Supply Chain

The CESAR Pathways Project: Modelling Canada's Low Carbon Future

CESAR CANADIAN ENERGY SYSTEMS ANALYSIS RESEARCH

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INTRODUCTION

The success of Canada's economy is dependent on the strength of its supply chains and the freight transportation systems that support them [1]. But it comes at a price of massive GHG emissions, carrying 11% of Canada's GHG total [Fig. 1].

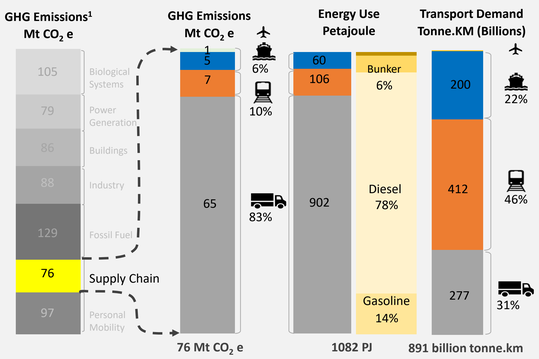

Fig. 1: Canada's Freight Transportation GHG Emissions, Energy Use, Transportation Demand [2][3][4]

GHG FACTORS

Demand for Transportation continues to increase and mode share splits remain relatively constant [Fig. 2].

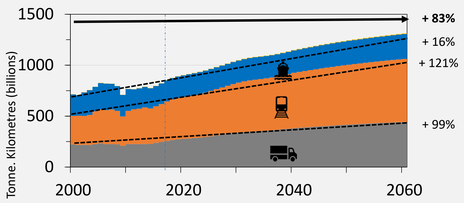

Fig. 2: Activity and Mode Share Splits from Reference Scenario [5]

With energy intense truck transportation maintaining a large share of the demand, GHG emissions are growing at a rapid pace [Fig. 3].

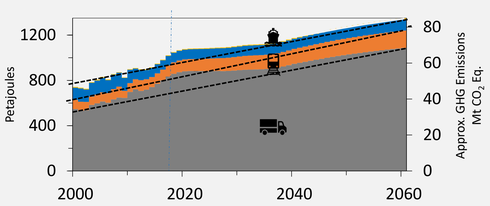

Fig. 3. Energy Use & Approximate GHG Emissions (downstream) from Reference Scenario [5]

GHG REDUCTION STRATEGIES

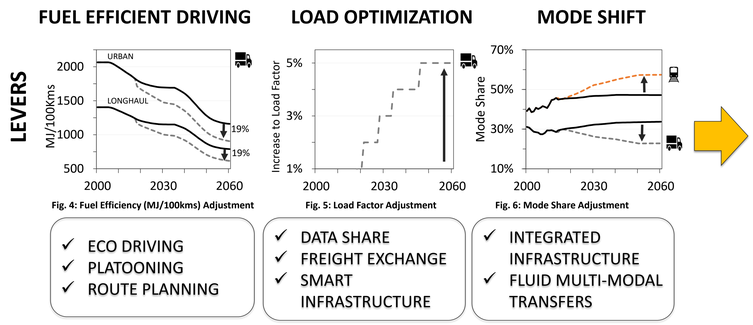

Fig. 4: Fuel Efficiency (MJ/100kms) Adjustment **Fig. 5: Load Factor Adjustment** **Fig. 6: Mode Share Adjustment**

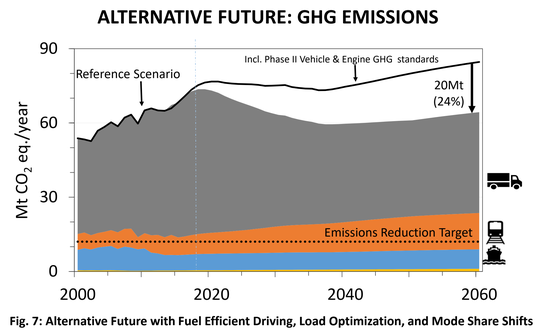

Fig. 7: Alternative Future with Fuel Efficient Driving, Load Optimization, and Mode Share Shifts

A TRANSITION TO LOW CARBON FUELS IS CRITICAL!

Once thought impossible, zero emissions trucking has now turned into reality with both hydrogen fuel cell and battery electric heavy duty vehicles being commercialized by multiple manufacturers as soon as 2019 [6].

The below scenario explores how converting long-haul fleets to **hydrogen fuel cell electric (HFC) vehicles** and short-haul urban fleets to **battery electric vehicles (BEV)** will help bring the freight sector closer to the reduction targets.

