

## Probabilistic Carbon Abatement Costs of Green Hydrogen for Heavy-Duty Trucks

<sup>a</sup> Department of Mechanical and Mechatronics Engineering, University of Waterloo, 200

\* Corresponding author: [xiaoyu.wu@uwaterloo.ca](mailto:xiaoyu.wu@uwaterloo.ca)

Uncertainty surrounding carbon abatement creates challenges for policymakers and stakeholders evaluating the risks associated with transitioning to low-carbon fuels, particularly hydrogen, in heavy-duty trucking. This paper examines the carbon abatement potential of using hydrogen in heavy-duty road freight, considering input parameter uncertainty. Our analysis is built on the combination of cost of hydrogen and Monte Carlo-based framework that accounts for the complex relationship between renewable energy availability, electricity costs, capital expenditures (CAPEX), operational costs (OPEX), and carbon emissions intensity. By exploring various scenarios, we identify instances where adopting hydrogen as a fuel for heavy-duty vehicles makes both economic and environmental sense. Additionally, the study explores how major parameters should change to reach the target carbon tax, set at CA\$170/t<sub>CO<sub>2</sub></sub> in 2050. The results showed that levelized cost of carbon abatement (LCCA) become economically competitive when cost of hydrogen is very low e.g., electricity generation mix with minimum percentage of renewable energy sources. The findings also indicated that to reach the target LCCA, significant reduction of solar panels CAPEX, FCEV capital costs, cost of electricity, discount rate are a key objective. Our comprehensive analysis provides valuable insights for policymakers, industry stakeholders, and decision-makers seeking effective pathways to reduce carbon emissions in heavy-duty road freight.