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THE ROLE OF POWER-TO-GAS IN THE FUTURE ENERGY SYSTEM: HOW MUCH IS NEEDED AND WHO WANTS TO INVEST?

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The role of power-to-gas in the future energy system: how much is needed and who wants to invest?[1]

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BACKGROUND AND CONTEXT

Increased levels of variable renewable power generation, such as wind and photovoltaic solar, have led to an increased requirement for flexible resources on the power system that can respond quickly to changes in renewable supply. Much of the focus in recent years has been on accommodating shortages of renewable power, by finding sources of generation that can flexibly supply electricity, and by reducing demand. However, as the penetration of renewable power increases worldwide, there are an increasing number of hours of excess renewable supply, where the electricity generation exceeds demand. One potential use for such excess supply is power-to-gas.

Power-to-gas units use electricity to produce a gas such as hydrogen or methane. In the case of hydrogen, electricity is used to split water into hydrogen gas and oxygen. The hydrogen produced has many applications in industry or can be injected directly into the gas grid and used to produce heat in homes and businesses, blended with natural gas. If the hydrogen is produced by renewable electricity that would otherwise be curtailed (or wasted), the hydrogen can be considered carbon-free gas.

This work considered the incentives to invest in a power-to-gas plant on a future energy system based on the Irish electricity system with high levels of wind penetration. A mathematical model was used to determine the optimal amount of investment in power-to-gas under various levels of wind. The literature to date investigates the profitability of power-to-gas units without determining the optimal level of investment in same. In contrast, our research determines the

[1] This Bulletin summaries the findings from: Lynch, M.Á., Devine, M.D., and Berstch, V. (2019), "The role of power-to-gas in the future energy system: market and portfolio effects", *Energy*, Vol. 185, pp. 1197-1209. Available online: https://www.sciencedirect.com/science/article/abs/pii/S0360544219314306

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profit-maximising investment in power-to-gas itself as an outcome of the market modelling. It was assumed that hydrogen produced is sold as gas in the gas grid. We consider various electricity generation firms with different portfolios of coal, gas and wind generation. We also assume that wind generation attracts a subsidy in the form of a price premium added on to the market price.

RESULTS

The results show that once wind power accounts for more than 50% of the electricity generated on the system, it is economic to invest in power-to-gas. The higher the wind level, the higher the investment. However, the power-to-gas unit itself is loss-making. The total revenues earned by the power-to-gas unit from selling the hydrogen it produces are less than the capital costs of investment in power-to-gas. The incentives for investing in power-to-gas are therefore driven not by the profitability of power-to-gas itself, but by market and portfolio effects. In particular, a firm that invests in power-to-gas, but does not own any wind generation, will see a net decline in total profits. Conversely, a firm that owns both power-to-gas and wind generation will see greater profits than if they owned wind only. This is because the power-to-gas unit increases the demand for electricity at high wind hours, which in turn increases electricity prices, and increases revenues for wind. Power-to-gas can therefore be found in a profit-maximising portfolio, even though it itself is loss-making.

POLICY CONCLUSIONS

There are two main policy conclusions from this work. The first is the poor information provided by existing metrics such as net present value or marginal abatement cost when determining the value of isolated investments. The value of any given investment will vary depending on the composition of the market and firm's portfolio, and so technologies should not be considered in isolation. In particular, policy-makers should avoid providing preferential treatment to a particular technology over another on the basis of the individual technology's cost-effectiveness. Rather, policy should support technology-neutral goals, such as decarbonisation.

Secondly, subsidisation of renewable power may increase the financial viability not just of the renewable technology in question but also of other technologies. Furthermore, the presence of power-to-gas on the system increases the total subsidy costs incurred by consumers. The subsidies paid by electricity consumers therefore benefit not just wind owners, but owners of other technologies. Policy-makers should be cognisant of this effect when designing support and subsidisation schemes.

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