

Hydrogen Status Update: The Fuel of a Carbon-Free Future?

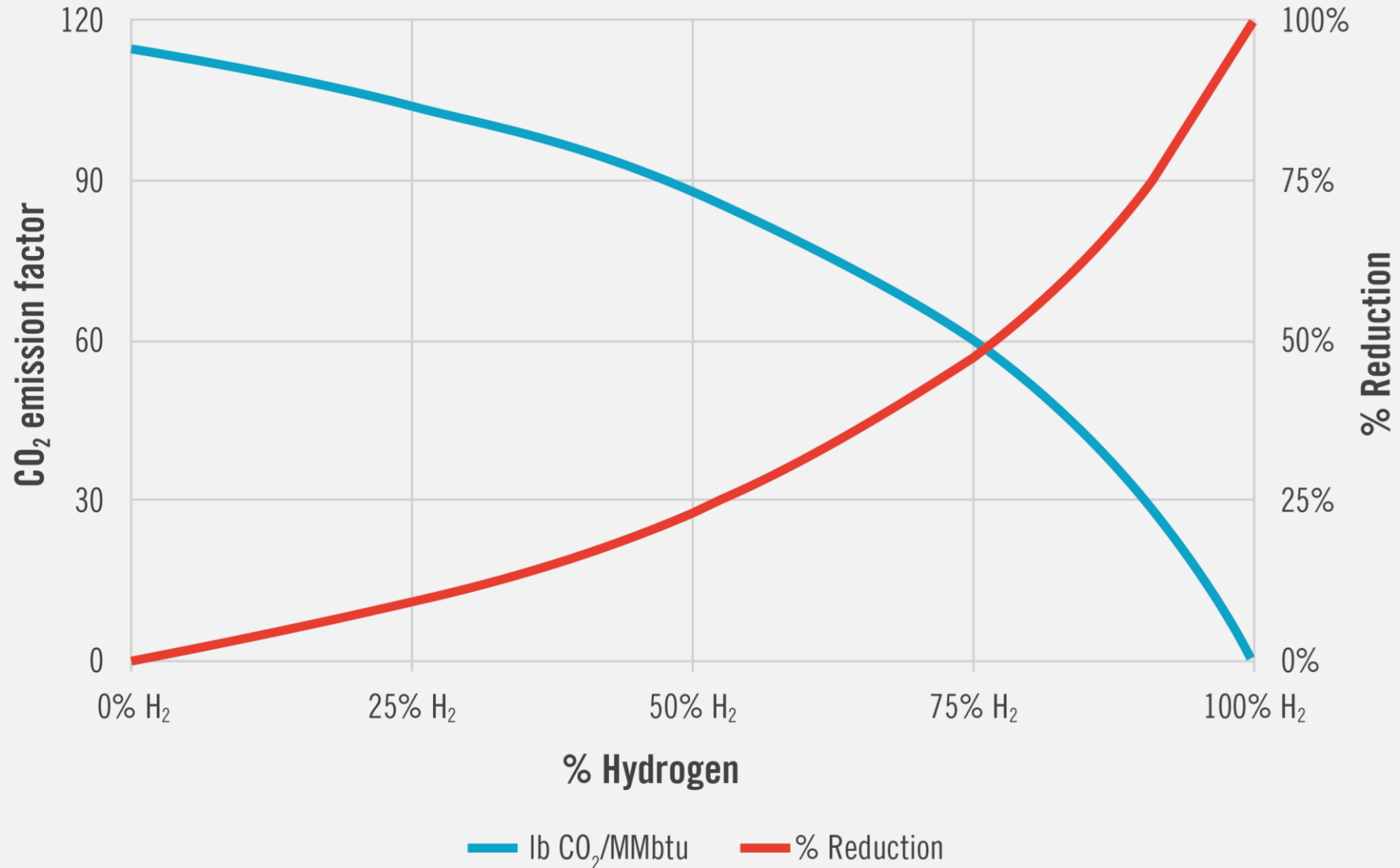
Presented by: Brian Petermann, PE

CIBO Policies & Technology Conference: September 2023

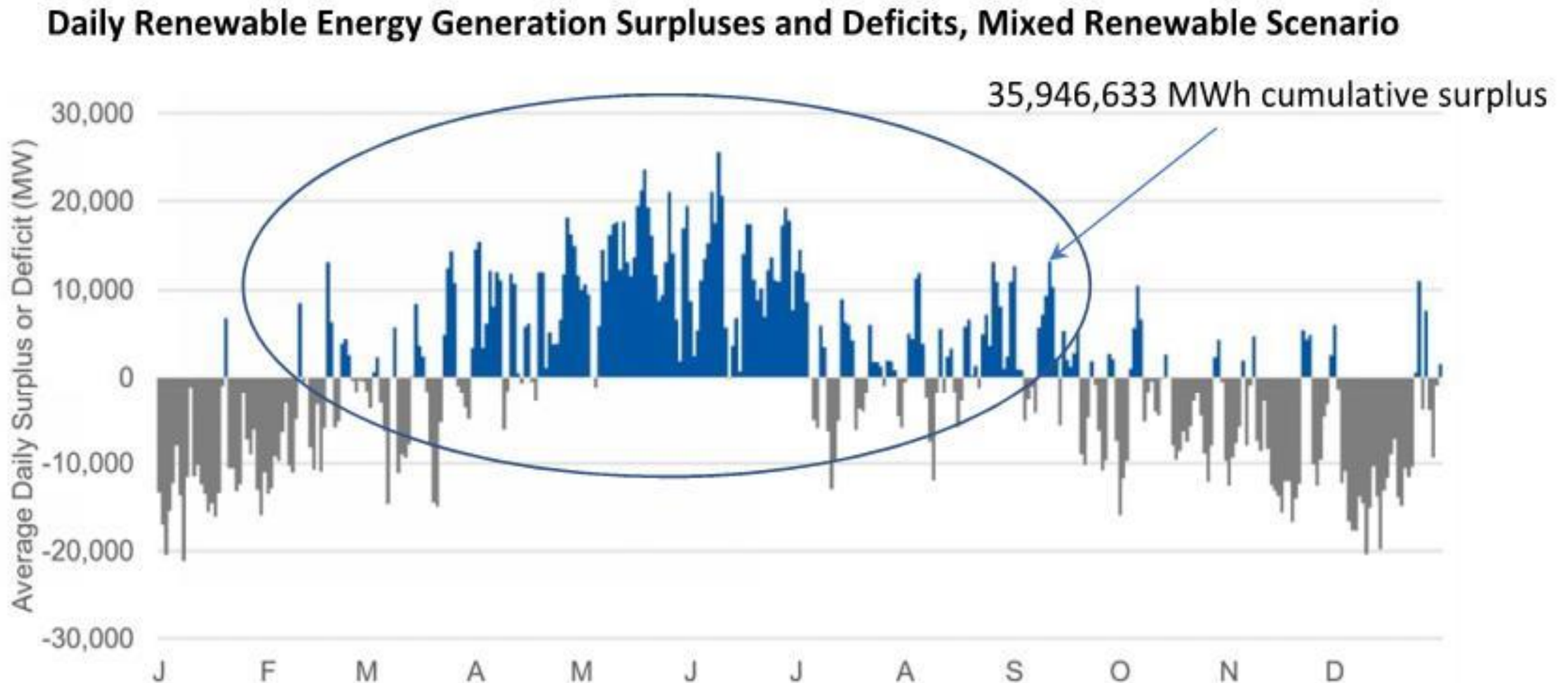


Review & Deeper Dive of Science and Drivers

Driver 1: It's All About Reducing CO₂e Emissions



Driver 2: Long-Term Storage of Excess Renewables



