

Oklahoma Hydrogen Production, Transportation and Infrastructure Task Force

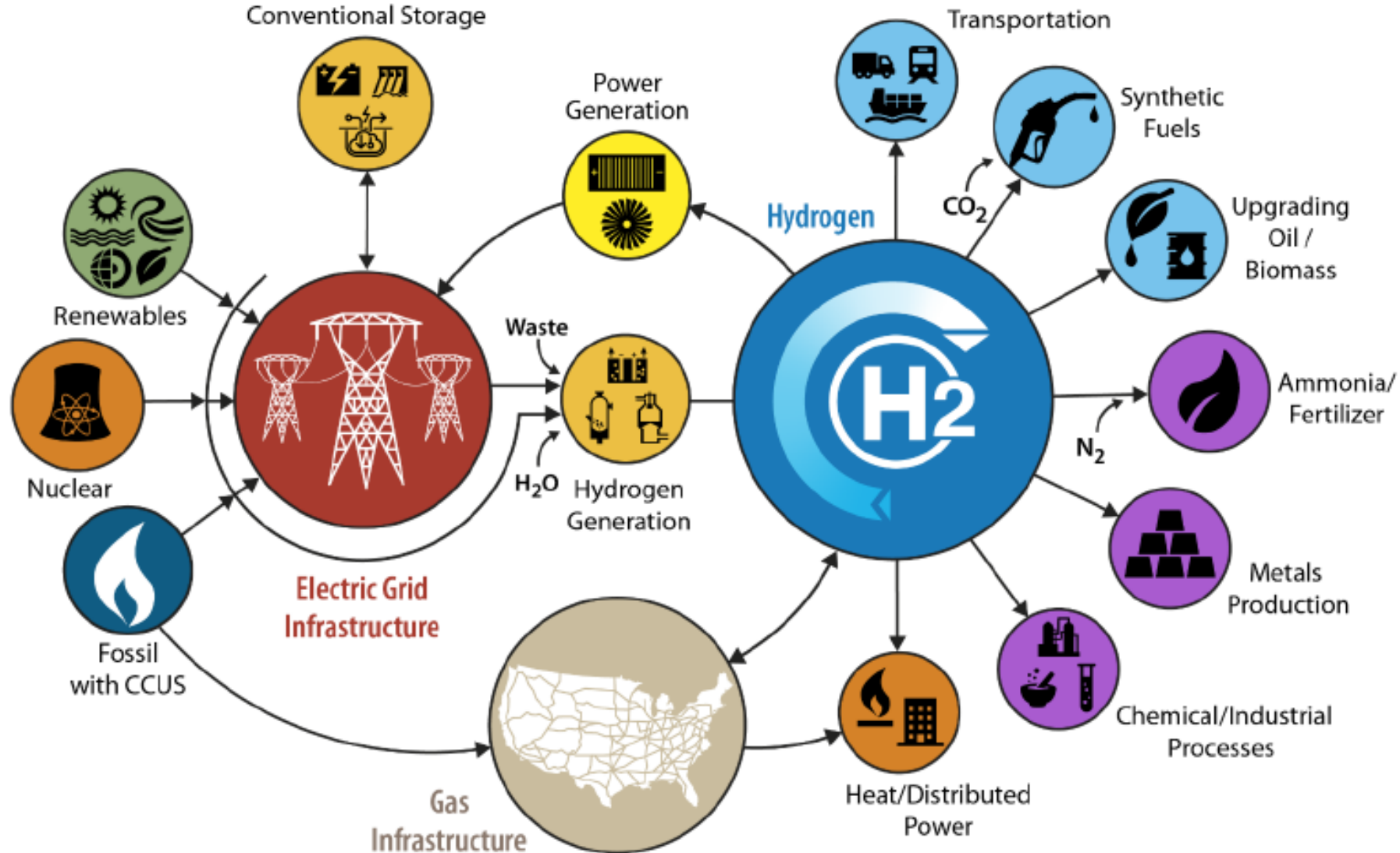
Introduction to the Hydrogen Economy



OKLAHOMA

Hydrogen Fundamentals

The Hydrogen Economy – H2@Scale





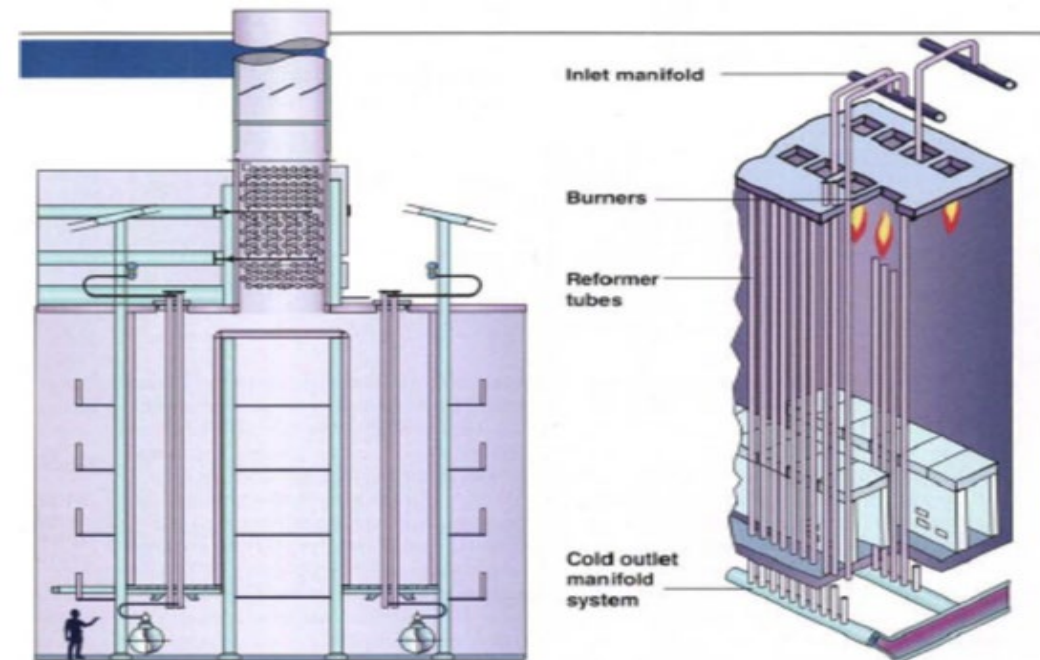
Hydrogen Fundamentals

- Hydrogen is colorless, odorless and has the highest energy content by **weight** of any fuel – 3X higher than gasoline
- Hydrogen is the most abundant element in the universe; however, it is rarely found in its elemental form
- Hydrogen is produced from a hydrogen-containing feedstock
 - Steam Methane Reforming (SMR) from natural gas
 - Gasification and pyrolysis
 - Water via electrolysis
- 99% of the US hydrogen production is derived from fossil fuels and 1% from electrolysis.
 - 95% of fossil fuel derived hydrogen produced today is from steam methane reforming
 - 4% is produced via gasification
- Hydrogen is used within oil refineries, to produce ammonia (NH_3 for fertilizer) and methanol production

