

Hydrogen Production, Industrial Uses and Energy Conservation

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LBI Foundation

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PSEG

🌔 PSEG

An award-winning energy company comprised of an electric and gas utility and a nuclear generation business

PSE&G

- New Jersey's largest electric and gas utility: 2.3 Million Electric and 1.9 Million Gas Customers
 Won the 2022 Edison Award winner, the electric utility industry's most prestigious award
- •Ranked first in Customer Satisfaction with both residential electric and natural gas service in the East among large utilities by J.D. Power*
- •Received the 2022 ReliabilityOne® Award for the Mid-Atlantic Metropolitan Area, 21st consecutive year PSE&G has received the reward

•Built more transmission facilities in PJM and NJ than any other operating utility over the past ten years

•Making transmission upgrades to support offshore wind

PSEG Power & Other

Operates Salem 1 & 2 and Hope Creek, USA's 3rd largest site
Generates about 40% of NJ's electricity and 85% of its carbon-free power
PSEG Long Island contracts
Potential Hydrogen and RNG investments
Potential offshore wind transmission investments

Powering a future where people use less energy, and it's cleaner, safer and delivered more reliably than ever

* PSE&G Company received the highest score in the East Large segment of the J.D. Power 2022 U.S. Electric Utility Residential Customer Satisfaction Study of customers' satisfaction with electric utility residential services and the J.D. Power 2022 U.S. Gas Utility Residential Customer Satisfaction Study of customers' satisfaction nationally among gas residential customers. Visit jdpower.com/awards for more details.

Hydrogen Headlines



Nikola Snags \$42 Million From California

To Build Hydrogen Truck Stations – Forbes

Snubbed as a regional 'hydrogen hub,' Nebraskans remain charged up about clean energy growth Even without federal hub funding, two Nebraska expansion projects to move forward, companies say – Nebraska Examiner

Nuclear hydrogen is promising, says US energy Loan Programs Office director – hydrogenfuelnews.com October 4, 2023

Mercedes-Benz hydrogen truck prototype covers more than 650 miles on one fill – Automotive News October 02, 2023

California Lawmakers Reach \$106 Million

Hydrogen Fuel Deal - hydrogenfuelnews.com

Hydrogen is:

✓ the simplest,
 most abundant
 element in the
 universe





 \checkmark colorless,

odorless,

tasteless, and

flammable



 \checkmark created with a

"primary"

energy

source



 \checkmark a fuel that

produces only

water, heat, and

electricity







Hydrogen Production

- Approximately 10 million metric tons (MMT) of hydrogen is produced in the US each year.
- Major producers include Air Products, Linde, Air Liquide
- Hydrogen production methods include
 - Steam Methane Reformation (SMR)
 - Coal gasification
 - Waste gasification
 - Electrolysis
- 95% of the H2 produced is the US is produced with Steam Methane Reforming
- Production is done at large central plants, as well as smaller plants at, or near, the end user.



Current and Future Uses of Hydrogen



High School Chemistry Pop Quiz!

H_2O + Energy $\rightarrow 2H_2 + O_2$	Hydrogen is produced by electrolysis, the oxygen can be captured for use or released into the air
$H_2 + O_2 \rightarrow Energy + H_2O$	When hydrogen is burned, it releases energy (heat) and produces only water as a byproduct
$CH_4 + H_2O (+ heat) \rightarrow CO + 3H_2$ $CO + H_2O \rightarrow CO_2 + H_2$	Steam methane reforming (SMR) produces CO and H ₂ in primary reaction but then carbon dioxide as a byproduct in the water-gas shift reaction
$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + Energy$	Combustion of methane (natural gas) produces energy (heat) and water but also carbon dioxide when burned

The Colors of Hydrogen



What is Electrolysis?

- Electrolysis is the process of using electricity to split water into hydrogen and oxygen. This reaction takes place in a unit called an electrolyzer.
- Electrolyzers consist of an anode and a cathode separated by an electrolyte. Different electrolyzers function in different ways, mainly due to the different type of electrolyte material involved.
- Main types of electrolyzers:
- > Alkaline (ALK): Uses a liquid alkaline solution as the electrolyte.
- > PEM: Uses a polymer electrolyte membrane as the electrolyte
- Solid Oxide (SOE): Uses a solid ceramic material as the electrolyte, and requires higher temperature to operate, therefore requires steam input.



Hydrogen Benefits – Clean Energy Transitions

- Clean hydrogen produced with renewable or nuclear energy, or fossil fuels using carbon capture, can help to decarbonize a range of sectors, including long-haul transport, chemicals, and iron and steel, where it has proven difficult to reduce emissions.
- Hydrogen-powered vehicles would improve air quality and promote energy security.
- Hydrogen can also support the integration of variable renewables in the electricity system, being one of the few options for storing energy over days, weeks or months.
- Added flexibility to the grid, complementing alternatives such as batteries and demand response.

