PATHWAYS TO NET ZERO EMISSIONS FOR ONTARIO

Overview

Study Objective

Develop a techno-economic analysis of two decarbonization scenarios in terms of energy system costs, feasibility, and implications for EGI and Ontario's Energy system, including the potential role of low carbon and renewable gases.

The scenarios examined were defined to look at all sectors to understand the economy-wide path to net zero:

Diversified	Low and zero carbon gases and the gas delivery infrastructure are used in combination with end-use electrification to reduce GHG emissions in all sectors.
Electrification	Electrification of all sectors, with low and zero carbon gas use limited to cases where no reasonable alternative energy source exists

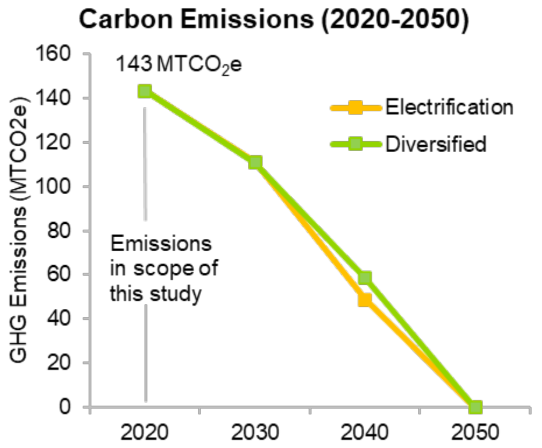
Modeling Approach

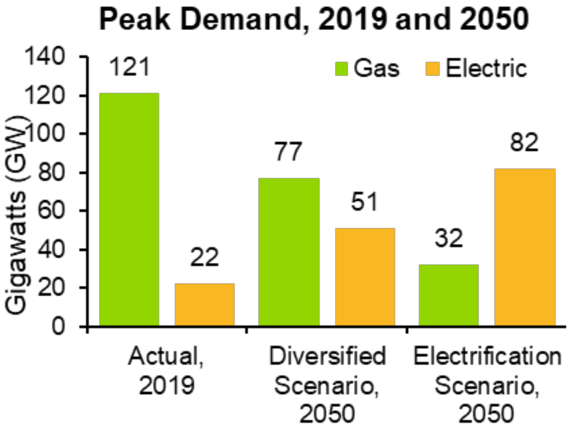
Guidehouse configured its Low Carbon Pathways (LCP) model for Ontario, which identifies optimized, lowest-cost pathways to achieve net zero within the assumptions of each scenario

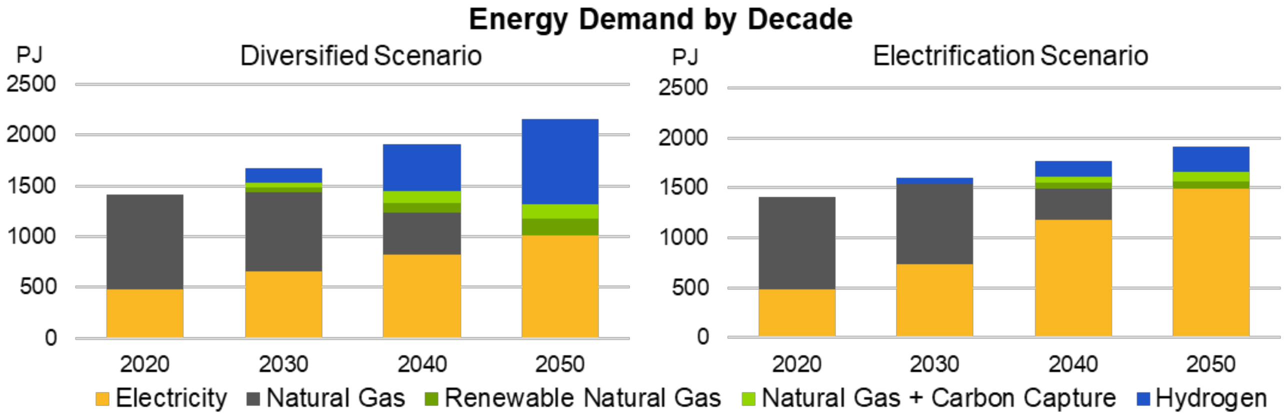
OBJECTIVE FUNCTION	**The model's primary objective function is to minimize energy system costs over the analysis horizon (2020-2050) – including supply and infrastructure costs.** • Supply Costs • Infrastructure Costs
DECISION VARIABLES	**The model determines the optimal capacity and dispatch for supply and infrastructure, to meet forecasted demand in each scenario.** • Supply Tech Capacity & Dispatch • Infrastructure Capacity & Dispatch
CONSTRAINTS	**The model is constrained by existing and planned supply and infrastructure capacity, interim & final emissions reduction targets, and balancing energy supply and demand.** • Emissions • Supply & Infrastructure Capacity • Energy Balance

- Expands on previous energy transition scenario analysis (ETSA) done by Enbridge Gas that forecasts gas demand from 2020 to 2038.
- Extends forecasts from 2038 to 2050 and develops electricity demand scenarios that are internally aligned with the underlying assumptions.
- Each scenario includes end user costs

