DECARBONIZATION OF LONG-HAUL TRUCKING IN EASTERN CANADA

SIMULATION OF THE e-HIGHWAY TECHNOLOGY ON THE A20-H401 HIGHWAY CORRIDOR

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PROJECT COLLABORATOR

IET INSTITUT DE L'ÉNERGIE TROTTIER

PREPARED FOR

Energy Modelling Initiative
Bringing the Tools to Support Canada's Energy Transition

Introduction

- Freight transportation is one of the most challenging sector to decarbonize
  - Heavy truck sector = 8% of national emissions and tripled since 1990
  - Complex (logistics chains, regulations and cross-border traffic…)
  - Supports daily economic activities

- Current initiatives are insufficient to place Canada on a clear path towards zero-emission road freight
  - Carbon tax; improving standards for heavy-duty trucks; subsidizing alternative truck technologies and fuels; Clean fuel standard for regulating minimum levels of biofuels in diesel.

- Limits of the current approach has led to considering new option: e-highways
  - Overhead catenary system to directly power heavy truck engines equipped with pantographs, on dedicated highway corridors

Objective of the study

- Simulate the potential of e-highway technology for the decarbonization of heavy freight transport on a 1,300 km highway connecting Quebec, Montreal and Toronto, up to the U.S. border

- Based on a GIS analysis of current flows of heavy vehicles, according to the present capacity of the highway

- Study considers hybrid diesel-catenary electric trucks (class 8 and above). The technology is suitable for other energy sources: long-range battery, hydrogen, bio-gas, etc.

Trucks + **Pantograph** + **Overhead lines**

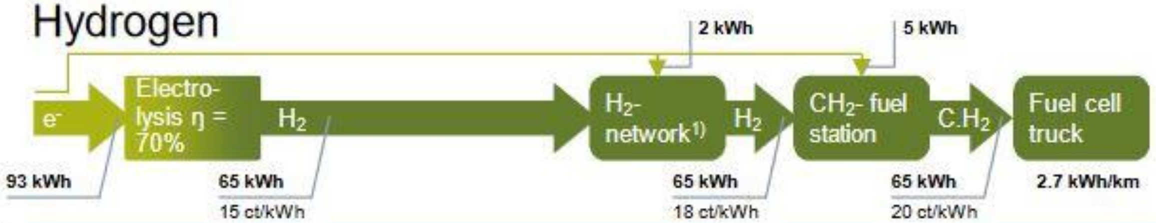
Relevance in the Canadian context and benefits

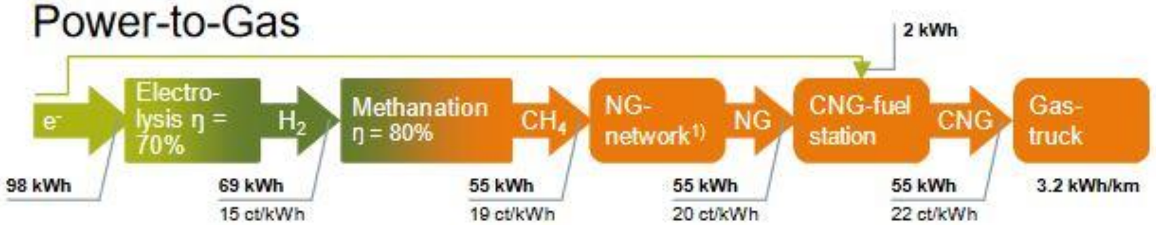
- Linear transportation network
- Clean and affordable electricity
- Use of existing road infrastructure
- Flexibility (transfer from hybrid system to battery over time)
- Tested in cold climate (Sweden)

- Known technology
- Efficiency given direct use of electricity
- No downtime for recharging batteries (for 100% electric trucks)
- Low maintenance and repair costs
- Significant potential for GHG emissions reductions

