Canada's Hydrogen and Fuel Cell Sector

Hydrogen & Fuel Cell Symposium
Vienna, Austria
November 23rd, 2020

Mark Kirby
Pres/CEO, CHFCA

CHFCA
Clean. Efficient. Energy.

Sponsoring Members

Cummins

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

NRC · CNRC

Introduction

Mark Kirby, President & CEO – Appointed August 2019

Private sector background:

S2G / Fortress (biotechnology/H_2)
Ballard Power (fuel cells)
Questair (hydrogen purification)
Praxair (global industrial gases)

Expertise: Commercializing clean technology

Agenda

- CHFCA
- Members and Capabilities
- H2/FC Activity in Canada
- Why Hydrogen?
- What is Needed to Commercialize
- Examples of Commercial Projects
- Investing in Canada

Overview of the Canadian Hydrogen and Fuel Cell Association

CHFCA
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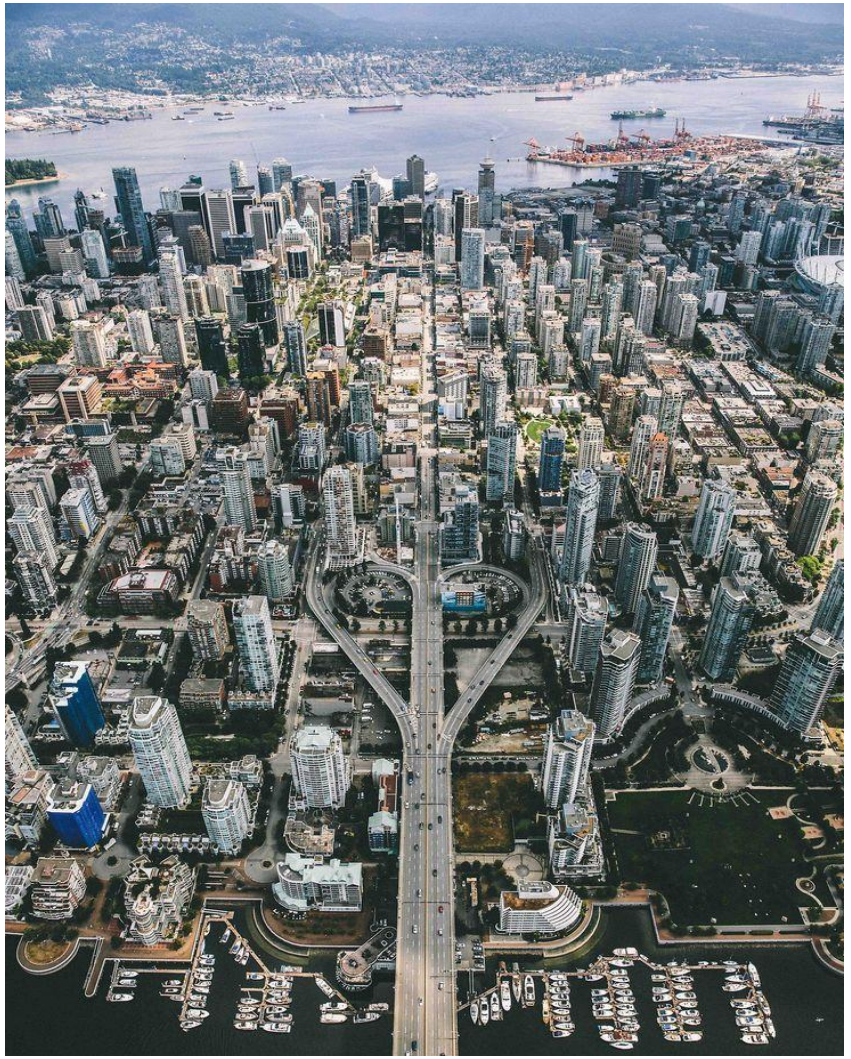
- **National association** representing the hydrogen and fuel cell sector in Canada
- **Headquartered** in Vancouver, British Columbia
- One of the senior hydrogen associations globally
- **"Voice of the Sector" for Canada**: Government relations, market development and trade, education and outreach, member networking and support
- **Vision:** Accelerate hydrogen energy, to help communities and industries thrive while transitioning to a clean, carbon-neutral world, and to grow Canada's leading hydrogen energy and fuel cell companies.



Member Companies of the CHFCA

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Canadian Nuclear Laboratories / Laboratoires Nucléaires Canadiens

Cummins

NRC·CNRC

Executive

BALLARD

Hydro Québec

Powertech — The Power of Trust. The Future of Energy.

MESSER Gases for Life

TOYOTA

ENBRIDGE

FORTIS BC™

Industry

HTEC Hydrogen Technology & Energy Corporation

Air Liquide

GREENLIGHT INNOVATION

Hydrogen Optimized — Conceptualize. Commercialize. Scale.

ITM POWER Energy Storage | Clean Fuel

ILF CONSULTING ENGINEERS

UNILIA

Harnois

Earnscliffe Strategy Group

AVL

DAIMLER

Sacré-Davey ENGINEERING

GHD

HYUNDAI

intertek

Small Business

FILGO

Sonic

TERRESTRIAL ENERGY

RANGELAND ENGINEERING

dpoint technologies

DANA

EMCARA

LOOP

Terrella Energy Systems Ltd.

Blue-O Technology Inc. Since 2008

Palcan

NextHydrogen — Innovation in water electrolysis

IRDI SYSTEM

Hydrogen In Motion

QUADROGEN

TANDEM TECHNOLOGIES

nel

TESTNE ENGINEERING

xebec — A world powered by clean energy

SBI BIOENERGY INC.

