



Transition Accelerator: Building Transition Pathways to a Net-Zero Emissions Canada



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The Transition
Accelerator



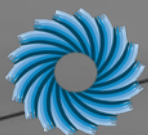
L'Accélérateur
de transition



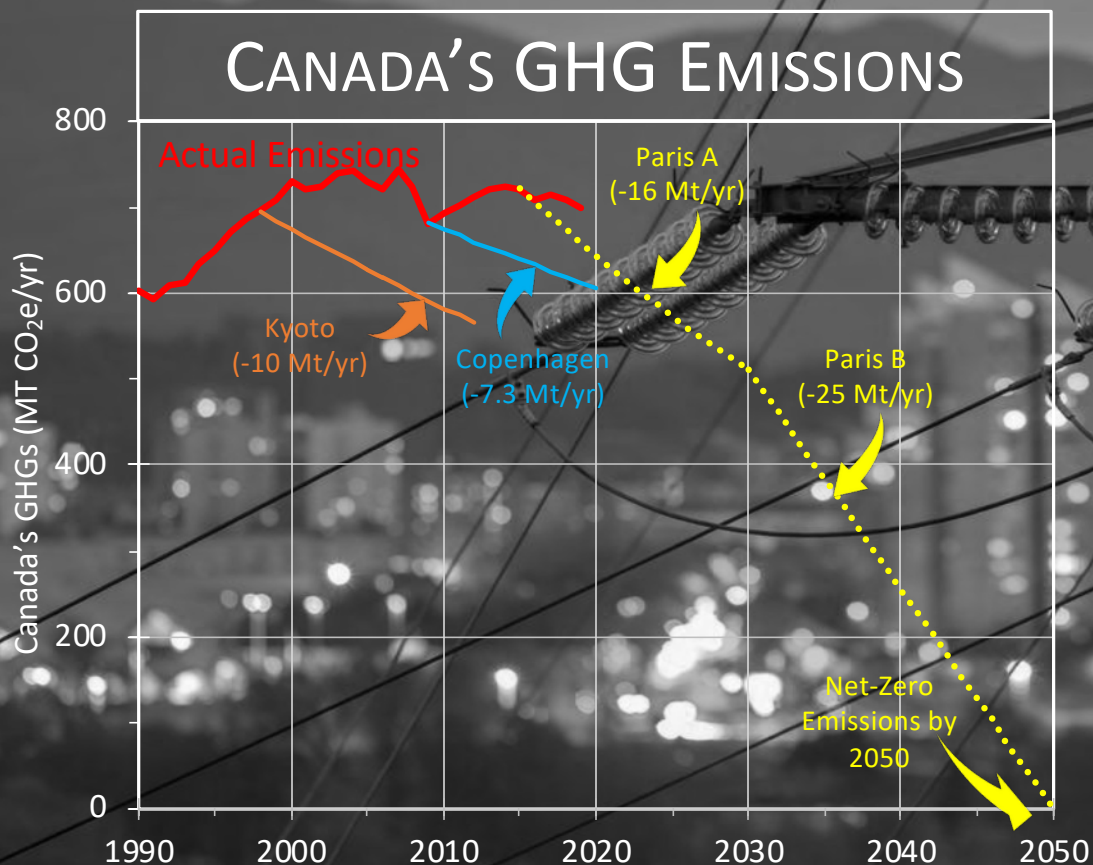
Outline

1. The net-zero challenge
2. About the Transition Accelerator
3. Building transition pathways to a vibrant hydrogen economy





CANADA'S GHG EMISSIONS



NET-ZERO EMISSIONS BY 2050

- ☐ COMMITTED TO BY CANADA AND 15+ OTHER COUNTRIES
- ☐ INCLUDES EMISSION REDUCTIONS PLUS CARBON REMOVAL TECHNOLOGIES

Transformational changes
are needed...

**How to get there?
How can Canada win?**

The Transition Accelerator



L'Accélérateur de transition

- ❑ A new pan-Canadian, non-profit, charitable organization;
- ❑ Established with the encouragement and support of philanthropic foundations across Canada.
- ❑ Headquartered in Calgary, Alberta
- ❑ Mandate to accelerate systems-level transitions of sectors in Canada to address major business or social challenges where significant greenhouse gas reductions can be built into the solutions;



Dan Wicklum, Ph.D.
President and CEO

The Transition Accelerator

L'Accélérateur de transition



The Transition Accelerator

L'Accélérateur de transition

Philosophy:

- ❑ **Understand** that we live in a time of transformative / disruptive change that can be good or bad;
- ❑ **Harness Technology, Business Model and Social Innovations** already at play for other business / societal objectives to ensure they align with GHG reduction goals;
- ❑ **Influence policy and investment decisions** to build industry-led consortia that will ‘**direct disruptive forces**’ and achieve societal goals, including climate change.

