

CHP 101

Concepts, Technologies, Benefits and Opportunities

**The National Summit on Combined Heat and Power
September 13, 2021**

Cliff Haefke

US DOE Midwest & Central CHP Technical Assistance Partnership
Energy Resources Center, University of Illinois Chicago



CHP Technical Assistance Partnerships

Agenda

- Intro to DOE CHP TAP
- CHP Concepts
- CHP Technologies
- CHP Opportunities
- CHP Resources

U.S. DOE CHP Technical Assistance Partnerships (CHP TAPs)

- **End User Engagement**

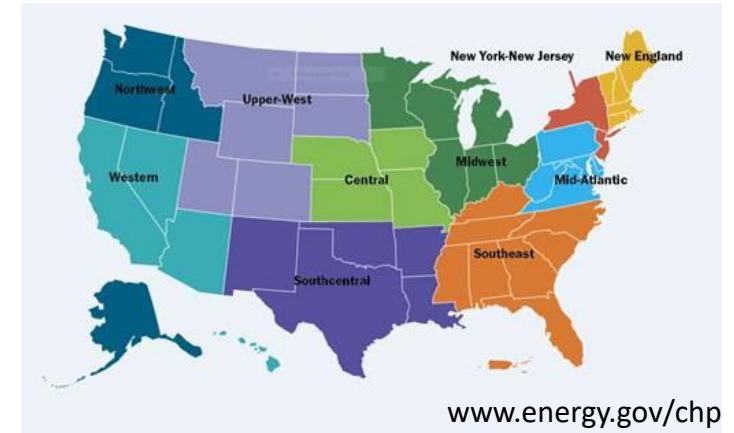
Partner with strategic End Users to advance technical solutions using CHP as a cost effective and resilient way to ensure American competitiveness, utilize local fuels and enhance energy security. CHP TAPs offer fact-based, non-biased engineering support to manufacturing, commercial, institutional and federal facilities and campuses.

- **Stakeholder Engagement**

Engage with strategic Stakeholders, including regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP to advance regional efficiency, promote energy independence and enhance the nation's resilient grid. CHP TAPs provide fact-based, non-biased education to advance sound CHP programs and policies.

- **Technical Services**

As leading experts in CHP (as well as microgrids, heat to power, and district energy) the CHP TAPs work with sites to screen for CHP opportunities as well as provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.



National Manufacturing Day 2019 at the University of Illinois at Chicago

DOE CHP Technical Assistance Partnerships (CHP TAPs)

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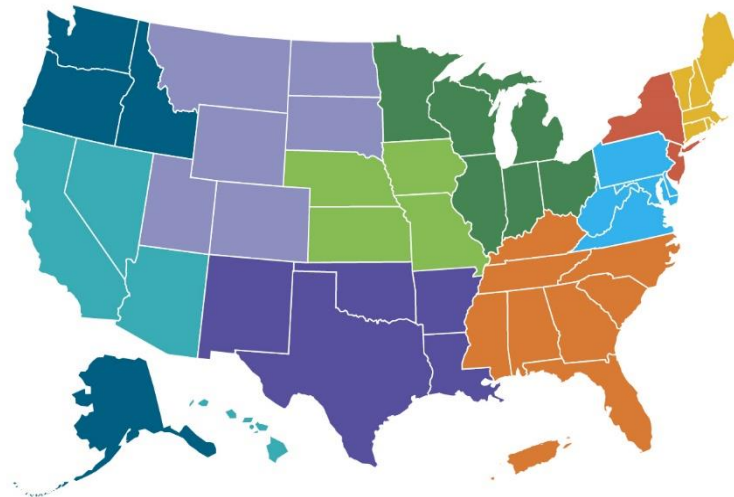
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CHP: A Key Part of Our Energy Future

- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
 - Space Heating / Cooling
 - Process Heating / Cooling
 - Dehumidification

