Techno-Economic Analysis of Green Hydrogen Distribution for Heavy Transport: A Western Australian Case Study

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Introduction

- Western Australia (WA) heavily depends on its extensive road network for economic activities, with industries like mining relying on heavy road transport, contributing significantly to the state's carbon emissions.
- The primary focus is to examine the techno-economic aspects related to the transportation and distribution of hydrogen (H_2) as a fuel for Heavy-Duty Trucks (HDT) operating in Western Australia, excluding green H_2 production **(Figure 1).**
- The final deliverable is a flexible model with a user-friendly, graphical interface allowing users to input specific parameters and explore and optimize hydrogen supply chain options for WA.

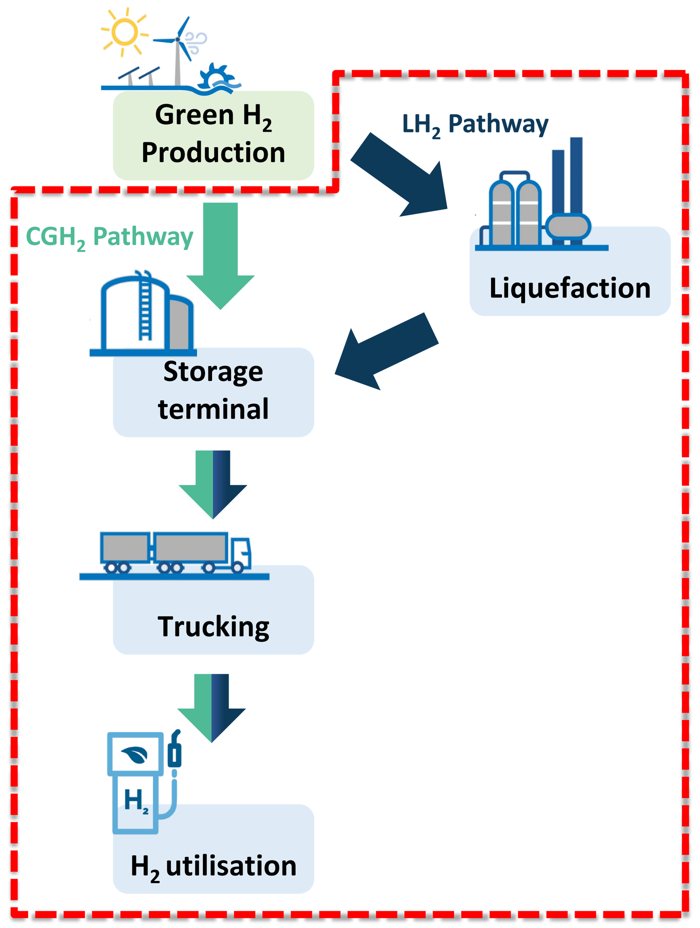

Figure 1: Green H_2 value chain

Figure 2: Preliminary study area

Methodology

- The framework **(Figure 3)** is developed for two delivery modes; Liquid Hydrogen (LH_2) and Compressed Gas Hydrogen (CGH_2), inspired by the currently available model – HDSAM [1].
- Calculates the Levelised cost of Hydrogen (LCOH) for both LH_2 and CGH_2.