Hydrogen Fundamentals

Production Methods: Steam Methane Reforming

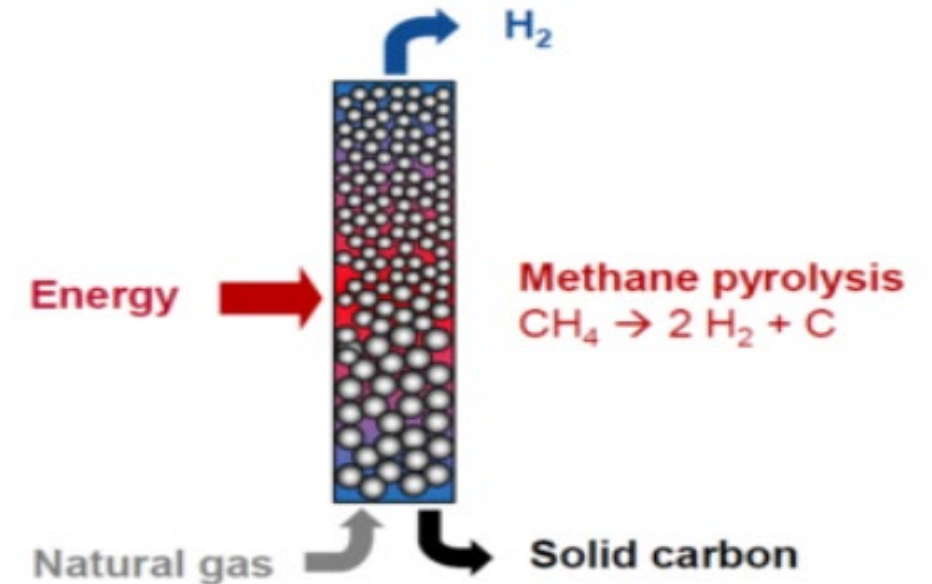
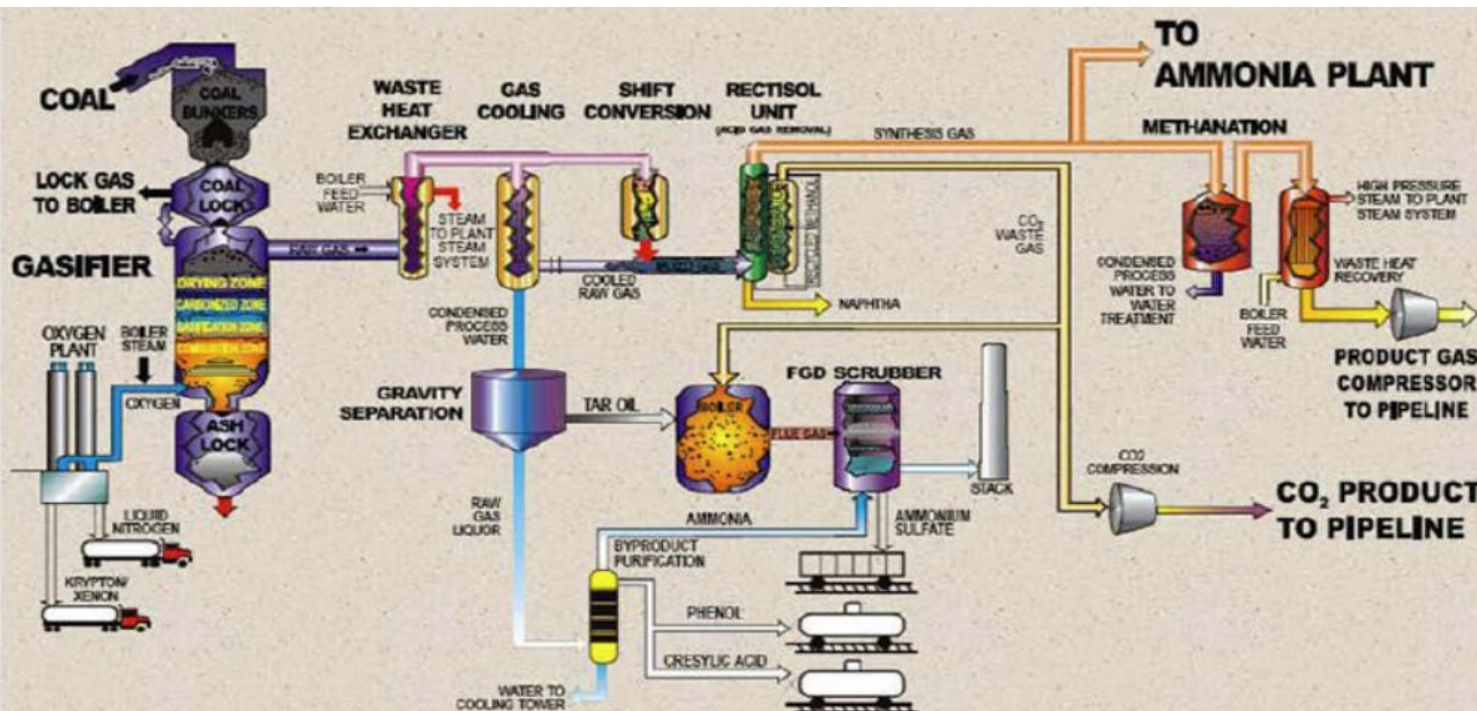
- Steam Methane Reforming (SMR) utilizes steam and a catalyst to separate methane into hydrogen and carbon dioxide
- CH_4 (methane) + 2 H_2O (steam) \longrightarrow 4 H_2 (hydrogen) + CO_2 (carbon dioxide)
- Reliable and low-cost hydrogen production
- OK fertilizers operate large scale SMRs, while refineries utilize smaller scale SMRs
- An OK fertilizer captures CO_2 which is used for enhanced oil recovery



