



State of the Market for CHP, Microgrids, and Hydrogen in the Northeast



CHP Alliance Northeast Chapter
September 13, 2023

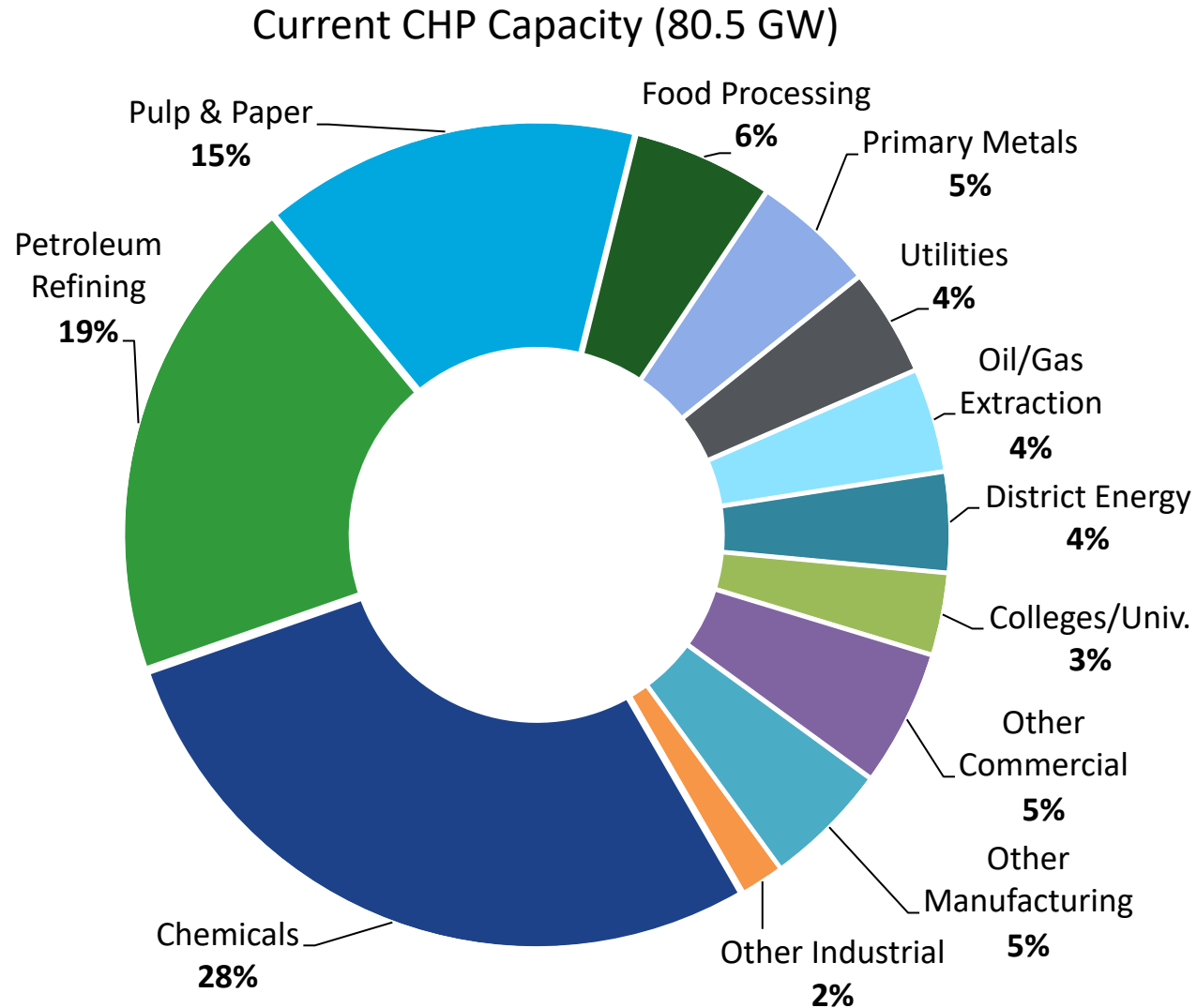
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ICF



- Overview: CHP and microgrids in the U.S.
- The need for hydrogen to meet GHG targets
- Hydrogen as a fuel for CHP
- Opportunities for hydrogen CHP development
 - Hydrogen Hubs
 - Inflation Reduction Act
- Pairing Hydrogen Hubs with CHP and microgrid installations

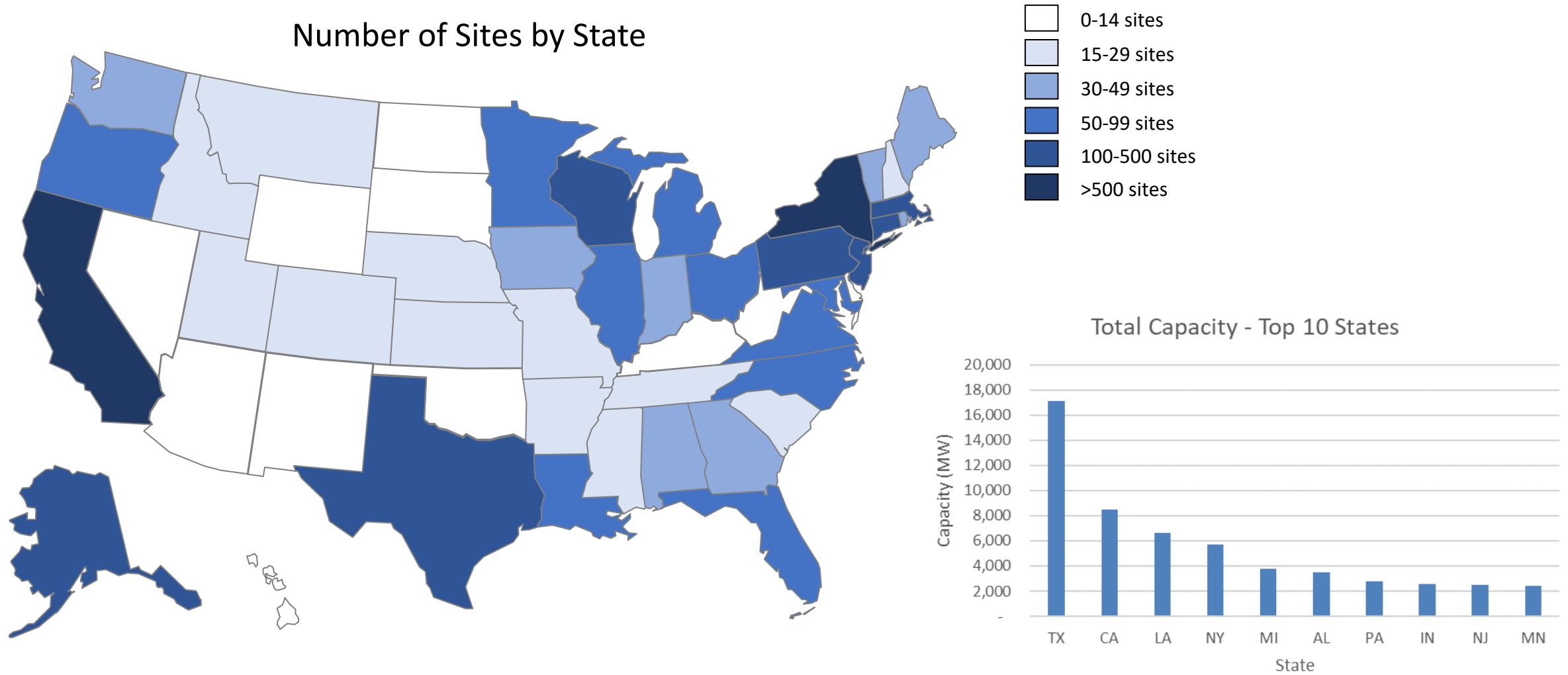
→ Agenda

CHP Installations Today in the United States



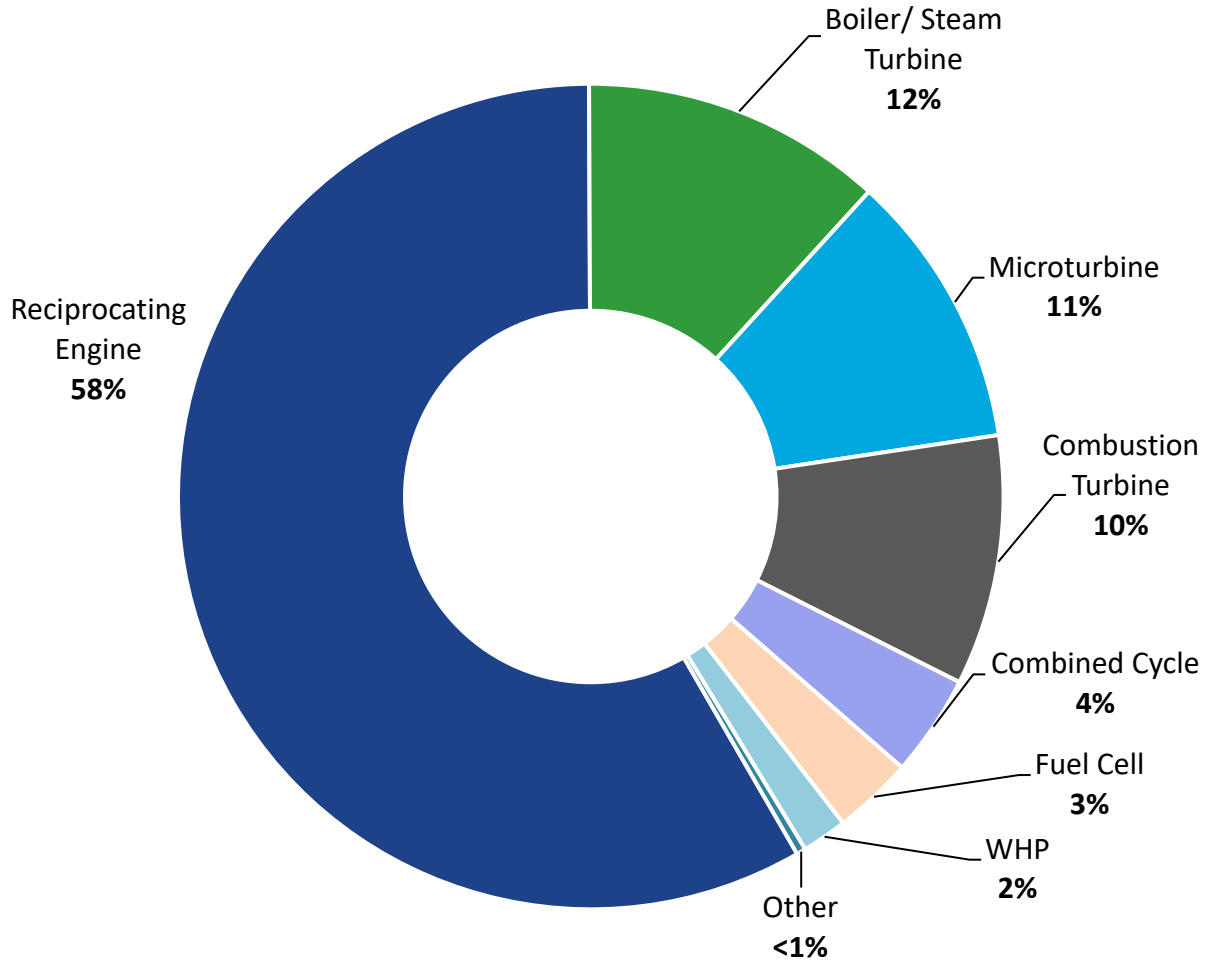
- **80.5 GW** of installed CHP at more than **4,720 sites**
- Estimated 6.5 percent of U.S. electric grid generating Capacity; 13 percent of annual grid generation
- Avoids more than **1.3 quadrillion Btus** of fuel consumption annually
- Avoids **over 192 million tons of CO₂** annually compared to separate heat and power production

