

REINHOLD ENVIRONMENTAL®



2023 Reinhold/PCUG Round Table Presentation

Cohosted by Duke Energy and Vistra in The Westin Hotel,
Cincinnati, OH on June 26-27, 2023

All presentations posted on this website are copyrighted by **REINHOLD ENVIRONMENTAL®** (RE). Any unauthorized attempts to print, to download, to modify, to incorporate into other presentations, to link to other websites or to obtain copies for any other uses than the training of attendees to RE Conferences is expressly prohibited unless approved in writing by RE or the original presenter. RE does not assume any liability for the accuracy or contents of any materials in this library which were presented and/or created by persons who were not employees or subcontractors of RE.

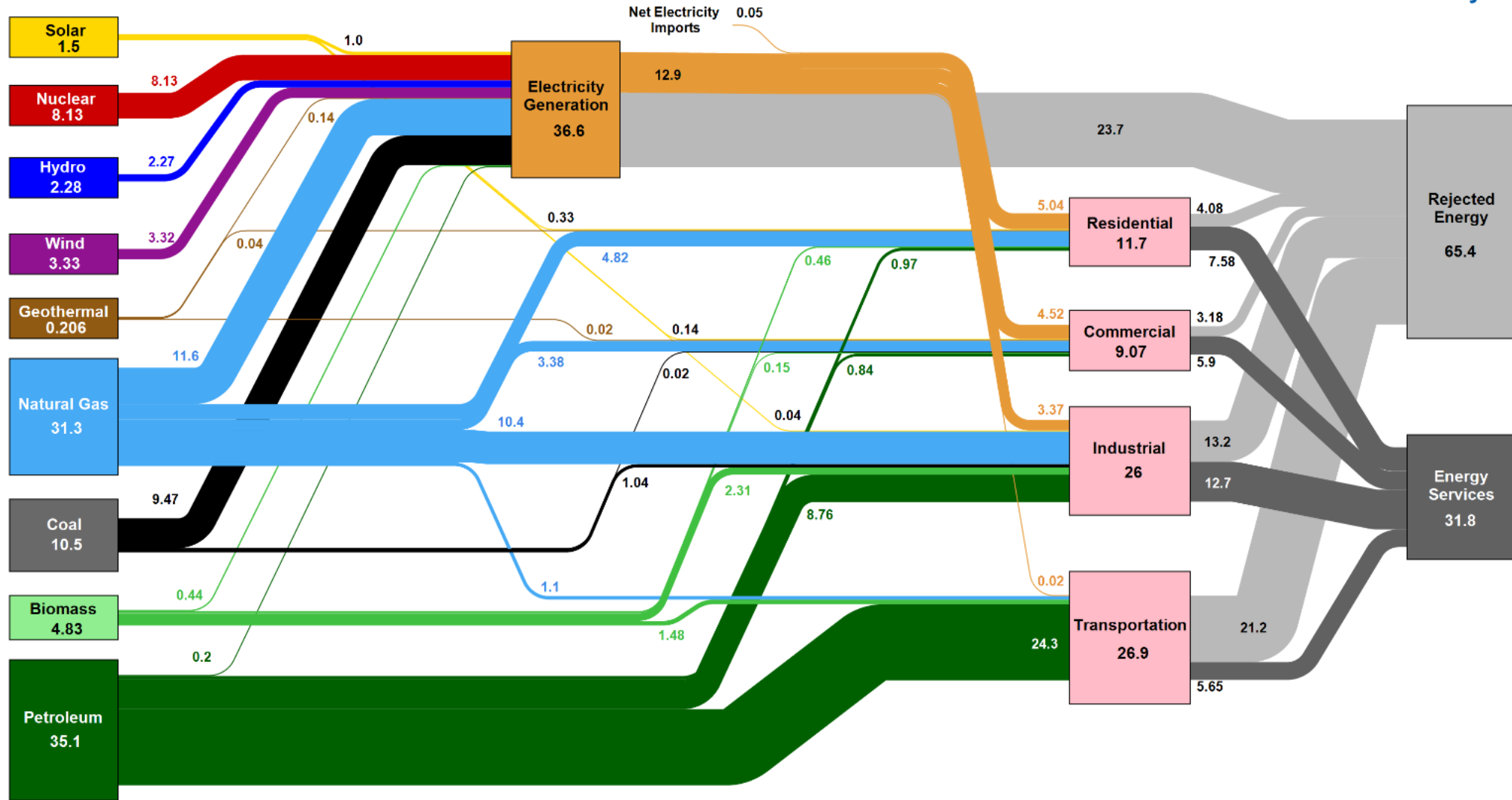
Hydrogen

Enabling Economic Development through clean energy infrastructure investment.