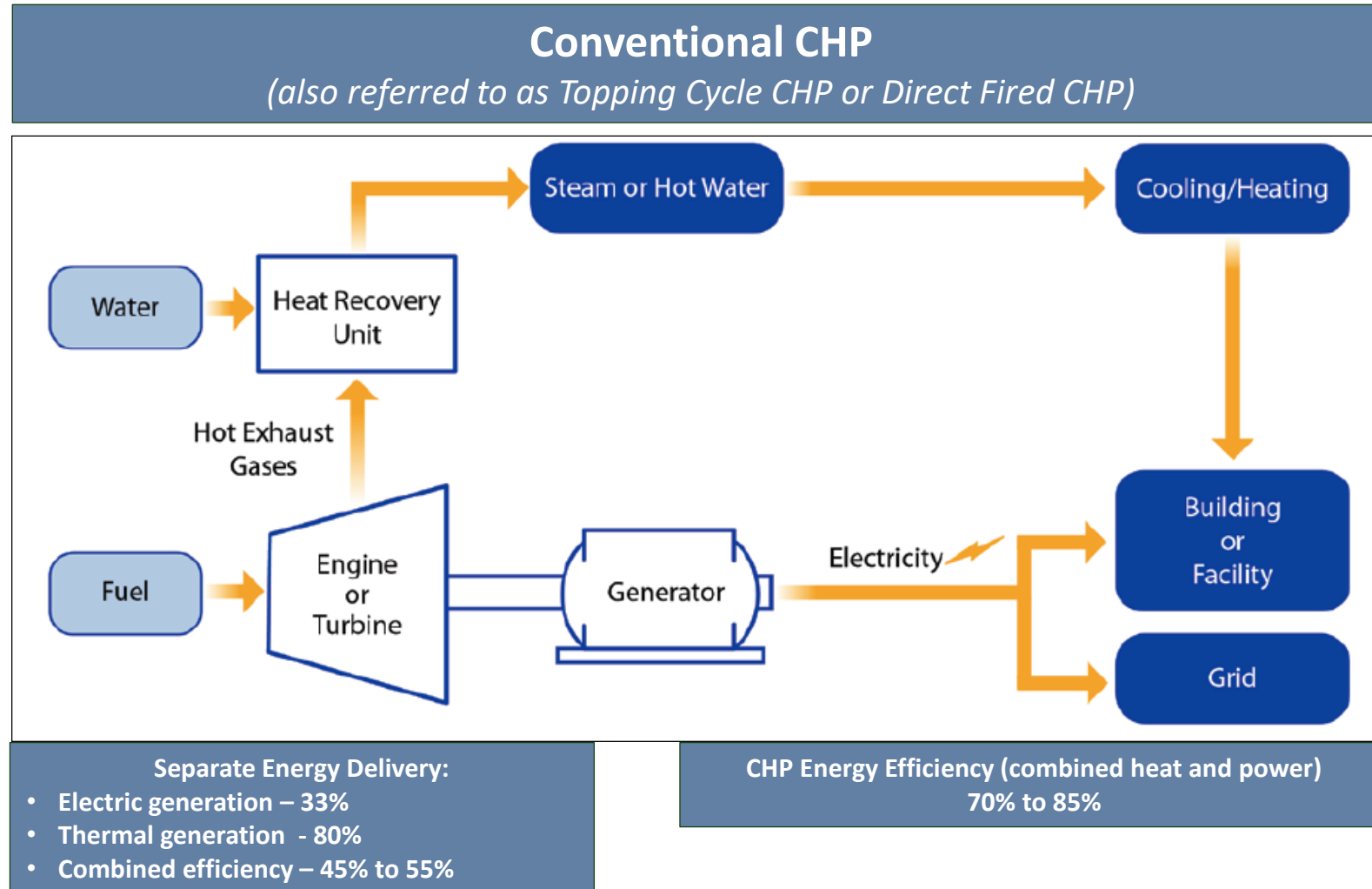


CHP applications can operate at about 75% efficiency, a significant improvement over the national average of about 50% for these services when provided separately.

Source: <https://www.energy.gov/eere/amo/combined-heat-and-power-basics>

Defining Combined Heat & Power (CHP)

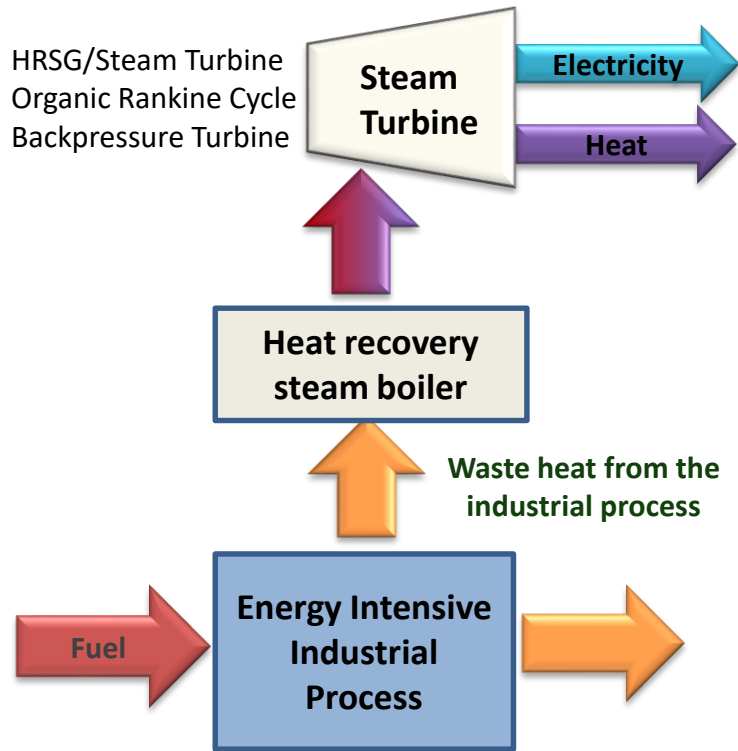
The on-site simultaneous generation of two forms of energy (heat and electricity) from a single fuel/energy source



Defining Combined Heat & Power (CHP)

The on-site simultaneous generation of two forms of energy (heat and electricity) from a single fuel/energy source