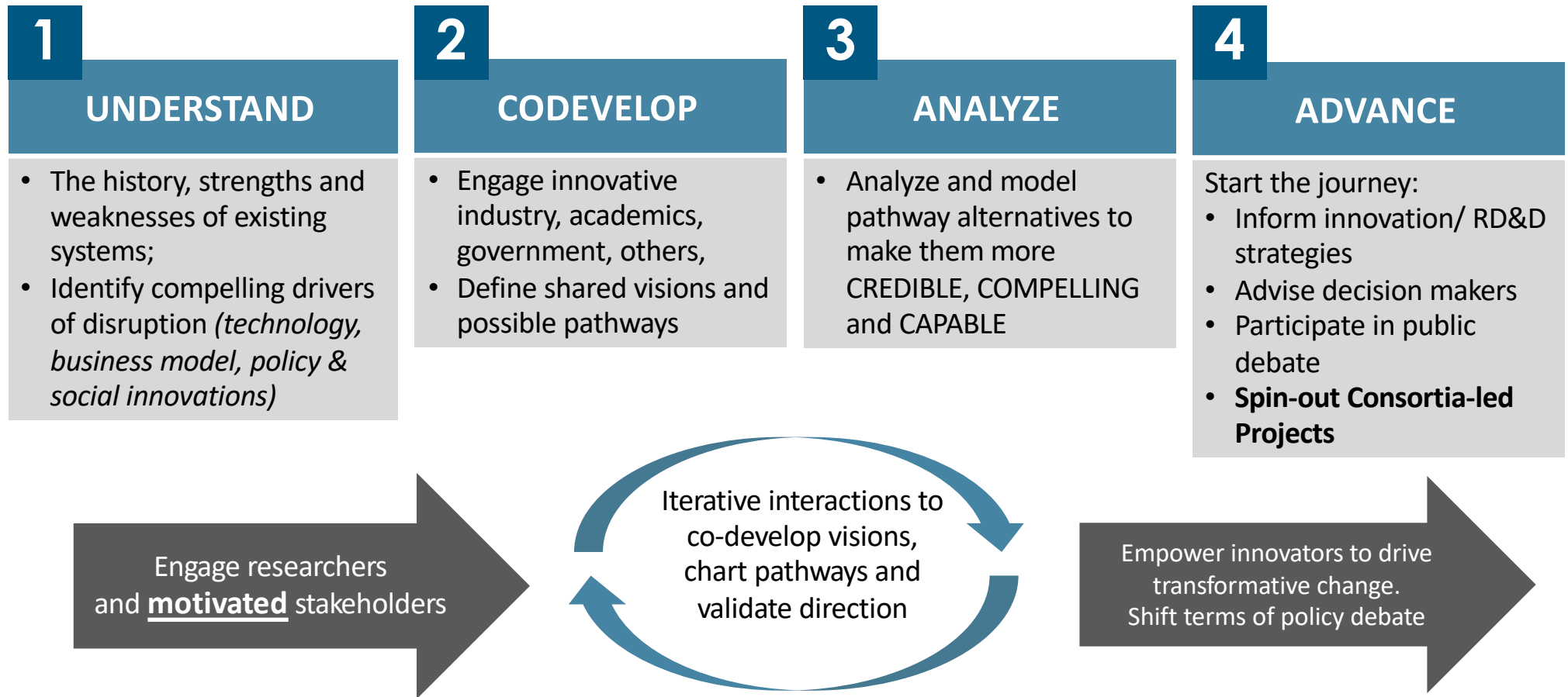
"We cannot predict the future, but we can invent it"

Dennis Gabor, Nobel Prize in Physics (1971)



<https://www.transitionaccelerator.ca/blueprint-for-change>

Transition Accelerator Methodology



TRANSITION PATHWAYS

- The sequence of actions (*technology deployments, investments, policies, etc*) needed to achieve a desired end point;
- Pathways differ for regions and sectors across Canada; they must be purpose-built;

Accelerator Initiatives:

1. Cross border electricity trade;
2. Autonomous Vehicles on Demand;
3. Agrifood sector;
4. **The Hydrogen Economy.**





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TOWARDS A NET-ZERO CANADA

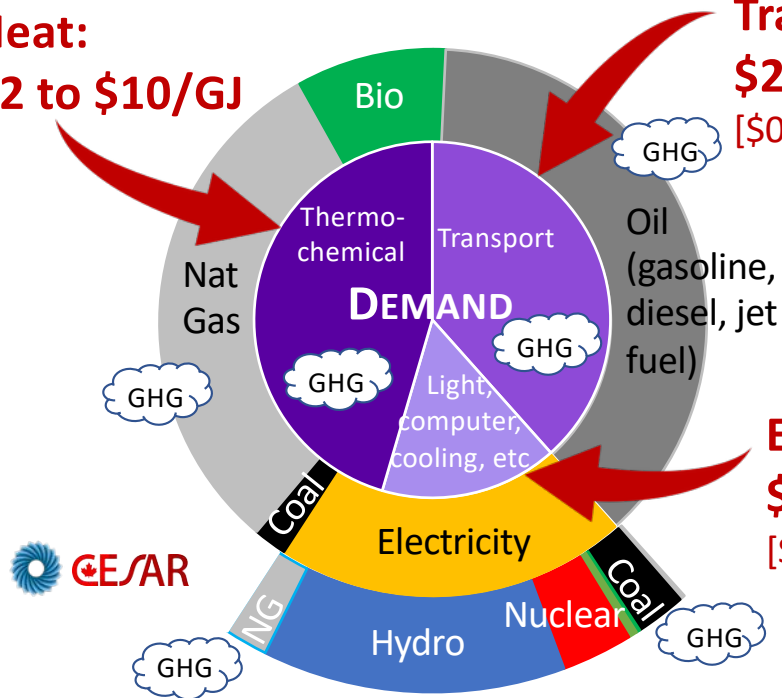
Today's Energy Systems:

Cdn End Use Demand: ~8000 PJ/yr

Heat:
\$2 to \$10/GJ

Transportation:
\$25 to \$38/GJ
[\$0.90 to \$1.30/L]

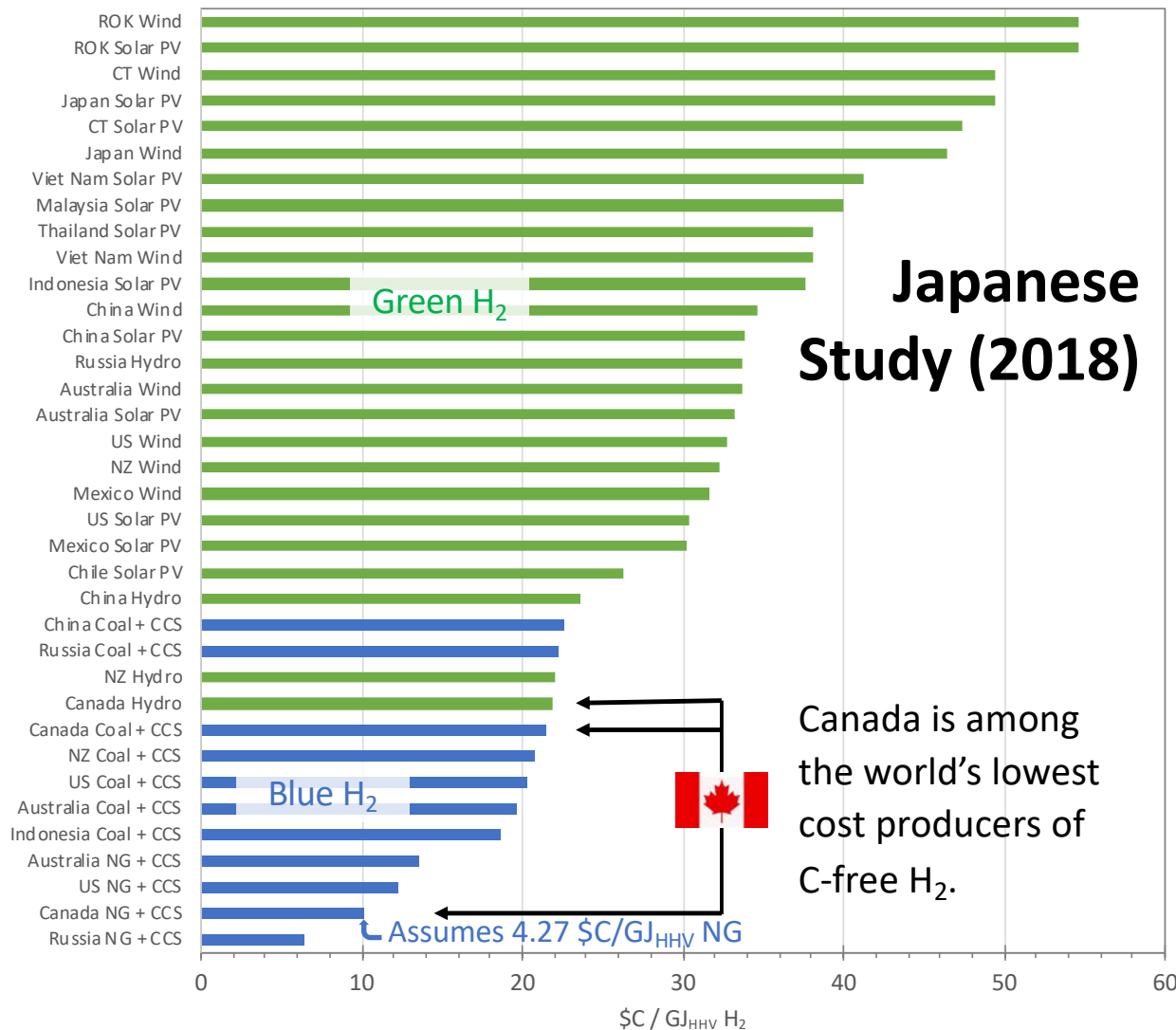
Electricity:
\$14 to \$28/GJ
[\$50 to \$100/MWh^e]



