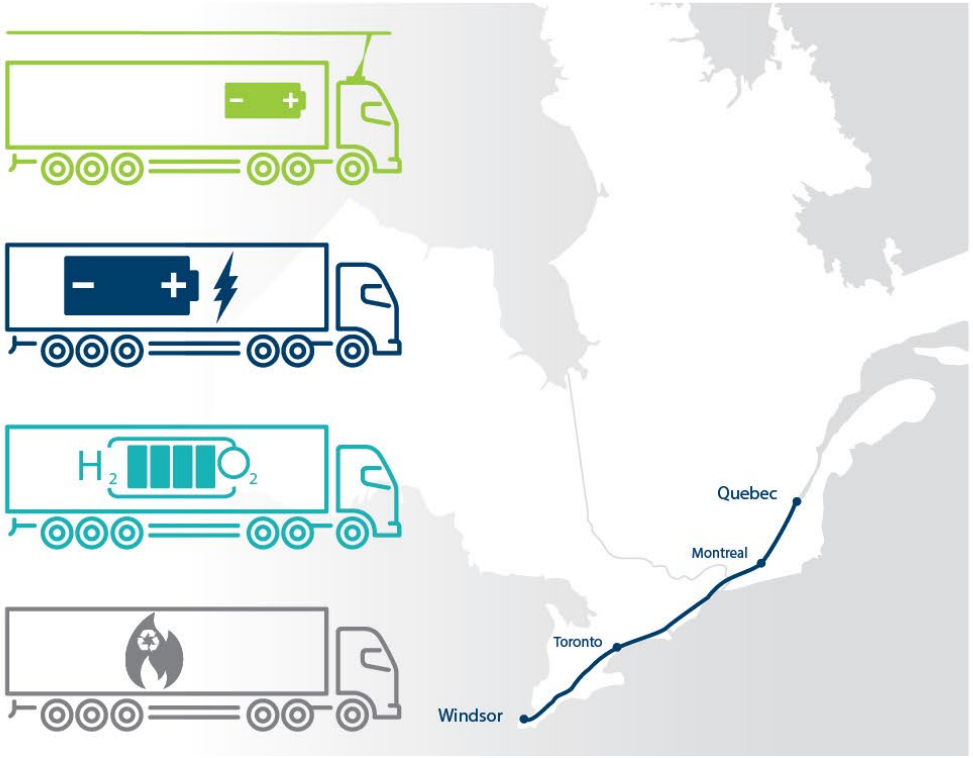


DECARBONIZING LONG-HAUL TRUCKING IN EASTERN CANADA

A COMPARISON OF TECHNOLOGIES ON THE A20-H401 HIGHWAY CORRIDOR BETWEEN QUÉBEC AND WINDSOR

Chair in Energy Sector Management
HEC MONTRÉAL

PROJECT COLLABORATOR
cpcs solutions for growing economies

PREPARED FOR
Québec

MANDATE AND OBJECTIVE

Mandate: The Chair in Energy Sector Management at HEC Montréal and CPCS are carrying out, in collaboration with the Government of Québec, a technoeconomic study comparing class 8 technologies to decarbonize long-haul trucking, with a focus on the Highway corridor between Québec City and Windsor.

1. **Battery electric trucks**
2. **Hydrogen fuel cell electric trucks**
3. **Renewable natural gas trucks (RNG)**
4. **Electric road system with overhead conductive transmission (ERS-OCT)**

Workshop objective: Explore and validate transparently with experts from industry, government, academia and professional both the larger decarbonization context and key parameters to consider in the analysis.

RESEARCH TEAM AND COLLABORATORS

Chair in Energy Sector Management, HEC Montréal (Research Project Lead)

- **Johanne Whitmore**, Senior Researcher
- **Pierre-Olivier Pineau**, Professor and holder of the Chair

CPCS (Modelling Lead)

- **Mathieu Cyr,** Associate Vice President
- **Nick Roberts,** Senior Consultant

Government of Québec (Interministerial Committee)

- **Guillaume Paré,** Strategic Mobility Advisor, MELCCFP (Lead)

+ 8 representatives from ministries (MELCCFP, MTMD, MFQ, MEIE)

THE WORKSHOP, 25-27 APR 2023

- 50 stakeholders from different levels of decision-making from the academic, government, professional and industry sectors from QC, ON, Federal, US and EU
- Scoping conference (25 April) + 4 Roundtables (26-27 April)
- Workshop synthesis report to support CPCS simulations

CPCS Simulations

- Analysis of scenarios and 1st results (May – August)
- Review process
- Final publication and presentation (Fall-Winter)

WHY ?

