16th STS-AIChE Southwest Process Technology Conference

- CHP and Alternative Fuels
- Carlos Gamarra
- DOE Southcentral Onsite Energy TAP

Sept 22-23, 2025, University of Houston

Speaker Bio

Carlos Gamarra is the Vice President of Energy, Air, and IT at the Houston Advanced Research Center (HARC). His research centers on energy systems planning and deployment.

Since 2020, Carlos has led multiple U.S. Department of Energy–funded initiatives, including the Southcentral Onsite Energy Technical Assistance Partnership (TAP), accelerating the adoption of onsite energy generation and storage technologies at industrial and manufacturing facilities.

Since 2017, the Southcentral Onsite Energy TAP has provided over 400 no-cost technical assistance and supported the deployment of over 700 MW of onsite power capacity across Texas, Louisiana, Oklahoma, Arkansas, and New Mexico, advancing resilience, sustainability, and cost efficiency for large energy consumers.

Onsite Energy Technical Assistance Partnerships
U.S. DEPARTMENT OF ENERGY
Southcentral

Energizing CHP and Exploring Case Studies: Unlocking the Potential of Alternative Fuels

Carlos Gamarra, Director of Southcentral Onsite Energy TAP

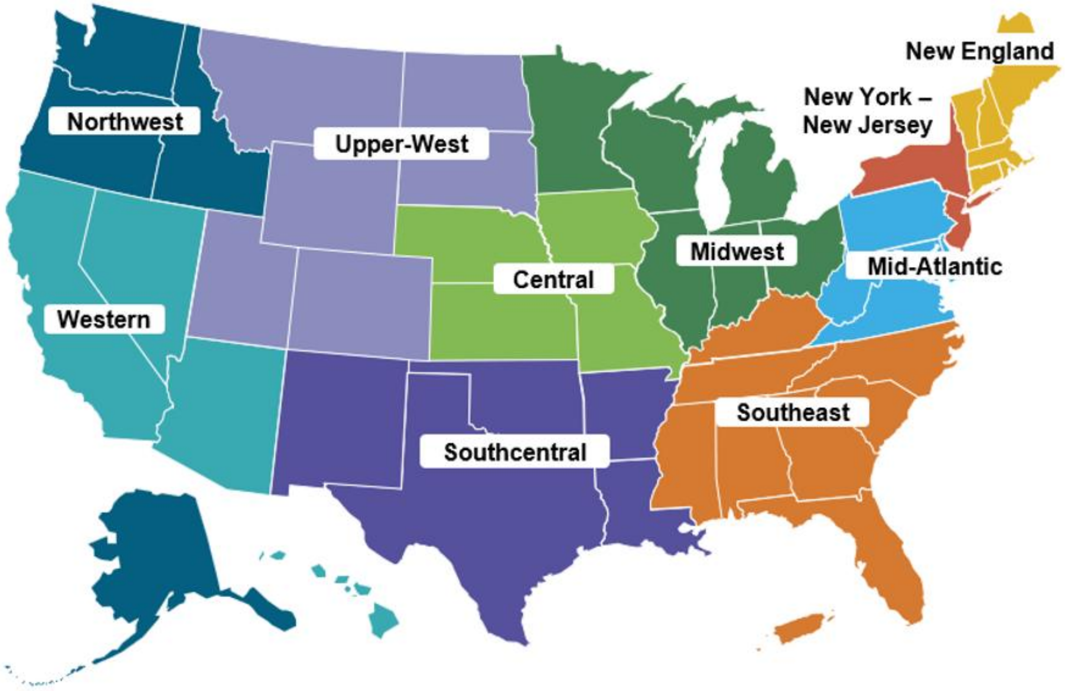
09/23/2025

Onsite Energy Technical Assistance Partnerships (TAPs)

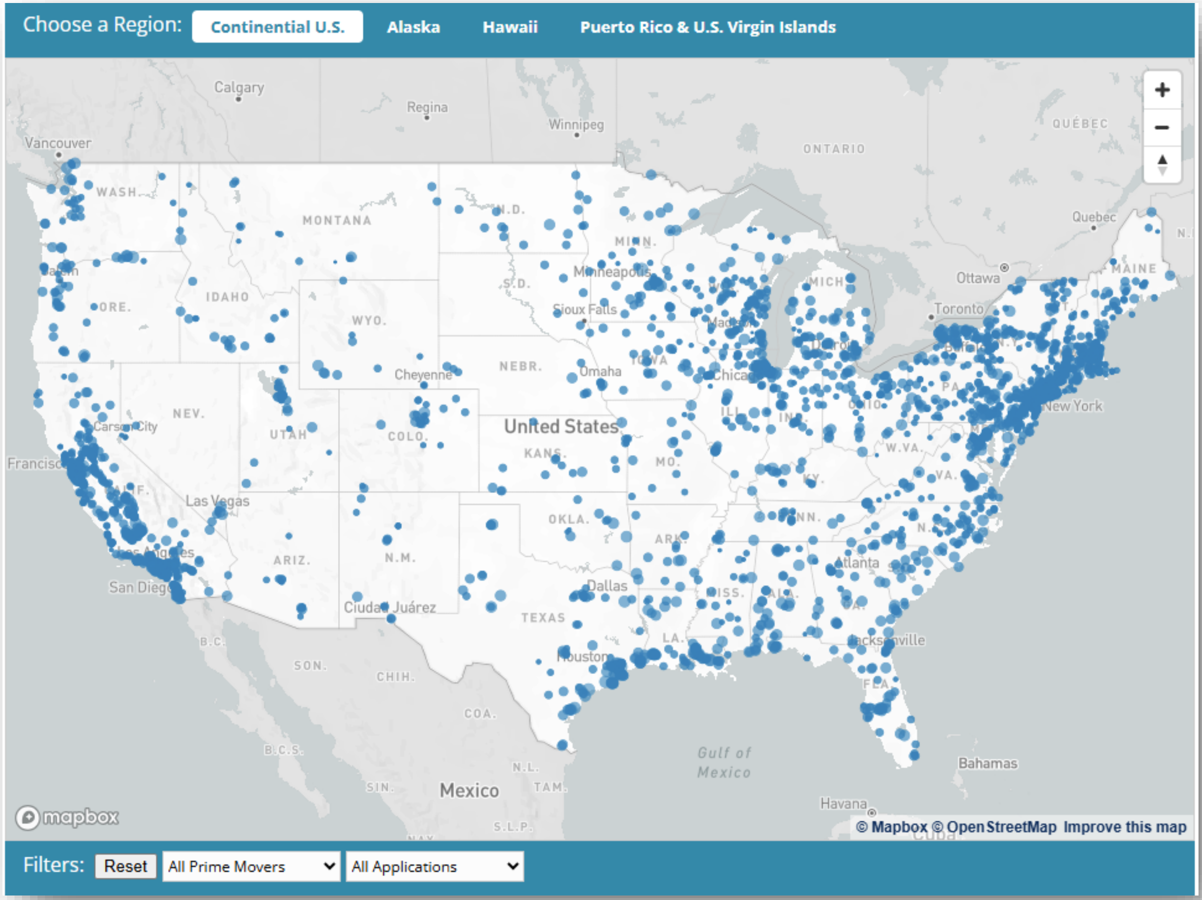
DOE's 10 regional Onsite Energy TAPs provide technical assistance to industrial facilities and other stakeholders about technology options for achieving onsite energy objectives. Key services include:

- **Technology screenings** and **data analysis** of economic and operational impacts of installing combined heat and power (CHP) and other onsite technologies.
- **Partnerships** and **engagements** with organizations representing industrial and other large energy users, such as data centers, to advance near-term solutions to energy needs and reduce costs with onsite energy.
- **Technical information** and **resources to educate** state and local government, industry, and other stakeholders to increase industrial competitiveness.

