Leveraging Hydrogen Production to Optimize Grid Performance in Atlantic Canada

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STRATEGIC POLICY ECONOMICS

Leveraging Hydrogen Production to Optimize Grid Performance

Outline: Opportunity in Atlantic Canada

Net Zero electricity demand

Atlantic Canada clean energy strategies

Domestic uses of hydrogen

Benefit of high-temporal modelling in understanding supply-demand relationship

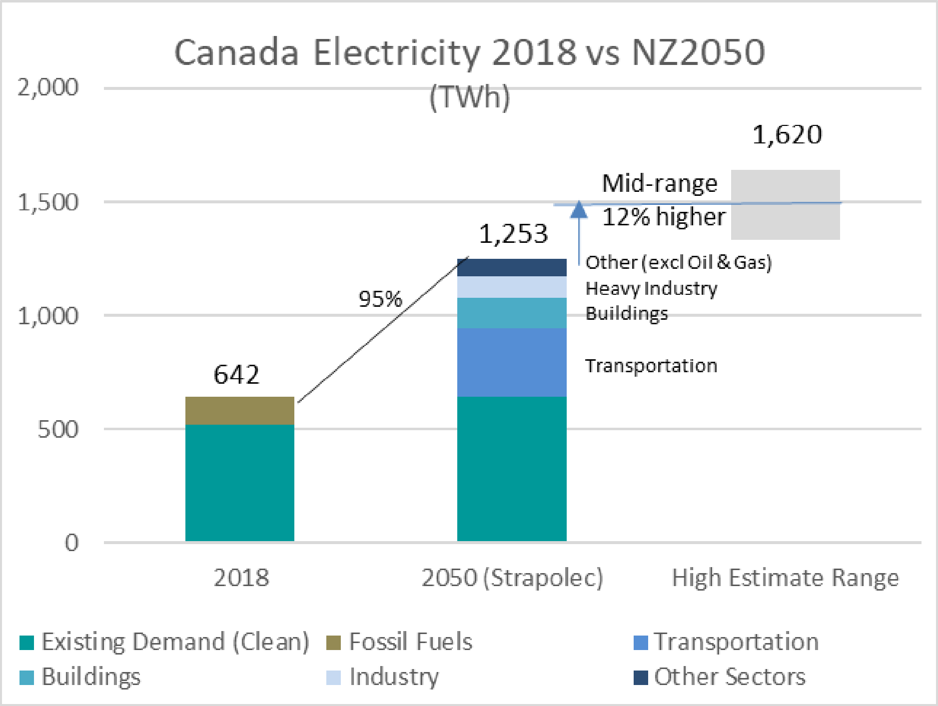
Supply dependent business drivers for electrolytic hydrogen production

Use of flexible hydrogen production to reduce the use of fossil fuels

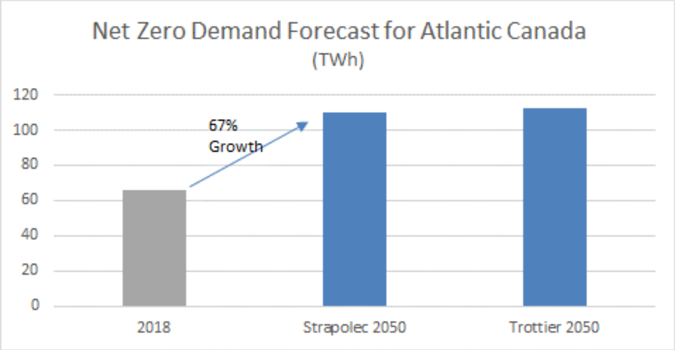
Context for emerging demand in a Net Zero economy

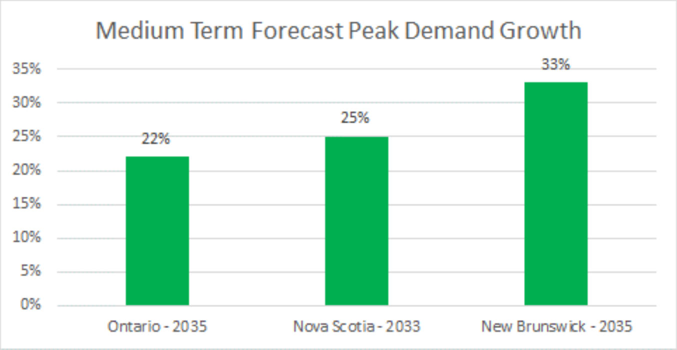
There is a need to significantly grow electricity infrastructure → Can hydrogen help?

