ONTARIO IS IMPORTANT NEAR-TERM MARKET FOR NEW NUCLEAR

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STRATEGIC POLICY ECONOMICS

Outline

Ontario is important near-term market for new nuclear

Introduction – Basis for an opportunity

Driving Factors

1. Emission reduction has significant implications for electrification
2. Nuclear can be deployed for more than just baseload, and offers the lowest cost system solution
3. Ontario has a supply gap that must embrace new procurement *now* to sustain reliability
4. Ontario needs new low-carbon supply *now* to advance a Net Zero ambition
5. Ontario should seek broader societal benefits from energy transition investments, which nuclear can offer

Closing and call to action

Introduction

Near-term opportunity for nuclear new build in Ontario and basis for pursuing it *now*

Ontario's electricity system is at a turning point

- Net zero ambitions are taking hold
- Significant amounts of clean electricity generation required
- Ontario government recently sought inputs

Many technologies will be required to achieve net zero by 2050

- Electrification, energy efficiency improvements, carbon capture

Ontario already faces a 3 GW capacity shortfall with Pickering Nuclear Generating Station closure

- Even without electrification to reduce emissions

Confluence of factors spells great opportunity for the nuclear sector

Paper looks at the unfolding supply and demand balance in Ontario and the significant opportunity that it presents for nuclear today

Sources: IESO 2020, Canadian Institute for Climate Choices, 2020; MENDM 2021; Strapolec Analysis

Electrification of buildings, transportation, industry needed for NZ2050

Known strategies may reduce emissions by 67%; Increase needed electricity by 130% to 190%

Energy efficiency & fuels could eliminate 68 Mt

- Building & transport (51), and industry (17)

Identified electrification potentially eliminates 91 Mt

- **Buildings** –Heat pumps and electric water heating
- **Transportation** –EVs for light vehicles and EV/hydrogen options for land-based freight
- **Industry** –Electrification and hydrogen for process heating and electrification of other equipment

Remaining 81 Mt involve uncertain measures

- Carbon capture, Renewable Natural Gas (RNG), biofuels and negative emissions technologies

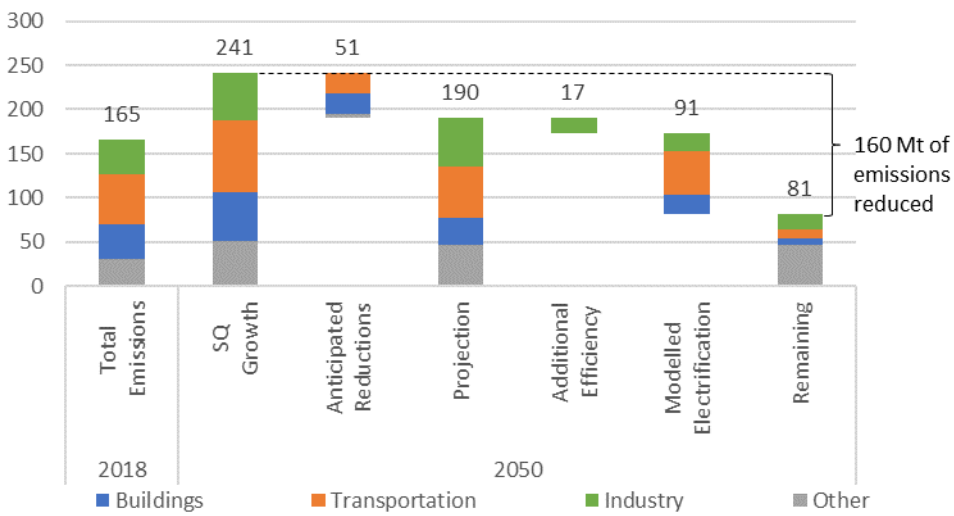
Achieving NZ 2050 could add between 230 and 345 TWh of electricity to Ontario's forecast

- Electrolytic hydrogen accounts for 40% of demand
- Lower range to 405 TWh total is optimistic minimum

With need for climate action, Ontario indisputably needs significantly more non-emitting energy

