Hydrogen Fleet Refuelling Infrastructure Ecosystem Studies

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H2GO AND CHANGE ENERGY SYSTEMS

HBCoC

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About H2GO

- H2GO Canada is a not-for-profit corporation created to accelerate the development of markets for hydrogen as a low-carbon transportation fuel in Canada.
- Philosophically our goal is to help create the correct “Ecosystem” for the deployment of Hydrogen Vehicle Refuelling Infrastructure.
- As a Not-For-Profit H2GO will collaborate closely with HBCoC, CHFCA, Government, and Academia in achieving this goal.

Developing the Ecosystem

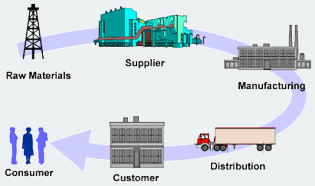
- Our 28 year Alt Fuel history has taught us that it is not enough to have:
  - Safe and reliable Hydrogen powered Vehicles
  - Safe and easy to use Hydrogen Vehicle Refuelling Facilities
  - A good (or even excellent) Economic Value proposition
- In order to successfully deploy an Alternative Transportation Fuel requires:
  - Comprehensive Regulations – backed by solid Codes and Standards
  - Government and public educated on the safety, benefits, and limitations
  - Market outreach that clearly communicates the full Value Proposition
  - A well established Vehicle supply chain and Servicing network.
  - A properly deployed Fuel supply chain and Refuelling network.
  - Well established Station Installation and Service capacity.
  - A properly trained and resourced workforce
  - This is a woefully incomplete list…

Recent work

- Over the past 8 months NRCan engaged H2GO to complete two reports:
  1) Modelling and Analysis of Hydrogen Vehicle Applications for Canadian Transportation
     - Discussed at the HBCoC meeting at U of T last November
  2) Analysis of Cross Sector Integration of Hydrogen and Fuel Cell Technologies in Canada
- These reports are in support of NRCan's work toward the development of a comprehensive Hydrogen Vehicle Deployment Pathway study.

#1 Modelling and Analysis of Hydrogen Vehicle Applications

- Since the 1990s members of the H2GO team have been engaged by Government, Industry, and Fleet Operators to evaluate the Life Cycle Techno/ Economic Value Proposition of many Alternative Fuels across a variety of:
  - Regions and markets
  - Vehicle Platforms
  - Fleet Applications
  - Fleet Sizes, and
  - Fuel Supply Chains.



- The model provides a Triple Bottom Line Value Proposition based on:
  - Economics – FVI incorporating all Fuel, Infrastructure, Vehicle, Capital and Operating costs - enables comparison of diverse markets and fuels
  - Net GHG emissions reductions (coupled with a growth model and GHGenius)
  - Direct Job Creation (coupled with a **growth model**)

Model Considerations

- The Modeling draws upon extensive experience in the Design, Project Management, and Operation of ~200 refuelling stations for Natural Gas and Hydrogen vehicle fleets (typically about 10/year). Ranging from 20 Fork Lifts to >600 Transit buses

- The Modeling Provides:
  - Direct comparison of fuels across different regions, vehicle platforms, applications, and fleet sizes
  - Regional Market Level to Individual Fleet Level
  - A 10 year outlook including forecasts of input values and growth scenarios
  - Costs and resources required to get from Here… to There.
  - Triple Bottom line based on specific End User Needs and Values (Economic, Environmental, Social)