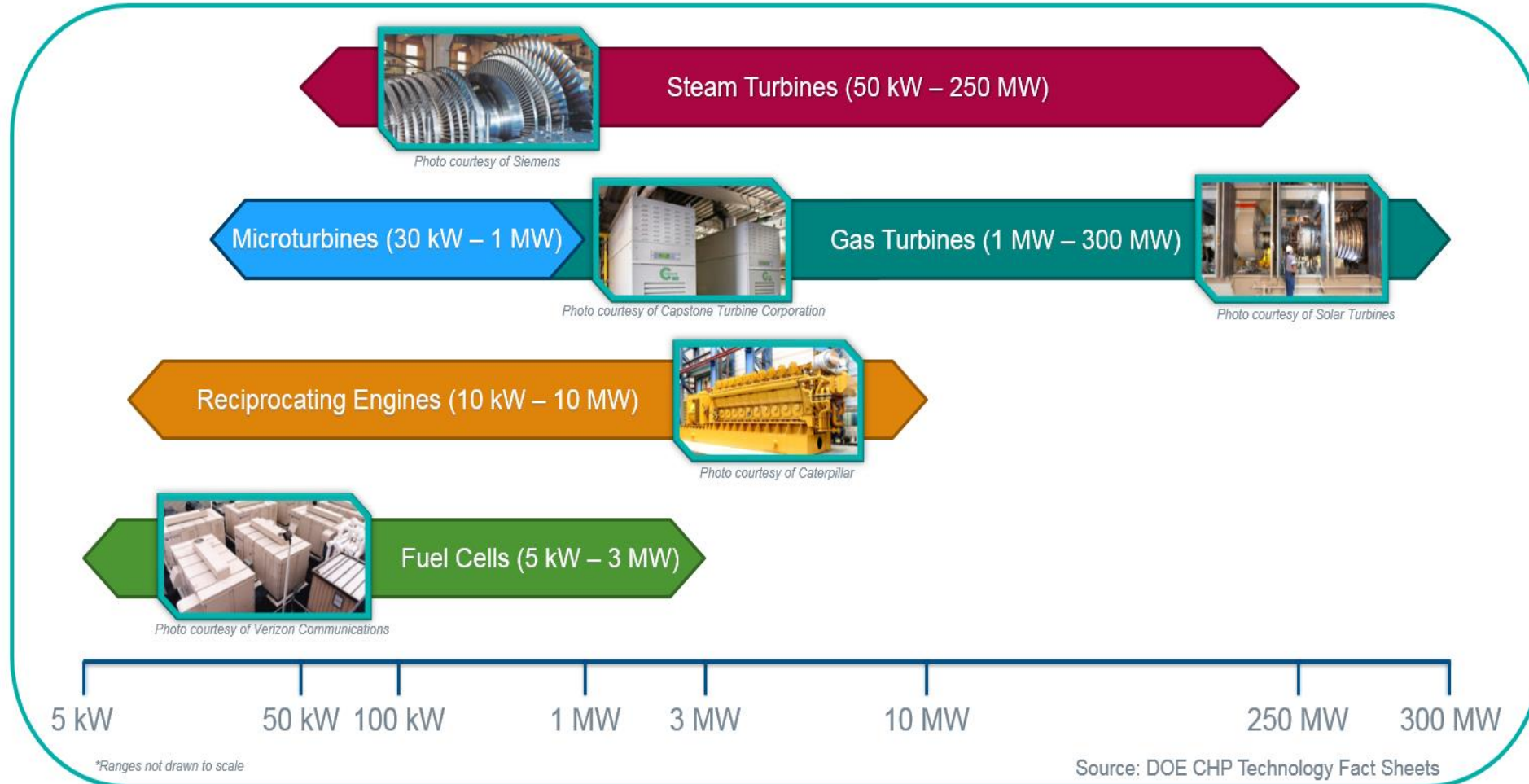
Waste Heat to Power CHP (also referred to as Bottoming Cycle CHP or Indirect Fired CHP)



- Fuel first applied to produce useful thermal energy for the process
- Waste heat is utilized to produce electricity and possibly additional thermal energy for the process
- Simultaneous generation of heat and electricity
- No additional fossil fuel combustion (*no incremental emissions*)
- Normally produces larger amounts electric generation (*often exports electricity to the grid; base load electric power*)



CHP Technology Prime Movers



Heat Recovery

Heat Exchangers

- Recover exhaust gas from prime mover
- Transfers exhaust gas into useful heat (steam, hot water) for downstream applications
- Heat Recovery Steam Generators (HRSG) the most common

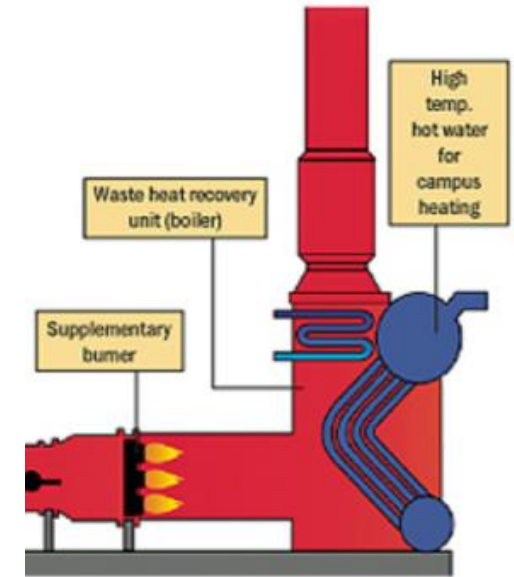


Image Source: University of Calgary

Heat-Driven Chillers

- Absorption Chiller
 - Use heat to chill water
 - Chemical process (not mechanical)
- Steam Turbine Centrifugal Chiller