PROTON TECHNOLOGIES

NORAM

Innovative Hydrogen SOLUTIONS

Academic

CERC Clean Energy Research Centre

UNIVERSITY OF TORONTO

SFU

RED RIVER COLLEGE

UNIVERSITÉ DU QUÉBEC À TROIS-RIVIÈRES — Savoir. Surprendre.

Consultant

A Truckenbrodt

Bennett Jones

ZEN Clean Energy Solutions

STRATEGY CORP

G Budd

Start-up

Gema Science

EKONA

HY2GEN

hydra

illuming power — energy innovation

I:NOMR

NU:IONIC TECHNOLOGIES

PLANETARY HYDROGEN

RH2C — Renewable Hydrogen Canada Corporation

Sauer Compressors USA

SYLAS Consulting Group

HYBRIZCEL

Member Capabilities

CHFCA
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FCEV Products

Fuel Cells, Products and Services for Transportation

Fuel Cells, Products and Services for Stationary Power

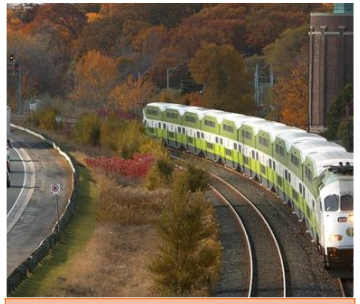
Hydrogen Supply

Hydrogen Production Equipment

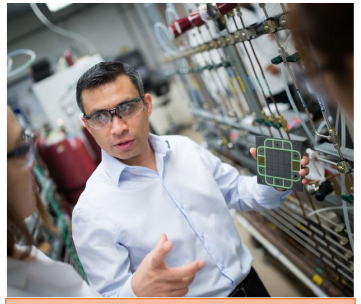
Hydrogen Fueling Stations

Leading Edge Technology Companies

Testing & Certification



Hydrogen Studies & Project Management



Research & Development

Member Activities

Canadian companies are involved in…

Commercial Fuel Cell Vehicle Sales	Fuel Cell Electric Vehicle Demonstrations	Hydrogen production	Distribution
• Forklifts • Buses • Med. duty trucks • Commuter trains • Cars • Hydrogen ICE conversions	• Drayage trucks • Heavy duty, long-haul trucks • Mine vehicles • Marine vessels • Freight rail • Aviation	• Electrolytic projects globally • Carbon capture • Sequestration • By-product capture	• Light duty hydrogen fuel stations • Gas blending • Pipelines • Storage