To get to net-zero:

- ☐ Stop combustion of distributed, end-use C fuels:
 - Vehicles, homes, etc
 - Replace with low C electricity if poss.,
 - ...or zero-emission fuel (hydrogen) if that better fits demand
- ☐ Dramatically reduce emissions from fuel & power production;
- ☐ Use negative emission technologies to get to net zero

... Start by focusing on transportation fuels since their high value makes them an easier target for alternatives...

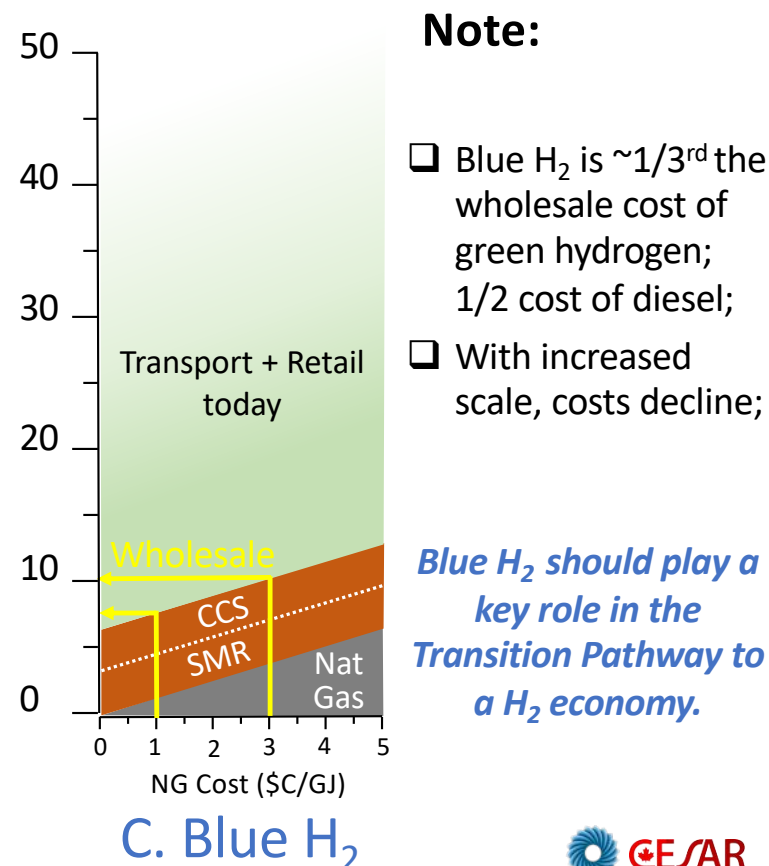
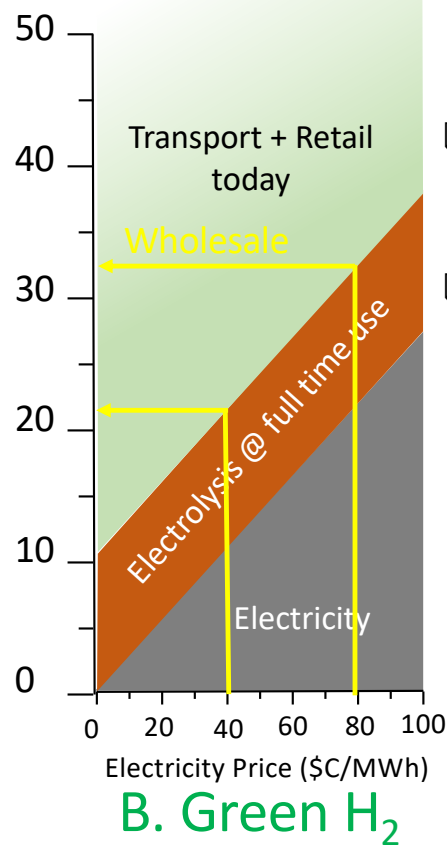
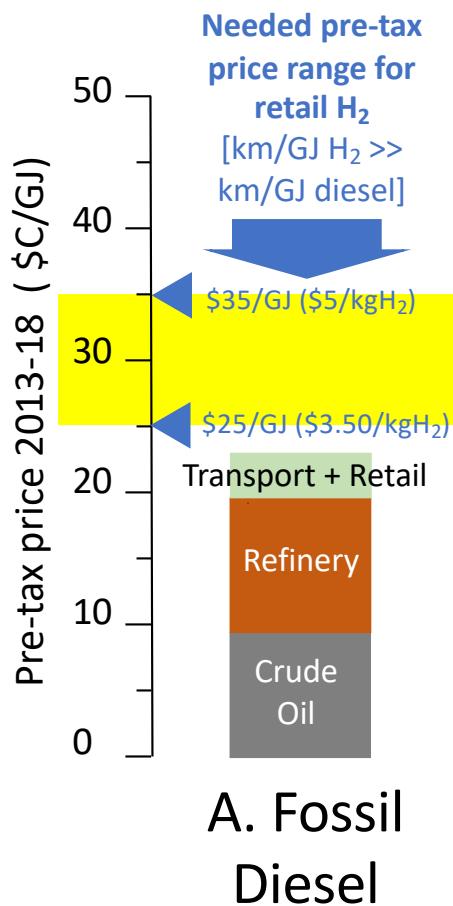