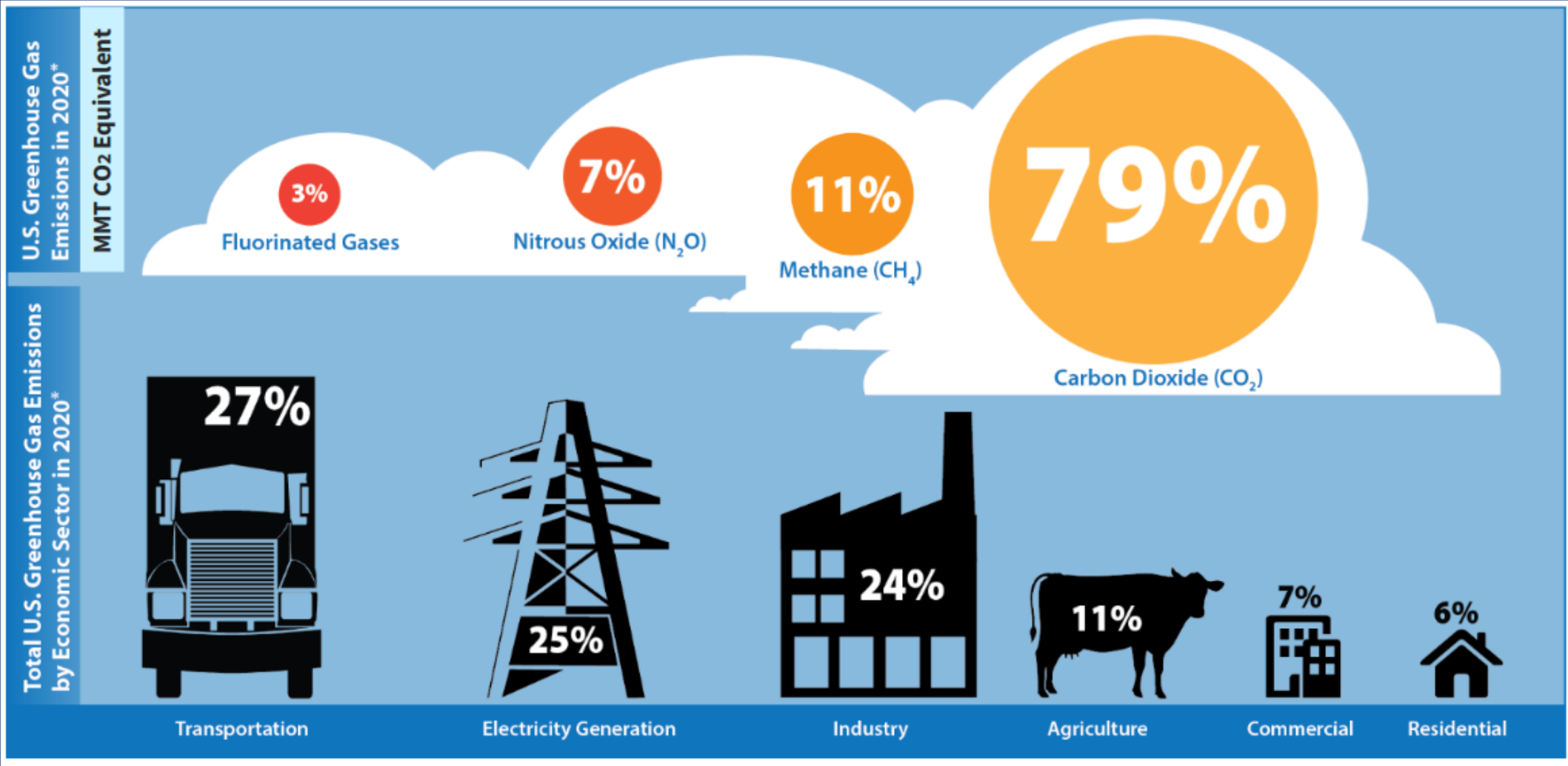
Emily Chatham
June 27th, 2023

Energy Consumption in the U.S.