Onsite Energy Technical Assistance Partnerships
U.S. DEPARTMENT OF ENERGY



Combined Heat and Power (CHP) Installations in the United States



Source: DOE CHP Installation Database (U.S. Installations through December 31, 2024 as of August 2025)

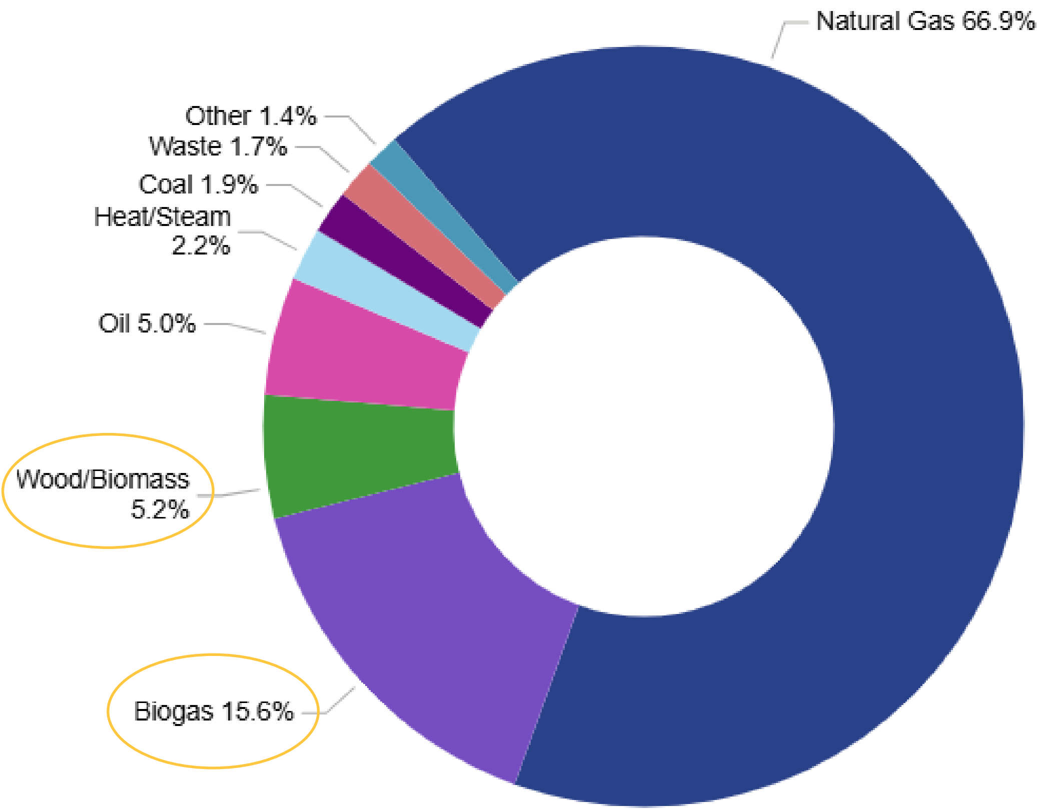
- **80.4 GW** of installed CHP at more than **4,100 sites**
- Estimated 6.1% of U.S. electric grid generating capacity; **12.5% of annual grid generation**
- **Avoids** approximately **1.2 quadrillion Btus of fuel consumption** annually compared to separate heat and power[1]
- Almost **$25 billion in estimated annual energy savings** compared to electricity and boiler fuel purchases[2]

[1] 2025 ICF analysis using 2023 AVERT and eGRID data

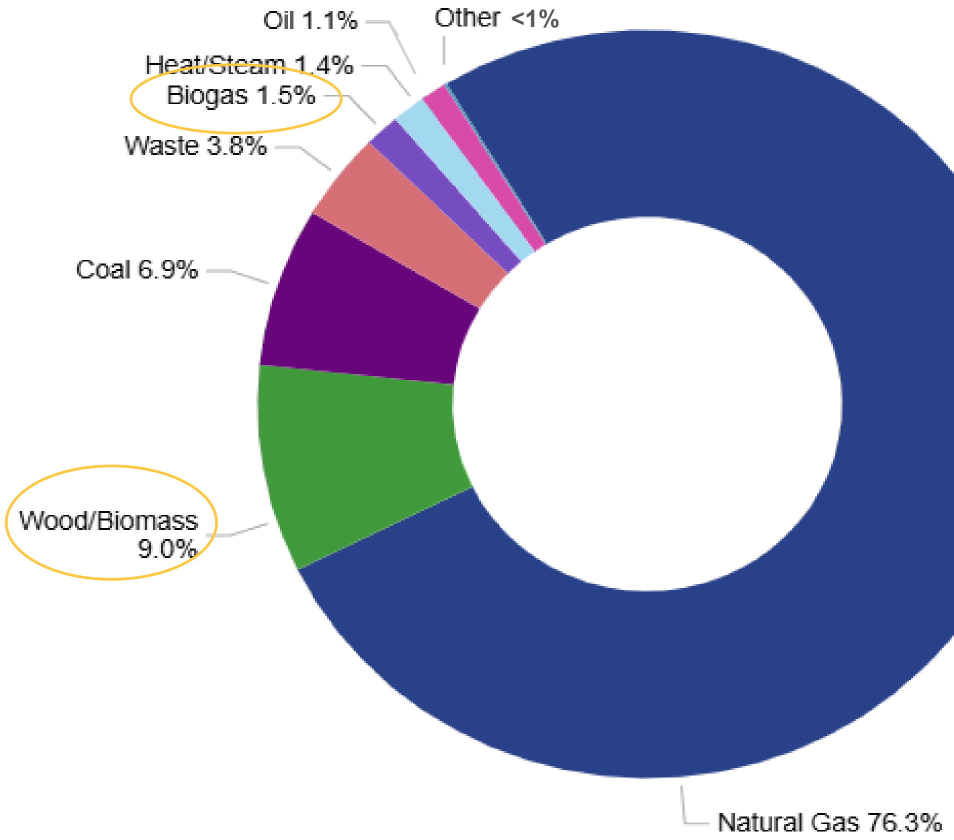
[2] Based on 2024 average electricity and fuel prices and estimated maintenance costs (does not include capital cost payments)

Existing CHP Installations by Fuel Type

By Site – 4,111 Sites

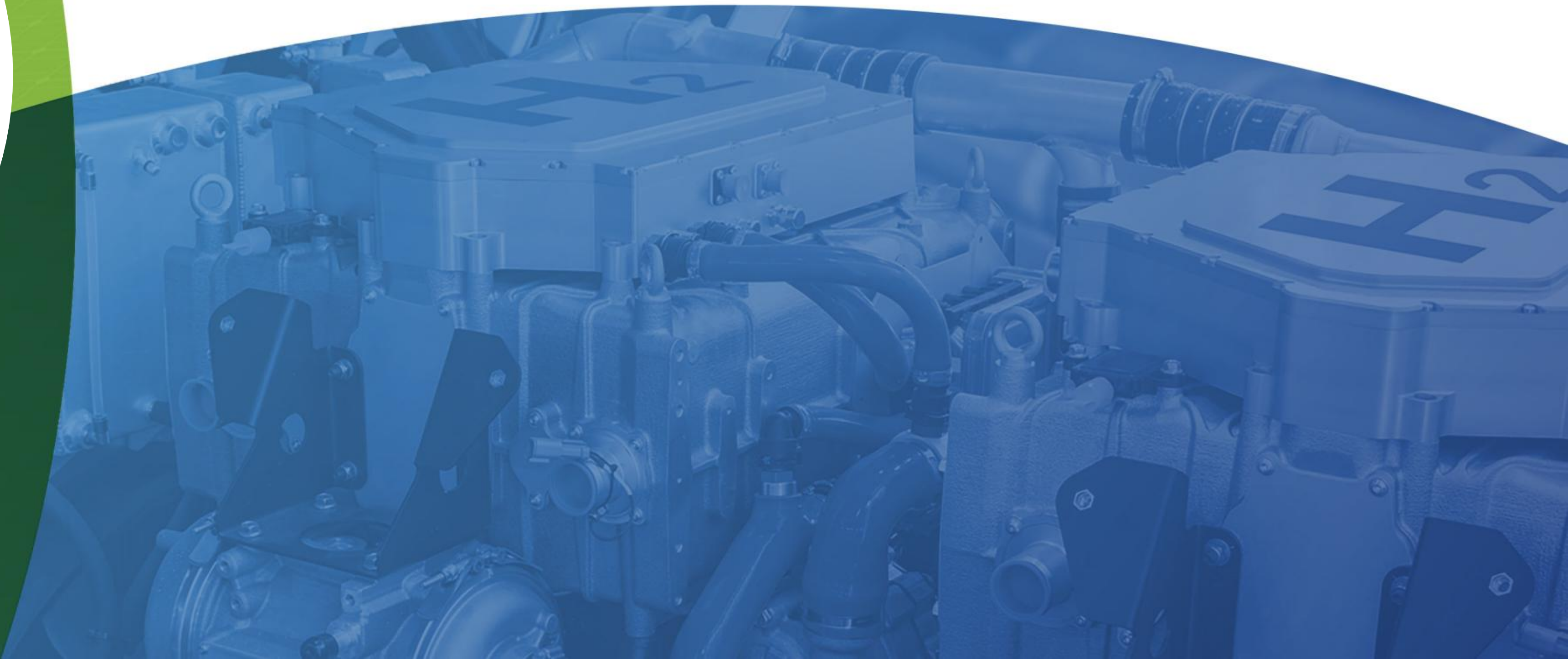


By Capacity – 80.4 GW



Source: DOE CHP Installation Database (U.S. Installations through December 31, 2024 as of August 2025)

