

#### Simulation of the "e-highway" technology for the decarbonization of heavy transport on the A20-H401 highway corridor in Eastern Canada

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## 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

Achieving Canada's net zero emissions goals by 2050 will require decisive action in this sector, both technologically and logistically

Current initiatives are insufficient to place Canada on a clear path towards zeroemission 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 of the A20-H401 highway corridor 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 road capacity of the A20-H401
- Study considers hybrid diesel-catenary electric trucks (class 8 and above)
- First step in a proposal developed by HEC Montréal and CPCS, in collaboration with government, university and private partners, to compare the costs and potential of different decarbonization technologies along the A20-H401 axis.



### The e-highway: a new concept based on centuryold technology





- A supporting structure built outside the road boundary holds two overhead catenaries, supplying the positive and negative electrical circuit.
- Electricity is transferred to the trucks through a pantograph installed on the roof.
- A secondary source of energy is used outside of electrified roads. This secondary source can be diesel or electricity (with a long-range battery), as well as hydrogen, bio-gas, etc.
- The technology is extremely flexible, as trucks equipped with the technology remain able to circulate on any road. The catenary system does not prevent other vehicles from using the electrified highway





### **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



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

California: 1.6km segment

Sweden: 2km segment

• Germany: 3 ongoing pilots

 10km electric road test track near Frankfurt

 5km portion of a motorway near Lübeck

a selected public test route between Kuppenheim and Gernsbach-Obertsrot

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





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# The model compares the costs and benefits with a business-as-usual baseline

Techno-economic parameters of the e-highway Scenario for deployment and adoption by the industry

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#### Costs

- Investment cost
- O&M cost, incl electricity

#### **Benefits**

- Savings on fuel
- Avoided CO<sub>2</sub>

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







## Assumptions (continued)

Parameter	Value	Basis
Extra capital cost per individual truck	50,000 CAD/truck	Extra investment per truck, covering the pantograph, the electric drive train, and a buffer battery.
Electricity consumption on e-highway	1.5 kWh/km	Value available in the literature range from 1.23 to 1.94
Diesel consumption on highway	0.45 liters/km	Average of 5.25 mpg (Ontario) and 5.35 mpg (Quebec)
Carbon contents of electricity	QC: 1.2 g CO2eq/kWh ON: 40 g CO2eq/kWh	Natural Resources Canada's 2017 National Inventory Report
Carbon contents of diesel	2.6 kgCO2eq/l	Natural Resources Canada's 2017 National Inventory Report
Cost of diesel	0.78 CAD/liter	Natural Resources Canada, 17 Feb. 2021. Taxes are excluded (0.389 CAD/liter)
Value of 1 ton of avoided CO2	50 to 170 CAD	





#### under maximum adoption assumptions, the infrastructure pays back in 10-20 years

	\$							
	Highway segments	Simple payback period @\$50/tCO2	Simple payback period @\$170/tCO2					
1.	<b>Rivière du Loup – Quebec</b> (without city areas)	25	13					
3.	Quebec – Montreal (without city areas)	23	12					
5.	Montreal – Prescott (without city area)	23	9					
6.	<b>Prescott – Toronto</b> (without city area)	20	8					
8.	<b>Toronto – Windsor</b> (without city area)	17	7					
Total	A20 – H401	20	9					

**Test #1:** 

Payback period is shorter on segments with higher traffic



Simple payback period: number of years after initial investment costs would be completely offset by net savings from avoided diesel consumption.

# Test #2: simulates a realistic, step-by-step 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





# Test #2: adoption by the industry is assumed to progress slowly





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# Test #2: under this "realistic" scenario, benefits outweigh the costs from \$85/tCO2



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# Test #3: Viability is sensitive to infrastructure cost and adoption rate







#### Limitations of the study and future research avenues



- Uncertainty on adoption rate of technology
- Relevance of technology for heavy truck industry (operational constraints) and better understanding of the preferences of the industry
- Financing structure and costs
- Benefits sharing allocation between different stakeholders
- > Other feasibility considerations ex: overhead clearance issues
- > Different configurations ex: alternative switching systems
- Different design for catenary trucks





## Link to download report

https://energie.hec.ca/e-highwaysimulationeastcanada/

### > Thank you:

- EMI for funding
- Academic collaborator:
  - Normand Mousseau, Institut Énergie Trottier Polytechnique Montréal
- Reviewers:
  - Peter Harrison, CPCS
  - Joel Carlson, CPCS
  - Patrik Åkerman, Siemens Mobility
  - Pierre-Olivier Pineau, HEC Montréal







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