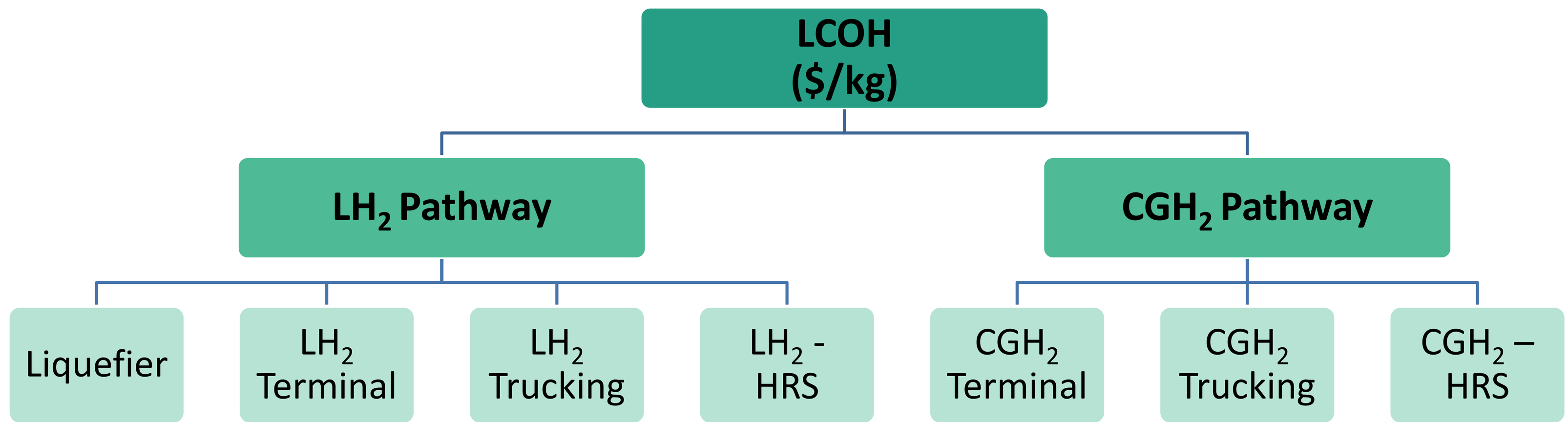

Figure 3: Framework for Hydrogen Distribution Model

- For each component, the Capital Cost, Operating & Maintenance Costs and Energy/Fuel Costs are calculated individually.
- The case study results identify optimal delivery methods, storage options, and transportation infrastructure, analysing the Levelised Cost of Hydrogen (LCOH) for heavy-duty transportation in WA across various penetration scenarios (low, medium, and high).

Major Outcomes

- To investigate most influential parameters and the effect of the parameters, for the delivery pathways, a sensitivity analysis was conducted.