Alberta & Canada: Internationally recognized as among the lowest cost producers of C-free hydrogen

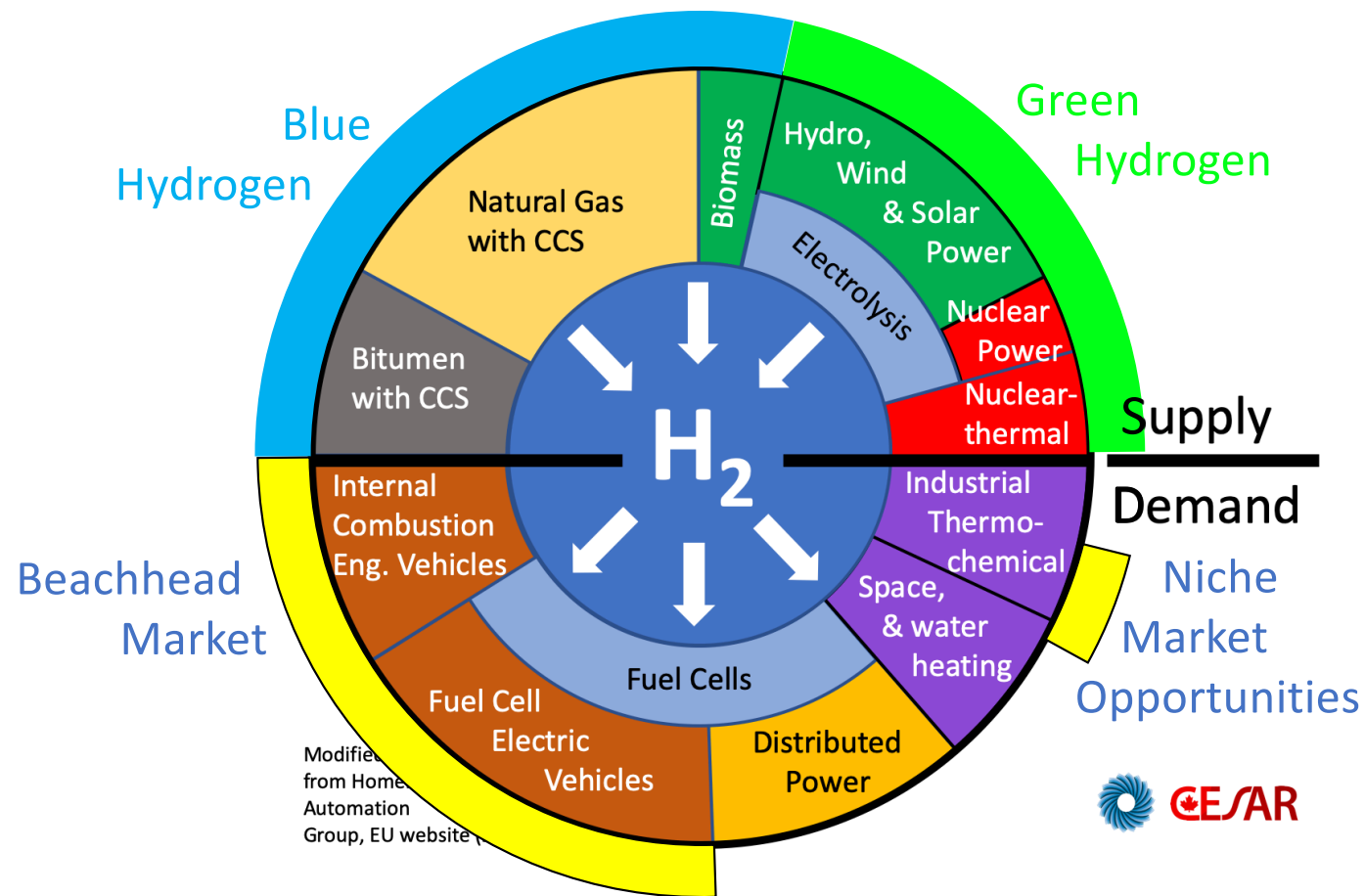
*The Japanese are interested
in importing liquid H₂ :
300,000 t/yr by 2030*

From: Asia Pacific Energy Research Centre. 2018. Perspectives on H₂ in the APEC Region. (Figure 3.4)
<https://aperc.ieeej.or.jp/file/2018/9/12/Perspectives+on+Hydrogen+in+the+APEC+Region.pdf>

HYDROGEN (H₂): COST COMPARISON WITH FOSSIL DIESEL



A HYDROGEN ENERGY SYSTEM





OUR APPROACH

1. Start with diesel / heavy freight market: Prove that HFCE works for sector

- | | | |
|--|---|--|
| WHY
DIESEL &
FREIGHT: | ✓ | Diesel prices (per GJ) are higher than electricity or heat |
| | ✓ | Concentrated demand corridors |
| | ✓ | Engaged sector |



AZETEC

ALBERTA ZERO-EMISSION TRUCK ELECTRIFICATION COLLABORATION

AN INDUSTRY-LED, \$15M CONSORTIA SUPPORTED
BY EMISSIONS REDUCTION ALBERTA WITH \$7.3M.