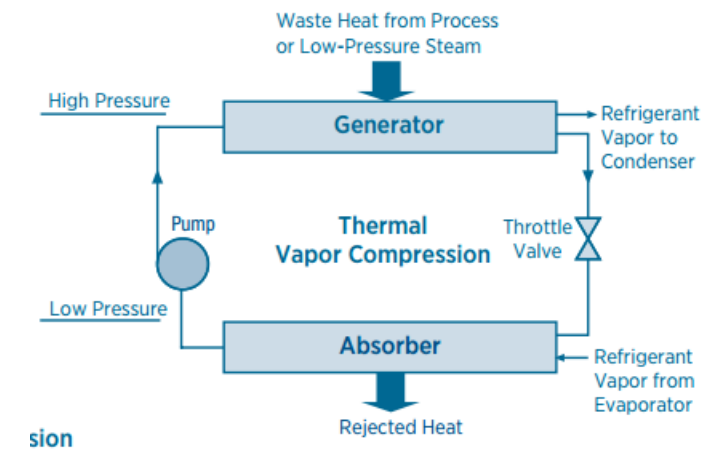


Image Source: DOE - EERE

What Are the Benefits of CHP?

- CHP is **more efficient** than separate generation of electricity and heating/cooling
- Higher efficiency translates to **lower operating costs** (but requires capital investment)
- Higher efficiency **reduces emissions** of pollutants
- CHP can also increase **energy reliability** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.

Critical Infrastructure and Resiliency Benefits of CHP

“Critical infrastructure” refers to those assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, national economic security, or national public health and safety.”

Patriot Act of 2001 Section 1016 (e)

Applications:

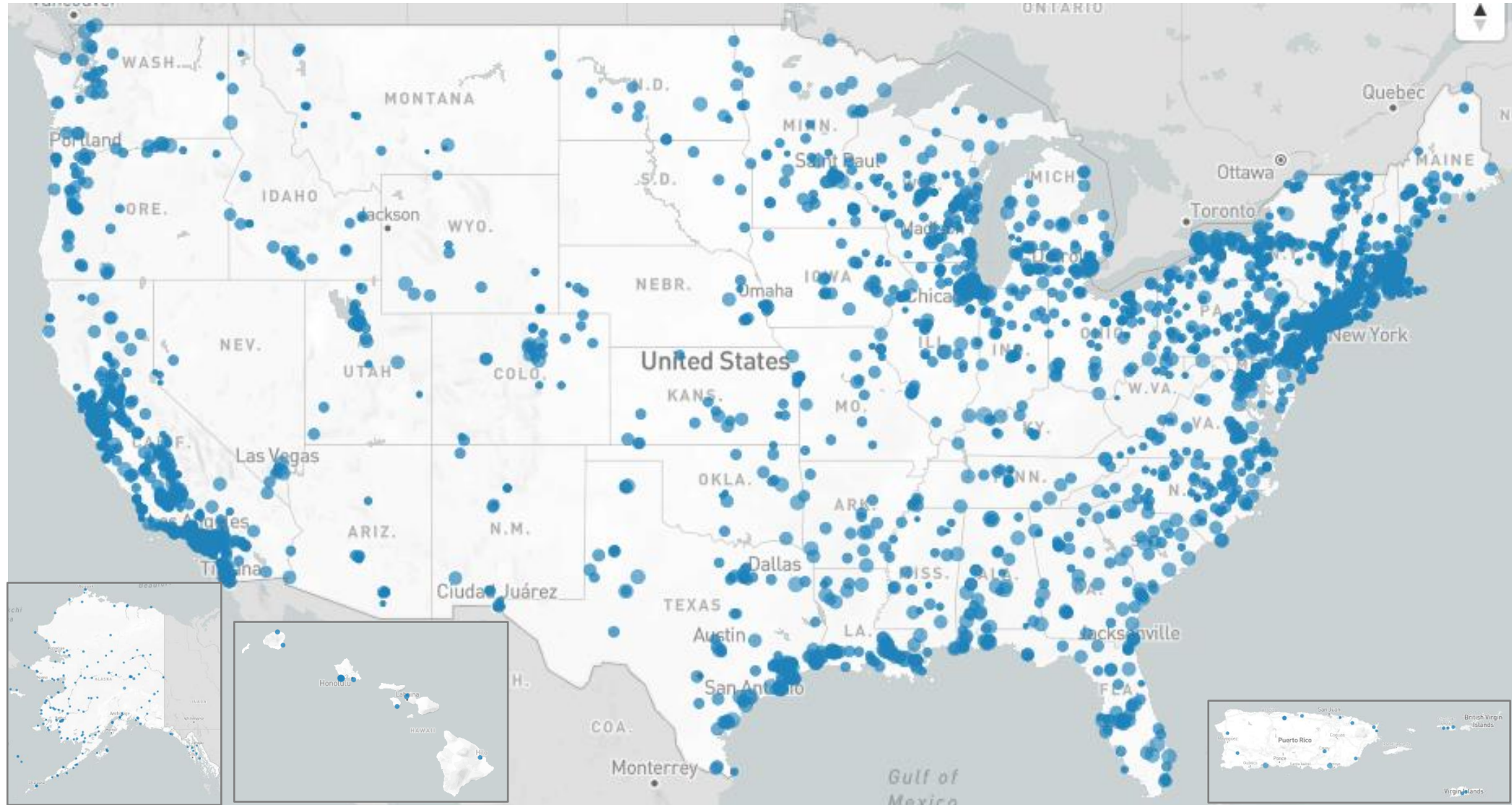
- Hospitals and healthcare centers
- Water / wastewater treatment plants
- Police, fire, and public safety
- Centers of refuge (often schools or universities)
- Military/National Security
- Food distribution facilities
- Telecom and data centers