Hydrogen Safety

Hydrogen Facts

- Hydrogen is no more dangerous than other flammable fuels, including gasoline and natural gas.
- Hydrogen has a rapid diffusivity (3.8 times faster than natural gas), which means that when released, it dilutes quickly into a non-flammable concentration.
- By volume, hydrogen has 1/3 of the combustion energy of natural gas.
- Hydrogen combustion has relatively low radiant heat, because hydrogen combustion produces cooling water vapor.
- Hydrogen has a higher oxygen requirement for ignition than other fossil fuels.

Federal Laws and Incentives

- Congress appropriated \$8 billion in the Bipartisan Infrastructure Law to create at least 4 hubs between 2022-2026.
- The Inflation Reduction Act established further incentives for clean hydrogen production with higher incentives for lower emission technologies. (up to \$3/Kg)
- DOE's Hydrogen Shot Goal reducing the cost of clean hydrogen to \$1 per kilogram within a decade
 - The Hydrogen Shot establishes a framework and foundation for clean hydrogen deployment in the American Jobs Plan



What is a Hydrogen Hub (H2Hub)?

- Networks of clean hydrogen producers, consumers, and connective infrastructure
- H2Hubs must also provide tangible benefits to host communities and workers (reduction in air pollution; equitable access to enterprise; quality permanent jobs)
- Must produce hydrogen that mees the Clean Hydrogen Production Standard



DOE Hydrogen Hub Process

On October 13th, 2023, President Biden Announced the seven DOE selected Regional Hydrogen Hubs

- Appalachian Hydrogen Hub (Appalachian Regional Clean Hydrogen Hub (ARCH2); WV, OH, PA) Funding up to \$925M
- California Hydrogen Hub (Alliance for Renewable Clean Hydrogen Energy Systems (ARCHES); California) Funding up to \$1.2B
- Gulf Coast Hydrogen Hub (HyVelocity H2Hub; Texas) will be centered in the Houston region Funding up to \$1.2B
- Heartland Hydrogen Hub (Minnesota, North Dakota, South Dakota) The Heartland Hydrogen Hub-Funding up to \$925M
- Mid-Atlantic Hydrogen Hub (Mid-Atlantic Clean Hydrogen Hub (MACH2); Pennsylvania, Delaware, New Jersey)-Funding up to \$750M
- Midwest Hydrogen Hub (Midwest Alliance for Clean Hydrogen (MachH2); Illinois, Indiana, Michigan) -Funding up to \$1B
- Pacific Northwest Hydrogen Hub (PNW H2; Washington, Oregon, Montana) Funding up to \$1B

Department of Energy Timeline

- Hub Full Application Submission Deadline: April 7th 2023
- Submission Deadline for Replies to Reviewer Comments May 31st 2023
- Pre Selection Interviews: Summer 2023
- DOE Selection Notifications: Fall 2023
- Expected Timeframe for Award Negotiations: Winter 2023-2024

SELECTED REGIONAL CLEAN HYDROGEN HUBS



Mid-Atlantic Hydrogen (MACH 2) Hub

Southern NJ, State of DE, Southeast PA

Potential PSEG Projects

- Power Purchase Agreement with PSEG Nuclear Power assets and Hydrogen Producers
- Hydrogen Production For refineries or other open markets
- Vehicle fueling stations trucks at ports, large city vehicles, airport ground equipment

Hydrogen can help with NJ's Decarbonization goals

NJ's Global Warming Reduction Act (law) requires the following emissions reductions by sector (based on the latest 2020 emissions inventory, published in 2022):

Sector	Current 2020Inventory (MMTCO ₂)	Target 2050 Emissions (MMTCO₂)	Reduction (%)
Transportation:	34.1	5.4	84 %
Buildings	23.1	2.7	88 %
Electricity	18.8	0	100%
Industrial	7.2	6.7	7%
Landfills	5.7	4.9	14%



PSEG Mach2 Project – South Jersey Hydrogen Production Plan

- PSEG is proposing to construct a hydrogen production facility with an initial daily production capacity of 25 metric tons
- Evaluating electrolyzer technologies including proton exchange membrane (PEM), uni-polar alkaline, and solid oxide
- Electricity used for the electrolyzer would be from nuclear power (Pink Hydrogen)





Thank you

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Department of Energy (DOE)-Willingness to Pay

Strategy 1: Target High-Impact Uses of Hydrogen

Clean Hydrogen Demand and Costs for Market Penetration



U.S. DEPARTMENT OF ENERGY