The Global Shift to Hydrogen and Lessons from the Nuclear Industry

Mike MacPhee - Presenter

Marvin Stemeroff

Graeme Cook

19Sep2023

Delivering a better world

- AECOM and Introduction
- The Hydrogen Shift
- Community and Social Consent
- Lessons from the Nuclear Industry
- Final Remarks

Global experience, local expertise

AECOM designs, plans and manages projects and programs that unlock opportunities, protect our environment and improve people's lives.

50k
People

7
Continents

150+
Countries

The Future of Energy — AECOM's Market Perspective

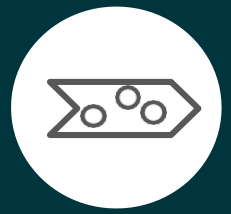
Sustainable, Secure, Available and Efficient

Energy Transition

Decarbonisation professional and project delivery services to support clients with the strategy and implementation of transitioning from fossil fuelled infrastructure to more sustainable alternatives.

Renewables & Sustainability

Enabling the development of new Wind, Solar and other Green Energy projects through a combination of siting, generation, grid connectivity solutions and supporting infrastructure.



Energy Delivery

Core Power services to provide solutions for Grid modernization including new utility services and interconnectors to enable clients to access Energy reliably and sustainably from point of generation to point of use.

Decentralised Energy

Strategic Green Energy consultancy and solutions to serve the growing local generation, micro- grid, decentralised storage and Energy management markets.

4

The rapidly growing integrated hydrogen market is the space to build our legacies for generational sustainability.

To enable hydrogen as a service, we leverage our combined Energy competencies to advise clients on:

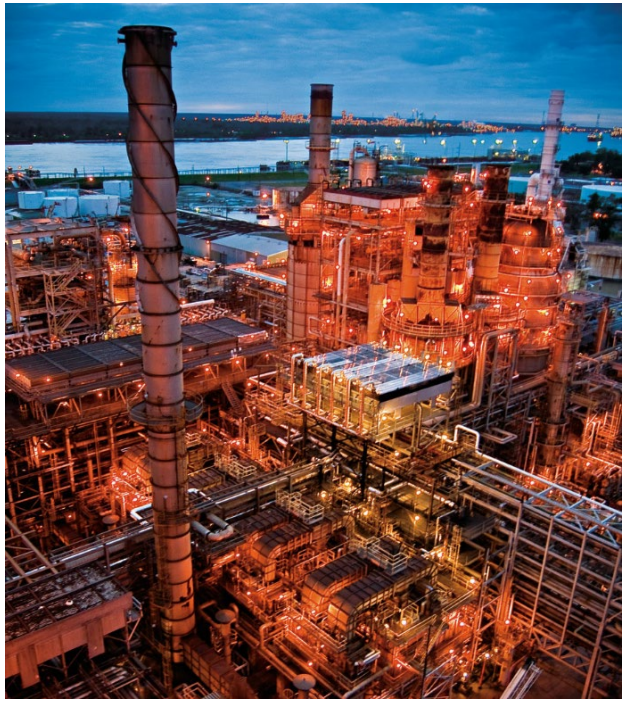
- ✓ how to decarbonize portfolios
- ✓ transition to sustainable alternatives
- ✓ delivering energy solutions meeting your customers needs
- ✓ innovations emerging in a decentralized dynamic ecosystem.

Introduction

- Hydrogen is currently used mainly in industrial processes
- Energy transition – shining a light on Hydrogen
- Safety
  - Explosive at wide range of concentrations
  - Colourless & odourless
  - Small molecule – difficult to contain and changes material properties
- Public interaction, public perception
- Lessons to be learned from the Nuclear Industry to maintain safety and trust

The Hydrogen Shift – Current

- **Current Usage - Industrial**
  - Haber-Bosch – 1913
  - Chemical Processes (ammonia, methanol)
    - 54 Mt [1]
  - Oil & Gas (Hydrocracking, Hydrotreating)
    - 40 Mt [1]



- **Everything else**
  - Energy Transition uses
    - “thousands of tonnes” [1]

