CENTRE D'INNOVATION CENTRE

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

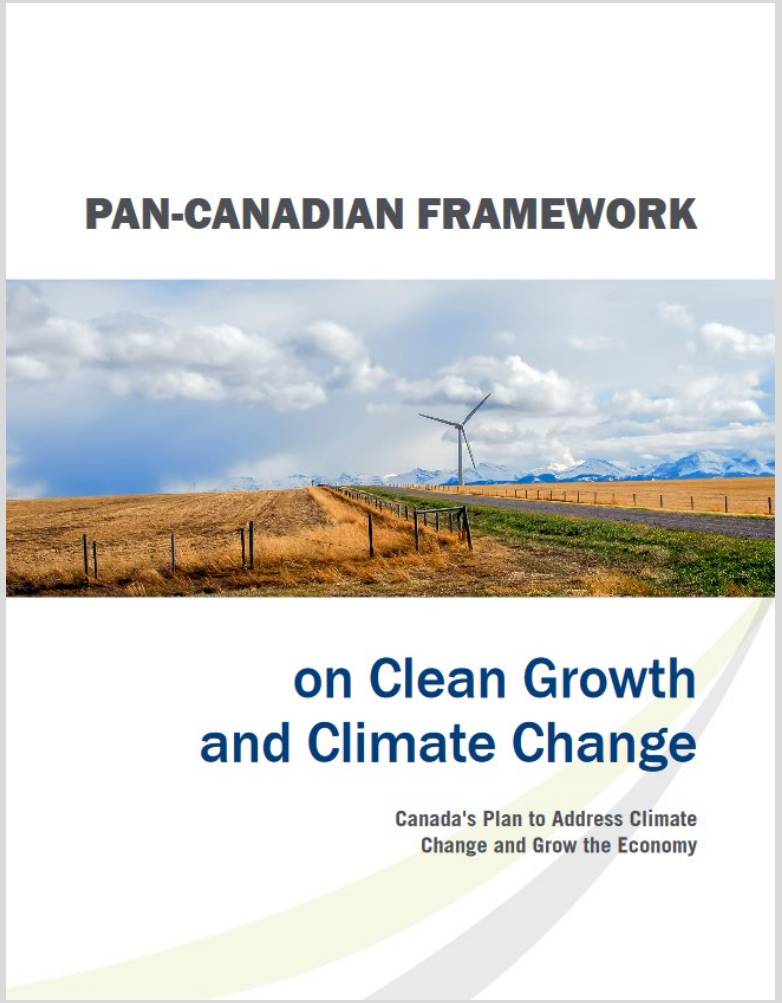
- Canada is host to internationally-leading hydrogen and fuel cell tech companies
- Canadian fuel cell technology is used in vehicles around the world
- Fuel cells are used in buses, locomotives, trucks, cars, forklifts, cranes, and more.

Existing Infrastructure

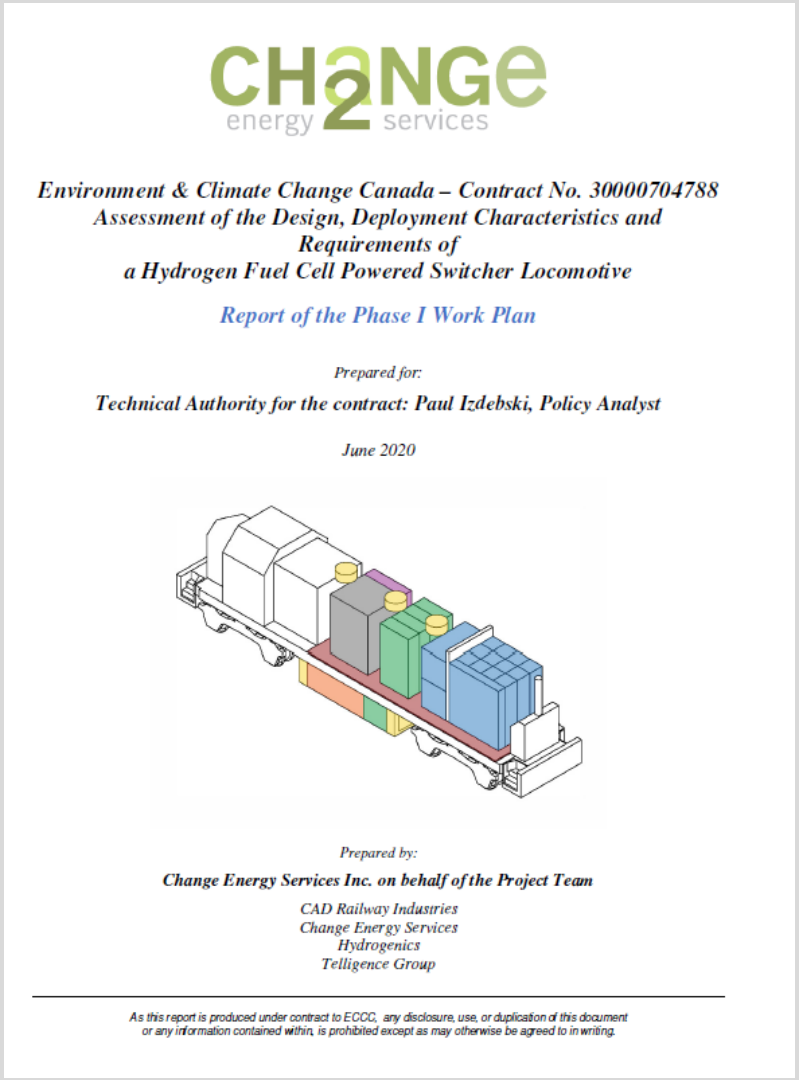
- Canada has widespread natural gas pipelines and storage infrastructure; could be repurposed for hydrogen
- Lots of naturally occurring places to store carbon created from the production of hydrogen

