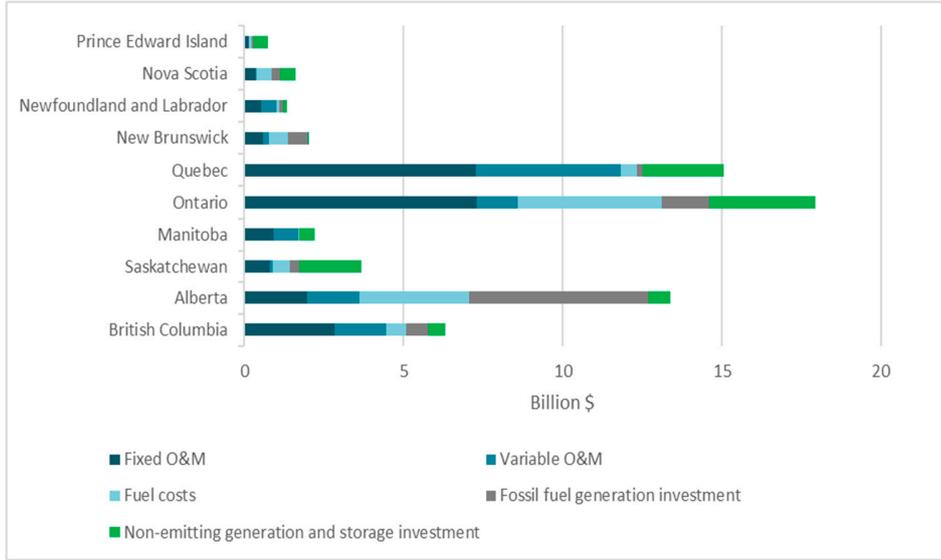


Figure S2: Breakdown of modelled total provincial electricity costs for the six modelled years