Driver 3: IRA Tax Credits + USDOE H₂HUB \$



U.S. DEPARTMENT OF
ENERGY

Office of
Policy

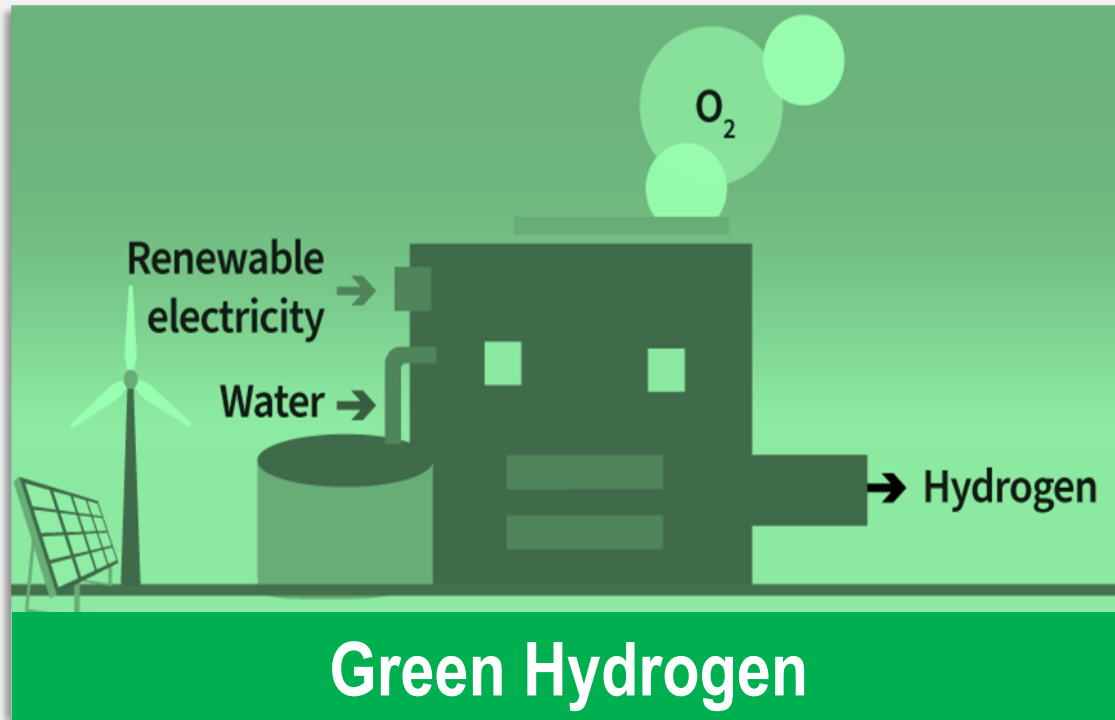
Investing in American Energy

Significant Impacts of the Inflation
Reduction Act and Bipartisan Infrastructure
Law on the U.S. Energy Economy and
Emissions Reductions



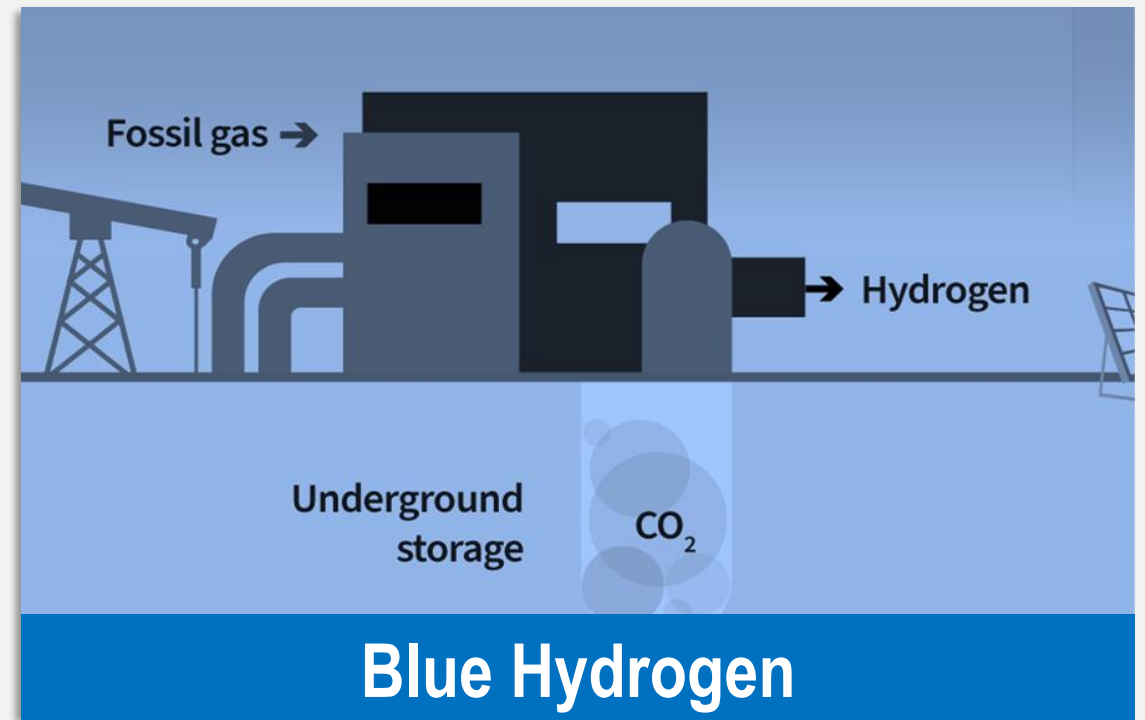
Production “Colors”