Hydrogen Fundamentals

Production Methods: Gasification and Pyrolysis

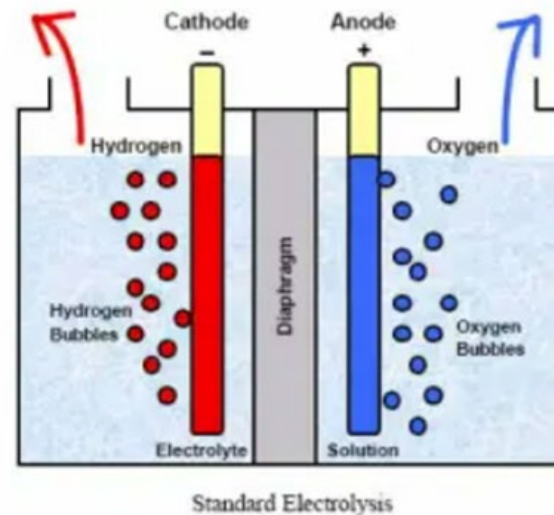
- Gasification of coal, biomass and waste is similar to SMR regarding energy intensity and carbon dioxide emissions
- Pyrolysis is the thermal decomposition of methane within a reactor containing a catalyst and heat
 - A benefit of methane pyrolysis is the production solid carbon with the hydrogen



