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SOLUTION FOR STORAGE OF GREEN HYDROGEN IN SALT CAVERNS

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Abstract

Production of green hydrogen is intermittent as electrolyzers that produce it rely on renewable power sources (solar, wind, etc.). Generation of power is intermittent as these power sources are entirely dependent on weather conditions or certain time intervals during the day. Wind power can only operate when the wind is blowing, and solar while the sun is shining. Downstream processes that utilize Hydrogen as a feedstock, such as ammonia production or liquefaction facilities, require steady-state flow and pressure conditions to operate. Green Hydrogen producers are seeking storage solutions to equalize flow and allow steady-state operations on a continuous basis. Geologic storage is attractive for large-scale Hydrogen operations. Salt Caverns, where geographically feasible, are currently the only commercially proven method for geologic Hydrogen storage. The typical product cycle in salt caverns is less than 12 cycles per year. To develop a new salt cavern or to convert an existing one for this high frequency (daily) Hydrogen storage and withdrawal cycles is challenging. The high frequency of product receiving, and delivery can lead to geomechanical instability and cause damage to the salt resulting in salt failures and loss of containment. Compressed Air Energy Storage (CAES) systems face similar issues. Gravity water compensation has been proposed to mitigate frequent pressure cycling of hard rock mined caverns in ACAES service. We propose similar engineering mitigations to limit the pressure changes in solution mined salt caverns during Green Hydrogen receipt and delivery cycles. A pumped brine compensation system is proposed to maintain a near-constant pressure in the cavern during product receipt and delivery.

A model was created for a gas compensation system and a brine compensation system. When comparing storage mass for the two systems, a standard cavern geometry was chosen to be constructable in many formations throughout the world. For a cavern of cylindrical shape 1,100 m (3600 ft) depth, 200 m (656 ft) in height and 40 m (130 ft) in diameter corresponds to a maximum of 3,540 metric tons (3,900 US ton) of hydrogen storage capacity. For a similar gas compensation system, the total hydrogen storable is about 685 metric tons (755 US ton). The model shows five times more capacity utilization with the brine compensation than what would be available with only gas compensation.

The additional equipment required for the brine compensation system involves above-ground storage ponds and brine pumps as well as the hydrogen dehydration equipment. For a given cavern volume, the brine compensation method can use commercially available process equipment and will significantly increase the underground storage availability.

Key words: Caverns for Gas Storage, Caverns for Liquid Storage, Compressed Air Energy Storage (CAES), Brine Pressure Compensation System, Hydrogen Storage, Green Hydrogen, Pressure Cycling, Salt Caverns, Computer Modeling