Estimated U.S. Energy Consumption in 2021: 97.3 Quads



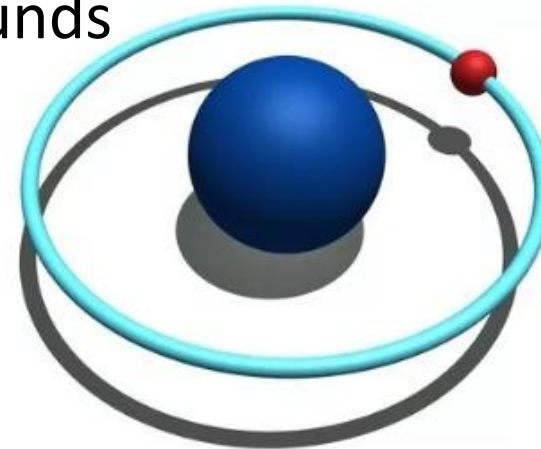
National Overall Greenhouse Gas Emissions by Economic Sector



U.S. Environmental Protection Agency (EPA). Greenhouse Gas Inventory Data Explorer, 2022. <https://cfpub.epa.gov/ghgdata/inventoryexplorer/>.

Hydrogen Basics

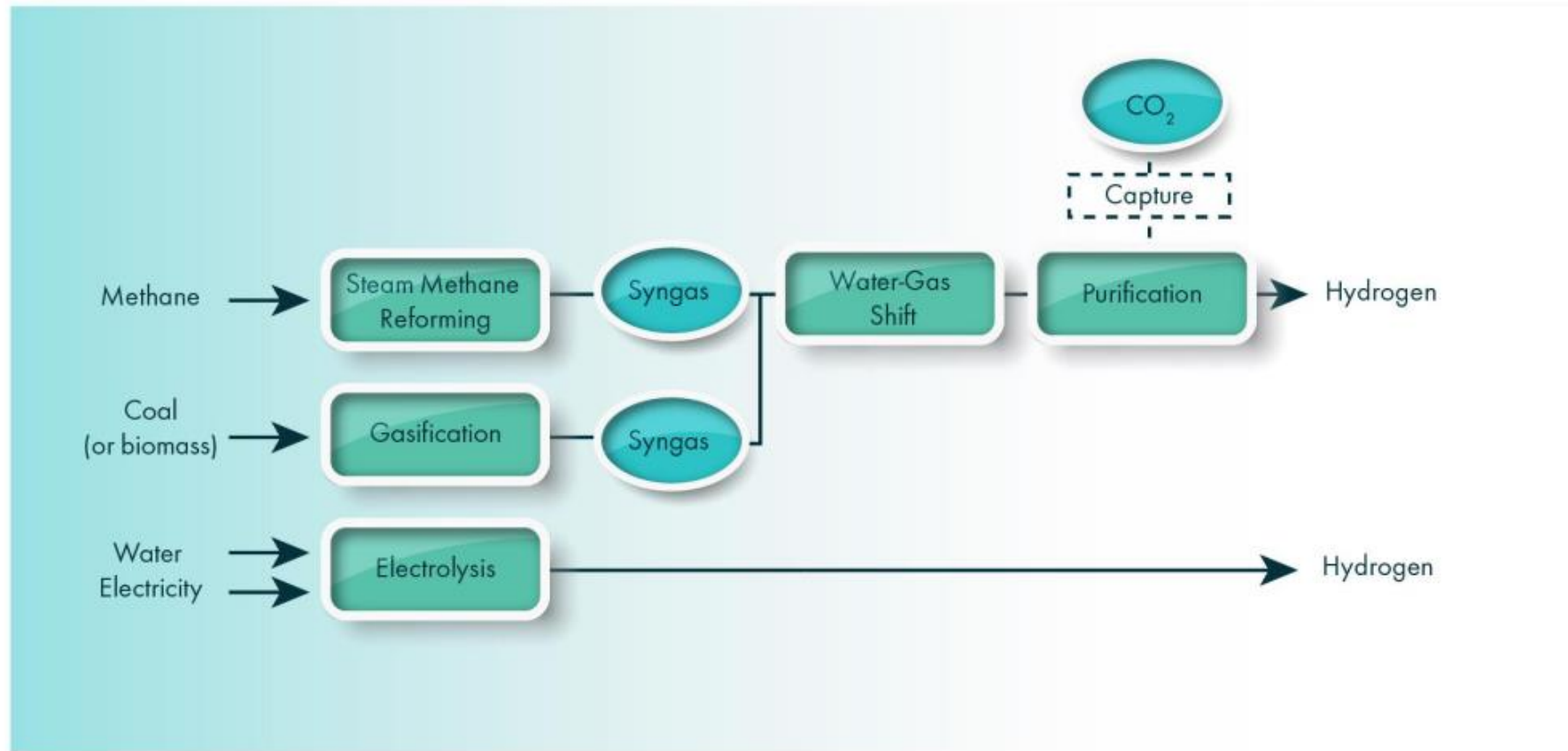
- Lightest element (H) on the periodic table
- It is the only element without neutrons
- It is colorless, odorless, tasteless, and nontoxic (sidenote: It is highly flammable but does not ignite unless an oxidizer and ignition source are present)
- Hydrogen has the lowest density of all atoms
- It can be liquified (LH2)
- Combines with other elements to form compounds
 - Hydrogen + Oxygen = Water
 - Carbon + Oxygen = Methane