Hydrogen Fundamentals

Production Methods: Electrolysis

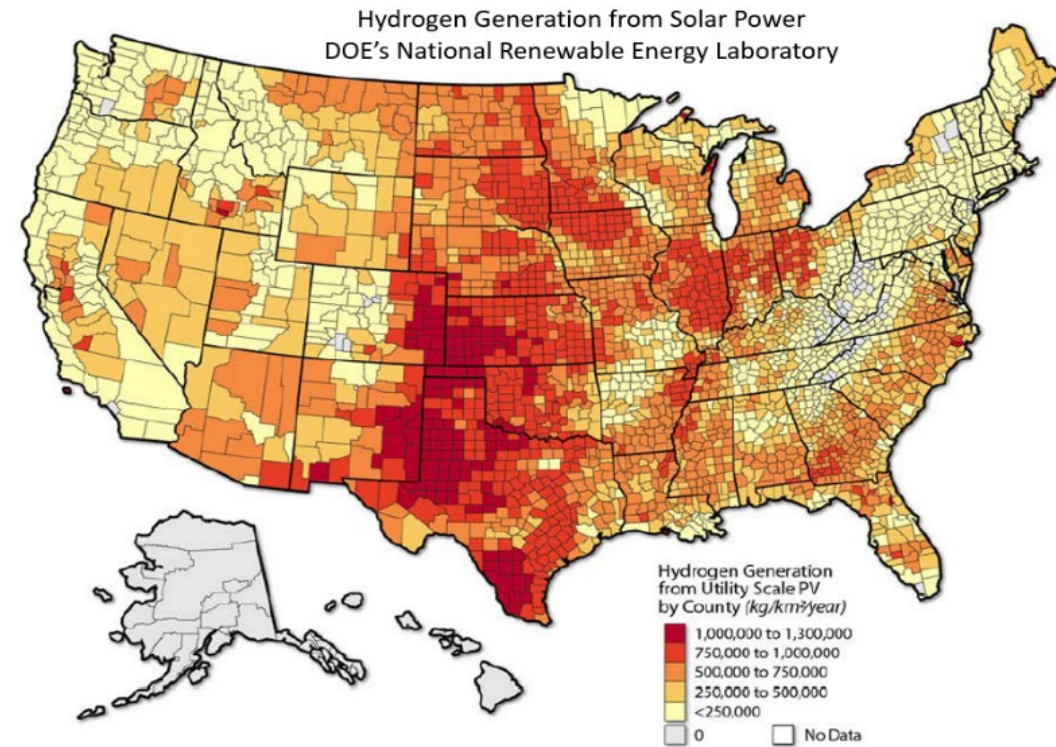
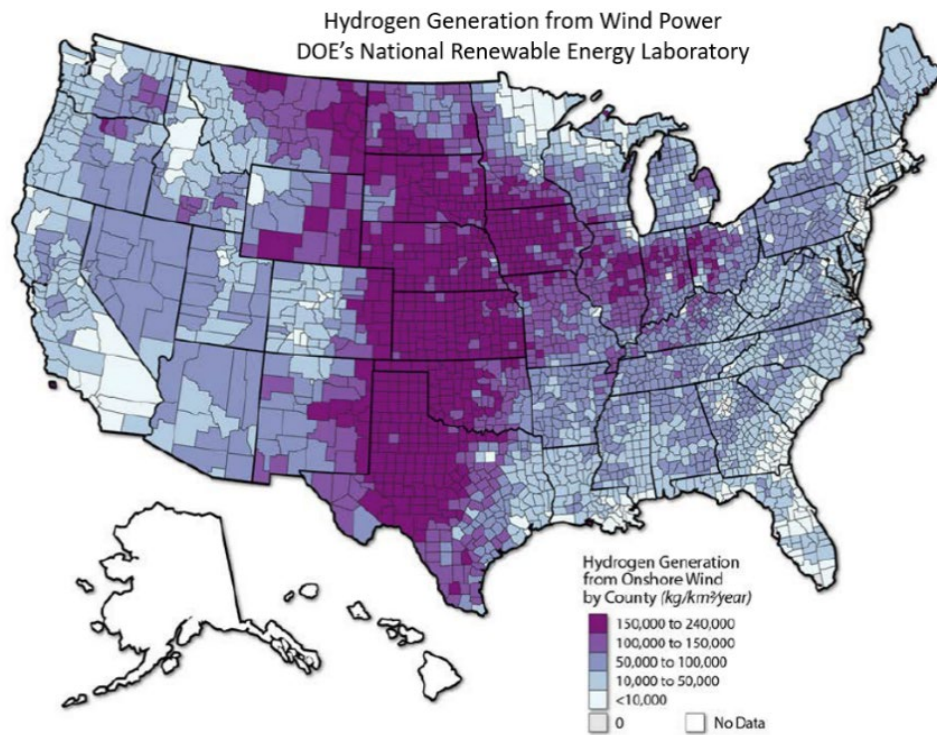
- Electrolysis utilizes electricity to split water (H_2O) into its constituent elements oxygen (O_2) and hydrogen (H_2)
- Wind and solar sources of electricity can be used for electrolysis, resulting in “green hydrogen”
- Production of hydrogen from renewable energy could provide balancing services for the grid
 - Use off-peak power and store hydrogen for power generation for on-peak power demand
- Currently electrolysis is more expensive than SMR, but this is an area of focus for DOE research



