ANALYSIS OF GREEN HYDROGEN TRANSPORTATION FUEL FROM RENEWABLE ENERGY IN NEW ZEALAND

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Overview

Hydrogen is gaining momentum in New Zealand. With potential applications including energy storage, industrial heating, chemical feedstock and green fuel, hydrogen holds a vast potential as an alternative energy vector. The New Zealand Government recognizes the need to explore hydrogen in order to meet climate change commitments such as the 2015 Paris agreement and net-zero carbon emissions by 2050 (MBIE, 2019). A high share of renewables in the electricity mix (International Energy Agency, 2017) places New Zealand in a position to produce green hydrogen energy from renewable sources through electrolysis.

One of the sectors where hydrogen can play a role as a clean energy vector is transport. In 2017, transport accounted for total greenhouse gas emissions of about 16 million tonnes of CO_2 equivalent. Emissions growth in the road transport sector is responsible for an overall increase of New Zealand's greenhouse gas emissions (Ministry for the Environment, 2019). In particular, the heavy vehicle fleet is considered "hard to decarbonize", where penetration of battery technology is difficult (Energy Transitions Commission, 2018).

This paper examines the feasibility of green hydrogen as a transport fuel for Very Heavy Vehicles (VHVs) in New Zealand. VHVs are defined as those vehicles whose mass exceeds 30 tonnes (Concept Consultancy, 2019). Green hydrogen fuel is attractive for VHVs for several reasons: First, VHVs tend to have definite travel patterns with routine back-to-base trips, suitable to be serviced by a centralized hydrogen refuelling facility. Second, growth of heavy traffic follows with GDP. Economic growth necessitates road freight activities (ANZ, 2019). Third, heavy vehicles consume diesel, a non-renewable fuel. Diesel is a depleting resource and its local prices are greatly influenced by international price volatility. Therefore, green hydrogen fuel holds a promise of decarbonizing VHVs without compromising road freight activities.

Methods

The methodology is summed up as follows: (1) establishing the hydrogen demand, (2) sizing the renewable energy source available, and (3) determining the price of hydrogen.

Hydrogen demand for VHVs was calculated by displacing diesel fuel consumption. In 2017, transport diesel accounted for 99.65 PJs in the total diesel consumption (MBIE, 2017). VHVs consumed 14.7% (or 14.8 PJs) of the transport diesel (Concept Consultancy, 2019). This figure was further refined per region using the diesel port offtake data from MBIE. From this, travel kilometres were obtained from a conversion of 43 L/100 km (Collier et al., 2019). Hydrogen demand volumes were calculated using the indicative hydrogen consumption of 13.6 kg/100 km from a Toyota semi-truck [REF].

Green hydrogen needs to be produced from purely renewable sources. Renewable energy projects with consented status were evaluated to determine whether there is sufficient capacity to supply the hydrogen fuel requirement. Proposed renewable generating plants are arranged per region (Electricity Market Information, 2018). In order to get GWh estimates from the indicative MW values, capacity factors of each renewable resource per region are used. GWh estimates from the proposed renewable generating plants are used to determine its sufficiency to power regional hydrogen production.

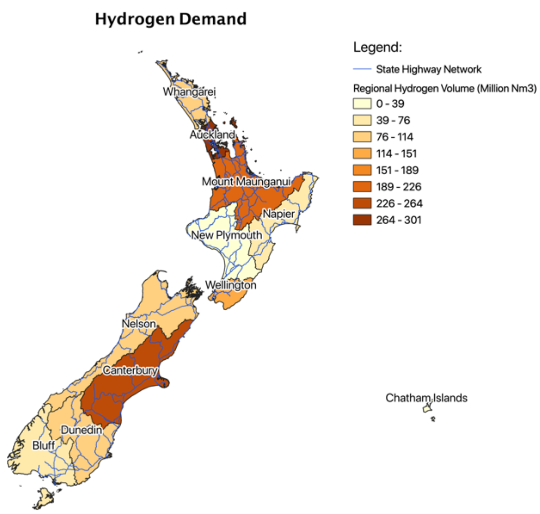
Lastly, the corresponding price of hydrogen is calculated based on the concept of levelized cost. Parameters such as electrolyser capital costs and electricity costs were calibrated based on a range of values. A sensitivity analysis was conducted to determine the factors that will greatly influence hydrogen prices.

Results

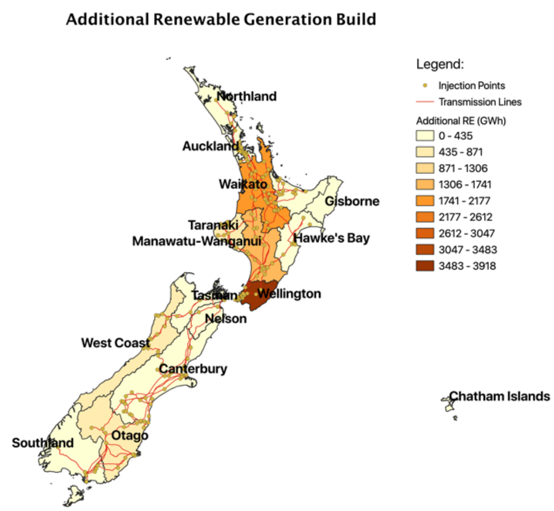
The results shown in this abstract are the initial outcomes of the research. Regional green hydrogen demand and additional renewable generating plant projects have been estimated. The overall hydrogen demand is 1,339 Million Nm^3, equivalent to 14.5 PJ (LHV[1]) to 17.1 PJ (HHV[2]) of electrolytic energy. This figure is close to the 14.7 PJ of equivalent diesel consumption in VHVs. This illustrates that green hydrogen is a viable fuel replacement for diesel in terms of overall energy content for VHVs.

The electrical energy equivalent of overall green hydrogen demand ranges from 4,009 GWh (LHV[1]) to 4,743 GWh (HHV[2]). The indicative additional consented renewable generating plants at 9,824 GWh is sufficient to meet the additional deman. Most of the hydrogen demand and renewable generating plants are located in the North Island. This makes sense as most of New Zealand's road freight activities occur where production and industrial activities, as well as the concentration of population, are located (ANZ, 2019).

The calculation of hydrogen levelized cost and sensitivity analyses will be included in the submission of the final paper.



(a)



(b)

Figure 1. Regional approximation of green hydrogen fuel demand (a) and additional renewable generating facility (b).

Conclusions

This paper establishes the green hydrogen fuel demand for VHSs and sizes the required renewable energy resource to meet the demand. Based on the initial results, electrolytic energy equivalent of overall green hydrogen demand is close to the equivalent diesel fuel consumption in VHVs. Also, additional consented renewable generating plants alone can drive the production of green hydrogen fuel at a national level. These are good indications that a green hydrogen fuel scenario for the VHV fleet is possible in New Zealand. The next step for this work in progress paper is to complete the calculation of hydrogen levelized cost and sensitivity analysis of the important factors that affect the prices of hydrogen.

[1] Low heating value or net calorific value of hydrogen, 33.3 kWh/kg
[2] High heating value or gross calorific value of hydrogen, 39.4 kWh/kg