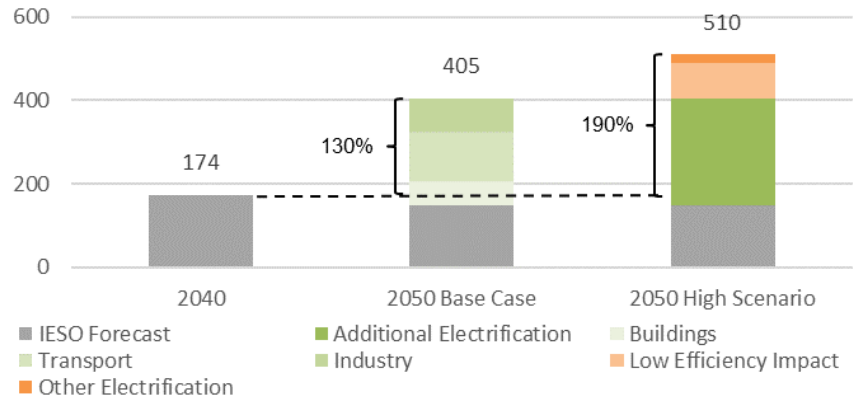
Emission Reductions by Assessed Sectors with Non-Emitting Electricity

(Mt CO_2e)



Forecast Electricity Demand by 2050

(TWh, NZ2050)



Base case is intended as a minimum estimate based on aggressive efficiency gains. The High Scenario has more moderate efficiency assumptions and estimates electrification for unassessed areas assuming significant carbon capture and direct air capture.

Source: ECCC 2020, Princeton, 2020, NRCan 2021, EIA 2020, Canadian Institute for Climate Choices, 2021; Strapolec Analysis,

Electrification will change the nature of demand

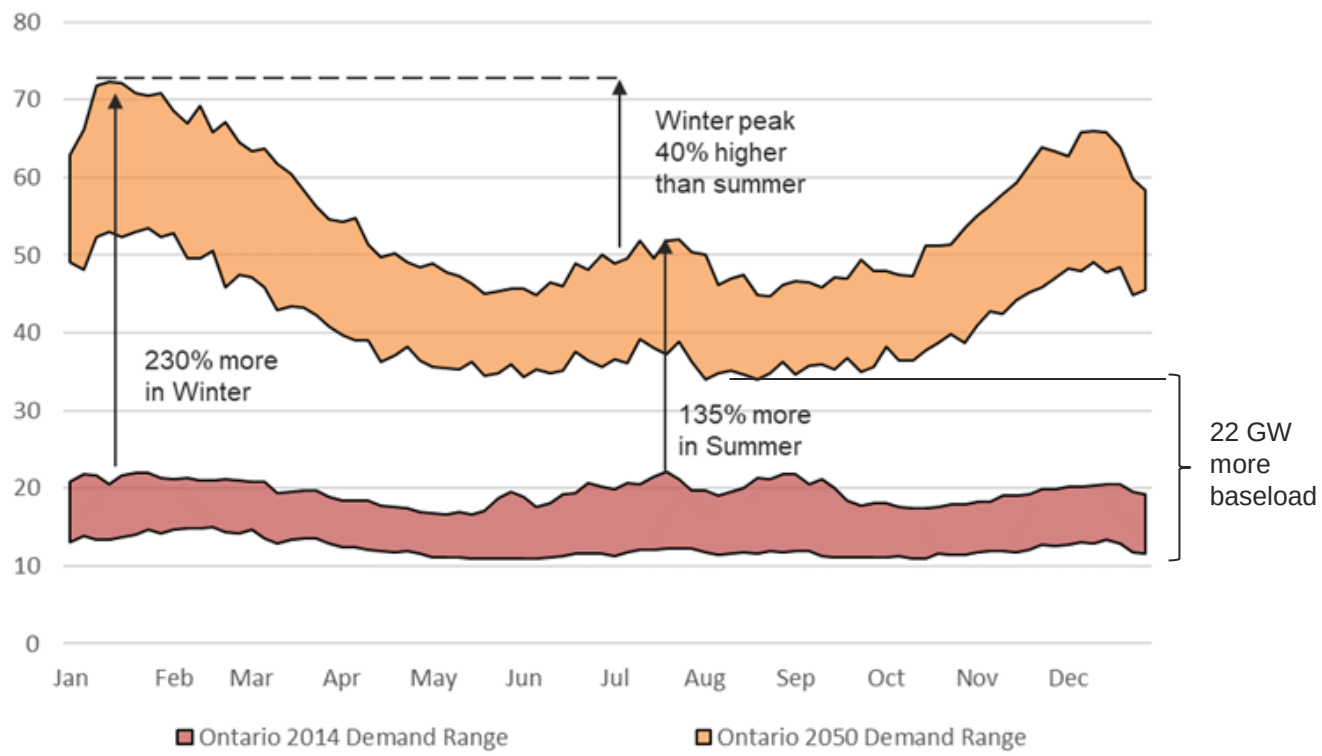
Home heating shifts to winter peaking, confluence of factors shifts to late evening peaking

