Seasonal Hydrogen Storage for Trucks

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CNL Hydrogen Strategic Initiative

Hydrogen cogeneration, safety & applied research for three markets

Transport Sector Decarbonisation

Hydrogen Production,

Safety,

Process design,

Concepts validation

Small Modular Reactor Cogeneration

Hydrogen production,

Safety,

Process design,

Materials research

Off-grid Community

Energy storage,

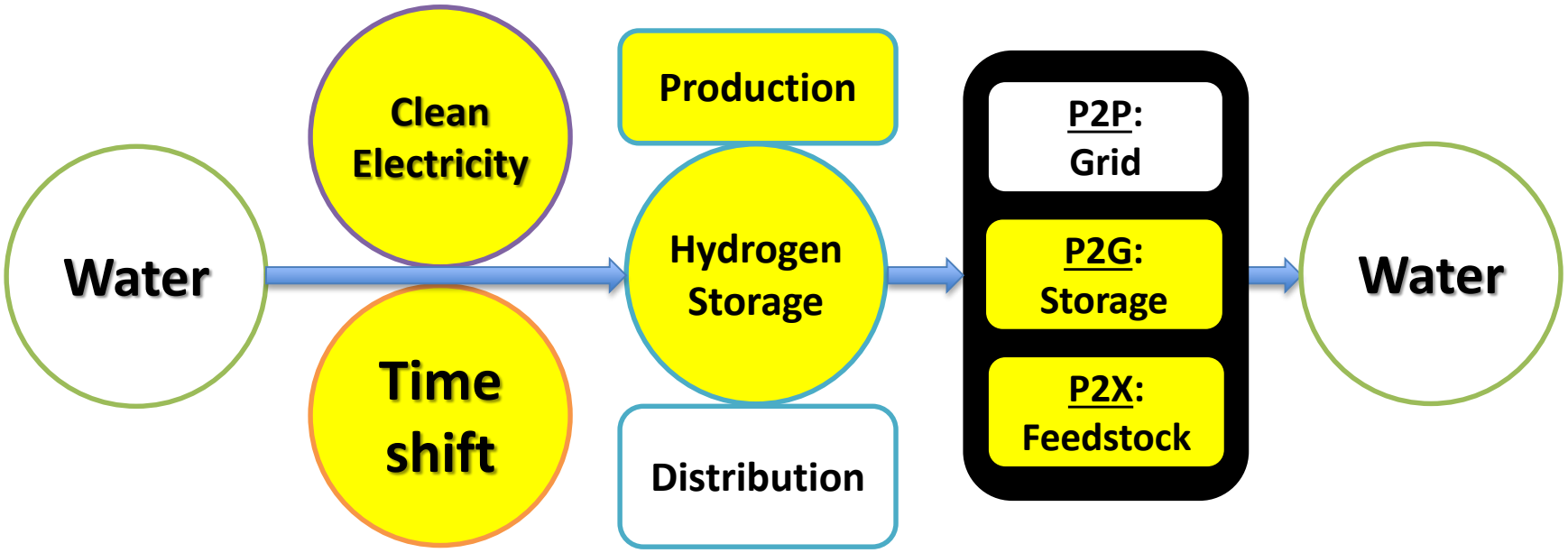
Safety,

Process design,

Feasibility and sustainability

Hydrogen R&D for Energy Sector

CNL's expertise in yellow filled boxes with end-to-end assessment



Hydrogen R&D for Transport Sector

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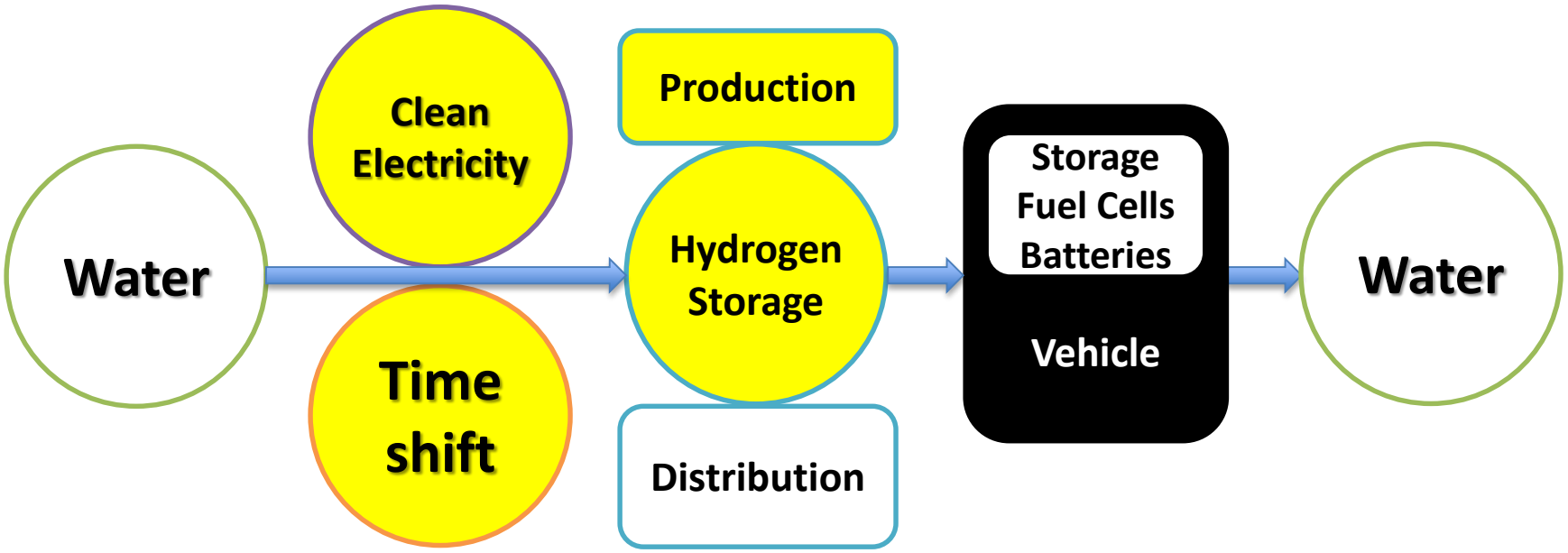


