Subsurface Storage of Energy Carriers: Lessons Learned in Europe – Options in the Middle East

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Abstract

The current and projected increase in the share of variable renewable energy sources in the energy mix attests to their significant role in the decarbonization of the energy sector. To counterbalance the fluctuations in electricity generation in energy systems with a high share of variable renewable energy sources the challenge of temporal matching between energy supply and demand however, needs to be addressed. 'Green hydrogen', which can be produced using the "Power to Gas" concept by means of electrolysis utilizing renewable electricity, is regarded as crucial in that context. In addition to using hydrogen in fuel cell electric vehicles (FCEVs), it can also be fed into fuel cells to generate electricity to compensate for low generation periods ("Power to Power").

In order to provide mid- to long-term accessibility to a mix of energy carriers, their storage recently moved more into focus. Unlike mechanical energy storage, energy storage using energy carriers such as hydrogen or natural gas provides an approximately 100 times higher energy density than e.g. compressed air energy storage for the same storage volume. Underground structures (e.g. depleted gas fields, aquifers, salt caverns, etc.) and surface installations such as pipelines or vessels can be considered viable storage options for hydrogen. For seasonal storage, underground storage can prove more favorable than above-ground storage technologies.

Natural gas storage in underground cavities has been practiced for decades. Storage in salt caverns is the most promising option due to its large storage capacity, followed by pumped hydro storage. Salt caverns are operationally safe, have low investment costs, high sealing potential and a low cushion gas requirement.

Experience gained from salt cavern operations and drilling in the context of natural gas and oil storage can be easily transferred to the case of hydrogen storage due to the similarities in cavern design, construction, and operations.

The storage of hydrogen in depleted oil and gas reservoirs has the advantage of reducing the geological exploration efforts resulting from the former use of such sites for oil and gas production. The contamination caused by the previous hydrocarbon extraction however requires a thorough contamination control, and gas upgrade units for purification may be required. Further geological risks associated with the storage of hydrogen include embrittlement due to long-term diffusion, which can cause leakage and failures, especially in the steel components.

In order to quantify future salt storage options, a recent suitability assessment of subsurface salt structures in terms of size, land eligibility and storage capacity has been undertaken for Europe. It included a quantification of the storage capacities of individual caverns, estimated on the basis of thermodynamic considerations based on site-specific data. The analysis was based on three different scenarios: onshore and offshore

salt caverns, only onshore salt caverns and only onshore caverns within 50 km from shore. The study showed that there is a significant overall technical storage potential across Europe. The presentation will summarize lessons learned from Europe and offers an outlook for the Middle East.