Existing U.S. CHP Installations by Sites and Capacity

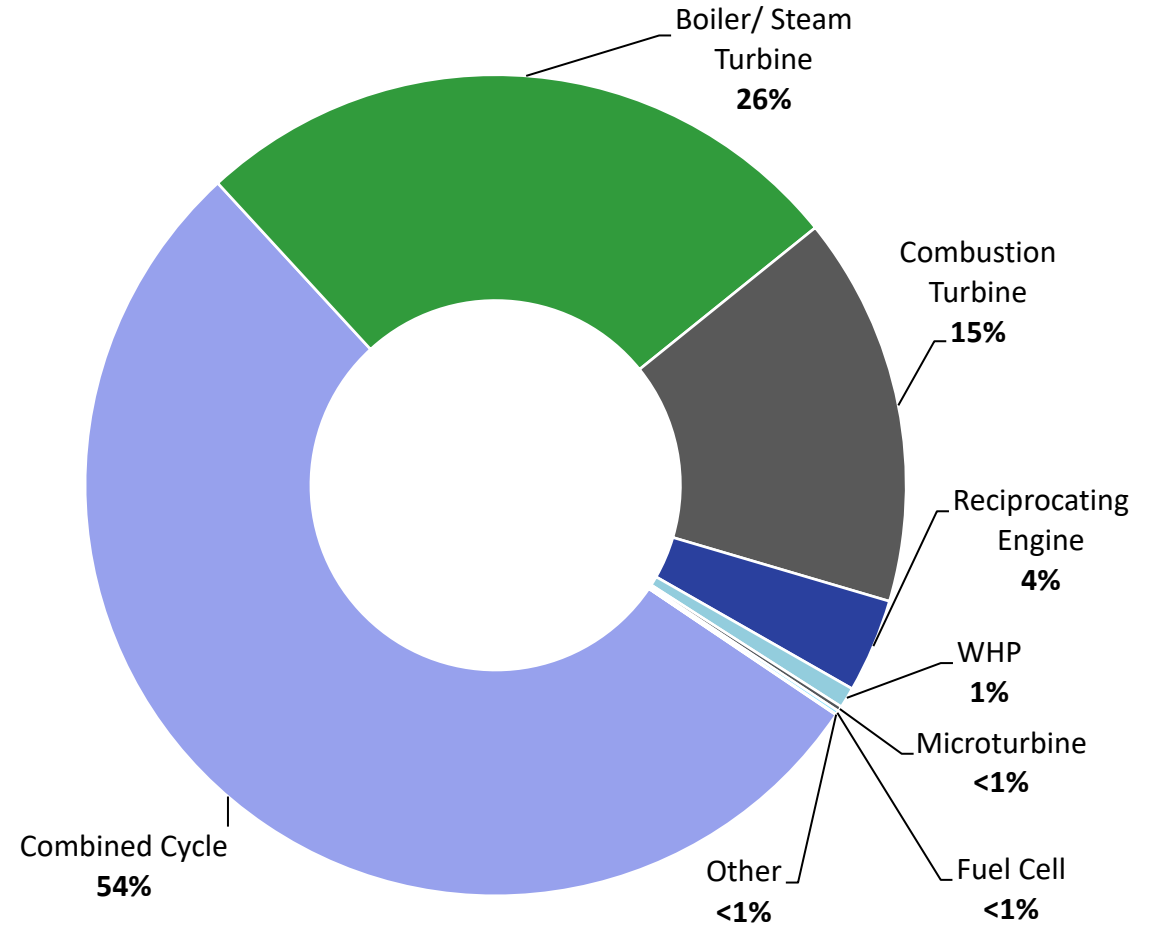


Existing CHP by Technology

By Site – 4,726 Sites

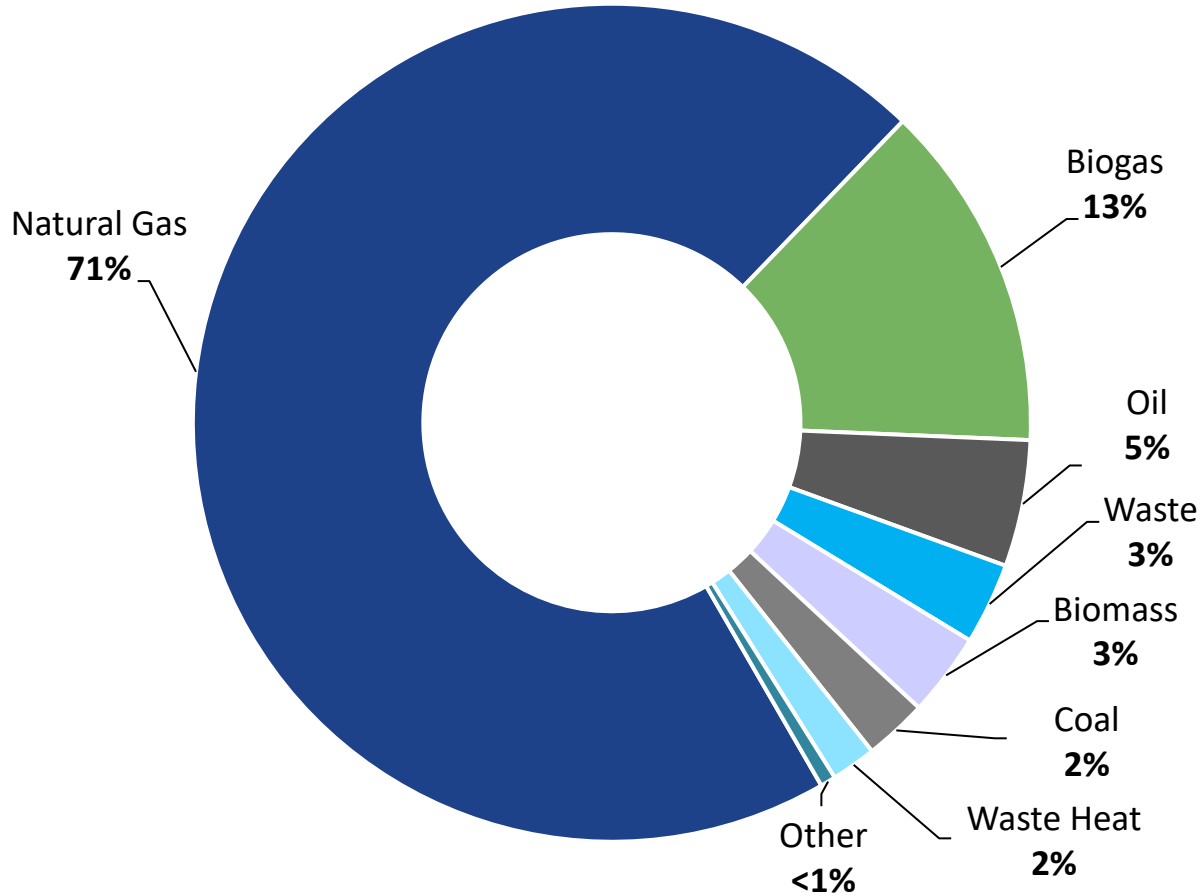


By Capacity – 80.5 GW

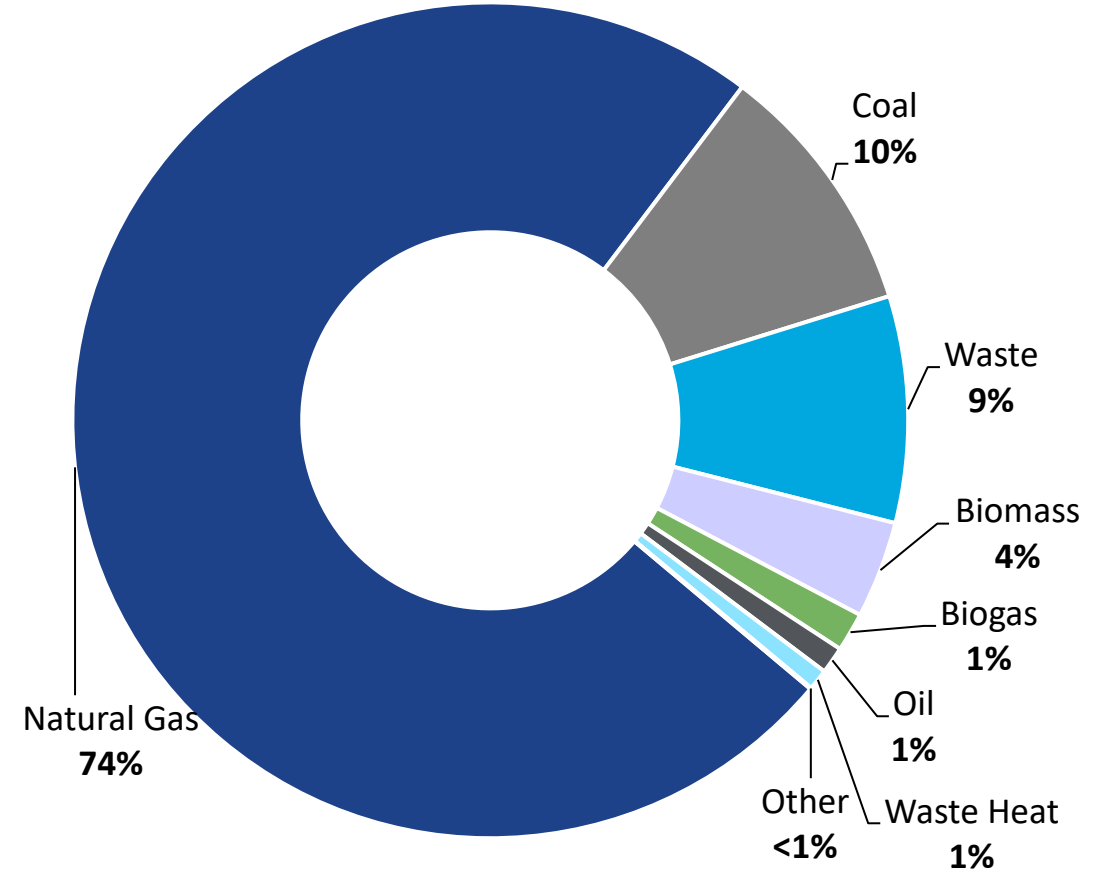


Existing CHP by Fuel Type

By Site – 4,726 Sites

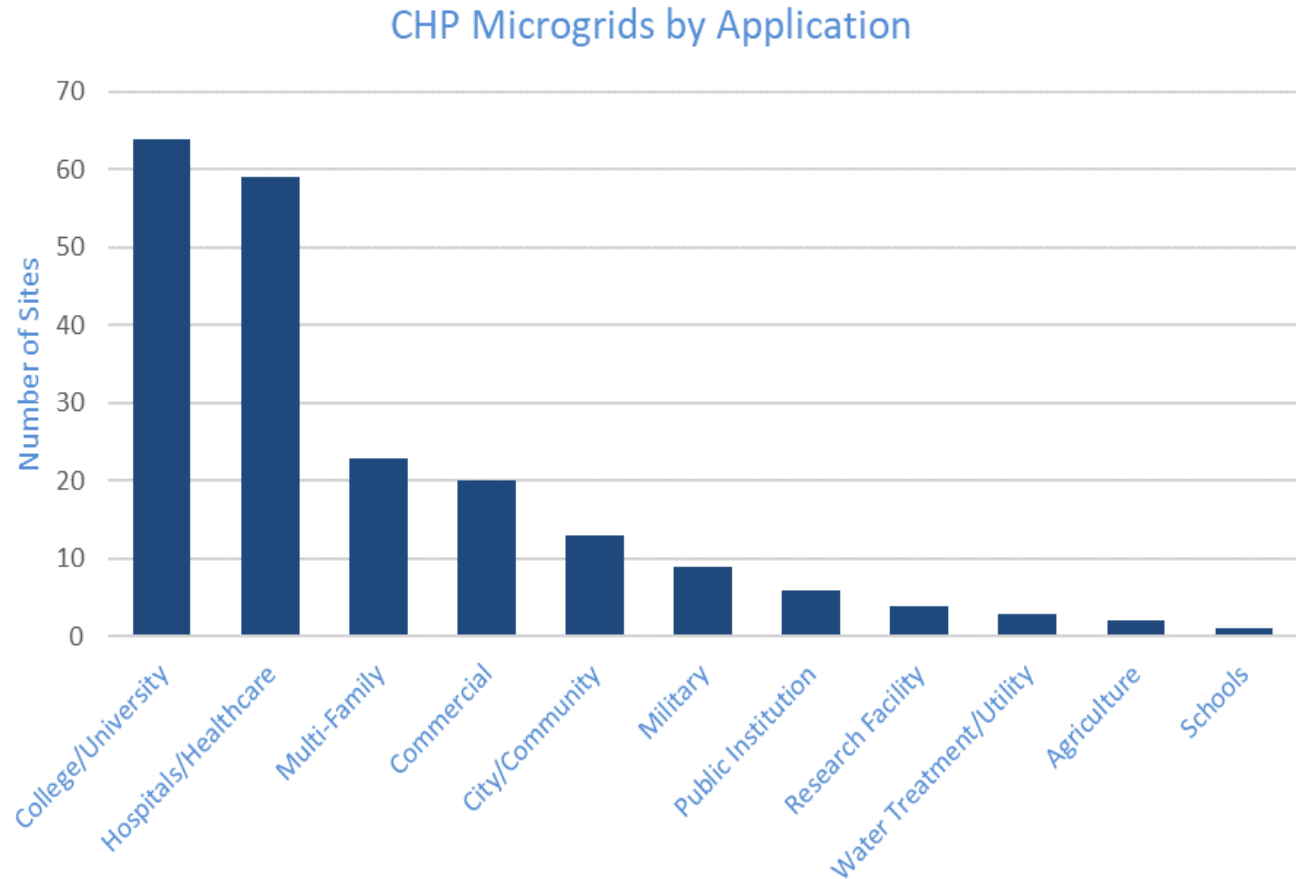


By Capacity – 80.5 GW



CHP Enables Resilient Microgrids

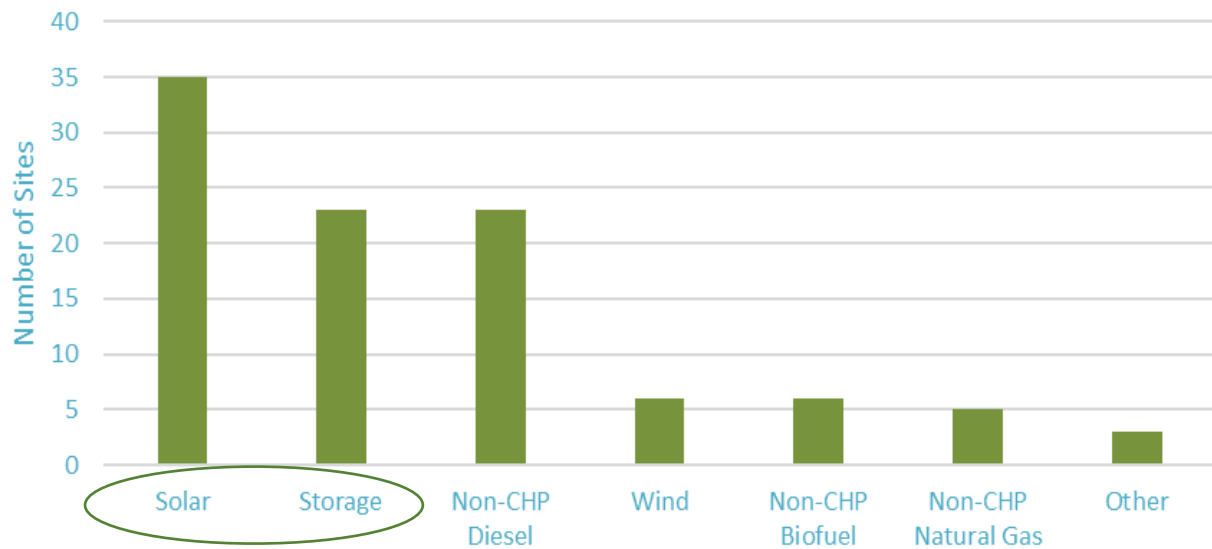
- DOE's [Microgrid Installation Database](#) tracks how CHP and other technologies are used in microgrids across the U.S.
- CHP provides reliable baseload heat and power, and can act as a resilient anchor for microgrids connecting multiple technologies and loads
- 204 microgrids (multi-technology or multi-building) currently use CHP
 - Total capacity: 2,824 MW
 - 2,398 MW (85%) from CHP
- CHP is most often used for microgrids at colleges/universities and hospitals (over 120 total sites)



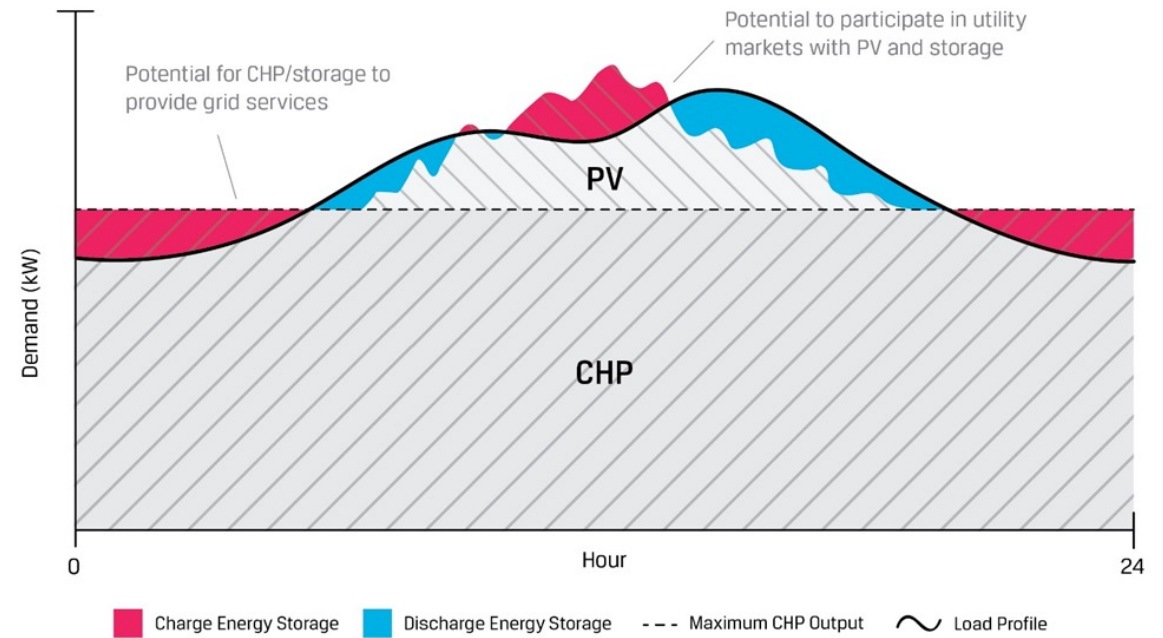
Hybrid On Site Generation Solutions for Microgrids with CHP

In microgrids, CHP is most often combined with Solar PV, Battery Energy Storage, and backup Diesel generators

Technologies Used with CHP in Microgrids



CHP + PV + Storage Microgrid

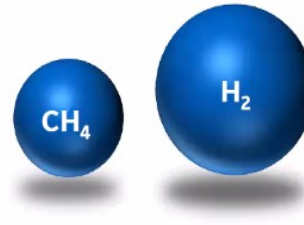