Electrolysis



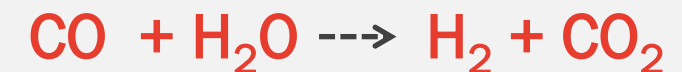
Renewables

Steam Methane Reformation

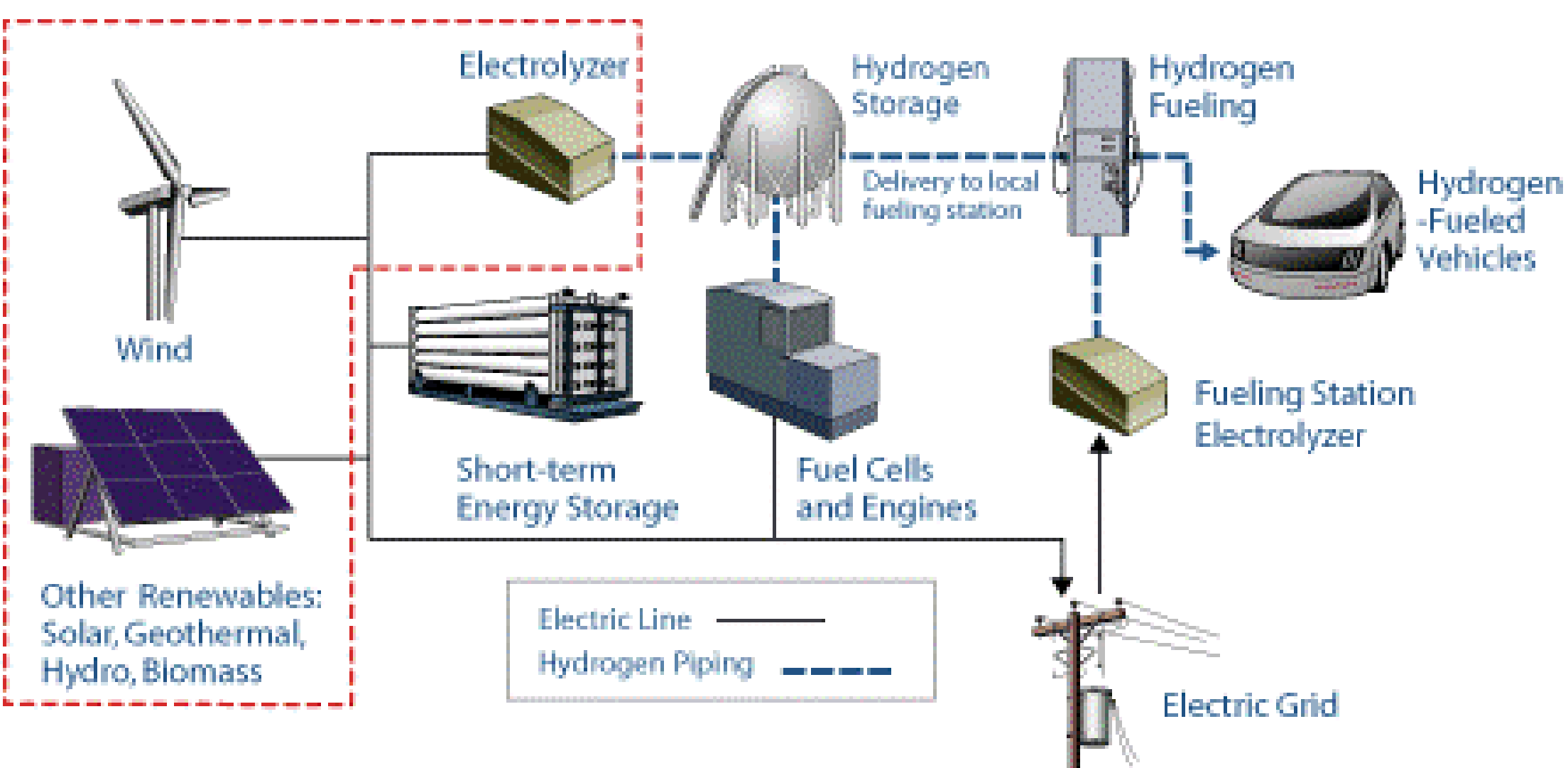


With Carbon Capture & Storage

THEN