Canada is preparing to embrace a Net Zero economy and the electrification that will come with it



Source: Strapolec analysis, excludes Oil & Gas and 50% of hard to decarbonize industrial high heat applications. Range reflects RBC, SNC, Trottier studies. RBC high end and Suzuki low end deemed outliers and not included





Source: Ontario IESO 2024 APO (vs 2025), NS Power 2023 10-Year System Outlook, NB: Our Path Forward to 2035 (vs 2022)

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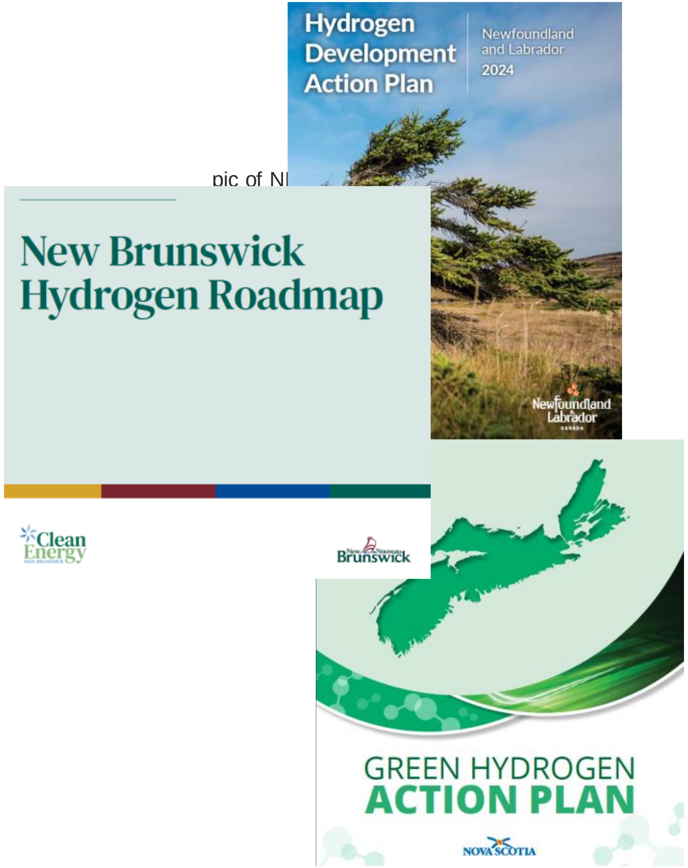
Atlantic Canada clean energy strategy options

Atlantic provinces have developed hydrogen ambitions

Possible energy options in Atlantic include:

- Electricity
  - Renewables, Nuclear, Hydro
  - Imports via Atlantic loop now recognized as not viable
    - Gull Island has potential, would need transmission
    - Offshore wind
- Biofuels and renewable natural gas
- Hydrogen
  - Newfoundland, Nova Scotia and New Brunswick all have hydrogen plans
  - Significant export potential in near term
  - Mostly from on and offshore wind for export to Europe
    - Due to economics of high wind speeds in Atlantic Canada
  - Potential hydrogen production facilities in the Port of Belledune in New Brunswick may leverage nuclear power