Green Hydrogen Will be Needed to Meet GHG Targets

- Over 30 Quads (quadrillion Btu) of natural gas consumption annually in the United States (EIA)
- Heat pumps and electrification options are suitable replacements for many natural gas applications
- High-temperature thermal loads currently rely on combustion processes; can be difficult/costly to electrify
- Biogas supply is limited for renewable natural gas (RNG); more fuels are needed
- **Green Hydrogen can be used with existing technologies, including efficient, resilient CHP systems**

Fuel System

Methane (CH₄): 912 lb/ft³
Hydrogen (H₂): 275 lb/ft³



To deliver the same energy content, hydrogen requires 3X more volume flow

Combustion System

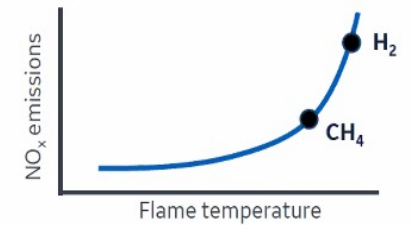
Methane (CH₄): ~30–40 cm/sec
Hydrogen (H₂): ~200–300 cm/sec



Hydrogen flames may increase risk of damage to combustion hardware

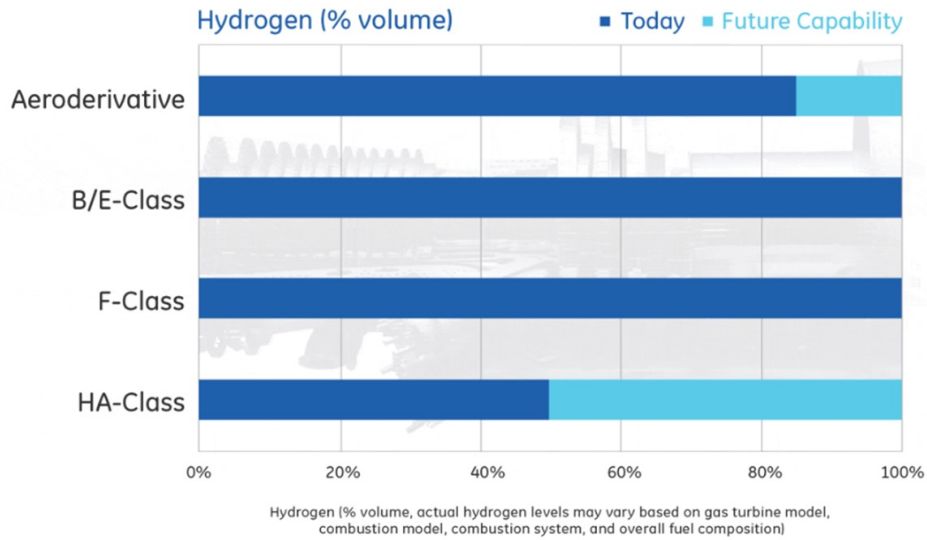
Emissions Aftertreatment

Methane (CH₄): ~3,565 °F
Hydrogen (H₂): ~4,000 °F



Operating on hydrogen may increase NO_x emissions

- Hydrogen can make use of existing infrastructure and equipment
- Hydrogen blends (10-30%) can be used with minimal modifications
- 100% hydrogen equipment options both currently available and under development