The hydrogen atom has one proton and one electron. (Image credit: <http://www.shutterstock.com/gallery-670804p1.html>>bobyramone, <http://www.shutterstock.com/gallery-95882p1.html>>Andrei Marincas | <http://www.shutterstock.com/>>Shutterstock)

Hydrogen Production – Overview

Key Hydrogen Production Pathways



Source: LCRI Report [3002021864](#)

Colors of Hydrogen

GREEN

Hydrogen produced by electrolysis of water, using electricity from renewable sources like hydropower, wind, and solar. Zero carbon emissions are produced.

TURQUOISE

Hydrogen produced by the thermal splitting of methane (methane pyrolysis). Instead of CO_2 , solid carbon is produced.

YELLOW

Hydrogen produced by electrolysis using grid electricity.

BLUE

Grey or brown hydrogen with its CO_2 sequestered or repurposed.

PINK/PURPLE/RED

Hydrogen produced by electrolysis using nuclear power.

BLACK/GRAY

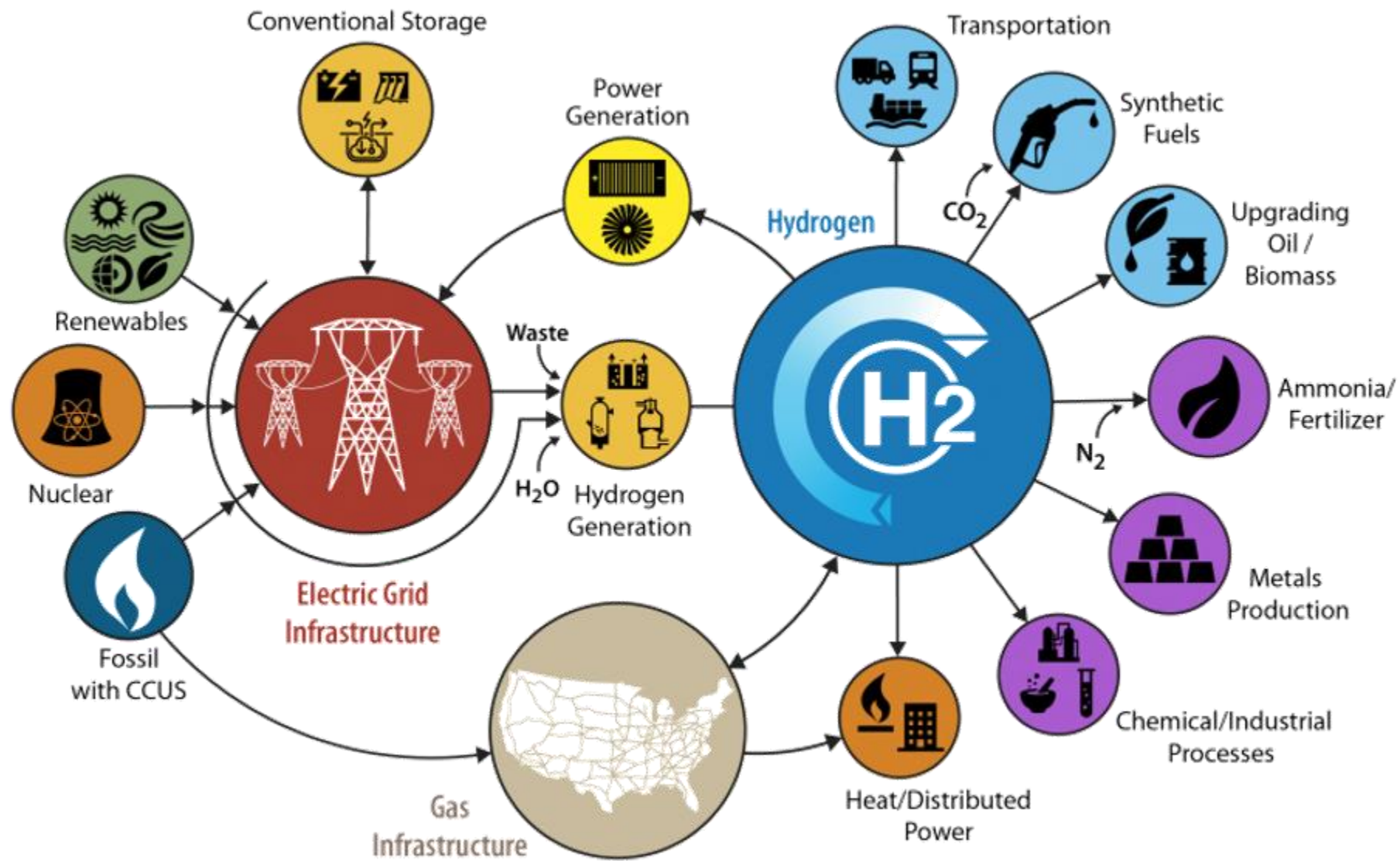
Hydrogen extracted from natural gas using steam-methane reforming.