Key Findings







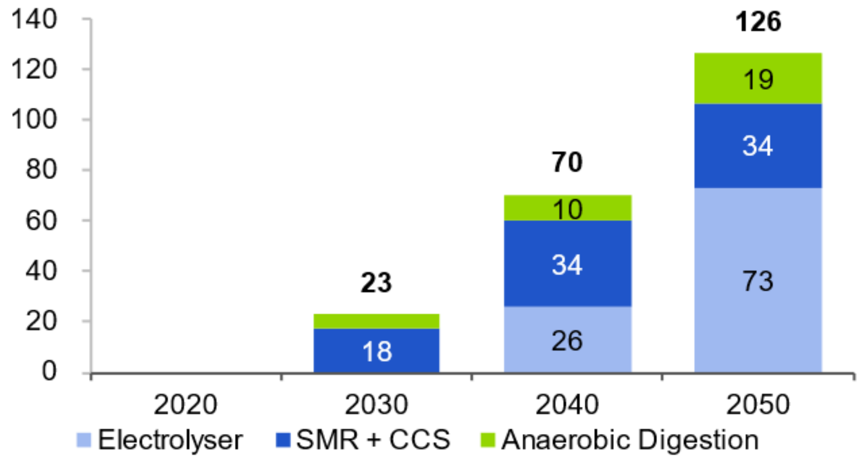
- Both scenarios achieve net zero by 2050.
- Both result in higher peak demand for electricity.
- Overall energy demand increases by decade, with a larger share met by hydrogen and renewable natural gas in both scenarios, but to a larger degree in the Diversified scenario.
- While the gas system peak declines for both scenarios in energy terms, the volumetric gas system peak rises significantly in the Diversified scenario, because hydrogen has a lower energy density than methane, so more volume is needed to provide the same amount of energy.

Key Findings – Gas Supply

- Both scenarios require a substantial scale-up of RNG supply capacity and leverage carbon capture and storage to achieve net zero.
- The Diversified scenario requires larger scale-up of hydrogen supply, met mostly by domestic production supplemented with imports from neighbouring regions. Increased hydrogen production requires additional electricity supply via green hydrogen.

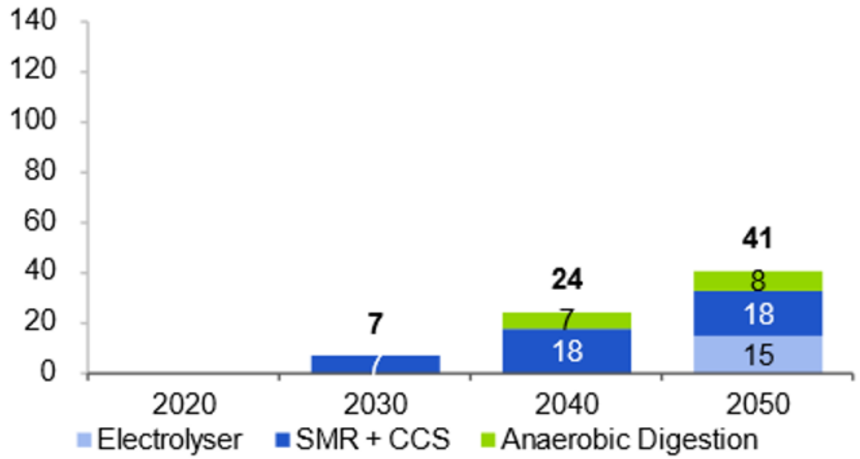
Diversified

Gas Supply Capacity (TJ/hour)



Electrification

Gas Supply Capacity (TJ/hour)

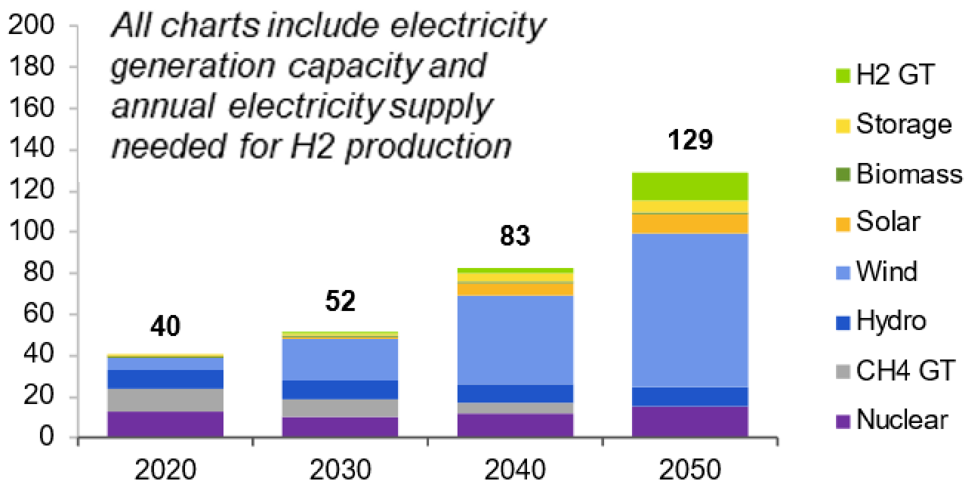


Key Findings – Electricity Supply

- Both scenarios require substantial buildout of electricity generation capacity, more aggressive in the Electrification scenario
- Higher peak demand is primarily met by wind and hydrogen-fired gas turbines

