Hydrogen Underground Storage Techniques

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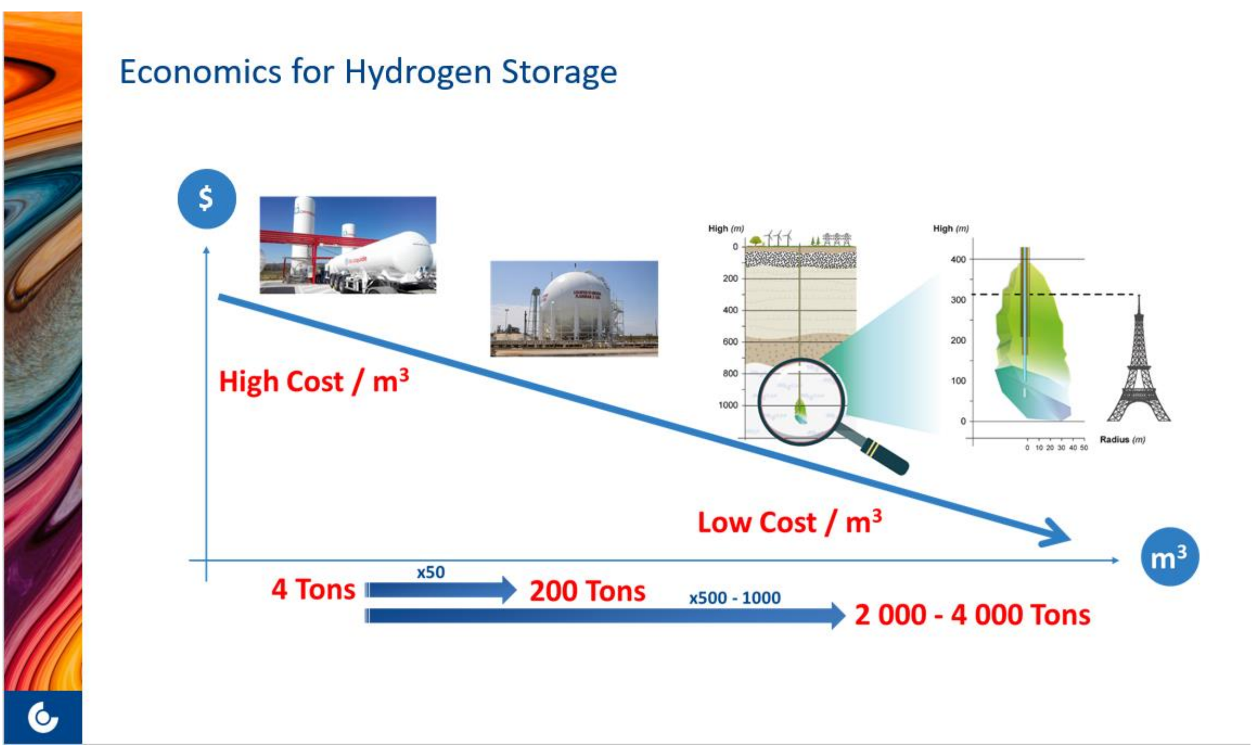
Context

In the context of the energy transition, hydrogen will be a key energy source for power generation, heat generation, and mobility. For large quantity of hydrogen storage, underground techniques present some advantages compared to surface storage:

- Environmental protection: Reduced footprint at surface, limited visual and social impact.
- Safety: Secure earthquake resistant technique
- Economical: Cost effective, almost everlasting, and low maintenance

Underground storage of natural gas has been used for over a century and, as of today, over 500 underground gas storage facilities totalizing over 170,000 million m^3 of working gas capacity have been developed in North America.

Worldwide, six salt caverns have been used for several decades for hydrogen storage for industrial process applications. In the preparation for the energy transition, several pilot projects of hydrogen underground storage in salt, depleted fields, and saline aquifers have been developed over the past few years.