Electrification of home heating will mean significantly greater electricity demand in the winter.

- EVs also have higher charging load in winter
- Industrial electricity demand and hydrogen production could be baseload operations
- Winter peaks could be 40% higher than summer.
- Profile of daily demand will also change, with future peaks occurring in the later evening,

Changing Nature of Demand for NZ 2050, Variability by Month

(GW by hour, 2014 vs. 2050, smoothed range excluding reserve)



The need for low-carbon baseload will increase dramatically

Sources: Strapolec Analysis; Fleetcarma, Charge the North, 2019; IESO data

Different types of demand drive distinct supply requirements

IESO has already identified the need to procure all supply categories; but more is required

Three demand types imply supply options:

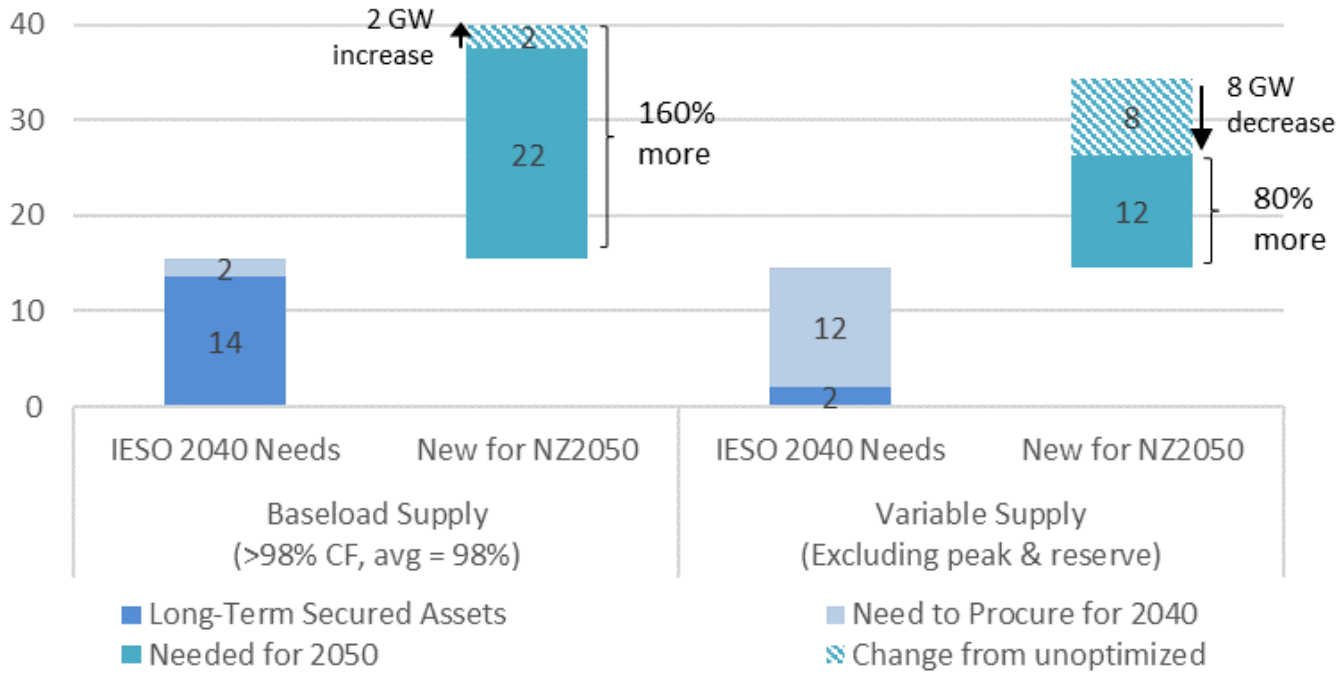
- Baseload demand is present 24x7, 365 days a year
- Variable demand (seasonal and daily)
  - Daily variable demand fluctuates throughout the day, every day
- Peak demand occurs less than 2% of the time