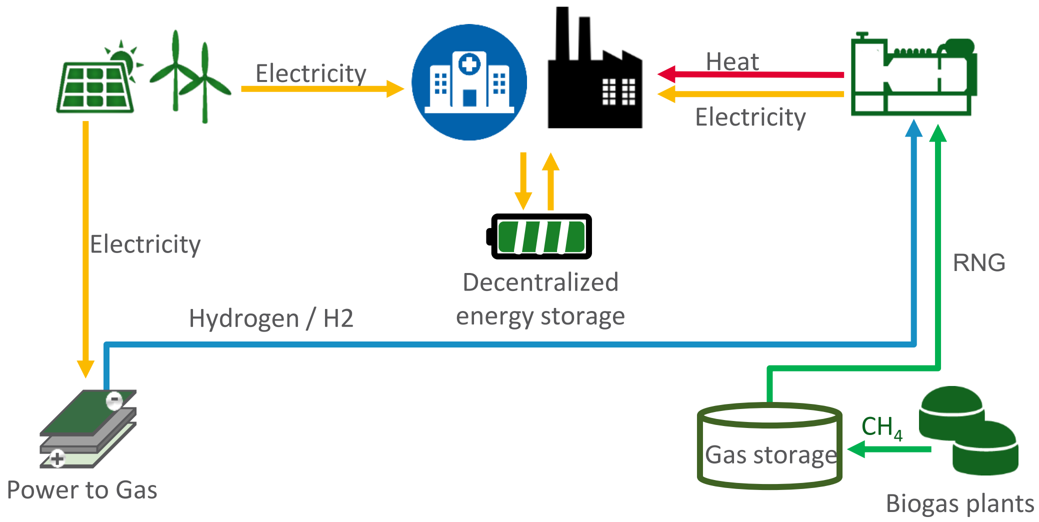
Considerations for Operating CHP Systems with Alternative Fuels



Considerations for Operating CHP Systems with Alternative Fuels

- CHP systems are fuel flexible - CHP currently uses biogas, biomass, and hydrogen where available, and will be ready to use higher levels of biogas, renewable natural gas (RNG) and hydrogen in the future
- CHP reduces energy costs and enhances operational reliability for the industrial host
- CHP is the most efficient way to generate power and thermal energy
- CHP's high efficiency can extend the limited supply of alternative fuels
- CHP can operate in response to grid conditions and/or provide ancillary services to support the grid and maintain stability

CHP Works with Modern Fuels and Technologies to Provide Energy Independence

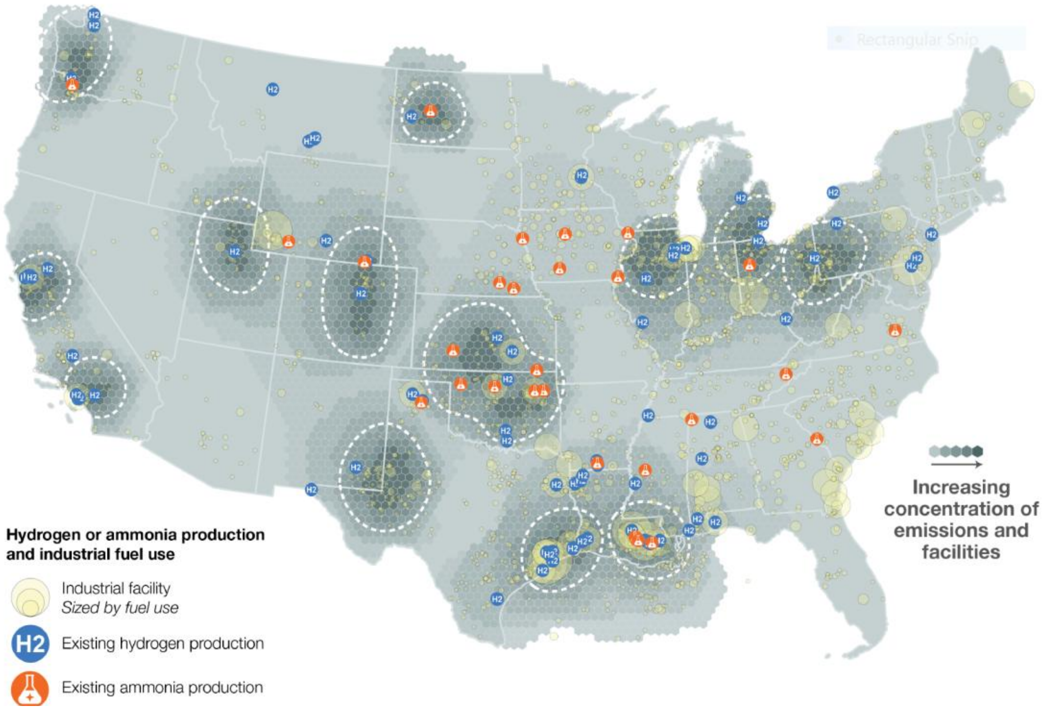


Source: Based on 2G Energy

Alternative Fueled CHP

- Existing CHP systems can utilize biogas and biofuels.
- All natural gas-fueled CHP is compatible with renewable natural gas (RNG).
- Most existing turbines and engines can operate on hydrogen mixtures up to 10-40%.
- All major engine and gas turbine manufacturers are working on the capability to operate at high levels of hydrogen, targeting 2030 for 100% hydrogen prime movers.
- CHP systems can be changed out or modified in the field to 100% hydrogen-fuel blends

The ultimate scale of alternative-fueled CHP deployment will depend on resource availability.

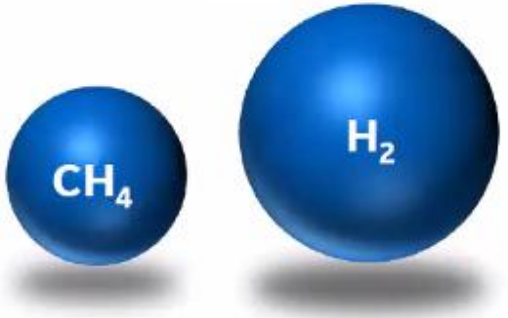


Source: Atlas of Carbon and Hydrogen Hubs, Great Plains Institute, February 2022

Use of Hydrogen will Require System Changes

Fuel System

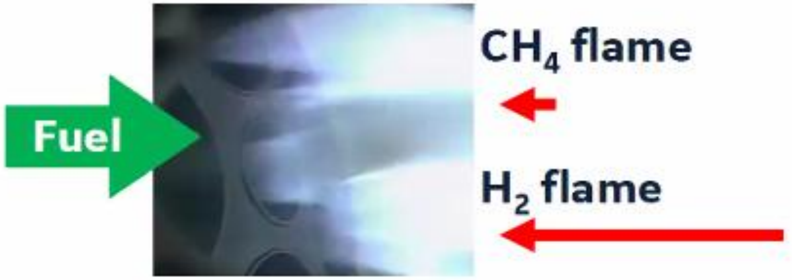
Methane (CH_4): 912 lb/ft^3
Hydrogen (H_2): 275 lb/ft^3



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

Combustion System

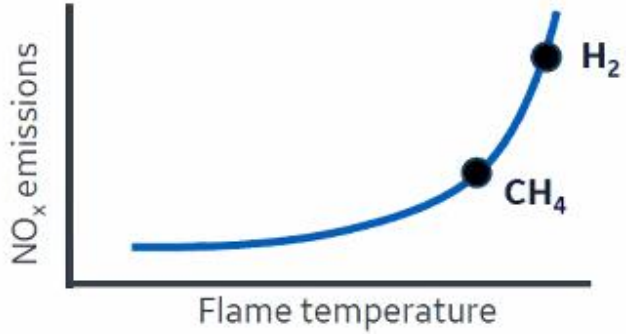
Methane (CH_4): ~30–40 cm/sec
Hydrogen (H_2): ~200–300 cm/sec



