Hydrogen Fuel Technology Analysis/Evaluation

Metrolinx Board Strategy Session

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SUMMARY

The purpose of this presentation is to provide the an update on the feasibility study being prepared as a part of Metrolinx' investigation of a hydrogen program.

This presentation will:

1. Provide an overview of the hydrogen program in Germany
2. Discuss Hydrail in the Ontario context
3. Discuss the hydrogen work streams Metrolinx has committed to completing

GERMANY – HYDRAIL CONTEXT

50% of German rail networks are not electrified.

Strong industry and public interest in reducing emissions along rail routes

Overhead catenary construction is **cost intensive, not profitable** on some sections, and **undesirable** in scenic areas.

Federal government's 2030 objectives:

55% reduction of CO2 emissions

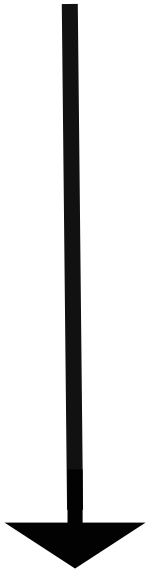
50% of electricity from renewable sources

Electric trains powered by hydrogen-operated fuel cells are seen as an interesting and promising option to **reduce emissions**, **grow an industry** and meet stakeholder expectations.

GERMANY – HYDRAIL HISTORY

Germany has a long history with hydrogen in transportation. The German government has identified hydrogen and HFC technology as **essential to the future of mobility and energy supply**.