Energy sector innovations can alter how demand is seen by grid

- Wires & Pipes integration reduces need for seasonal variable supply
- Emerging demand side management can smooth daily demand variability

Incremental New Supply Required by Demand Type

(GW, IESO 2040 vs. NZ2050)



Ontario must initiate procurement of 26 GW of new low carbon baseload over next 15 years

Ontario need for 2 GW emerges in 2026

Sources: Strapolec Analysis

Nuclear could also offer seasonal and variable daily supply options

Variable daytime supply enabled when paired with distributed storage

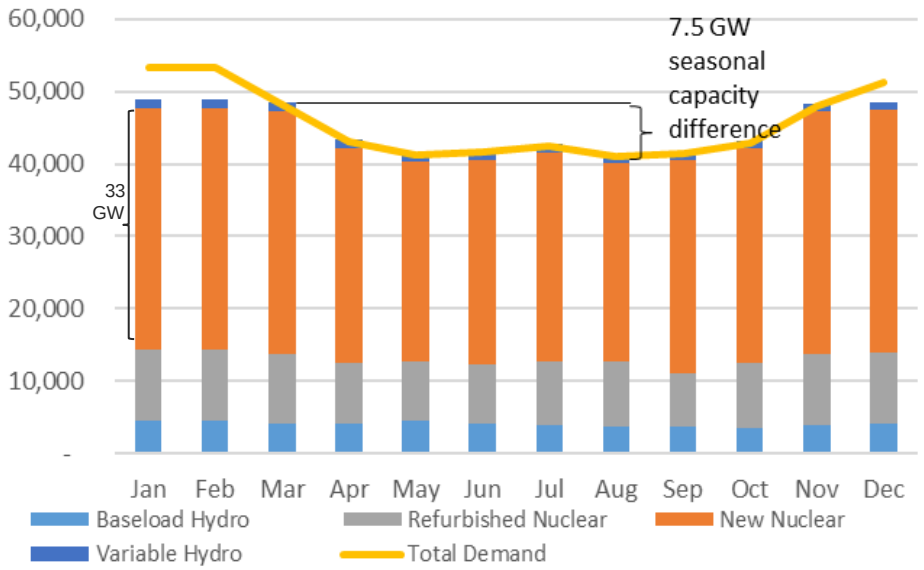
With a sufficiently large nuclear portfolio, a seasonal operating profile can be engineered

- Over 33 GW of nuclear baseload could mitigate 7.5 GW of the need for other variable supply

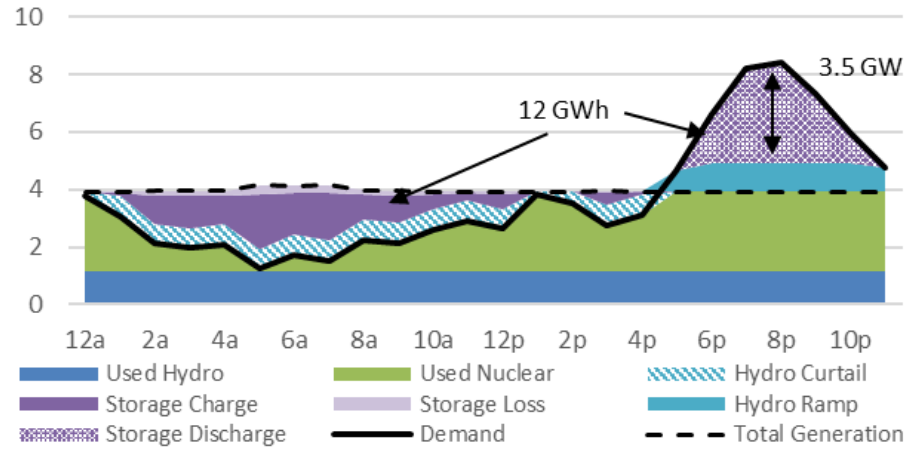
Variable demand could be served by baseload nuclear technologies when coupled with storage

