# SHASTA

## Subsurface Hydrogen Assessment, Storage, and Technology Acceleration

U.S. DEPARTMENT OF ENERGY
Fossil Energy and Carbon Management

NATIONAL ENERGY TECHNOLOGY LABORATORY

Pacific Northwest NATIONAL LABORATORY

Lawrence Livermore National Laboratory

***Project overview and current status***


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https://edx.netl.doe.gov/shasta/


PNNL-SA-170233

# Hydrogen as an enabler to a low-carbon future

- $H_2$ as an energy carrier could be a critical step enabling a low-carbon, and eventually a zero-carbon energy society
- $H_2$ has numerous benefits, can be generated by well-established and emerging technologies, and can be used in a variety of energy and transport processes
- $H_2$ as energy carrier may require a large network linking generators with consumers via transmission systems
- Large-scale geological $H_2$ storage balances inter-seasonal supply/demand discrepancies, de-couples energy generation from demand, and decarbonizes heating and transportation
- A significant gap is the ability to economically and safely store large amounts of $H_2$, much like how natural gas is stored today
- Large scale storage of $H_2$ can be achieved by utilizing our underground resources like how natural gas (NG) has been stored for the past century

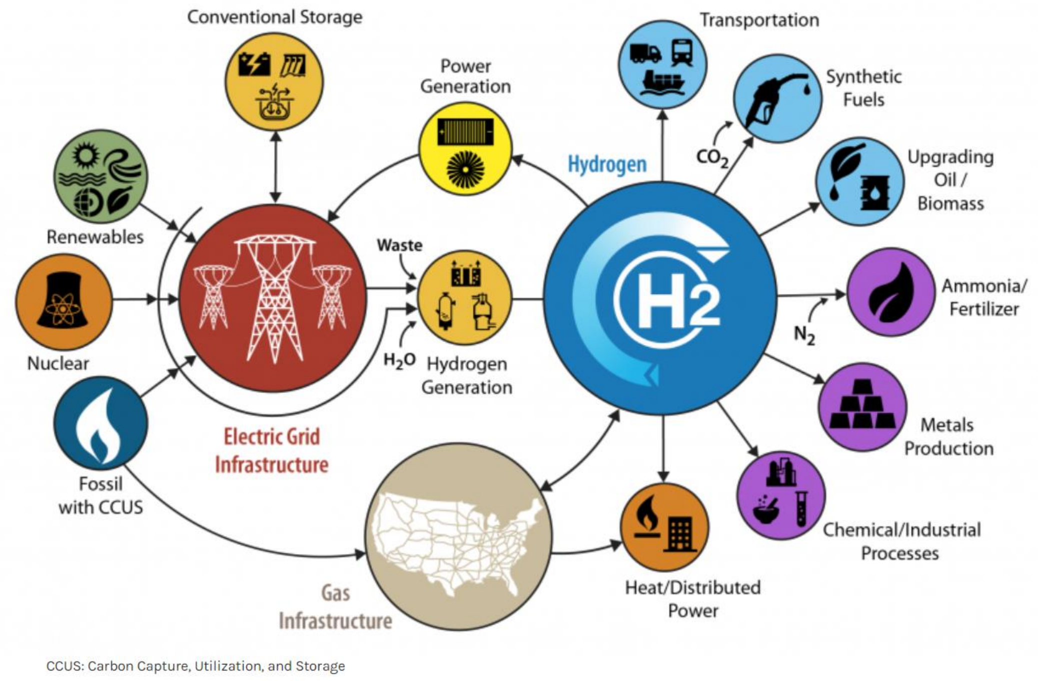


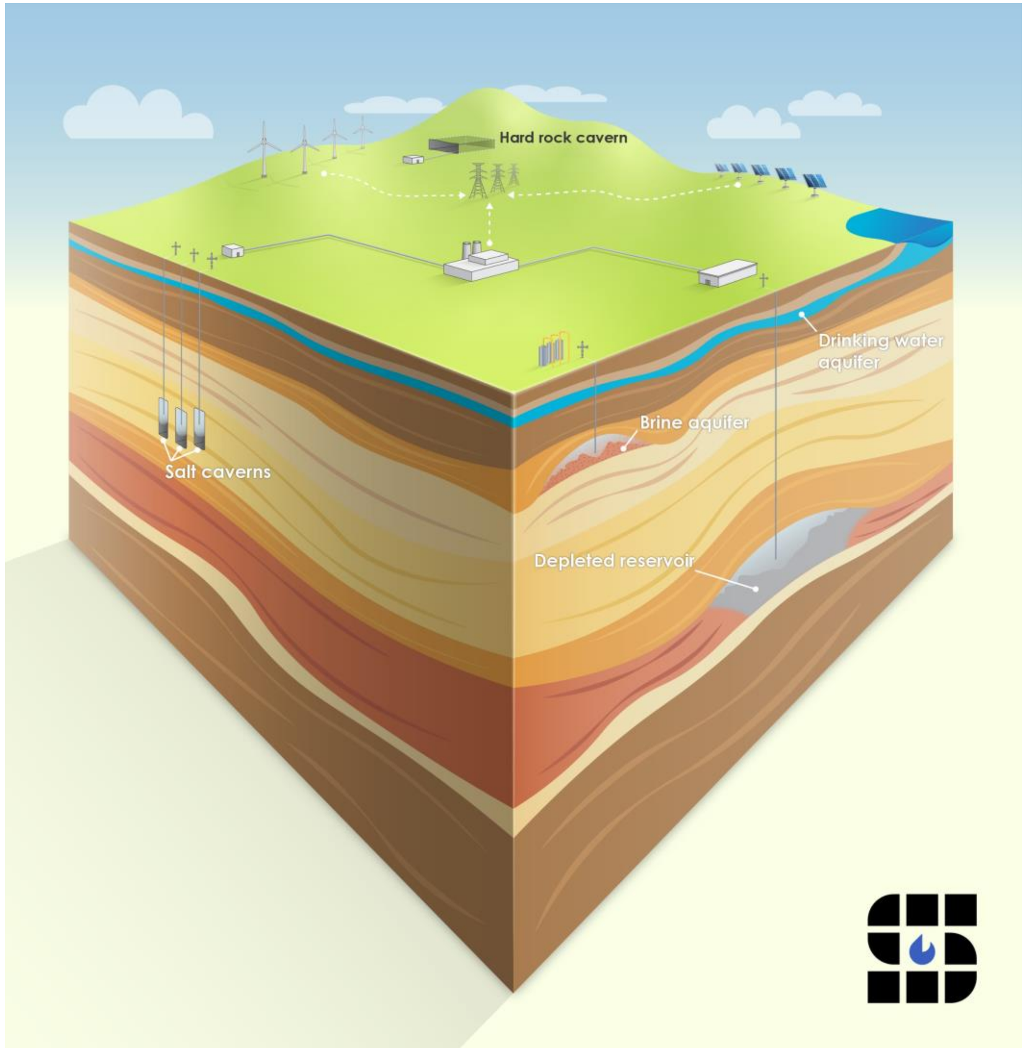

Image: https://www.energy.gov/eere/fuelcells/h2scale

# SHASTA — Project objective

**Address technological hurdles and develop technologies to enable public acceptance of subsurface storage of pure hydrogen and hydrogen/natural gas mixtures as a safe and effective bulk energy storage option**

**Specific Goals:**

- Quantify operational risks
- Quantify potential for resource losses
- Develop enabling tools, technologies, and recommended practices
- Develop a collaborative field-scale test plan in partnership with relevant stakeholders



# Project organization

## Research Focus

### Research Thrusts

- Risk Quantification (Experiment & Simulation)
- Enabling Technologies to Manage Hydrogen Storage
- Recommended Practices and Industry Engagement