Zero emission trucks are possible, but efficiency varies

Pathway	Range Cost per km	Efficiency WTW	Example vehicle
Electric Road Systems	**60 km** 19 ct/km	77%	
Battery	**48 km** 20 ct/km	62%	
Hydrogen	**24 km** 55 ct/km	29%	
Power-to-Gas	**17 km** 70 ct/km	20%	

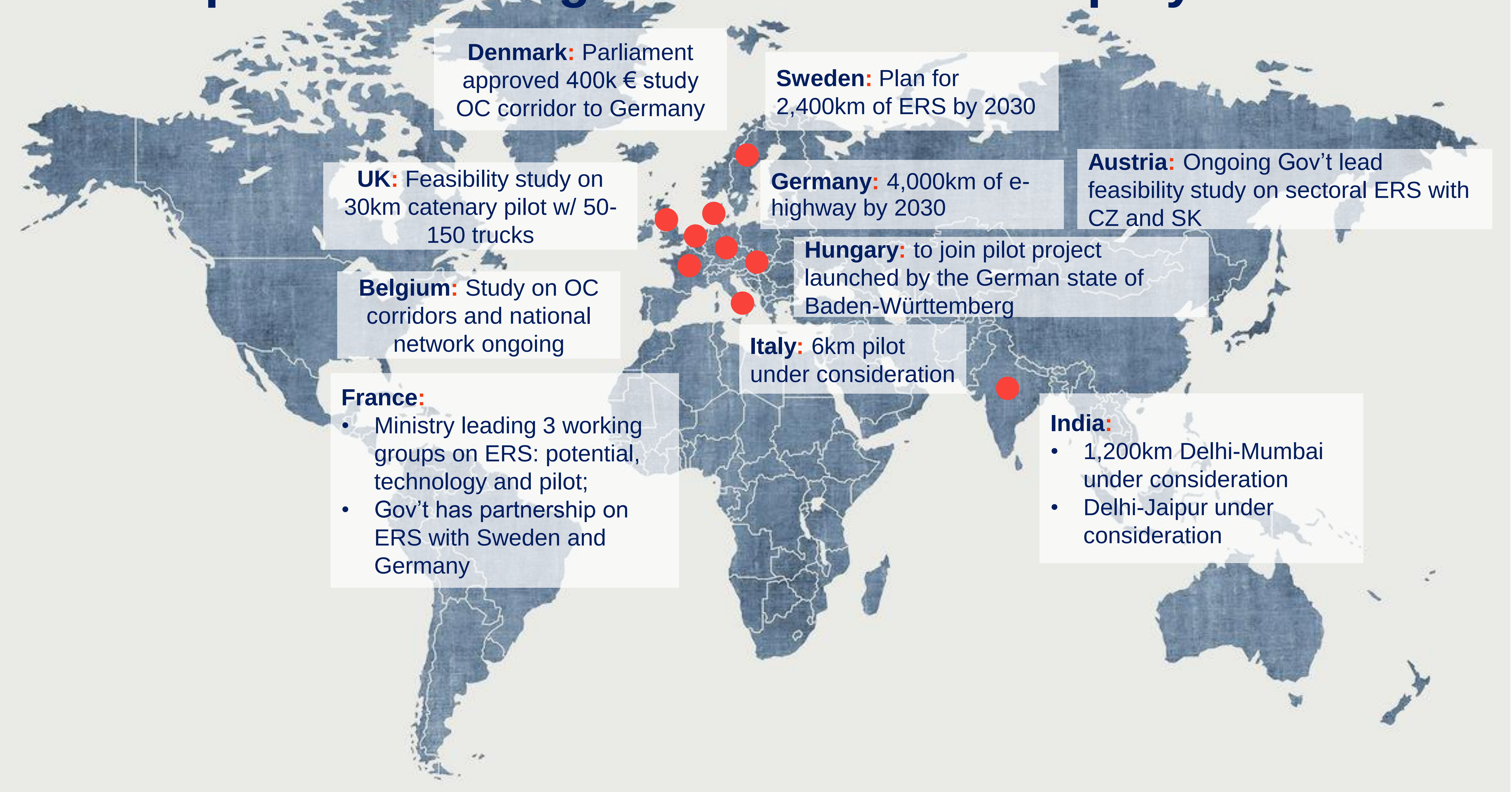




1) Including storage
Source: German Ministry of Environment

e-highways are being pilot-tested in several countries...