→

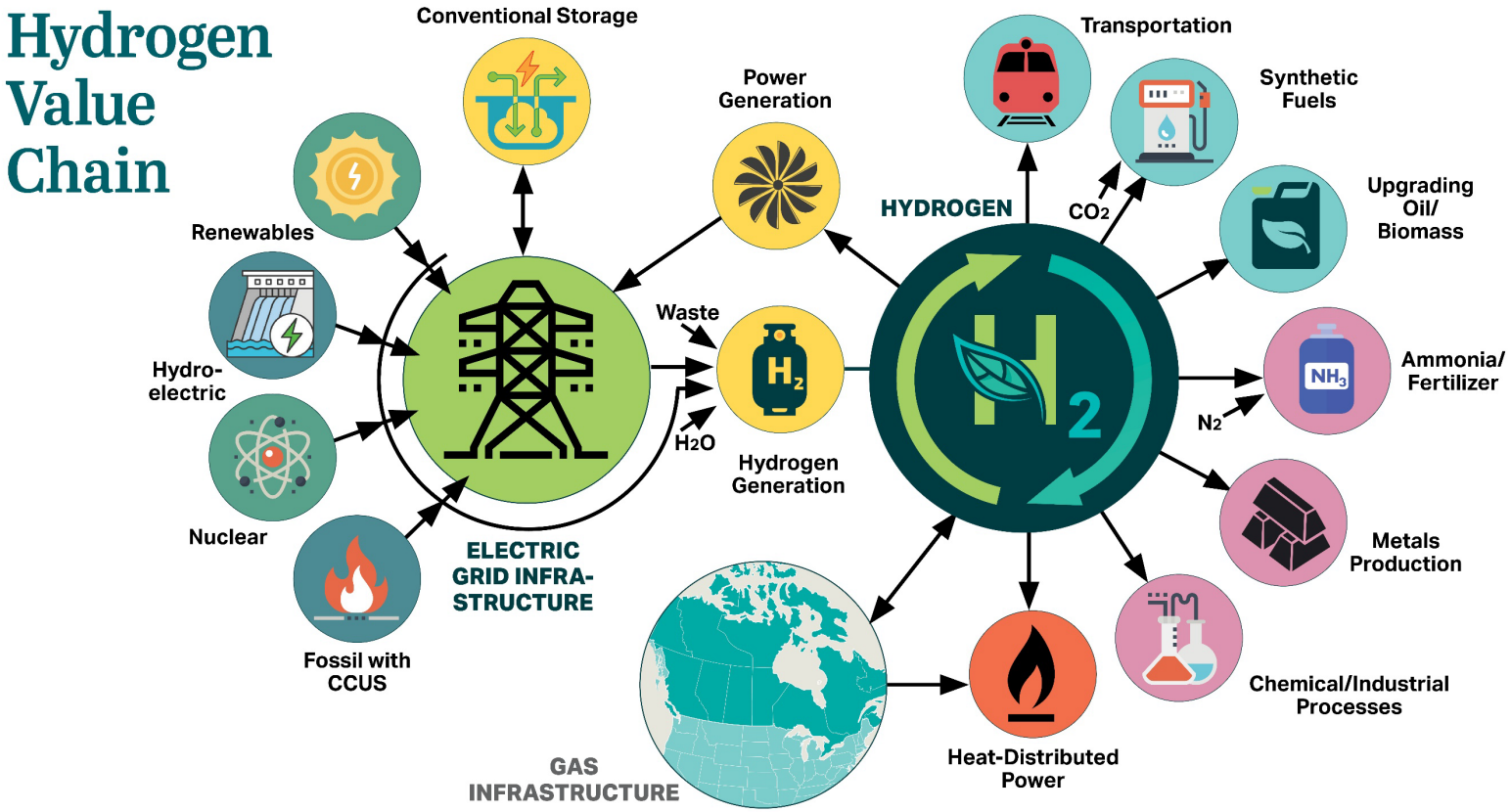
- Transportation (heavy and passenger)
- Steel
- Cement
- Building heating
- Power generation

[1] International Energy Agency (IEA), Report: Global Hydrogen Review, September 2022.

The Hydrogen Shift - Future

H_2 Opportunity	2030	2050
% of Delivered Energy	6%	30%
Hydrogen Demand	4 Mt-H_2	20 Mt-H_2
GHG Emissions Abated	up to 45 Mt-CO_2e	up to 190 Mt-CO_2e

Indication of the magnitude of scale-up expected in Canada between 2030 and 2050 [2]



[2] Natural Resources Canada, Hydrogen Strategy for Canada, Seizing the Opportunities for Hydrogen, A Call to Action, December 2020.