2002

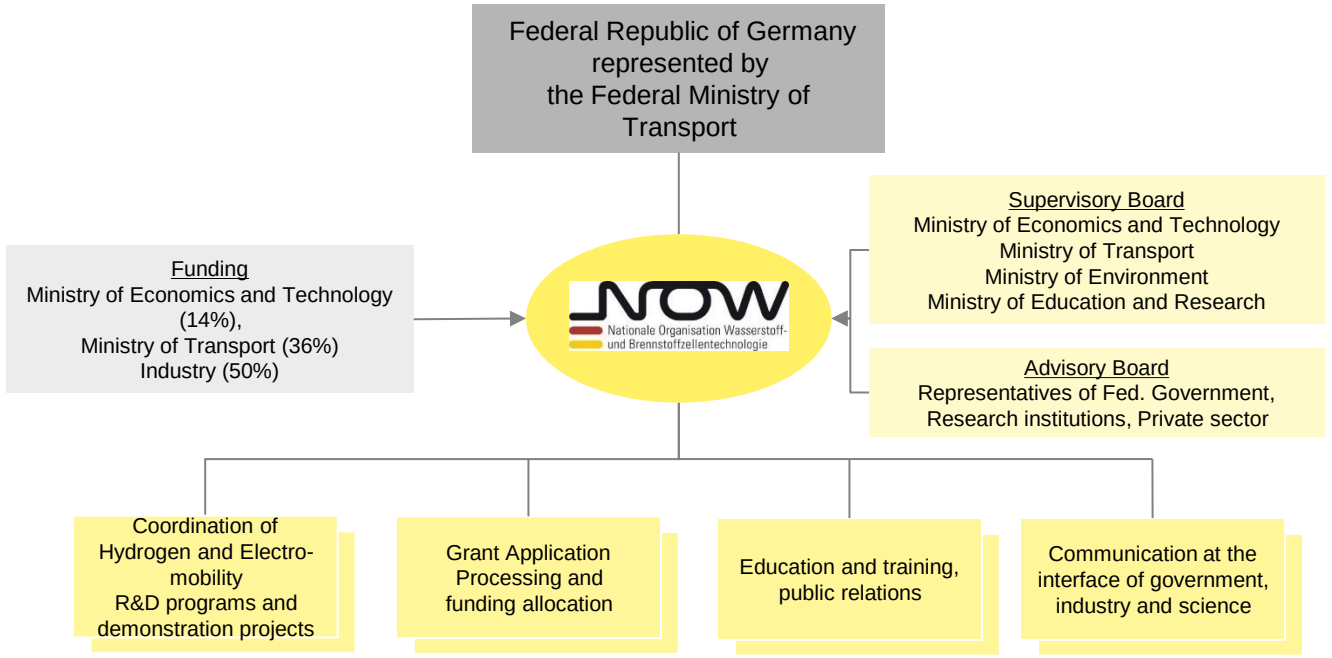


- 2002 - The Clean Energy Partnership (“CEP”) was established as a JV between government and industry, to **test the suitability of hydrogen as a fuel**.
- 2004 - First hydrogen filling station went into operation in Berlin. There is now a **network of 32 hydrogen fuelling stations** in Germany.
- 2006 - The government, industry and science established the National Innovation Programme for Hydrogen and Fuel Cell Technology (“NIP”) to **facilitate the development of these technologies**.
- 2008 - The CEP began **intensive public relations activity**, aimed at raising public awareness of hydrogen as a fuel and energy store.
- 2008 - The National Organisation Hydrogen and Fuel Cell Technology (“NOW”) was founded to administer the programs for NIP.

NOW

THE NATIONAL ORGANISATION HYDROGEN AND FUEL CELL TECHNOLOGY (NOW)

“NOW” was founded in February 2008 as a federally-owned company, with an initial budget of €1.4B.



The Federal Ministry of Transport and Digital Infrastructure intends to invest approximately €250MM in phase 2 of the NIP by 2019.

GERMANY – ALSTOM HYDRAIL IMPLEMENTATION

In 2014, the Federal Ministry for Transport and Digital Infrastructure, through the NIP, committed €7.9MM in support of the development of HFC powered rail vehicles.

- The vehicles are being developed and manufactured by train manufacturer, Alstom.
- NOW also **engaged EY Germany to conduct a study** to assess the feasibility of the use of HFC to propel trains in Germany.