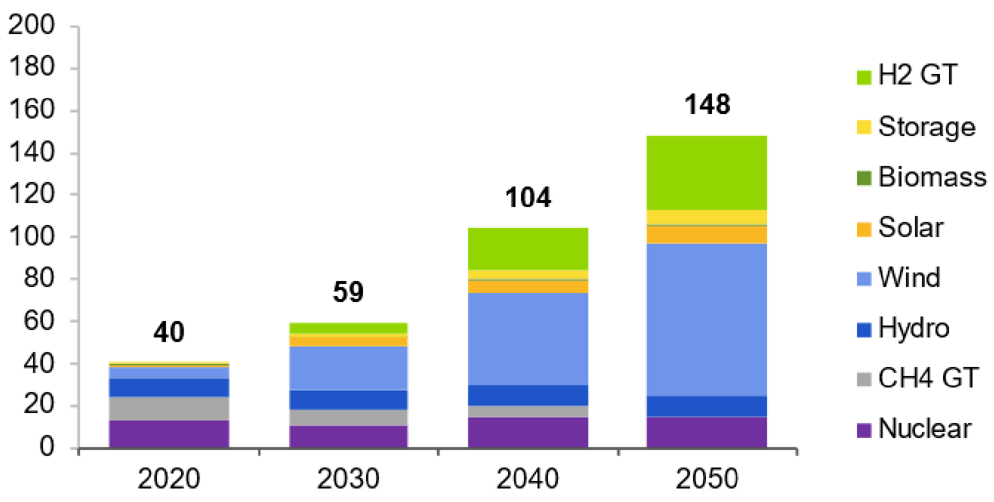
Diversified

Electricity Supply Capacity (GW)



Electrification

Electricity Supply Capacity (GW)



Key Findings

- The estimated cost for the Diversified scenario ($681 billion) is $41 billion less than that for the Electrification scenario ($722 billion), cumulative from 2022-2050, or 6% lower.
  - The reduced costs are due to less spending on electricity generation capacity and infrastructure, end user heating systems, and building energy efficiency retrofits.
  - The electricity and gas systems will become increasingly integrated
- Both scenarios face implementation challenges:
  - Diversified – relies on customer conversion to hydrogen-consuming equipment, including industrial use and gas heat pumps, as well as more rapid adoption of electrolyzer and CCS technologies.
  - Electrification – leads to more rapid growth in electric peak demand, which requires more rapid growth in electric generation capacity to avoid system failures, especially during extreme weather events.
- Highlights of Sensitivity analyses:
  - Lower cost distributed energy resources could drive increased deployment, leading to cost savings in both scenarios
  - Increased adoption of hybrid heating systems would further reduce electrical peak loads, which could drive cost savings in the Diversified scenario (~$9 billion relative to the core Diversified scenario, and 50 billion relative to the core Electrification scenario).

History of Changes to P2NZ Report

Guidehouse does not anticipate any further changes to the report.

Date	Description of Change
March 16, 2023	Updated cost results to include items that were omitted from the June 2022 version of the report.[1]
April 21, 2023	Updates to report to improve consistency between scenarios, to address intervenor feedback.[2]
May 26, 2023	Addendum to P2NZ report in response to undertaking JT9.16, which discusses the sensitivity of modeling results to different assumptions related to the emissions and production of blue hydrogen. The main result of this analysis was the main effect of increasing assumed emissions rates is to reduce the amount of blue hydrogen that is selected to meet demand, but that the cost differential between compared scenarios is not sensitive to blue hydrogen assumptions.

[1] *See March 16 cover letter for details.*
[2] *Changes are summarized in a table attached to Guidehouse's April 5, 2023 letter.*

Impact of Changes on Recommendations

- After completion of responding to the additional undertakings, Guidehouse continues to maintain the recommendations as they stand in Chapter 6 of the original report. For example:
  - Gas generation will continue to play a critical role in Ontario's electricity system, e.g., in the form of hydrogen-fired turbines to meet peak demand and ensure system resiliency and reliability
  - Low- and zero-carbon gases like RNG and hydrogen will play a role in the GHG emissions reductions of most sectors, particularly in hard-to-abate sectors like heavy transport and industry

- In addition, we find it important to highlight that the recommendations that have been presented in Chapter 6 also remain consistent with other similar studies and policies across the world. For example:
  - Develop integrated electricity and gas planning
  - Develop regulatory structures that value energy system resilience
  - Establish an RNG production binding target
  - Assess readiness for gas network to accept increasingly higher blends, including up to 100%, of hydrogen
  - Pilot CCUS projects