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



CHANGE energy services

Environment & Climate Change Canada – Contract No. 30000704788
Assessment of the Design, Deployment Characteristics and Requirements of a Hydrogen Fuel Cell Powered Switcher Locomotive

Report of the Phase I Work Plan

Prepared for:
Technical Authority for the contract: Paul Izdebski, Policy Analyst

June 2020

Prepared by:
Change Energy Services Inc. on behalf of the Project Team
CAD Railway Industries
Change Energy Services
Hydrogenics
Telligence Group

Transport Canada

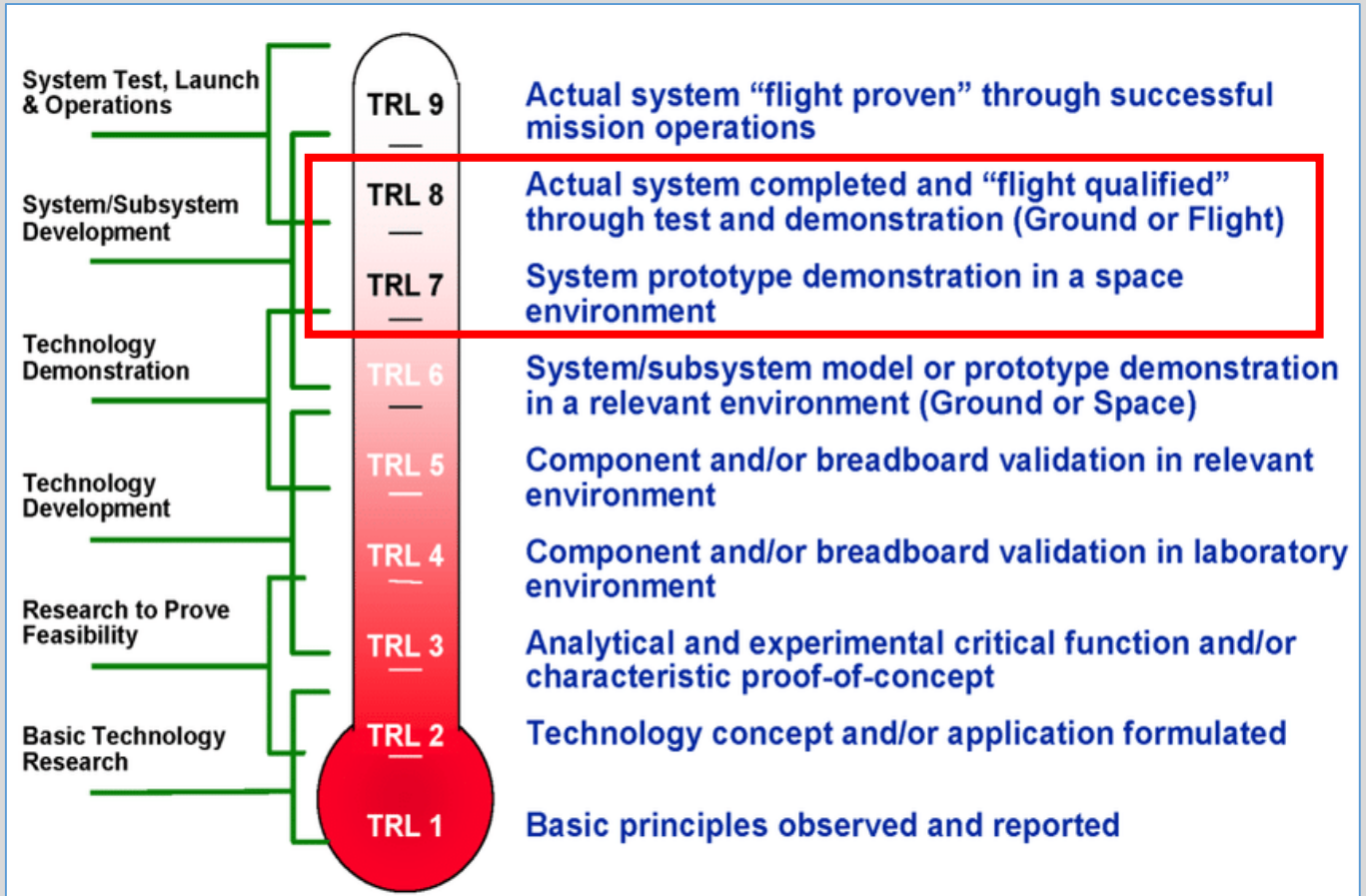
Environment and Climate Change Canada