- Initiatives to decarbonize long-haul road freight are limited due to the complexity of the sector, **lack of transparency, collaboration** and **independent study**. Incoherence within and between governments. Often politicized and special interest lead.
- Few studies have assessed the feasibility associated with the potential of decarbonization technologies in long-haul trucking along prominent highway **corridors through Canadian provinces** and into the USA
- Help provide **transparent data and assumptions on the technologies to allow others to use and update the data and the model for further studies and open collaborations**
- Results can be used within a more **systemic approach for decarbonizing long-haul freight** to assess the impacts of different technological/intermodality choices on electricity grid, infrastructure, and energy demand, and on reaching GHG reduction targets based on different pathway scenarios (e.g., Energy Modelling Hub, University of Windsor)

SCOPING CONFERENCE

April 25, 2023

PROGRAMME

8:30	**Introduction** by Johanne Whitmore (HEC) and Nicholas Roberts (CPCS)
8:45	**Part 1 | State of long-haul freight transportation** + Q&A
9:50	*Break*
10:00	**Part 2 | Technoeconomic Overview - Trucks and Infrastructure** + Q&A
11:15	*Break*
11:30	**Part 3 | International Perspectives and Lessons** + Q&A
12:45	

For biographies of the guest speakers, consult the PDF version of the programme https://energie.hec.ca/events/25apr2023

PART 1 | General Overview

State of long-haul freight transportation

Dr Pierre-Olivier Pineau, Professor, Chair in Energy Sector Management, HEC Montréal

Michael Roeth, Executive Director, North American Council for Freight Efficiency and Trucking Lead at the Rocky Mountain Institute

Government Perspectives — Federal, Québec and Ontario

Jordan Wolfe, Deputy Director, Zero Emission Trucking Program, Transport Canada

Alain Lemieux, Economist, ministère des transports et de la mobilité durable, Gouvernement du Québec

Carolyn Kim, Senior Director, Communities & Decarbonization Group, Pembina Institute

PART 2 | Technoeconomic Overview

Hydrogen Fuel Cell Trucks

Rymal Smith, Owner/Partner, Change Energy Services

Renewable Natural Gas Trucks

Francisco Doyon, Advisor development of natural gas for vehicle (NGV), Énergir

Overhead Conductive Transmission Trucks with dynamic charging

Dr David Cebon, Professor of mechanical engineer and Director of Centre for Sustainable Road Freight, University of Cambridge

Battery Electric Trucks

Charles Trudel, Technological Application Group Manager, Innovative Vehicle Institute

PART 3 | International Perspectives and Lessons

How to minimize cost uncertainty

Dr Matteo Craglia, Transport Analyst & Modeller, OECD - International Transport Forum

Decarbonizing logistics, intramodality, efficiency

Dr Maja Pieck, Professor of logistics, University of Westminster

US – Canada cross border challenges and energy demand on grid

Dr Georgiana Vani, Sessional instructor with the Department of Civil and Environmental Engineering and Research associate with the Cross-Border Institute, University of Windsor

US – Natural Renewable Energy Laboratory

Dr Arthur Yip, Researcher, National Renewable Energy Laboratory

ROUNDTABLES

Please read **Backgrounder**.

Wednesday, April 26

Table 1, 9:00-11:15am
Table 2, 1:00-3:15pm

Thursday, April 27

Table 3, 9:00-11:15am
Table 4, 1:00-3:15pm

The six questions to be discussed are in the PDF programme:
https://energie.hec.ca/events/25apr2023

cpcs
solutions
for growing
economies

Modeling approach.

Chaire de gestion
du secteur de l'énergie
HEC MONTRÉAL

CPCS.