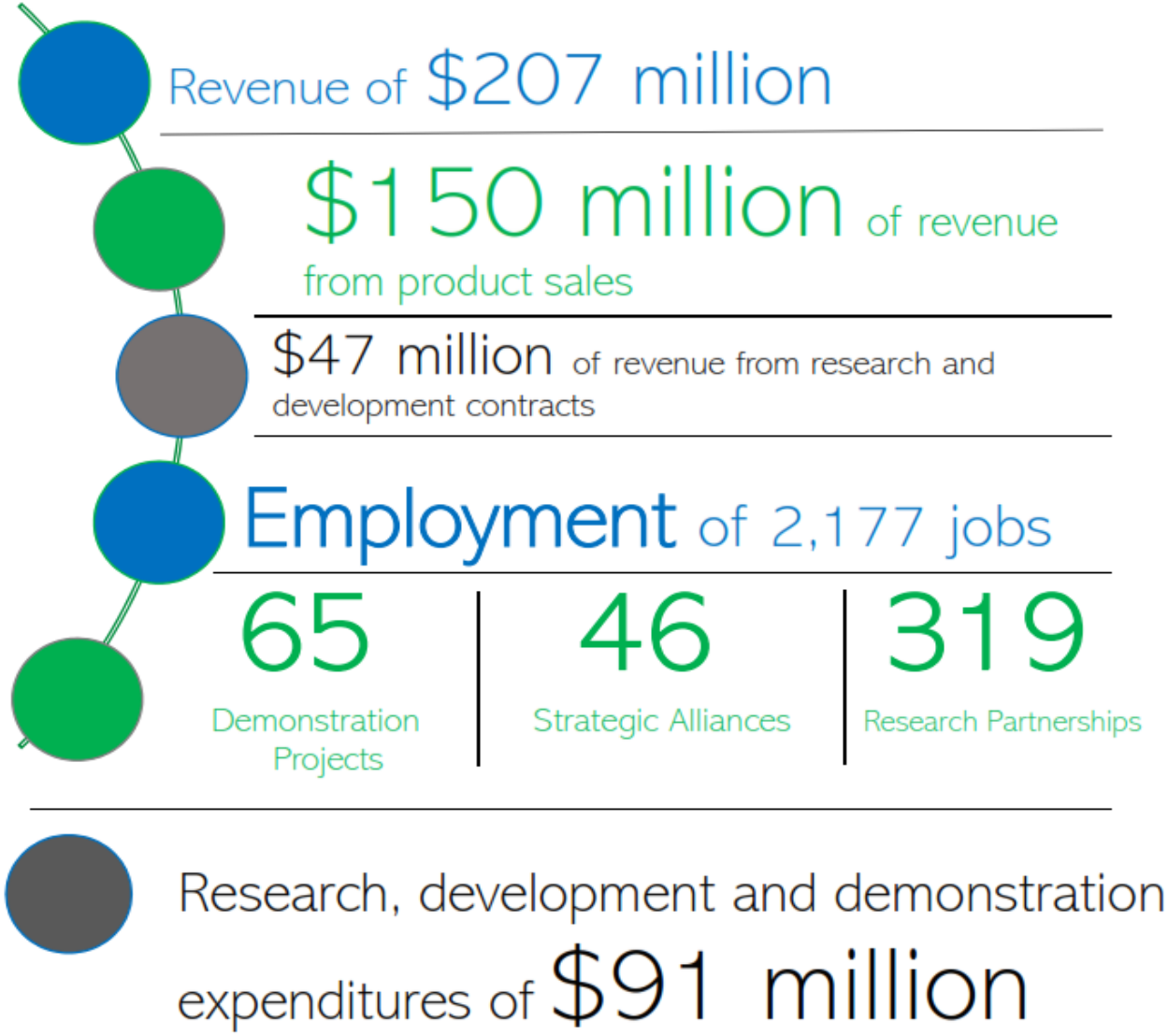
Canada Government Activities

Growing government support

Hydrogen Strategies	International Engagement	Policy	Funding

• **Hydrogen Strategy for Canada**
• British Columbia Roadmap
• Alberta Recovery Plan
• Ontario
• Quebec
• Maritimes
	• Clean Energy Ministerial Hydrogen Initiative
	• Codes & standards
	• Global Affairs
		• Net – zero 2050
		• Price on carbon
		• Clean Fuel Standard
		• Clean BC
		• BC & QC ZEV
		• Municipal ZEV & clean building targets
			• Federal
			  • NRCan programs
			  • ECCC
			  • NRC
			  • NSERC
			• Provincial recovery funds
			• New programs?

British Columbia



Fuel Cell Technology Exporting Powerhouse

Growing rapidly, attracting investment

Light-duty HFS (HTEC, Powertech)	•4 operating, 2 in construction, 10 in development
Hyundai & Toyota	•150+ light duty vehicles
McQuarrie / RH2C / FortisBC	•100 MW Power to Gas in BC
Volvo / Daimler	•HD fuel cell engine production in BC
Hydra, BC Chem, Truck Companies	•Byproduct H2, H2 ICE trucks •Working with Penticton Indian Band
FortisBC, BC Hydro, HTEC	•Power-to-gas, gaseous H2 distribution, HD port drayage

AVL Already In BC H_2/FC Cluster

AVL Office in Vancouver, BC

- Becoming a leading player in Canada
- R&D center
  - Established in 2018
  - 40 engineers
- Investment in Greenlight Innovation since 2016
- Business relationship with Westport.

Alberta

Alberta's Quest project hits milestone of 5 MM tonnes of CO2 sequestered

Hydrogen Powerhouse

World's largest blue hydrogen producer & low-cost producer

Hydrogen and CO2 pipelines

60+% of Canada's H2 production

Shell / CNRL	• Quest CCS project in AB – largest low-C H2 production globally - $1.35 B
ATA/ Bison/ Trimac	• Dana / Freightliner / Ballard • Heavy duty truck project
ATCO, Air Products	• Gas blending
Heartland Project	• Integrated blue hydrogen node • Production, pipeline, applications

Ontario

North America's first Power-to-Gas energy storage

Leading Hydrogen Technology

Selling hydrogen equipment for 70 years

Pipeline complex and merchant liquid hydrogen production in Sarnia

Automobile manufacturing centre – assembly and parts

Cummins/ Hydrogenics	•Fuel cell electric powertrains for global powerhouse
Enbridge, Cummins	•2.5/5 MW Power to Gas
Enbridge	•Gas blending
Metrolinx	•Hydrail project
Canadian Nuclear Labs	•SMR & high-temperature H2 production

