Combined Heat and Power: Utility – End User Partnerships

November 18, 2021

NC CLEAN ENERGY TECHNOLOGY CENTER

SOUTHEAST CHP TECHNICAL ASSISTANCE PARTNERSHIPS

CHP Technical Assistance Partnerships

Agenda

12:00 - 12:05 PM	**Welcome & Agenda Review** Christina Kopitopoulou, Senior Project Manager, Southeast CHP TAP
12:05 - 12:15 PM	**What is Combined Heat and Power? Introduction to US DOE Southeast CHP Technical Assistance Partnership Program** Christina Kopitopoulou, Senior Project Manager, Southeast CHP TAP
12:15- 12:35 PM	**Duke Energy – Clemson University CHP Collaboration** Zak Kuznar, Managing Director of Grid Solutions Development, Duke Energy Tony Putnam, Executive Director of Utility Services, Clemson University
12:35 - 12:45 PM	**CHP Utility – End User Model Description and Benefits** Ken Duvall, Managing Partner, Sterling Energy Group, LC
12:45- 1:00 PM	**Moderated Q&A Session**

Combined Heat and Power (CHP) Basics

November 18, 2021

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Southeast CHP TAP

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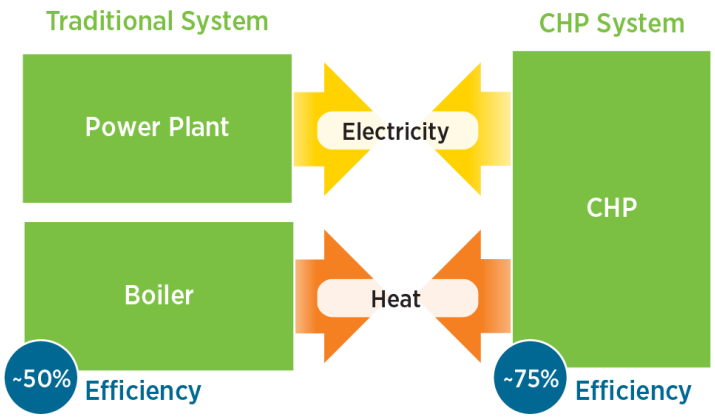
CHP Technical Assistance Partnerships

What is Combined Heat & Power?

CHP: A Key Part of Our Energy Future

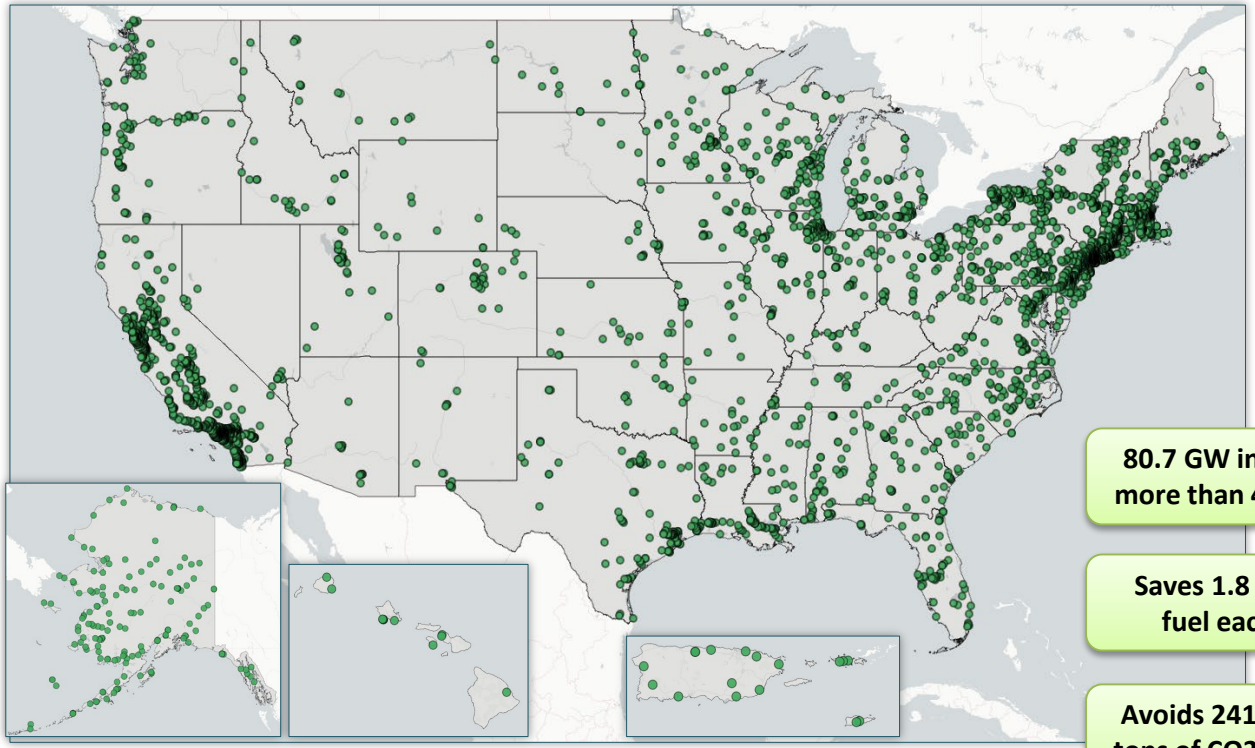
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Source: www.energy.gov/chp