WHITE

Hydrogen produced as a byproduct of industrial processes.

BROWN

Hydrogen extracted from fossil fuels, usually coal, using gasification.



Hydrogen Market

- **Hydrogen activity continues to accelerate**
 - Electrolyzers can create a significant load opportunity
 - Renewable developer consider electrolyzers a new offtake opportunity
 - Considered a key component to decarbonizing industrial processes
 - Creates opportunity to decarbonize CC/CT fleet via blending

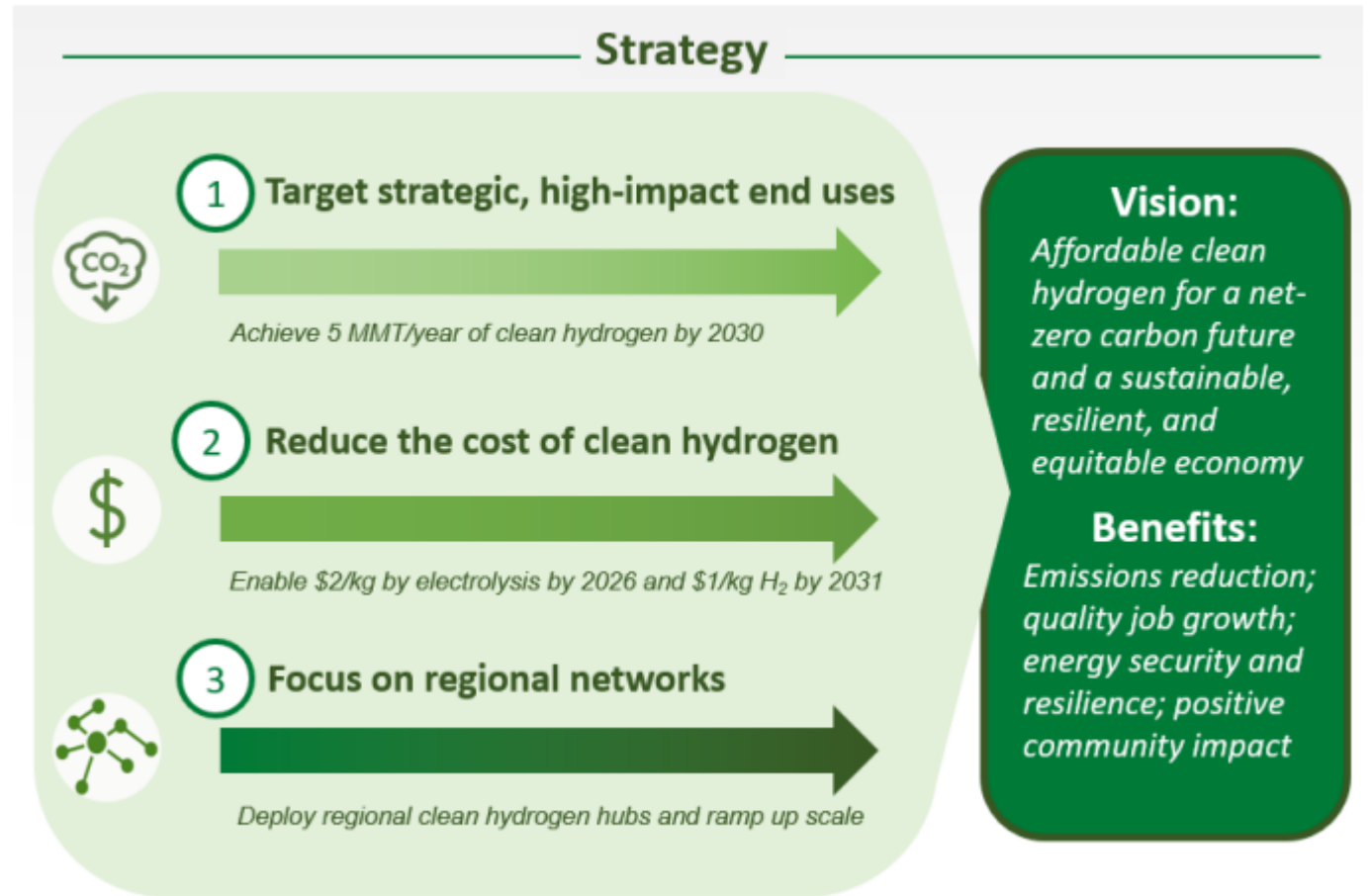


U.S. National Clean Hydrogen Strategy & Roadmap

- The DOE continually assessing the opportunities for hydrogen to contribute to national decarbonization goals across sectors over the next 30 years.
- November 2021: Infrastructure Investment and Jobs Act (Bipartisan Infrastructure Law) authorizes and appropriates DOE spend of \$62B, including \$9.5B for clean hydrogen.
- August 2022: Inflation Reduction Act provides additional policies and incentives for hydrogen.