Modeling Considerations

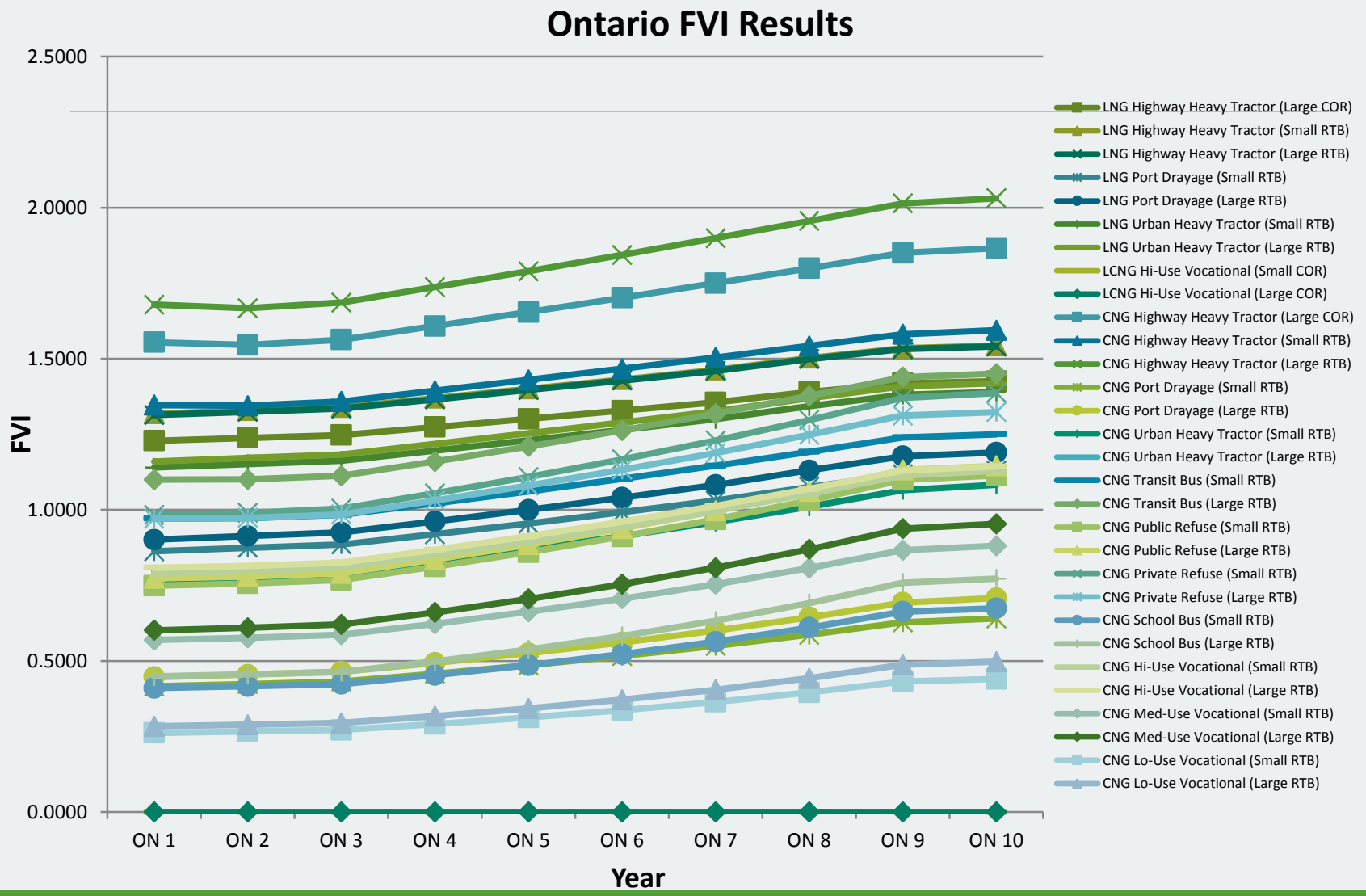
- The Modeling Includes:
  - Fleet location, size, and rate of Fleet deployment/replacement
  - Refuelling mode: Cascade, buffer, slow fill, private on-Site, retail forecourt
  - Fuel sources, blends, and modes of delivery
  - Local/Regional Regulations, and Costs of: Utilities, Fuel, Equipment, Construction, Manpower
  - Maintenance schedules
  - Miscellaneous costs such as training, insurance, resale values, etc.
  - Cost of facilities modifications (Maintenance bays, garages, etc.)
  - Policy Programs: local and national