CHP is used Nationwide



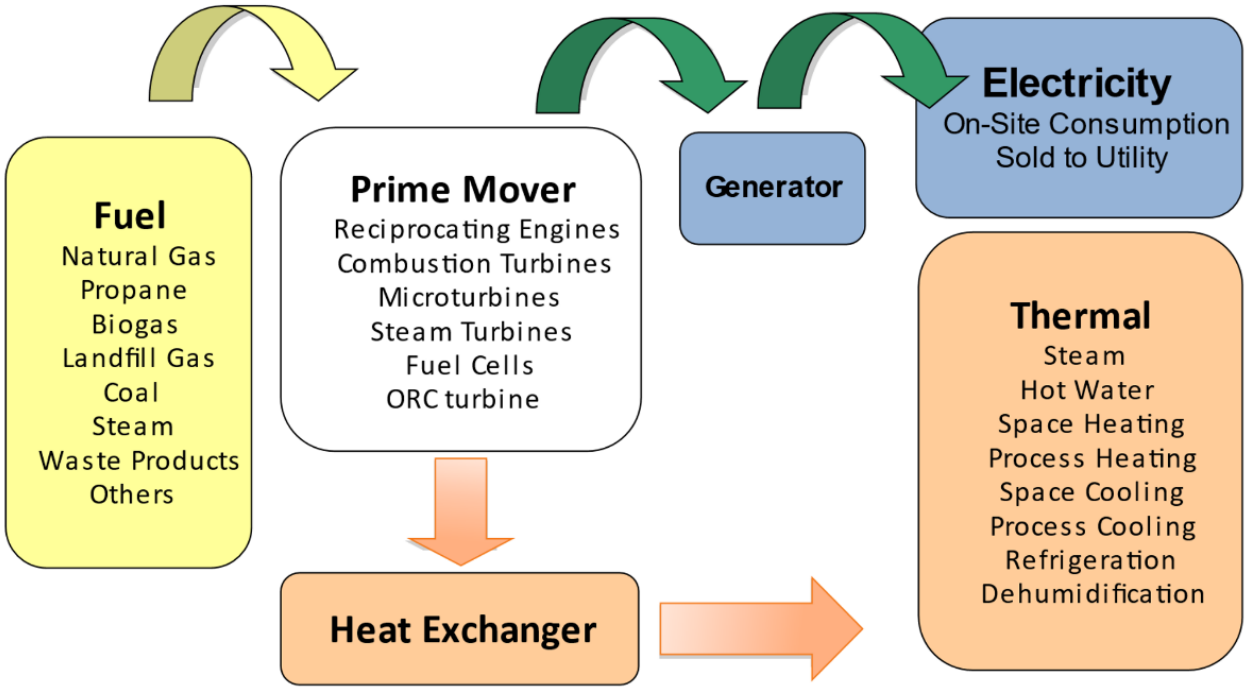
80.7 GW installed at more than 4,600 sites

Saves 1.8 quads of fuel each year

Avoids 241 M metric tons of CO_2 each year

Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2019)

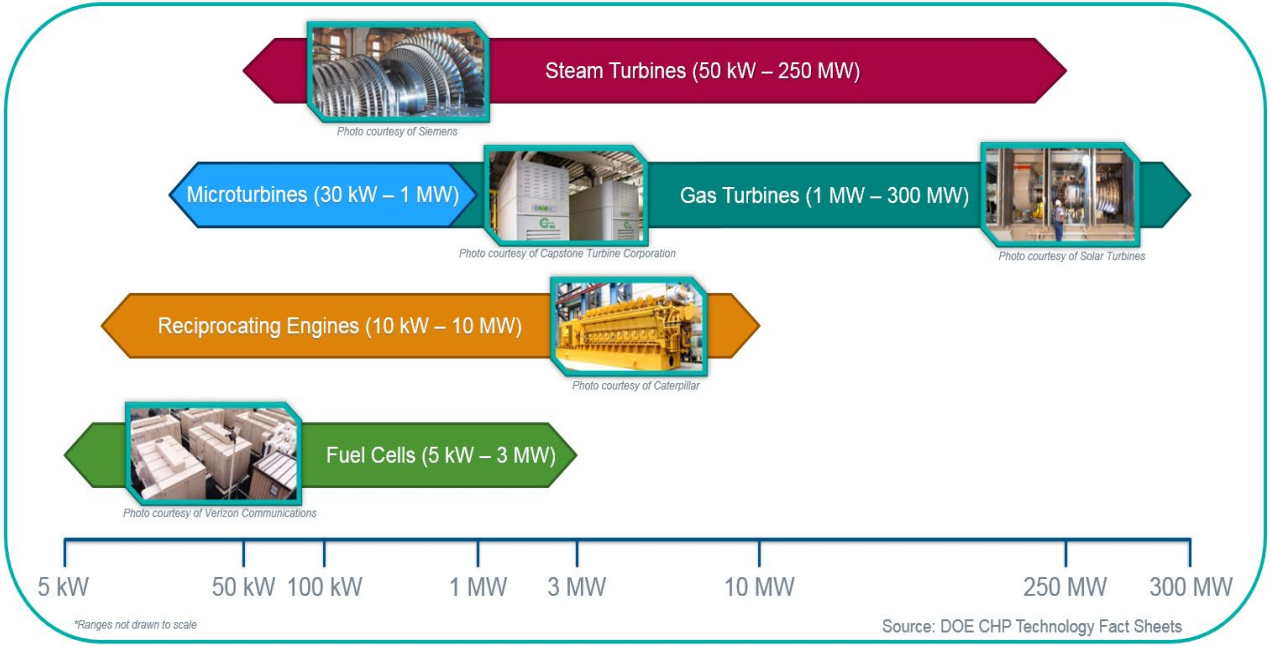
CHP System Schematic



Common CHP Technologies and Capacity Ranges

Five Common Prime Movers

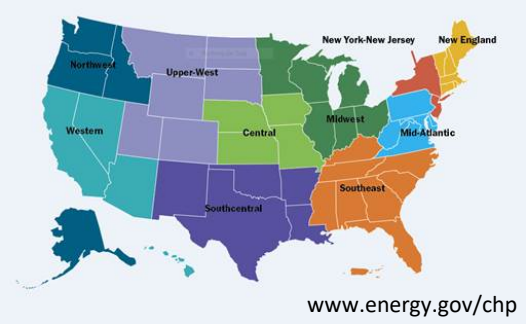
- Reciprocating engines
- Gas turbines
- Microturbines
- Fuel cells
- Steam turbines



What is the US DOE CHP TAP Program?

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.



CHP Technical Assistance Partnerships

DOE CHP Technical Assistance Partnerships (CHP TAPs)

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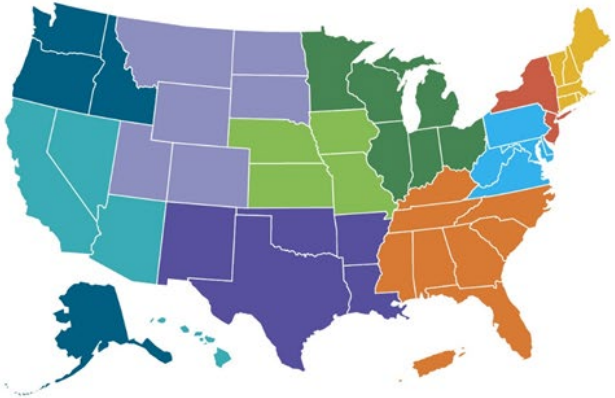