Funding Support:

EMISSIONS
REDUCTION
ALBERTA



The Transition
Accelerator

Fueling System:



HTEC
Hydrogen Technology & Energy Corporation

Lead Applicant:



Alberta Motor
Transport Association

Vehicle Design, Components and Manufacturing:



nordresa



Carriers:



Research, GHG Accounting and Commercialization: Project Management:



UNIVERSITY OF
CALGARY



CESAR
CANADIAN
ENERGY SYSTEMS
ANALYSIS RESEARCH



energyfutureslab

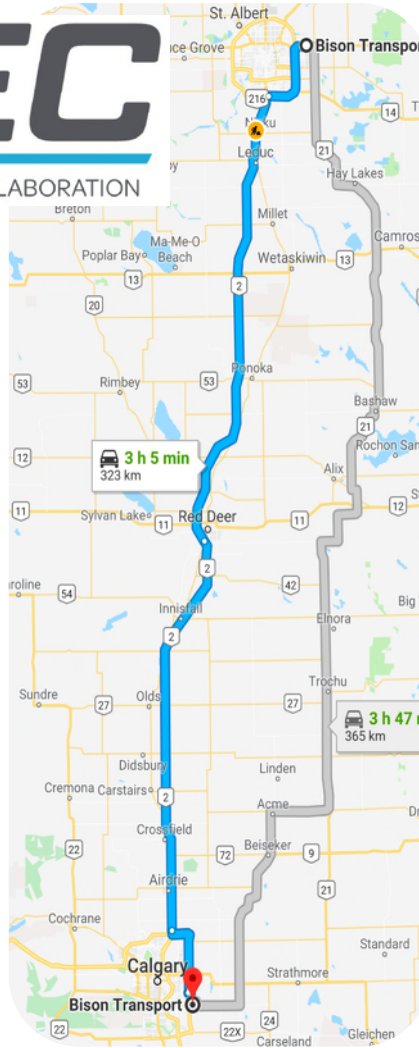
POWERED BY THE NATURAL STEP CANADA



ZEN
and the art of
CLEAN ENERGY
SOLUTIONS

AZETEC

ALBERTA ZERO-EMISSION TRUCK ELECTRIFICATION COLLABORATION



Two HFCE Class 8 Trucks

- ✓ Heavy Weight (63.5 t gross) B-Train
- ✓ 700 km (Edm→Calg, return) between refueling
- ✓ Zero Tailpipe Emissions

Timetable:

- ✓ Design & Build: July 2019 to June 2021
- ✓ Test on Road: July 2021 to Dec 2022

H₂ Produced from AB natural gas:

- ✓ Steam Methane Reformed (no C mgmt.)
- ✓ Cascade Refueling

Industry Led



- ✓ By AB Carriers under real-world conditions



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2. Build Supply and Demand at Scale and with Coordination

- | | | | |
|----------------|---|----------------|---|
| SUPPLY: | ✓ Low cost feedstock (NG); | DEMAND: | ✓ HFCE Trucks (when commercially available) |
| | ✓ Low cost 'blue' H ₂ , near demand centres; | | ✓ H ₂ blends with diesel in existing vehicles |
| | ✓ Potential for pipelines | | ✓ H ₂ to decarbonize NG pipelines & power gen |
| | | | ✓ Ind'l uses of blue H ₂ (bitumen, NH ₃ , steel...) |



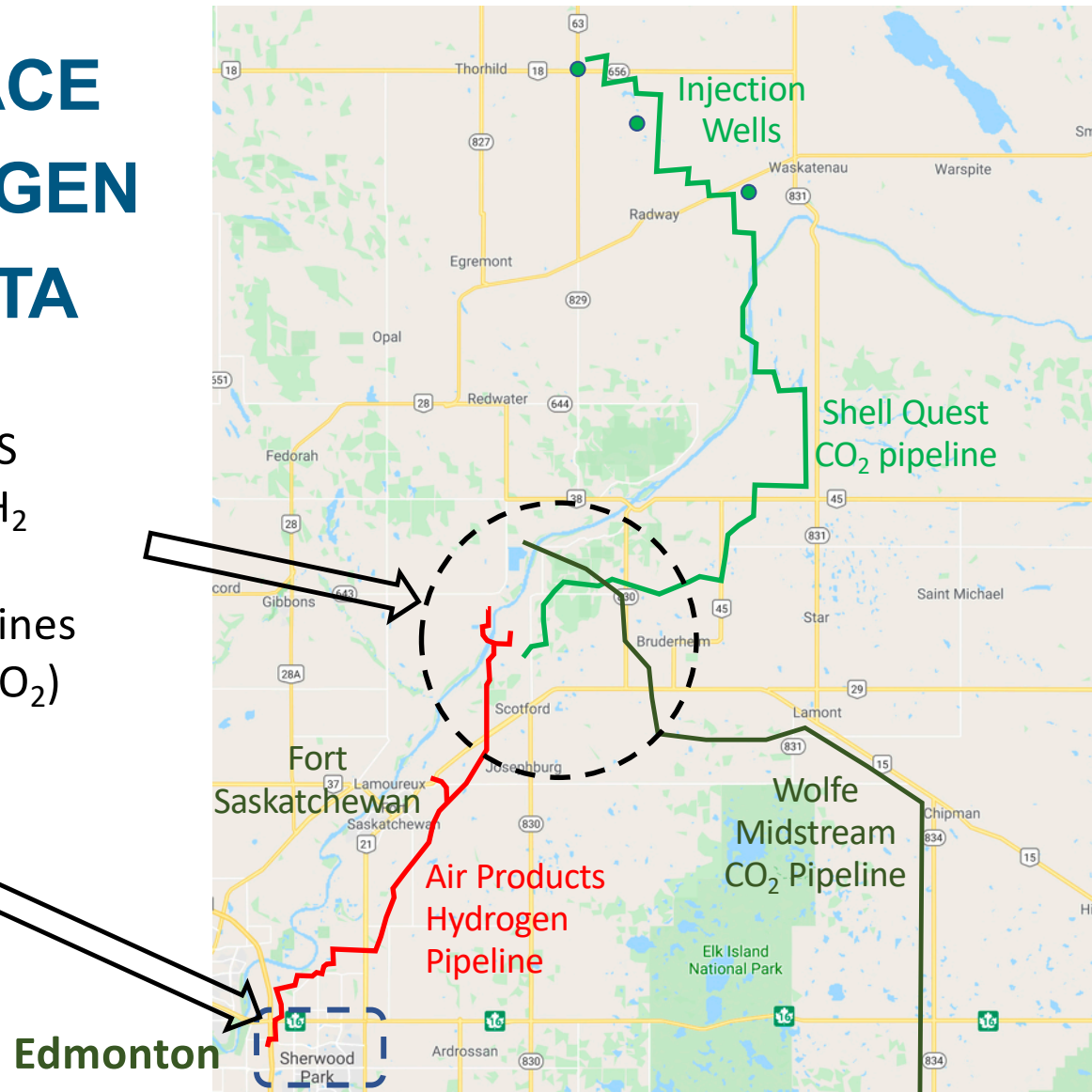
THE IDEAL BIRTHPLACE OF A VIBRANT HYDROGEN ECONOMY IN ALBERTA

'Blue' H₂ Supply from NG-SMR with CCS

- ❑ Put H₂ into pipeline @ ~\$1.5/kg H₂ (\$10/GJ)
- ❑ Put CO₂ into one of the CO₂ pipelines (includes CCS cost of \$35-\$55/t CO₂)