... and plans are being made for further deployment



Denmark: Parliament approved 400k € study OC corridor to Germany

Sweden: Plan for 2,400km of ERS by 2030

UK: Feasibility study on 30km catenary pilot w/ 50-150 trucks

Germany: 4,000km of e-highway by 2030

Austria: Ongoing Gov't lead feasibility study on sectoral ERS with CZ and SK

Belgium: Study on OC corridors and national network ongoing

Hungary: to join pilot project launched by the German state of Baden-Württemberg

Italy: 6km pilot under consideration

France:

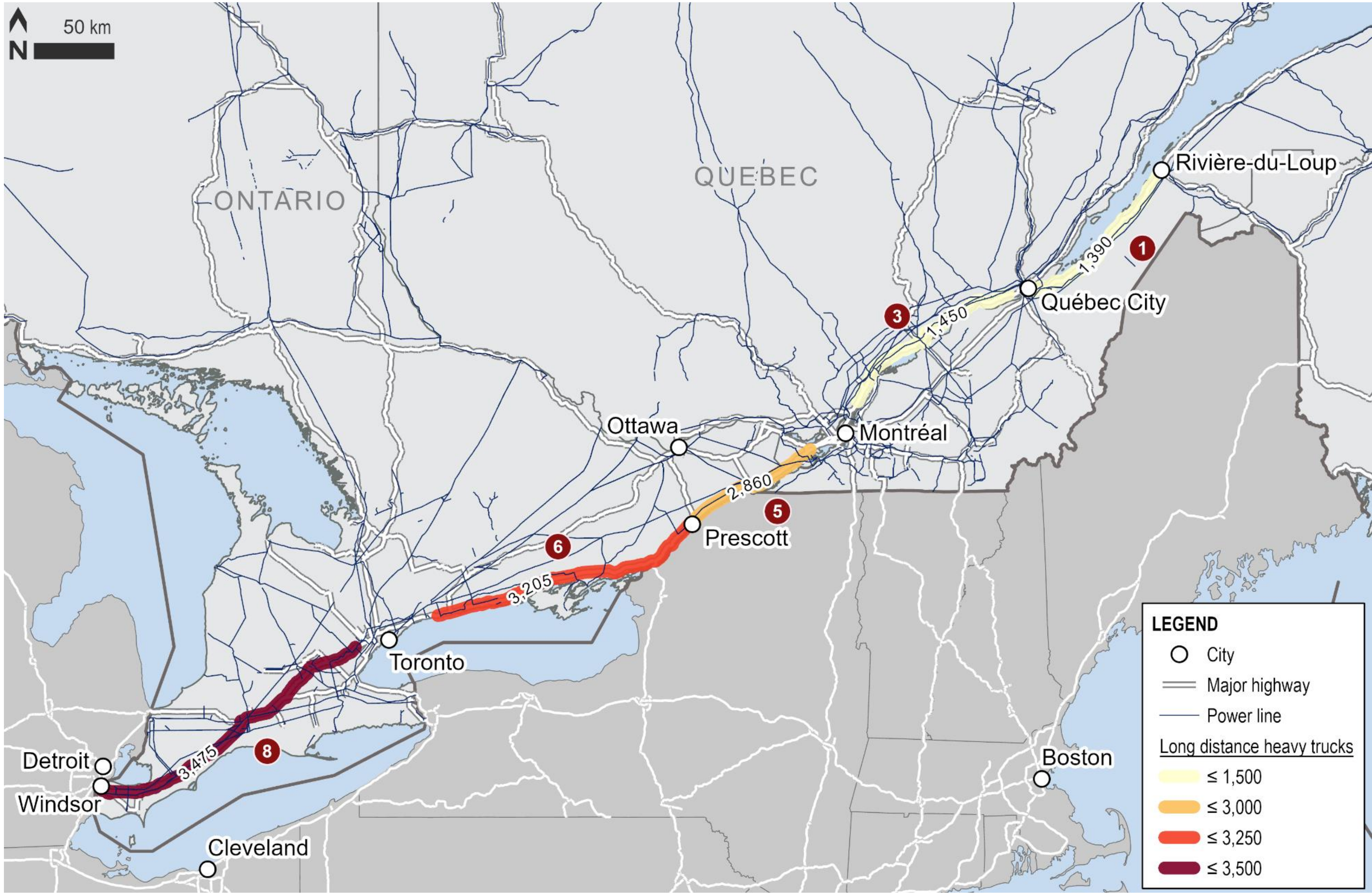
- Ministry leading 3 working groups on ERS: potential, technology and pilot;
- Gov't has partnership on ERS with Sweden and Germany