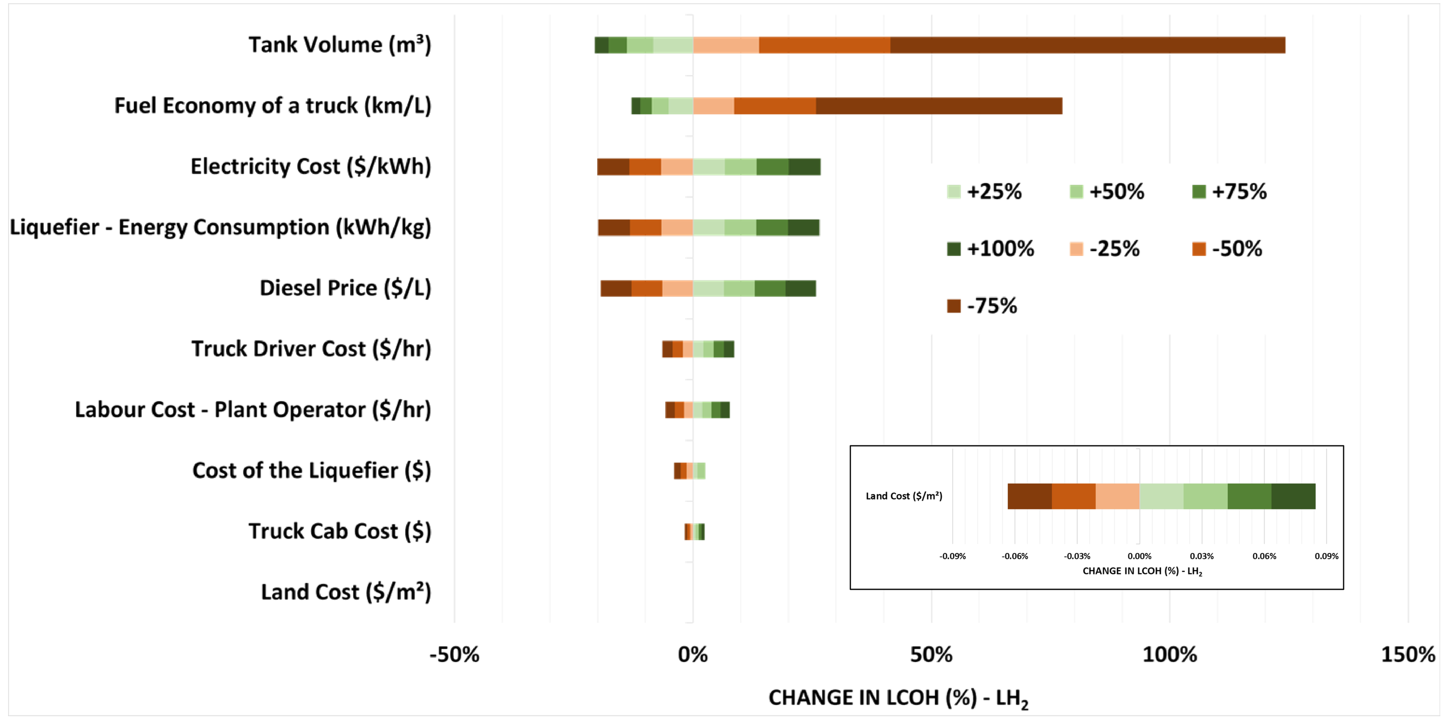

Figure 4: Most influential parameters for the LH_2 pathway

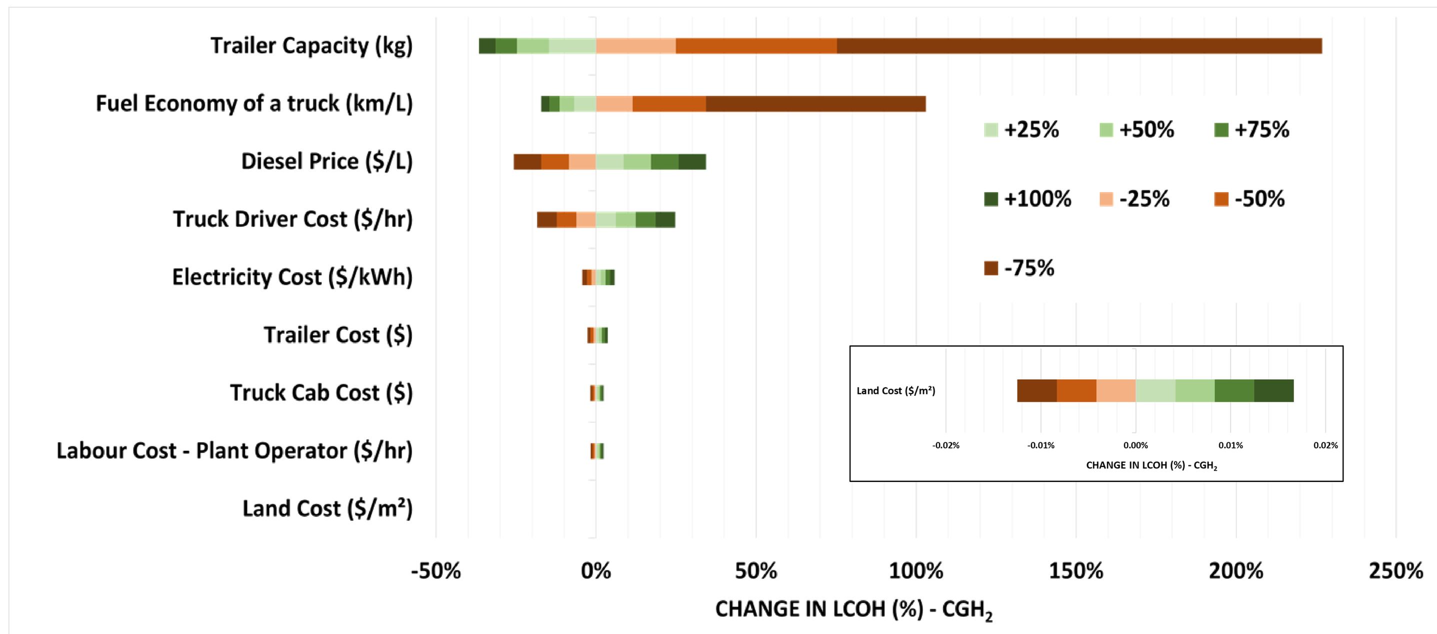

Figure 5: Most influential parameters for the CGH_2 pathway

- In Western Australia, hydrogen distribution costs for heavy-duty transport are primarily influenced by route distance, with increased OPEX observed on longer routes and a shift in cost dynamics favouring LH_2 over CGH_2 due to its higher transport efficiency.
- The analysis of LCOH for LH_2 and CGH_2 across varying demands and distances reveals a crossover point where LH_2 becomes more cost-effective beyond a certain distance, as shown below **(Figure 6)**.