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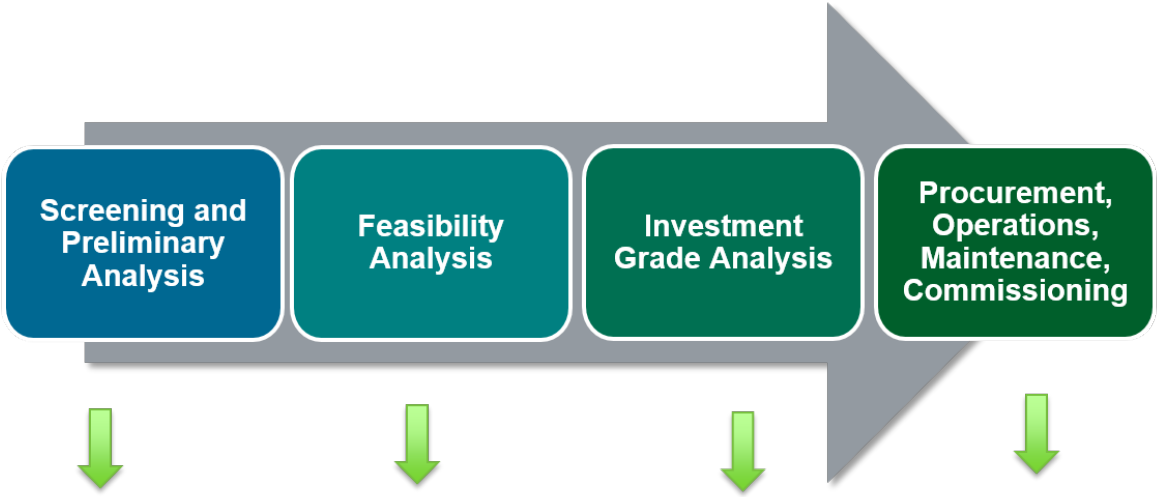
CHP Technical Assistance Partnerships

Steps to Developing a CHP Project and the Technical Assistance Available through the CHP TAPs



Quick screening questions with spreadsheet payback calculator; Advanced technical assistance to explore equipment or operational scenarios.

Perform 3rd Party reviews of site feasibility assessments: Estimates on savings, installation costs, simple paybacks, equipment sizing, and type.

Perform 3rd Party reviews of Engineering Analysis. Review equipment sizing and choices.

Review specifications and bids.

CHP Technical Assistance Partnerships

Ideal Conditions for a CHP System

1) Necessary conditions
   - ✓High Electric Usage
   - ✓Coincidental thermal load
   - ✓High hours of operation
2) Equipment replacement
   - ✓Older Back-up Generator
   - ✓ Replacing Chillers
   - ✓ Replacing Boilers
3) Customer motivation
   - ✓ Utility cost
   - ✓ Power reliability
   - ✓ Waste heat or biofuel untapped resource
   - ✓Sustainability & environmental
   - ✓Plans to expand facility
4) Other factors
   - ✓ EE measures already implemented
   - ✓ Centralized HVAC

Summary

- CHP can provide lower operating costs, reduce emissions, increase energy reliability, enhance power quality, and reduce grid congestion and avoid distribution costs
- CHP is a substantial energy efficiency option for facilities with coincident high electric and thermal load throughout the year, high hours of operation, and need for uninterruptible energy
- CHP resources are available at www.energy.gov/chp & www.sechptap.org

Thank You!

CHP – Utility / End User Partnerships



Zak Kuznar, Duke Energy – Managing Director, Grid Solutions Development
Tony Putnam, Clemson University – Director of Utility Services
Ken Duvall - Sterling Energy Group, LLC - Managing Partner

November 18th, 2021

Clemson University Combined Heat and Power Facility

- 14 MW
- Commercial Operation Date – 12/19
- Owned and operated by Duke Energy Carolina's
- All steam is sold to Clemson University
- Facility can also island the campus to provide back-up power

Purdue University Combined Heat and Power Facility

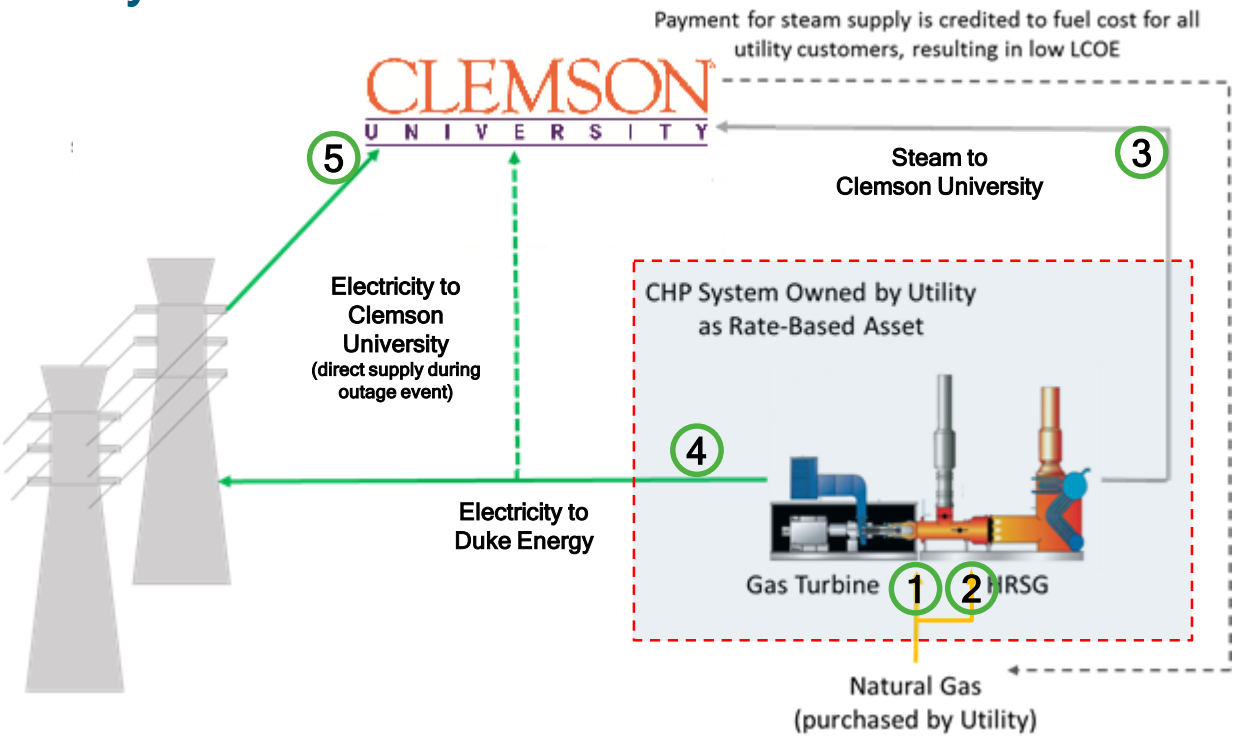
- 15 MW Gas Turbine
- Located on the Purdue University Campus in West Lafayette, IN
- Owned and operated by Duke Energy Indiana
- All steam is sold to Purdue University
- Facility will also be able to island the campus during a grid outage
- Under construction – COD Q1 2022

