U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Advanced Manufacturing Office

Securing a Decarbonized Future with Combined Heat and Power

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DOE Priorities: Catalyze Economy-Wide Decarbonization

BIDEN ADMINISTRATION CLIMATE GOALS

A carbon pollution-free power sector by 2035

Net-zero emissions by 2050

Make basic and applied research breakthroughs

Turn that research into deployable technologies

Catalyze deployment of clean energy and decarbonization technologies

- **CREATE GOOD-PAYING JOBS**
  associated with the fast-growing global market for products that reduce carbon emissions
- **PURSUE ENVIRONMENAL AND ENERGY JUSTICE**
  and target disadvantaged communities for new clean energy investments, jobs, and businesses
- **COLLABORATE ROBUSTLY**
  across the federal government, the fifty states, and the private sector

VISION

Expanded CHP as the Heart of Power and Thermal Generation in a Decarbonized Future

CHP systems fueled by biogas and biofuels, RNG, and hydrogen have a key role to play.

Achieving a net-zero carbon future will require a historic transformation in how the U.S. produces energy. Net-zero fueled combined heat and power technologies are primed for a substantial expansion, driving deeper emissions savings while offering a range of benefits in a decarbonized grid.

Unlocking decarbonization for energy-intensive sectors reliant on thermal energy.

Economically stabilizing a resilient, renewable-heavy grid.

Supporting competitiveness for manufacturers through new revenue models.

Net-zero carbon fuels yield deeper carbon savings

TODAY

Today's annual CHP emissions reductions of ~215 million tons of CO_2 per year equal:

42 million
passenger vehicles driven for one year

35 million
homes' electricity use for one year

215 billion
pounds of coal burned (one million railcars)

150,000
additional wind turbines

If today's CHP installations convert to renewable fuels

669 million tons/year
of carbon emissions could be reduced
– *over 35% of electric sector emissions*

422 million
tons/year from displaced grid emissions

247 million
tons/year from displaced thermal energy

If current CHP installations shifted to using 100% net-zero carbon fuels by 2030 while the grid reached zero carbon emissions in 2035,

a total of

2.0 billion tons of CO_2
would be avoided

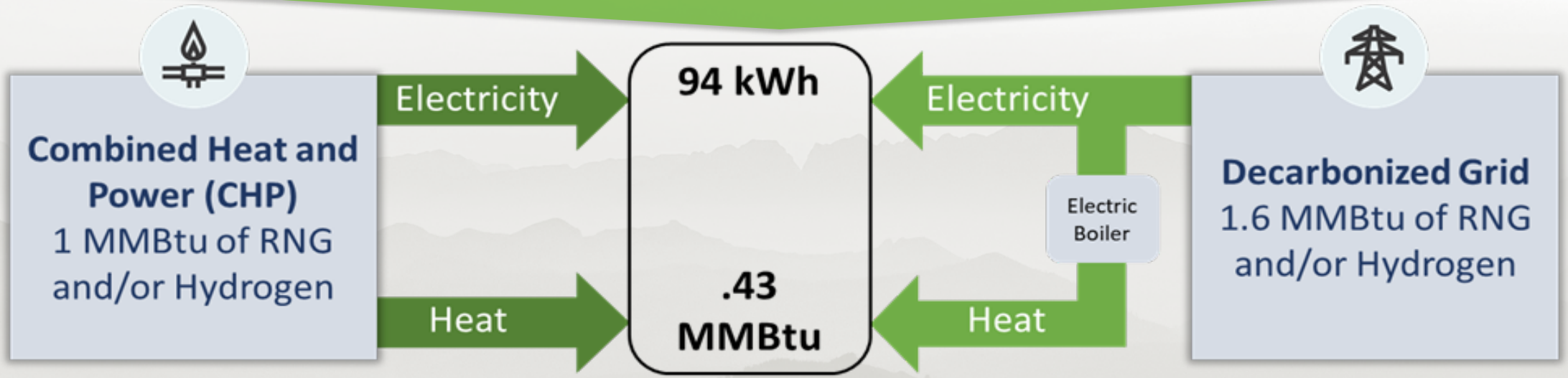
TOMORROW

*Internal ICF analysis using 2019 regional EPA AVERT emissions factors for displaced grid electricity

CHP: Uniquely Suited for Decarbonizing the Industrial Sector

CHP is uniquely positioned to accelerate the industrial decarbonization by addressing the need for high pressure steam and high temperature direct heat.