### S&T Outcomes

- Core- to reservoir-scale performance
- Materials compatibility
- Role of microbial interactions
- Simulation and monitoring tools
- Scientifically informed pilot test plan(s)

## Structure

### Project Direction

- DOE-FECM
- NETL-Program

### Project Advice

- Stakeholder Group

### Project Execution

- PNNL
- NETL-RIC
- LLNL
- Industry Partner(s)

# Work breakdown

1 **Risk Quantification**

- **State-of-Knowledge Report**
- **Research Capabilities**
  - Laboratory Upgrades
  - Simulation Upgrades
- **Fundamental (Applied) Science**
  - Rock-Gas Interactions
  - Flow Characterization & Dynamics
  - Microbial Interactions
  - Well Materials & Components
- **Risk Assessments**
  - Operational Risks
  - Safety Risks
  - Social License to Operate

2 **Enabling Technologies**

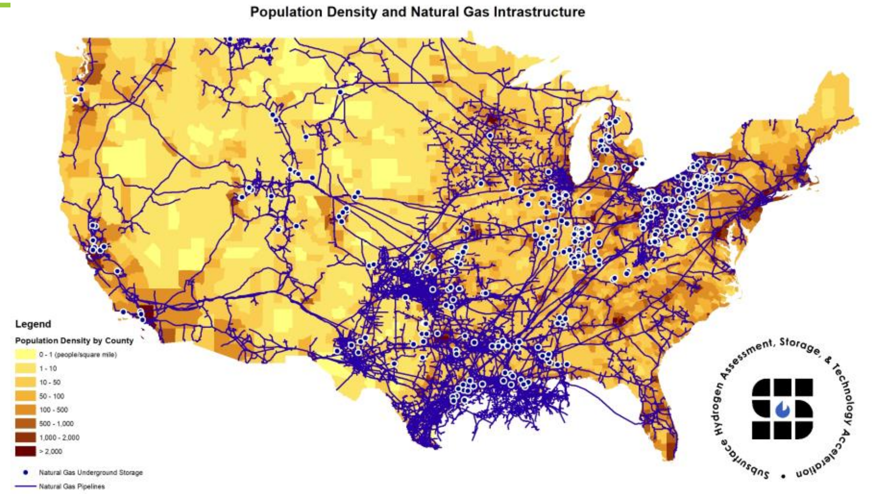
- **Software Development**
  - Open-Source Reservoir Simulator
  - Site-Screening Tool
- **Fiber-Optic Sensors**

3 **Stakeholder Engagement**

- **Recommended Practices Document(s)**
- **Techno-Economics and the Business Case**
- **Industry / Stakeholder Interactions**
- **Pilot Study Preparation**

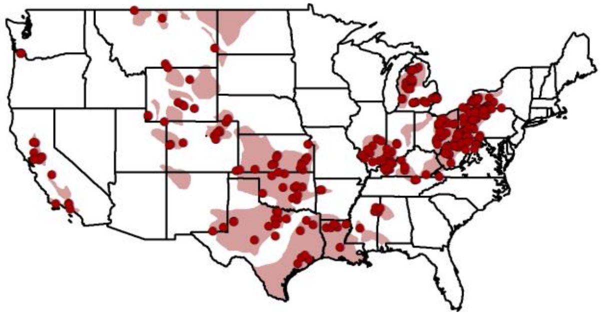
# Guiding questions: Subsurface storage systems

- Can we leverage our existing natural gas storage infrastructure and other subsurface resources to enable the use of $H_2$/NG blends and pure $H_2$ as an energy carrier?
- What are the benefits/risk of using different types of subsurface storage systems?