Source: NB: Our Path Forward to 2035 (vs 2022), NS 2030 Clean Power Plan

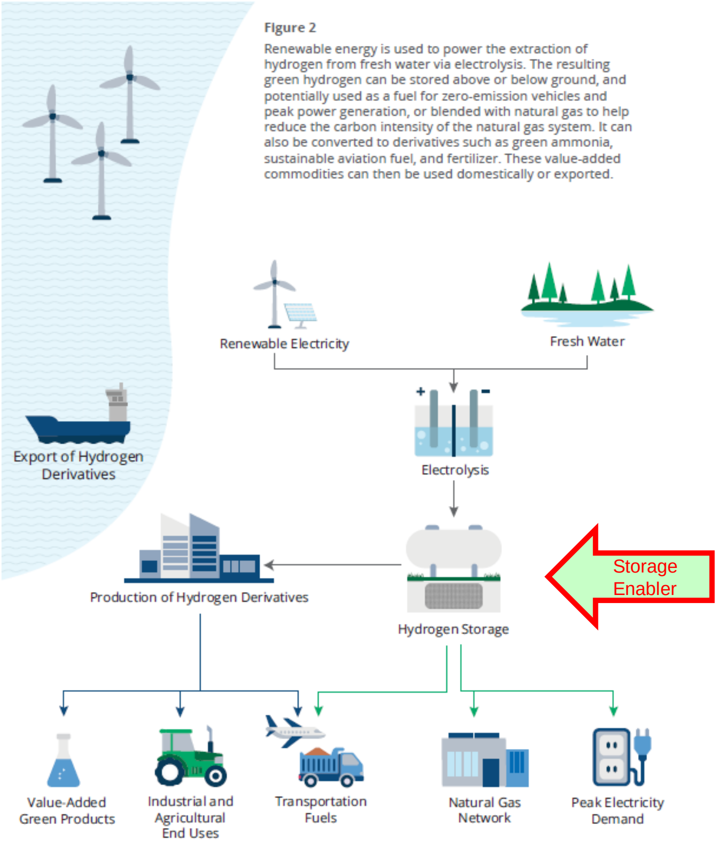
Hydrogen strategies involve many applications for domestic use

Storage capability is an enabler for both exports and domestic use

- Greening mineral production and value-add to mineral products (NL)
- Electricity Peaking supply and grid balancing
- Blend down the natural gas system
  - Possible home use in lieu of propane
- Transport fuels
- Fuel switching for hard to abate sectors
- Hydrogen derivatives for industry, agriculture and fuels

Seasonal and other storage of hydrogen is identified as an enabler

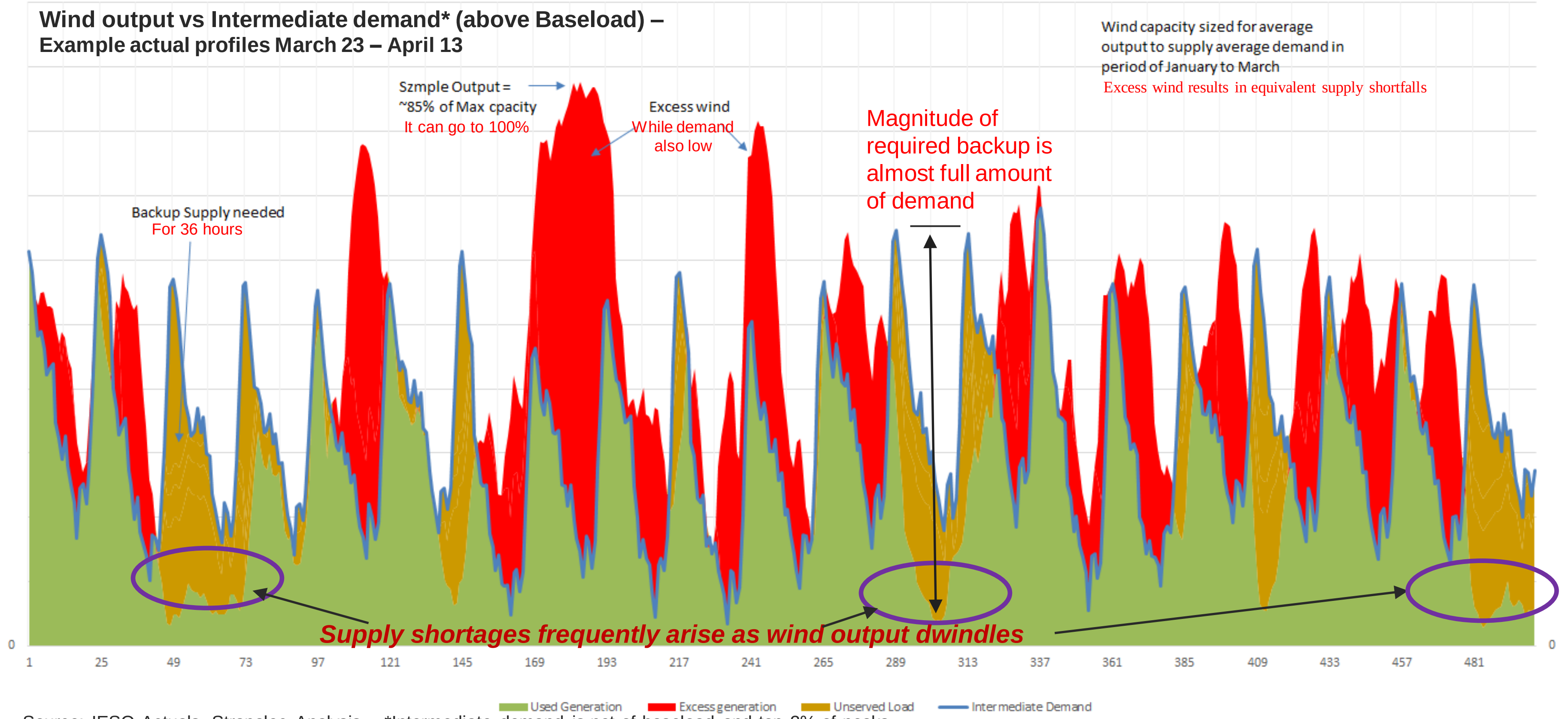
- Strategies for hydrogen production could consider electricity system supply and demand dynamics