Hydrogen flames may increase risk of damage to combustion hardware

Emissions Aftertreatment

Methane (CH_4): ~3,565 °F
Hydrogen (H_2): ~4,000 °F



Operating on hydrogen may increase NO_x emissions

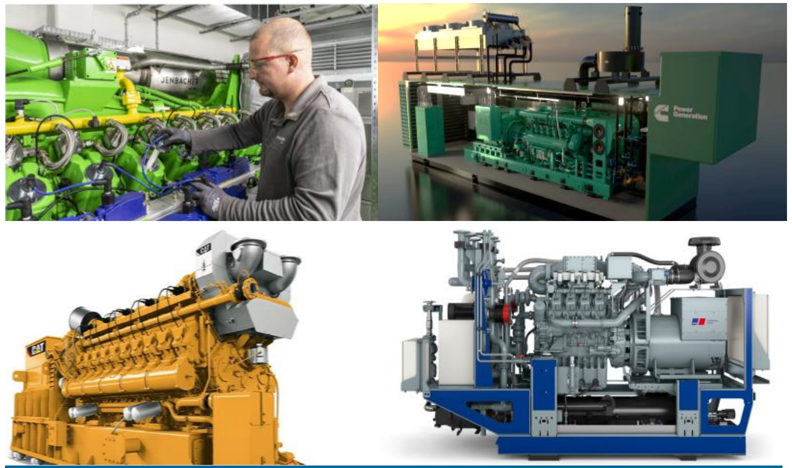
Source: Exergy Partners Corp. 2021 CHP Alliance Summit

Design Differences between Natural Gas and Hydrogen Combustion Turbines

System/Procedures	H_2 Volume Impact on Turbine: 0% – 10% – 30%[1]	10% – 30%[1] – 50% – 70%[1]	50% – 70%[1] – 100%
Burners and combustion chamber	No change	Modified burner may be required	New burner design
Combustion monitoring system	n.a.	n.a.	n.a.
Fuel supply system	No change	Ensure all components Stainless Steel	Pipe diameter increase Purging system
Control/protection systems	No change	Additional gas detection	All hazardous area electrical equipment to Gas Group IIC
O&M Procedures	No change	Leak check of gas fuel system after maintenance inspections	Start-up/shutdown on conventional fuel
	No modifications needed	**Smaller modifications may be required**	**Modifications needed**

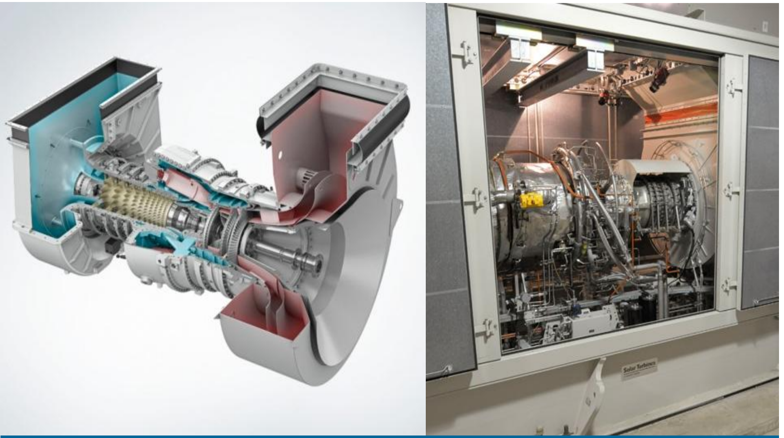
Source: Siemens Energy 2021

CHP Prime Mover Hydrogen Status



RECIP ENGINES SOME @ 100% H_2 TODAY - TARGET 2030

MICROTURBINES 70 TO 100% H_2 TESTING

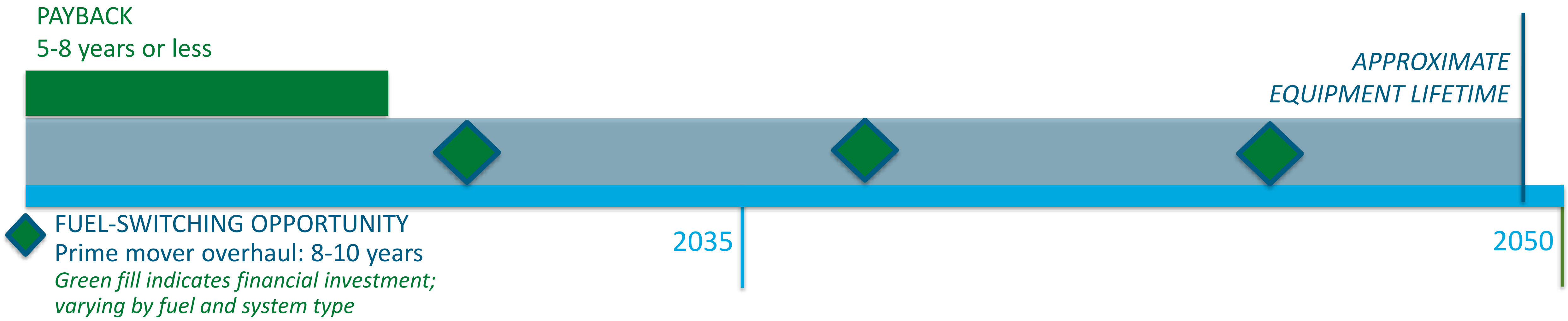


GAS TURBINES SOME @ 100% H_2 TODAY - TARGET 2030

FUEL CELLS 100% H_2 COMPATIBLE TODAY

CHP Life Cycle Offers Multiple Opportunities for Fuel Switching

- Payback periods and regular maintenance schedules offer multiple decision points for reoptimization of the CHP system as alternative fuels become more available:
  - Payback: Typical payback for CHP installations is between 6–8 years. After the initial equipment and installation costs are recovered, future investment decisions can be based on operating costs only.
  - Fuel-switching opportunity: Industrial CHP prime movers require periodic overhauls on an 8 to 10-year cycle (at ~10 to 15% of the original installation cost), which offer at least three opportunities to switch fuels.



Hydrogen Potential for Industrial Sector and CHP (ICF Outlook)

- **Hydrogen production and use will increase, but hydrogen will not be ready to replace natural gas for most applications until the 2030s.**
  - Hydrogen will first be used in applications that already utilize hydrogen (not replacing natural gas), or applications that are willing to pay a higher cost (forklifts/trucks).
  - By 2030, the cost of hydrogen will be lower and supply will be higher, enabling industrial facilities to start replacing natural gas consumption - first with hydrogen blends, and then with dedicated pipelines.
- **Industrial facilities with strong decarbonization targets may opt for onsite hydrogen production.**
  - Particularly those located far from hydrogen distribution hubs and CCS geology.
  - Blue hydrogen (SMR with CCS) will be the predominant production technology in the 2020s, with green (electrolytic) hydrogen increasing.
  - Hydrogen demand (and supply) expected to ramp up in 2030s and 2040s, met primarily by new green hydrogen production.
  - Lower share available for industrial/CHP applications compared to RNG, but higher quantities produced.
- **Emissions reduction goals and policies supporting hydrogen will enable long-term growth and availability as a fuel for CHP.**

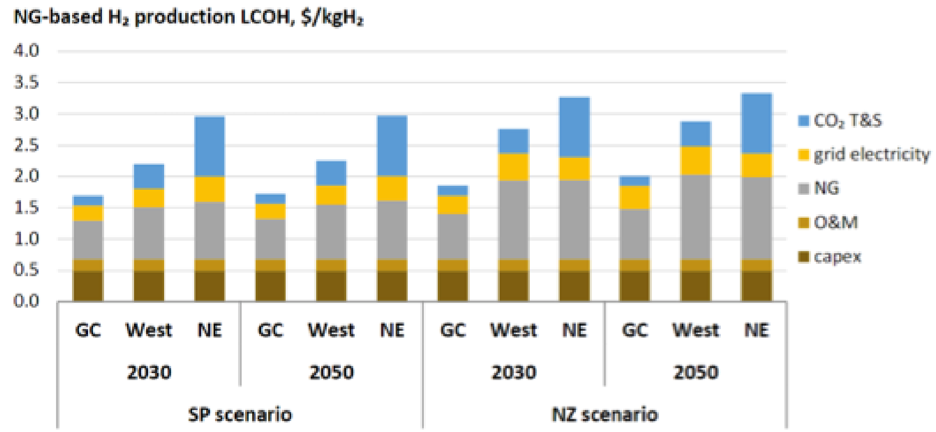
DOE and NPC Hydrogen Production Cost Forecasts