Hydrogen applications considered in the Modeling

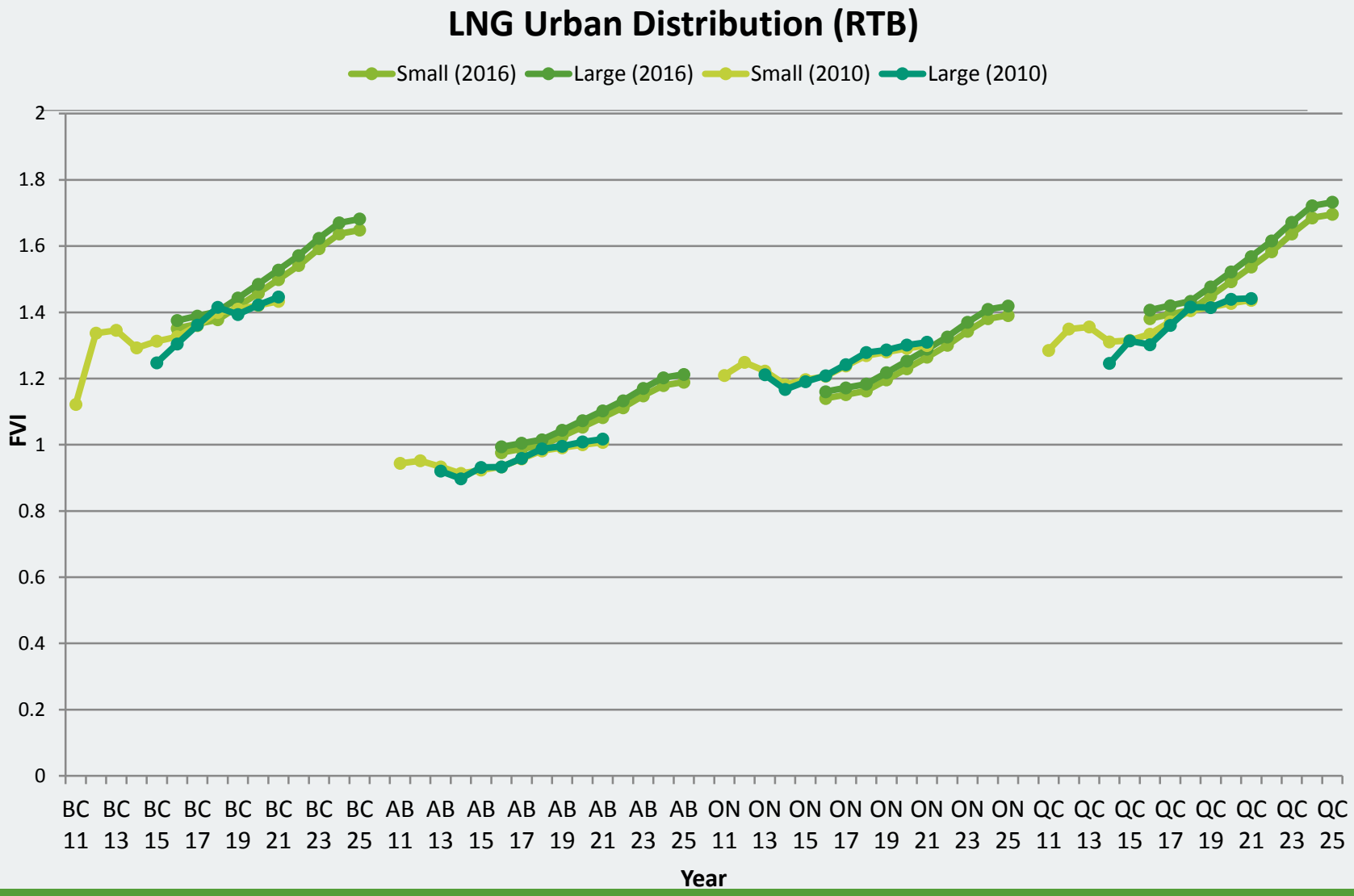
- Applications are many and varied with different operational demands and sustainability goals
  - Each end user has requirements related to economic value, Power, Range, Refueling time, Convenience of Refuelling infrastructure, and values placed on GHG/CAC emissions and Societal benefit

Application	Fleet Size	Mileage (km)	Consumption (kg/year)	Rank	Average FVI
Electrolytic Hydrogen Stations					
Forklift (RTB)	Small – 20 Large – 100	12,000	425	1	0.78591
Med/Heavy-Duty Commercial (COR)	Small – 40 Large – 250	60,000	1,773	2	0.36525
Med-Duty Commercial (RTB)	Small – 40 Large – 250	50,000	1,279	3	0.31822
Long-Range Personal (COR)	Small – 40 Large – 250	30,000	290	4	0.21157
Med-Duty Personal (RTB)	Small – 40 Large – 250	20,000	261	5	0.13950