What does Utility-Owned CHP look like – Structurally

Simplified Structure for Utility-Owned CHP

Meter Points for Utility-owned CHP

1. Fuel to Gas Turbine
2. Fuel to Duct Burner
3. Steam/Thermal to Host
4. Electricity Produced by CHP
5. Electricity to Customer
   Utility continues to serve Customer Electric Load



Value to the Utility and Customers

- Combined Heat and Power uses a natural gas turbine to generate electricity and utilize the waste heat to provide steam to a customer for critical processes such as heating, hot water, and other thermal processes. This highly efficient and clean integrated energy process has numerous advantages:
- Host customer and <u>all customers</u> benefit due to –
  - <u>Low cost generating asset for all customers</u>
  - 25-50% Higher efficiency meaning lower net heat rate and LCOE
  - Substantially reduced T&D losses (particularly peak hours when I^2R losses are highest from heat, equipment loading & congestion)
  - Greater system resiliency provided by CHP (both steam and electric)
  - Substantially reduced emissions (including CO_2) and low water use
  - Avoided future T&D capital investments due to CHP 'unloading' T&D system
  - Much faster planning and development cycle – helps utilities fine tune expansion plans and avoid costly over/under building capacity

Emissions Reductions in South Carolina

Table 2: Annual Emissions Savings

	CHP System	Displaced Electricity Production	Displaced Thermal Production	Emissions Savings	Percent Savings
NO_x (tons/year)	34.11	39.97	22.78	28.64	46%
SO_2 (tons/year)	-	29.85	0.13	29.99	-
CO_2 (tons/year)	72,105	94,487.18	26,635	49,017.80	40%
CH_4 (tons/year)	1.36	2.76	0.50	1.90	58%
N_2O (tons/year)	0.14	1.23	0.05	1.14	89%
Total GHGs (CO_2e tons/year)	72,175	94,925.17	26,661	49,411.21	41%
Equal to the annual GHG emissions from this many passenger vehicles:				9,587	
Equal to the annual GHG emissions from the generation of electricity for this many homes:				6,716	

Equal to the annual greenhouse gas emissions from 9,587 passenger vehicles.

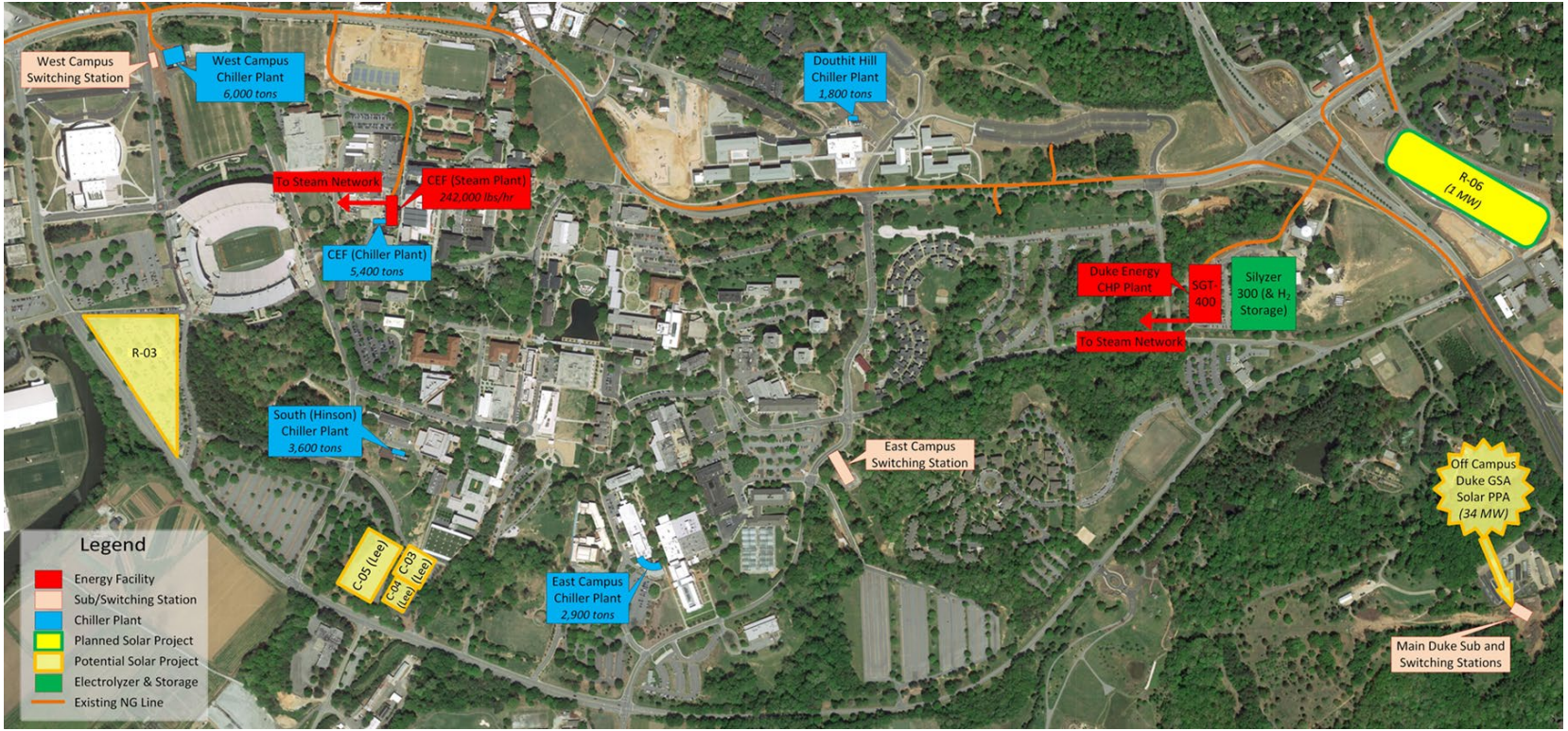
Equal to the annual greenhouse gas emissions from the generation of electricity used by 6,716 homes.