DOE forecasts for cost of H2 without tax credits

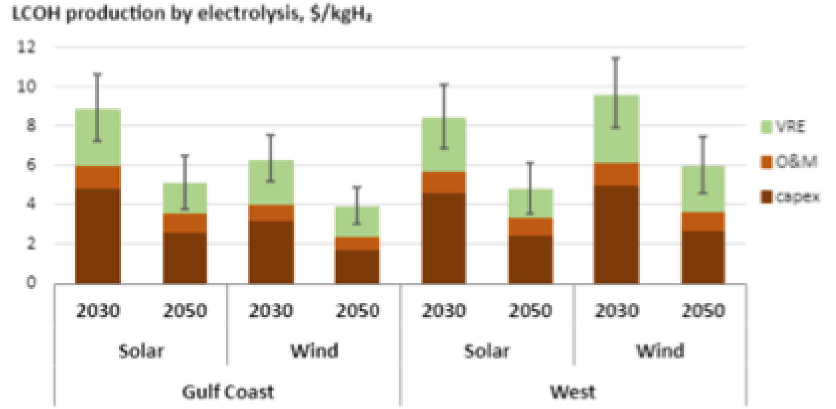
- Green hydrogen production from onshore wind to be $1.2/kg by 2050*.
- Hydrogen production cost will stabilize at $1.2/kg* by 2050.

NPC forecasts for cost of H2 without tax credits

- Green hydrogen production cost in 2050 to be $3.02-5.15/kg, varying by region and policy scenario**.
- Hydrogen production cost in 2050 to be $1.96-3.16/kg, varying by region and policy scenario.



Note: Unsubsidized production via ATR + 95% CO_2 capture. GC = Gulf Coast, NE = Northeast, SP = Stated Policies scenario, NZ = Net Zero scenario. Does not include costs due to California cap and trade regulation.



Note: Unsubsidized production when VRE capacity matches the electrolyzer capacity (no VRE overbuild). Error bars indicate the range of $LCOH_p$ for a low case (capex -\$500/kW_e, power consumption -2 kWh_e/kgH_2 vs. base case) and high case (capex +\$500/kW_e, power consumption +2 kWh_e/kgH_2 vs. base case).

Pathways to Commercial Liftoff - Clean Hydrogen (energy.gov)
(HARNESSING HYDROGEN - A Key Element of the U.S. Energy Future (npc.org)

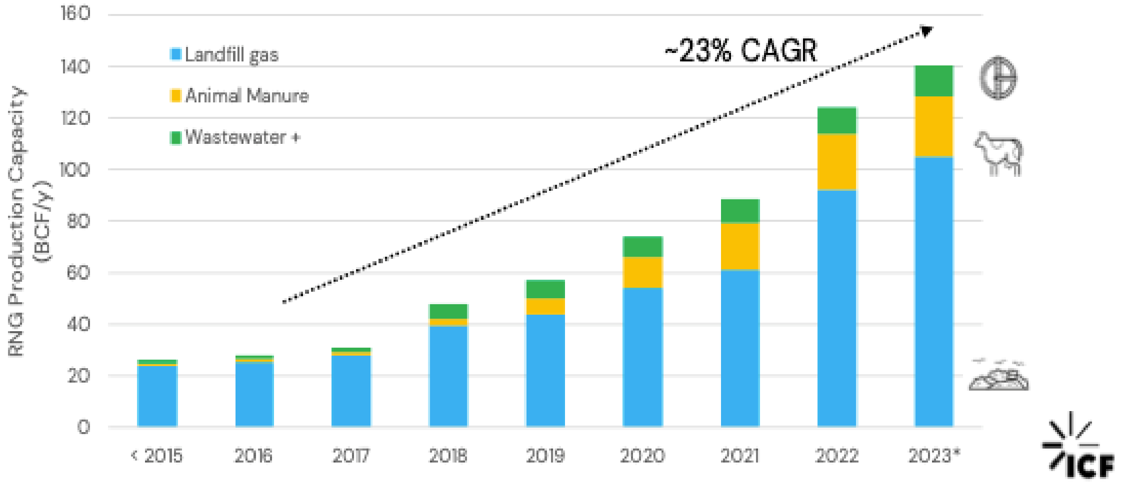
*Assuming $17/MWh; 2020 Dollar
**Assuming $42/MWh-$61/MWh, depending on the region

Biogas/RNG Market Expectations (2024 ICF Outlook)

- **Near-term demand** will come from transportation fuel, utility offtake, and voluntary markets. There is unknown demand emerging for biogas as feedstock for renewable hydrogen production.
- **Demand will outstrip supply until at least 2030.** Though ICF has a more bullish outlook for RNG production than other market analysts (e.g., upside potential of 500 BCF/y by 2030), the demand emerging is considerably higher (see table).
- **Production costs will moderate as larger market actors and utilities continue to engage more.** Market is considered "bespoke" but there are scaling opportunities that can help to moderate costs.
- **Realizing long-term RNG production potential will require feedstock diversification, move towards thermal gasification, and decarbonization policies.** Biogas is in a period of transition—the next 3-5 years will determine if it is a 2-3% decarbonization solution or a 10-15% decarbonization solution.

CHP and industrial sector demand will overlap with "utility offtake" and "voluntary markets" (2030 estimates)

Sector	Est. Demand (BCF/y)	Comments
Transportation Fuel	110	Robust market in California; modest demand in emerging low carbon fuel markets (e.g., Oregon and Washington)
Utility Offtake	550	Boosted by regulatory commitments domestically, including in states like California, Colorado, Minnesota, Nevada, New Hampshire, Oregon, Vermont and in Washington DC
Voluntary Markets	100	Corporate commitments from industrial buyers (e.g., AstraZeneca, L'Oreal) and others (e.g., University of California)

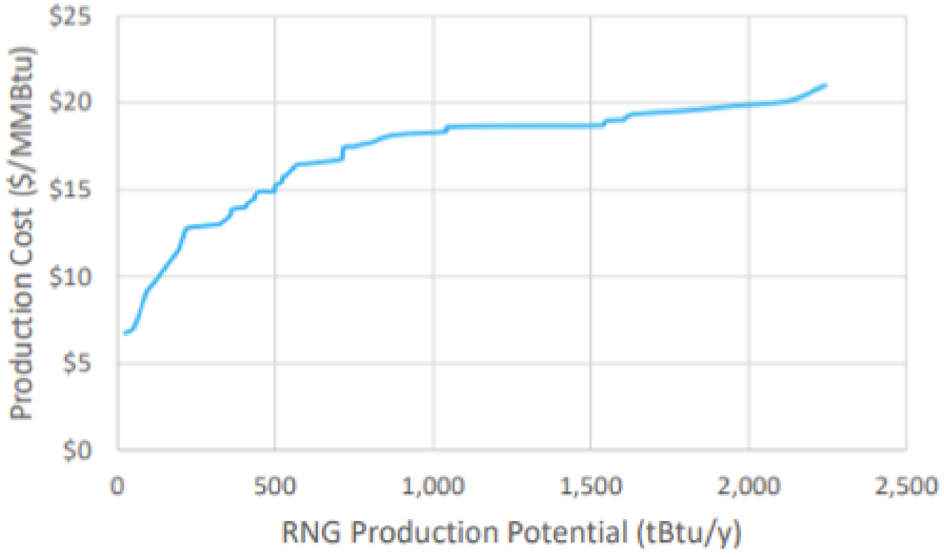


Biogas and RNG Resources: Future Cost Projections (AGF)

Costs are dependent on a variety of assumptions:

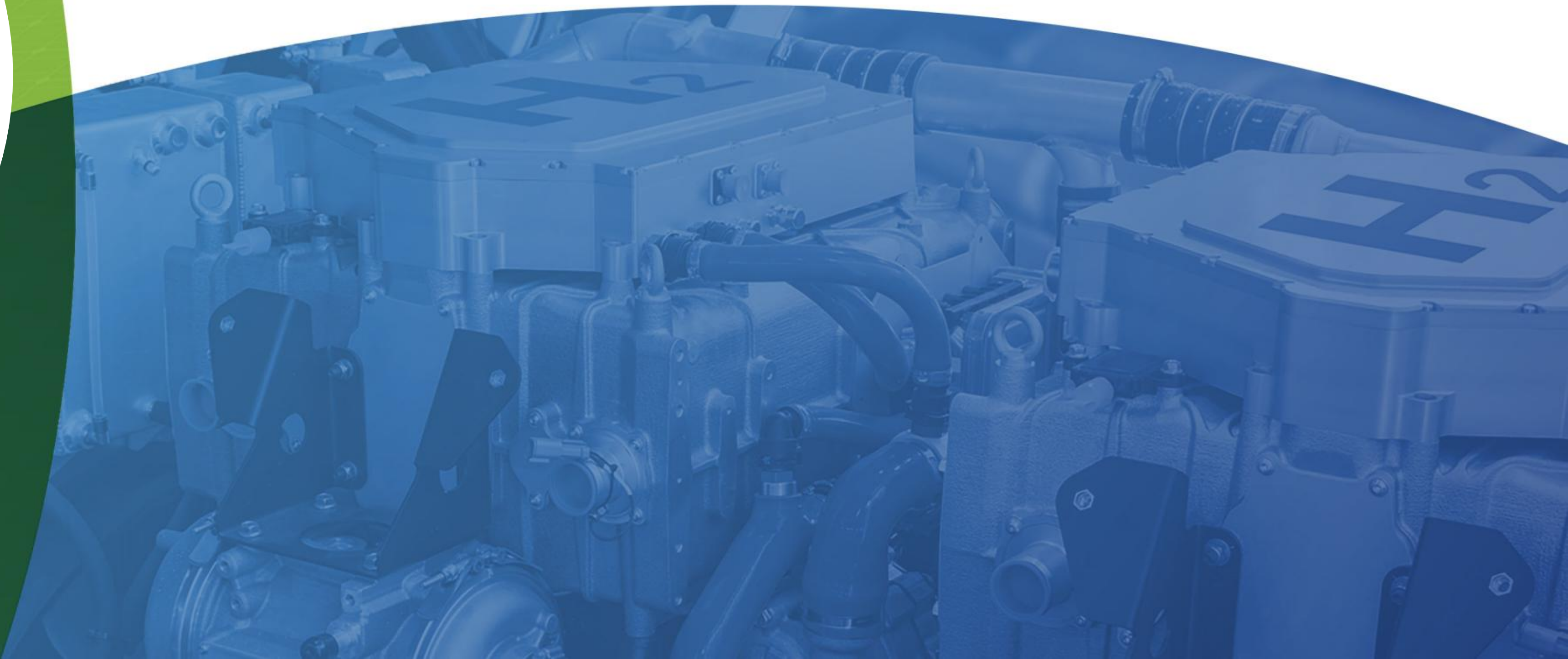
- Feedstock costs.
- Revenue that might be generated via byproducts or other avoided costs.
- Expected rate of return on capital investments.
- Facility size and production capacity.
- Gas conditioning, upgrading, and compression costs.
- According to the American Gas Foundation report, the majority of RNG produced in the high resource potential scenario should be available for under $20/MMBtu in the U.S. in 2040.
- Cost reductions are possible as the RNG for pipeline injection market matures, production volumes increase, and the market evolves.
- Tax credits for biogas have been recently updated. [Transition from IRC section 48 to section 48E](#).

Figure 34. Combined RNG Supply-Cost Curve, less than $20/MMBtu in 2040



Note: After 2020-2025 inflation, these estimates will likely increase by ~25%

Case Studies of Hydrogen, and Direct Use Biogas and Landfill Gas Fueled CHP Systems



Case Studies of Hydrogen, Biogas, and Landfill Gas Fueled CHP Systems

- Hydrogen
  - Duke Energy / Clemson University – South Carolina
  - Eight Flags Energy CHP Plant – Florida
  - District Energy St. Paul – Minnesota
- Biogas [direct use]
  - Paul Bruner Water Pollution Control Plant - Indiana
  - Downers Grover Sanitary District – Illinois
  - St. Cloud Nutrient, Energy and Water (NEW) Recovery Facility– Minnesota
- Landfill Gas [direct use]
  - Gundersen Health - Wisconsin
  - GM Fort Wayne Assembly Plant – Indiana

Duke Energy / Clemson University Clemson, South Carolina

The Duke Energy owned and operated CHP system at Clemson University

Project Snapshot: Utility Partnership Model

Application	Utility + College/University
Capacity	17.8 MW
Prime Mover	Gas Turbines & Steam Turbines
Fuel Type	Natural Gas / Hydrogen
Thermal Use	District Energy
Installation Year	2020

Project Highlights:

Clemson University, Duke Energy, and Siemens Energy partnered on a pilot project to study the use of hydrogen for energy storage and as a fuel source for the CHP plant. The project, called H2-Orange, will evaluate hydrogen production, storage, and co-firing with natural gas. The 15 MW gas turbine is capable of up to 65% hydrogen.

Source: https://chptap.lbl.gov/profile/438/ClemsonUniversityDukeEnergy-Project_Profile.pdf

Project Testimonial

"One of the primary goals in Clemson's Sustainability Plan is for the university to be "a model of energy sustainability" and become carbon neutral by 2030. Combined heat and power, and solar energy combined with various innovative energy storage strategies will play important and complementary roles in achieving this goal over this decade"
- Tony Putnam, Executive Director of Utility Services at Clemson University

"By locating generation sources near load centers with a high thermal demand, this results in one of the most efficient units in the Duke Energy fleet ."
- Zachary Kuznar, Managing Director of Regulated Renewables at Duke Energy

Eight Flags Energy CHP Plant
Fernandina, Florida

Project Snapshot: CHP Hydrogen Test Program

Application	Pulp and Paper Mill
Capacity	23 MW
Prime Mover	Combustion Turbine
Fuel Type	Natural Gas (and hydrogen blending)
Thermal Use	Process Steam, Hot Water
Installation Year	2016

Source: https://www.youtube.com/watch?v=1UaNWrRBMpo

Project Highlights:
Chesapeake Utilities Corporation successfully blended hydrogen with natural gas to power the Company's Eight Flags Energy CHP. The Eight Flags CHP hydrogen test program was intended to refine the operational practices and requirements for safe transportation and injection of hydrogen into a distribution system.

Source: Chesapeake Utilities Corporation Completes Testing of Hydrogen Blending in Continued Move Toward Lower Carbon Energy Sources - Chesapeake Utilities Corporation

Project Testimonial
"Natural gas has been the obvious choice for years; blending hydrogen with natural gas provides even lower carbon impacts without sacrificing the qualities that make natural gas a desired industrial fuel choice."
- Jeff Householder, President and CEO.

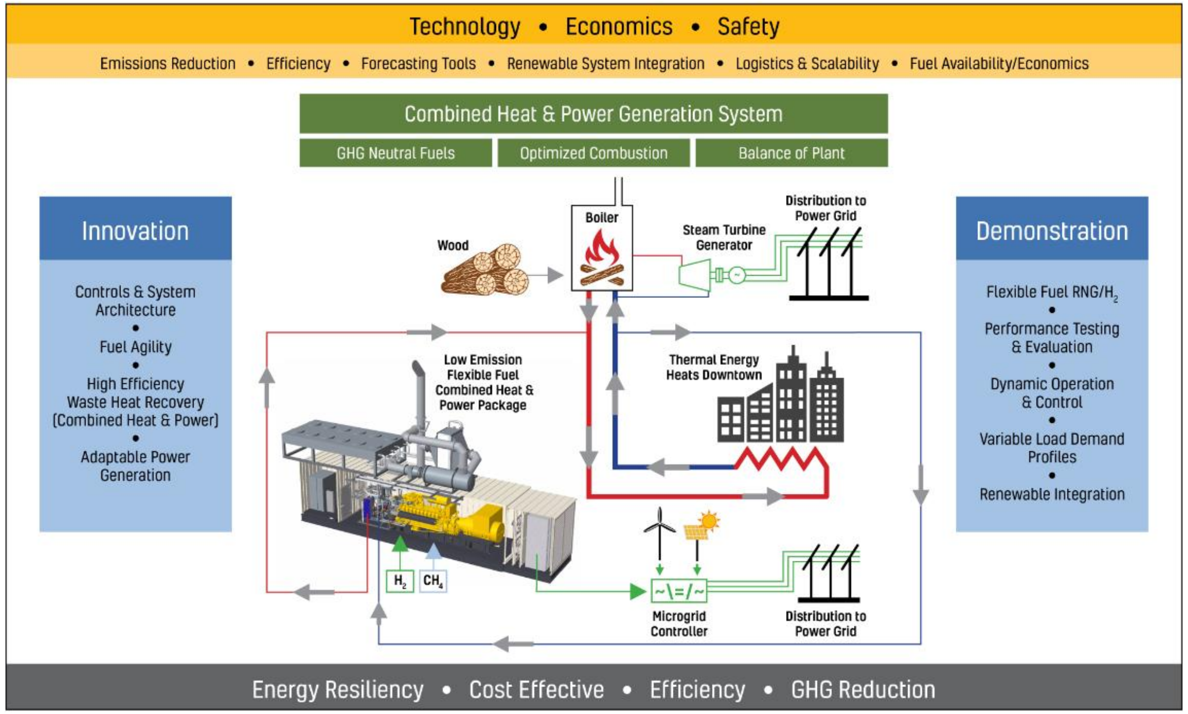
District Energy St. Paul (DESP)
St. Paul, Minnesota

