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Potential and Opportunities for Hydrogen Storage in Salt Caverns

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Abstract

Hydrogen is regarded worldwide as a crucial energy carrier in a future energy system with a high share of variable renewable energy sources, especially in order to balance fluctuations in electricity generation, as an alternative for fossil resources in the industry and for mobility applications etc. This can be compensated for by flexibility measures such as large-scale energy storage. Salt caverns hereby offer the most promising option for large-scale underground storage of chemical energy carriers such as natural gas or hydrogen, owing to their relatively low investment cost, large storage capacity, high flexibility, high safety potential and low cushion gas requirement. Salt caverns have shown high reliability and suitability for the storage of natural gas on an industrial scale in the past decades. Significant know-how can be gained from the storage of natural gas and applied to the geological and geotechnical design considerations of salt caverns for hydrogen storage.

Gas Infrastructure Europe (GIE) assessed that by 2050, the total demand for underground hydrogen storage for Europe should be around 0.45 PWh_{H2} and concludes that additional storage sites need to be developed. However, if all of the currently existing natural gas storage facilities in Europe were to be converted to hydrogen storage, total storage capacity would be insufficient related to the total storage demand identified by GIE. Therefore, the construction of new caverns for hydrogen storage must be considered. In a recent study, a preliminary geological suitability assessment of new salt cavern locations across Europe estimated a considerably large theoretical hydrogen storage potential. Among all investigated regions, northern Europe, and especially Germany, show the largest technical storage potentials due to their large abundance of salt dome structures originating from the Zechstein Basin.

The interest in hydrogen is a worldwide development reflected in a number of national and international hydrogen initiatives and plans (e.g. US, EU, Germany, France, UK, The Netherlands, Denmark etc.). Based on these hydrogen strategies several research and demonstration projects started including hydrogen storage in caverns.

Analogous to natural gas, the storage of hydrogen in caverns will fulfill the classic tasks of a storage in the supply chain: balancing the differences between production and demand, buffering for the pipeline grid, securing the hydrogen supply in case of technical problems or political conflicts etc. The estimation of the storage potential is an important element for matching the needs of production, transport and consumption of hydrogen. A methodology for the potential estimation was developed for Germany and the findings were presented at SMRI Meetings in 2015 and 2020. The research within SMRI already created a valuable overview on the salt locations worldwide which can now be used as a basis to determine the potential for hydrogen storage in salt caverns. The methodology could be applied to further locations in Europe and worldwide. Within the paper an exemplary location will be presented.

Key words: Salt Caverns, Gas Storage, Geology, Hydrogen Storage, Potential Estimation, Rock Mechanics, Storage Cavern, Salt Deposits