- Up to 4 GW of baseload could mitigate the need for 3.5 GW of variable supply

Illustrative Nuclear Portfolio for Low-Cost Seasonal Supply
(MW, NZ2050)



Supply Benefit of Coupling Nuclear Baseload with Distributed Storage
(GW by hour, NZ2050)



The potential for new nuclear procurements in the next 15 years is over 37 GW

Source: Strapolec analysis

Integrated low-emitting hybrid supply options are all cost competitive

Nuclear options should offer some cost advantage

Nuclear ideally suited to baseload supply

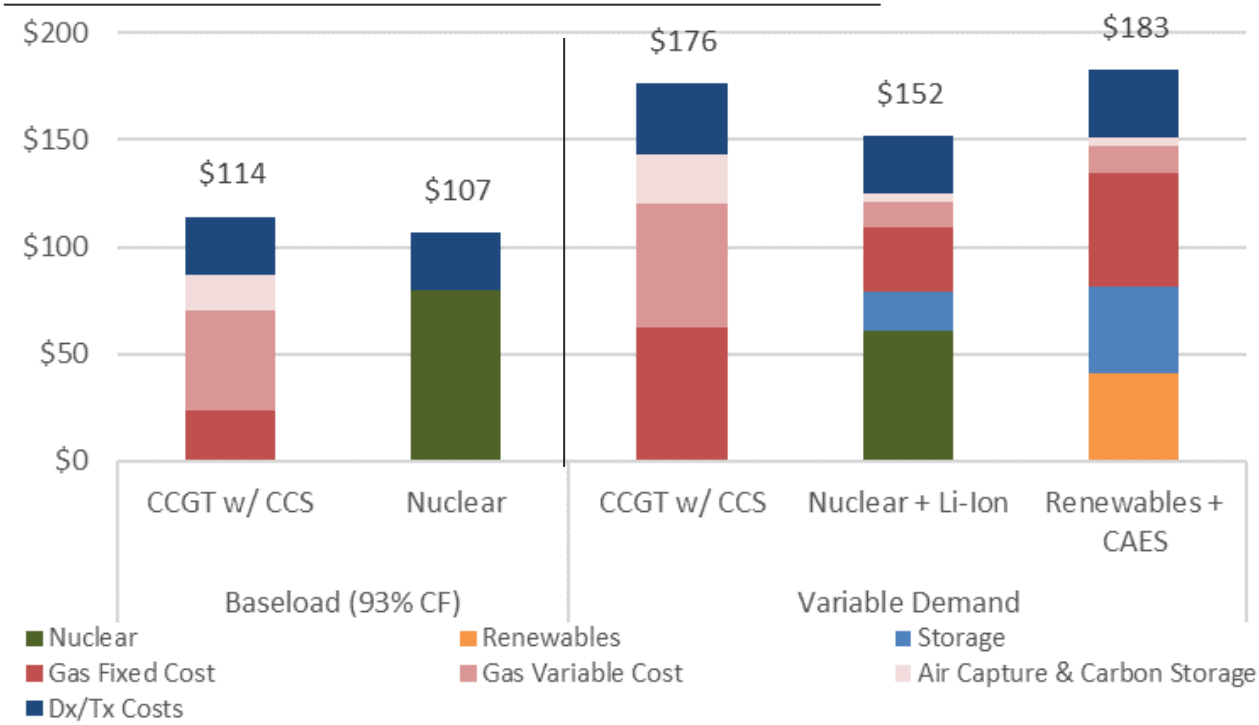
- Gas-fired generation with carbon capture (CCGT w/ CCS) more expensive due to need for air capture and sequestration

Hybrid options are viable for variable supply

- Natural gas fired generation equipped with carbon capture
- Nuclear coupled with distributed storage and natural gas
- Renewables (predominantly wind) coupled with natural gas and both li-ion and CAES storage

Integrated Low-emitting Variable Supply Solutions Costs

($/MWh CAD, NZ2050, 2018$ for 2035 installations)



Note: NREL assumptions for nuclear dropped due to financing assumptions
Costs shown after conversion to Canadian context and include full life cycle costs include waste and decommissioning

A nuclear-based supply system may be the lowest cost and most flexible and viable option for procuring now