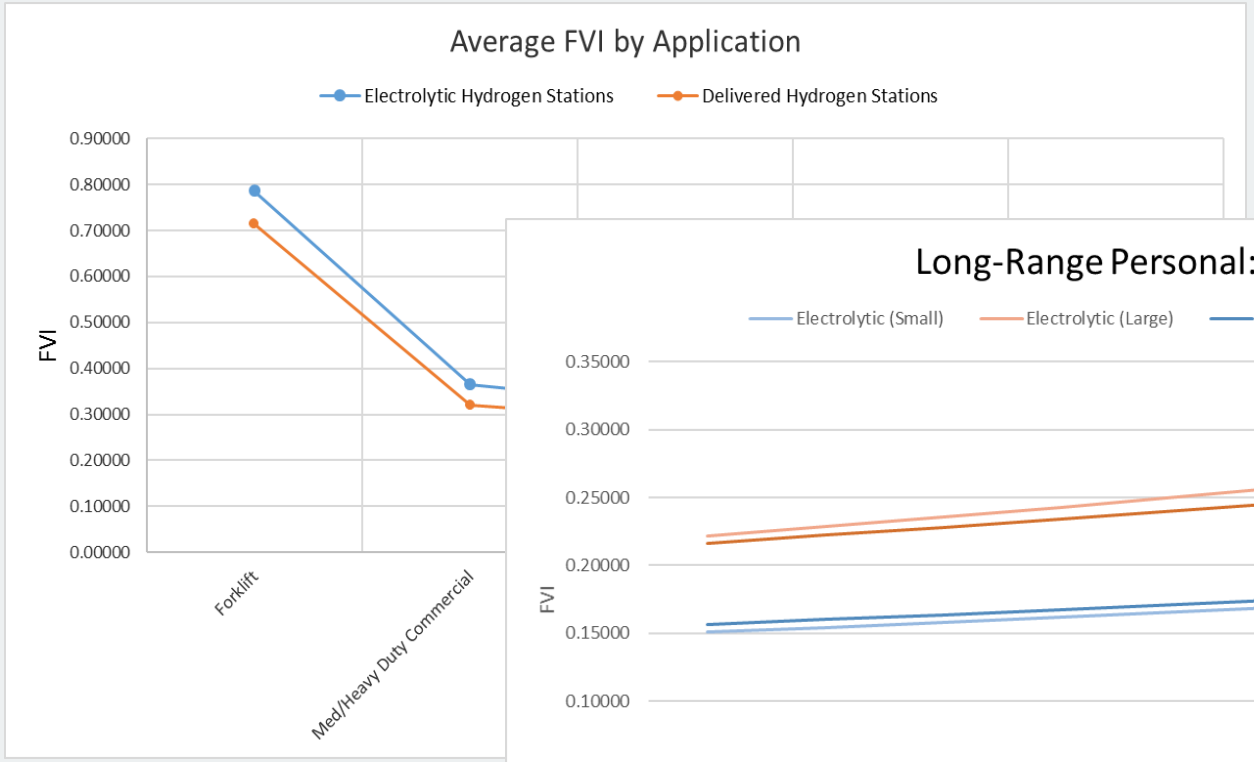
Modelling Results – 10 Year Window

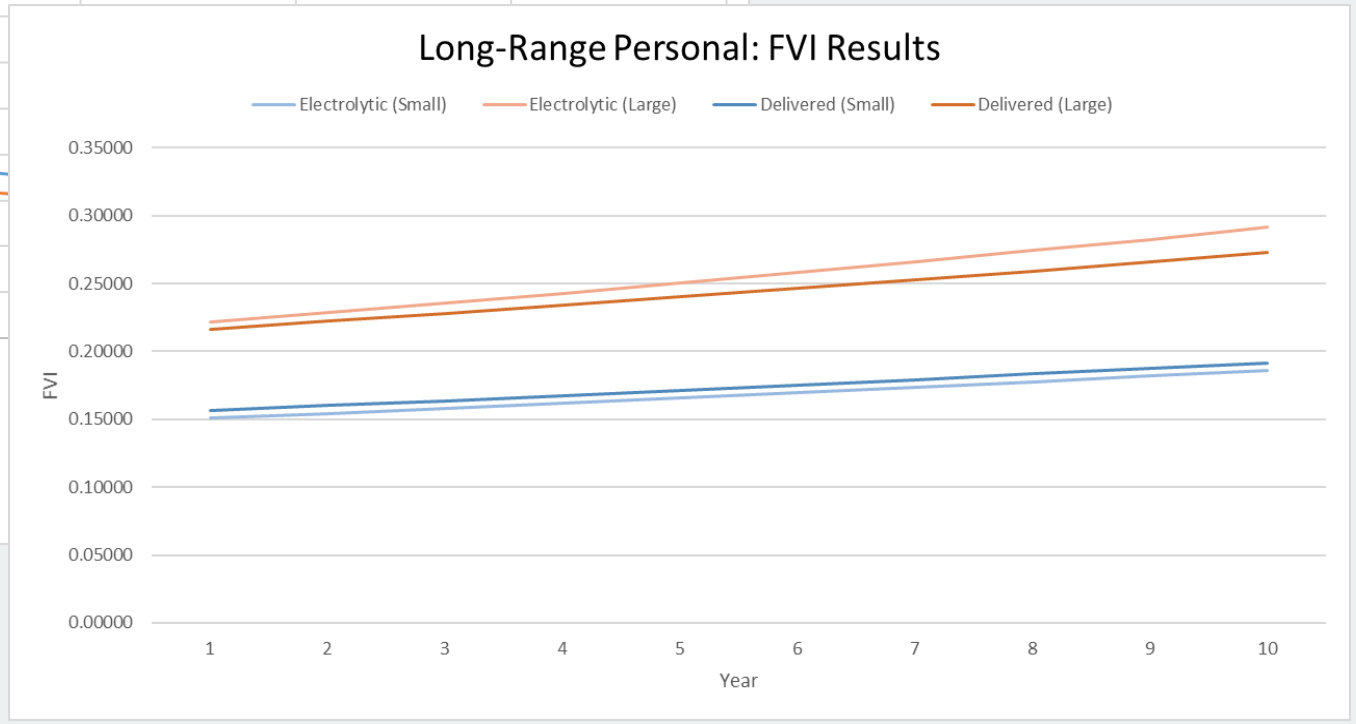


Modelling Results



Sample Results





Conclusions from the modeling exercise

- Realistic cost targets: that a $ minimum currently occurs at a fuel cost between $2/gLe and $4/gLe (vehicle efficiency-corrected).
- Infrastructure design break points: In Ontario, delivered hydrogen is cheaper for loads of up to 25 - 75 vehicles/day. Then on site production is cheaper.
- Value Drivers: Although FVI is the most tangible market driver, other value drivers must also be considered. E.g.; passenger vehicles place value on convenience
- Bus and rail transit applications were not included in this analysis. It is expected that hydrogen will fare well base on the economic FVI augmented by government GHG reduction goals.
- Municipal landfills, ADs, and WWTPs can Methane as a feedstock for SMR hydrogen production yielding a very low (or negative) carbon footprint.
- Full market deployment requires retail hydrogen stations deployed on inter-urban corridors have high commercial risk and will require policy support for development.

#2: Cross Market Synergies – Back Ground

- Hydrogen Fleet Refuelling Infrastructure is not Stand Alone – rather it will be part of a broader Hydrogen Market
- Purpose of the report: To provide a baseline catalogue of cross-sector hydrogen applications and discuss synergies with the large scale deployment of HFCVs and Refuelling Infrastructure.
- The report identifies and assesses these cross sector synergies by examining various:
  - Hydrogen Sources
  - Supply chain pathways
  - Hydrogen end-uses

Cross Market Synergies - Method

- The preliminary assessment involved:
  - Discussions with subject area experts from government (2), NGOs (4), industry (4), academia (3)
  - Additional research and review of current literature.