Canada

- **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?



NASA Technology Readiness Levels. https://www.researchgate.net/figure/NASA-Technology-Readiness-Levels-Source-27_fig1_330508248 [accessed 4-March-2020]

EMD Model GP-38-2/3

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

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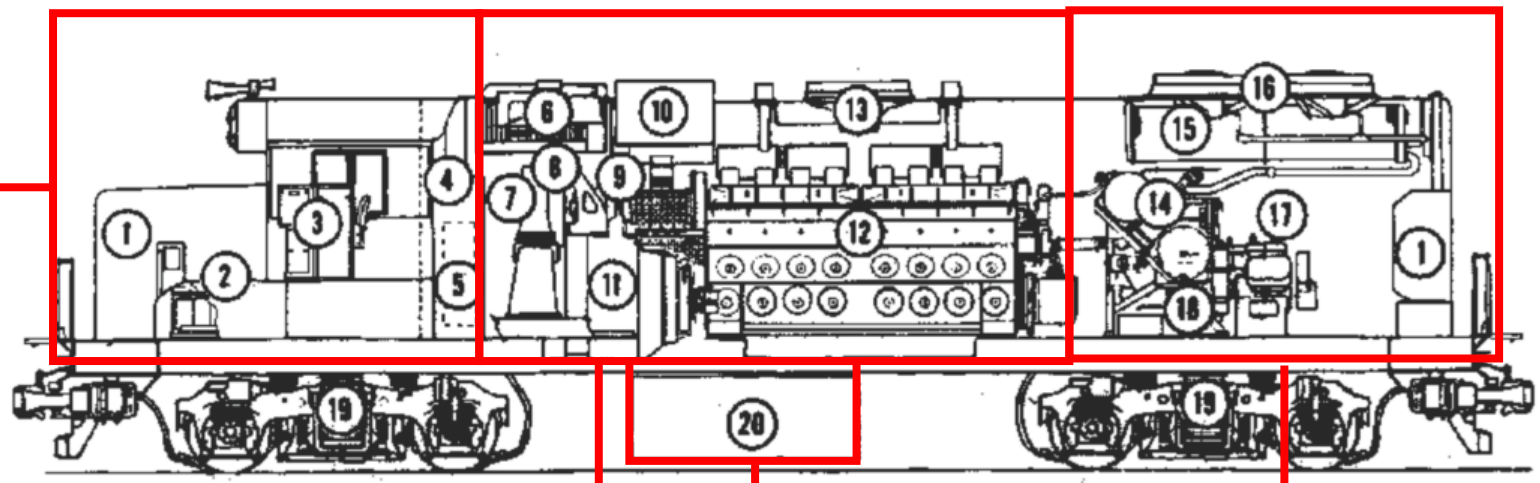
Quick Look at a Diesel Locomotive

2,140 hp = 1,131 kWh

EMD GP38-2
2000 THP
59'02" long



- Operator Cab
- Electronic control systems

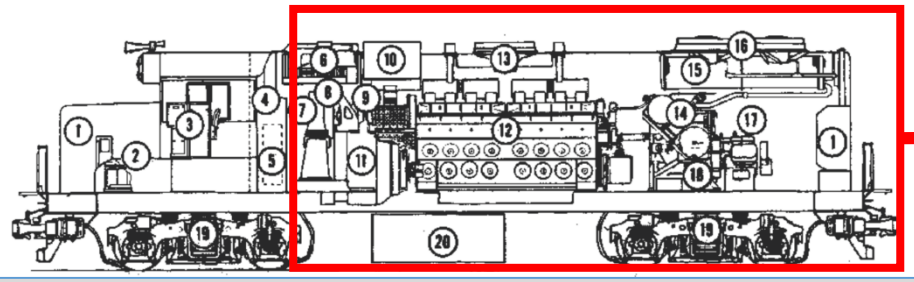
- Diesel Engine
- Electrical generators
- Exhaust controls