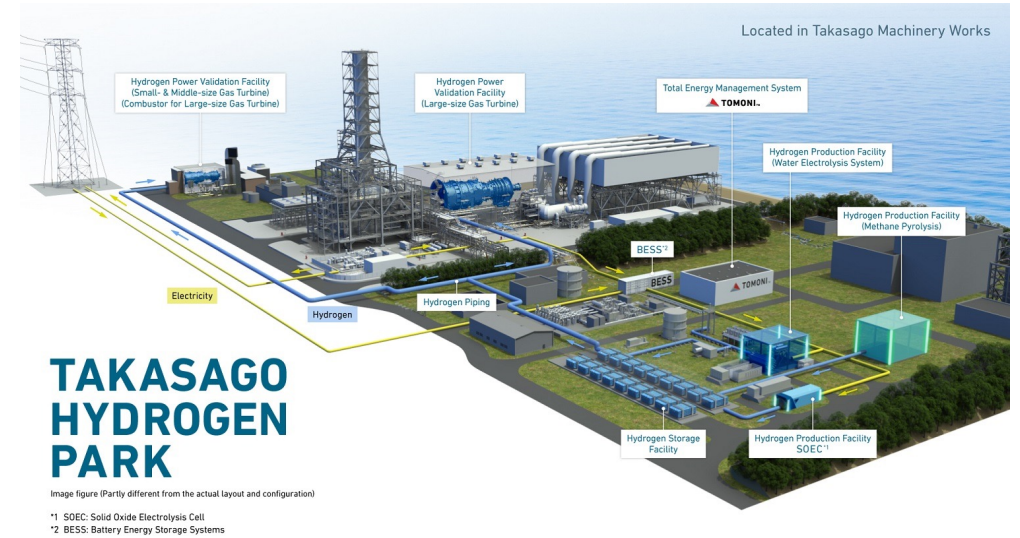
Source: <https://www.ge.com/gas-power/future-of-energy/hydrogen-fueled-gas-turbines>



GE 6B.03

Source: <https://www.ge.com/gas-power/products/gas-turbines/6b>

➔ Power Generation and Existing Equipment



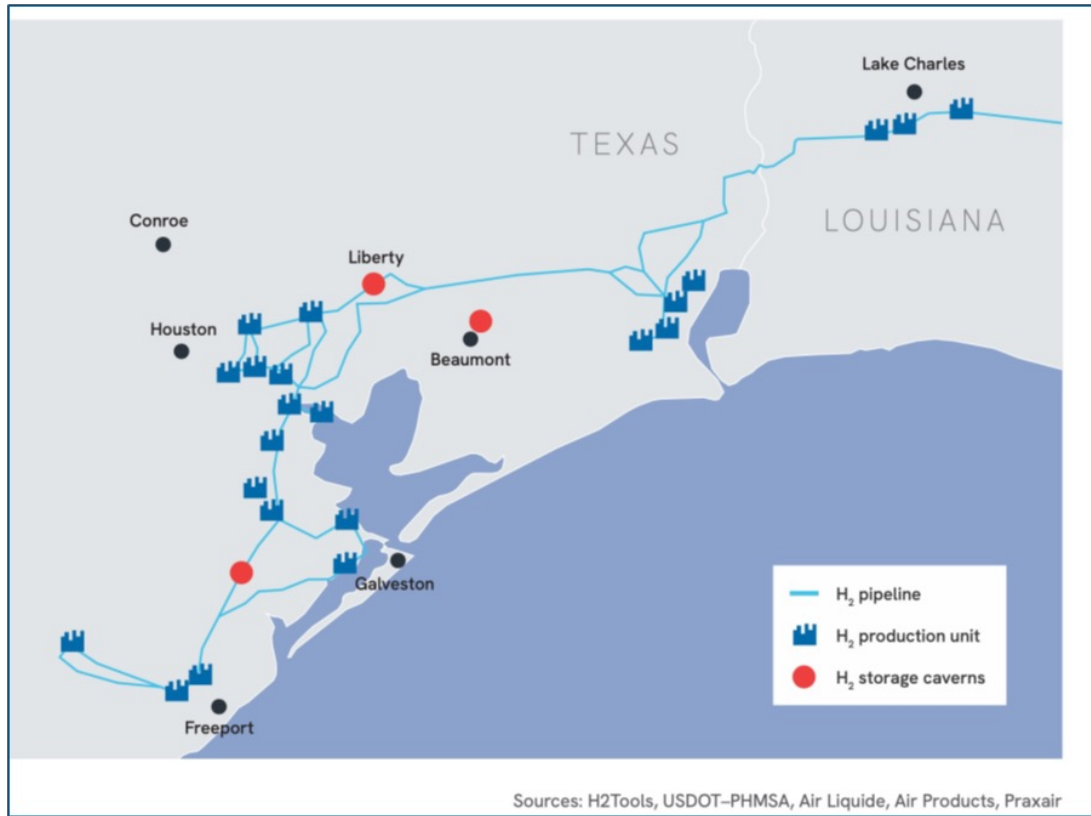
Source: <https://www.ge.com/gas-power/products/gas-turbines/6b>

Source: <https://power.mhi.com/news/20220222.html>



2G agenerator, 115-750 kW

Source: <https://www.ge.com/gas-power/products/gas-turbines/6b>



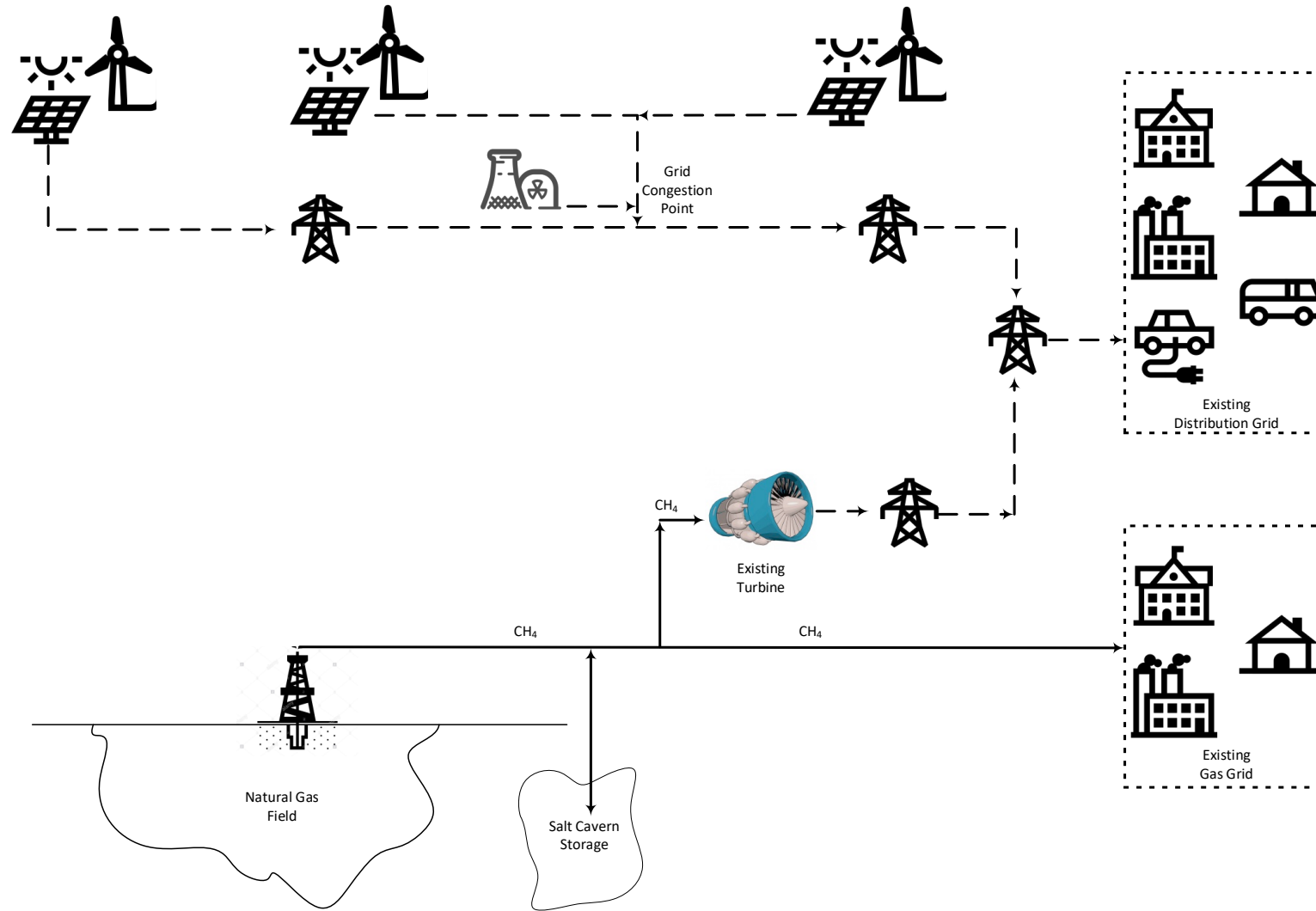
- Hydrogen liquefies at -423°F
 - Between 1-2% boils off per day
- Hydrogen is extremely small
 - Can traverse through polymer pipes and fittings
 - Leaks out of reservoirs (other than salt caverns)
 - Can embrittle steels at higher pressures
- Limited H₂ infrastructure in place
 - 1,600 miles of H₂ piping vs 2.6 million miles of natural gas piping
 - 54 hydrogen fueling stations in California vs 8,269 conventional fuel stations

→ **Hydrogen is difficult to store & transport, future systems to be more distributed**

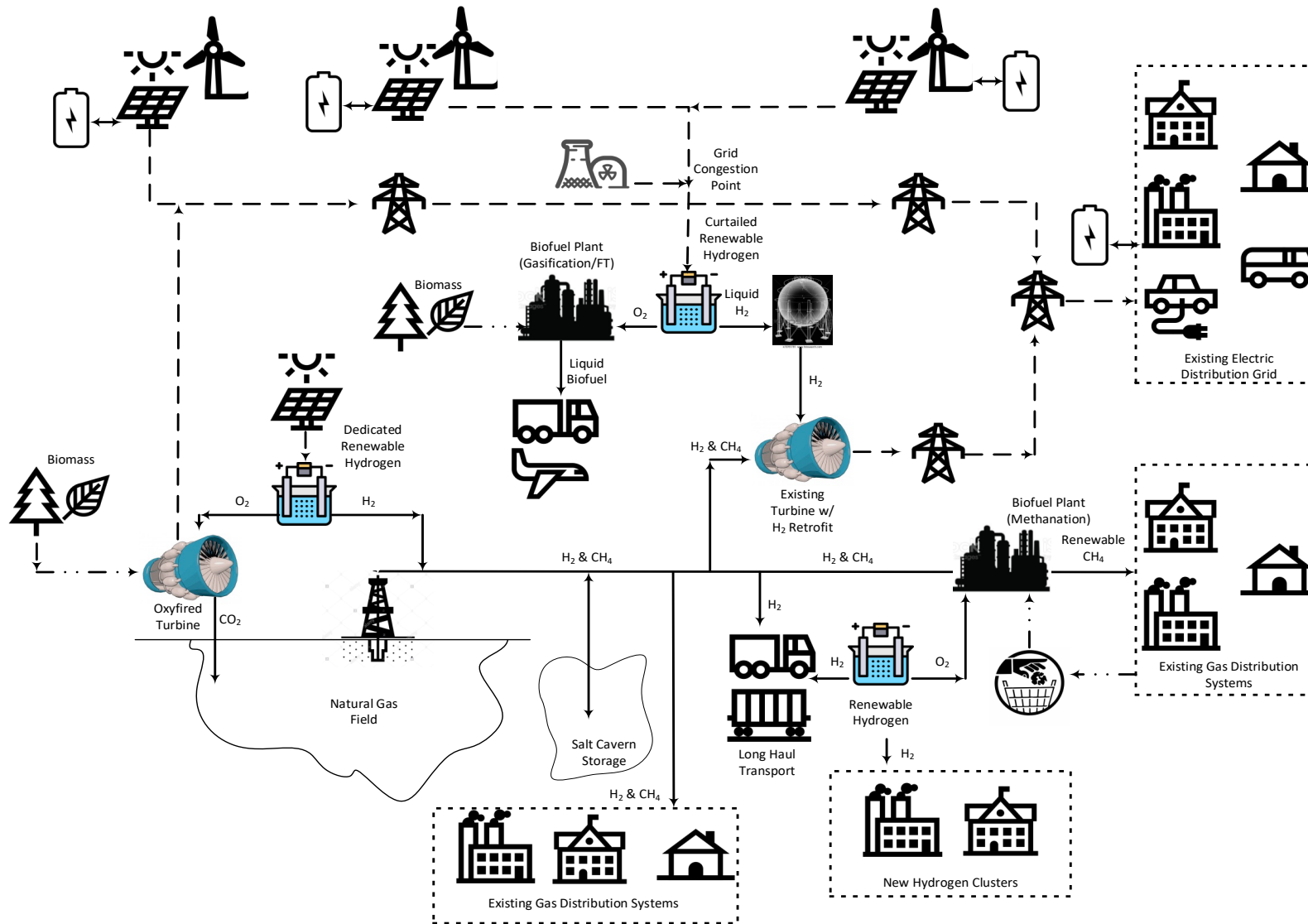


- DOE Office of Clean Energy Demonstration supporting development of Regional Clean **Hydrogen Hubs**
- Hydrogen Hub: “a network of clean hydrogen **producers**, potential clean hydrogen **consumers**, and **connective infrastructure** located in close proximity.”
- Hydrogen is both an **energy carrier** and a **fuel**