Quebec

Air Liquide building carbon-free hydrogen production in Becancour Quebec

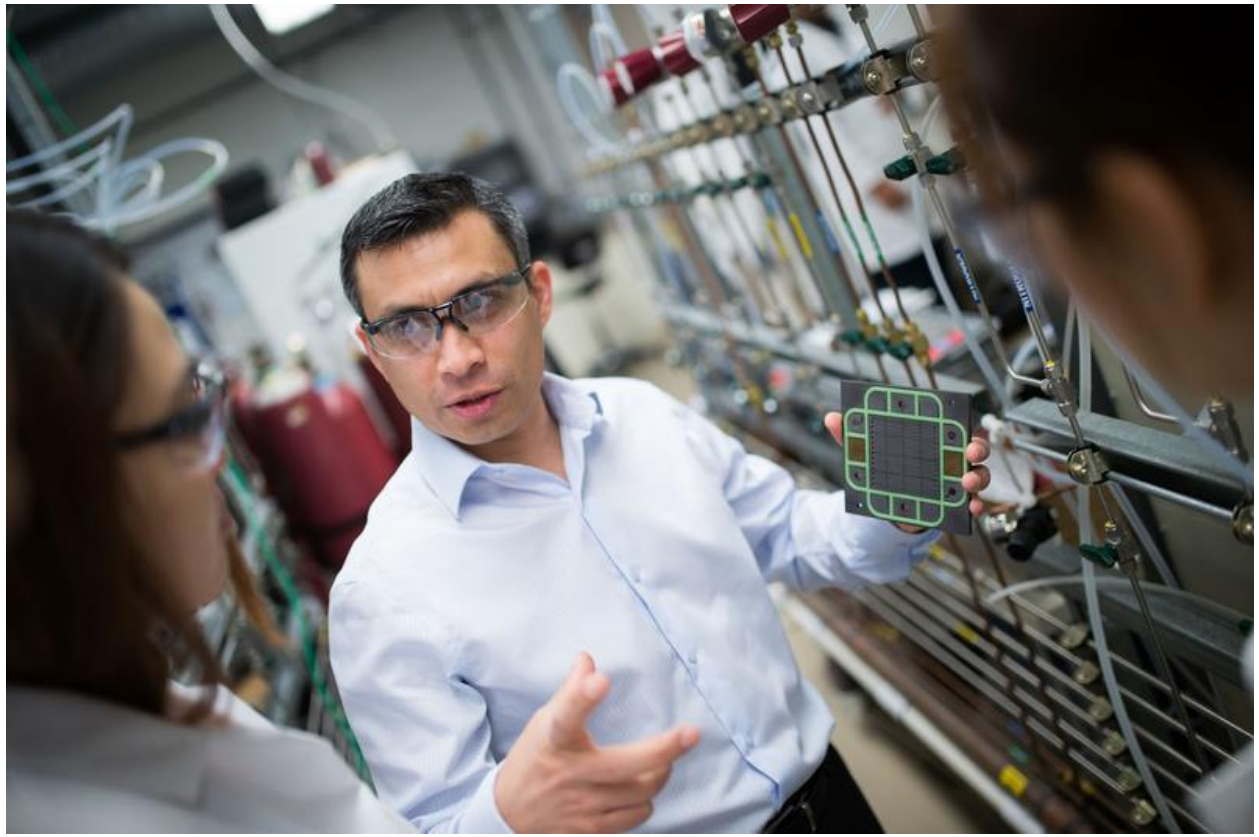
Green Hydrogen Powerhouse

Two merchant plants since 1980's

Battery and EV leader

Air Liquide / Cummins	• LH2 plant expansion in Quebec w/ 20MW PEM electrolyzer
Light-duty HFS (HTEC, Cummins)	• 1 operating in Quebec City , more in development
Hyundai & Toyota	• 50+ light duty vehicles on the road
Tugliq / Glencor	• Mine vehicle project in Quebec
HyGen / Greenlight	• Renewable methanol production in Quebec

Research & Development



Canada's leading role in H2 and fuel cell research and technology development since the early 1980's

Strong university commitments and international partnerships

Key players

- Universities in British Columbia, Ontario, Quebec, Canadian Nuclear Laboratories, National Research Council Canada

Why is Hydrogen Important to Canada?

1. Because it is Essential

- To the buildout of a clean energy grid
- To decarbonize tough sectors
- To achieve net-zero 2050
- 20-30% of Canada's energy will be supplied as hydrogen by 2050

2. Because it is a Canadian Strength

- Top 10 hydrogen producer and leading low-carbon hydrogen producer
- Home of leading fuel cell and hydrogen companies
- Major energy and energy technology exporter (power, nuclear, coal, oil, natural gas)
- Hydrogen allows us to continue exporting our energy – with no carbon
- A huge business and export opportunity for Canadian companies

3. Because it provides a Choice

- For Canadians and Canadian industry
- Of how to decarbonize in the most cost effective and efficient way
  - How to electrify transportation
  - How to heat homes and fuel industry with zero emissions
- **Sometimes the only choice; often the best choice**

The inclusive solution…

- All regions
- All sectors
- Environmentalist to oil worker

How Much Hydrogen?

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4.1. Potential Markets for Fuel Hydrogen in Canada

