U.S. DEPARTMENT OF
ENERGY

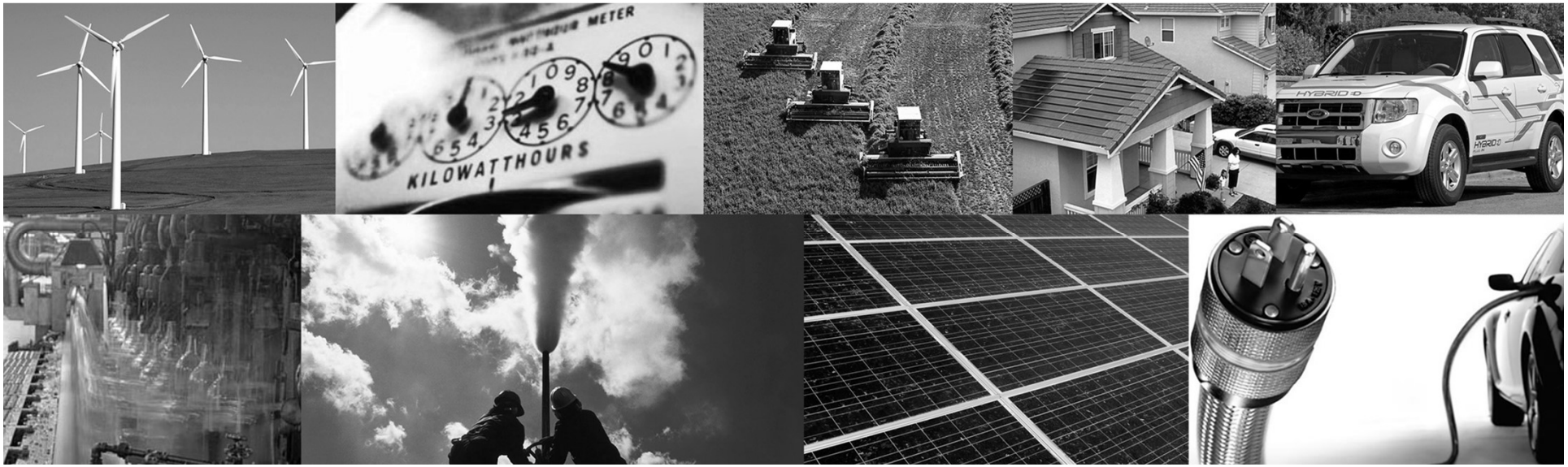
Office of
ENERGY EFFICIENCY &
RENEWABLE ENERGY

U.S. DOE Combined Heat & Power: Resources for Energy Service Companies

Tuesday, November 17, 2020

3:00 to 3:45 pm eastern

Webinar



Agenda

- **Session Moderator**
  - *Suzanne Watson*, Technical Advisor, New England CHP TAP
- **U.S. DOE Technology Partnerships Program**
  - *Anne Hampson*, DOE Technical Partnerships Program Manager
- **CHP Technical Assistance Partnerships (CHP TAPs)**
  - *David Dvorak*, Director, New England CHP TAP
  - *Kyle Rooney*, Assistant Director, New England CHP TAP
- **CHP Market Update**
  - *Bruce Hedman*, Senior Technical Advisor, DOE Deployment Program
- **Packaged Systems Accelerator and eCatalog:** *Bruce Hedman*