Value to Clemson University

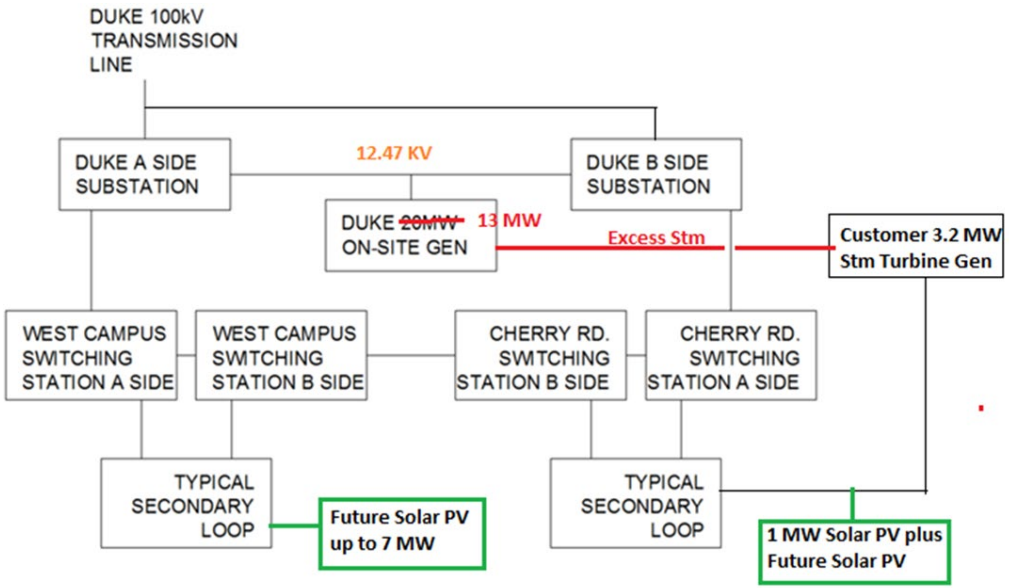
Background - In 2015 to support Clemson University main campus growth, Clemson was planning major modernize to our 1960's electrical distribution with a second fully redundant utility substation as collaborative discussions started on a utility owned and operated CHP alternative which changed the direction of our campus distribution electrical utility upgrades:

- Lower cost and more efficient means of meeting Clemson's thermal energy need
- Reliable and resilient means to provide campus-wide back-up power during outages and reduce or eliminate restoration time – microgrid capabilities
- Cost effective method to achieve net neutrality of carbon emissions by 2030, with the ultimate goal being an all-encompassing approach to decarbonization
- CHP system is a major step toward this goal with higher efficiency thermal energy, integration of solar energy and innovative energy storage strategies

Value to Clemson University



Value to Clemson University



The 12.47 kV campus electrical system is being reconfigured to a multi-level loop topology which includes a new substation with Duke Energy and integration of the new Duke CHP plant on the East side of campus - Existing campus 5 MW CHP and future on-campus solar and energy storage

Clemson University - Hourly Load Demand

Electric Load
Average: 13.2 MW
Peak: 20.6 MW

Heating Load
Average: 10.7 MW
Peak: 20.6 MW

Cooling Electric Load
Average: 2.8 MW
Peak: 7.4 MW
*(COP = 4.7)

Clemson Decarbonization Target

Clemson University - 2030 "Net-Zero" Strategy

Projected Estimation

Timeline	Description	Scope 1 - MTECO2/yr	Scope 2 - kWh	Scope 2 - MTECO2/yr	Scope 1 & 2 Change
2018	Current State	27,500	169,900,000	89,600	117,100
2022	CHP Steam	2,100	169,900,000	118,980	121,080
2022	CU Steam Turbine Gen	2,100	156,278,000	111,796	**113,896**
2022	1 MW Solar Canopy	2,100	154,778,000	111,005	113,105
2023	34 MW GSA Program Solar	2,100	69,778,000	66,179	**68,279**
2025	Energy Saving Projects	1,900	53,778,000	57,741	59,641
2027	Campus Growth	2,000	59,778,000	60,905	**62,905**
2028	CHP Steam Fuel Impact				
2030	Duke Grid Improvement	2,000	59,778,000	42,393	**44,393**

MTECO2 = metric ton CO2 equivalent

2030 Duke Grid CO2 Estimate = 0.48 lbs/kWh

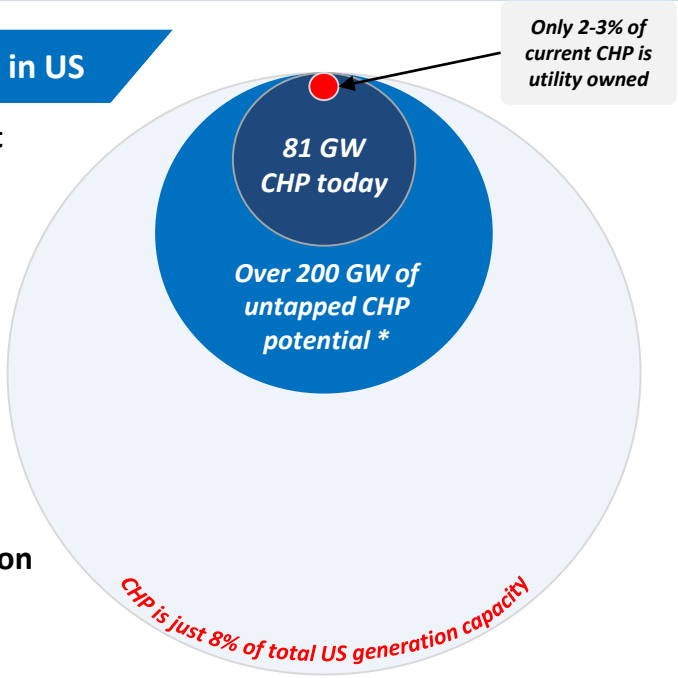
CHP Steam contributed with approx. 29,000 MTCO2/year with reductions in Scope 1

Duke Energy Carolinas Renewable Energy Credit Program 40% reduction

Thoughts for Today's Wrap-up Discussion

CHP is an Invaluable National Efficiency Resource – but is vastly underutilized in US

- Well applied CHP is the **most efficient method of generating power**; **doubling current grid efficiency** – unloading grid, reducing T&D losses & emissions
- CHP is based on **established technology** with **lower investment risk,** faster planning & development in smaller MW – and **can be permitted in any** air quality district
- CHP **significantly reduces emissions and water use and can help *electrify and decarbonize* high temperature thermal loads where no RE solution exists today**
- CHP supplies energy at point of use **enhancing resiliency and establishing foundation for microgrid developments**
- CHP provides other **uniquely valuable local benefits**, providing for **economic/industrial development**, **jobs and expansion of local tax base**, **retention of high value customers**



* Source: DOE/ICF CHP Deployment Study March 2016

So, Why is CHP so Underutilized? Are there Solutions?