Mar 2017

Test-runs on a test track in Lower Saxony

End 2017

Trial operations, pending approvals from the Federal Railway Authority

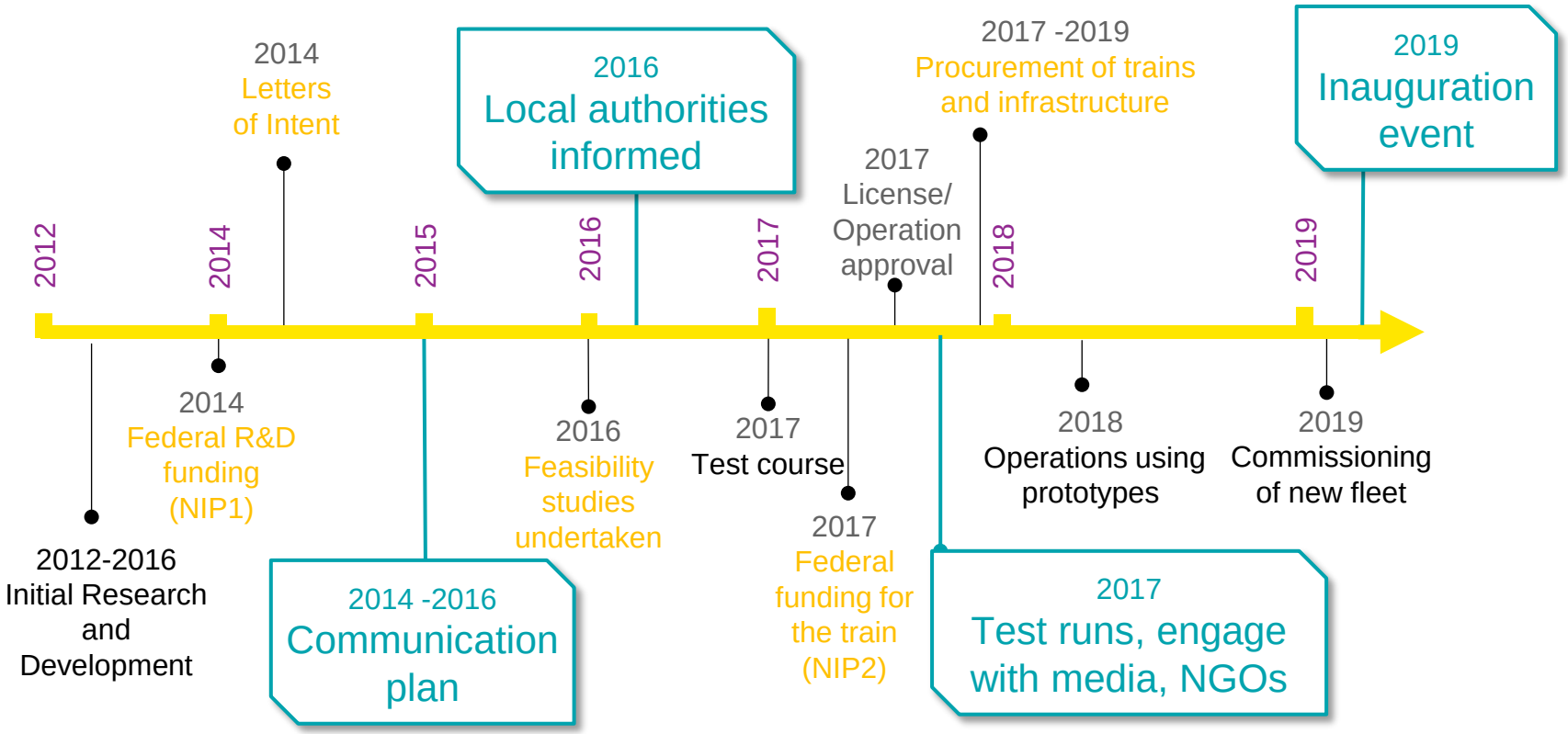
Mid 2018

Deployment into regular operations

- The German states of Lower Saxony, North Rhine-Westphalia, Baden-Württemberg and the State of Hesse have **signed Letters of Intent** for the purchase of HFC powered train sets.
- A total of 60 trains sets have been ordered to date.

Alstom Coradia iLint (Hydrogen EMU, DE)