→ Hydrogen Hub Concept

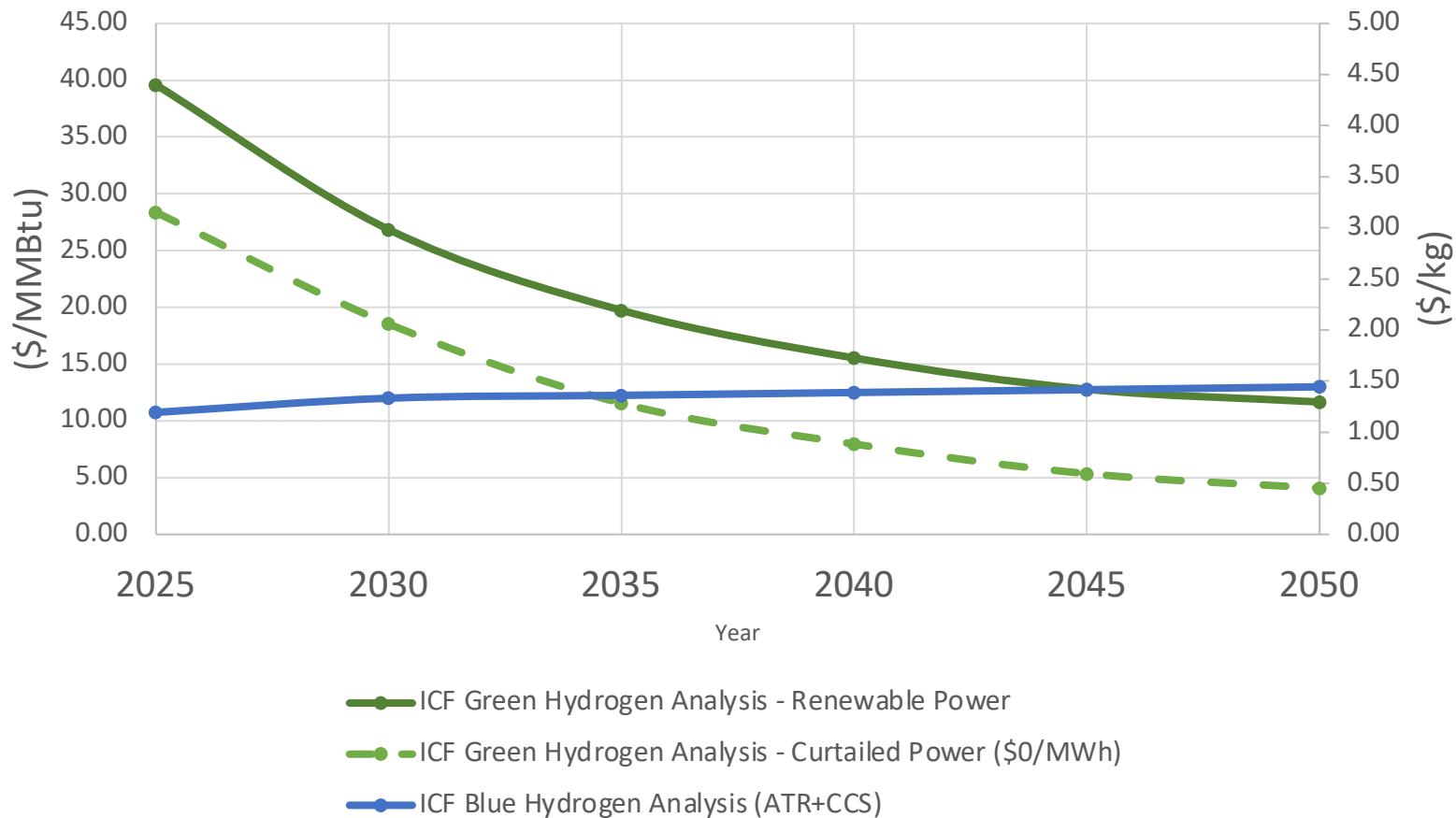


➔ **Demand for both electricity and fuel in existing infrastructure**



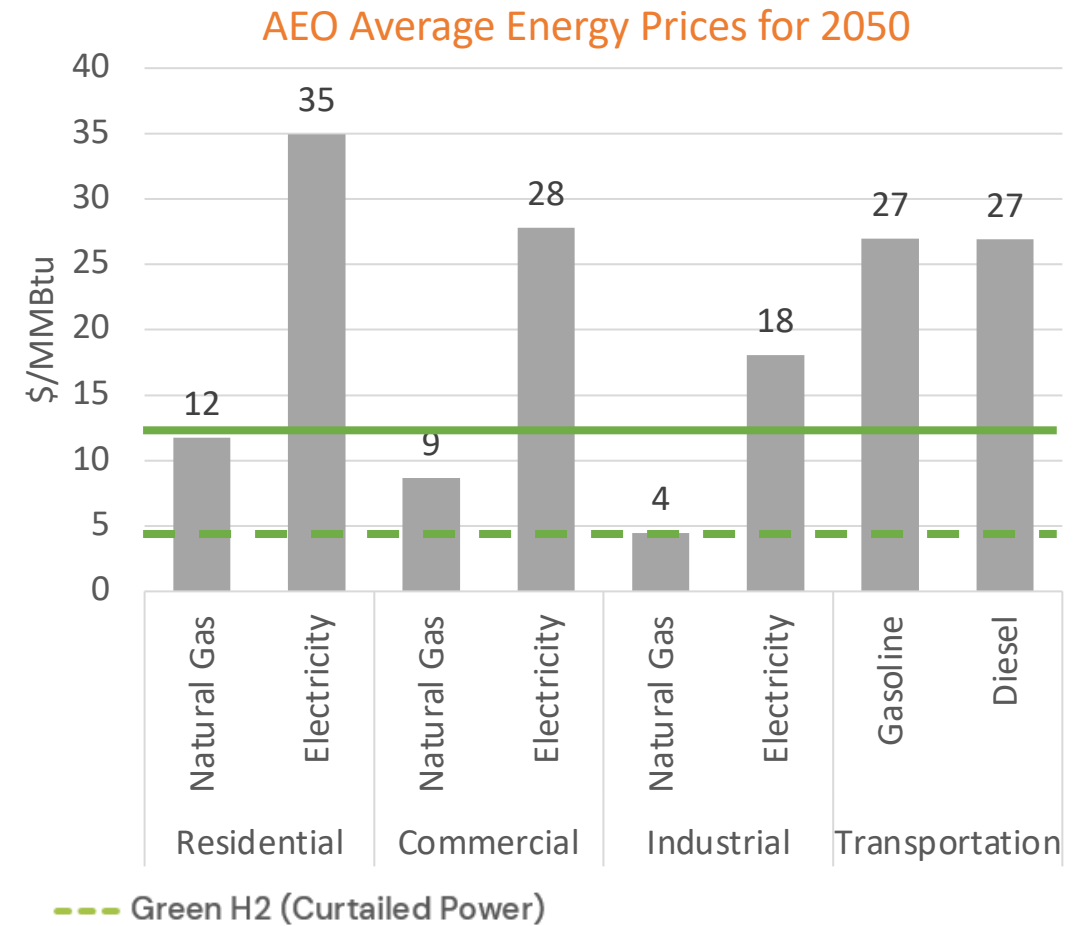
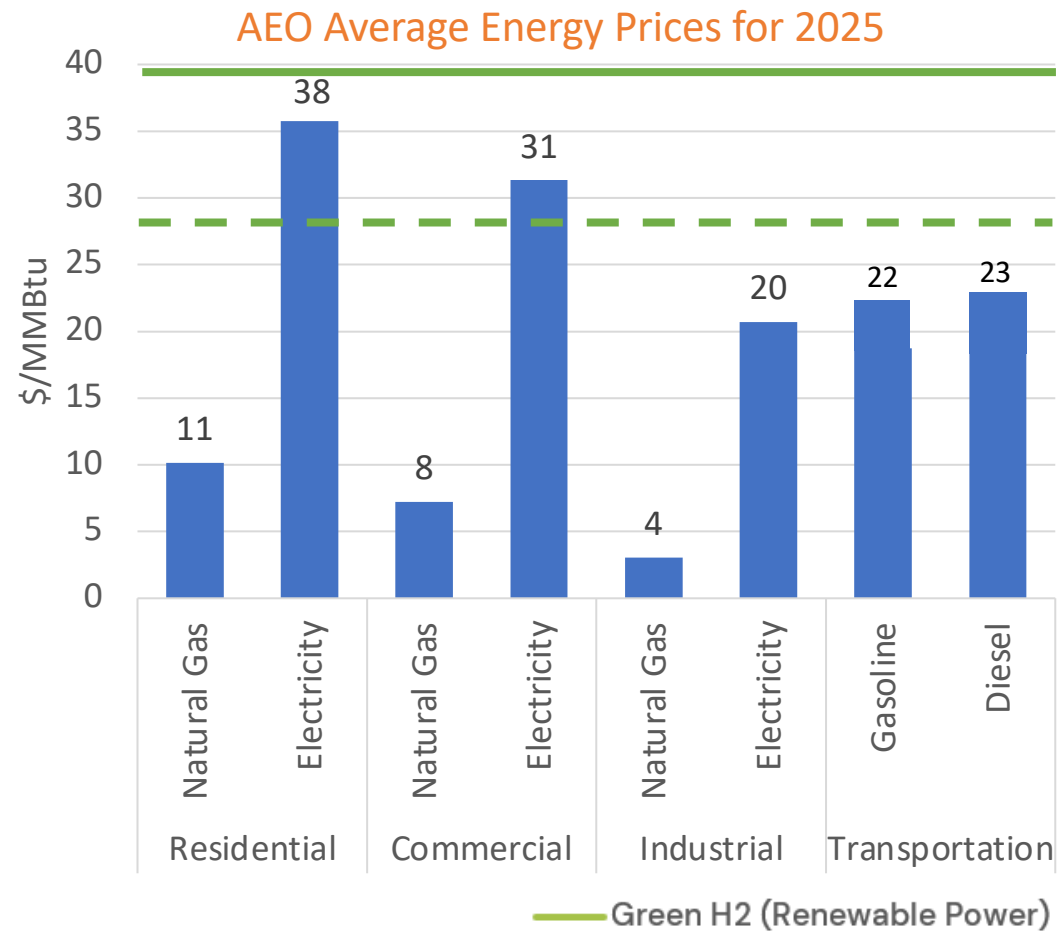
➔ **Hydrogen hubs pair local resources with demand**

Hydrogen Production Cost (\$2022)