The industrial sector is slated to require fuel well into the future.
CHP will remain the most efficient way to use net-zero fuels.



60% more RNG or hydrogen would be required to produce the same amount of electricity and heat with grid power and an electric boiler compared to CHP.

Infrastructure Bill – Opportunities for CHP

Section 40521 – Future of Industry Program and Industrial Research and Assessment Centers ($400M)

- Grants for covered projects at small-to-medium manufacturers that increase energy efficiency or reduce emissions, recommended by an IAC, CHP TAP, or 3rd party energy assessment
- Up to $300,000 and not more than 50% of project cost

Section 40209 – Advanced Energy Manufacturing and Recycling Grant Program ($750M)

- Grants for advanced energy property at small-to-medium manufacturers in census tracts near closed coal mines or closed coal power plants

Section 40556 – Model Guidance for CHP Systems and WHP Systems

- Review existing rules and procedures relating to interconnection service and additional services throughout the United States for electric generation with nameplate capacity up to 150 megawatts connecting at either distribution or transmission voltage levels to identify barriers to the deployment of combined heat and power systems and waste heat to power systems.

Looking Forward: AMO's CHP Activities

R&D Activities

for flexible, net-zero fueled CHP that support the electric grid on demand while meeting the host site electric and thermal loads.

- power electronics for seamless connection to the grid
- system designs for efficient part-load operation

CHP Technical Assistance

providing resources for CHP implementation that improves resilience and decreases emissions

- CHP as a valuable distributed generation option, among renewables and storage
- market resources covering fuel, system sizing, etc.

U.S. Manufacturing Support

for a strong, diverse American manufacturing sector that leads the world in sustainability & innovation

- workforce development
- community-based manufacturing assistance
- Justice40

CHP Market Trends

Move toward smaller CHP installations in "non-traditional" CHP applications – Packaged CHP Systems

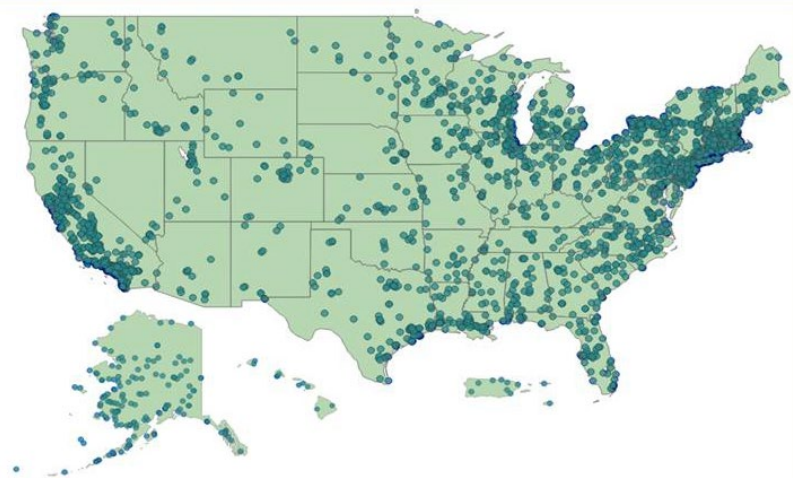
Value of resilience as a key driver for CHP

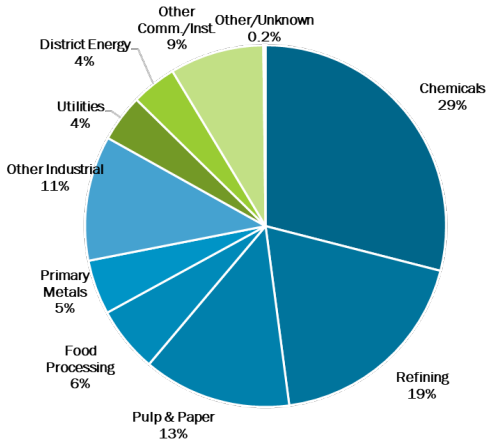
CHP as an anchor for resilient microgrids