Source: EIA, NREL, Navius, Strapolec Analysis

Ontario has a low-emitting supply procurement challenge

Undertaking procurement to more than double electricity capacity in only 30 years is aggressive

Ontario has a known sustained need for 14 GW of generation by 2030 (planned + capacity auction)

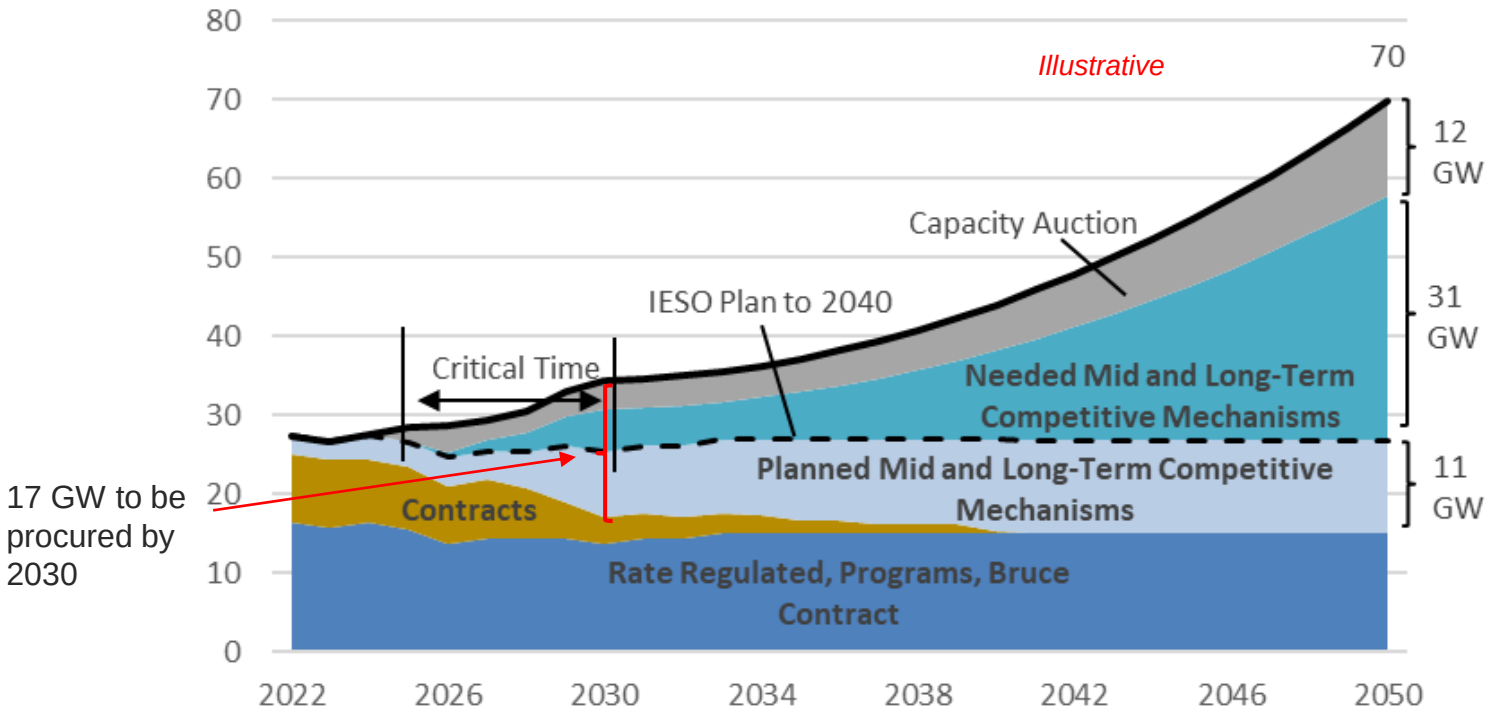
- Ontario's 2030 emission target implies additional 37 TWh
  - 6 GW more capacity needed above current 3 GW gap
- Reliability of Ontario's energy infrastructure is at risk

NZ2050 requires over 55 GW of new generation

- Bulk sources for low-emitting firm generation of this scale, along with transmission, take many years to develop
- Only natural gas options may be viable in near term given reliability risk of a 9 GW shortfall in 2030

Ontario Procurement Needs Under Minimum Electrification Scenario

(GW by Year, illustrative ramp of deferred capacity buildout pre & post 2030)