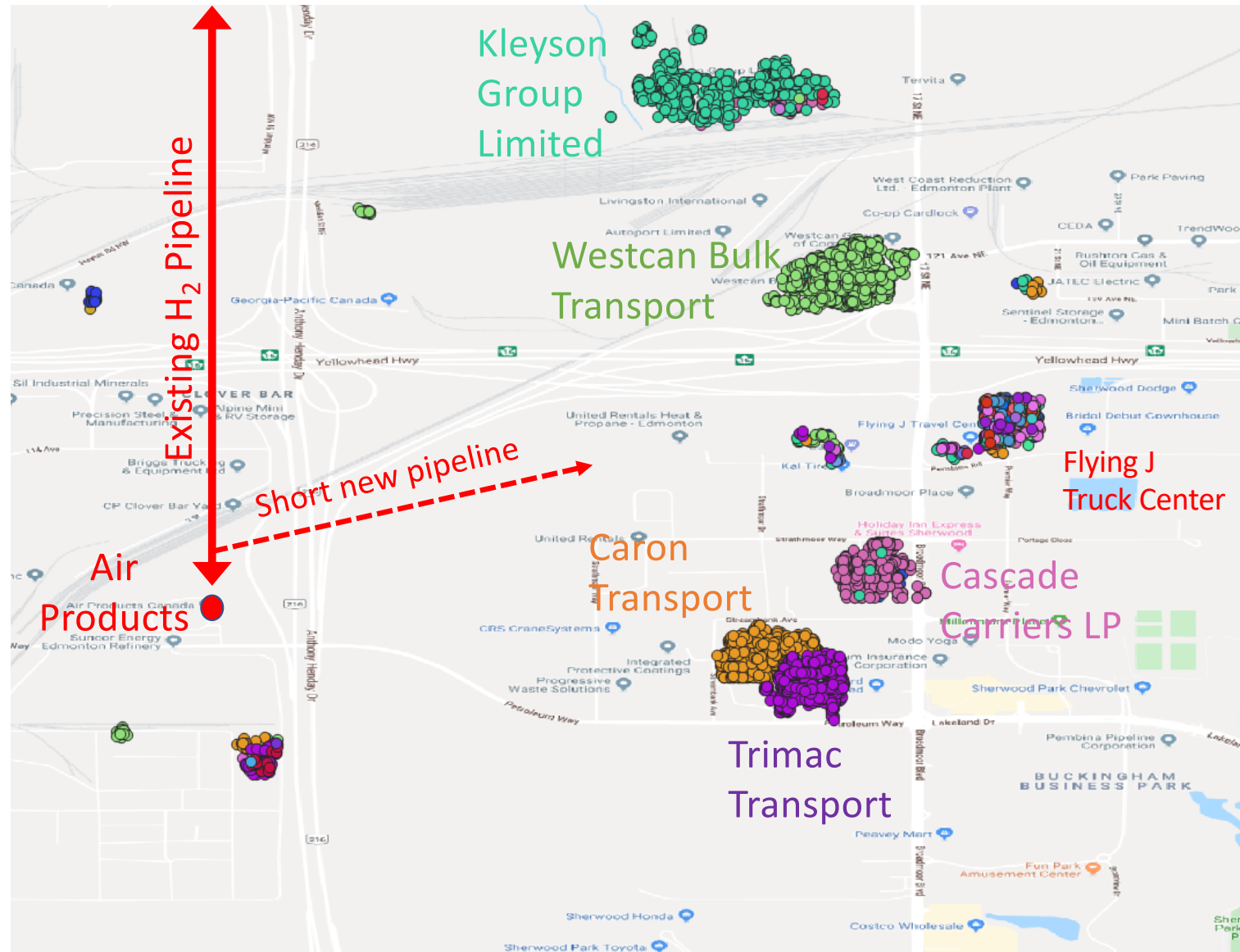
'Blue' H₂ Demand

- ❑ Wholesale price @ ~\$2-\$2.5/kg H₂
- ❑ Retail price out-competes diesel
- ❑ Meet clean fuel standard



DEMAND CENTRE NEAR H₂ PIPELINE

- Dots show GPS location of parked trucks
- Different colours for each company



H₂-Diesel Bi-fuel Trucks

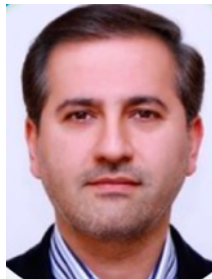
Technology Providers:



**U Alberta researcher experts to
validate, report, improve**



Dr. Bob Koch



Dr. Vahid Hosseini

- ☐ Diesel Vehicle Retrofit
- ☐ On board tanks @ 350 bar (similar to HFCE)
- ☐ Typically provides 30%-40% of the fuel energy from H₂
- ☐ In Alberta, H₂ cost could be lower than Diesel
- ☐ Companies Claim:
 - 90% reduction in particulate emissions
 - ~50% reduction in NO_x
 - 30-40% reduction in CO₂ emissions
- ☐ If H₂ not available, vehicle runs can run on diesel alone (lower risk than HFCE)
- ☐ Conversion cost: *(Getting details)*