Micro CHP

Growing interest in CHP by utilities

Challenges

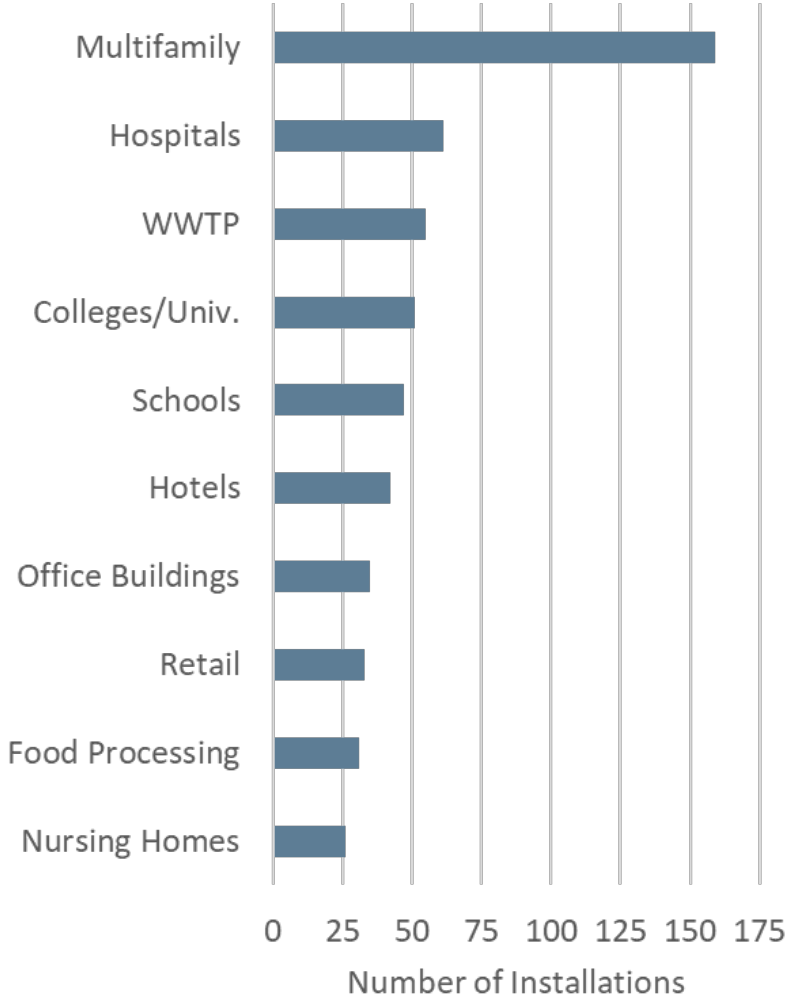




CHP Market Trends – The Last Five Years

- 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
- Natural gas continues to be the dominant fuel - 67% of new capacity, but renewable fuel use continues where available – 12% of new projects
- Resilience a key driver in critical infrastructure applications and microgrids
- Increasing interest in hybrid systems that integrate CHP with renewables and energy storage
- Growing push back on natural gas CHP