  - These interviews and reviews enabled development of a qualitative assessment of Cross-Sector Opportunities and Challenges

Cross Market Synergies - Findings

- The report includes:
  - A catalogue of hydrogen:
    - Sources: waste H_2 collection, electrolysis from P2G systems, electrolysis, SMR, etc.
    - Delivery Pathways: On-site (wire or natural gas), truck (gaseous, liquid), pipeline, etc.
    - Uses: Industrial, stationary power, district heating systems, etc.
  - A "Complementarity Table" which provides:
    - An overview of the opportunities and challenges of multiple use deployment in a Canadian context, and
    - A high-level analysis of potential synergies among complementary applications.

Cross Market Synergies – Findings

- High Level Findings (Details to follow!):
  - Sources of low-carbon hydrogen for on-road vehicle use, in scalable volumes were identified.
  - Economic synergies varied depending on the localized H_2 supply and vehicle mix.
  - A limited number of supply chain alternatives were identified that could be readily realized.
  - Expanding the market for hydrogen, overall, by integrating a range of end-uses generated some strong logistical and economic synergies. However, these still face technology and infrastructure deployment challenges.

Cross Market Synergies – Recommendations

- Recommendations for further action include the following:
  - Conduct industry-wide focus groups to review the assessment results, and further explore the most promising opportunities.
  - Conduct a quantitative analysis of the most promising cross-sector opportunities to assess the volume/cost potential for FCEV hydrogen supply.
  - Regularly update the “Complementarity Table” . Industry may use this as an information tool to help self-identify cross sector opportunities in support of FCEV deployment.
- ***The two reports discussed here will feed into NRCan’s “Hydrogen Pathway Study” which is anticipated to be undertaken later this year… Stay Tuned!***


THANKS