H₂-Diesel Bi-fuel Trucks

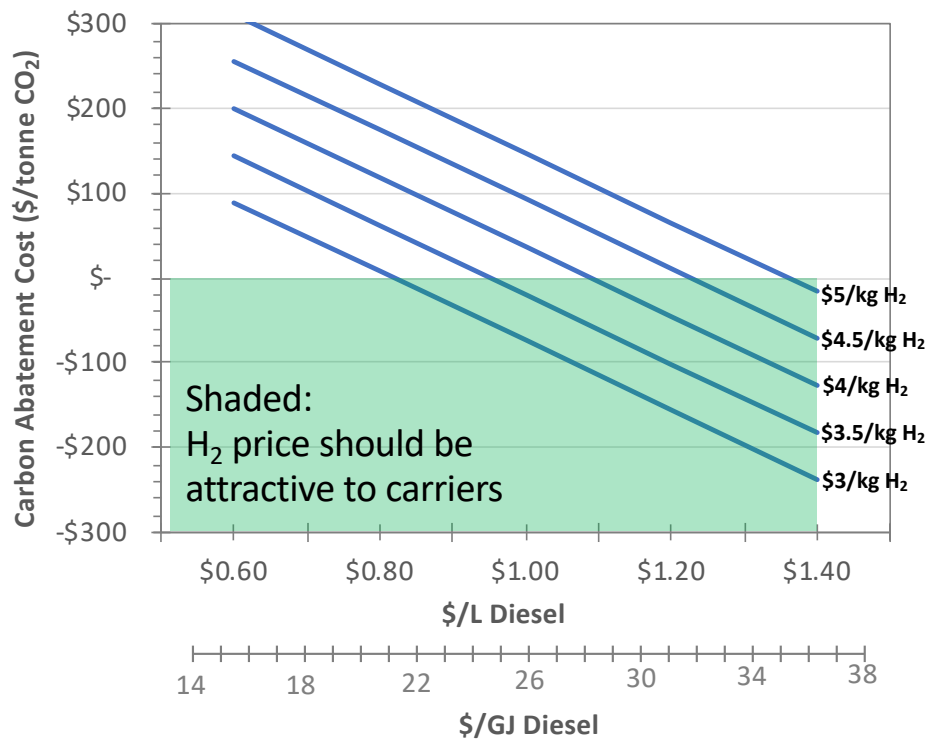
Strategic Role in a Transition Pathway

- ☐ Potential for rapid growth of H₂ demand to justify infrastructure investment on major corridors;
 - ☐ Fueling Stations ☐ Blue hydrogen production
 - ☐ Vehicle retrofits ☐ Pipelines ☐ Vehicle Storage Tanks
- ☐ Once fueling stations are in place, there is potential to attract and grow HFCE OEMs and vehicle fleets;
- ☐ Creation of cost-effective hydrogen fueling infrastructure;
- ☐ With gov't support, there is low risk and some benefits to freight sector;
- ☐ Potential to generate credits under the clean fuel standard;
- ☐ Increase comfort of industry in working with hydrogen.

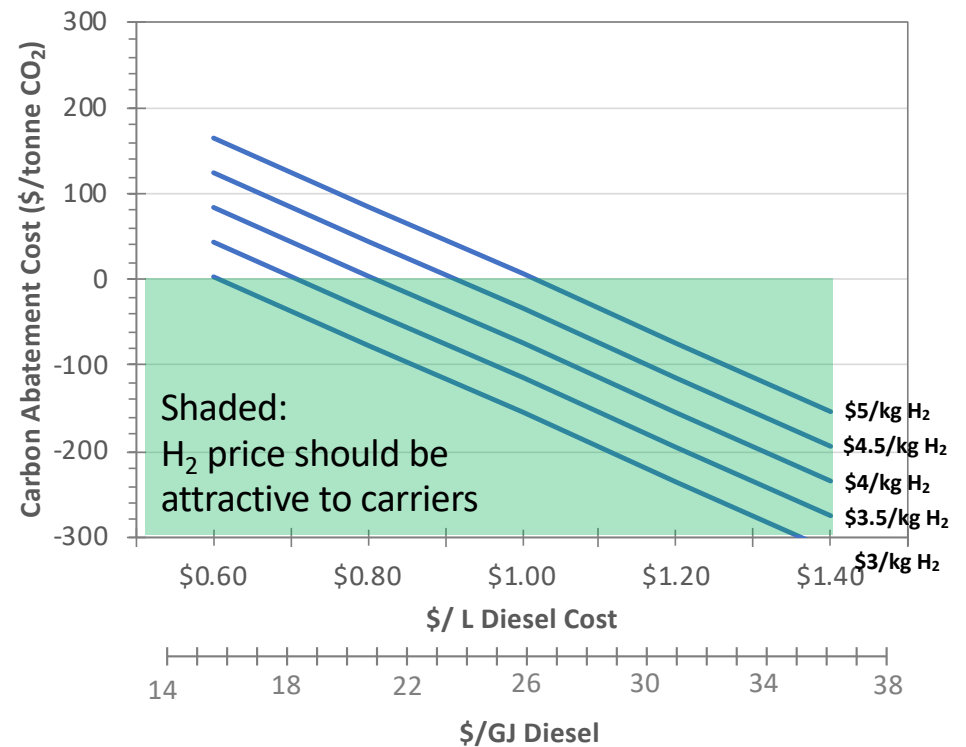


CO₂ Abatement Cost of H₂ Alternatives to Diesel

H₂-Diesel Bi-Fuel Vehicle



H₂ Fuel Cell Electric Vehicle





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3. Grow Supply and Demand along Transportation Corridors

- ✓ Scale is critical to preserve economics & attract investment
- ✓ Remember: Net Zero by 2050 (*don't be shy...*)

BUILDING A HYDROGEN ECONOMY



STRATEGY: Engage...

1. Demand

- ❑ 2 → 100 → 1000's trucks + trains etc
- ❑ Focus on major routes & return to base
- ❑ Link to other trends (e.g. autonomy)

2. Vehicle and OEM mfg's

- ❑ Reduce cost by scaling prod'n
- ❑ Invest in Alberta

3. H₂ producers / delivery agents

- ❑ Provide fuel for a limited number of strategically placed, high volume fueling stations (~2-10t H₂/day)
- ❑ Build on regional strengths for H₂ production / distribution

