SOLAR WIND STORAGE
NO SUN, NO WIND, NO PROBLEM

Technical Assistance Request

Background

Hydrogen will be a major factor in the renewable energy future, especially in regard to grid-scale renewable energy storage. Undoubtedly batteries will play a significant role in the renewable energy future, but they do have limitations as far grid-scale applications are concerned. Currently salt caverns provide the only means for storing large amounts of compressed hydrogen gas but because of several factors, including limited cycles per year, they are relegated to seasonal storage. We are confident we have a viable and cost-effective method of storing large amounts of hydrogen gas that can handle the energy storage for applications that require storage capacities and duration greater than that offered by batteries and with flexibilities and frequencies that salt caverns do not have.

Our solution is to store large volumes of hydrogen in underground chambers, constructed specifically for hydrogen storage, that can be built at any location and provide the most cost-effective means of pressuring the gas during storage and transportation. The storage system is based on constructing man-made underground chambers using conventional equipment and techniques that are regularly used by the mining industry. The chambers can be rotary drilled from the surface in common geological formations found throughout the United States. Since the chambers are drilled from the surface, they are cylindrical in shape and can easily be lined with steel tubing and then capped to create a large fully-sealed underground tank that uses the surrounding rock strata to reinforce the storage container.

Assistance Request

While our patented energy storage system is based on existing technologies and requires no technological breakthroughs, there are still challenges to be met. To prove the concept, we need to secure financial aid and construct a working prototype storage chamber which can fully validate the fundamental principles and operational aspects of the storage concept. To accomplish these goals we need assistance in the following areas.

<u>Thermodynamic Analysis</u>

- One of the key features of our storage system is the ability to use the water in the chamber to regulate the available storage volume. Adjusting the storage volume to balance with the amount of hydrogen gas being stored eliminates the heating and cooling problems associated with the compression and expansion of a gas in a large constant volume container. We request an expert assessment of this claim.

<u>Materials Analysis</u>

- The chambers are drilled from the surface and this process creates a large cylindrical chamber. Metal or composite cylinders can then easily be used to line the chamber. We need assistance in determining what materials are best suited to prevent leakage and prevent hydrogen corrosion or metal embrittlement.

Environmental Issues

- If hydrogen leakage from the chamber should occur, what would be the effects, if any, on the surrounding strata and ground water?
- If leakage is a problem, can a passive set of boreholes be grouted in place against the rock boundary, as a leakage control pathway. We would like feedback on the leakage concern in general and whether a planned drainage approach is the best option.

Chemical Analysis

- Are river water, lake water and ocean water all suitable for use in the chamber?
- Will there be any chemical reactions between these types of water and the pressurized hydrogen?
- Once inside the chamber is dissolved oxygen in the water coming out of solution an issue?
- If there are any interactions at the water-hydrogen interface, can a floating seal consisting of an inert liquid, be installed between the water and hydrogen to prevent these interactions?

Techno-Economic Analysis

- What will be the cost of drying the hydrogen gas as it comes out of the chamber? Is this offset by not drying the gas as it comes out of the electrolyzer?
- We need to determine at what level of curtailed solar energy is it be more cost effective to store the curtailed energy in our storage system rather than curtail it?
- We have calculated a Levelized storage cost of $1.65 per kg of hydrogen. This amount compares favorably to storage costs for salt caverns[i] but we request expert assistance for confirmation.
    - Our calculations are based on the following specifications for a mid-range storage chamber.
    - Chamber size: 8.2 feet in diameter x 1250 feet deep
    - Maximum storage capacity: 65,000 ft^3
    - Capital construction cost: $6.35 million
    - Storage capacity: 52,284 kg of hydrogen (5,000 psi)
    - Annual consumption: 627,408 kg (based on one full cycle/month)
    - Capital recovery factor: 0.16
    - Computed with 10-year return with a 10 percent annual interest
    - Levelized storage cost per kg of stored hydrogen = $1.65/kg

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[i] Geologic Storage of Hydrogen: Scaling up to Meet City Transportation Demands
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