Source: NS Green Hydrogen Action Plan

High-temporal fidelity clarifies renewables-demand relationship

Wind intermittency & demand misalignment requires backup for reliability - Ontario Example



Source: IESO Actuals, Strapolec Analysis. *Intermediate demand is net of baseload and top 2% of peaks

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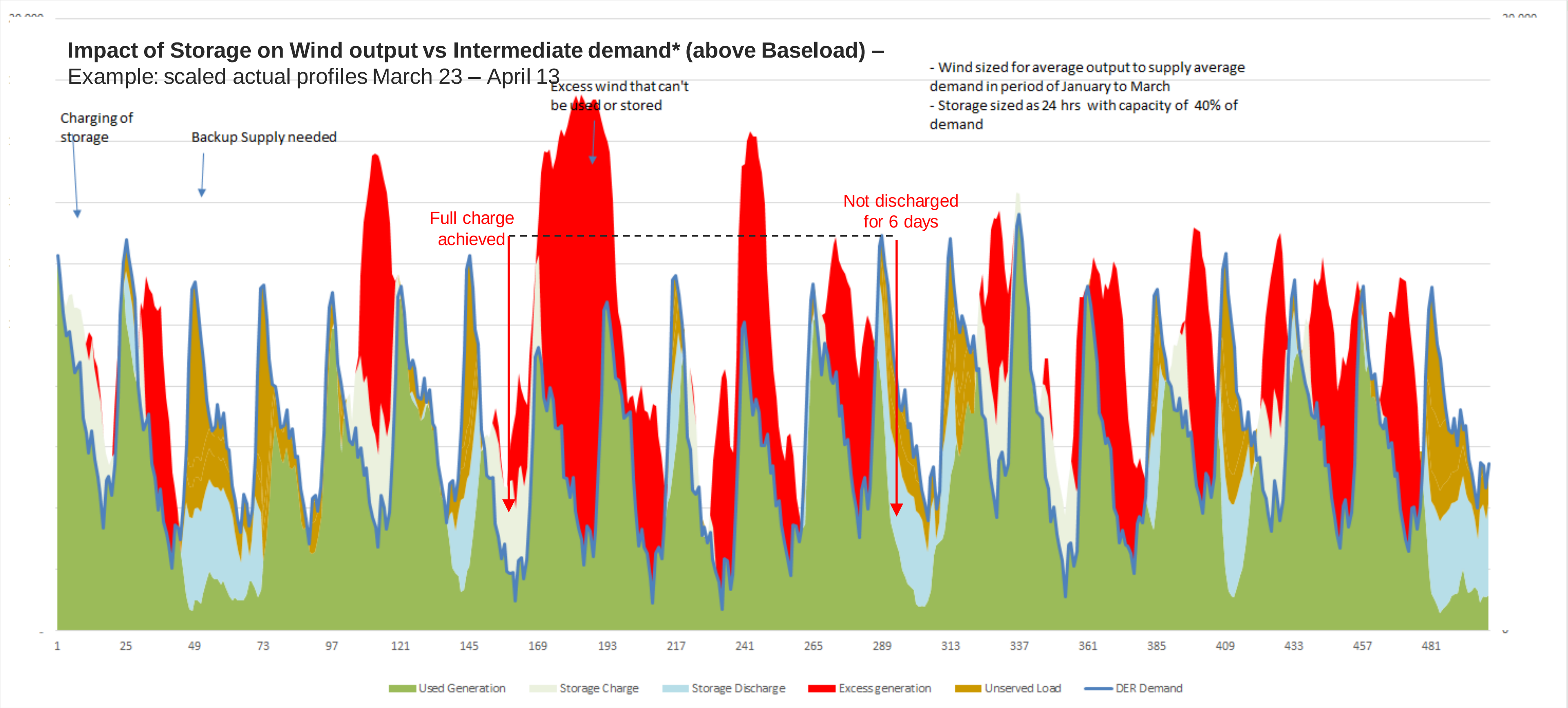
High fidelity modeling of renewables + storage highlights peaks