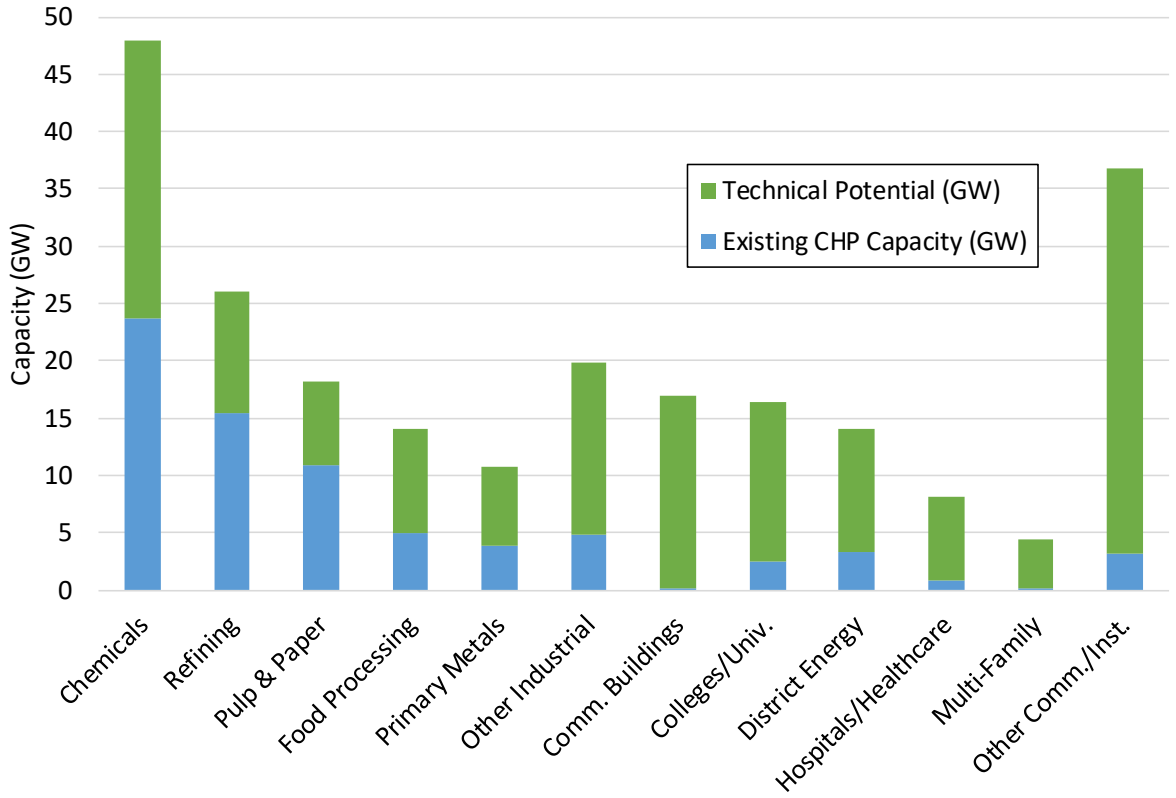
Top CHP Applications 2015-2019



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

Packaged CHP System Markets are Growing

- Large CHP potential in small/midsized industrials, commercial, institutional, government and military applications
- Markets utilize smaller, packaged CHP systems (< 10 MW)
- Markets have limited CHP experience
- Users have limited technical resources
- History of issues with system performance and with CHP sales and service support
- Many perceived risks by both users and suppliers



Non-traditional markets represented 35% of the capacity and 70% of the projects installed since 2008