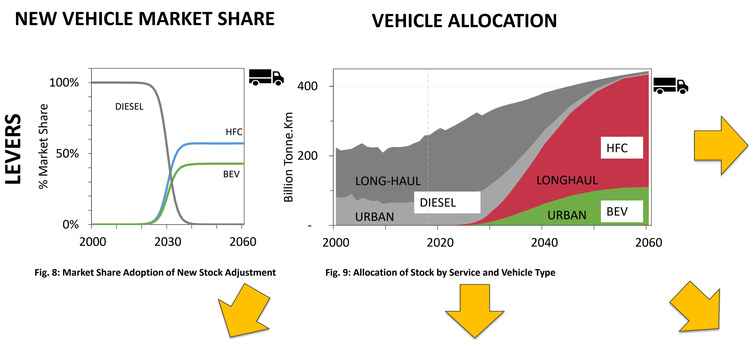

Fig. 8: Market Share Adoption of New Stock Adjustment **Fig. 9: Allocation of Stock by Service and Vehicle Type**

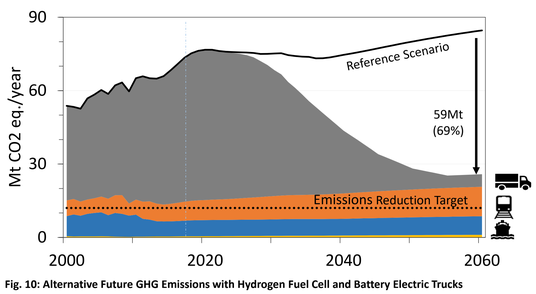

Fig. 10: Alternative Future GHG Emissions with Hydrogen Fuel Cell and Battery Electric Trucks

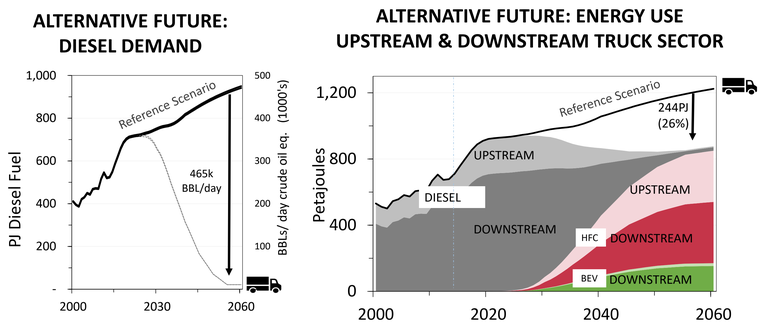

Fig. 11: Change to Diesel Demand in Alternative Future **Fig. 12: Alternative Future Energy Demand with HFC and BEV** **Fig. 13: Truck Sector Alternative Future Upstream & Downstream GHG Emissions with HFC & BEV**

NOTES

- Mode share shifts, load optimization, and fuel efficiency measures are important to stabilize the system and reduce waste BUT the gap from the reduction target remains enormous.
- **Autonomous/Driverless Trucking** has the potential to be in conflict with the mode shift strategy.
- **E-commerce trends** have the potential to be in conflict with the load optimization strategy.
- If the freight sector is going to reach an 80% GHG remission reduction and direct the disruption of autonomous trucking and online retail, an investment in suitable alternative fuel technology is urgently needed.

COMPARING LONG-HAUL HEAVY DUTY TRUCKS

DIESEL INTERNAL COMBUSTION →

Distance & Payload	Fuel Economy [7]	Fuel Used*	Energy Content (HHV)	Power Train Eff. [8]	Useful Energy	Energy Lost*	GHG Emissions*
1000 km 20 Tonne	1.75 Kg/ T-100km	393 Kg (470 L)	45 MJ/KG	35 %	6,300 MJ (1750 kWh)	11,700 MJ (3,250 kWh)	1.3 T CO_2 eq.

← HFC- ELECTRIC (Theoretical)

Distance & Payload	Fuel Economy *	Fuel Used*	Energy Content (HHV)	Power Train Eff. [8]	Useful Energy	Energy Lost*	GHG Emissions*
1000 km 20 Tonne	0.40 Kg/ T-100km	79 Kg (2,090 L)	142 MJ/KG @ 700 Bar	56 %	6,300 MJ (1750 kWh)	4,950 MJ (1,375 kWh)	0 T CO_2 eq.

* Calculated figure, light grey boxes are fixed variables

Fig. 14: Calculated Fuel Requirements for a HFC Long-haul Truck Based on an Equivalent Diesel Heavy Duty Truck

- The electrification of trucking will bring Canada close to its emission reduction targets BUT the targets cannot be reached without alternative fuels for rail and marine as well [Fig. 10].
- As the demand for diesel declines [Fig. 11], the hydrogen economy can play into Canada's economic strengths of our richness in natural gas, our abundance of renewable energy, and our strong pipeline network for distribution.
- Even with upstream emissions, HFC & BEV vehicles are more desirable than diesel from a GHG and energy use perspective [Fig. 12&13].
- Steam Methane Reform (SMR) production of hydrogen will have upstream emissions that are moderately higher than Canada's projected average grid emissions for H2 production by electrolysis [Fig.13].

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