Even 24-hour storage still needs significant backup generation



Source: IESO Actuals, Strapolec Analysis . *Intermediate demand is net of baseload and top 2% of peaks

Managing hydrogen production from wind vs nuclear

Intermittent vs baseload supply entails different business drivers

Wind operating factor location specific intermittency range:

- 33% (historical on shore Ontario, 35% onshore in US, projected 40% in future)
- 42% (average global off-shore performance in 2022)
  - 52% highest US performance
- Significant variability in seasonal output

Nuclear reference operating factor is 93%

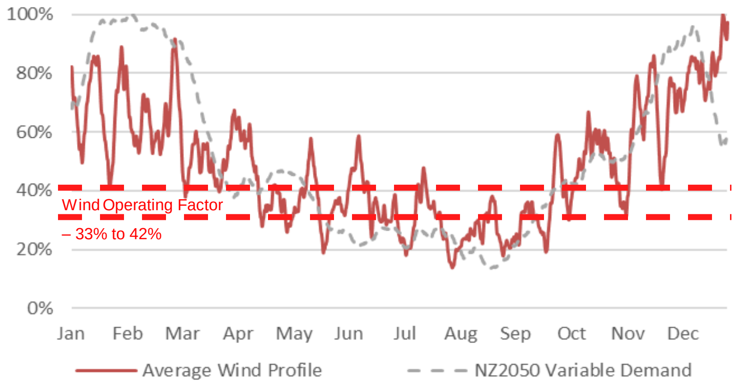
- Largely due to planned maintenance and/or refueling

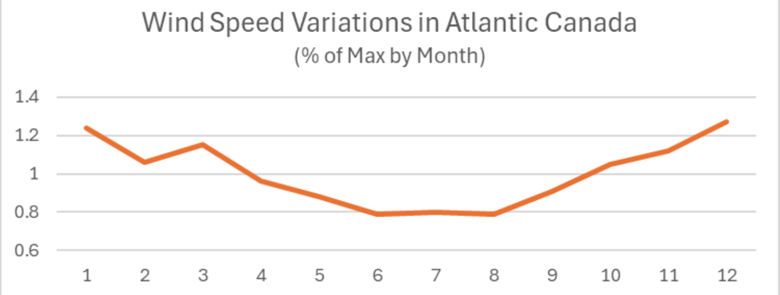
Capacity factor affects

- Cost-effective use of hydrogen production infrastructure
  - Wind-based business driver of hydrogen operations is "*operate when you can*"
  - Nuclear/baseload-based business driver of operations is "*optimize operational efficiency*"
- Need for storage
- Support to grid demand/supply misalignments

Ontario wind energy may track winter demand, but is volatile

(% of max, NZ2050 Demand vs. 2016 Wind Production, 7-day running avg.)





Source: https://globalwindatlas.info/en

https://www.statista.com/statistics/1368679/global-offshore-wind-capacity-factor/#:~:text=Between%202010%20and%202022%2C%20the,wind%20stood%20at%2042%20percent.; https://www.nortonrosefulbright.com/en/knowledge/publications/d77f6a16/global-offshore-wind-canada ; IESO data, Strapolec Analysis

Seasonal hydrogen production to mitigate peaks - Ontario example

Coupled with a baseload electricity supply, hydrogen production levels could be optimized