- **Most Utilities Still View CHP as Competition to Utility Supply which is Real, in Today's Traditional Business Models**
- **But, New Structures have been Demonstrated to Make CHP Win/Win/Win - for Utility, Hosts, and All Customers**

Impediments to CHP Development are Well Documented

Utilities

- Even with Rapid Industry Transition to DER, Most utilities still view CHP as a **competitive, customer-owned resource**, and few evaluate in IRPs
- Most Support CHP intellectually, but prefer ***not in my back yard*** *approach*
- **Why? Utilities Lose Load & Revenue *on the margin*,** when CHP is installed behind-the-meter, leading to **higher fixed costs spread to all customers**

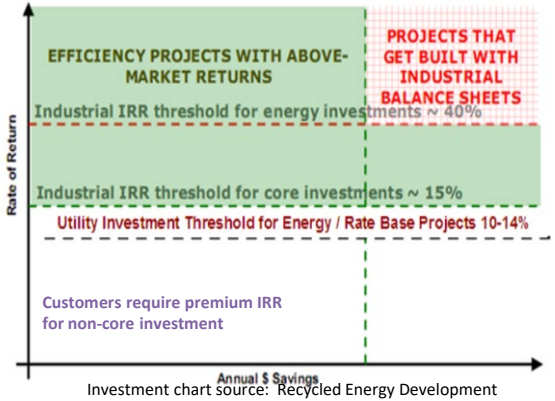
End Users (industrial, institutional, military)

- **We all Know, End Users Prefer to invest capital in 'core-business' projects**, not capital-intensive energy systems like CHP
- Traditional, **<u>well documented hurdles</u>** plus **new hurdles** (growing opposition to natural gas as a fuel source) block many developments
- Thus, CHP that is developed is **typically installed behind-the-meter but <u>hundreds of excellent sites with continuous thermal are never developed</u>**

Hurdles to Increased Use of CHP

- Financial uncertainty
- CHP cost and performance uncertainty
- Regulatory uncertainty
- Electric utility uncertainty
  - Utility goal is affordable and reliable power
  - Generally neutral to negative on CHP
  - CHP represents a loss of revenue to the utility and can result in the deferral of investment
  - This often results in unfavorable tariffs, drawn out interconnect and other roadblocks to CHP

Institute for Industrial Productivity



Investment chart source: Recycled Energy Development
Upper chart source: Institute for Industrial Productivity

Business Models and Policies Must be Aligned to Produce Win/Win Outcomes

Rethinking & Restructuring CHP's Role in Our Industry starts with Gaining a Shared Understanding of the Import Role CHP Can Play in Our Changing Industry

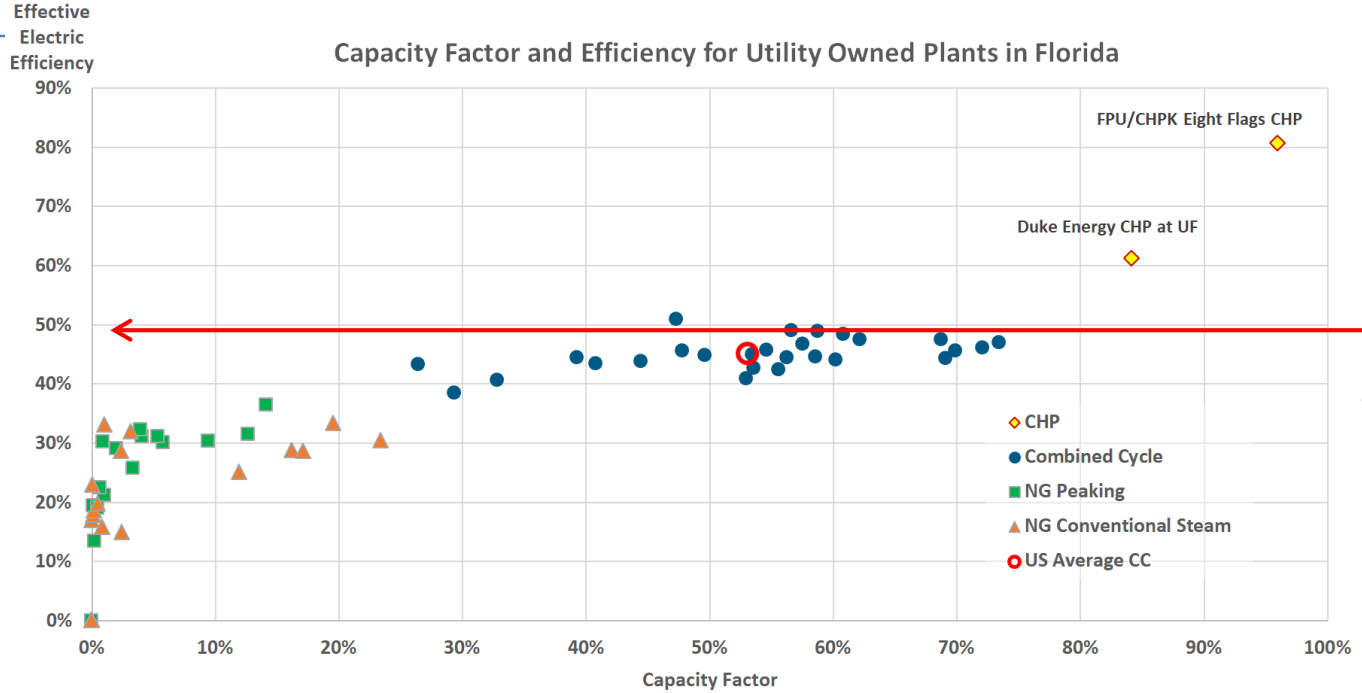
Traditional Perspective

- CHP = Competition from Customer
- CHP = Resource Too Small for Us
- CHP is not Renewable

New Perspectives

- CHP = Double Grid Efficiency
- CHP = Lower GHG Emissions and can operate on RNG and Green H2 when available
- CHP = Reduced T&D Losses
- CHP = Increased Resiliency
- CHP = '*Electrification*' of Large, High Temp Thermal Loads the Fastest Growing Source of $C0_2e$ where there are No RE Solutions
- CHP = Partnering with Largest Customers to be Total Energy Supplier

Natural Gas Generation including CHP – state of Florida



Note Difference between Two Utility Owned CHP Plants in Florida operating substantially higher Electric Efficiency & Capacity Factor than any other natural gas plant in Florida

(2019 Data is consistent with previous years operations)

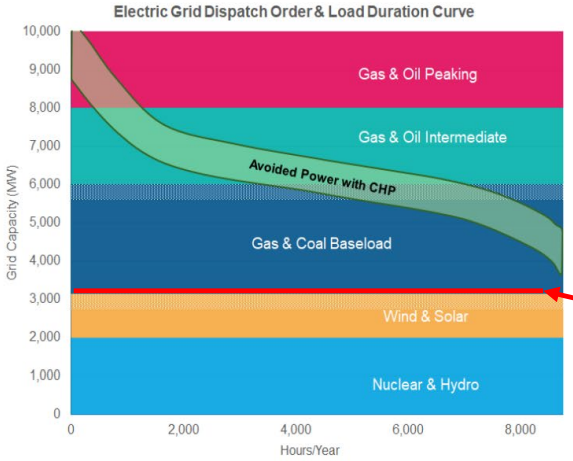
Notes:

- All combined & simple cycle data based on reports DOE EIA-960 and EIA-923 for 2019. All data and efficiency calculations based on HHV.
- Duke Energy owned 45 MW CHP at UF capacity factor based on EIA-960 and EIA-923, and verified by 2018 operating data.
- Capacity factor and efficiency for Eight Flags CHP based on actual operating data provided for calendar year 2019. Unit was also uprated during Feb 2019 outage to 21.5 MW net.
- Effective electric efficiency accounts for grid losses and includes a credit for the displaced thermal fuel for CHP.
- Per EPA eGRID 2020 (2018 data), total grid losses for central station plants in FL is 4.88%, US average is 4.87%. Losses associated with CHP of 2.44% due to proximity of generation to point of consumption.

Let's Discuss CHP as an Important Decarbonization Solution

Evaluating CHP Emission Impacts

- **Displaced grid emissions for CHP are based on *marginal utility generation***
  - Marginal units are those at the "top of the stack" that set the electricity price in real-time or day-ahead pricing
  - Currently, marginal generation tends to be provided by units fueled by gas, oil, and in some cases coal
    - For CHP systems that operate 24/7, average *fossil fuel* emission factors from eGRID can be used
    - For CHP systems that operate during day/evening hours, average *non-baseload* emission factors from eGRID provide a better estimate
- **Limitations in accurately estimating marginal emissions with eGRID, especially as renewables increase**

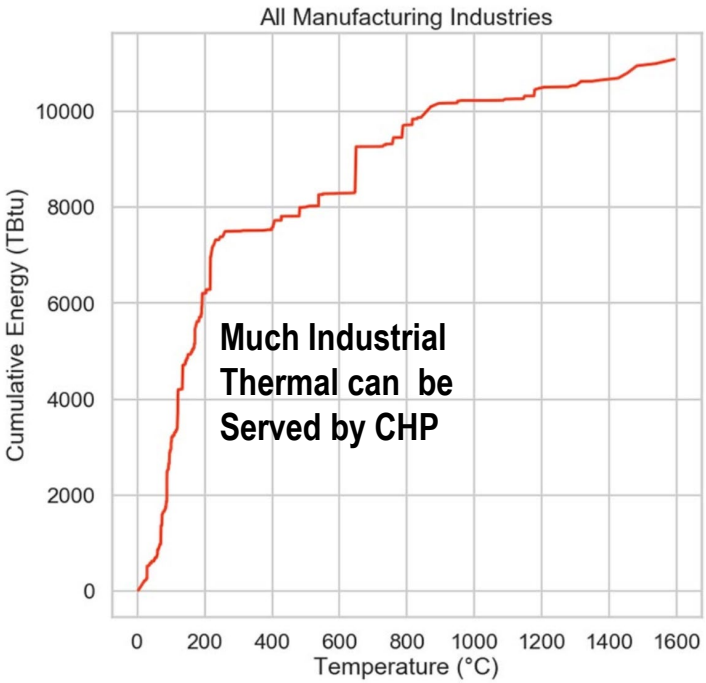


CHP's low net heat rate allows it to be dispatched here, just above Nuclear and Renewables always displacing coal, NG and oil

Source: IFC Study: CHP Greenhouse Gas Emission Reduction Potential: 2020-2050 Grid Emissions Comparison

CHP Can help Mitigate Today's Growing Thermal Emission Challenge

- Energy used for heating and cooling is responsible for **39% of globa energy-related greenhouse gas emissions**.
- Industrial sector emits **1/3 of all greenhouse gas emissions today, will be largest emitter by early 2040s, greater than electric**
- Energy used to produce heat is responsible for **2/3 of all energy demand in the industrial sector** and 1/5 of all global energy demand
- Space and water heating constitute **39% of total energy consumption** in buildings.
- Today there are no viable Renewable Solutions for the High Temp and high volume thermal loads
  - Green H2, RNG, CSP too costly and not readily available today

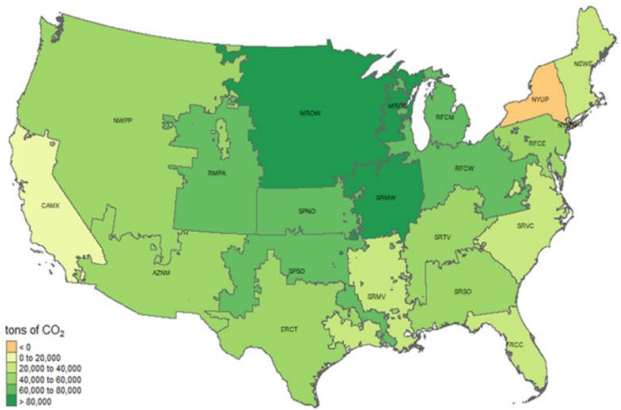


https://www.nrel.gov/analysis/solar-industrial-process-heat.html
https://data.nrel.gov/submissions/118

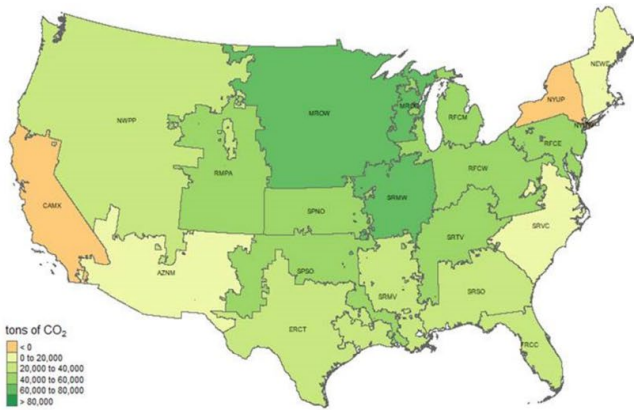
ICF 2020 Study Concludes CHP will have net Negative Emissions VS Grid Through 2050 in all regions except CA and NY