- Providing opportunities for up to 50 MMT by 2050.
- “All of government approach to clean hydrogen...this inclusive and collaborative approach is critical to the success of this expansive technology.”

Regional Clean Hydrogen Hubs

- \$8B in federal funding + \$8B in cost share for the development of networks of clean hydrogen producers, potential customers, and connective infrastructure.
- Enable large-scale clean hydrogen production close to high priority hydrogen users.
- Allow the sharing of critical mass infrastructure.
- Drive scale in production, distribution, and storage to facilitate market liftoff.
- Create place-based opportunities for equity, inclusion, and sustainability.
 - Reducing environmental impacts, creating jobs, securing long-term offtake contracts, jumpstarting domestic manufacturing and private sector investment.



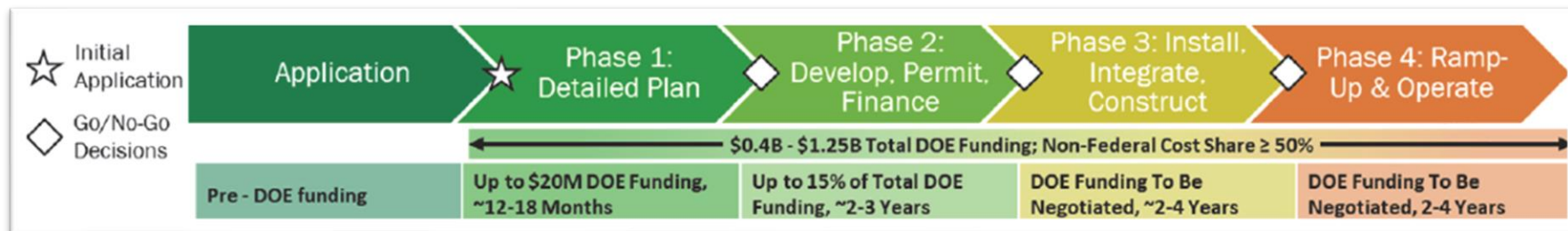
DOE H2Hubs Program Overview

Hub Requirements:

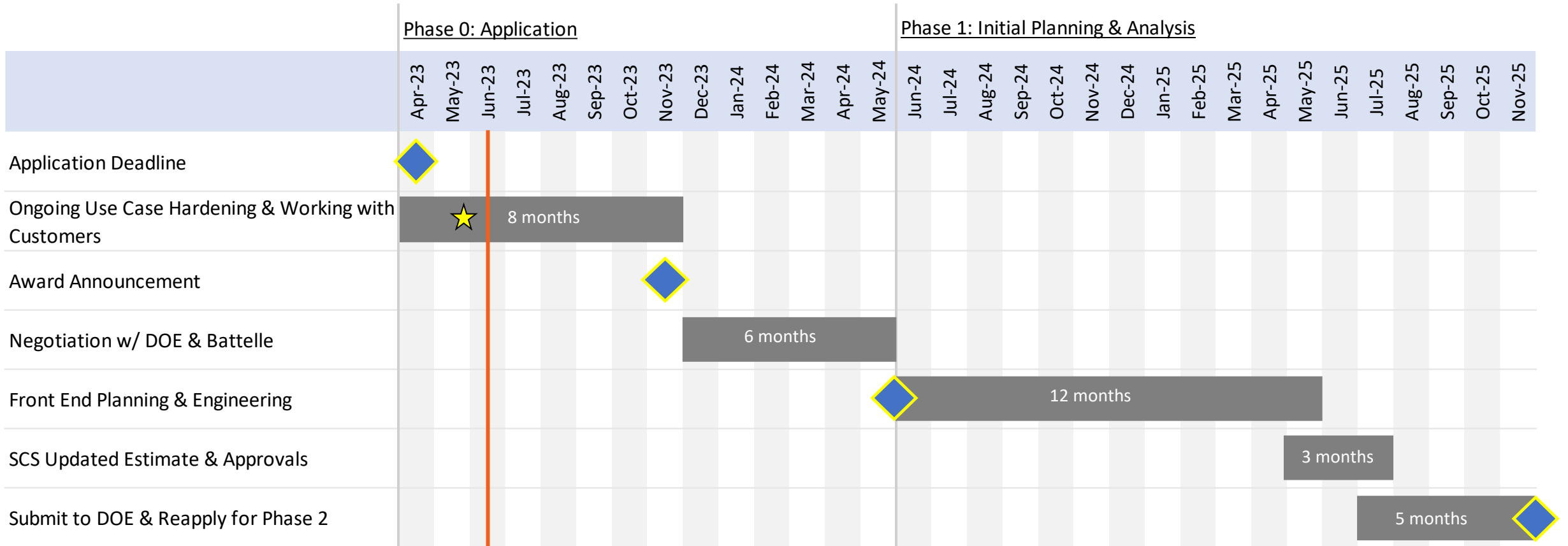
- Produce 50-100 metric tons H2/day
 - Match production and demand
 - Focused on commercial-scale infrastructure deployment
- Minimum 50% non-Federal cost-share
 - Up to \$1.25B available
- Target of 6-10 hubs with geographic and feedstock diversity
(at least one is expected to be produced from nuclear-sourced energy)
- Total project length: 8-12 years

Timeline:

- DOE Funding Opportunity Announcement on Sep 22, 2022
- ~~Concept Paper due Nov 7, 2022~~
 - ~~20 pages~~
- ~~Encourage full application notifications Dec 2022~~
- ~~Full Application due April 7, 2023~~
- ~~Submit response to comments June 2023~~
- Pre-selection Interview – Summer 2023
- Award Notifications – Fall 2023
- Award Negotiations – Winter 2023/24
- Phase 1 Begins – Q1 2024



Timeline Through Phase 1

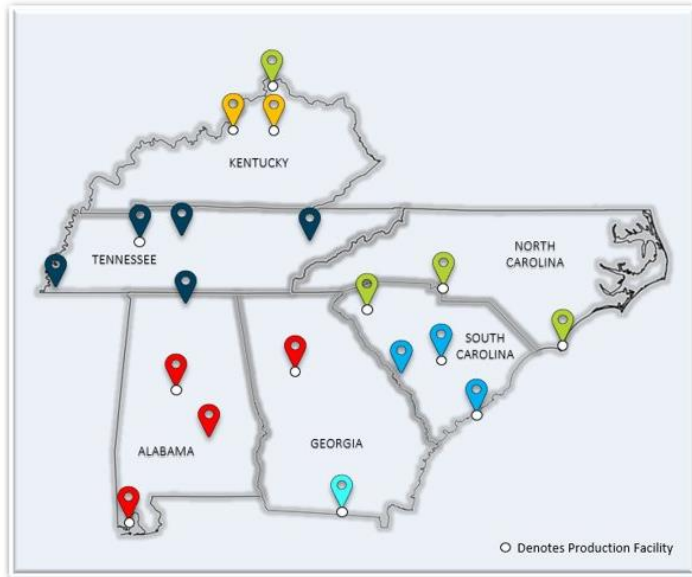


★ Received and responded to DOE reviewer comments. We view DOE’s comments as positive as they highlighted several strengths each proposal brings to the table, while providing an opportunity to address any perceived weaknesses.