Source: ICF - Examining the current and future economics of hydrogen energy

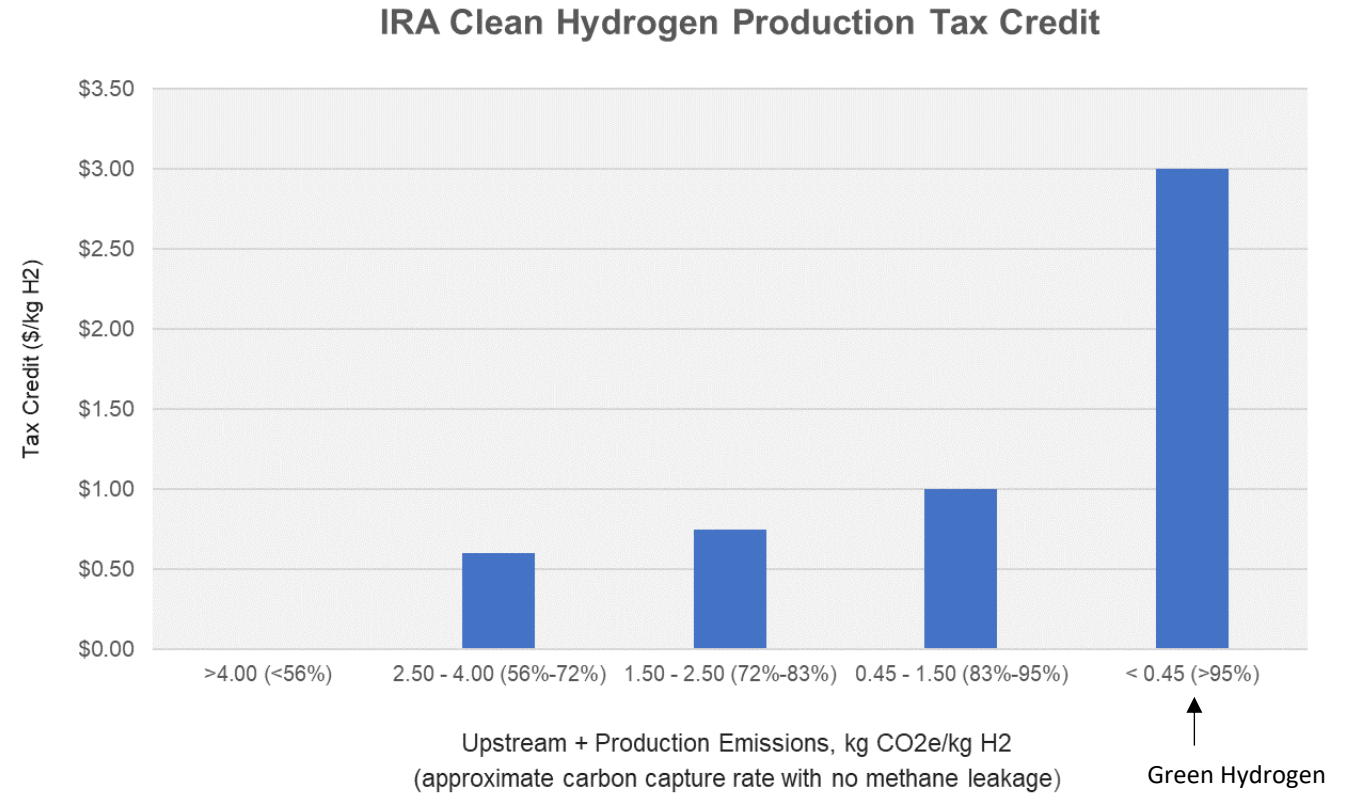
➔ **Declining hydrogen production prices over time**



- Delivered energy prices/costs are national averages from EIA’s 2022 Annual Energy Outlook (AEO)
- Hydrogen production costs are an ICF calculation for green hydrogen, based on assumptions on previous slide
- These bars do not account for relative efficiency of equipment using different fuel types

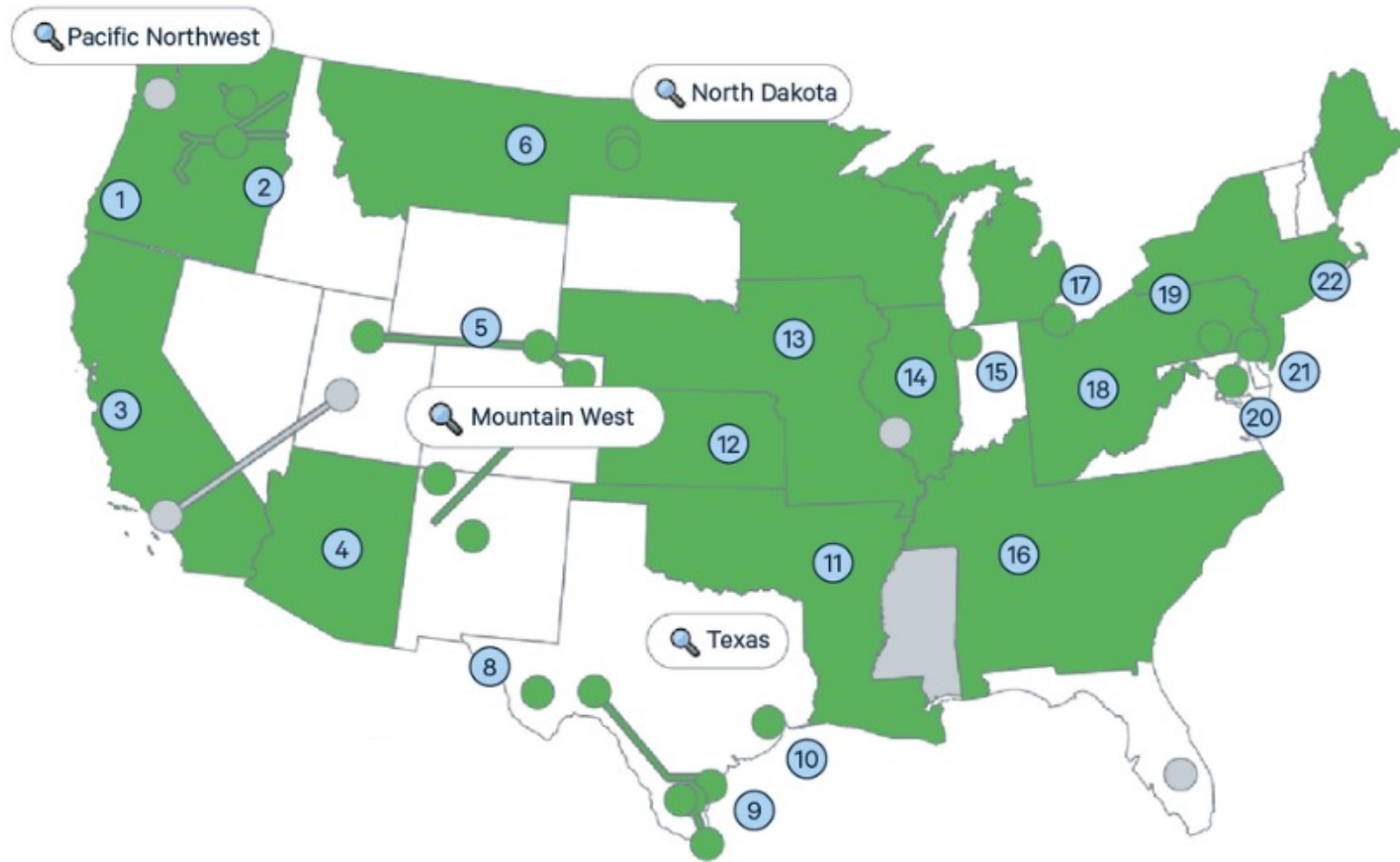
→ Hydrogen production costs in context of delivered energy prices

- **Inflation Reduction Act (45V)** heavily incentivizing green hydrogen production
- Build hydrogen hub with PV + wind + electrolyzer, earn **\$3/kg produced**
- Additional incentives for energy storage (including H₂ storage)



→ **Inflation Reduction Act: Incentives for Clean Hydrogen Production**

Proposed Hydrogen Hubs

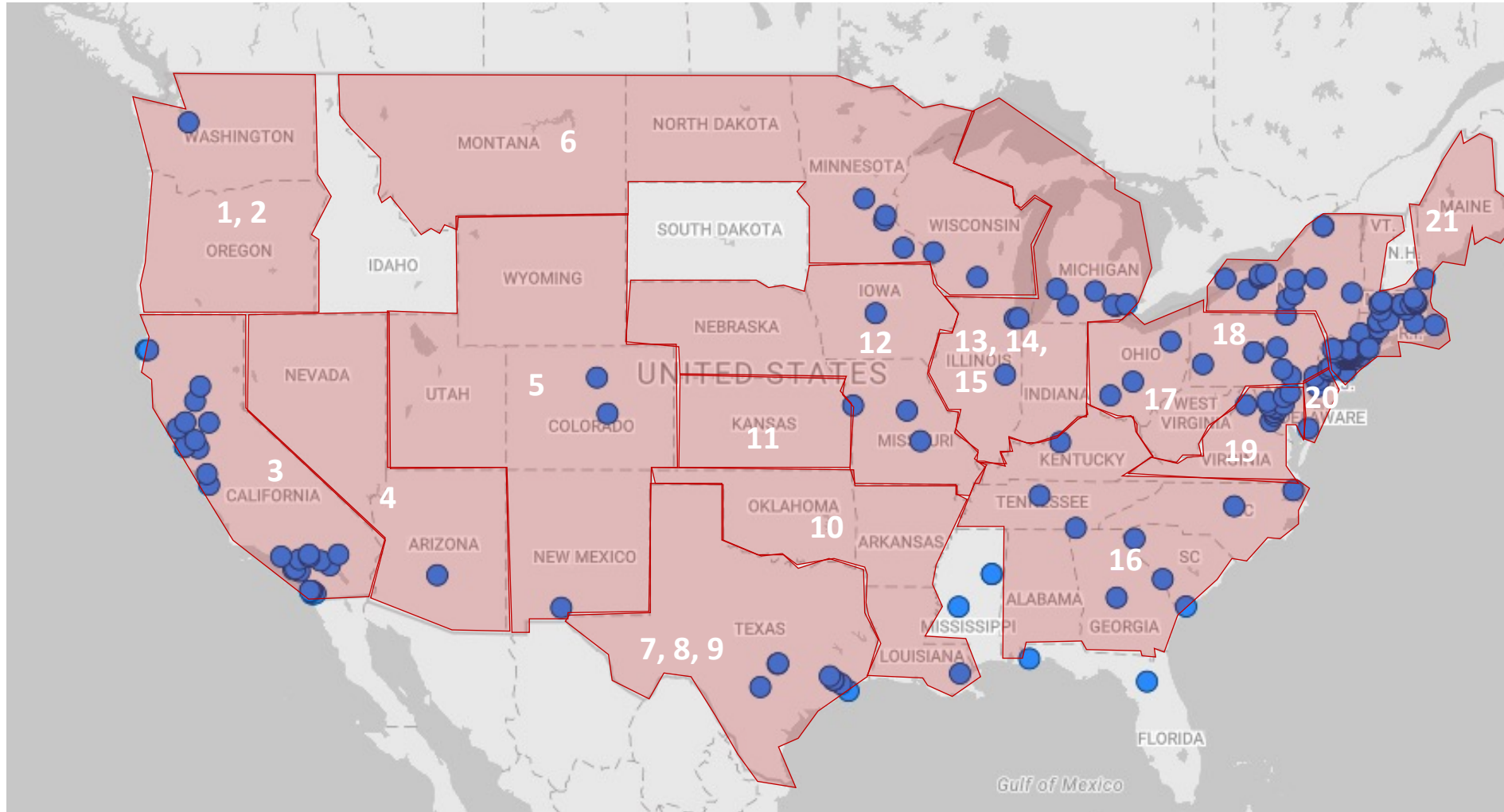


- ① Pacific Northwest Hydrogen Hub
- ② Obsidian Pacific Northwest Hydrogen Hub
- ③ Alliance for Renewable Clean Energy Systems (ARCHES)
- ④ Southwest Clean Hydrogen Innovation Network (SHINe)
- ⑤ Western Interstate Hydrogen Hub (WIH2)
- ⑥ Heartland Hydrogen Hub
- ⑦ Hawai'i Pacific Hydrogen Hub
- ⑧ Trans Permian Hydrogen Hub
- ⑨ Horizons Clean Hydrogen Hub
- ⑩ HyVelocity Hydrogen Hub
- ⑪ HALO Hydrogen Hub
- ⑫ HARVEST Hydrogen Hubs Coalition
- ⑬ Mid-Continent Hydrogen Hub
- ⑭ Midwest Alliance for Clean Hydrogen (MachH2)
- ⑮ Northwest Indiana Hydrogen Hub
- ⑯ Southeast Hydrogen Hub
- ⑰ Great Lakes Clean Hydrogen Hub
- ⑱ Appalachian Regional Clean Hydrogen Hub (ARCH2)
- ⑲ Decarbonization Network of Appalachia
- ⑳ Mid-Atlantic Hydrogen Hub (MAAH)
- ㉑ Mid-Atlantic Clean Hydrogen Hub
- ㉒ Northeast Hydrogen Hub