Integration of Hydrogen

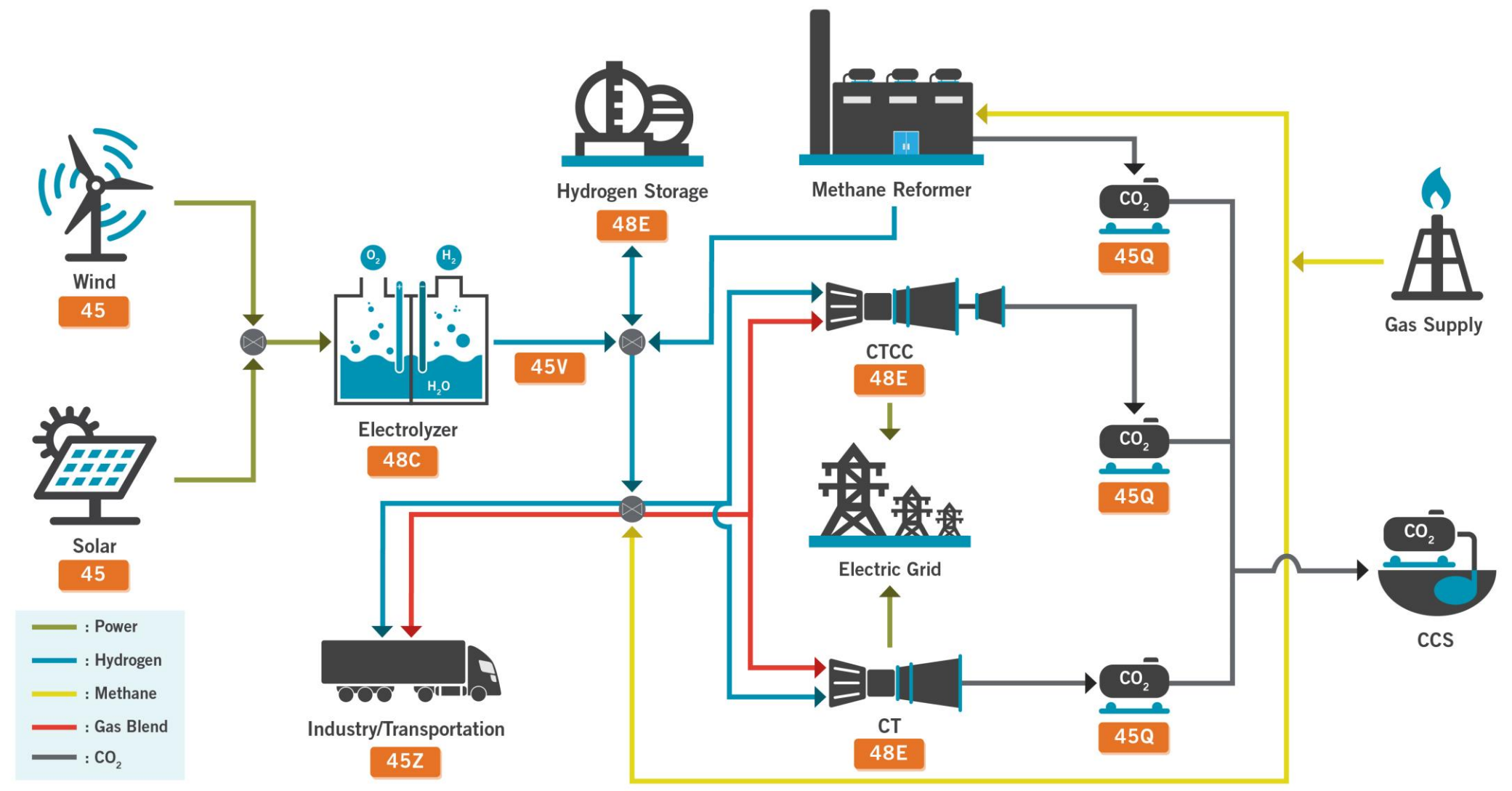


Status and Trends

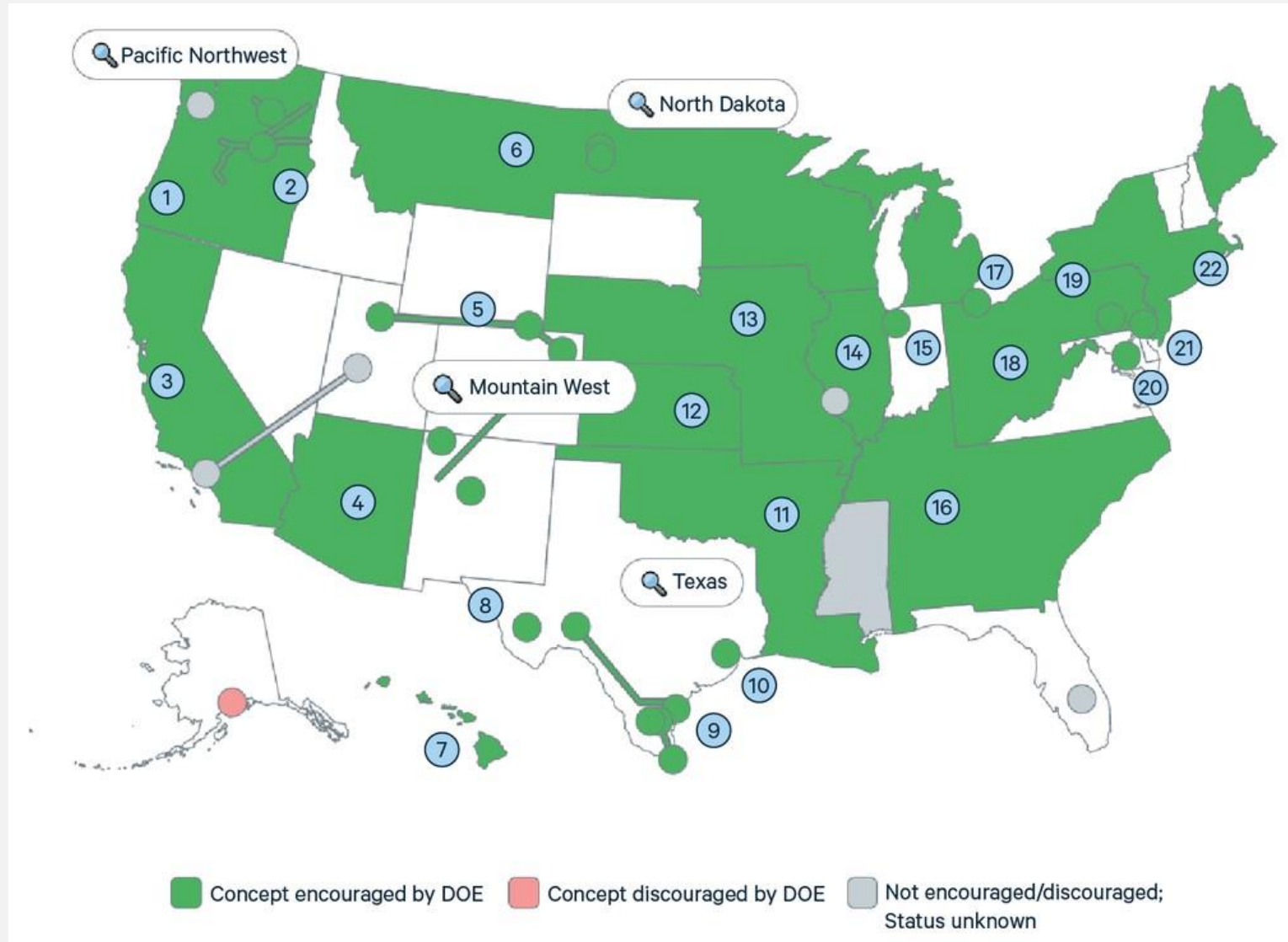
Clean Energy and Carbon Management Tax Credits

