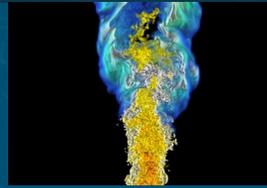


Geologic Storage of Hydrogen



Presented by

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Basic Storage Requirements

High porosity, high permeability, hold adequate volumes of gas, extract gas at high rates, contain and trap gas, and cushion gas

Geologic storage is used for **oil, natural gas, compressed air, helium, & hydrogen**

Geologic Storage - Types



Salt Caverns

Salt caverns are solution mined cavities within either salt domes or bedded salts that do not match reservoir volume capacity.

Depleted Oil/Gas Reservoirs

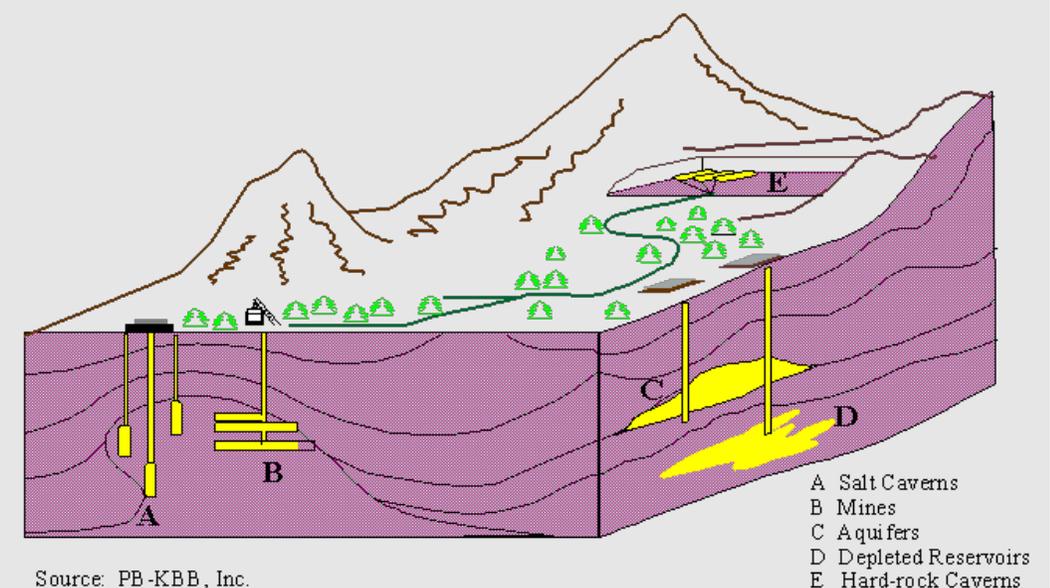
Depleted reservoirs are proven gas reservoirs that are easy to develop and operate due to existing infrastructure.

Aquifers

Aquifers are similar in geology to depleted reservoirs, but have not been proven to trap gas and must be developed.

There are other storage options available currently and in the near future, such as abandoned coal mines, lined hard rock caverns, and refrigerated mined caverns.

Figure 1. Types of Underground Natural Gas Storage Facilities



Because hydrogen is a light, small molecule

The molecule characteristics and the hydrogen purity demand may limit storage options. Future analyses may be needed to investigate possible issues with hydrogen storage.

Potential issues?

- Mixing of hydrogen with natural gas? –depleted gas/oil reservoirs
- Flow, diffusion and fingering of hydrogen into water-bearing units? –depleted gas/oil reservoirs and aquifers?
- Hydrogen embrittlement? –all storage options?
- Chemical reactions? –depleted gas/oil reservoirs and aquifers?
- Biological reactions? –depleted gas/oil reservoirs and aquifers?

Storage Integrity

- Fingering of Hydrogen
- Dissolution into surrounding water
- Leaky wells
- Contamination
- Chemical/mineral reactions

Hydrogen Mobility

- High mobility (2X that of natural gas)
- Low viscosity (1/2 that of natural gas)
- Leak potential higher than natural gas
- Fingering with surrounding water will be more prevalent

Hydrogen storage in **Salt** caverns does not pose significant issues.



Purity Integrity

- H₂ Mixing – depleted natural gas reservoirs
- Biological reactions/methanogenesis – the loss of H₂ to production of methane
- Chemical reactions – loss of H₂ and production of toxic gas

Possible Solutions

- Mixing – several known examples suggest mixing can be controlled by production rate and cushion gas
- Methanogenesis – a study suggests control by pH and salinity
- Chemical reactions - unlikely if pressure and temperature increased



Hydrogen Embrittlement

- Wells
- Surface infrastructure
- Hard Rock Cavern liners

Well Sealing Materials

- elastomers, casing cements, etc.

Possible Solutions

- Operation at low pressure and temperatures for existing infrastructure
- Use of alternate materials, such as carbon steel

Questions to be Addressed

Q: Can H₂ permeate through these materials?

Q: Does H₂ chemically alter the materials?

Q: What is an acceptable leak volume? Affect the environment?

Q: What is the latest technology available for large scale H₂ containment?

- liners
- coatings/sprays?
- alternate materials?

Q: Is there a cost effective solution?