India:

- 1,200km Delhi-Mumbai under consideration
- Delhi-Jaipur under consideration

Our model simulates the deployment of an e-highway on the A20-H401 corridor

- The corridor (1344km) is divided into segments
- Real truck flow data is extracted from a Geographical Information System (GIS)
- The model compares the costs and benefits of the e-highway with a business-as-usual baseline
- Benefits are: savings on fuel + avoided CO2



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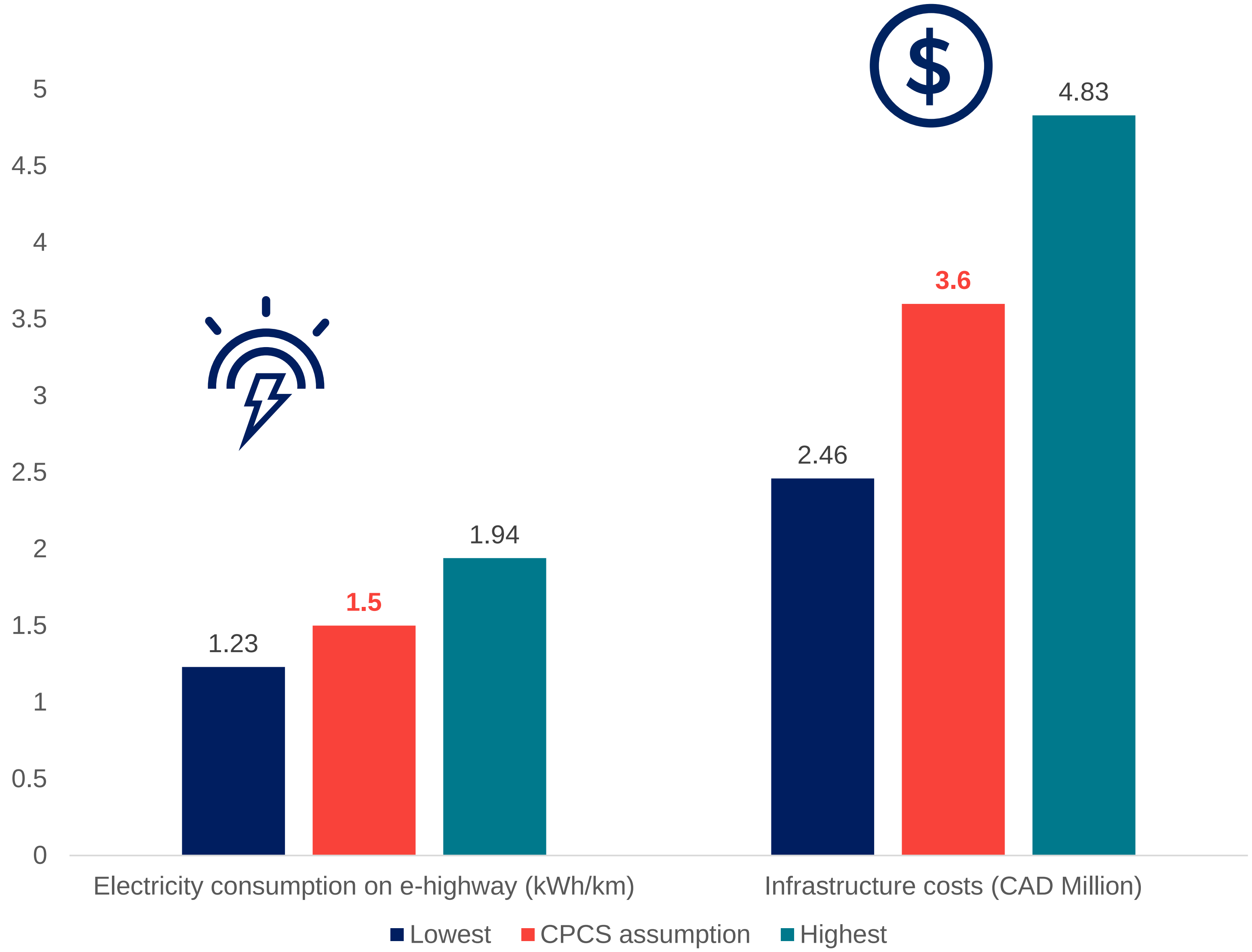
Techno-economic parameters of the e-highway come from a review of the literature