Utility Ownership of CHP

The Ford Engineering & Research Center

Source: Ford Motor Company

Clemson University

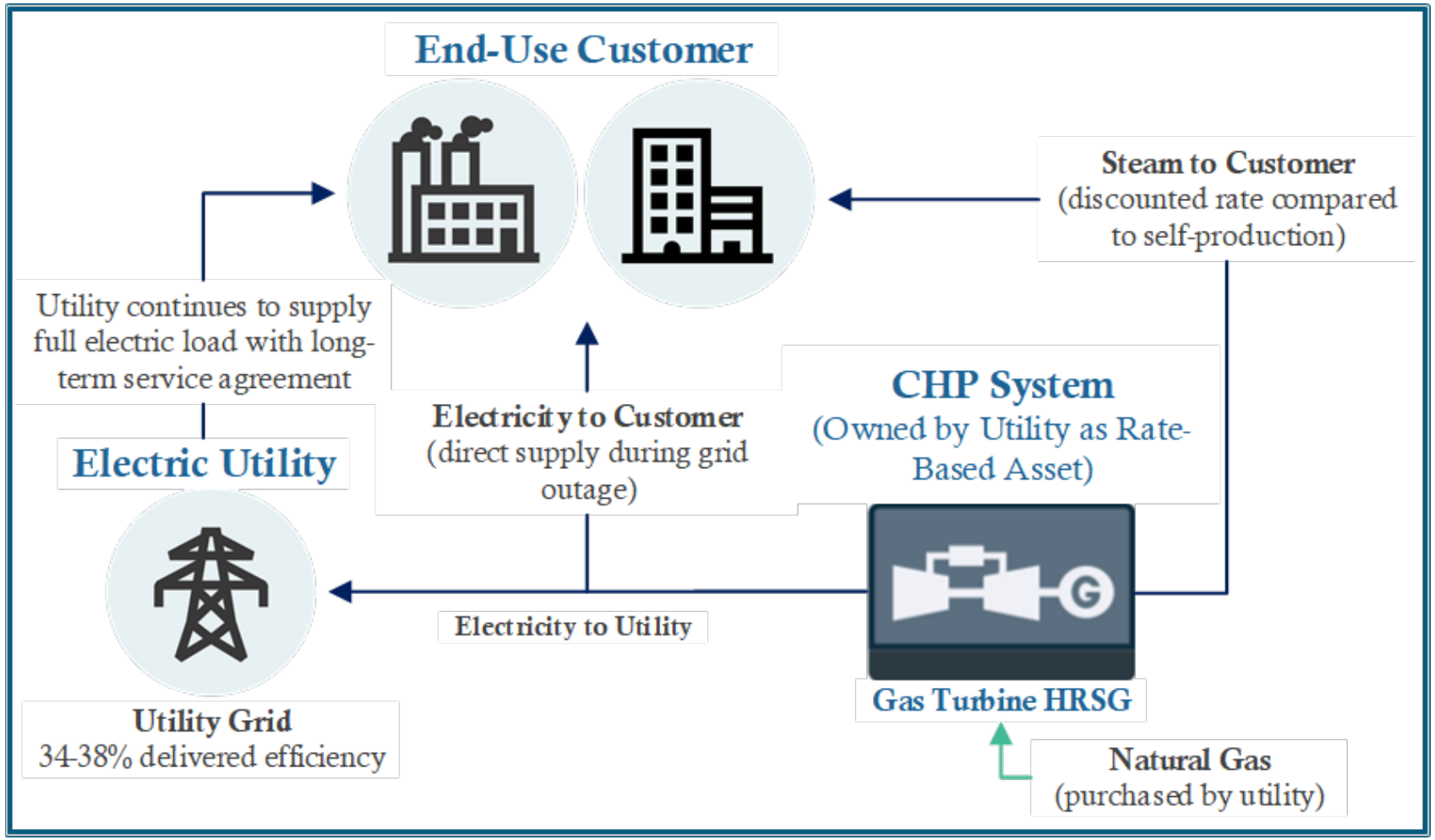
Source: Duke Energy

Purdue University

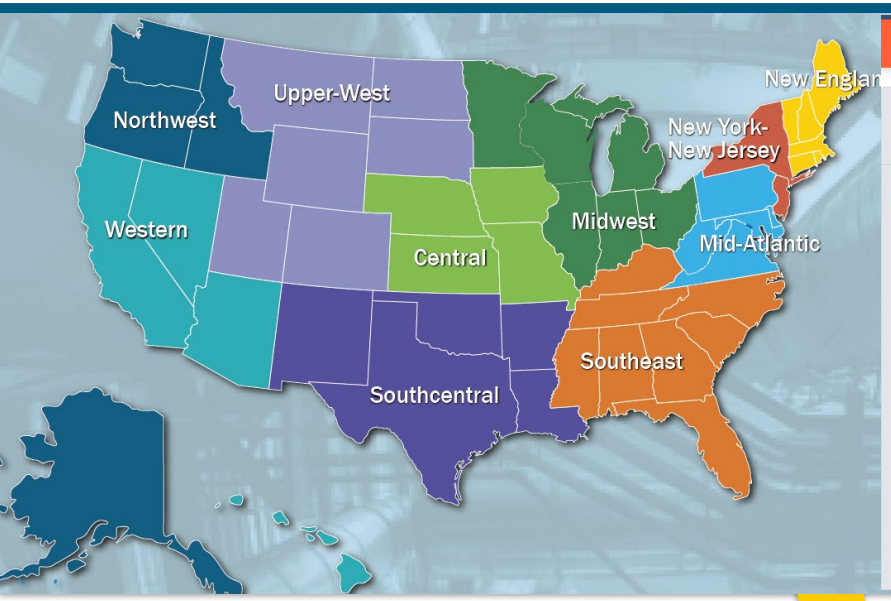
Source: Purdue University

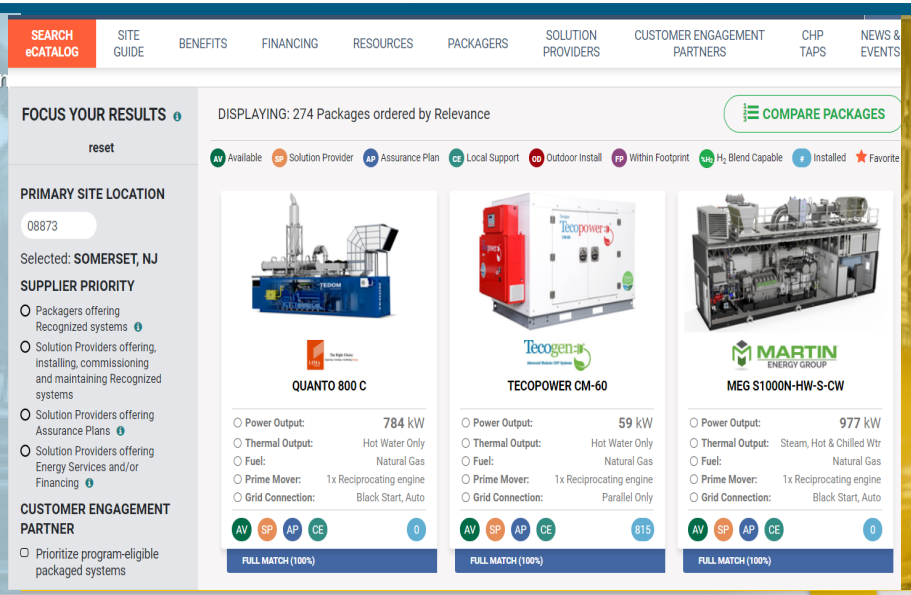
	Dearborn, MI	Clemson, SC	West Lafayette, IN
Utility	DTE	Duke Energy	Duke Energy
Year	2019	2019	2022
Size	34 MW	15 MW	16 MW
Host Type	Research Campus	Campus/University	Campus/University
Host Name	Ford Motor Company	Clemson University	Purdue University
Term of agreement	30 years	35 years	35 years
Main drivers	Grid congestion, campus reliability and resilience	Campus energy system reliability and resilience	Campus energy system reliability and resilience
Regulatory oversight	Request for cost recovery approved	Cost recovery for thermal PPA approved	CPCN granted; request for cost recovery approved

Business Model for Utility-Owned CHP



Today's Combined Heat and Power Deployment Program





10 regional CHP

TECHNICAL ASSISTANCE PARTNERSHIPS

provide fact-based technical support

- vendor, fuel, & technology neutral
- assistance covers site screening through procurement, operations, maintenance, & commissioning
- education & workforce development opportunities

Evaluating & deploying

PACKAGED SYSTEMS

reduce | risk to end-user and supplier
project cost & installation time

PACKAGED CHP ACCELERATOR

verify improved project performance, cost, & installation practices

CHP ECATALOG

web-based, searchable catalog of recognized packaged CHP systems & suppliers