Hydrogen Fundamentals

Renewable Energy – DOE Hydrogen Corridors

- Locating the intersection of renewable energy and water resources

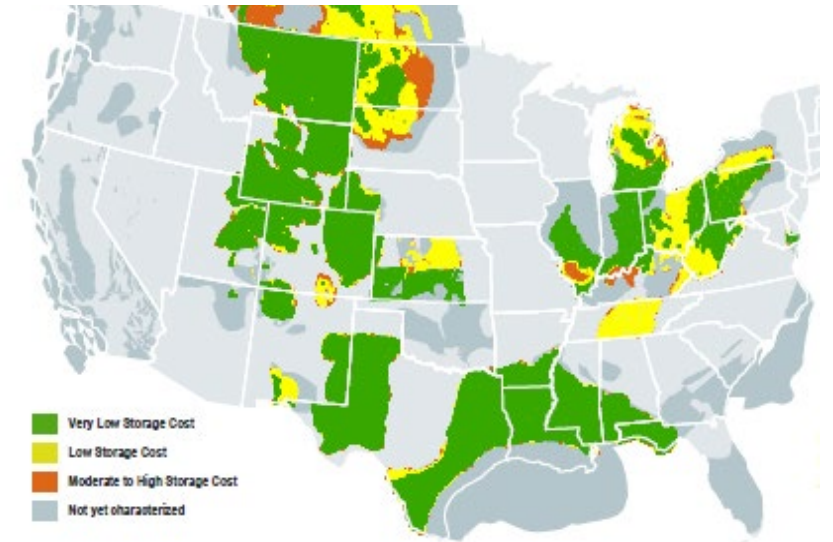


Hydrogen Fundamentals

Carbon Capture Use and Storage

- Leverage Oklahoma's natural gas supplies for the hydrogen economy
- SMR with Carbon Capture: "blue hydrogen"

US Carbon Sequestration Formations



Optimized Transportation Network for Economy-Wide CO₂ Capture and Storage
Great Plains Institute

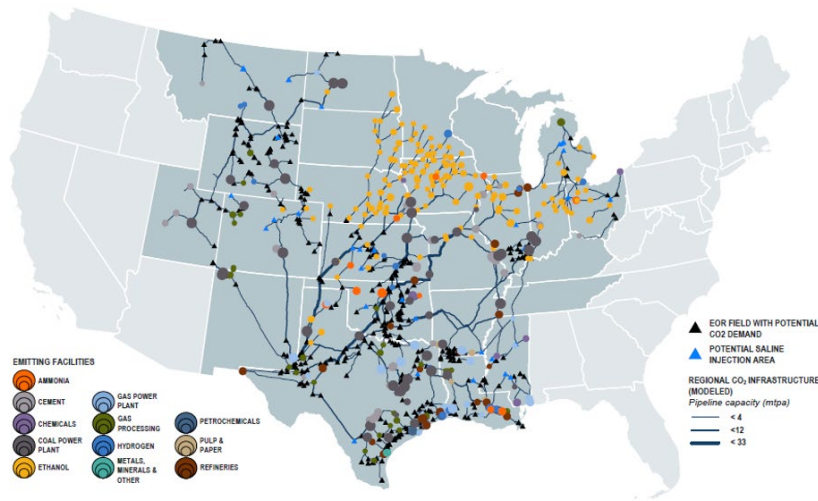
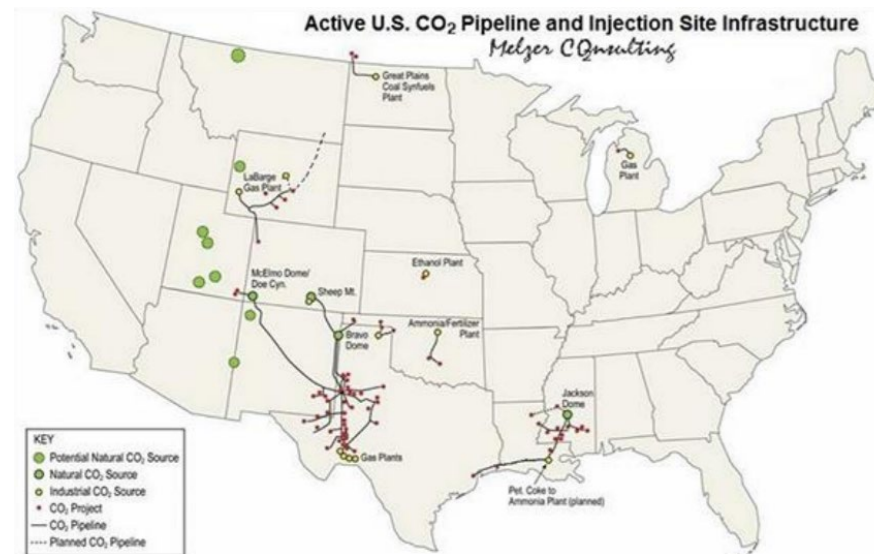


Figure authored by GPI based on results from the SimCCS model.