[Hydrogen Hubs: Get to Know the Encouraged Applicants \(resources.org\)](https://resources.org)

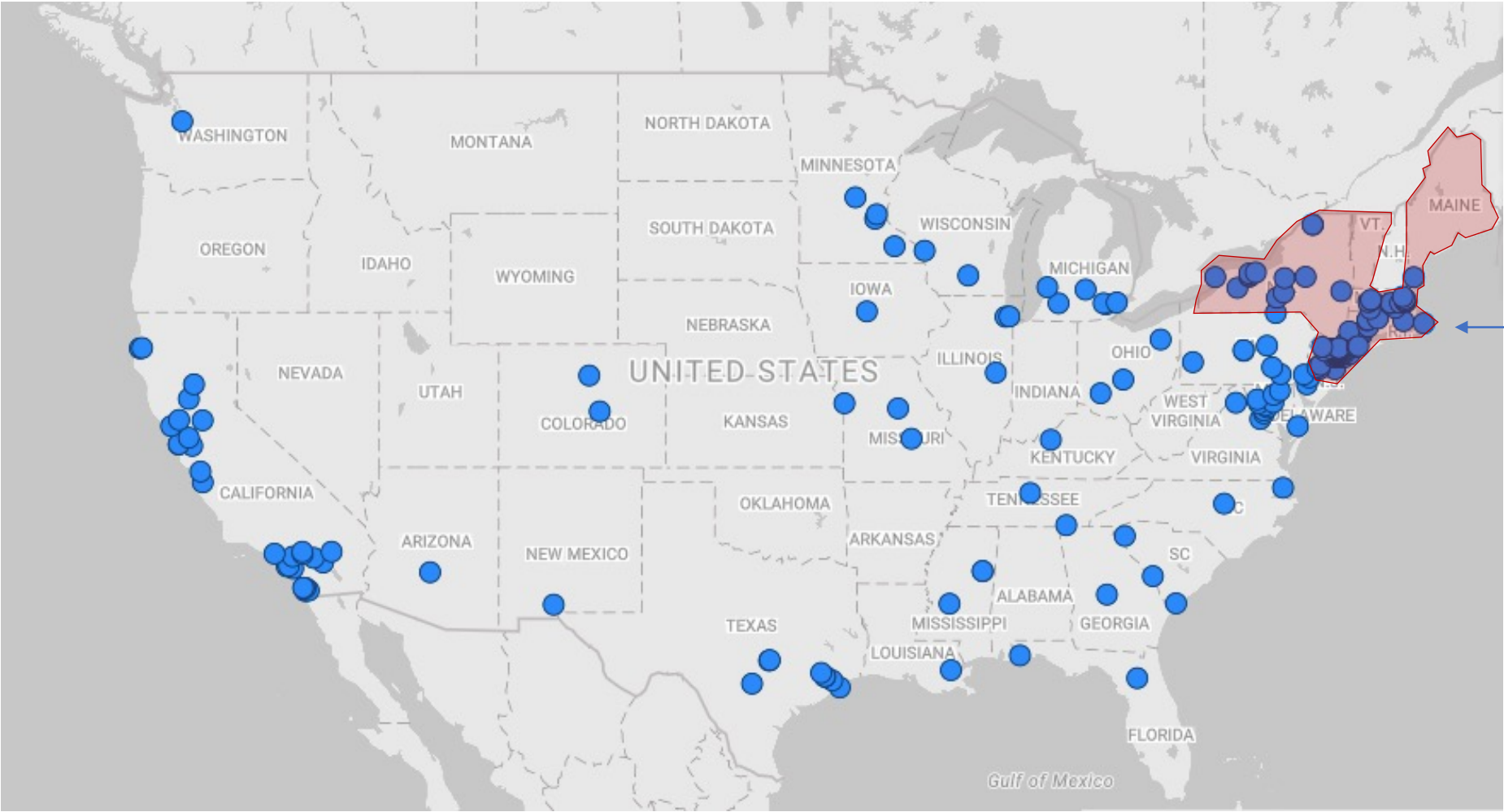
Source: DOE Microgrid Installation Database, as of July 2023

Microgrids with CHP for Hydrogen Hubs: Continental US



1. Pacific Northwest Hydrogen Hub (WA, OR)
2. Obsidian Pacific Northwest Hydrogen Hub (WA, OR)
3. Alliance for Renewable Clean Hydrogen Energy Systems (CA)
4. Southwest Clean Hydrogen Innovation Network (NV, AZ)
5. Western Interstate Hydrogen Hub (UT, CO, NM, WY)
6. Heartland Hydrogen Hub (MT, ND, MN, WI)
7. Trans Permian Hydrogen Hub (TX)
8. Horizons Clean Hydrogen Hub (TX)
9. HyVelocity Hydrogen Hub (TX)
10. HALO Hydrogen Hub (OK, AR, LA)
11. HARVEST Hydrogen Hub (KS)
12. Mid-Continent Clean Hydrogen Hub (IA, MO, NE)
13. Midwest Alliance for Clean Hydrogen (IL, IN, MI)
14. Northwest Indiana Hydrogen Hub (IN)
15. Great Lakes Hydrogen Hub (MI)
16. Southeast Hydrogen Hub (GA, AL, TN, SC, NC, KY)
17. Appalachian Regional Clean Hydrogen Hub (OH, WV, PA, KY)
18. Decarbonization Network of Appalachia (PA)
19. Mid-Atlantic Hydrogen Hub (VA, MD, DC)
20. Mid-Atlantic Clean Hydrogen Hub (PA, DE, NJ)
21. Northeast Clean Hydrogen Hub (NY, CT, NJ, MA, RI, ME, VT)

Microgrids for Hydrogen Hubs: Northeast Clean Hydrogen Hub



Northeast Clean Hydrogen Hub

Source: DOE Microgrid Installation Database, as of July 2023

Northeast Clean Hydrogen Hub

Location: New York, Connecticut, New Jersey, Massachusetts, Rhode Island, Maine and Vermont

Sources for Hydrogen Production: Renewable energy and nuclear energy for green and pink hydrogen

End Uses: Industrial (to decarbonize process-heat), transportation (aviation, shipping, on-road and rail applications), power generation, and heating

Lead Partner: NYSERDA

Partnership: Public-Private Partnership (7 states and 100+ partners)

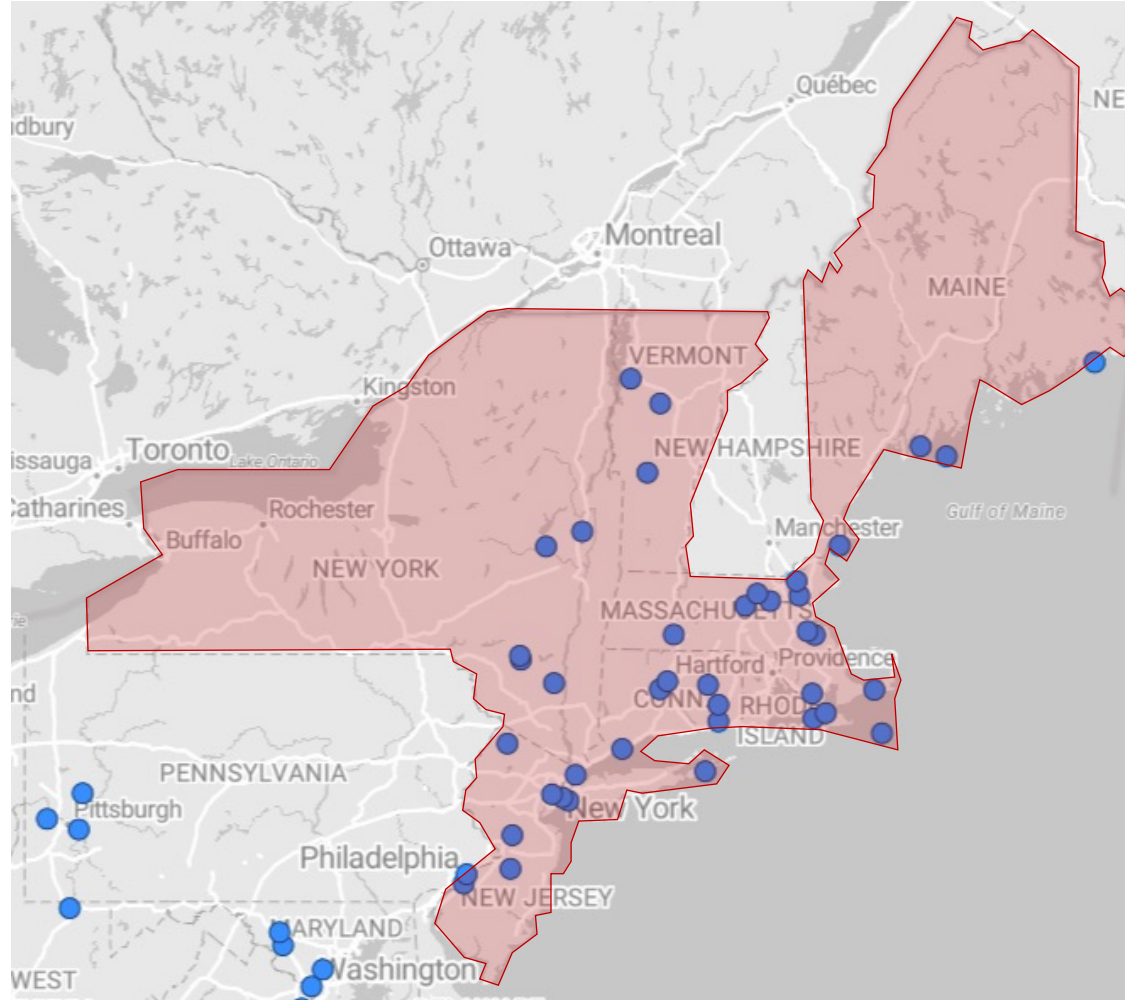
Funding Needs: \$3.62 billion from both DOE and non-federal sources (\$1.25 billion from DOE) – award to be announced Fall 2023

Development Plan: Four phases of development over the course of 10-12 years

“The projects included in the proposal are proposed to be sited to form a **regional hub** of integrated projects **across states** collectively **producing and utilizing clean hydrogen**, advancing a vision that enables a **long-term sustainable clean hydrogen industry** in the northeast region, and establishing **strategic connections** to other clean hydrogen hubs.”