Ontario urgently needs low emitting supply options today, an opportunity for nuclear to put up its hand

Sources: Strapolec Analysis, IESO 2020, 2021

Ontario is facing an unavoidable extended period of high emissions

Ontario won't have low emissions electricity for 15 years without a change in plan

Delays in long-term asset procurement could result in greater emissions in 2035 than when coal plants operated

If procurement started today, the 9 GW of new low-emitting generation required for 2030 may not be in service before 2035

Ontario at risk of losing its clean energy status

With a non-emitting grid, 60% of economy wide emission reductions deferred to after 2040

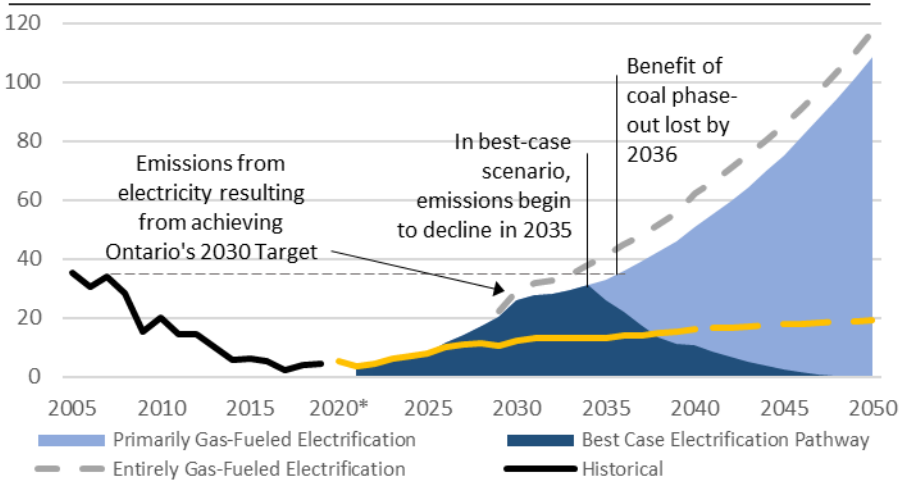
- But a practical accelerated procurement of clean energy defers over 80% of reductions to after 2035
  - Sets Canada's 2030 emissions reduction target back by 13%

Without non-emitting resources, Ontario cannot meet NZ

Race between non emitting generation and net zero emissions dictates a need to start procuring for low carbon supplies <u>now</u>

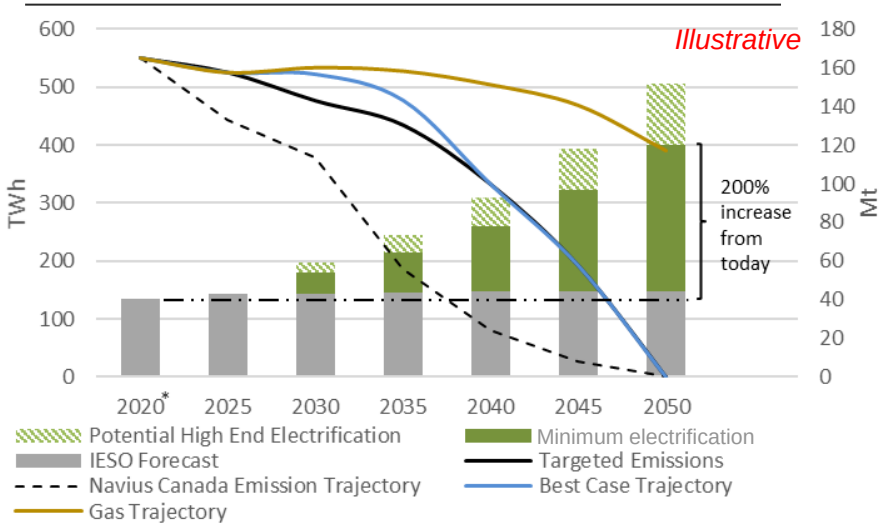
Emissions Implications of Electricity Options

(Mt, 2005-2050)



Ontario's Electrification and Provincial Emissions Reduction Profile

(TWh & Mt)