CPCS is a management consulting firm **specialized in transportation and energy sectors**. Our team advises in strategic, economic and policy mandates related to passenger and freight transportation.

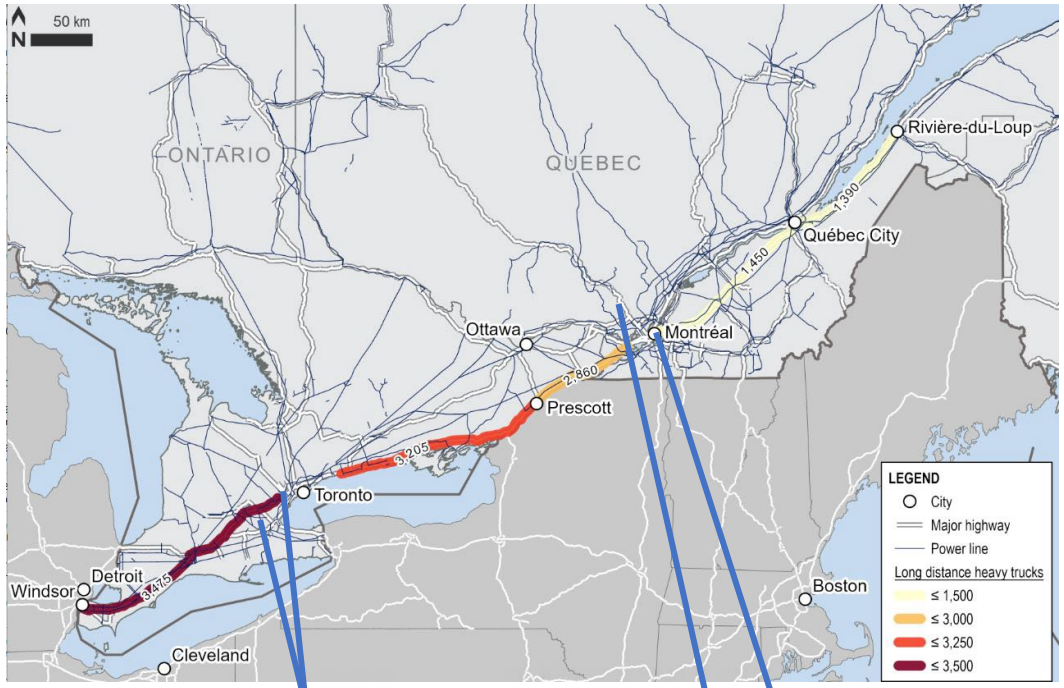
Nick Roberts, P. Eng. Senior Consultant at CPCS

- Dual master's degree in finance and management from leading business universities in Europe
- Mechanical engineering undergrad from the University of Waterloo
- Has led various technical studies and business cases across Canada on zero emission public transit and freight

Mathieu Cyr. Associate Vice President at CPCS

- MBA and master's degree in environment (M.Env)
- Project manager on 150+ studies in Canada, US and Africa
- Specialized in socio-economics, market analysis, risk analysis and impact assessment
- Comprehensive understanding of the implementation of public policies and project development

Importance of the corridor.



Corridor highway 401 – Autoroute A20

- Canada's busiest long-haul trucking corridor
- Largest population centres in Canada
  - Greater Toronto Area
  - Montréal
- Hubs for intermodal facilities, warehousing and distribution
- Links cross-border trade with US via Windsor-Detroit
  - Ambassador Bridge
  - Gordie Howe Bridge
- Serves Port of Montréal (2nd largest container port in Canada)
- Connections to major air cargo hubs:
  - Montréal-Trudeau and Mirabel Intl.
  - Toronto Pearson and Hamilton Intl.

Toronto Pearson
300,000 tonnes/year

Hamilton Intl.
122,000 tonnes/year

Port of Montréal
41 Mt per year (total)
1.7 million TEUs

Montréal-Trudeau
81,000 tonnes/year

Mirabel Intl.
79,000 tonnes/year

Statistics Canada. Table 23-10-0254-01 Air cargo traffic at Canadian airports, annual (2020) and latest available data from Canadian Port Authorities (2021)

CPCS's project scope.