Hydrogen Underground Storage – Four Techniques

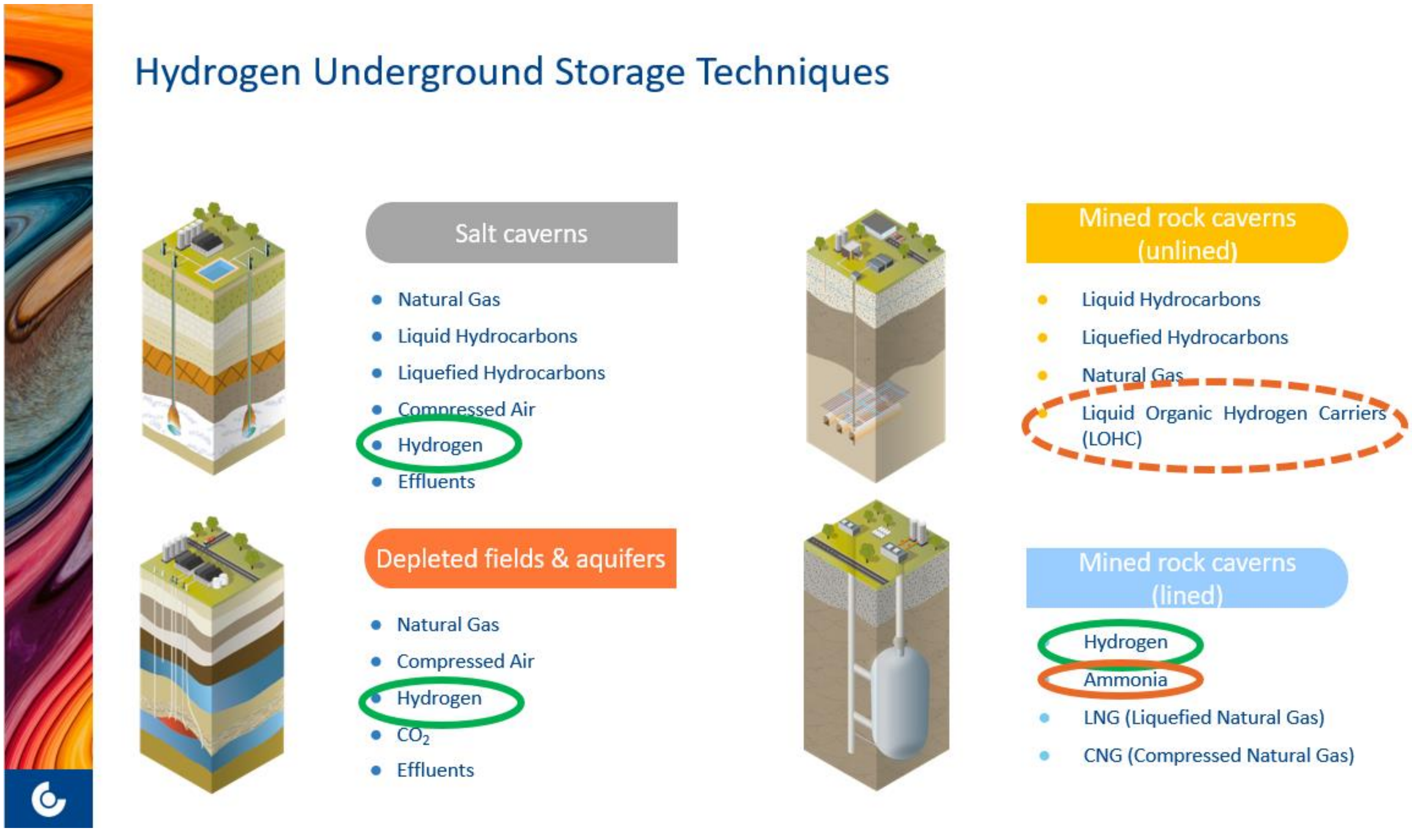
Among various underground storage techniques, some are ready for commercial use, while others require research and development (R&D) efforts.

Salt Caverns: Salt caverns are the most mature means of storing hydrogen underground. They are created by injecting freshwater or low-salinity water (e.g. sea water) into a well drilled down to a geological layer of salt. It leaches the salt. Salt-saturated brine is extracted and possibly used as a raw material. The cavern's diameter typically ranges from 50 to 100 meters, and its height can reach several hundred meters when the salt formation is thick enough. Salt caverns do not require lining; the salt itself acts as a natural sealant. This technique has been used for hydrogen storage for over 50 years.

Porous Rocks: Another method involves using naturally porous rocks covered by a layer of thick and impermeable rock, creating a geological trap. The porous rock can be a depleted oil or gas field or an aquifer. Feasibility depends on site-specific conditions. When favorable conditions exist, porous media storage can offer the highest storage capacities. This technique has been used in the past for hydrogen mixed with methane and carbon dioxide (known as town gas). Recent R&D efforts focus on various aspects, including impacts of biochemical activity.

Hard Rock Caverns for hydrogen carriers: When neither salt nor suitable geological traps are available in the targeted area, hard rock caverns can be constructed to store hydrogen. These caverns are proposed for storing hydrogen once it has been converted into a liquid carrier, such as ammonia. A lined rock cavern is used to prevent ammonia-water contact. Pressure and temperature must be adjusted to optimize the entire supply chain. Ammonia's properties allow for proper storage conditions without excessive pressure or temperature. Other liquid carriers, both organic and inorganic, are also considered. The need of a liner should be addressed for each of them.

Direct Injection into Lined Rock Caverns: The last solution involves directly injecting hydrogen into a lined rock cavern. This can be implemented as compressed storage (gaseous hydrogen) or cryogenic storage (liquid hydrogen). The choice depends on the entire supply chain. High pressure or very low temperature may necessitate a liner. In Europe, several teams are actively developing solutions for compressed hydrogen storage in lined rock caverns, which has led to a recent demonstration at pilot scale. Commercial solutions are nearly available. The readiness level for hydrogen storage in lined rock caverns, which implies very low temperatures, is lower.



Conclusions

The capital expenditure (CAPEX) for these techniques depends significantly on geology, storage capacities, and operational requirements. Accurate cost estimations and comparison of these solutions require clearly defined assumptions.

Underground hydrogen storage has a history of over 50 years. Ongoing R&D efforts are necessary to mitigate risks and expand the solution portfolio.