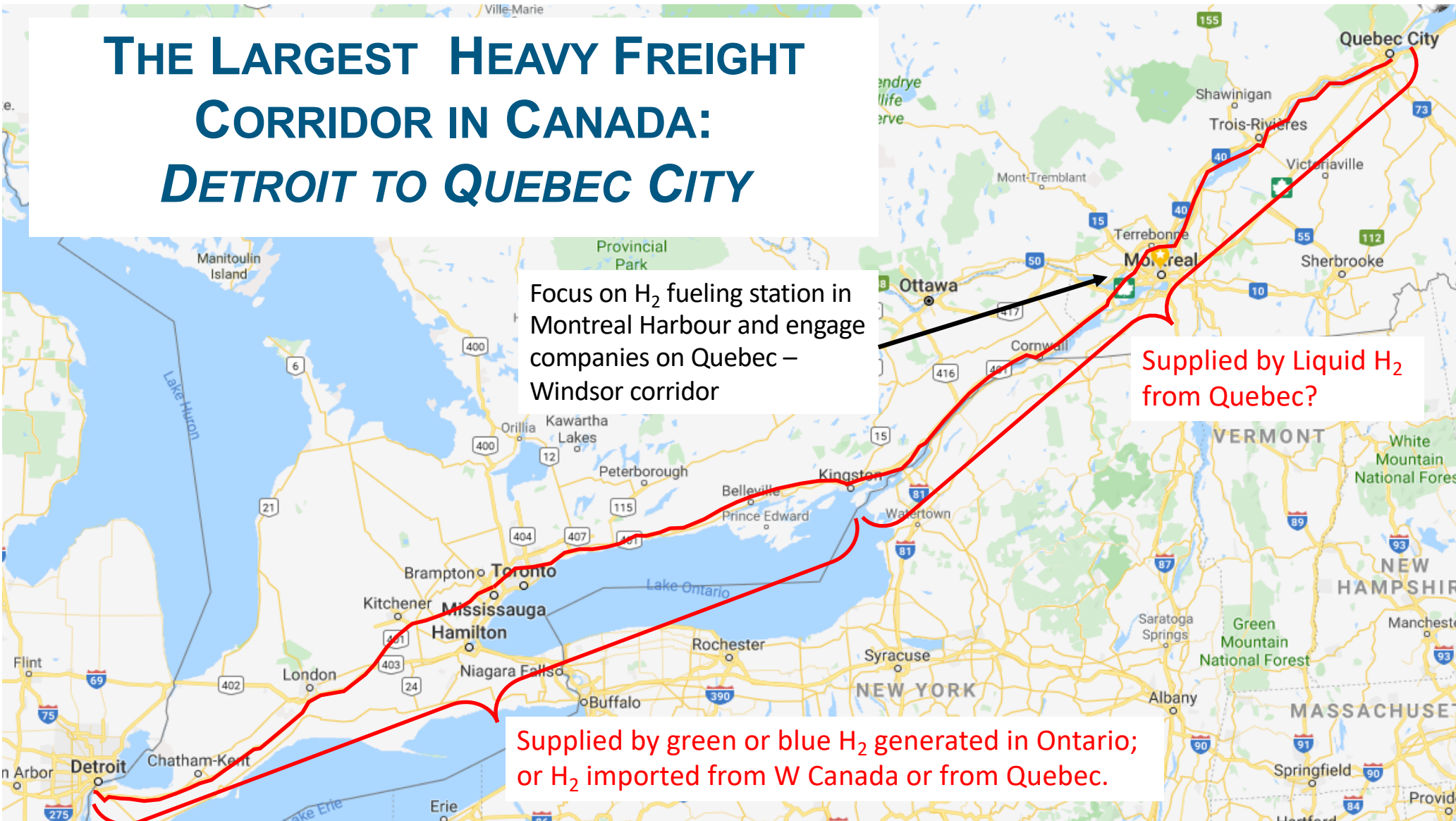
...through Pilots, Demonstration & Commercialization Initiatives

THE LARGEST HEAVY FREIGHT CORRIDOR IN CANADA: *DETROIT TO QUEBEC CITY*

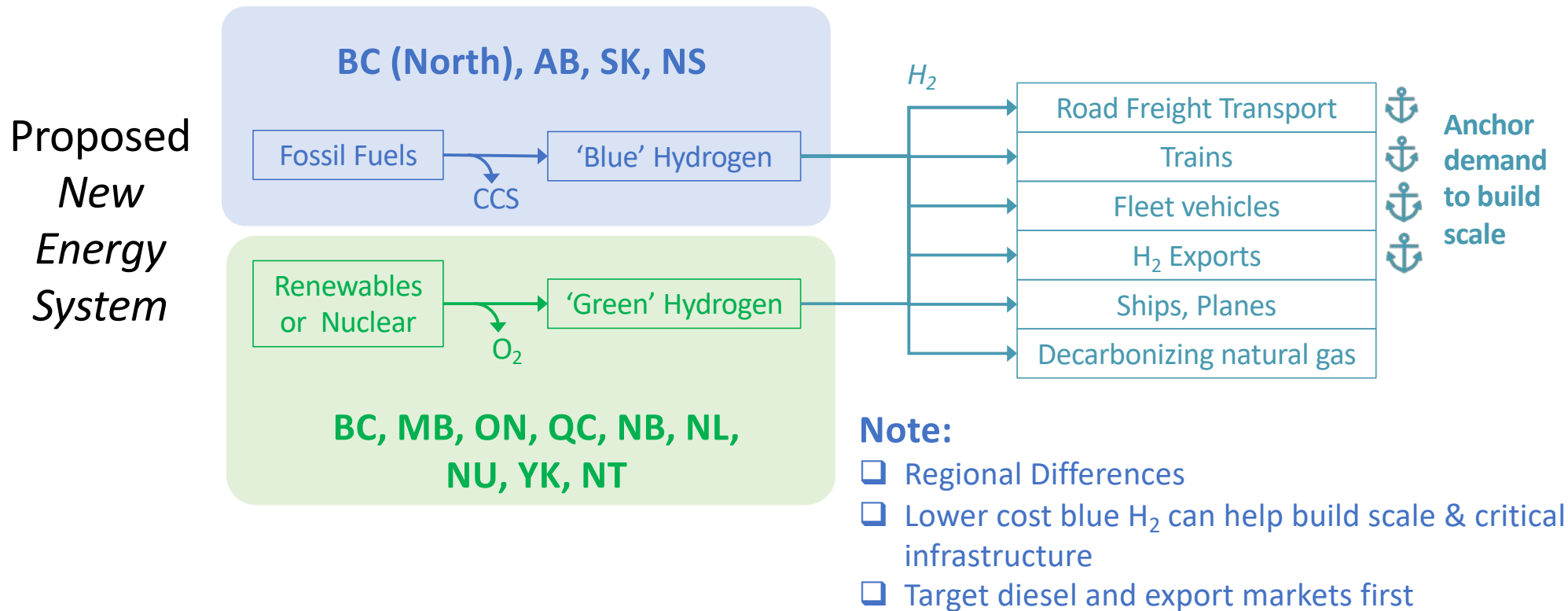
Focus on H₂ fueling station in
Montreal Harbour and engage
companies on Quebec –
Windsor corridor

Supplied by Liquid H₂
from Quebec?

Supplied by green or blue H₂ generated in Ontario;
or H₂ imported from W Canada or from Quebec.



OUR PROPOSAL: A H₂ ECONOMY ANCHORED BY HEAVY FREIGHT: *AN ENERGY SYSTEM THAT WORKS FOR ALL PARTS OF CANADA*



A HYDROGEN ECONOMY SHOULD ENABLE A LOW CARBON GRID