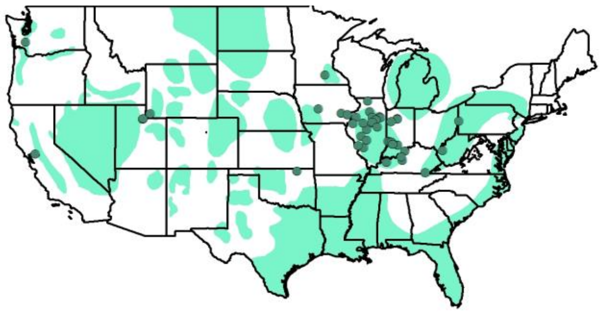



Distribution of existing UGS storage fields (blue circles with white outlines), NG distribution pipelines (blue lines), Proximity to major population densities (shaded from yellow to orange)

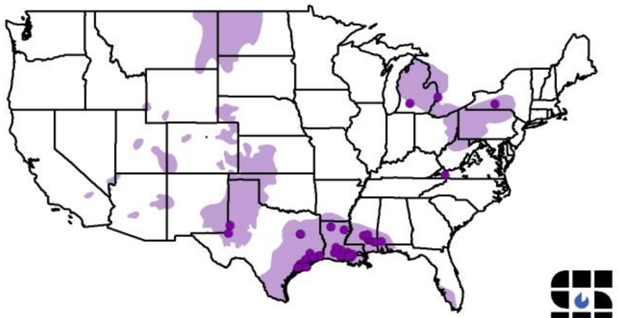
Depleted Oil and Gas fields

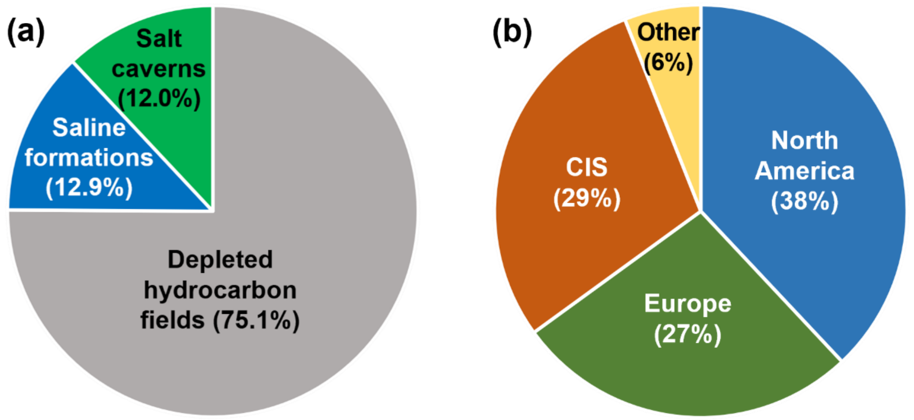


Saline Aquifers



Salt Caverns



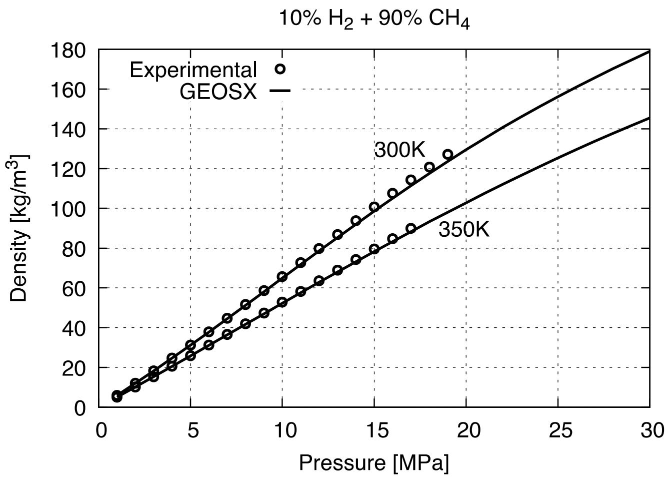


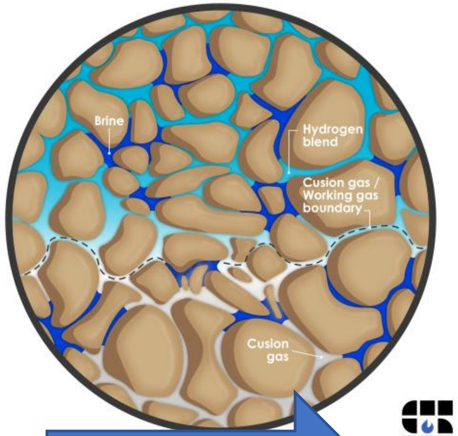

Breakdown of UGS storage volumes by storage types (a) and by region (b)