	Tax Code	Tax Credit
45 PTC	45Q	Carbon capture and sequestration
	45V	Clean H2 production
	45X	Advanced manufacturing production
	45Y	Clean electricity production
	45 Z	Clean transportation and fuel production
48 ITC	48C	Advanced energy project
	48E	Clean electricity investment

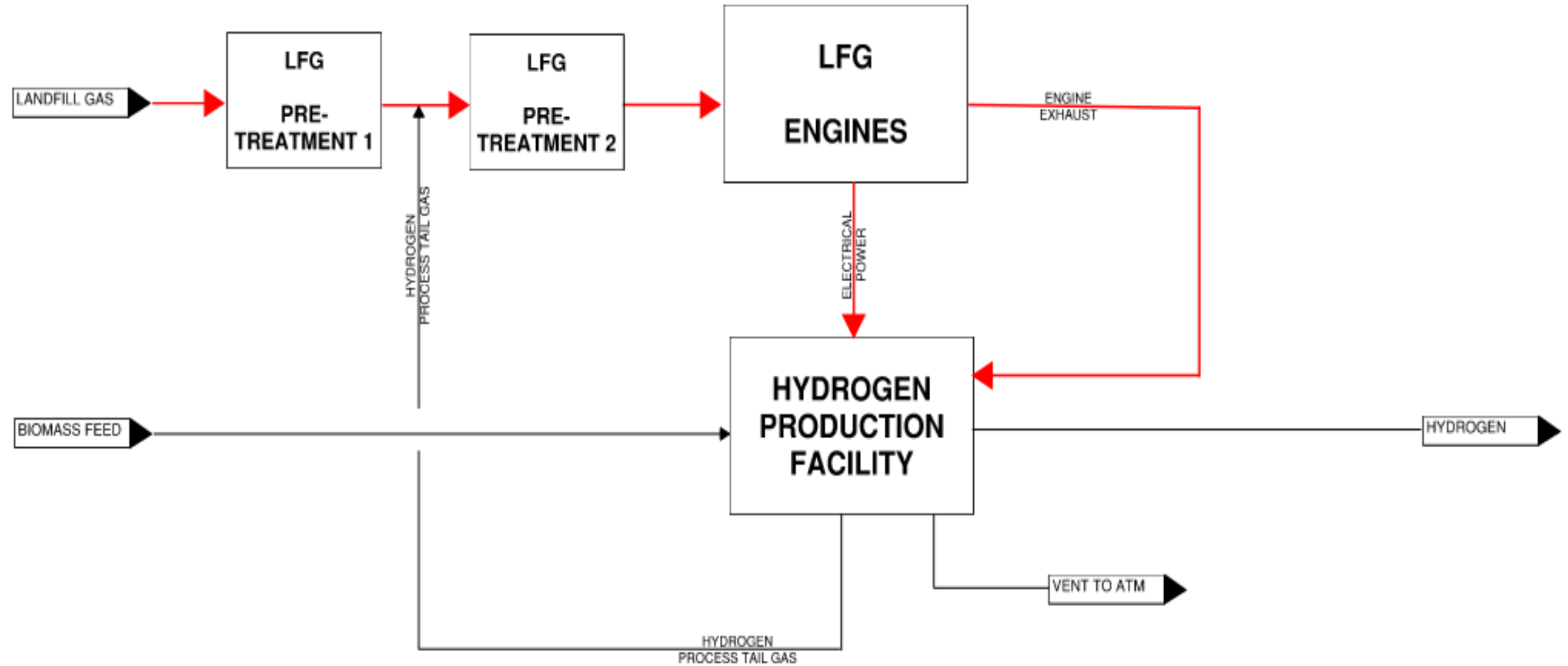
Green Hydrogen and IRA Tax Credits



US DOE \$8 Billion Funding for H2Hubs



PROCESS BLOCK DIAGRAM



Costs and Prices 2021 - 2023

- 25-40% efficiency
 - » 2023 -- higher
- 20,000 gallons of water for 100 MWh
 - » 2023 -- same.
- \$100-150/MMBtu expected for green hydrogen
 - » 2023 -- \$24 - \$57 per MMBtu
- \$40/MMBtu for grey hydrogen (SMR)
 - » 2023 -- \$5 - \$12 per MMBtu
- \$5/MMBtu for pipeline natural gas
 - » 2023 -- same