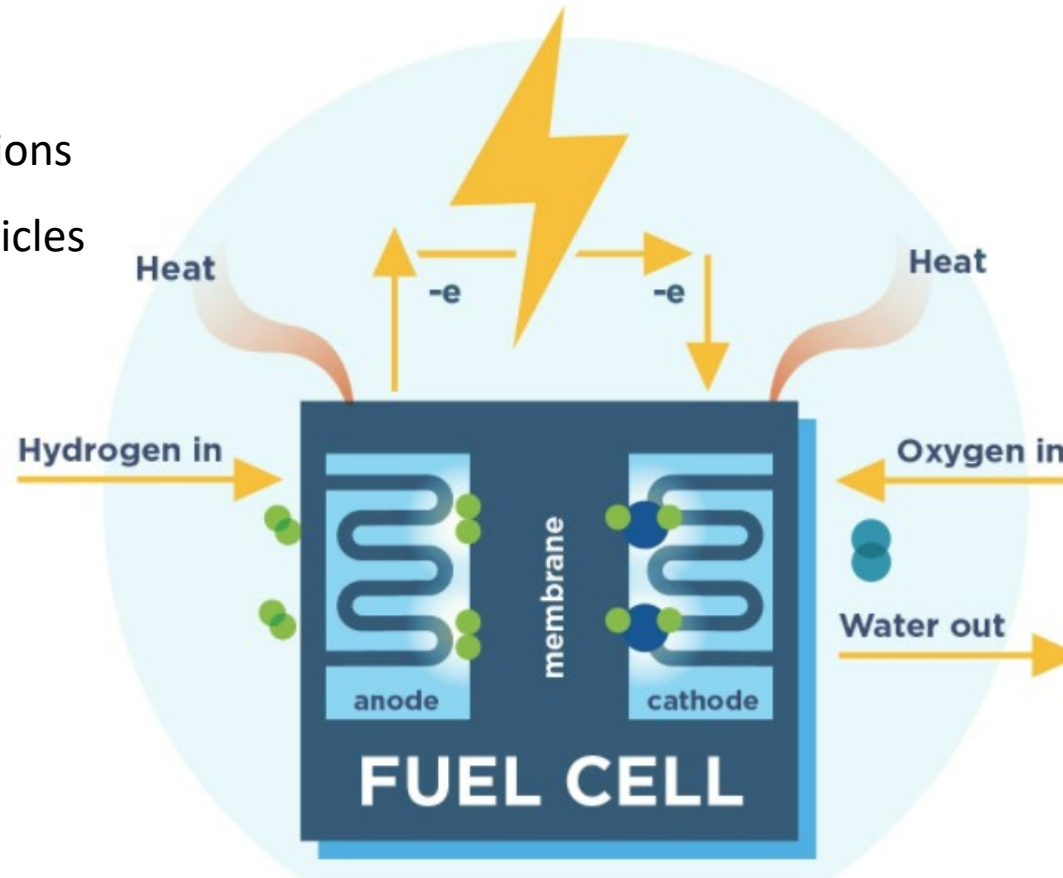
Active U.S. CO₂ Pipeline and Injection Site Infrastructure
Melzer Consulting



Hydrogen Fundamentals

Fuel Cells

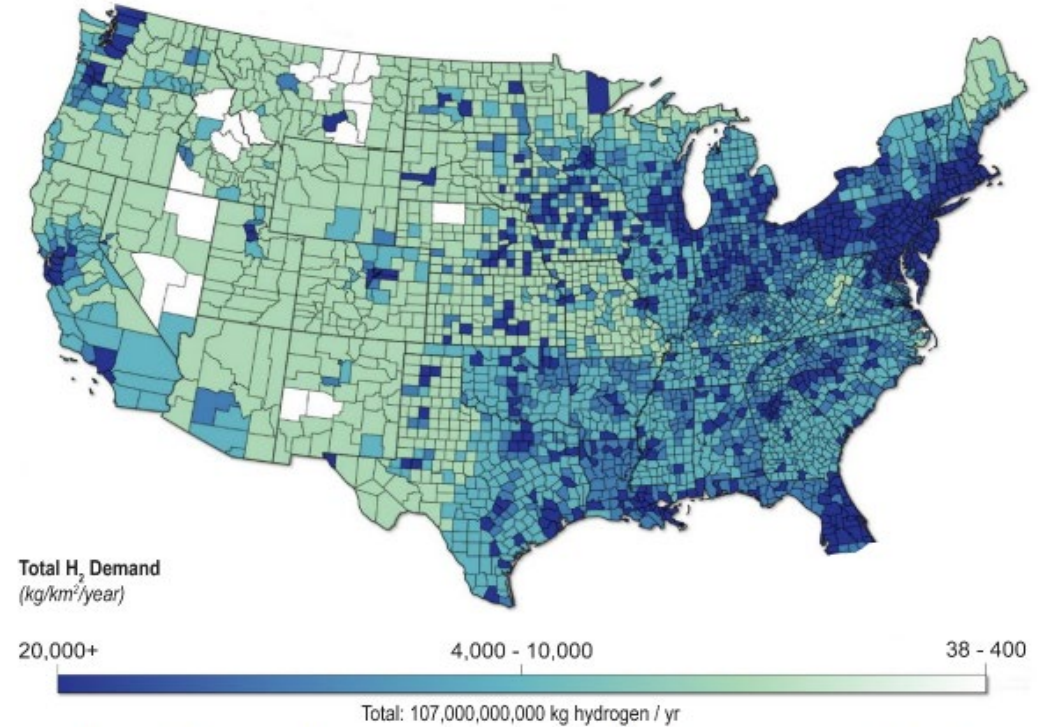
- Fuel cells work like batteries, but they do not run down or need recharging
- Hydrogen as the fuel source exhausts heat and water
- Uses
 - Power generation applications
 - Surface transportation vehicles with substantial range