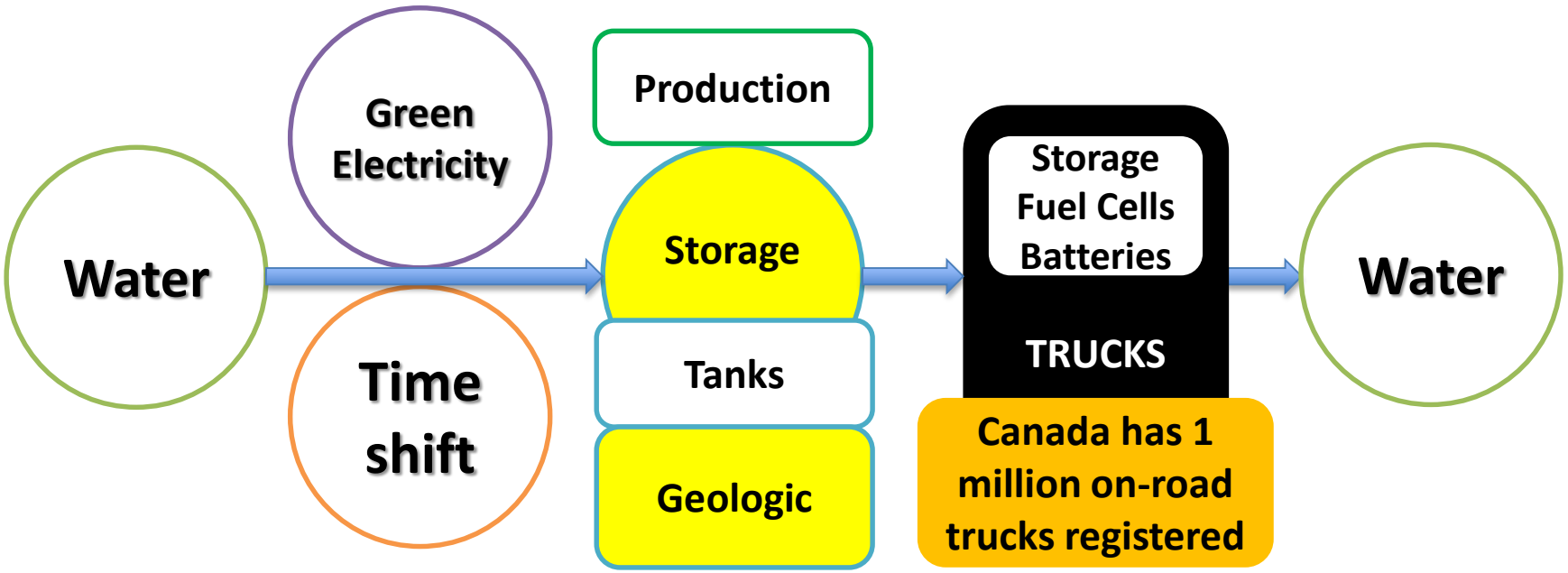
GHG Reduction Ambitions for Trucks

Global push for change in fueling trucks, are we ready to support that

- Anheuser-Busch orders 800 hydrogen-powered semi trucks from Tesla rival Nikola (May 2018, CNN)
- Hydrogen-fueled truck maker announces $1 billion Arizona plant (Jan. 2018, Reuters)
- Toyota's hydrogen fuel cell trucks are now moving goods around the Port of LA (Oct. 2017, The Verge)
- Toyota fuel cell trucks to be used by Seven-Eleven stores in Japan from 2019 (June 2018, Mainichi)
- Kenworth showcases its Hybrid Electric Cargo Transport truck (Jan. 2018, Truck News)
- Daimler Adds Two Electric Trucks in Race Against Tesla, VW (June 2018, Bloomberg)

Hydrogen Meets On-Road Trucks

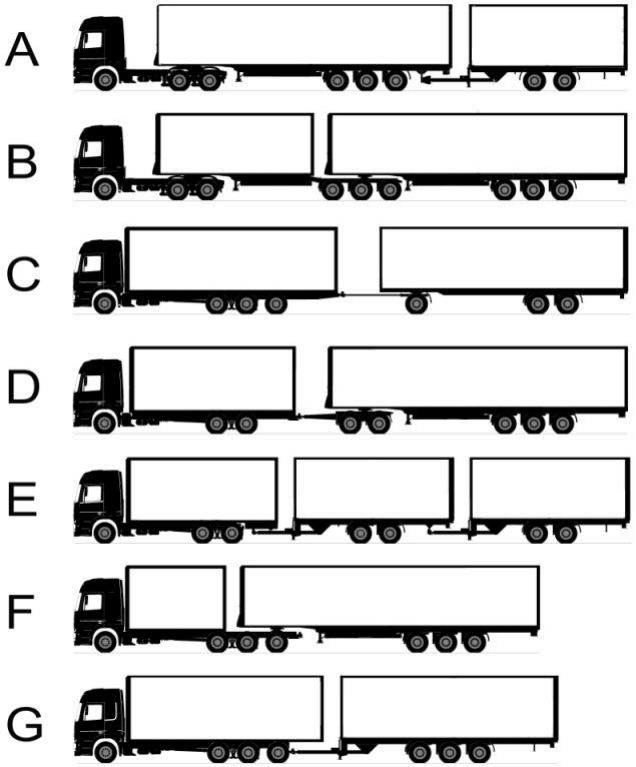
CNL's project on large-scale energy storage provides part of the solution



Hydrogen for Trucks

CNL's energy storage model used to assess grid, hydrogen and trucks

- Trucks classified:
  - Canada - Category 1 to 7 for heavy trucks.
  - Europe - Class A to G for semi-trailers.
  - US - Class 1 to 9 (pick-up to super-heavy).
- CNL took the full range of weights of trucks - from 5 tonnes to 65 tonnes allowed in Canada
- This provides a substantial range of comparison that any truck operator could use



CNL Energy Storage Model

Key assumptions used in the model

Trucks assumptions:

- 200 km/day or 58,400 km/year
- Operating 292 days/year
- Average speed 70 km/h
- 30% energy penalty for stop/start
- Current focus on operating cost only
- Carbon cost at 20 $/tonne of CO_2

Electrical grid assumptions:

- Surplus during <=0 $/MWh periods
- Transmission, distribution and regulation charges included

Hydrogen assumptions:

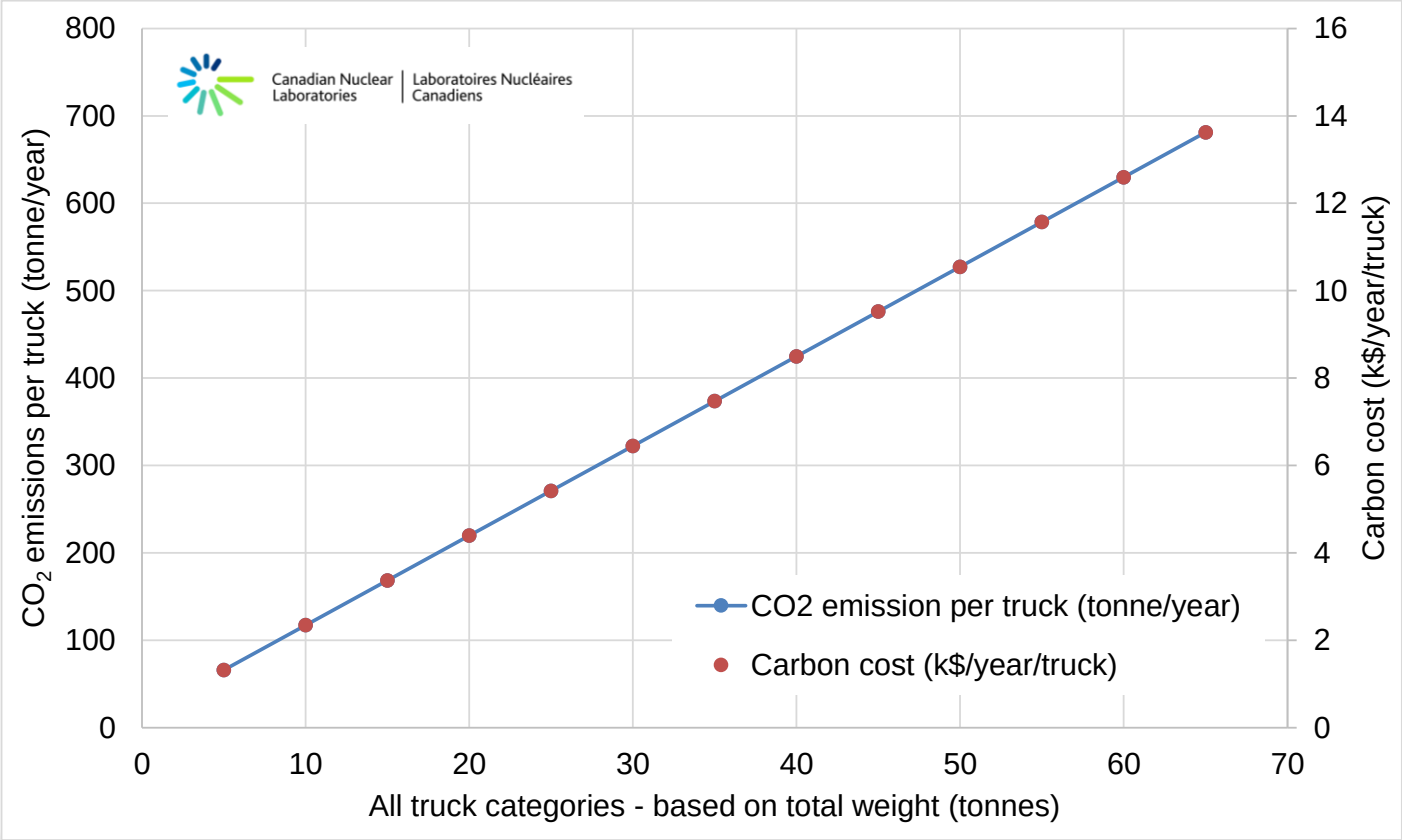
- PEM electrolyser at 500 $/kWe
- Mid-pressure tanks at 100 $/kg
- Geologic storage at 3 to 30 $/kg
- Storage pressure at 13 Mpa
- Hydrogen production from 20% of surplus electricity and when HOEP is below or equal to 0 $/MWh

Acronyms:

- HOEP – Hourly Ontario Electricity Price
- GHG – Greenhouse Gas

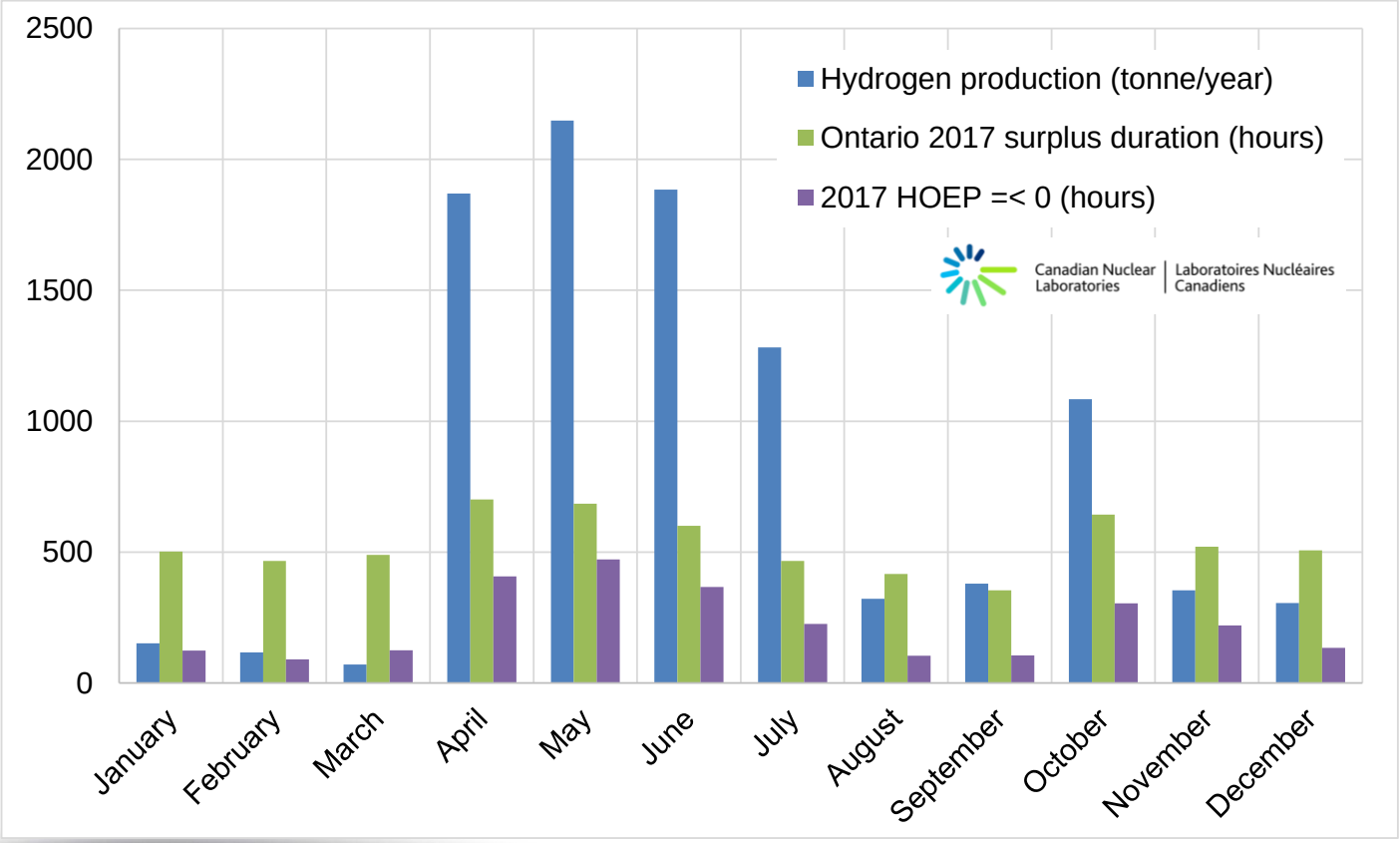
Diesel as Truck Fuel Needs Replacing

Preliminary results from CNL model – carbon costs are significant



Grid Surplus for Hydrogen Production

Preliminary results from CNL model – a need for large-scale storage

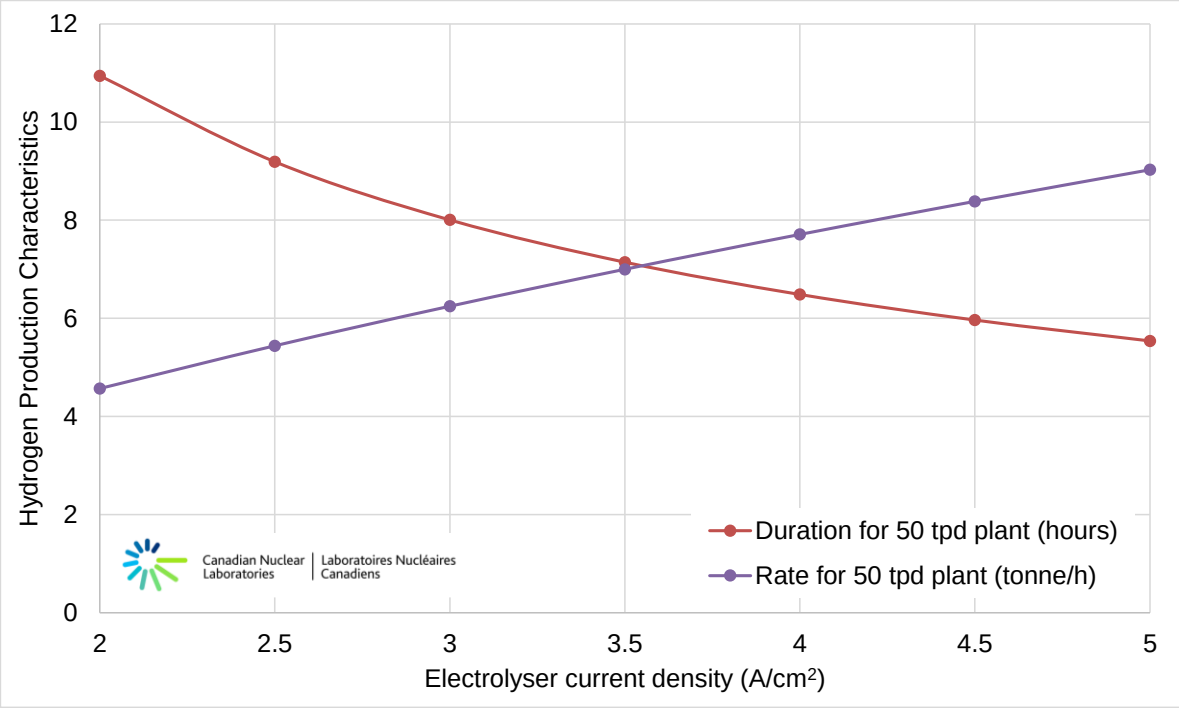