[Seven States in NE Regional Clean Hydrogen Hub Announce DOE Proposal for Funding and Designation as a National Hub - NYSERDA](#)

Microgrids with CHP for Northeast Clean Hydrogen Hub

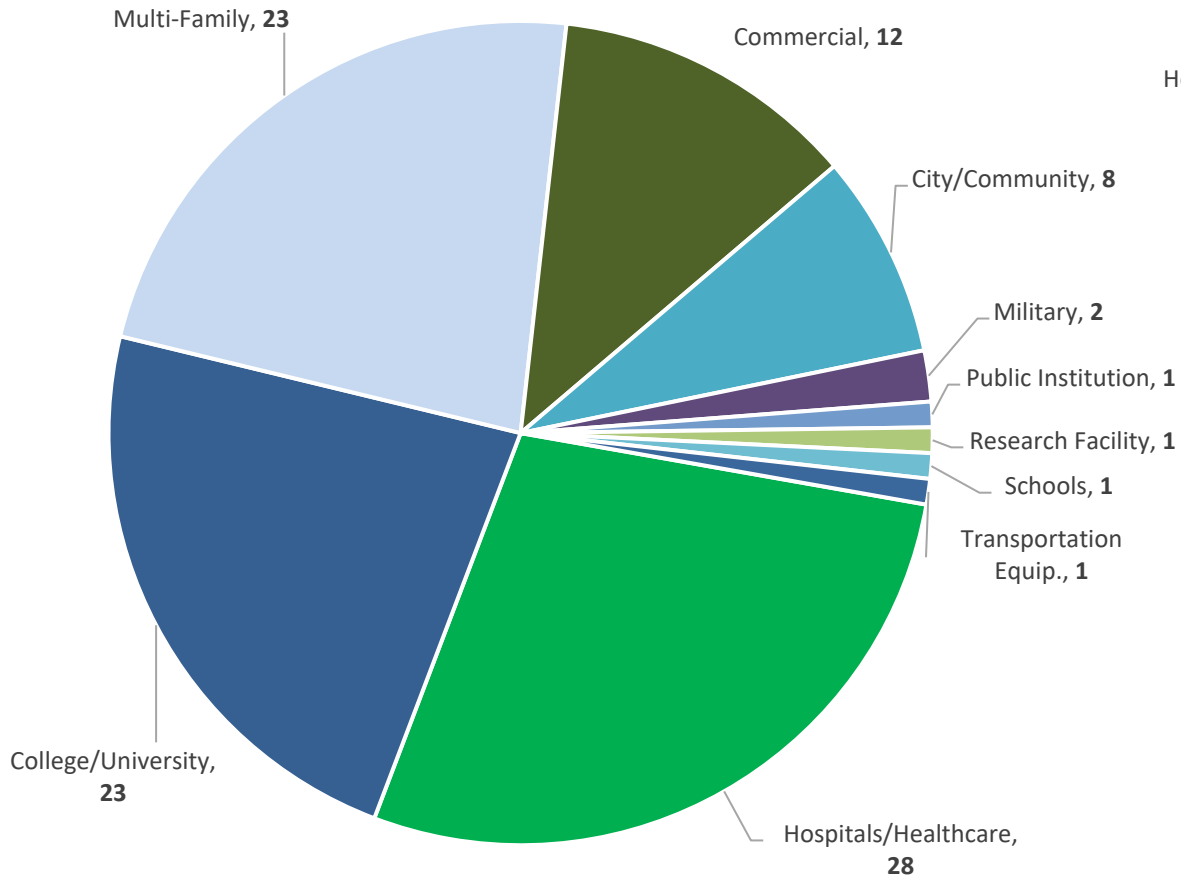


100 operational microgrids located within the Northeast Clean Hydrogen Hub geographic area use CHP (99 using Natural Gas)

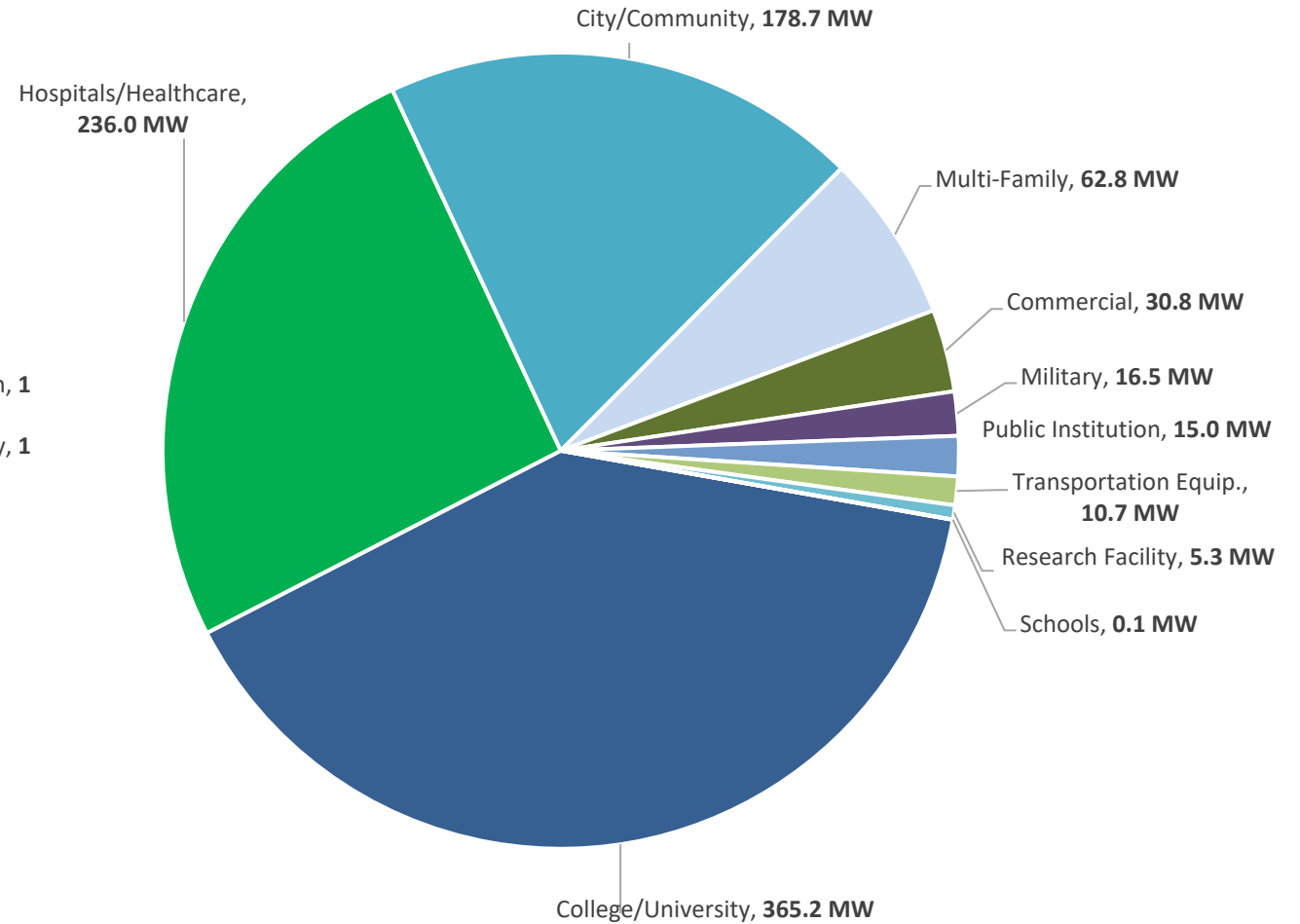
- New York: 56
- Connecticut: 15
- New Jersey: 11
- Massachusetts: 17
- Rhode Island: 0
- Maine: 1
- Vermont: 0

Northeast Clean Hydrogen Hub Microgrids with CHP

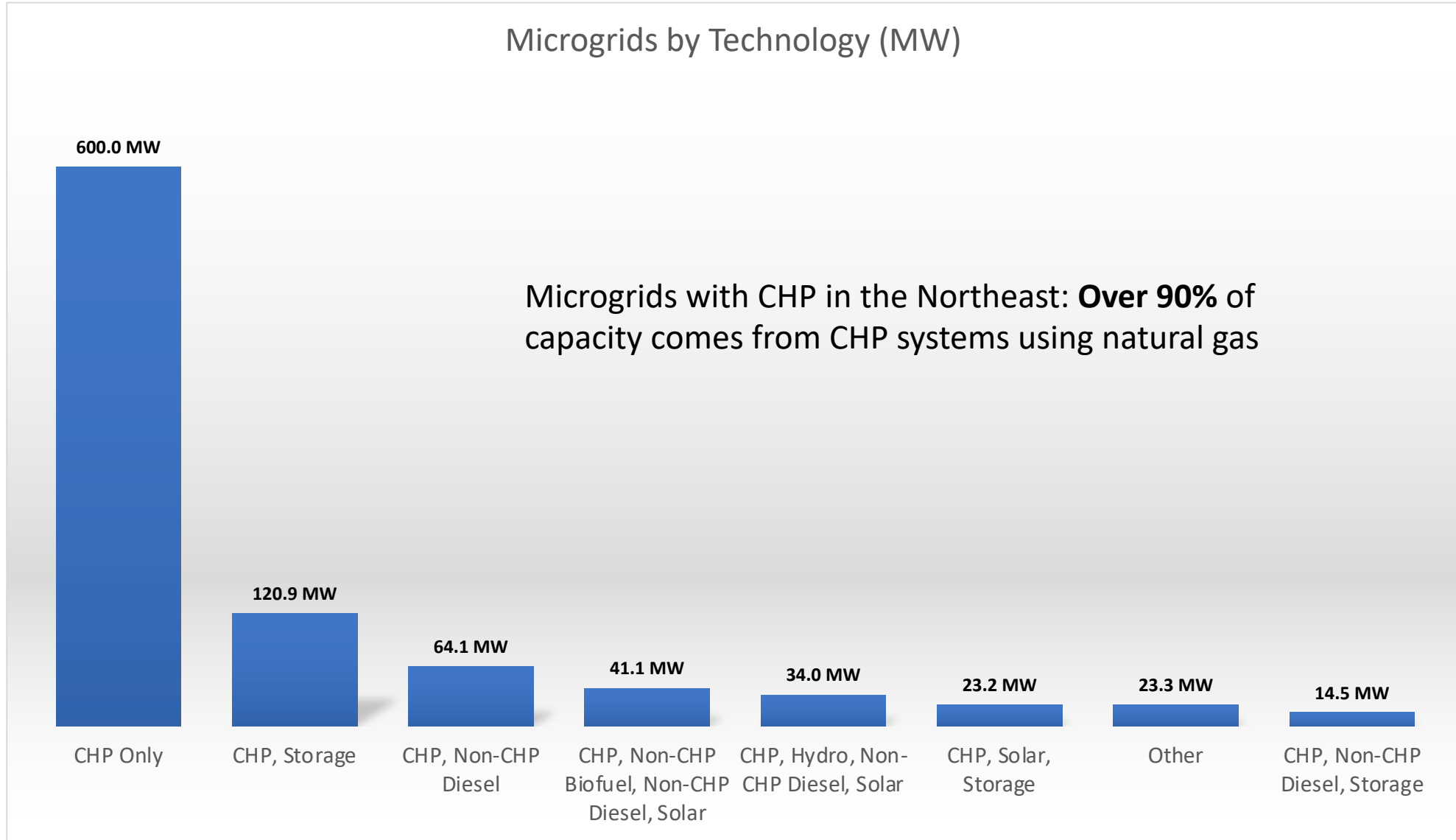
CHP Microgrids by Application (100 Sites)



CHP Microgrids by Application (921MW total)



Northeast Clean Hydrogen Hub Microgrids with CHP



- Over 4,700 CHP systems across the U.S., more than 70% using natural gas
- CHP provides efficient, reliable, resilient heat and power for microgrids at critical facilities
- *Need to decarbonize natural gas heat and power without creating additional burden on local electric grids*
- With limited potential for RNG production, more sources of renewable fuels will be needed to decarbonize CHP
- Hydrogen hubs and IRA incentives will spur green hydrogen production, including **Northeast Clean Hydrogen Hub**
- 100 microgrids with CHP currently located in Northeast, could incorporate green hydrogen from Northeast Hub... make those connections!

→ **Key Takeaways**

Questions?

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