CAN HYDROGEN DECARBONISE THE ENERGY SECTOR IN ASIA?

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Overview

Major energy importers and consumers in Asia, such as Japan, China and South Korea, have policies which aim to promote the production and utilisation of hydrogen as a fuel for transport and for electricity generation. Using hydrogen as a fuel results in no local air pollution and, if it is produced from electrolysis powered by renewable electricity, then it is completely greenhouse gas (GHG) emission free. Given constraints on land availability for renewables and Paris GHG emission reduction commitments, Japan is looking to import hydrogen from countries such as Australia, which has plenty of capacity for renewables and is an existing LNG trading partner. However, given their high near-term future demand for hydrogen, they are developing alternative methods of large-scale hydrogen production such as the Hydrogen Energy Supply Chain project. The hydrogen in this case is produced from the gasification of brown coal and 90% of the emissions will be sequestered in a saline aquifer off the coast of Victoria, Australia. Hydrogen will be liquefied and shipped to Japan.

In order to increase understanding of the emerging hydrogen energy sector, CSIRO launched the National Hydrogen Roadmap in August 2018 (Bruce, et al., 2018). The roadmap provided a comprehensive overview of hydrogen value chain (production, storage, transport and utilisation) technologies and the associated costs and opportunities. The production of hydrogen in Australia from renewables for export to Asia was one of the key hydrogen pathways explored. Building on from this work, more recent studies have calculated the potential hydrogen demand for the energy sector in Asian countries (Acil Allen, 2018).

The aim of this study is to determine the potential for hydrogen to meet demand in the energy sector in Asia, to understand which fuels it is replacing and to calculate the impact of hydrogen on reducing GHG emissions. For instance, if hydrogen is replacing natural gas and coal in the electricity sector, then emissions will decrease. However, if it is displacing renewables, emissions could potentially increase depending on the method of hydrogen production. These issues will be explored through the use of CSIRO's techno-economic modelling suite of the global energy sector, the Global and Local Learning Model (GALLM) to explore scenarios of hydrogen uptake in Asian regions.

The modelling scenarios were developed with energy sector stakeholder input as part of the CSIRO and the Australian Energy Market Operator (AEMO) GenCost project. This project uses a consultative process and applied modelling framework to produce electricity generation technology capital cost projections. These costs are used by various government and industry sector stakeholders for grid planning and investment decisions.

Methods

GALLM has been developed by CSIRO to project the capital cost and uptake of electricity generation and alternative fuel conversion technologies. GALLM is solved as a mixed integer linear program to produce a least-cost solution for which the constrained electricity and/or transport supply are matched to a given level of electricity and/or transport demand over time. The model features endogenous technological learning through the use of experience curves at both the global and local scale.

GALLM has 13 regions based on OECD regional definitions, including current and future expected importers of Australian hydrogen in the Asian region, namely China, Japan and S Korea. It also features 27 electricity generation technologies and in the road transport sector, batteries and fuel cells are available alternative technologies for vehicles that share learning with the electricity sector (Hayward & Graham, 2013)(Graham, Hayward, Foster, Story, & Havas, 2018) (Hayward, Foster, Graham, & Reedman, 2017) (Hayward & Graham, 2017).

GALLM has constraints on renewable resource availability in India, Japan, S Korea, South East Asia and Western Europe, based on a review of the literature around technical limits of resources, land availability and rooftop availability (for rooftop PV) (Hayward & Graham, 2017). This means these countries/regions are limited in their ability to rely solely on renewables for electricity generation and so would benefit from access to imported hydrogen to reduce GHG emissions. China (and the remaining regions) have unlimited renewable resources (relative to expected electricity demand). However, other studies have modelled unlimited renewable potential in all regions. See for example (Bogdanov, et al., 2019).

In order to explore the impact of hydrogen in these regions the following scenarios will be modelled in GALLM:

- High variable renewable energy and electrification: no renewable resource constraints and a high hydrogen price. Hydrogen is not needed for decarbonisation as there are unlimited renewables.
- Diverse technology response: tightly constrained renewable resources mean more technologies are needed to reduce emisions, including imported hydrogen. Hydrogen will have a low price in this scenario.
- Central scenario: renewables are constrained and only existing renewable energy policies are modelled. This has a medium hydrogen price.

The scenarios take into consideration key drivers of model outcomes, such as carbon pricing, renewable policies, rates of electrification of demand sectors such as transport, technology learning rates and renewable resource constraints.

Results

We have no results so far as this is work in progress. Results will be included in conference paper.

Conclusions

We have no conclusions so far as this is work in progress. Conclusions will be included in conference paper.

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