Includes grid and embedded, assuming carbon capture/sinks address 40% of emissions. Minimum reflects reduced heating load due to hybrid devices. Navius emission projection scaled to Ontario and to reach 0 Mt emissions in 2050. *2019 emissions used in place of 2020, to remove impact of COVID-19 pandemic

Sources: Navius 2021, Strapolec Analysis; IESO 2020

Procurement criteria should consider societal benefits

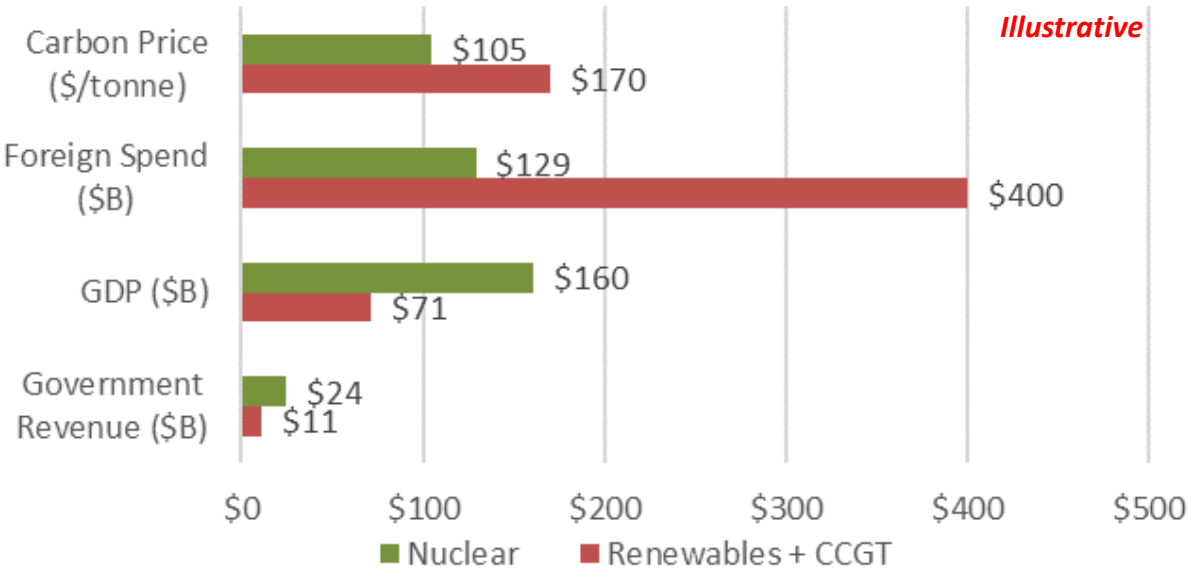
Energy infrastructure involves hundreds of billions in capital spend that can be leveraged

Societal Benefits

- **Secure domestic energy supply**
- **Rapid de-carbonization**
- **Enhance economic growth with infrastructure spend**
- **Industrial policy to nurture business opportunity**
- **Innovation for the energy transition**

Economic Impacts of Infrastructure Choices

(For development and construction plus 20-year operations)



Note: Values compared on an equivalent electricity cost basis of $114/MWh. Government revenue illustrated as 15% of GDP. Carbon price from 2016 analysis vs federal backstop to achieve 2030 targets. Foreign spend and GDP based on simulation of options

Nuclear options offer improved societal benefits suggesting competitive advantage in a broad procurement

Sources: Strategic Policy Economics, Ontario's Emissions and the Long-Term Energy Plan, 2016; Strategic Policy Economics, Distributed Energy Resources in Ontario: A Cost and Implications Assessment, 2018; Strategic Policy Economics, Advancing Ontario's Energy Transition: Leveraging Policy Tools, 2021; Strapolec analysis

Closing and call to action

The opportunity for defining the future of nuclear in Ontario is *now*

The nuclear sector in Ontario should stand up ***now*** and encourage consideration of net zero in Ontario's energy planning and procurement process

- This position has been communicated to the MENDM in its recent consultation on long –term energy planning

Absent an alternative credible option for decision makers:

- Natural gas generation procurements will be made that have long-term consequences
- A potential nuclear market may be deferred for more than a decade
- Ontario's status as a clean electricity jurisdiction will be put at risk
- Canada's 2030 emission reduction ambitions will be unattainable

Nuclear sector must do the hard work to inform a policy course for a better future

There is no risk in getting started