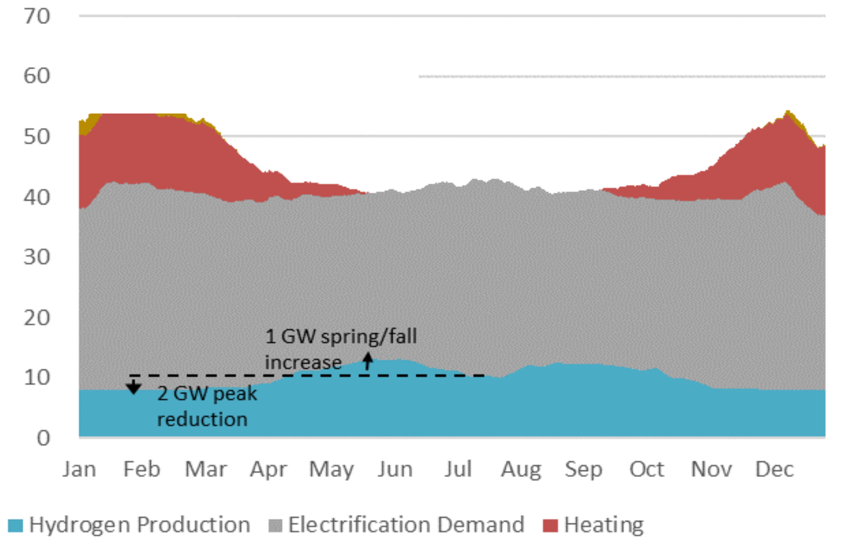
Fuel switching to electrical home heating (with heat pumps) will increase seasonal electricity demand in winter

- Ontario example currently has limited electrical heating
- New Brunswick, for example, already has significant resistance heating,
  - Shift to heat pumps may moderate growth in peak needs

Seasonal hydrogen storage could enable higher electrolyzer production in the summer to reduce this impact

- Electrolyzer operating factor will still be higher than with intermittent renewables supply
  - System benefits could offset cost of efficiency losses on electrolyzers
- Managing hydrogen production to free-up generation to *reduce* system infrastructure costs
  - The greater the distribution of electrolyzers, the bigger the benefit, but need to consider storage implications

Annual Electricity Load Profile
(GW by Hour, NZ2050)



Source: Strapolec Analysis, Electrification Pathways for Ontario, 2021

Hydrogen's flexible load management and demand response

An alternative to traditional peak + reserve supply when coupled with baseload

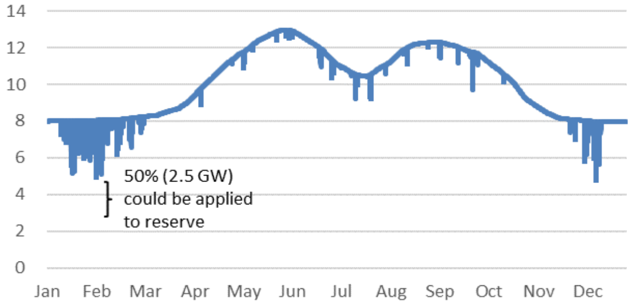
High-fidelity modelling shows how electrolytic hydrogen's ability to rapidly change production rate / electricity needs can:

- Enable large-scale demand response equivalent to installed base
  - Reducing need for peaking and reserve capacity
- Offer continuously active demand response
  - Replicate peaking gas supply plants
  - Act as an alternative to electricity storage
  - Reduce need for seasonal only capacity
- Provide risk mitigation to capacity forecasting
  - Using hydrogen as distributed reserve resource allows for the reduction of planned Tx and Dx capacity
  - Critical to manage the pace of system expansion

Hydrogen demand response can be less costly than gas peakers

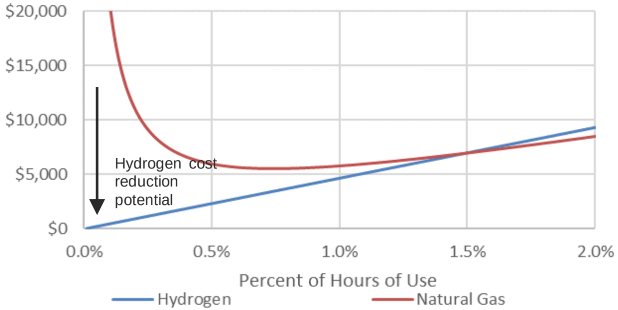
Hydrogen Production Levels and Demand Response
(GW by hour, NZ2050 peak demand simulation)

Seasonal production profile Illustration



Source: Strapolec Analysis

Hydrogen Cost of Providing Flexibility
($/hour used, 1 MW)



Source: IRENA, 2020; IESO, 2020; EIA, 2021; NREL, 2020; Strapolec Analysis

Source: Strapolec Analysis, Electrification Pathways for Ontario, 2021