Hydrogen Production Planning

Preliminary results from CNL model – when electricity price is the lowest

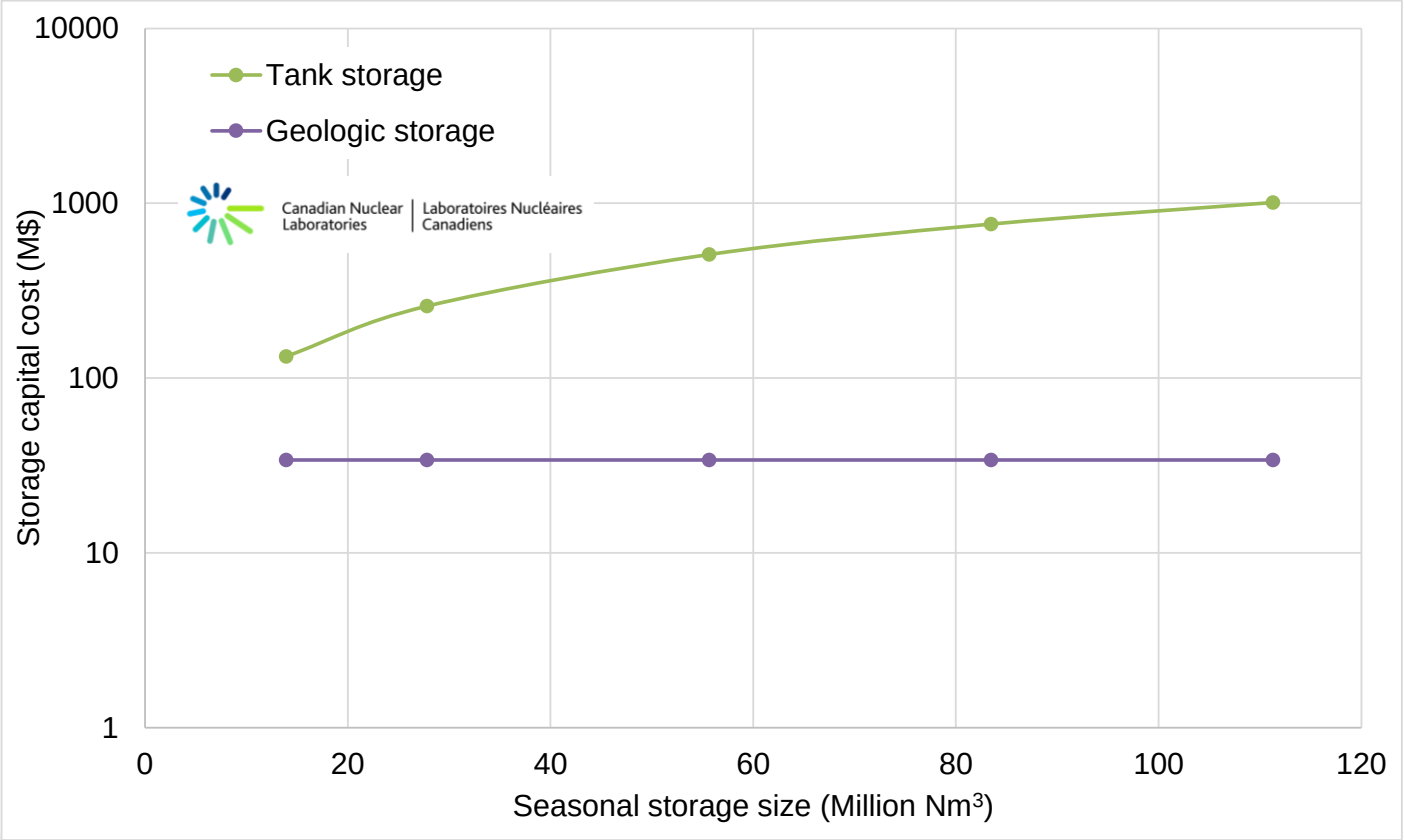
Electrolyser operating characteristics:

- For the same installed size, could increase hydrogen production capacity by increasing current density



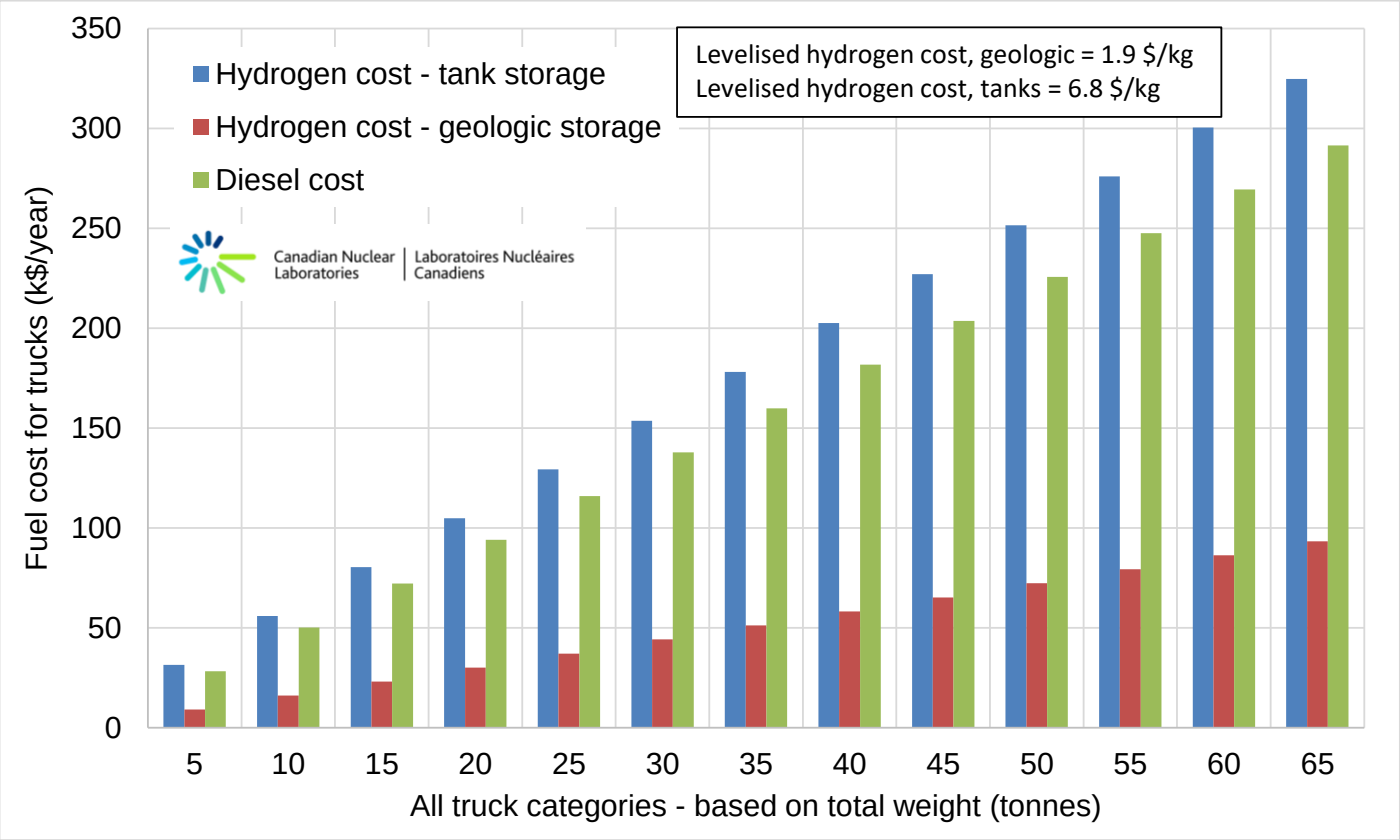
Large-scale Seasonal Storage

Preliminary results from CNL model – cost of tanks scale with size



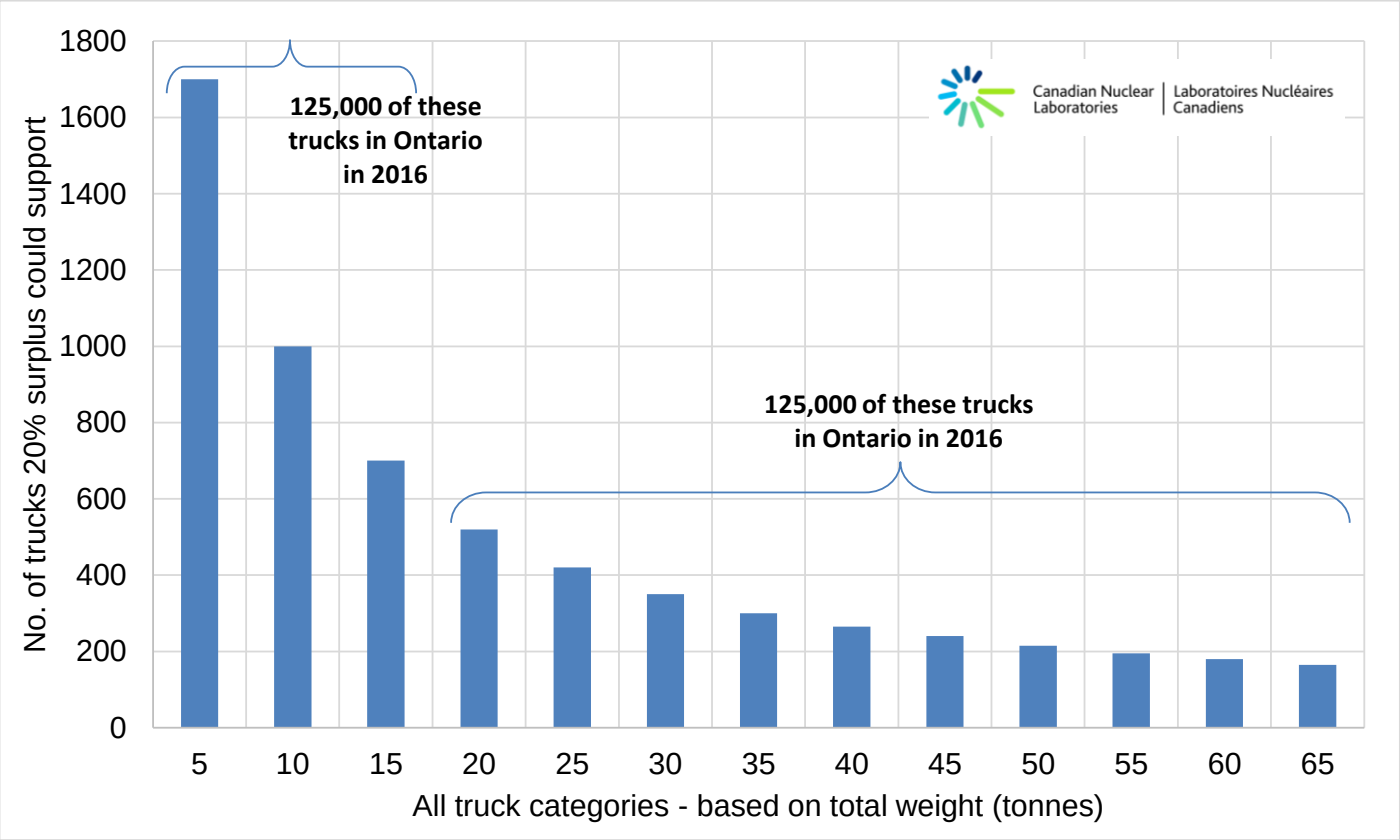
Operating Costs for Trucks

Preliminary results from CNL model – fuel costs vary with storage option



Potential for Deployment of H_2-Trucks

Preliminary results from CNL model – Ontario surplus has potential



Next Steps

CNL is assessing geologic storage potential, starting with Ontario

- Geologic storage is economical for seasonal storage
- Current CNL project to assess geologic sites suitable to store hydrogen
  - Begin with sites in Ontario, then expand to rest of Canada

Summary

Hydrogen powered trucks are getting real and they need hydrogen

Storage:

- Hydrogen produced using electricity from the grid needs viable large-scale storage (such as geologic) to improve economics
- Geologic storage could become a necessity for storing large quantities of hydrogen produced from other clean production processes as well

Trucks and vehicles:

- CNL has developed models to assess vehicle fleets powered by hydrogen to support long-term policies for GHG reduction
- We could provide case-specific hydrogen from grid assessments for different truck fleets or other vehicle fleets

Thank You