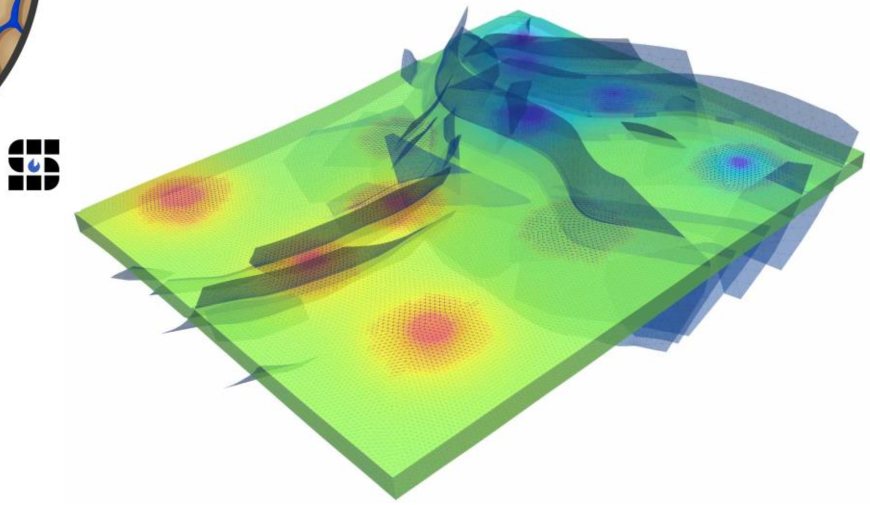
# Guiding questions: Reservoir performance

- What is the impact of rock and fluid properties on storage efficiency and energy availability?
- How can $H_2$/NG/brine flow dynamics be managed?
- What mechanisms could lead to resource losses?

