Transport Canada

Overview of a project to assess feasibility of a switcher locomotive retrofitted with hydrogen fuel cells
Hydrogen in Canada

- Canada has the opportunity to capitalize on a robust hydrogen economy

Hydrogen production

- Canada is one of the top 10 producers of hydrogen in the world
- **82% of our electricity is from non-GHG sources;** Canada’s electricity supply system is amongst the lowest carbon intensity globally

Hydrogen expertise

- Canada is host to internationally-leading hydrogen and fuel cell tech companies
- Canadian fuel cell technology is used in vehicles around the world
- Fuel cells are used in buses, locomotives, trucks, cars, forklifts, cranes, and more.

Existing Infrastructure

- Canada has widespread natural gas pipelines and storage infrastructure; could be repurposed for hydrogen
- Lots of naturally occurring places to store carbon created from the production of hydrogen
Canada’s Emission Goals

• Canada has made commitments to reduce it’s emissions
  ✓ 30% reduction in 2030 compared to 2005
  ✓ Net-zero emissions in 2050

• The rail sector contributes a small amount to our national GHG emissions; about 4%.

• Rail equipment is long-lived -> 30+ years.

• We must examine zero-emissions options now, so that they are commercially ready in time to be common-place by 2050.
Hydrogen Switcher Locomotive Feasibility Study

- Brings together industry experts:
  - Understanding the current status of hydrogen technology, and TRL for the rail sector
  - Offers insights into the cost of a locomotive conversion; infrastructure cost.
  - Provides guidance for what a Canadian demonstration project could look like.

Report is available online
Why a Switcher Locomotive?

**EMD Model GP-38-2/3**

<table>
<thead>
<tr>
<th>Technology Readiness Levels</th>
<th>Description</th>
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<tbody>
<tr>
<td>TRL 1</td>
<td>Basic principles observed and reported</td>
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<tr>
<td>TRL 2</td>
<td>Technology concept and/or application formulated</td>
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<tr>
<td>TRL 3</td>
<td>Analytical and experimental critical function and/or characteristic proof-of-concept</td>
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<td>TRL 4</td>
<td>Component and/or breadboard validation in laboratory environment</td>
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<tr>
<td>TRL 5</td>
<td>Component and/or breadboard validation in relevant environment</td>
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<tr>
<td>TRL 8</td>
<td>System/subsystem model or prototype demonstration in a relevant environment (Ground or Space)</td>
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<tr>
<td>TRL 7</td>
<td>System prototype demonstration in a space environment</td>
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<tr>
<td>TRL 8</td>
<td>Actual system completed and “flight qualified” through test and demonstration (Ground or Flight)</td>
</tr>
<tr>
<td>TRL 9</td>
<td>Actual system “flight proven” through successful mission operations</td>
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</tbody>
</table>

- Similar to line-haul locomotives
- Emissions are localized
- Close to refuelling

NASA Technology Readiness Levels. [https://www.researchgate.net/figure/NASA-Technology-Readiness-Levels-Source-27_Fig1_330508248](https://www.researchgate.net/figure/NASA-Technology-Readiness-Levels-Source-27_Fig1_330508248) [accessed 4-March-2020]
Quick Look at a Diesel Locomotive

- Operator Cab
- Electronic control systems
- Diesel Engine
- Electrical generators
- Exhaust controls
- Fuel tank
- Cooling fans and radiators
- Air compressor (brakes)

EMD GP38-2
2000 THP
59'02" long

2,140 hp = 1,131 kWh
Changes from Diesel to Hydrogen

- Remove the diesel engine, fuel tank, cooling system, electricity generators
- New equipment will be required for these components in a hydrogen locomotive

- Air compressor
- Power converter (DC/AC power as needed)

- Proton Exchange Membrane Fuel Cells
  - 1,760 kWh vs 1,131 kWh
- Hydrogen fuel storage tanks

- Lithium-ion battery packs
Status of the Key Components for Hydrail

- Fuel Cells
- Lithium-Ion Batteries
- Hydrogen Storage Tanks
- Power Control System

How does it all come together in a locomotive?
Vision for a Demonstration Program

A demonstration program could build experience and identify best design & operating practices. It could help advance a Proof of Concept that is safe, reliable, and sustainable.

- Partner with rail industry
- More than just proving the tech works; prove its benefits and self-sustainability
- Develop low-carbon supply chains wherever possible
- Develop a hydrogen ecosystem for rail

Commercial success is the goal
Exploration: Find out what works
Share the knowledge
What a demonstration program could look like

**Objective:**
Advance the technologies working together in a locomotive and iterate towards self-sustaining hydrogen operations in a rail yard

**Key Outcome(s):**
- Advancement of the technologies working together in a locomotive
- Development of codes and standards, best practices
- Thorough understanding of safety
- Incorporation of hydrogen into normal business

**Timeline:**
5-10 years

**Partners:**
- Railway companies
- Locomotive OEMs
- Federal, provincial, municipal governments
- First responders
- Codes and Standards bodies
- Communities
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