Intermountain Power / ACES Update



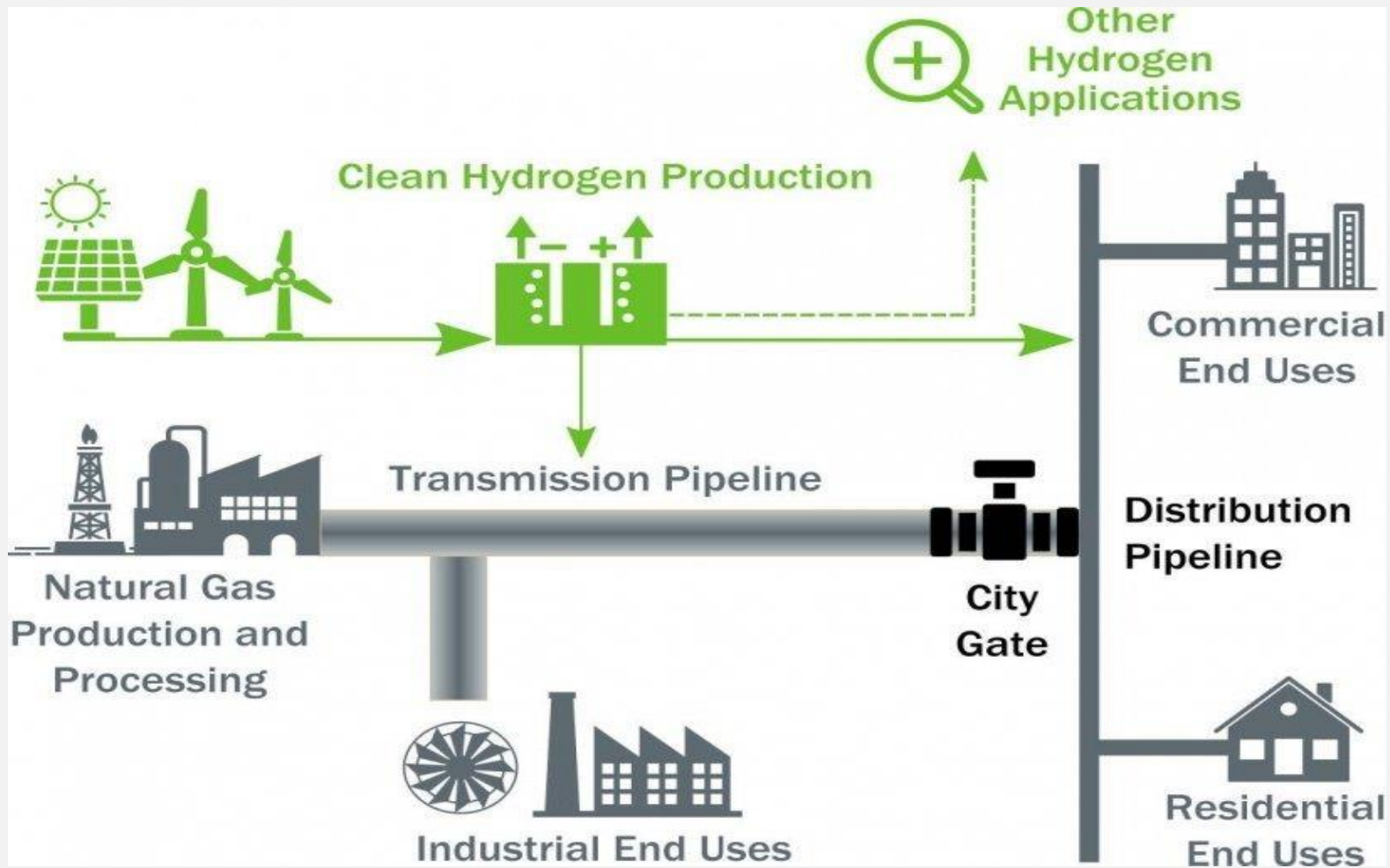
- IPA: Sited in Delta, Utah
- IPA: Repower existing coal plant
- IPA: 30% H₂ then 100% by 2040
- ACES: Hydrogen production with alkaline electrolyzers
- ACES: Hydrogen storage proposed in nearby salt caverns
- Will improve with IRA Tax credits and awarding DOE H2HUB \$\$

Turbine Technology is Coming Along

- Mitsubishi Power Delivers Hydrogen-Ready Gas Turbines to Utah Project (7/27/23)
- 30% Hydrogen Upon 2025 Startup
- 100% by 2045 (5-year delay)



Hydrogen Blending Update



Per U.S. Dept. of Energy

In the US:

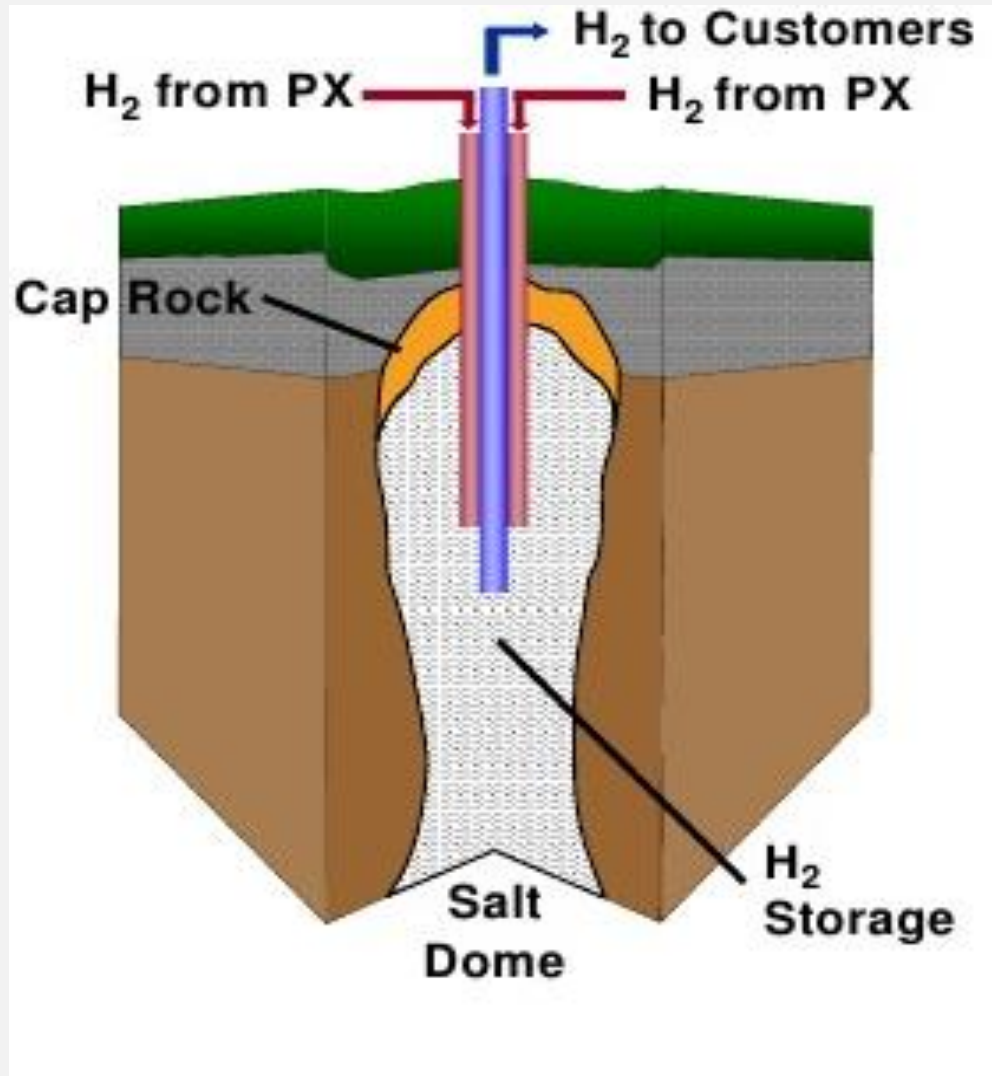
- 3 million miles of natural gas pipelines
- 1600+ miles of hydrogen pipelines.

