ASIA-PACIFIC
SOLAR RESEARCH CONFERENCE

Techno-economic analysis of PV driven Hydrogen electrolysis - key drivers to economic feasibility

Jonathon Yates[1], Rahman Daiyan[2], Rob Patterson[1], Rose Amal[2] and Nathan Chang[1]

[1]School of Photovoltaics and Renewable Energy Engineering, University of New South Wales
[2]School of Chemical Engineering, University of New South Wales
E-mail: jonathon.yates@student.unsw.edu.au

Introduction

Hydrogen is thought to be one of the most promising technologies for the future of clean and affordable energy. Its versatility allows for emissions reductions in sectors which have struggled to do so such as long-haul transport, chemicals, and iron and steel (International Energy Agency, 2019). However, the current technologies for low-carbon production of hydrogen are costly so the industry is almost entirely reliant on coal and natural gas today.

In Australia, there is a renewed focus on hydrogen through the National Hydrogen Roadmap (Bruce, et al., 2018) which describes Australia as having a high potential to export hydrogen, in particular to Asian countries. It recognises hydrogen generation from Victoria's brown coal resources and at the same time employing carbon capture and storage (CCS) to reduce CO2 emissions. This "green hydrogen" is thought to be particularly valuable to countries like Japan and Korea as it allows them to reduce their carbon footprint whilst importing energy.

Recent economic evaluations of hydrogen from renewables have focused mainly on electrolysis technologies. Whilst promising, electrolysis is yet to be used at a commercial scale for the production of hydrogen so the capital cost is high, although this is predicted to fall (Schmidt, et al., 2017). Also, many of these analyses do not factor in the additional selling price of green hydrogen which could be significant as countries try to reach certain emissions targets.

In this work, the economic feasibility of PV-driven hydrogen electrolysis is examined and the conditions required for economic feasibility are determined.

As there are significant uncertainties in both the current and expected future costs of setting up and running such a PVE system, as well as uncertainty in the selling price of the produced H2, we use a Monte Carlo cost and uncertainty methodology as developed and described in Chang, 2018. This allows us to identify key drivers and key uncertainties influencing this analysis and understand the conditions within these uncertainties that are needed for this technology to be commercially viable.

Key Inputs

The study will look to identify some key inputs which affect the economic feasibility of this type of green hydrogen production.

The capital cost of the equipment is one of the main factors with many sources expecting a potential decrease as hydrogen starts to enter the commercial energy market. Current costs are quite high but future predictions will also be modelled in the Monte Carlo analysis.

Running cost of the hydrogen production process may also be a key factor in the economics of production with this likely being critical to the short run marginal cost of the system. Operation and maintenance, replacement of parts such as electrodes and the electricity cost will all need to be modelled and estimated as part of the study.

Electricity cost is particularly important as this can change depending on how the plant is run. For example, the marginal electricity cost could be almost nothing if only PV power was used however this would lead to a low capacity factor of the system, as most electrolysers cannot be ramped up or down. Alternatively, some grid electricity could be used to allow for higher capacity factors but as a result incur a higher running cost. One goal will be to analyse and optimise this PV-to-grid electricity ratio.

Finally, the selling price of hydrogen will also be a critical input into the model. Whilst it is currently used widely in the chemical industry the selling price is likely to change as it is used for energy production. Also the effect of an increased demand for hydrogen, and the idea that “green hydrogen” could be more valuable, both need to be considered for this input.

Results

It is expected that this study will identify what the key drivers and barriers are to making this carbon-free hydrogen technology economically feasible and what market conditions would allow its commercial operation to be possible.

References

Bruce, S., Temminghoff, M., Hayward, J., Schmidt, E., Munnings, C., Palfreyman, D., Hartley, P., 2018, ‘National Hydrogen Roadmap’, Australia: CSIRO.

International Energy Agency, 2019, ‘The Future of Hydrogen’, Paris: IEA.

Schmidt, O., Gambhir, A., Staffell, I., Hawkes, A., Nelson, J., Few, S., 2017, ‘Future cost and performance of water electrolysis: An expert elicitation study’, *International Journal of Hydrogen Energy*, 48, p30470-30492.

Chang, N.L., Ho-Baillie, A., Wenham, S, Egan, R.J. et al. 2018, ‘A techno-economic analysis method for guiding research and investment directions for c-Si photovoltaics and its application to Al-BSF, PERC, LDSE and advanced hydrogenation’, *Sustainable Energy & Fuels*, 2, p1007-1019.