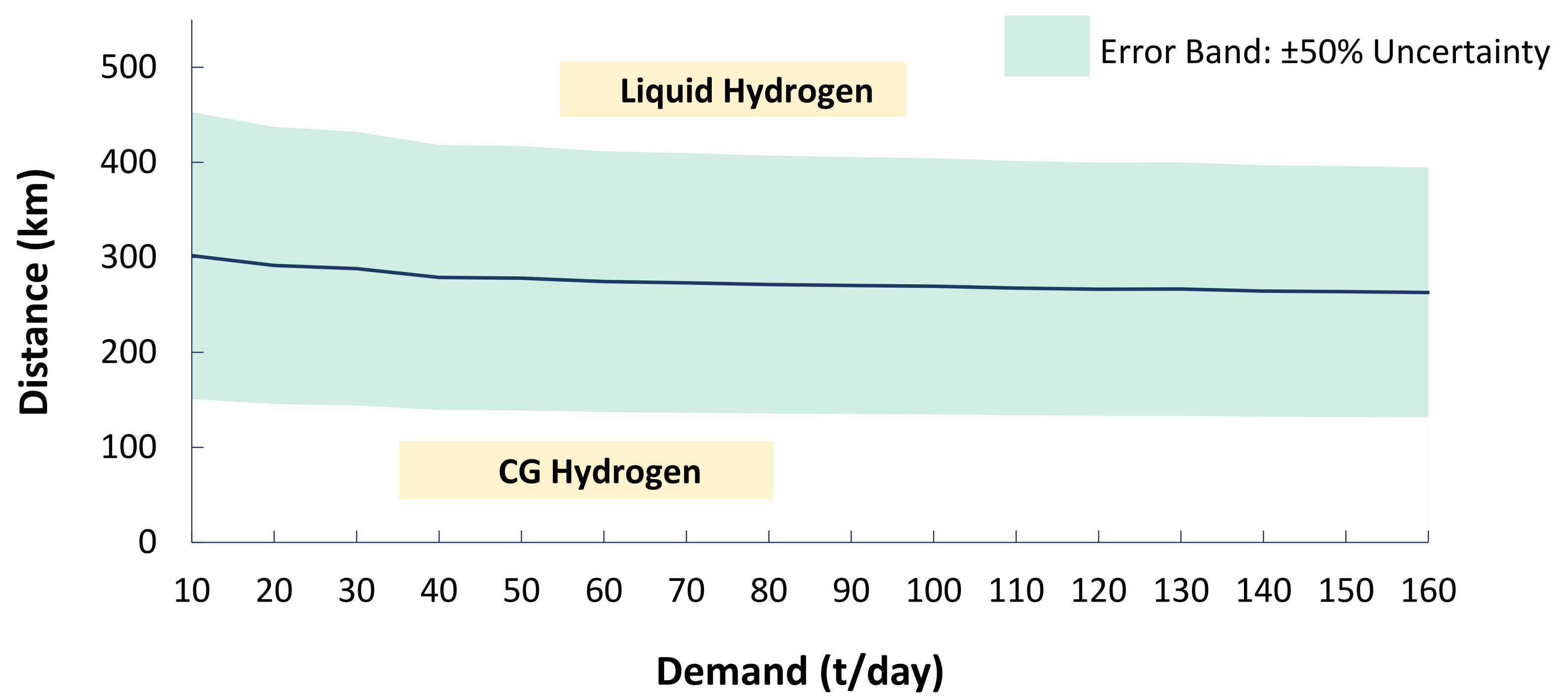

Figure 6: Crossover point analysis between LH_2 and CGH_2

- To address the computational complexity of the full hydrogen delivery model (HDM) with ~170 inputs, a multiple linear regression-based correlation model **(Figure 7)** was developed using 10 key parameters.
- This simplified model allows rapid scenario analysis, integration with Power BI for visualisation, and supports efficient integration with other techno-economic models to facilitate collaborative research and nodal network analysis