US DOE HyBlend Initiative

- www.energy.gov/sites/default/files/2021_08/hyblend_tech_summary.pdf
- **Two year study –Began in 2021**
- **Test pipeline materials with varied H2 concentrations**
- **Testing up to approx. 1,500 PSI (100 Bar)**
- **6 national labs / over 20 partners**
- **Project to last until 2023**
- **\$15 million R&D budget**



Hydrogen Storage Issues



ENERGY

Hydrogen has:

- » Low energy by volume
- » Higher compression energy

Making hydrogen difficult to store.

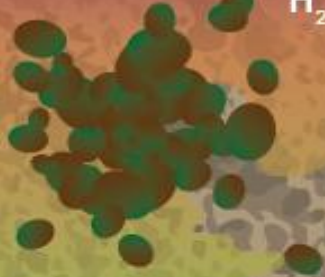
BIOCHEMICAL

Hydrogen has Unique Properties:

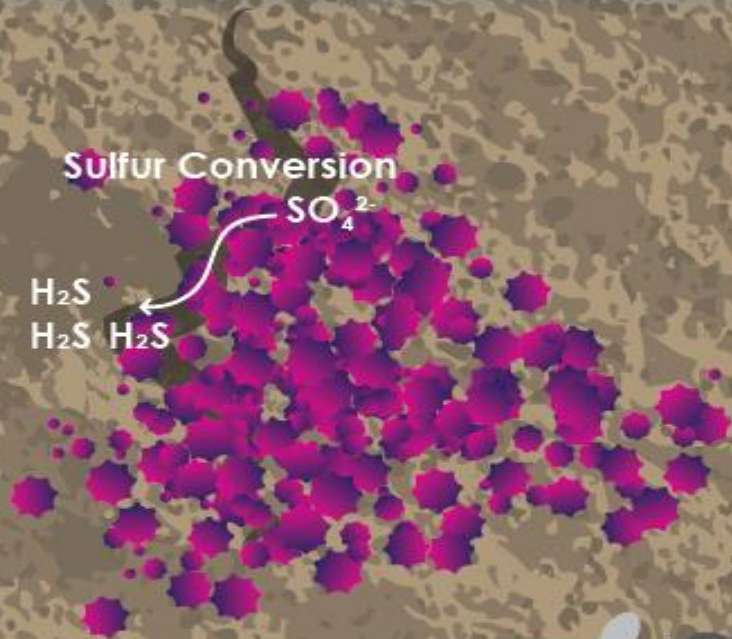
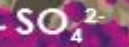
- Caprock sealing and contaminants
- Geochemical reactions
- Biological reactions
- Multi-phase flow and geo-mechanical

Caprock

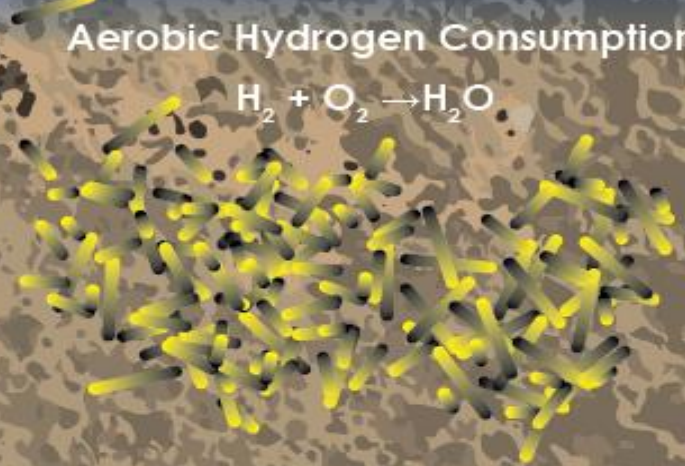
Methane Production



Sulfur Conversion



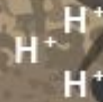
Aerobic Hydrogen Consumption



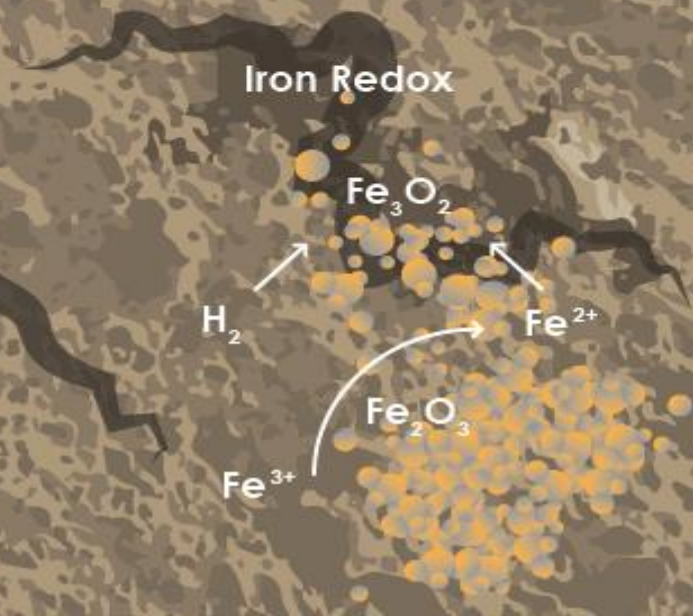
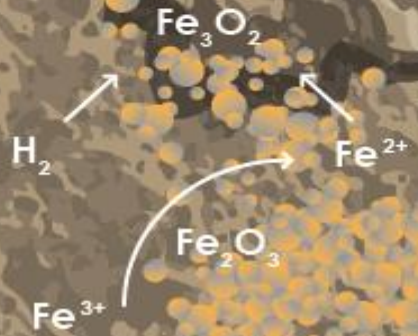
Biofilm Formation