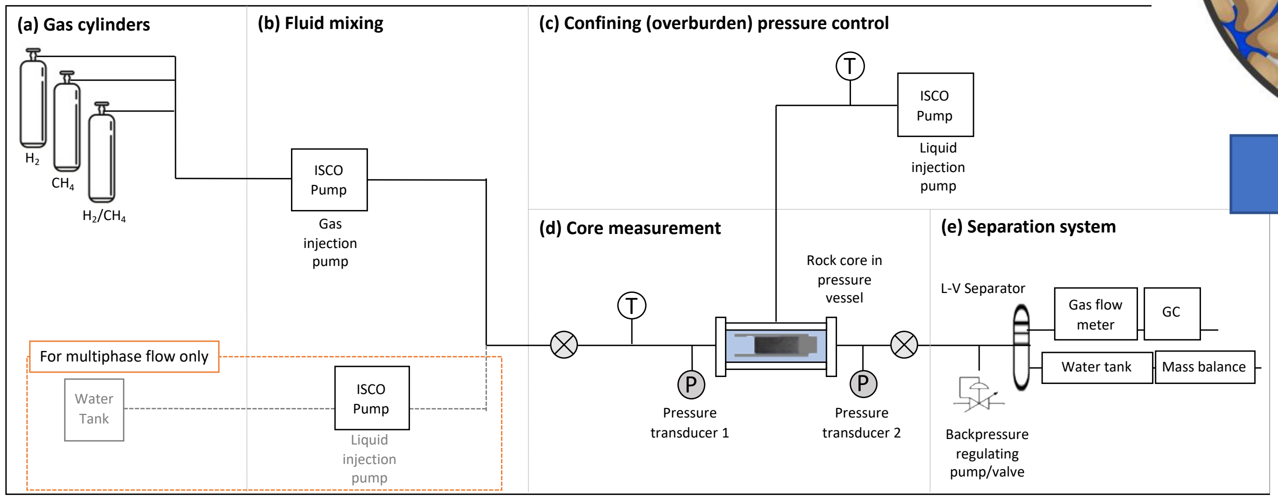
Numerical studies



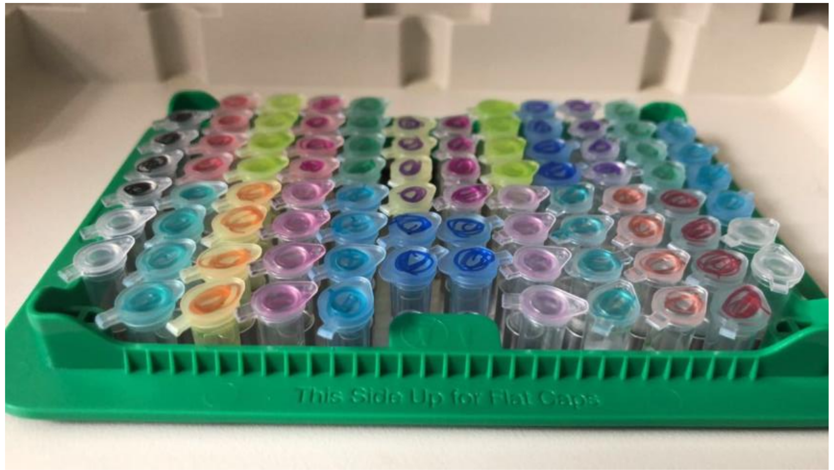



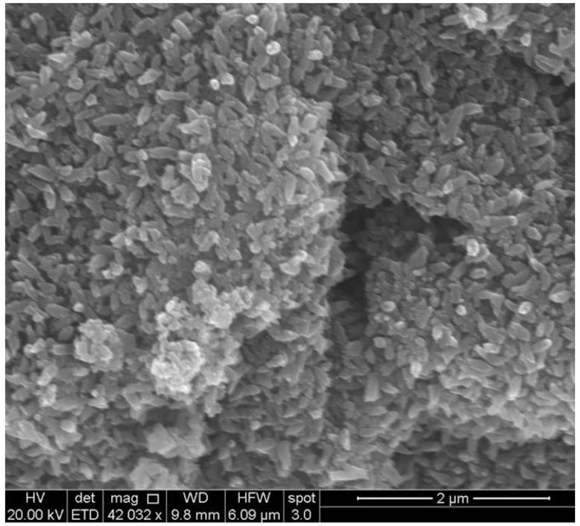
Lab experiments & characterization

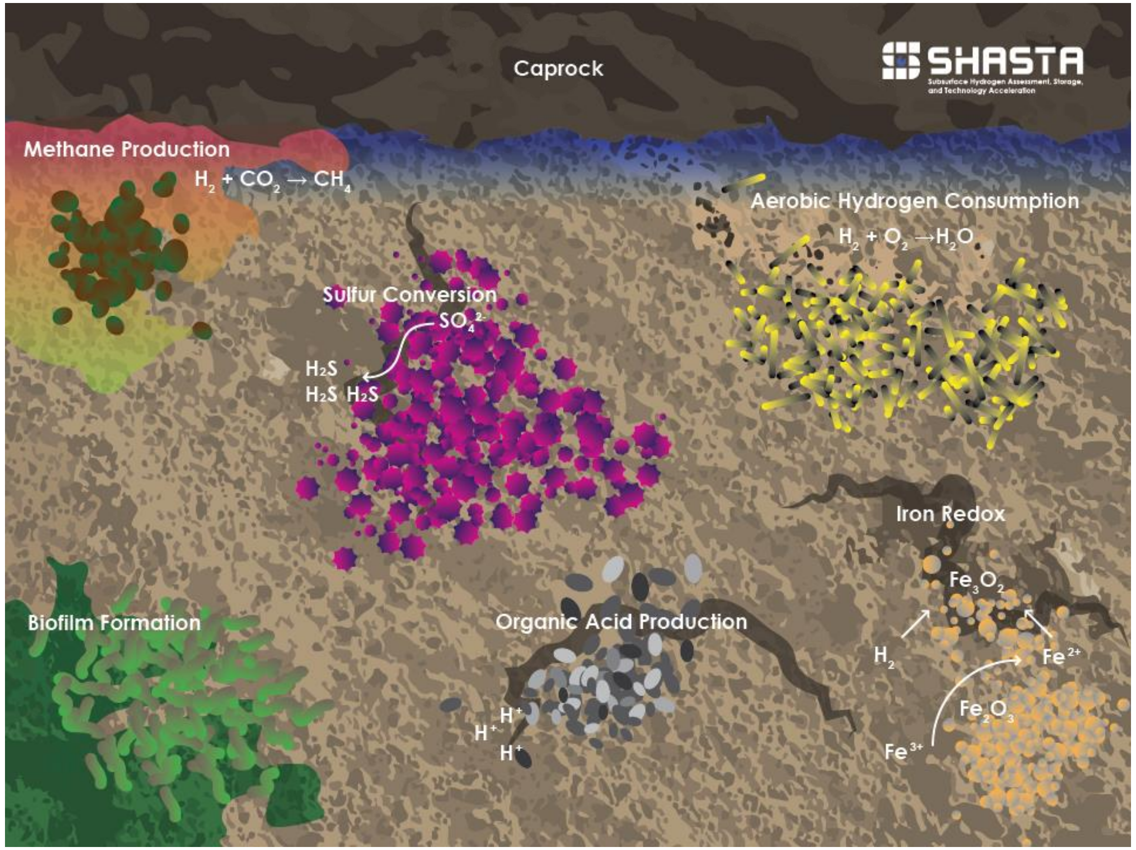