CHP (if properly configured):

- Offers the opportunity to improve Critical Infrastructure (CI) resiliency
- Can continue to operate, providing uninterrupted supply of electricity and heating/cooling to the host facility



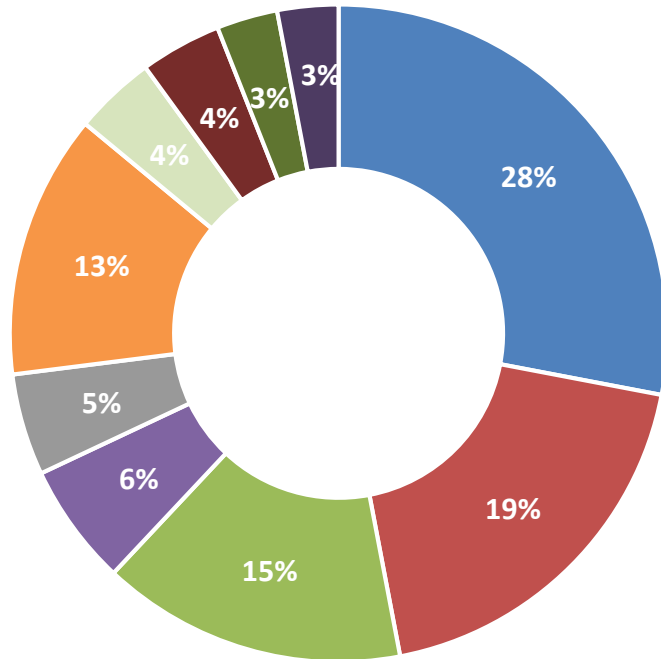
CHP Today in the United States



Slide prepared on 2-26-21

CHP Today in the United States

Existing CHP Capacity



- Chemicals
- Refining
- Pulp & Paper
- Food Processing
- Primary Metals
- Other Industrial
- Utilities
- District Energy
- Colleges/Universities
- Other

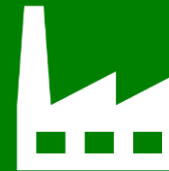
Source: DOE CHP Installation Database (U.S. installations as of December 31, 2020)



Avoids more than **1.3 quadrillion Btus** of fuel consumption annually.



Avoids **210 million metric tons of CO₂** compared to separate production.



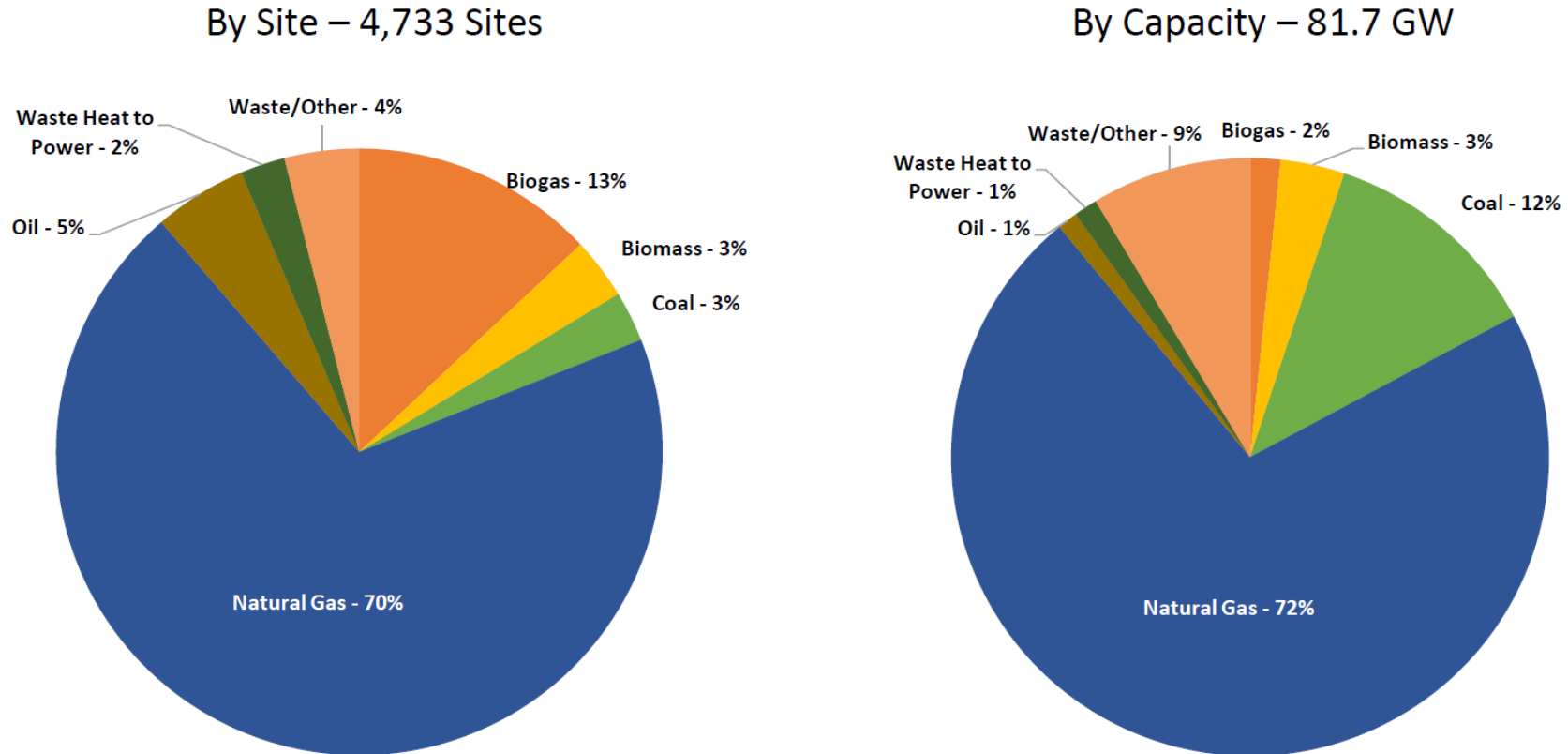
81.7 GW of installed CHP at more than **4,700** industrial and commercial facilities.