Scan for current PBI demo

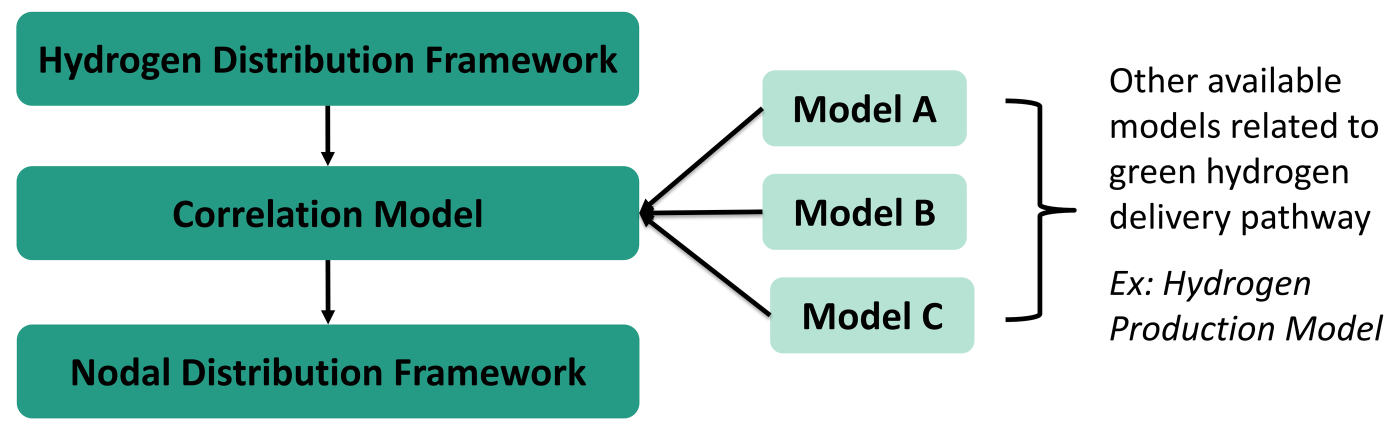

Figure 7: Schematic representation of the correlation model approach

- To determine the best-fit mathematical representation of the input-output relationship, linear, quadratic, and cubic polynomial models were evaluated **(Figure 8)**. Based on RMSE and R^2 metrics, the cubic model demonstrated the highest accuracy for both distribution pathways

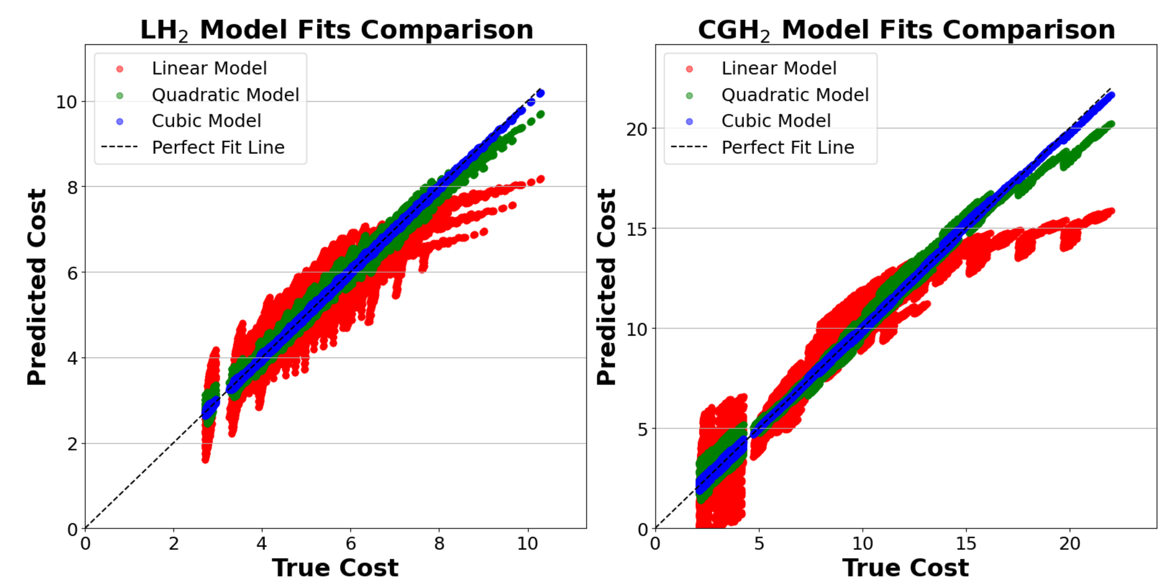

Figure 8: Comparison of model fits for LH2 and CGH2 Pathways

	RMSE	R-Squared
Linear	0.566	0.837
Quadratic	0.090	0.996
Cubic	0.016	0.999

	RMSE	R-Squared
Linear	1.172	0.902
Quadratic	0.332	0.992
Cubic	0.078	0.996

- For future work, the correlation model will be applied to a nodal distribution framework to evaluate optimised hydrogen delivery networks for the preliminary study area **(Figure 2)** under varying production and demand scenarios.
- The analysis will also be extended to compare mine-site and central hub hydrogen production by identifying the option with lower distribution costs to local hydrogen refuelling stations.

References

[1] Argonne National Laboratory, “Hydrogen Delivery Scenario Analysis Model (HDSAM).” (2022)

Acknowledgments

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