Developing

MARKET RESOURCES & TOOLS

- CHP Installation Database
- Microgrid Installation Database
- CHP functionality – REopt Lite tool
- CHP Resilience Site Screening Tool
- Resilience Risk Evaluation Tool
- Case Studies and Best Practices

Combined Heat and Power and District Energy R&D Portfolio

- **The current CHP RDD&D portfolio is guided by two workshops:**
  - Winter 2016 Workshop on Dispatchable Distributed Generation: Manufacturing's Role in Support of Grid Modernization (Web link *HERE*)
  - Fall 2020 Virtual CHP Workshop (Web link *HERE*)

- **CHP RD&D Projects**
  - FY 2018 Flexible CHP FOA – 6 projects, three on power electronics, three on prime movers
  - FY 2018 Lab Call – 3 projects, 1 on waste heat recovery in district energy and 2 on materials for more efficient turbines
  - FY 2019 Multi-topic FOA – 3 projects on high heat to power CHP systems
  - FY 2020 Multi-topic FOA – 2 demonstration projects on Flexible CHP in a renewable-powered DE system
  - FY 2022 FOA (planned) –demonstrations in a renewably-supplied DE system

Learn about projects here: https://www.energy.gov/eere/amo/combined-heat-and-power-chp-and-district-energy

Project Overview: Caterpillar with NREL and District Energy St. Paul

Flexible CHP Demonstration in a District Energy System Integrated with a Renewably-Fueled Municipal Generating Station

Objective: Demonstrate a 2 MW flexible natural gas/hydrogen CHP system at a municipal generating station. The project team will develop and demonstrate a unique-to-the-industry power delivery and control system.