Parameter	Value
Capital cost of infrastructure	CAD 3.6 million / km
Truck's electricity consumption	1.5 kWh/km
Extra capital cost per individual truck	From $70,000/truck today to $20,000/truck in 2040
Carbon contents of electricity	QC: 1.2 g CO_2e/kWh ON: 40 g CO_2e/kWh
Value of carbon	Increase from $30/t CO_2e today to $170/t in 2030

Test n°1: under maximum adoption assumption, the infrastructure pays back in 10 years

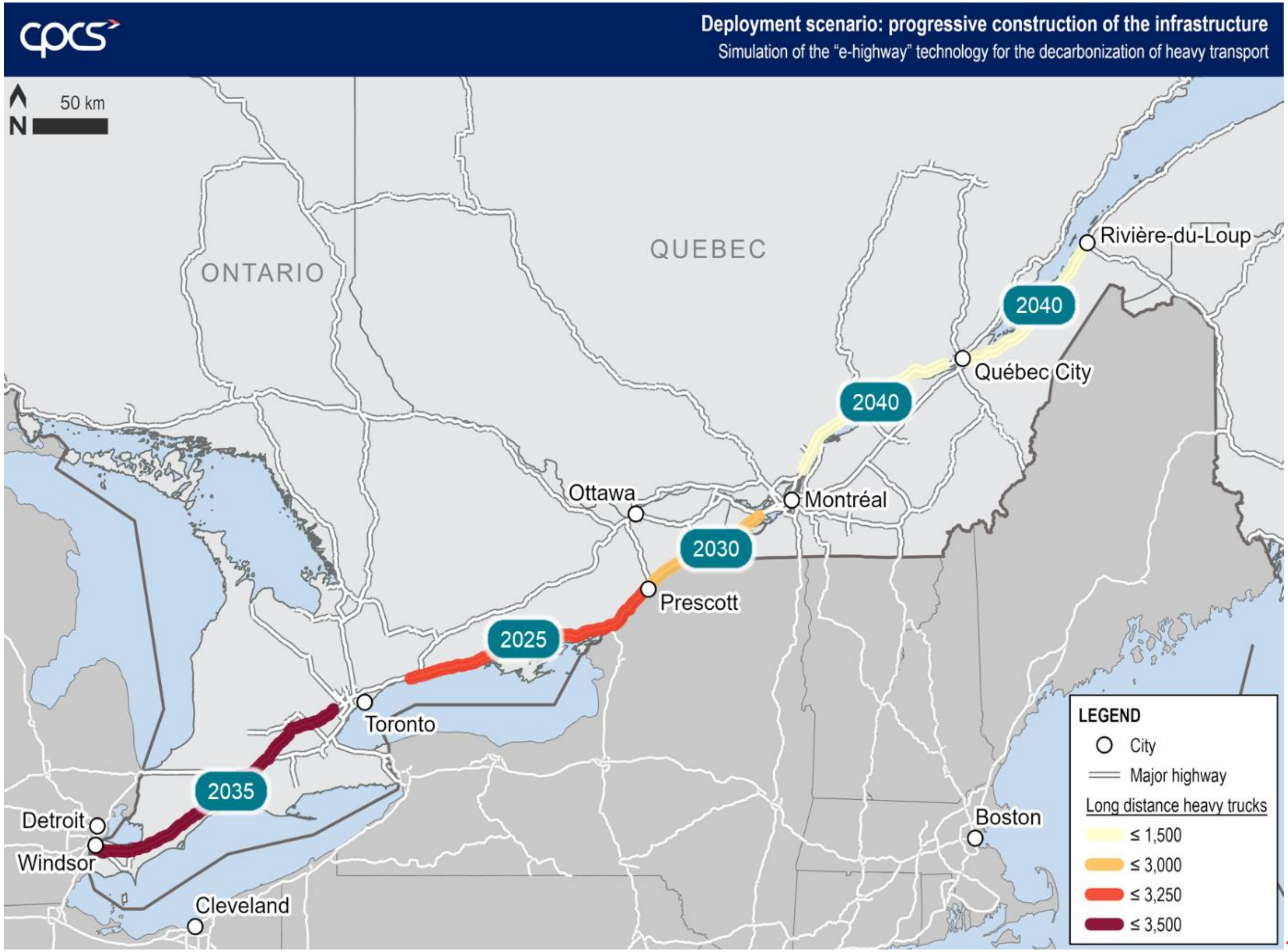
Highway segments	Simple payback period	Avoided GHG, $MtCO_2$/year
Rivière du Loup – Quebec (without city areas)	12	0.3
Quebec – Montreal (without city areas)	11	0.3
Montreal – Prescott (without city area)	8	0.4
Prescott – Toronto (without city area)	8	1.0
Toronto – Windsor (without city area)	7	1.2
A20 – H401	**9**	**3.2**

* **Payback period is shorter on segments with higher traffic**

Simple payback period: number of years after which the initial investment costs are completely offset by the benefits (fuel savings and avoided GHG)

Test n°2: progressive deployment scenario

- Start with South-West: denser traffic
- 5-year increments to allow for construction time
- North East portion of the route last to be electrified
- Progressive adoption by the industry, from 0.2% of the heavy truck fleet in 2025



Test n°2: Under the progressive scenario, the economic rate of return ranges from 7 to 10%

$4.1 billion investment in infrastructure

$0.7 billion extra cost for trucks

Costs

VS

Benefits

Yearly GHG reductions: 2.8 Mt CO_2e

$360 millions CAD d'économie de carburant

ERR: 7%
(10% for segments with highest traffic)

Economic rate of return: discounted economic benefits expressed as a % of initial investment. Similar to an interest rate

Test nº3: Viability is sensitive to fuel and infrastructure costs, and adoption rate

Source CPCS, 2021.

Conclusion

An interesting option at first sight

- **Pays back in 7 years** on segments with highest traffic if 100% adoption
- **ERR of 7 to 10%** with a progressive, more realistic adoption scenario
- **Reasonable abatment costs** ranging from $65/t CO_2 (high traffic, high adoption) to $200/t CO_2 (entire range, progressive adoption)

... While many questions remain open

- What is the **trucking industry**'s perception of the technology, is it compatible with operational constraints?
- Is the technology able to withstand Eastern Canada's **harsh winters**?
- What is the **optimal design** to maximize adoption and benefits?
- How should **costs and benefits be allocated** among stakeholders?

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