Southern Company's Hydrogen Hub Opportunities

SE Hydrogen Hub

Hydrogen from electrical infrastructure



- Transportation applications are backbone and connective infrastructure
- Production focus
 - Nuclear and solar potential to enable clean electrolysis
- Offtake focus
 - Ports (in-land and coastal)
 - Transportation (marine, rail, and on-road)
 - Industrial/Chemical Processing (plastics, ammonia production, steel manufacturing)

MachH2

Hydrogen from nuclear, renewables and natural gas w/ CCS



- Multistate coalition of public and private entities
- Production Focus: Nuclear, renewables and natural gas with CCS
- End-use focus: heavy-duty transportation, SAF, agriculture, refining and steel manufacturing
- Nicor is engaged in opportunities for hydrogen delivery via dedicated pipeline and associated infrastructure directly to end-users

Hydrogen adds options for flexibility, turndown and repowering

World's Largest Fuel Blending of H₂ and Natural Gas – June 2022

- Hydrogen safely received, handled and combusted
- Hydrogen blended up to 21.9% by volume into one gas turbine (3,000 lbs/hr)
 - ✓ NOx emissions maintained below permitted limits
 - ✓ CO₂ reduced by up to 7%
 - ✓ CO emissions reduced allowing increased turndown
 - ✓ Slight efficiency gain observed

Opportunities Ahead

- Gas air-cooled (GAC) conversion
- Potential future blending tests of 30% to 50%
 - Pyrolysis development with Mitsubishi
- Site-specific studies or repowering options



	Today	Post GAC Conversion	With GAC and 30% H ₂ Blend
Startup Time	180 Minutes	150 Minutes	60 Minutes
Ramp Rate	17 MWs/Minute	18 MWs/Minute	42 MWs/Minute
Turndown	60% Full Load	50% Full Load	35% Full Load

Hydrogen Industry Highlights...(Constellation)

S&P Capital IQ PRO

Constellation claims record 38% hydrogen blend in Siemens Energy turbine

Wednesday, May 24, 2023 12:42 PM CT

By Bill Holland
Market Intelligence

Constellation Energy Corp. ran a Siemens Energy AG turbine at an Alabama power plant on a blend of hydrogen and natural gas that contained 38% hydrogen, "nearly doubling the previous blending record for similar generators," the company said in a May 24 news release.

"This test proved what we've suspected for years — that blending clean hydrogen with natural gas can safely reduce emissions without major modifications to an existing plant that's well over a decade old," Constellation President and CEO Joe Dominguez said in the statement.

Siemens said the blending demonstration showed that its goal of building turbines that can burn 100% hydrogen by 2030 is within reach.

The Biden administration planned to set emission limits that would eventually require new and existing fossil fuel-fired power plants to adopt technologies such as carbon capture or green hydrogen. Under the proposed standards, released May 11 by the US Environmental Protection Agency, almost all coal-fired power plants without carbon capture



Ongoing Hydrogen Opportunities

- “Studies”

- SuperTruck 3 – DOE Electric Truck Project - Hydrogen microgrid to be sited at a plant with emphasis on resilient power and fleet Class 4-6 trucks
- FEED Study – EPRI study to evaluate siting and needs for hydrogen production on site
- Pre-FEED study- evaluating compact hydrogen generator from GTI for distributed, gas based production



Southern
Company

IRA Incentives for Clean Energy Deployment

Inflation Reduction Act (IRA) Key Incentives

Provisions shown next to applicable section



Electricity

- 13101: Production tax credit (PTC) extension
- 13102: Investment tax credit (ITC) extension
- 13103/13702: Solar in low-income communities
- 13104: Extension of credits for captured CO₂ (45Q)
- 13015: Production tax credit for existing nuclear
- 13701/13702: New clean electricity PTC (45Y) and clean electricity ITC (48E)

Industry and Fuels

- 13104: Extension of credits for captured CO₂ (45Q)
- 13204: Production credits for clean hydrogen (45V)
- 13201/13202: Extension of incentives for biofuels
- 13203: Sustainable aviation fuel credit

Buildings

- 13302: Residential clean energy credit
- 13303: Energy efficient commercial building deduction
- 13304: Energy efficient home credit
- 50121: Home energy efficiency credit
- 50122: High efficiency home rebate program

Transportation

- 13401: Clean vehicle credit
- 13403: Commercial clean vehicle credit
- 13404: Alternative refueling property credit

Ongoing model development to build most aspects of these incentives into US-REGEN