- Fuel tank

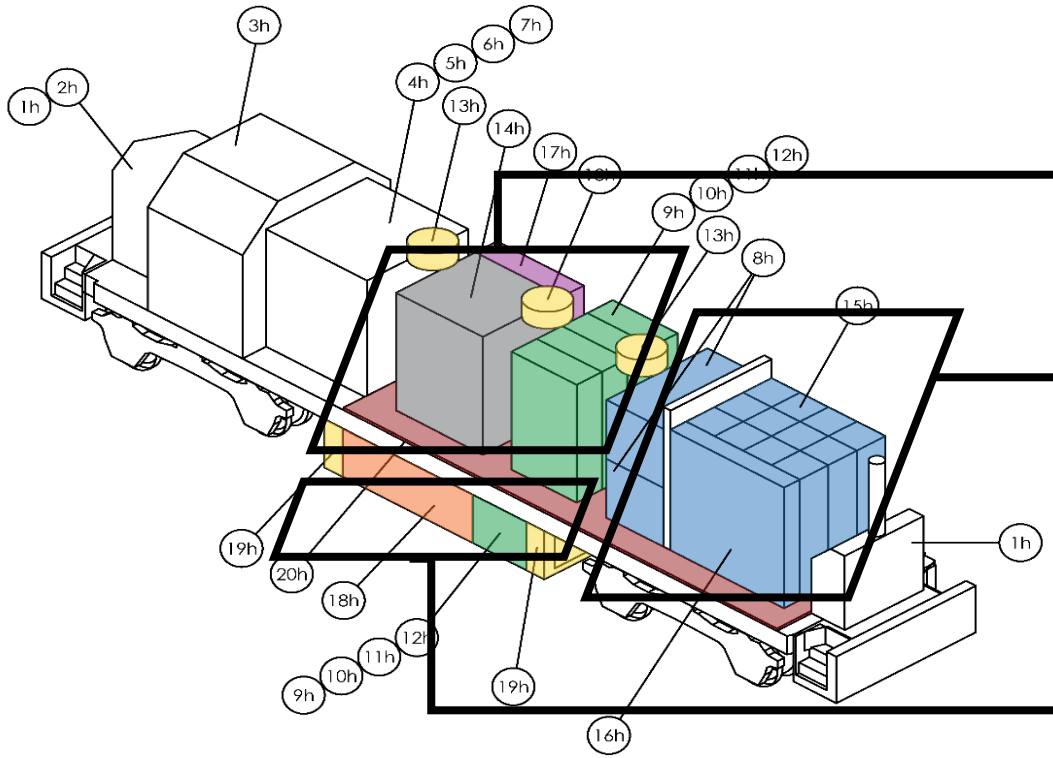
- Cooling fans and radiators
- Air compressor (brakes)

Changes from Diesel to Hydrogen

EMD GP38-2
2000 THP
59'02" long



- 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.

Commercial success is the goal

Exploration: Find out what works

Share the knowledge

Partner with rail industry

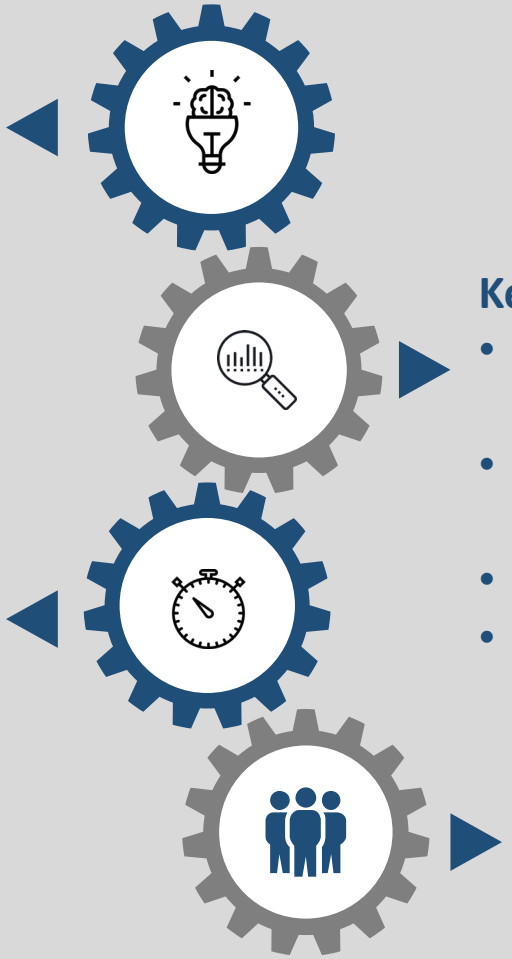
More than just proving the tech works; prove its benefits and self-sustainability

Develop low-carbon supply chains wherever possible

Develop a hydrogen ecosystem for rail

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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