Organic Acid Production

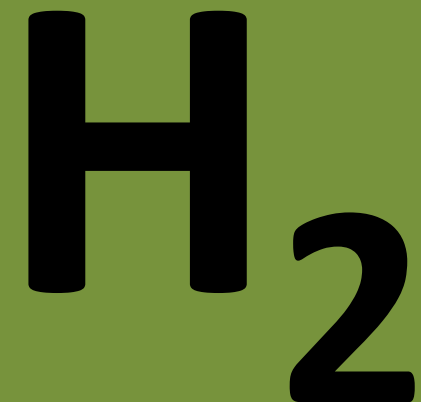
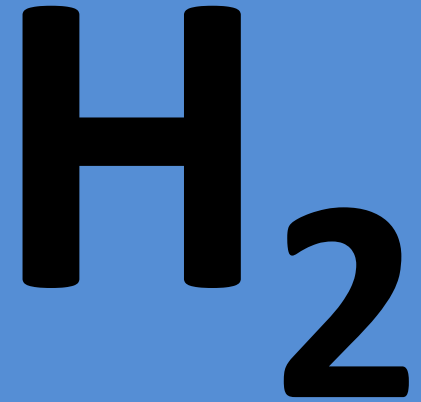


Iron Redox



Hydrogen Future as THE Clean Energy Fuel?

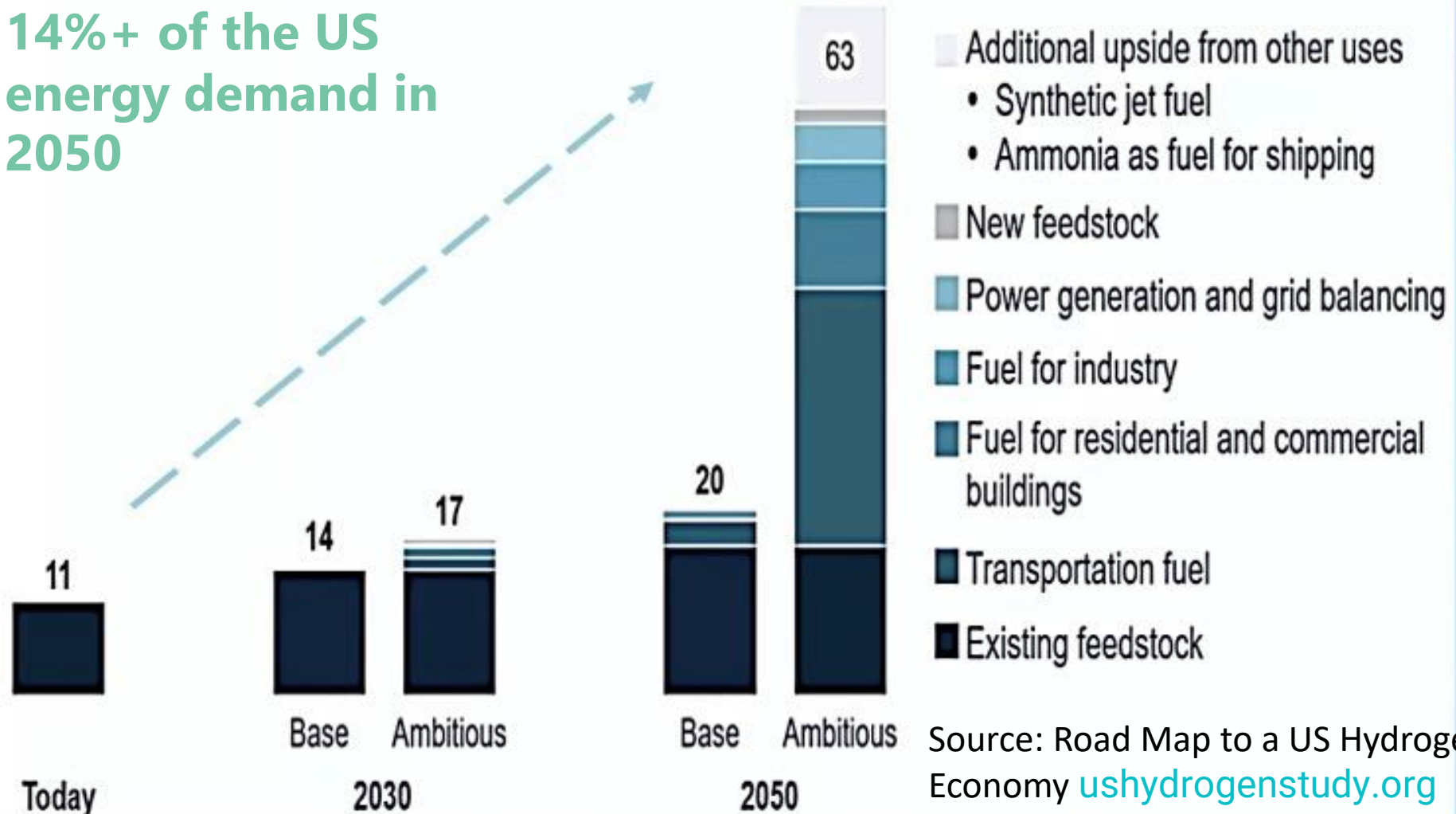
- Cost and tech of H2 will limit large growth
 - » Even w/tax credits, H2 still costly
 - » Technology hurdles
 - » End-User hurdles
- Blue H2 at first
 - » Existing gas infrastructure and large supply
- Hubs will develop
- Growth of H2 will be slow
 - » Initial small blending
 - » Increased blending if end-users can accept
 - » Dedicated Green H2 prod w/power production



Forecasted Hydrogen

Million metric tons per year

14%+ of the US energy demand in 2050



Source: Road Map to a US Hydrogen Economy [ushydrogenstudy.org](https://www.ushydrogenstudy.org)

“Difficulties mastered are opportunities won.”

–Winston Churchill
March 21, 1943



Photo credit: Moritz Mentges on Unsplash

Thank you



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