7% of U.S. electric generating capacity



CHP is Fuel Flexible



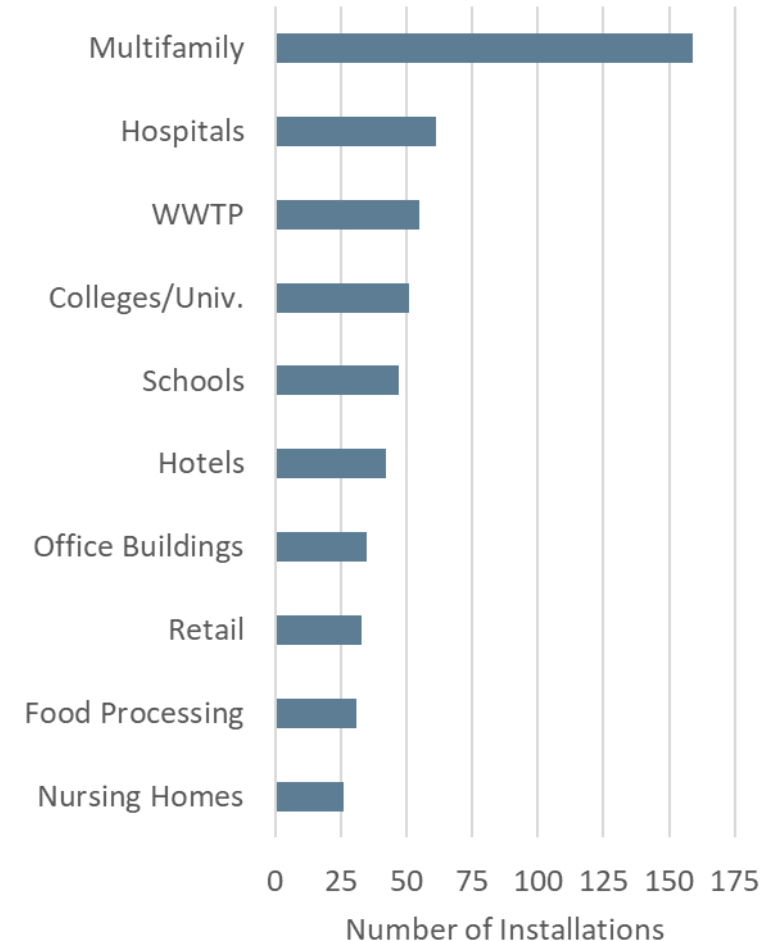
Source: DOE CHP Installation Database (U.S. installations as of December 31, 2020)

Growing Interest in lower-carbon fuels including RNG and Hydrogen

CHP Market Trends

- Growing activity in non-traditional CHP markets (light industrial, commercial, institutional, multi-family) – 88% of installs
- Move toward smaller CHP installations - recip engines and microturbines make up 77% of installs
- Increase in packaged CHP system offerings (DOE Packaged Systems eCatalog)
- Resilience emerging as a key driver, especially for critical infrastructure applications and microgrids
- Increasing interest in hybrid systems that integrate CHP with renewables and energy storage
- Looking for complete solutions and flexible financing solutions
- Questions on CHP's role in decarbonization

