THE EFFECT OF HYDROGEN PRODUCTION GROWTH TO THE RENEWABLE ENERGY SECTOR

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Overview

The energy transition becomes the goal of many countries ever since the Paris Agreement was signed back in 2016. It raised awareness and fueled significant research in renewable energy technology that ultimately results in a substantial reduction in the cost of generating electricity. It appeared as if we were getting closer to achieving sustainable energy and will soon be less reliant on fossil fuel as the main source of energy. However, the penetration of renewable energy in the electricity market seems to be constricted, especially in lesser developed countries. In fact, the utilization of fossil fuel to generate electricity is still growing (IEA 2022). Recently, hydrogen is under the spotlight as a solution to energy transition. Hydrogen combustion waste is water, which is harmless. It exists in gaseous form that can be stored easily while maintaining its energy content and thus, hydrogen appears to be the solution of the intermittent issue of renewable energy sources. Hence, there is a significant number of hydrogen production projects all around the globe (IEA 2021).

There are several different methods of producing hydrogen (IRENA 2019, IEA 2019). However, to be less reliant on fossil fuel, a green hydrogen method is what many countries are currently pursuing. It is called green hydrogen since it does not involve fossil fuels and there is no carbon waste in any of its processes. It uses power from renewable energy to perform water electrolysis to produce hydrogen. This would mean that a significant growth in hydrogen would have to come with a significant increase in renewable energy production. Hence, this research takes a closer look at the effect of hydrogen production growth to the renewable energy production structure. As electricity is one of the biggest part of the costs of producing green hydrogen, investors would always choose the most profitable path in its hydrogen production project. From an investment decision perspective, there is an option whether to use electricity from the grid or build an independent renewable energy power source. This research provides insights about the effect of the growth in hydrogen production quantity, as well as technology, on the investment decisions that would dictate the nature of renewable energy production. Would hydrogen economy growth drives decentralization of renewable energy?

Methods

Structural models that represent the investment decision of the two options are developed. Since the price of green hydrogen differs significantly depending on the electrolysis technology and the location, the levelized cost of hydrogen (LCOH) is used as a proxy for profitability. Lower LCOH value implies higher profitability. The model for using the electricity from the grid is shown in Equation (1). Since the plant will be using the grid, the electricity cost will be exposed to market forces. Depending on the characteristics of the electricity market, the electrolysis process may be carried out during the peak period that has higher electricity tariff. The plant can be less reliant on electricity tariff by scaling up its facilities.

$$Total\ Cost = Capital\ Cost_{electrolysis} + Electricity\ Cost \quad (1)$$

Meanwhile, the independent power source model is shown in Equation (2). Since the plant has its own independent power source, it can perform electrolysis all year round. However, the cost of building the facilities of the power source would be included in the model. In addition, the capacity of the power source would dictate the hydrogen production capacity.

$$Total\ Cost = Capital\ Cost_{electricity} + Capital\ Cost_{electrolysis} + Electricity\ Cost \quad (2)$$

The IEA data is used for the parameters on capital cost of electrolysis as well as capital cost for renewable energy (IEA 2019). The electricity tariff is based on average retail price of electricity (EIA 2022). The capacity factor and hydrogen conversion factor data are according to published research (IEA 2022, Element Energy 2018). The minimum cost of both options depending on the hydrogen output is simulated and compared to provide insights on investment opportunities. Furthermore, the growth of hydrogen production technology is simulated as well. Hydrogen production technological advancement can come into two different forms; a decrease in the capital cost and an increase in the conversion factor. Both cases are included in the analysis.

Results

Based on the preliminary simulations results, the option to build an independent power source is never deemed attractive from an investment perspective. The cost of hydrogen production overall using an independent renewable source will always be more than relying on power from the grid at the current conditions. In the preliminary model, the economies of scale is being ignored. However, given the significant gap of the total cost, the effect would be insufficient nevertheless.

The technological improvement in hydrogen production is also simulated. A substantial capital cost reduction of up to 50% as well as enhancement in hydrogen conversion factor of up to 100% are being considered. The LCOH significantly improved, however, it is insufficient to flip the attractiveness of the investment options. This is due to the fact that both options experience a cost reduction. The largest impact of reducing the gap between the two options actually comes from technological enhancement in renewable energy generation based on simulation results. For example, an increase in the rernewable energy capacity factor or an even greater reduction in the capital cost.

Conclusions

The structural model provides an investment perspective on hydrogen production that is currently being pursued rigorously by many countries as part of energy transition goals. IEA (2019) predicts that hydrogen would grow significantly in the energy field, especially for green hydrogen. This research provides insights on the renewable energy sector conditions that have to support such growth. The technological improvement in the hydrogen production would definitely bring the production cost of hydrogen down, yet it has a negligible effect on decentralization of renewable energy generation. From an investment perspective, building an independent renewable energy source for green hydrogen production would be an unnecessary cost that significantly impact its economic feasibility. This implies that the growth of hydrogen economy would bring heavier dependency on the electricity grid to deliver reliable power. Decentralization of renewable energy generation would have to start from its own technological advancement.

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