Project Snapshot: Hydrogen Blending R&D Project

Application	Downtown District Energy System
Capacity	2 MW
Prime Mover	Reciprocating Engine
Fuel Type	Hydrogen or Hydrogen Blends
Thermal Use	Space Heating and Cooling
Installation Year	2025

Project Highlights:
Caterpillar Inc., the National Renewable Energy Laboratory (NREL), and District Energy St. Paul will demonstrate a 2MW flexible natural gas/hydrogen combined heat and power (CHP) system at a municipal generating station. This project will demonstrate natural gas/hydrogen flexible fuel CHP systems for stationary power applications.

Source: https://www.energy.gov/sites/default/files/2022-09/1.13%20-%20Singh.pdf



Project Testimonial
"As a leading authority on CHP systems and the deployment of advanced energy technologies that promote sustainability, District Energy St. Paul is the ideal choice for hosting this demonstration. The project will help Caterpillar further extend our expertise in hydrogen-fueled power systems performing under the highest expectations of real-world applications."
- Jason Kaiser, VP for Caterpillar's Electric Power Division

Paul L. Bruner Water Pollution Control Plant
Fort Wayne, Indiana

CITY UTILITIES
WATER THAT WORKS

Project Snapshot: Biogas-Fueled CHP

Application	Wastewater Treatment Plant
Capacity	800 kW
Prime Mover	Reciprocating Engines
Fuel Type	Biogas
Thermal Use	Hot Water
Installation Year	2015

Project Highlights:
In October 2015, the operation of two 400 kW spark ignited, reciprocating engine / generator CHP systems began. The two units have operated, on average, at over 91% availability, providing approximately 6,426,300 kWh annually, satisfying approximately 31.5% of the facility's electric requirements.

Source: https://chptap.ornl.gov/profile/179/Paul_L_Bruner_Water_Pollution_Control_Plant-Project_Profile.pdf

WPCP Anaerobic Digester Tanks
(Photo Courtesy of WPCP)

Two 400kW Engine Driven CHP Systems w/ Heat Recovery
(Photo Courtesy of WPCP)

Project Testimonial
"The installation and operation of the CHP system has provided us both greater operating efficiency and resiliency, while launching our corporate efforts to become energy neutral".
- Douglas J Fasick, Chief Sustainability Officer, City of Fort Wayne

Downers Grove Sanitary District
Downers Grove, Illinois

Downers Grove Sanitary District

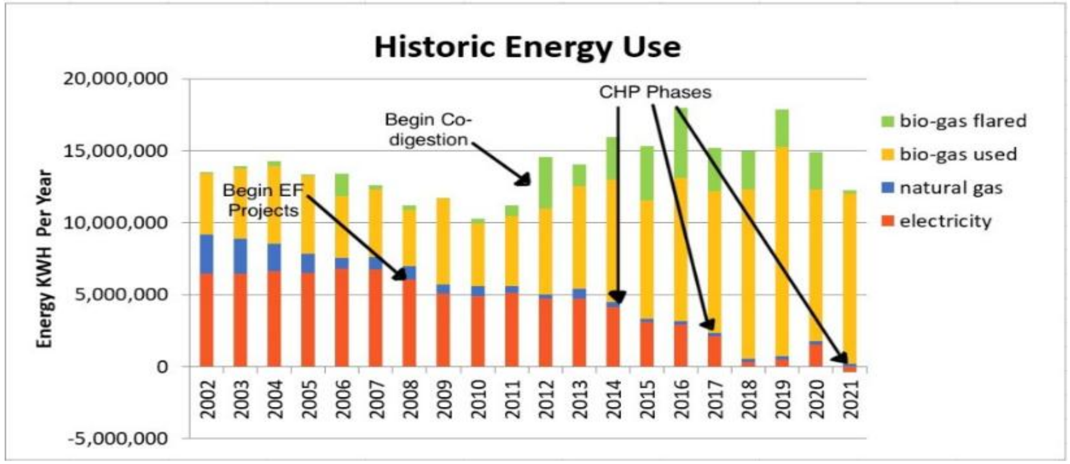
Project Snapshot: Biogas and FOG-Fueled CHP

Application	Wastewater Treatment Plant
Capacity	750 kW
Prime Mover	Reciprocating Engines
Fuel Type	Biogas and Co-Digesting FOG
Thermal Use	Hot Water
Installation Year	2014, 2017, 2021

Project Highlights:
The CHP system is fueled by anaerobic digester generated biogas. This fuel is generated from the plant's five anaerobic digesters, three primary and two secondary, which are utilized to stabilize the sludge removed from the wastewater. The CHP system produces 3,254 kBtu/hr of thermal energy that is recovered in the form of hot water and utilized to keep the mesophilic anaerobic digesters at the proper operating temperature (95° to 98° F) to ensure maximum digester efficiency.

Source: https://chptap.ornl.gov/profile/58/DownersGrove-Project_Profile.pdf

375kW CHP Engine/Generator Set
Source: DGSD



Project Testimonial
"The key to continued net zero energy operation at our plant is maintaining the high availability factor and trouble-free operation with our entire biogas fueled CHP system"
- Amy Underwood PE, General Manager, DGSD

St. Cloud Nutrient, Energy and Water (NEW) Recovery Facility
St. Cloud, Minnesota

CITY OF ST.CLOUD MINNESOTA

Project Snapshot: Microgrid CHP System

Application	Wastewater Treatment Plant
Capacity	1.26 MW
Prime Mover	Reciprocating Engines
Fuel Type	Biogas (including co-digestion)
Thermal Use	Hot Water
Installation Year	2016

CHP Units 1 and 2 – Total 1.26 MW Biogas Fueled
Source: St. Cloud NEW Recovery Facility

220 kW (left, installed 2017) and 240 kW (right, installed 2020) Solar Arrays
Source: St. Cloud NEW Recovery Facility

Project Highlights:
The local utility generated power now serves as a backup to the onsite generated power from the CHP system and solar arrays.

Source: https://chptap.ornl.gov/profile/477/St_Cloud_Nutrient_Energy_and_Water_Recovery_Facility-Project_Profile.pdf

Project Testimonial

"Generating our own power on-site through the use of biogas from our digesters to fuel our CHP system has improved electric service reliability while significantly reducing our natural gas costs."
- Emma Larson, Assistant Public Utility Director

Gundersen Health System
Onalaska, Wisconsin

Project Snapshot: Landfill Gas-to-Energy System

Application	Healthcare
Capacity	1,137 kW
Prime Mover	Reciprocating Engine
Fuel Type	Landfill Gas
Thermal Use	Space Heating/Cooling, Hot Water
Installation Year	2012/2016

CHP Engine Generator Set with Heat Recovery and Gas Clean Up
Source: DOE CHP TAP

Project Highlights:
A landfill gas collection system was already in place at the La Crosse County landfill, located 1.5 miles from the clinic and was collecting an average of 300 cubic feet of landfill gas per minute that was subsequently flared. Recognizing an available resource, Gundersen teamed up with La Crosse County to explore a public-private partnership to develop a landfill gas-to-energy project.