GERMANY – HYDRAIL TIMELINE FOR IMPLEMENTATION



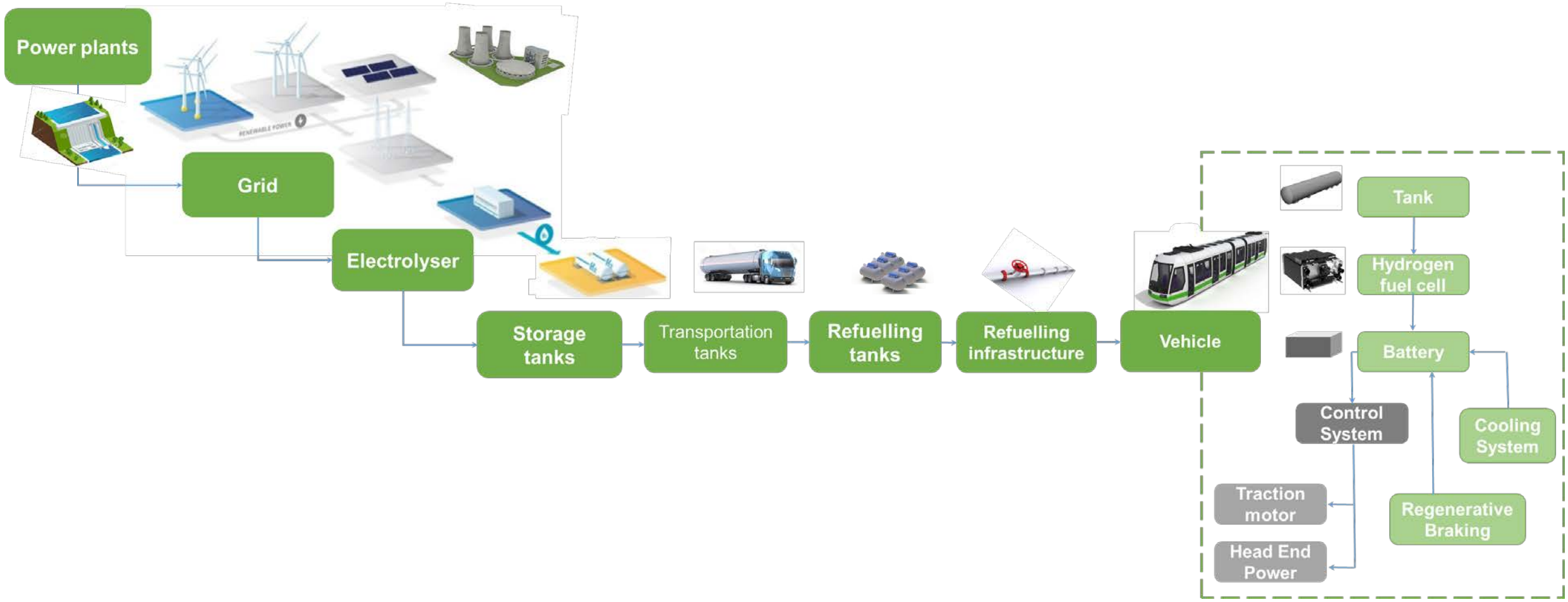
CONTEXT – HYDRAIL IN ONTARIO

Hydrail refers to rail vehicles powered by hydrogen fuel cell (HFC) technology. In Ontario context, Hydrail has several potential benefits including:

- Supports Ontario's climate change goals if hydrogen is produced using Ontario's decarbonized electricity system;
- Potential to use electricity surpluses for hydrogen production;
- Could mitigate the significant capital outlay and eliminate deployment challenges associated with installing overhead catenary wires on live railway corridors;
- Could allow for the electrification of sections of the GO network that cannot be electrified by traditional means; and
- Could position Ontario to be a global leader in hydrogen technology and kick start the hydrogen economy.

THE HYDROGEN RAIL SYSTEM – SYSTEM DESIGN

The components form an integrated hydrogen rail system as shown in the generic diagram below:



FEASIBILITY STUDY – OBJECTIVES AND SCOPE

- The primary objective of the study is to investigate how a Hydrail system could be configured to deliver the proposed RER level of service;

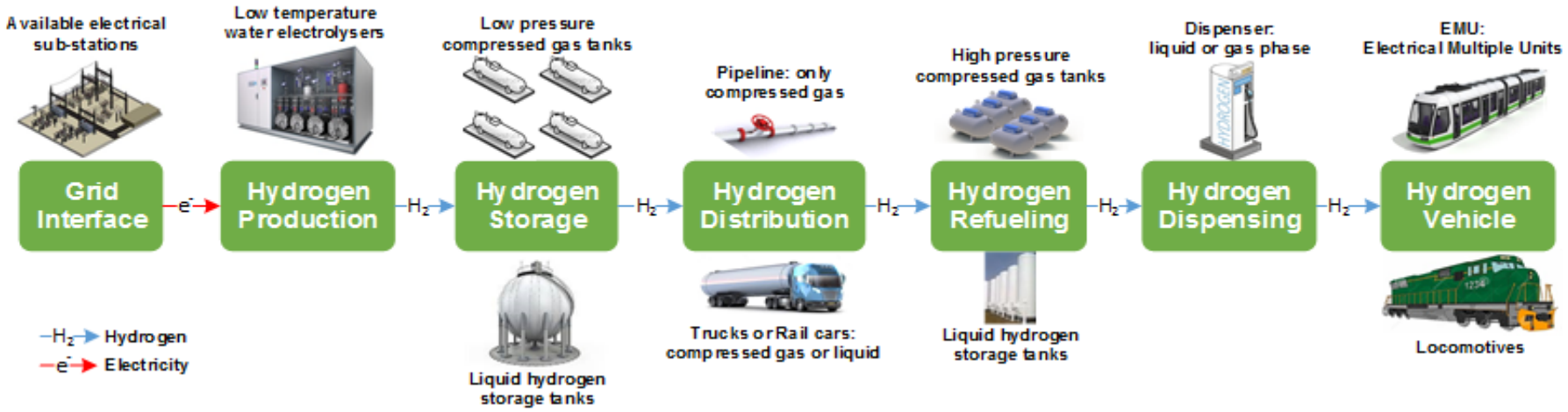
- To achieve this object the Hydrail team is studying the:
  - sizing of the hydrogen fuel cell and battery systems on the vehicles needed to operate RER;
  - sizing of the hydrogen fuel tanks on the vehicles for at least a full day range between refuelling;
  - amount of electricity required to produce the required hydrogen for the system;
  - footprint of the facilities that would need to be built for hydrogen production, storage and fuelling the trains;
  - operational processes for refuelling the trains;
  - maintenance and renewal requirements of the Hydrail system components.