	Key Milestones & Deliverables
Year 1	• Complete requirements documentation • Complete subsystem sizing and specification
Year 2	• Complete system layout and design • Complete bill of material
Year 3	• System commissioning complete • Final Report

Project Overview: Clemson with NREL and Teco Westinghouse

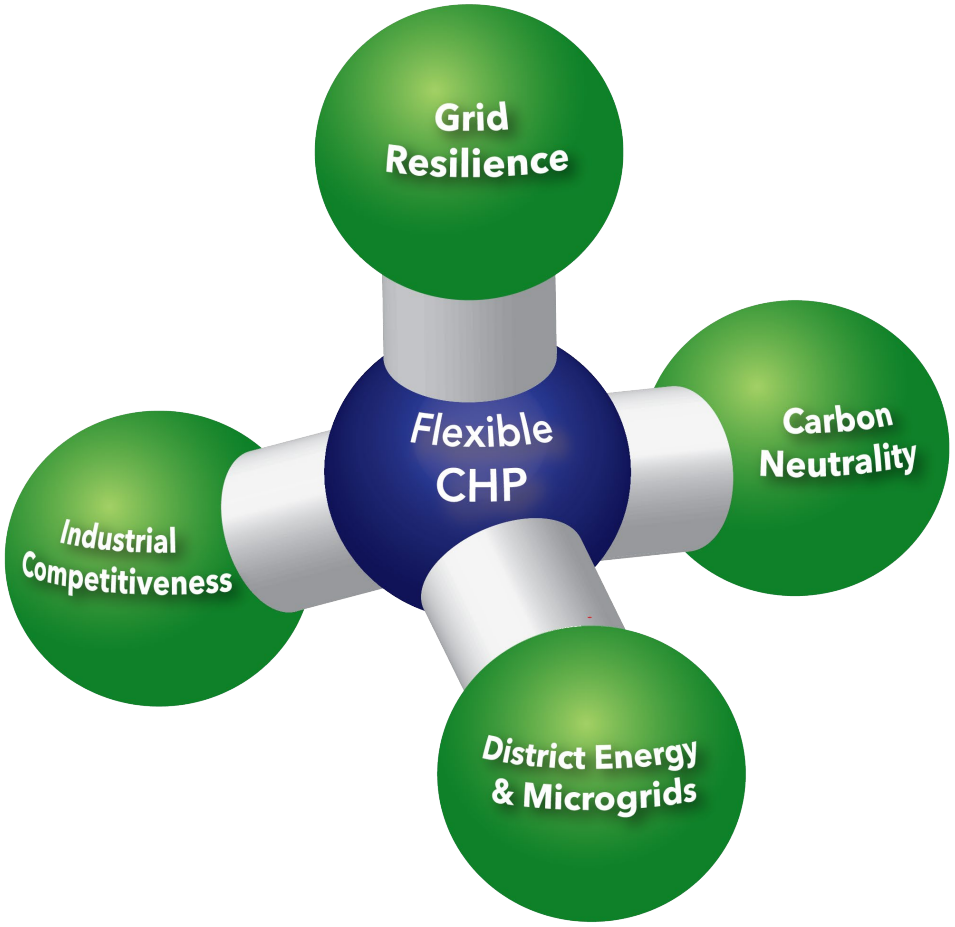
Megawatt Scale, Multi-Source Heat Recovery System with a Flexible Grid Interconnect

Objective: **This project will focus on discovering the opportunities for using an Organic Rankine Cycle (ORC) in multi-source heat recovery applications utilizing a single turbo expander and flexible electrical generation system.**

Goals:

- Create a model-based Use Case analysis tool for the multi-source heat recovery system to streamline technical and economic viability assessments
- Implement a scalable, distributed control architecture for complete system dynamic control
- Enable a demonstration of megawatt scale, multi-source heat recovery system suitable for applications in the 1 – 20 MWe range
- Realize a system cost of less than $1,800/kWe through reduced grid interconnection costs, increased system operational flexibility to respond to grid needs and highly scalable architecture for multi-source heat recovery applications

Questions?



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