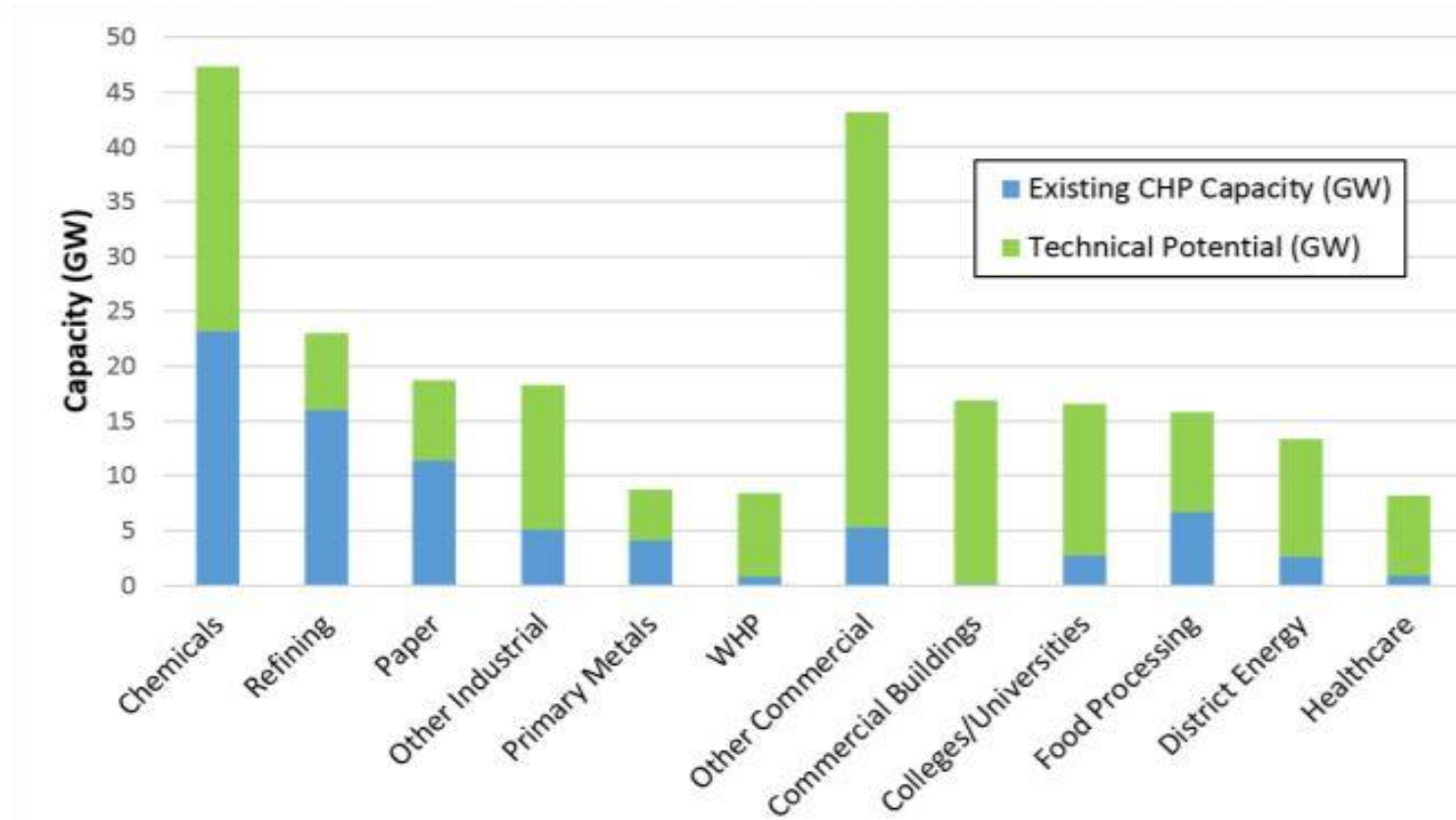
Top CHP Applications 2015-2019



Source: DOE CHP Installation Database (U.S. installations as of August 31, 2020)

Where is the Remaining Potential for CHP?

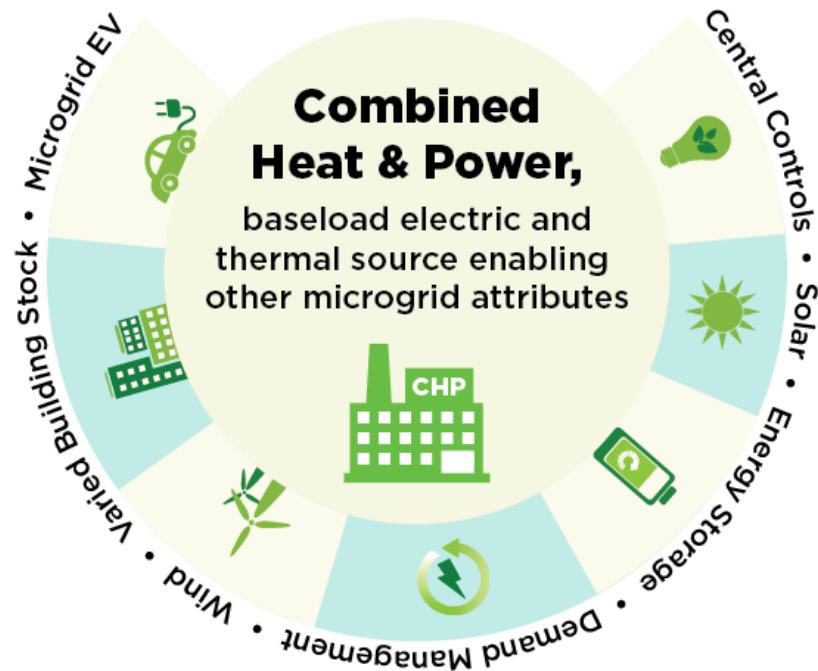
Existing CHP Compared to On-Site Technical Potential by Sector



U.S. Dept. of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States", March 2016.



CHP Can Enable Other Microgrid Technologies



A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid.

A microgrid can connect and disconnect from the larger utility grid to enable it to operate in both grid-connected or island-mode.

