Assessing the Techno-Economic Feasibility of a Wind-Tidal Lagoon Hybrid System for Green Ammonia Storage in Wales, UK

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Introduction. Wind, solar and marine technologies are on the focus of research, development and implementation. Wind offshore facilities keep increasing, with farms such as Walney Extension (UK) that has reached capacities of 659 MW (IPCC, 2018). Similarly, cumulative installed capacity of solar thermal installations reached an estimated 456 GW (IEA, 2019), whilst solar photovoltaic systems have also received a large boost with installed capacities that reached almost 300 GW by 2016 (IEA, 2019). Finally, marine energy has a vast potential that with better economics and energy management could free the potential of 748 GW power by 2050 (World Energy Council, 2016). However, all these sources experience considerable intermittency in terms of energy production, thus requiring storage media to support energy demands.

One of the methods proposed for energy storage is green ammonia, chemical produced from hydrogen obtained by electrolysis. Using ammonia, hydrogen storage can be up to 30 times cheaper, easy handled, more volumetric energy dense, and less risky than liquified hydrogen (Valera-Medina et al, 2018). Therefore, as part of the decarbonisation strategy of Wales, country that currently assesses the use of tidal energy, this work proposes the use of hybrid systems that gather wind and tidal energy for the production of ammonia as energy and fertilizer vector.

Methodology. Initially, 10 different locations across Wales were considered and their wind and tidal potential determined. Results denoted the large potential of South Wales. Economic analyses were performed for production of ammonia in such a region. Finally, an improved hybrid system that utilises Fuel Cells for production and utilisation of ammonia was implemented and economically assessed. Levelized Cost of Electricity (LCOE) and Levelized Cost of Ammonia (LCOA) were all compared and optimised using a non-linear algorithm that includes hourly costs of electricity in the UK and global ammonia market costs.

Results. Although initial results denoted the high potential of the region of South Wales for generation of power up to 2,523 GWh.yr^{-1}, the economics showed the unprofitable production of ammonia consequence of the cost of electrolysers and the labour hand for the construction of the tidal lagoon. Further optimisation also depicted a negative economic scenario, with models that show synthesized ammonia producing energy at prices between £60 to £100 per MWh or being sold to the market at a price of £258/tonne. LCOE and LCOA were then compared. LCOE was calculated at £415.5 per MWh whereas LCOA was calculated at £530 per tonne. As such, although generating revenue, both scenarios were unprofitable for 120 years, which is the lifetime of the tidal project. However, sensitivity analyses also foresee profitable conditions due to an expected decrease in prices caused by the reduction in the cost of electrolyzer components and better construction methods.

Conclusions. Although green ammonia is currently not economically viable under today's economic and technological conditions, the use of cheaper electrolysers with mature hybrid systems that employ tidal and wind energy can become a method for large scale, affordable decarbonisation in Wales.

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