- In addition the feasibility study is also assessing the:
  - regulatory requirements of a Hydrail system;
  - environmental consequences;
  - financial implications;
  - socio-economic benefits;
  - how Hydrail would function as an operational railway;
  - expected timeframe develop Hydrail into an operable RER solution;
  - potential commercial arrangements for implementing Hydrail.

- We are also studying the opportunity of extending Hydrail beyond the current scope of RER Electrification so that it covers the whole GO Rail network and thereby enables the proposed remaining diesel locomotives to be replaced by HFC locomotives.

OPERATIONAL SIMULATION MODEL – BACKGROUND

- There are seven system components to the Operational Simulation Model;
- The rail vehicle component has been based on:
  - The characteristics of a Bombardier ALP-46 locomotive and a Bombardier Twindexx bi-level EMU;
  - The train service pattern in the current RER business case.



Bombardier Twindexx

Bombardier ALP-46

- Hydrogen Production and Hydrogen Storage can be distant from the Hydrogen Refuelling in which case Hydrogen Distribution by truck or pipeline is required; or it can be close to the Hydrogen Refuelling in which case Hydrogen Distribution is not required.

HFC BI-LEVEL EMU CONCEPT DESIGN PROJECT– OBJECTIVES AND STATUS

- We are undertaking this project in order to understand:
  - whether it would be feasible to build a HFC Bi-level EMU that can deliver the RER level of service;
  - the impact of integrating a HFC system into Bi-level EMU trains that are available from the major rail vehicle manufacturers, particularly in relation to seating capacity and vehicle performance.
- Scope of work:
  - up to four rail vehicle manufacturers will be engaged to prepare concept designs, commencing in November 2017 and completing in March 2018;
  - Metrolinx will pay each manufacturer a stipend, provided they submit a completed design package by the end of this period;
  - Hydrogenics will be engaged, through a Design Services Support Agreement, to prepare a HFC reference kit design for all the rail vehicle manufacturers to use and to support them during the design phase.
- Current status:
  - RfP documentation for the procurement of rail vehicle manufacturers to undertake the concept design was posted on MERX on September 15 with proposals from interested proponents due to be submitted by mid-November;
  - a Design Services Support Agreement with Hydrogenics is being prepared.
- The completion of this project will enable Metrolinx to:
  - validate the assumptions in the Feasibility Study Report relating to costs and delivery timescales of acquiring HFC powered Bi-level EMUs as an alternative to standard Bi-level EMUs;
  - prepare a functional specification for a HFC powered EMU that could be used for procurement if Metrolinx decides to progress with Hydrail as an alternative to RER Electrification.

HYDRAIL SYMPOSIUM

Together, the Ministry of Transportation and Metrolinx have invited over 200 industry leaders to join together for a discussion on ***Hydrail in Ontario: Examining Opportunities for Wireless Electrification***.

Industry leaders in fuel cell technology and transit will gather for an all-day symposium on **November 16, 2017** to examine the potential application of hydrogen fuel cell technology to electrify the entire GO rail network. Facilitated discussions of key issue items such as economic development, sustainability, and safety of a Hydrail option, will take place as well as educating key stakeholders on how Hydrail could work in Ontario.

The day will allow for a broad array of subjects to be discussed – from macro trends around the world and across industry, to micro-trends at local level. During the first portion of the day, attendees will hear from speakers who will begin to explore the use of hydrogen fuel technology in use around the world today. The second part of the day will focus more closely on the application of this technology in a hydrail system and will include opportunities for attendees to interact and share ideas through a variety of workshops that will explore critical themes associated with the application of hydrail. The day will conclude with a session moderators who will convene to discuss, reflect on key learnings, questions, feedback and outcome of day's dialogue.

Some notable speakers include:

- Dr. Sunita Satyapal, Director, Fuel Cell Technologies, U.S. Department of Energy;
- Wolfram Schwab, VP Regional Platform – Products & Innovation, Alstom;
- Dr. Christine LaFleur, Risk and Reliability Analyst, Sandia National Laboratories, New Mexico.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