With a CHP system providing baseload electric and thermal energy, microgrids can add:

- Solar and wind resources
- Energy storage
- Demand management
- Central controls
- Electric vehicle charging

Flexible CHP systems can ramp up and down as needed to balance renewable loads and provide grid services



Growing Utility Participation

Utility-Owned CHP for Grid Generation

- Build, own, and operate CHP at customer sites as part of resource planning



CHP as a Distribution System Resource

- Encourage customers to install CHP as non-wires alternative to enhance grid stability, alleviate grid congestion, or defer investments



CHP in Utility Energy Efficiency Portfolio

- Encourage customers to install CHP to gain low-cost energy savings



US DOE Packaged CHP Systems eCatalog

Launched Nov 8, 2019

39 recognized Packagers

23 recognized Solution Providers

260 Package Offerings

- 193 reciprocating engine
- 74 microturbine
- 4 gas turbine
- 235 natural gas
- 35 digester gas
- 18 hydrogen blends
- 24 kW to 16.7 MW
- Multiple suppliers and packages in every zip code

10 Customer Engagement Partners

*June 10, 2021 Status

The screenshot displays the eCatalog interface with the following components:

- Search Filters (Left Panel):**
 - FOCUS YOUR RESULTS:** reset | save search | favorites
 - PRIMARY SITE LOCATION:** Zip Code (Selected: Somerset, NJ)
 - SUPPLIER PRIORITY:**
 - Packagers offering Recognized systems
 - Solution Providers offering, installing, commissioning and maintaining Recognized systems
 - Solution Providers offering Assurance Plans
 - Solution Providers offering Energy Services
 - CUSTOMER ENGAGEMENT PARTNER:**
 - Prioritize program-eligible packaged systems
 - POWER OUTPUT (kW):** Help Me Choose (kW, Size)
 - Consider Multiple Units
 - *Default includes a max. of 120% of unit size and a min. of 70% of unit size.
 - PRIME MOVERS:**
 - Reciprocating engines (168)
 - Combustion turbines (2)
 - Microturbine (122)
 - THERMAL OUTPUTS:**
 - Hot Water Only (209)
 - Hot Water and Chilled Water (1)
 - Steam Only (2)
 - Steam and Hot Water (16)
 - Steam, Hot Water, and Chilled Water (4)
 - FUEL TYPE:**
 - Natural Gas (285)
 - Digester Gas (7)
 - GRID CONNECTION TYPE:**
 - Grid Parallel Only (83)
 - Grid Island, Black Start, Auto Transfer (192)
 - OUTDOOR INSTALLATION:**
 - Required (180)
- Product Listings (Main Area):**
 - Showing 187 packages ordered by Relevance.
 - Filters: AV Available, SP Solution Provider, AP Assurance Plan, CS Local Support, CO Outdoor Install, FP Within Footprint, U.S.A. Packaged, Installed, Favorite.
 - AVUS 1500C NG:** 2G logo, Power Output: 1,508 kW, Fuel: Natural Gas, Prime Mover: 1x Reciprocating engine, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - C800S-ICHPP HPNG DM MAX EFFICIENCY:** ELG logo, Power Output: 800 kW, Fuel: Natural Gas, Prime Mover: 4x Microturbine, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - ECOMAX 9 NGS 1.1 HW:** AB logo, Power Output: 838 kW, Fuel: Natural Gas, Prime Mover: 1x Reciprocating engine, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - CG132B-16 POWER HEAT MAX CONTAINER NG:** CAT logo, Power Output: 784 kW, Fuel: Natural Gas, Prime Mover: 1x Reciprocating engine, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - QUANTO 800 C:** QUANTO logo, Power Output: 784 kW, Fuel: Natural Gas, Prime Mover: 1x Reciprocating engine, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - MEG S1000N-HW:** MARTIN ENERGY GROUP logo, Power Output: 988 kW, Fuel: Natural Gas, Prime Mover: 1x Reciprocating engine, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - AVUS 2000C NG:** UNISON logo, Power Output: 1,928 kW, Fuel: Natural Gas, Prime Mover: 1x Reciprocating engine, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - CPT - SOLAR TURBINE - TAURUS 70:** COGEN logo, Power Output: 7,501 kW, Fuel: Natural Gas, Prime Mover: 1x Combustion turbines, Grid Connection: Black Start, Auto. FULL MATCH (100%).
 - XRGI 25:** Lochinvar logo, Power Output: 24 kW, Fuel: Natural Gas, Prime Mover: 1x Reciprocating engine, Grid Connection: Parallel Only. FULL MATCH (100%).

<https://chp.ecatalog.lbl.gov//>

More Presentations from DOE Representations this Week



CHP Technical Assistance Partnerships (DOE)

- 9/13, 3:30PM ET
- Gavin Dillingham
 - Director, DOE Southcentral and Upper West CHP TAP
 - Program Director, Houston Advanced Research Center



CHP Workforce and Jobs

- 9/14, 3:15PM ET
- Anne Hampson
 - Technical Partnerships Program Manager, U.S. DOE Advanced Manufacturing Office



CHP Technologies: Microgrids and District Energy

- 9/15, 11:00AM ET
- Carol Denning
 - Director, US DOE Western CHP TAP
 - Center for Sustainable Energy



Summary

- CHP can provide lower operating costs, reduced emissions, increased energy reliability, enhanced power quality, and reduced grid congestion
- A variety of CHP technologies and sizes are available
- Trends are showing growing activity in non-traditional CHP markets, movement towards smaller CHP installations, and increased interest in hybrid systems and lower carbon fuels
- CHP resources are available at www.energy.gov/chp and through the DOE CHP TAPs (www.energy.gov/chptap)

Thank You

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CHP Technical Assistance Partnerships

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