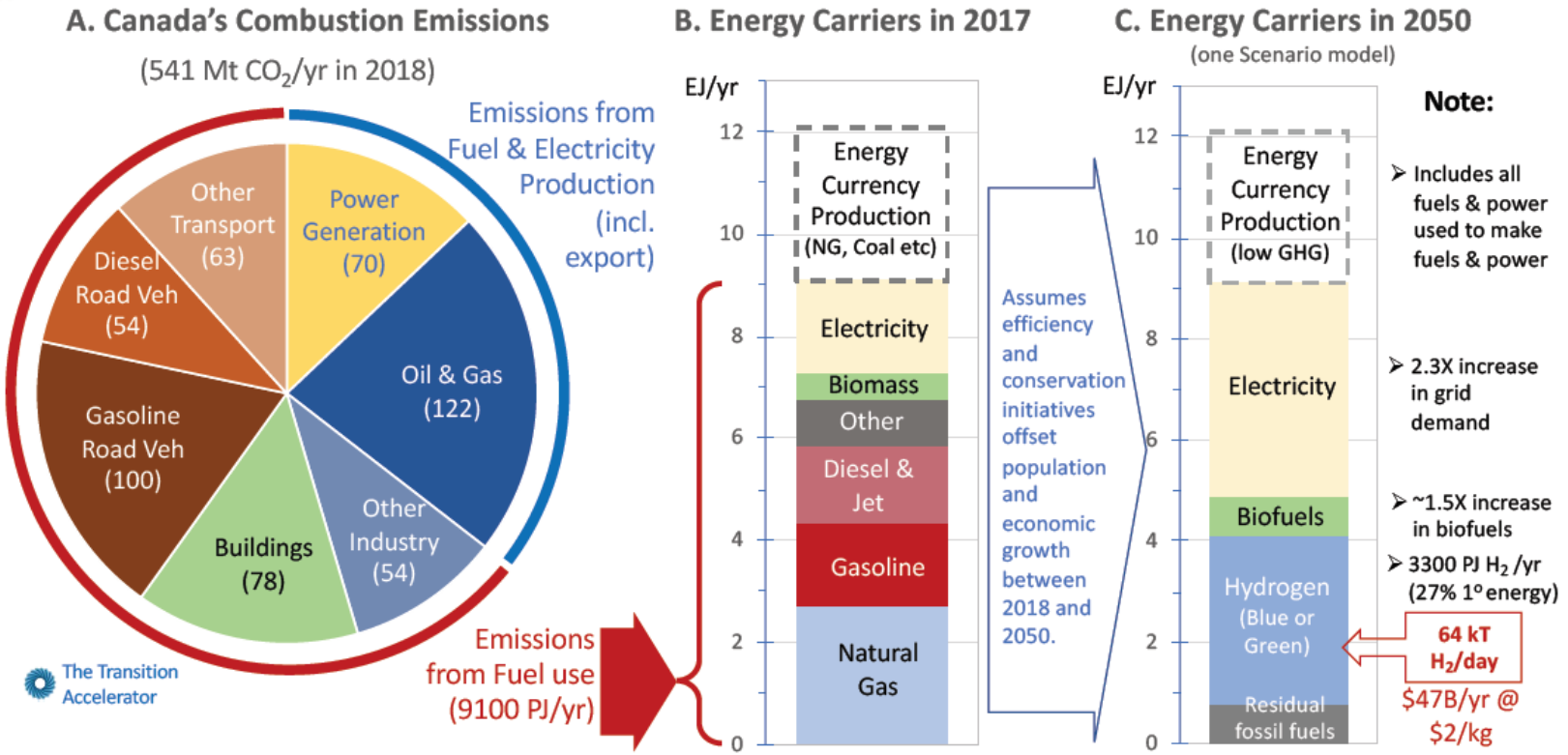

Figure 4.1. A scenario projection for the potential market for fuel hydrogen and low/zero carbon electricity in Canada in a net-zero emission energy system in 2050. Panel A from the National Inventory Report 2020. Panel 2 from the NRCan comprehensive energy database.

To achieve net-zero 2050:

- More than doubling of clean power production
- Significant biofuels
- ~30% of energy from H_2
  - assumes modest penetration of light duty sector
  - 10 to 20X increase in H2 production – just for domestic needs
  - $47 B market at wholesale cost

We're going to need a LOT of hydrogen…

Maintaining Canadian Leadership

France:
"A total of €7 billion will be spent by 2030 to develop green hydrogen…"

Boost Investment & Deployment

CHFCA initiatives:

- Continue international marketing and partnerships
- Support the Hydrogen Strategy for Canada and provincial strategies
- Increase communications
- Foster partnerships and projects
- Advocacy at all levels for supportive policy and increased funding

China will roll out a new package of policies to support hydrogen fuel cell vehicles to improve the industry's supply chain and technologies, a government official said on Saturday.

California:
…currently 8,475 FCEVs, the majority of these are in California.
"Those vehicles are supported by 42 hydrogen fuelling stations in California and there are now 48 fuel cell buses in operation and an emerging fuel cell shuttle bus market,"

Germany:
"a further EUR 7 billion is now earmarked to scale up the technology and secure the establishment of a domestic green hydrogen market."

CHFCA Priorities

Aligned with the Hydrogen Strategy for Canada

National Organization	National & International Sector Task Forces	Regional Branches
• International & national conferences, missions, trade shows • International and national partnerships • Communications • National advocacy	• In partnership with other associations & government • Focus on sectors ready for commercialization (e.g.: Urban Transit, Gas Blending) • Education/communication about opportunity for H2/FC • Address barriers & reinforce drivers for adoption	• Support Regional Blueprints • Develop “hydrogen hubs” • Coordinate projects and funding • Stimulate new projects through member-up collaboration • Communication

Advancing Hydrogen Energy in Canada

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The Hydrogen Strategy for Canada acknowledges hydrogen is essential for net zero 2050 - up to 30% of Canada's energy

- Must scale up H2 production 10+X (not including export opportunity)

Canada needs to build out a clean power grid AND a clean hydrogen grid

- The combination is cleaner, cheaper and more reliable
- Provide a Using H2/FC is as environmentally friendly as battery/electric

Key sectors must be transformed

- Task forces to communicate and address barriers
- Source suitable products and hydrogen supply
- Skills development

