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STORAGE OF HYDROGEN IN SOLUTION MINED SALT CAVERNS FOR LONG DURATION ENERGY STORAGE

Jay Evans, Global Gas Group LLC and Tom Shaw, LK Energy LLC

Abstract

Hydrogen storage in solution mined caverns can provide utility-scale, long-duration energy storage to support grid integration of renewable energy generation and hydrogen fuel management. A Hydrogen Energy Storage ("HES") facility consists of:

1) A hydrogen production plant using electrolysis, steam reforming, and, or other methods,
2) Underground storage caverns created in a salt formation; and,
3) An energy distribution facility that delivers hydrogen gas to a combustion gas turbine, gas engine, or fuel cell for power generation, gaseous hydrogen truck load-out to supply industrial or mobility fuel markets, and, or the interconnection to a load-serving hydrogen pipeline.

Electrical utilities and other large industrial and commercial energy consumers are adopting goals to increase use of renewable energy in response to government mandates and, or customer preference. As a result, renewable generation capacity, primarily wind and solar, now constitutes 23.4% of generation capacity in the United States. However, matching intermittent and scattered renewable energy supply with variable, often concentrated demand is difficult because 1) solar is a diurnal resource, 2) wind is weather-dependent, and 3) extreme hot or cold weather conditions, that drive peak demand, are commonly associated with stagnant air masses and low wind conditions. The design requirement to reliably serve peak demand with intermittent resources requires greater gross generation capacity, a diversity of resources with lower utilization, and, or combustion peaking capacity fired with carbon-based fuel. The excess of capacity during seasonal low demand, peak solar generating hours, or transmission congestion increasingly results in renewable energy being curtailed. These intermittent, curtailed resources can produce "green" hydrogen, by electrolysis, for the industrial gas and mobility fuel markets, if sufficient long-duration storage is available to provide a rateable, reliable supply at a predictable cost.

Salt caverns are ideal for long-duration hydrogen storage for a number of reasons, including:

1) Withdrawal, of "discharge" of hydrogen is highly flexible both in rate, duration, and volume.
2) With the proper surface facilities, HES can simultaneously deliver stored energy to multiple physical markets.
3) Caverns are a mature, financeable storage technology that have been successfully used for storage of compressed gases for over 75 years and for hydrogen, in specific, at six locations since 1972.
4) At scale, solution-mined caverns have the lowest unit cost of currently available storage technologies.
5) The conditions appropriate for high-quality renewable generation in much of the United States and Europe, such as the western United States and Europe, which are coincident with areas of suitable salt deposits.

Consequently, hydrogen generation by electrolysis coupled with salt caverns is uniquely suited to meet the market need to shift excess off-peak energy to meet dispatchable on-peak demand, and to match intermittent, often low value, renewable generation resources with stable, rateable, higher value demand in industrial and mobility markets.

Key words: hydrogen, storage, salt cavern, power generation, renewable integration, green energy storage, long duration energy storage, energy storage.