Lifetime Carbon Emission Reductions for CHP Systems

2020-2035



2035-2050



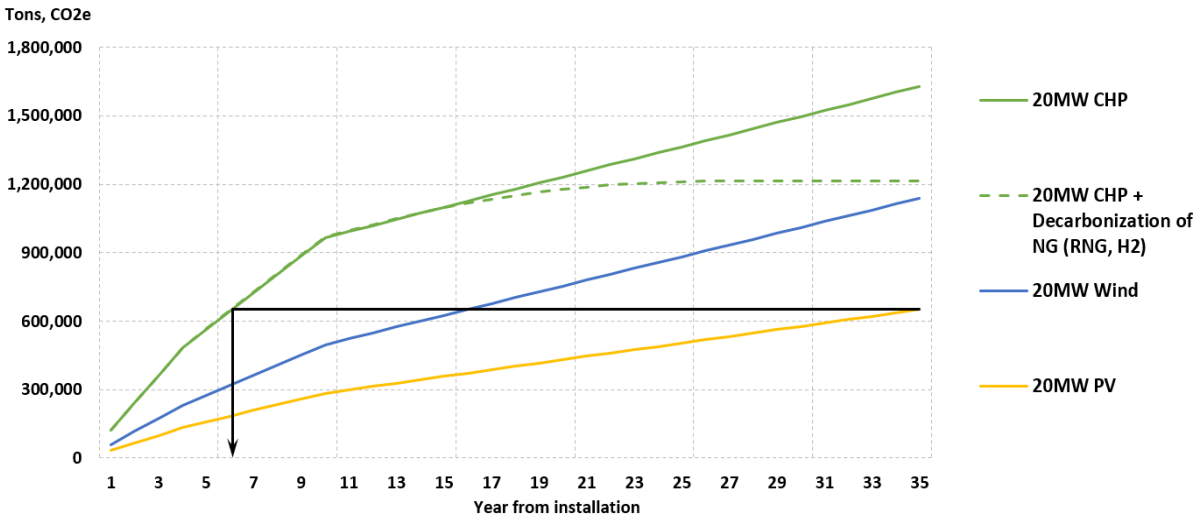
Source: IFC Study: CHP Greenhouse Gas Emission Reduction Potential: 2020-2050 Grid Emissions Comparison

A Closer Look at Life Cycle Emissions Benefits of 20 MW of New Capacity

comparing natural gas CHP with Wind and PV

Analysis Based on Marginal Grid Resource Avoided

- 20 MW CHP displaces coal and natural gas with 95% capacity factor compared to 22% for PV and 35% for Wind
- CHP is a low carbon resource not zero carbon like Wind & PV but it reduces grid carbon
- CHP's high operating efficiency and capacity factor allows it to reduce more $C0_2e$ than same total capacity of zero carbon wind or PV
- Time Value of when Emissions Reduced have Added Value



Base Case marginal grid offsets – Southeastern and Midwestern Utility Territory Examples

- Y1-4 average 95% coal, ~1,900 lb CO_2e/MWh
- Y5-11 average ~55% coal, ~1,440 lb CO_2e /MWh
- Y12 on, 100% NGCC, ~840 lb CO_2e /MWh
- ~561 lb CO_2e /MWh (net FCP heat rate of 4800, including 4.1% T&D loss reduction credit)
- Decarbonization case assumes natural gas reduction is accelerated beginning Y14 and carbon free by Y27. Both grid and CHP are decarbonized by Year 27 with RNG and Green H2 produced by electrolyzers powered by new Wind and PV resources
- Capacity Factors: 95% for CHP, 22% for PV, and 35% for Wind

What if Every US Utility Developed 30 MW of CHP Like Duke Energy ?

- Duke Energy has ~ 4.5% of US Generating Capacity and to date has Developed 30 MW of CHP Capacity
  - Also Owns and Operates 47 MW CHP in Florida

- This would add between 650-750 MW of New Efficient CHP and $1.7B of new Rate Based Investment to Utilities
  - With No Lost Revenue & Load to spread back to all customers
  - Reduced ~ 25 MTCO2/year over half Billion MTCO2 over 20 years
  - Improved Local Resilience providing for microgrid developments like Clemson and Purdue Universities

KEY TAKEAWAYS

Regulators

- Require all Utility IRPs to *at least evaluate* CHP for implementation of EE incentives and/or Utility in front of meter investment, with related supportive policies /goals
- Refine policies & standards to *value benefits on both sides of meter*- and evaluate CHP (like storage and other DR) on level playing field with traditional supply options
- *Streamline development and approval process* for utility investment or EE Incentives for CHP that meet "test" for efficiency and CPVRR (Cumulative Present Value of Revenue Requirements)
  - Eliminate CPCN requirement for CHP under 25 MW if criteria met (for efficiency, LCOE, CPVRR) to fast track benefits

Utilities

- Work with key customers to screen, then *collaborate in a formal CHP evaluation and development process*
  - *Use Market Expertise – Don't Need to Build, O&M by Utility – Just Own to Capture Benefits*
- Explore New Business Models and review benefits with regulators and policymakers, *encourage EE incentives and/or utility investment options* to capture and monetize benefits on both sides of meter
- *Evaluate CHP in each IRP for both EE Incentives and/or Utility in front of meter inve*stment
  - Encourage policies to evaluate CHP (like storage and other Distributed Resources) on level playing field with traditional supply options – not just busbar level evaluations)
  - Consider Evaluating CHP as a "Portfolio" of Investments with multiple 'host' sites much like PV and Wind is viewed in IRP
  - Consider Issuing RFP for CHP Investments by Utility that meet efficiency, location, and CPVRR targets

End Users

- If self-owned CHP does not work (to secure investment funding approvals), ***engage directly with the utility*** **to explore** ***collaborative development*** **options & benefits**.
- Work to document **the** ***full range of benefits***, including thermal and electric resilience, islanding, **emissions** reduction / carbon value, and enhanced or increased production, plus grid benefits

Equipment Suppliers / Developers

- Where inside-the-fence CHP does not work, ***engage directly with customer and utility to explore collaborative development options & benefits***, including grid benefits
- Engage with utilities to provide development expertise, evaluation and support and to document benefits on both sides of the meter
- **Continue to streamline EPC supply options, modularization, process and technology enhancements** to continue driving development costs and EPC $/kW and O&M costs down

US DOE & TAPs

- ***Actively Engage*** **with Utilities, Regulators, Policymakers and Environmental Organizations** to Present CHP as an Essential Part of the Solution for the Energy Industry's Transition to a Cleaner and More Resilient System

Thanks for your Time . . .

Expanding CHP - in front of and behind meter - Should be a National Efficiency Imperative

Shaw Fibers Columbia, SC
14 MW Behind Meter

Georgia-Pacific Taylorsville, MS
8 MW Behind Meter

Duke Energy Carolinas, Clemson, SC
14 MW In Front of Meter

Eight Flags/Chesapeake Amelia Is, FL
22 MW In Front of Meter

MIT Cambridge, MA
46 MW Behind Meter

DTE CHP at Ford Dearborn, MI
34 MW In Front of Meter

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