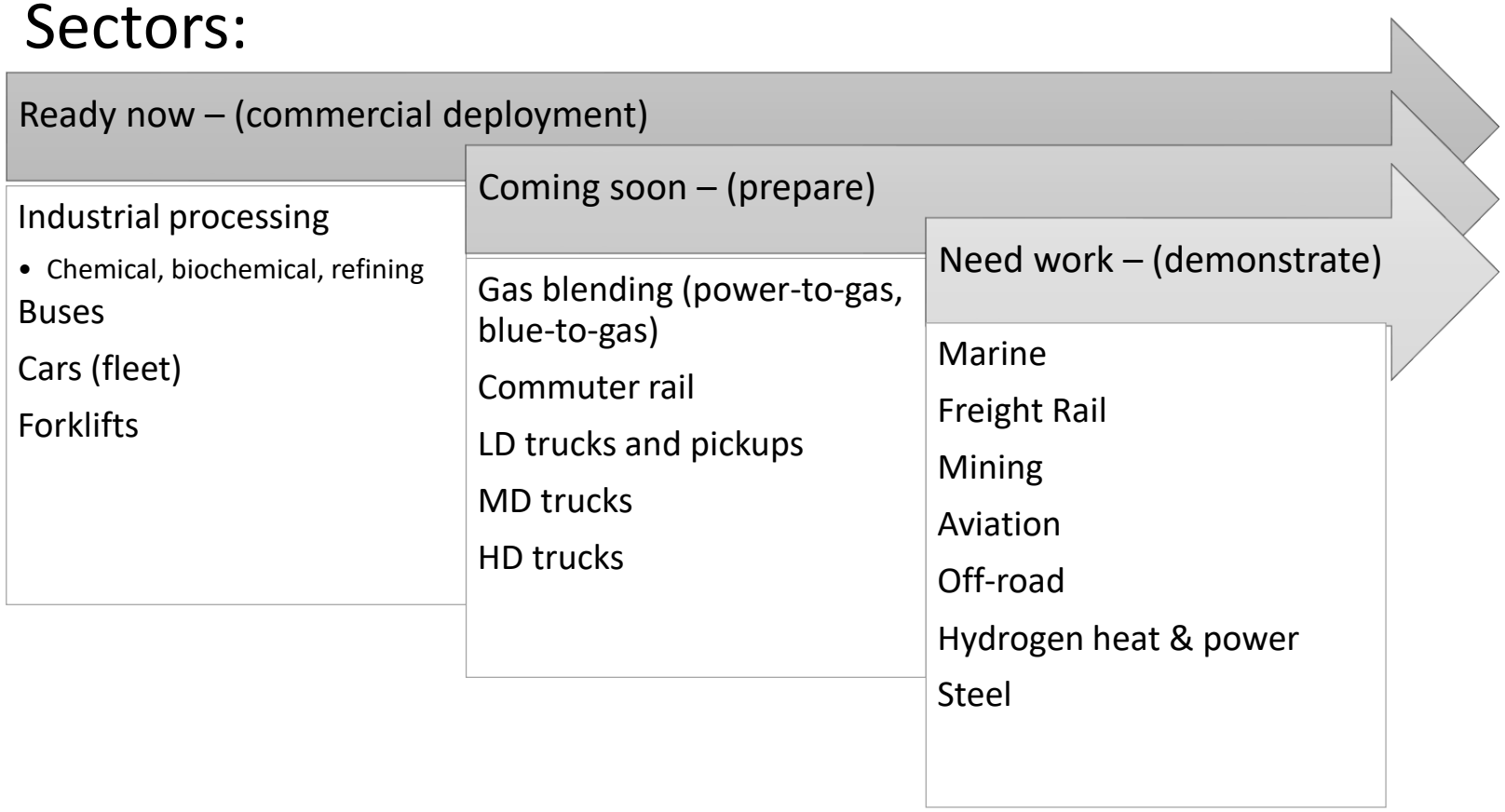
Getting to scale is critical

- Combine applications to provide significant demand
- Cluster in "hubs" around low-cost, clean hydrogen supply

Business Case

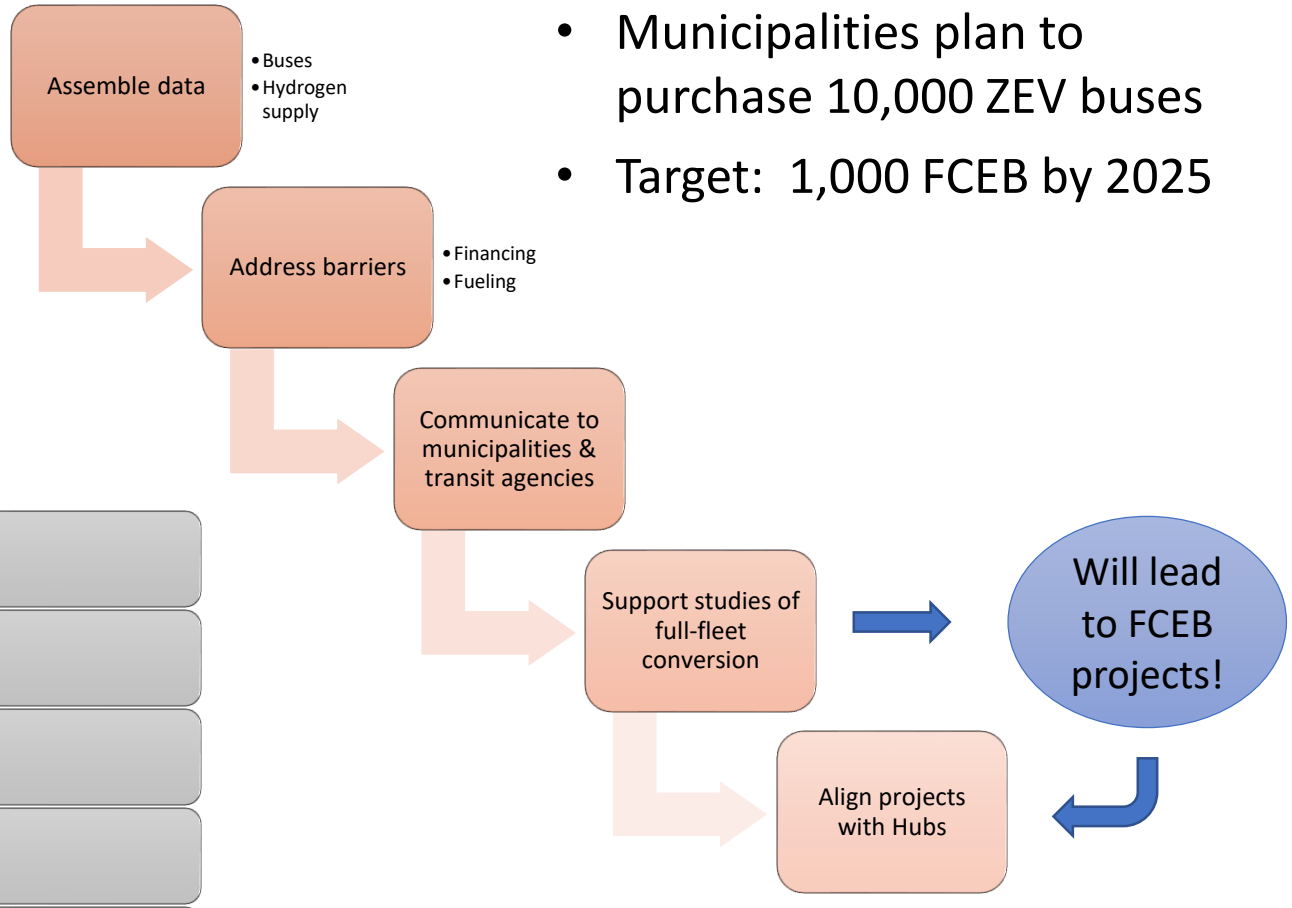
- Requirements:
  - Cost-effective, commercial products
    - Some are available
    - Many more needed
  - Low-cost, clean hydrogen
    - Delivered
    - Dispensed from fueling stations
  - Scale
  - Regulatory push
    - Low-carbon fuel standards
    - ZEV mandates
  - Government support
    - De-risk investment
    - Early adopter support