# Guiding questions: Microbial interactions

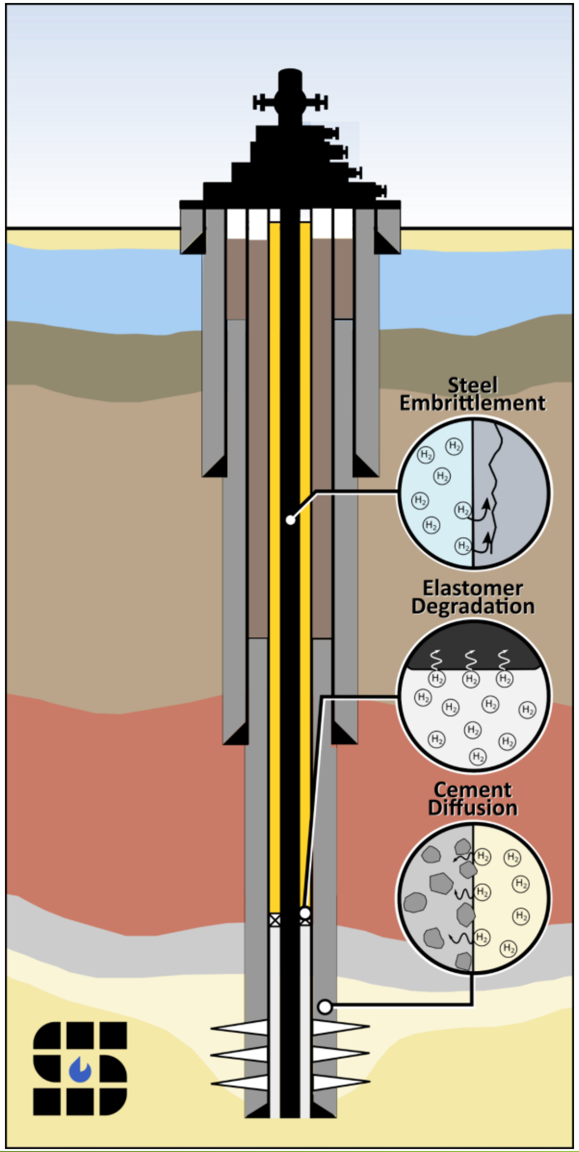
- What are possible impacts of biogeochemical processes?
- What microbial populations and reservoir conditions could be problematic?
- Over what time scales are impacts likely to be realized?