Project Testimonial

"The project (cost) is paying back quite nicely because it's off-setting a big portion of our electricity bill as well as our natural gas bill and we're providing a revenue stream for the county."
- Jeff Rich, Executive Director, GL Envision, Gundersen Health System

"This is a good use of a previously unused natural resource and it is an excellent example of what a public-private partnership can achieve in our community."
- Hank Koch, Solid Waste Director, La Crosse County

Source: https://chptap.ornl.gov/profile/92/GundersenOnalaska-Project_Profile.pdf

GM Fort Wayne Assembly Plant
Fort Wayne, Indiana

Project Snapshot: LFG CHP – DOE Better Project Award

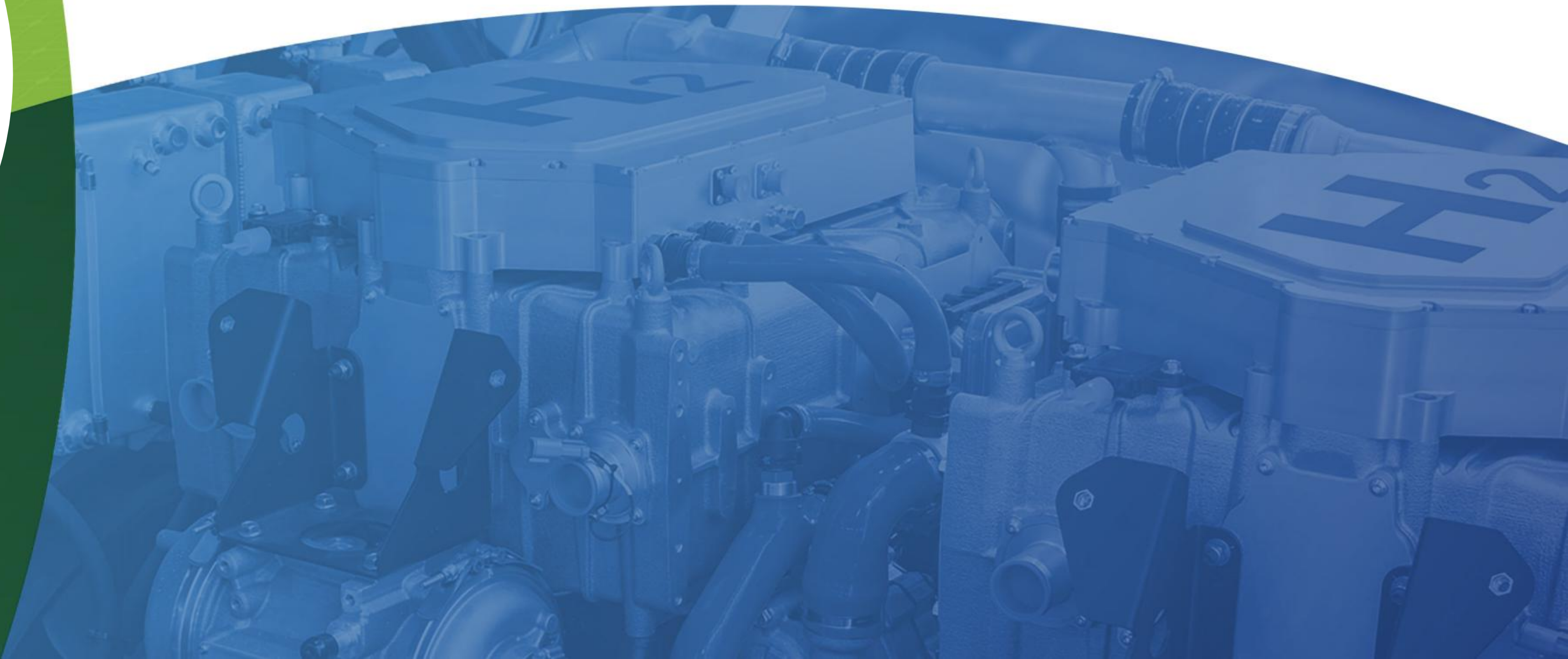
Application	Manufacturing
Capacity	1,600 kW
Prime Mover	Reciprocating Engines
Fuel Type	Landfill Gas
Thermal Use	Space Heating/Cooling
Installation Year	2020

Project Highlights:
Heat recovery units were added to existing landfill gas powered generators and now 80% of the site's building heating needs are met by the recovered waste heat.

Source: https://chpalliance.org/wp-content/uploads/2019/08/DOE-IEDO_Meegan-Kelly.pdf

Project Testimonial
"As a Better Climate Challenge Goal Achiever, GM has reduced its greenhouse gas emissions by 50% and is sharing its successful strategies with others. Learning from leaders is key to accelerating the clean energy economy of the future."
- Jeff Marootian, Principal Deputy Assistant Secretary for Energy Efficiency and Renewable Energy

Connect with your Regional Onsite Energy TAP



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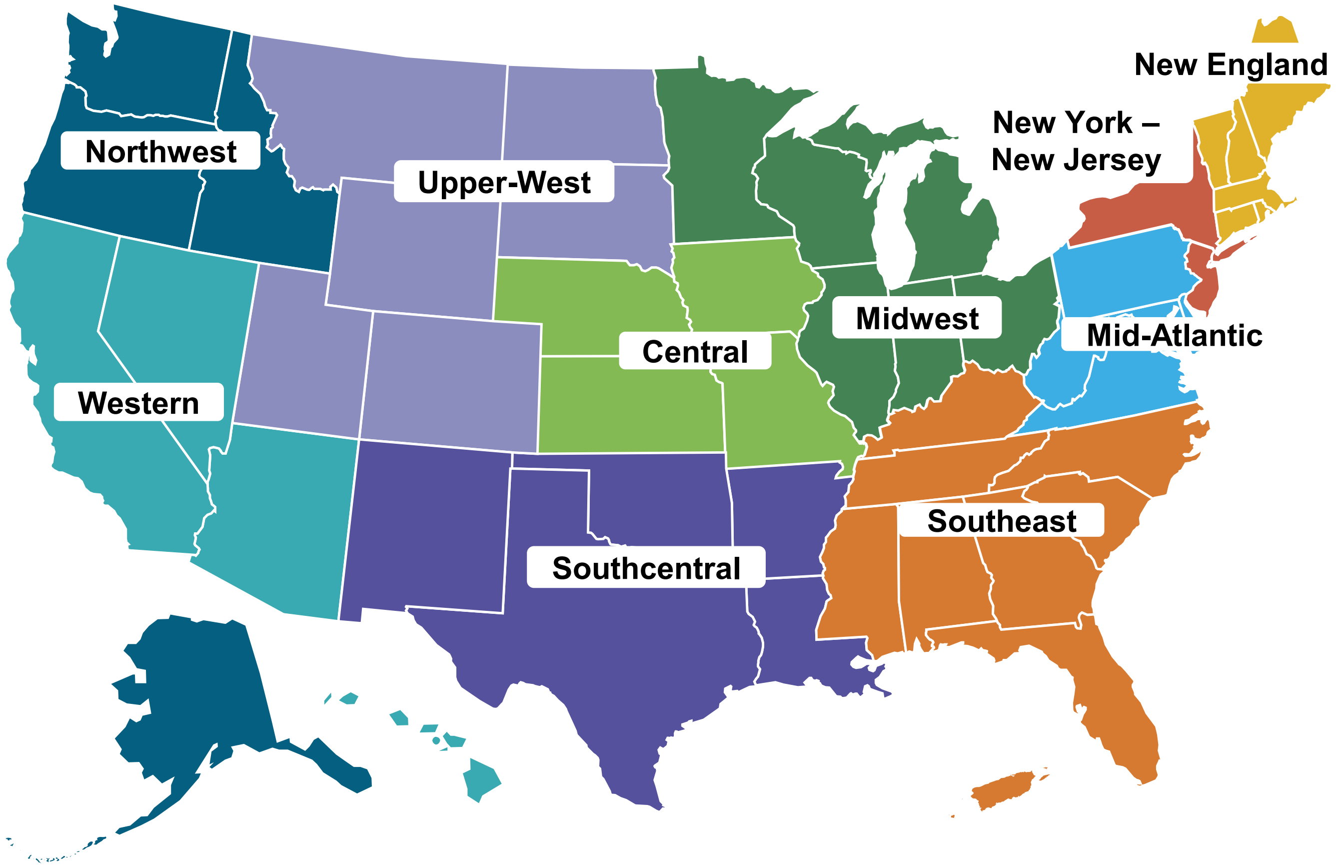
Onsite Energy Technical Assistance Partnerships
U.S. DEPARTMENT OF ENERGY



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