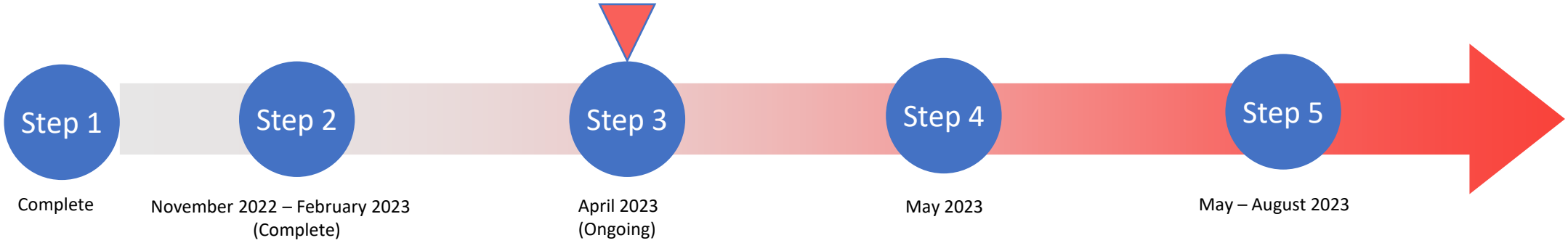
Step 1: Identify in scope vehicle technologies to assess

Step 2: Literature review of technical and economic parameters

Step 3: Validation of data through expert consultations

Step 4: Define operating parameters for simulation

Step 5: Cost-benefit and sensitivity analysis scenarios



CPCS modeling methodology.

Step 1: Identify in scope vehicle technologies to assess

Baseline (BAU):
- Diesel

Net zero technologies:
- RNG
- Battery electric
- Battery w/ catenary
- Hydrogen fuel cell

Step 2: Literature review of technical and economic parameters

Vehicle costs and performance specs
- Battery / fuel tank size (kWh, L, kg, MJ)
- Operating range (km)
- Payload / cargo capacity (kg)
- Purchase price ($)
- Major component cost ($) (e.g. battery pack, traction motor, fuel cell, etc.)
- Energy / fuel consumption (e.g. kWh/km, L/km)
- Charging / refueling time (minutes, hours)
- Maintenance ($/km)
- Operating lifecycle (km, years)

Infrastructure costs and performance specs
- Unit costs (e.g. $ per station)
- Charging / refueling capacity and output (kW, L or kg per minute)
- Cost equivalent per kilometer ($/km) – inclusive of capital and operating / maintenance

Socio-economic parameters
- Fuel prices ($/L, $/kg, $/MJ)
- Electricity price ($/kWh)
- Cost of GHG emissions ($/tonne) – carbon prices (ON and QC)
- Energy / fuel emissions (CO2e per L or kWh)

Step 3: Validation of data through expert consultations

Review input parameters / assumptions on vehicle and infrastructure lifecycle costs with:
- Industry, manufacturers, government, academics

Step 4: Define operating parameters for simulation (GIS data)

Long-haul trucking, A-40 / 401 statistics
- Traffic volumes (number of trucks on highway)
- Distribution, average of trucking distances (km)
- Truck stop locations (e.g. potential refueling / recharging) and distance between stops

Step 5: Cost-benefit and sensitivity analysis scenarios

Key output metrics for CBA:
- Total lifecycle cost (vehicle + infrastructure)
  - Breakdown by cost component (e.g. purchase, fuel / electricity, maintenance, infrastructure, etc.)
- Cost equivalent per kilometer ($/km)
- Cost $ per tonne CO2e mitigated (technologies compared against diesel as BAU case)

Sensitivity analysis:
- +/- 25% on key parameters (e.g. purchase price, fuel and electricity prices, infrastructure CAPEX)

Out of scope parameters / analysis for CPCS:
- Forecasting of fuel prices, component prices and performance improvements (e.g. battery price trends)
- Forecasting timeline and improvements of upstream electricity / power generation (e.g. grid emissions reduction)
- End of life costs environmental impacts for disposal / recycling of components