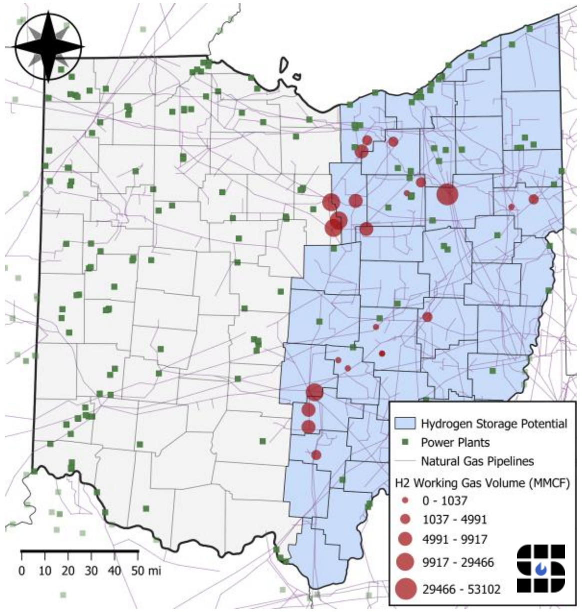
# Guiding questions: Well integrity

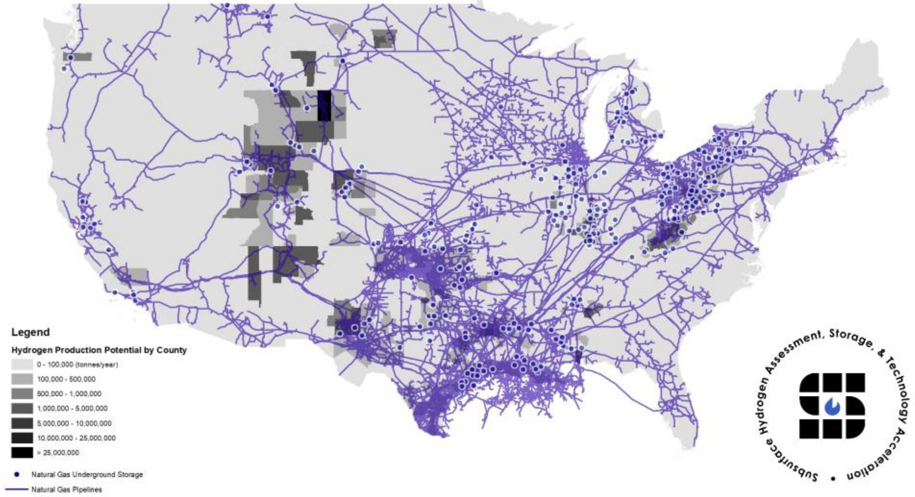



- What is the long-term durability of well construction materials?
- Is $H_2$ leakage along wellbores an issue?
- Are existing wells suitable for exposure to $H_2$?
- Do we need to change our well testing and surveillance approach?

# Guiding questions: Social, regulatory, and technoeconomic considerations

- How can we increase awareness and improve public perception of UHS to enable local acceptance of this technology?
- Are the regulations in place to allow this technology, what scientific-basis can we provide to inform regulatory decisions?
- Can we provide tools and use-case scenarios to support industry acceptance and deployment at the city and region scale?

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***Questions?***


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