Sectors:



Example: Urban Transit Task Force ZEV Transit Buses

- Most advanced of heavy-duty FCEV applications
- Many studies and solid data available
- Commercial products available
- Current hydrogen supply modes are sufficient
- Well suited to Canada: cold weather & hills
- Policy and funding in place: ZEV mandates & funding



- Municipalities plan to purchase 10,000 ZEV buses
- Target: 1,000 FCEB by 2025

Supported by members, associations and NRCan

Example: Alberta Heartland Project

- Hydrogen Supply
  - Pipeline extension
  - SMR with CCS/U
  - 90+% capture
  - <$2/kg
- Applications
  - Industrial processing (chemical, refining, fertilizer)
  - Blending with NG
  - Heavy duty trucks
  - Buses & municipal vehicles

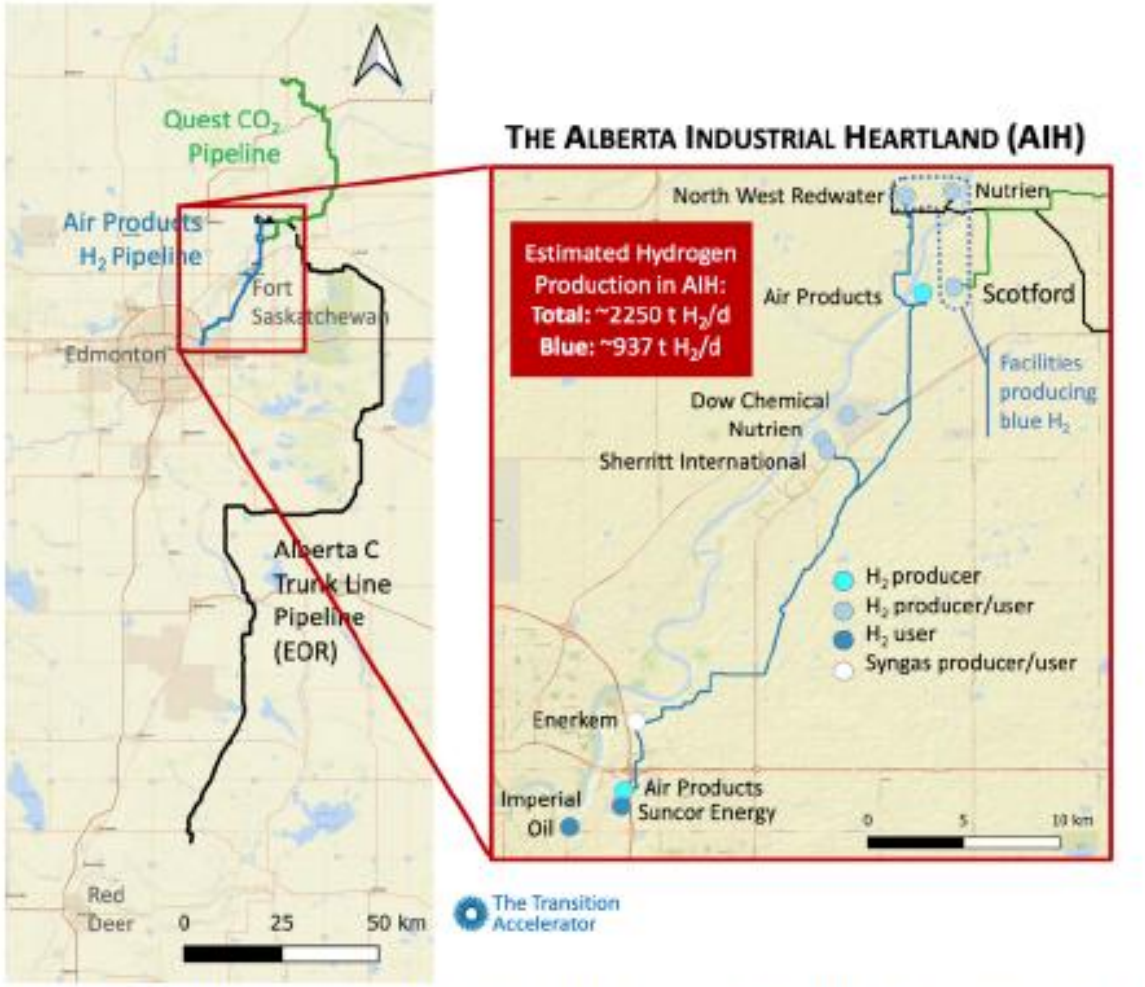
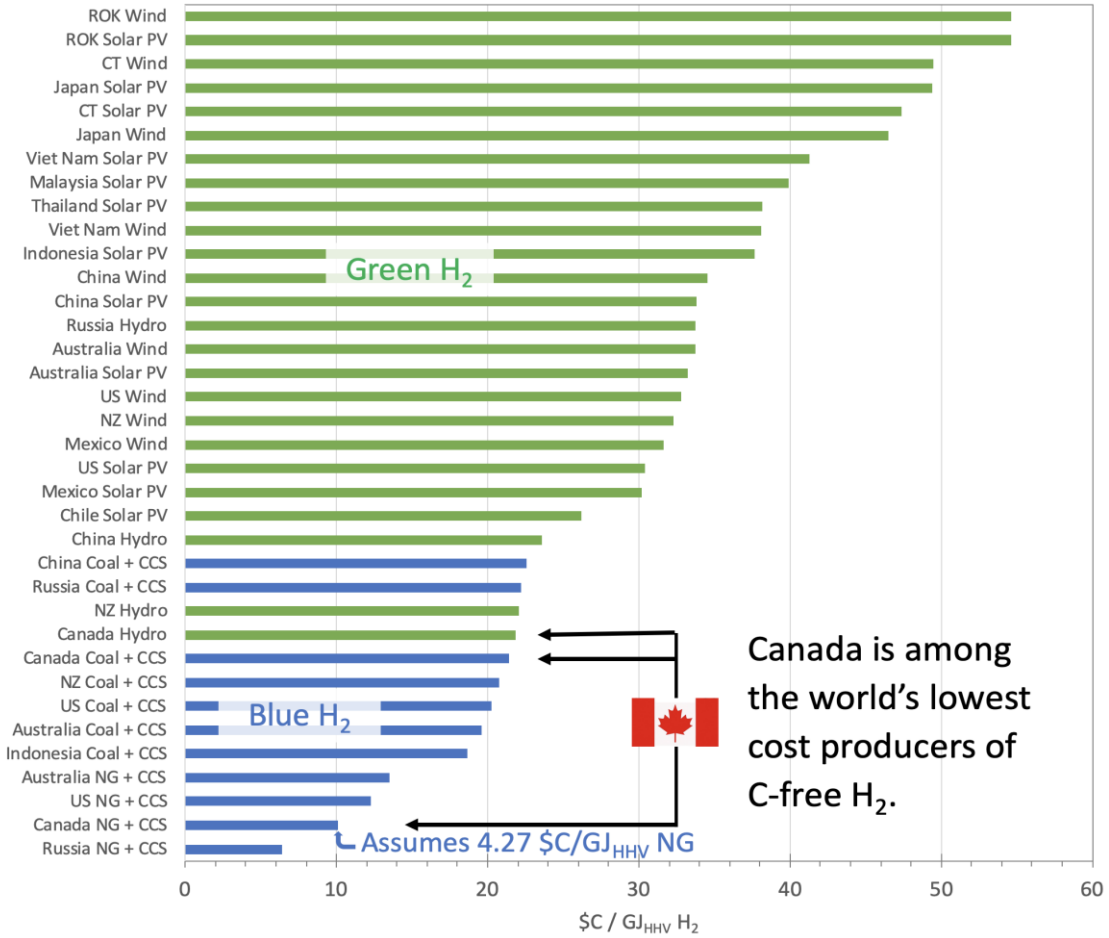


Figure 3.2. Map of hydrogen and carbon capture and storage infrastructure in the Alberta Industrial Heartland.

Low-cost Clean Hydrogen



- Low-carbon intensity heating and transportation fuel
- Canadian strengths:
  - Fossil fuel reserves
  - Low-cost clean power
  - Hydrogen production & technology
    - With low/no CO2 emissions
  - Sequestration/Storage
  - Pipeline transmission of energy
  - Energy exports
- Requirements
  - International standards for clean hydrogen
  - Pipelines to move hydrogen to urban centres and tidewater

Source: David Layzell – Transition Accelerator

Investing in Canada

I. Excellent Economic Fundamentals

II. A Highly Competitive Business Environment

III. A Dynamic Workforce

IV. A Conducive Environment for Leading-edge Innovation

V. Easy Access to Markets

VI. An Excellent Place to Live

VII. A Prime Venue for Foreign Direct Investment

Summary

Hydrogen and Fuel Cell Leadership

- Leading hydrogen and fuel cell companies
- Low-cost clean hydrogen production from abundant energy resources
- Leading research
- Supportive government policy and incentives
- Demonstrations and deployments
- Hydrogen Strategy for Canada to drive commercialization
    - Supported by CHFCA and member companies

- Plus, Canada is a great place to invest!

Opportunities

- Supply of fuel cell products, services and technology
- Supply of hydrogen and hydrogen products, services and technology
- Partnerships
- Opportunities for project development and to supply products and services to Canadian projects
- Investment in companies and projects
- Set up a business in Canada

Thank You!

Canadian Hydrogen and Fuel Cell Association

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