Insight in the design and cost of underground hydrogen storage coupled to a dedicated offshore wind farm

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The total demand for hydrogen in Europe was 8.7Mt in 2020 and is expected to be 20Mt in 2030. Due to the Russian invasion of Ukraine, in 2022, the European Commission introduced REPowerEU with enhanced goals for hydrogen production within the EU. REPowerEU aims for an anticipated usage of 20 Mt hydrogen by 2030, divided equally between domestically sourced (10 Mt) and imported (10 Mt) production. Hydrogen earns the "green" label when produced through electrolysers directly connected to a renewable energy source, thus circumventing power grid reliance. To facilitate this, dedicated wind farms specifically designed for hydrogen production are under development. However, producing hydrogen from wind energy presents a significant challenge to production security due to the intermittent nature of wind energy.

It is expected that in the near future the industry will be the primary consumer of green hydrogen. For many industries, the most effective means of reducing emissions lies in transitioning from fossil-based hydrogen to green hydrogen. This sector requires hydrogen both as a feedstock and, in certain cases, as an energy carrier. The industry will have a constant consumption profile and often possess limited means of demand response. In order to match supply and demand, storage of hydrogen will be required.

The mismatch can occur on a seasonal scale and with large quantities. Furthermore, due to the lower energy density of hydrogen compared to oil or methane, large storage volumes are necessary. As of now, the most practical and economically viable approach to seasonal hydrogen storage remains underground storage, with a particular emphasis on salt caverns and lined rock caverns.

This theses aims to give an insight in the required capacity and costs of the storage site. In order to do this a techno-economic model will be developed of a dedicated offshore wind farm coupled to an underground hydrogen storage facility. When the model is finished is should help to give a better insight in the the security of supply and quantity of curtailment. Moreover it could help predict the conditions inside the storage (pressure and temperature). Additionally, it seeks to enhance our understanding of how demand response and line packing affect the system. Finally the sensitivity analysis will spotlight uncertainties arising from assumptions and model intricacies, achieved by exploring a range of scenarios.

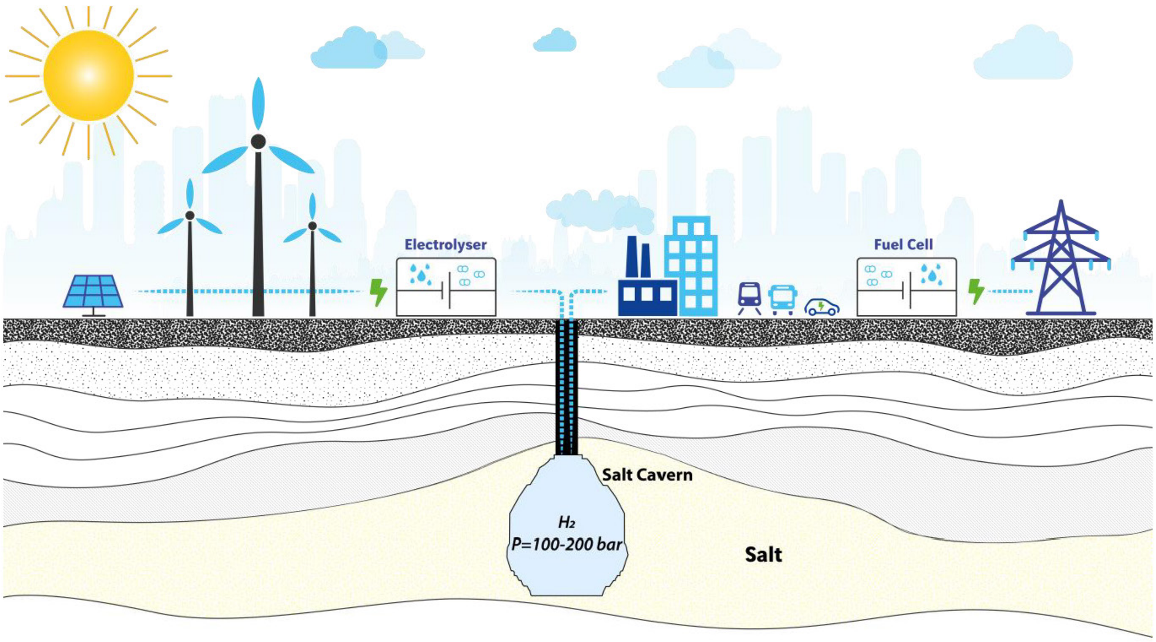

Figure 1: Hydrogen storage in salt cavern