The Hydrogen Shift

- **Production**
  - Co-location with Nuclear and Renewables
  - On-site production (warehouses, transportation hubs, etc.)
  - Decentralized distributed sub-station scale production
- **Storage**
  - Very large scale → Geological – subsurface cavernous structures
  - At distributed production sites
- **Distribution**
  - New dedicated and repurposed existing gas infrastructure
- **Usage**
  - Refuelling stations
  - Public transportation (bus terminals, rail yards)
  - Warehouse and Fleet vehicles
  - Domestic appliances

→ CLOSER TO COMMUNITIES!

Community and Social Consent

- Emerging or unfamiliar technology = public opposition (e.g., nuclear/SMR)
- Failure to adequately address can lead to project rejection even with regulatory approvals
  - Examples of public rejection with regulatory approval:
    - OPG low-level waste repository, 2019
    - Toronto Municipal Solid Waste proposal for Kirkland Lake Adam's Mine, 2004

- **Problem**: failure to understand the conditions necessary for social consent
  - Consent does not require the public to want the project or be happy about it, but rather to recognize that it is a solution to an important larger issue (reducing CO2 emissions)
  - Consent from even the most ardent opposition means that although they might not agree with the project they at least will not stand in its way.

Community and Social Consent

- **Solution**: strategic planning prior to project announcement

- Consider **5** Steps:

1. **What problem does the problem address?**
   a) Ensure clarity, articulate in lay terms and allow a stakeholder to become a contributor toward resolving an important issue

2. **Does the Public see the problem the same as the project?**
   a) Validate with a cross section of Public stakeholders
   b) Ascertain if stakeholders agree the problem is worthy of solving with the same urgency as seen by the project → e.g., OPG LLW Deep Geological Repository (DGR) was confronted by a public that did not understand or agree with the urgency of the issue, let alone the solution itself.

Community and Social Consent

- **5** Steps continued:

3. **Are the affected Indigenous groups and stakeholders adequately identified?**
   a) Map out who is affected and how? List the publicly affected interests that may arise from project Implementation
      i. Amend design and execution plan to better align with interests and concerns
      ii. Prepare a more effective indigenous and stakeholder engagement plan

4. **Can the project build and sustain public trust?**
   a) Trust is built upon open two-way dialogue
   b) Demonstrate genuine care about the interests and a willingness to act to mitigate negative effects from the project

5. **What is the plan?**
   a) look, listen, and learn about the aspirations and challenges related to the project, work collaboratively

Community and Social Consent

- **The value of the five steps is two-fold:**

1. It helps to clarify choices for the project proponent and the public based upon mutually developed information and facts, and

2. It lays a platform for dialogue that enhances the chance of achieving social consent.

These principles identified above have been applied successfully in industries facing many similar hurdles in obtaining public consent for important infrastructure projects

Lessons from the Nuclear Industry

- **Public and environmental safety, social consenting, demonstrated reliability**
  - Central themes in nuclear as a pathway to success
- **Canadian Nuclear Safety Commission (CNSC)** – Regulator for nuclear energy & materials in Canada
- **Quality Assurance – CSA N286-12, CSA N299**
  - Nuclear Safety *Culture* → *"do the right things right"*
- **Collaboration**
  - International Atomic Energy Agency (IAEA)
  - Institute of Nuclear Power Operators (INPO)
  - World Association of Nuclear Operators (WANO)
  - Candu Owner's Group (COG)

European Hydrogen Safety Panel (EHSP) and the Hydrogen Incidents and Accidents Database (HIAD)

Lessons from the Nuclear Industry

- **Experience with Hydrogen**
  - Used in modest amounts for generator cooling
  - Significant experience trying to ***PREVENT*** H2 production!
    - Radiolysis, High Temp oxidation of Zirconium
    - E.g., Three Mile Island, Chernobyl, Fukishima
  - Passive Autocatalytic Recombiners (PARs)
    - Possible mitigation for dangerous unwanted H2 accumulation in key locations, dispersion to atmosphere as GHG
    - Design, optimal locations & quantities
  - Materials Research – Hydrogen embrittlement, pressure tube hydrides

Final Remarks

- **Similarities between industries**
  - Public interaction, public image, people and environmental safety impacts
- **Social Engagement and Consenting**
  - Lessons to be learned winning consent, a proven approach
- **Evolving Future**
  - Both required for the energy transition from now to 2050
- **Culture**
  - A Nuclear Safety Culture can be applied to ensure safety through Human Performance and continuous improvement

Thank you.

Delivering a better world

aecom.com

AECOM

Delivering a
better world