Hydrogen Fundamentals

Uses

- The majority of hydrogen today is utilized within refineries, ammonia and methanol production
- Blending into natural gas pipeline infrastructure
- Electricity grid balancing
 - Energy storage and power generation
- Transportation fuel
 - Light, medium and heavy-duty vehicles
- Biofuels and synthetic fuels
- Steel production

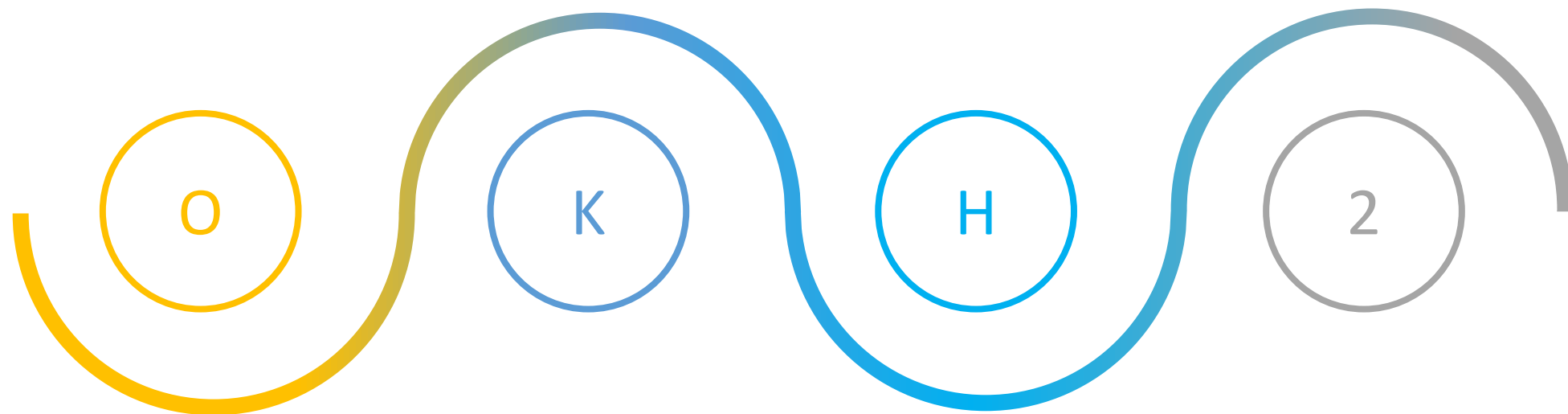


DOE's National Renewable Energy Laboratory
Consumption Potential Industrial and Transportation



Development of a Statewide Roadmap for a Hydrogen Economy

Next Steps - Discussion



Power and
Water

Incentives and
Taxation

Technology,
Infrastructure
and
Transportation

Statewide
Roadmap



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OK H2 Task Force

Wrap Up

- Email comments, questions and ideas to:

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