Suzanne Watson

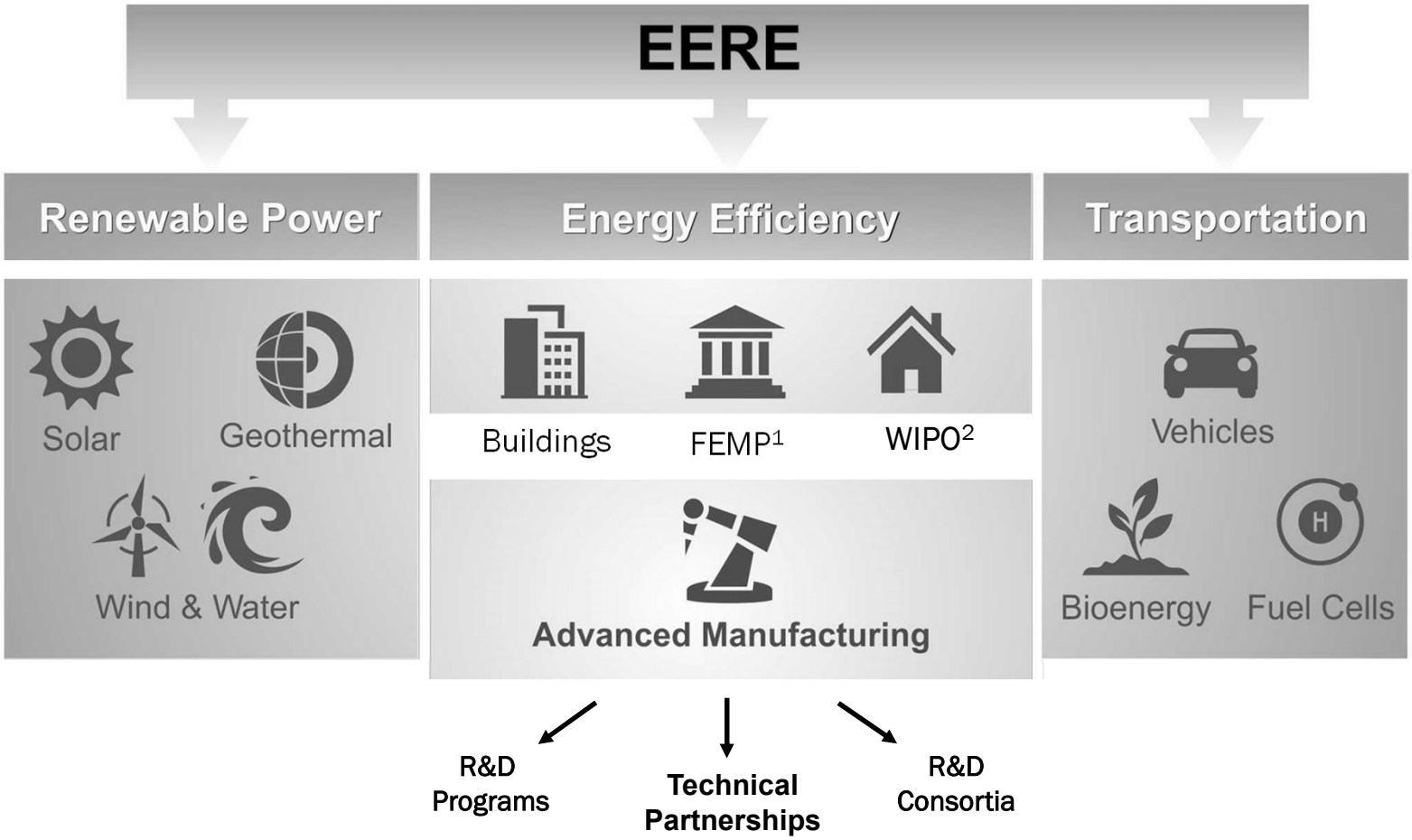

Anne Hampson


David Dvorak


Kyle Rooney


Bruce Hedman

The Advanced Manufacturing Office is located within DOE's Office of Energy Efficiency and Renewable Energy (EERE)



[1]Federal Energy Management Program
[2]Weatherization & Intergovernmental

Technical Partnerships

Direct engagement with Industry

Driving the continuous improvement and wide-scale adoption of proven technologies (e.g., CHP) to reduce energy use in the manufacturing sector

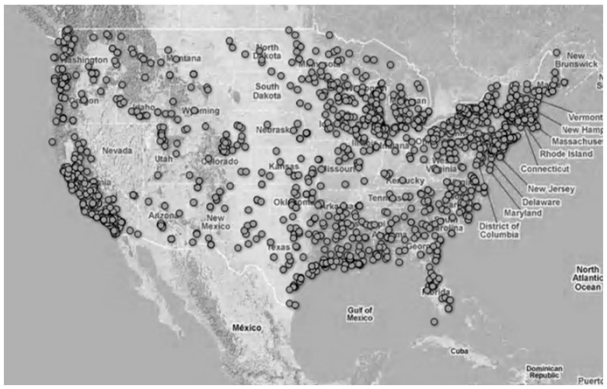
Five Core Programs

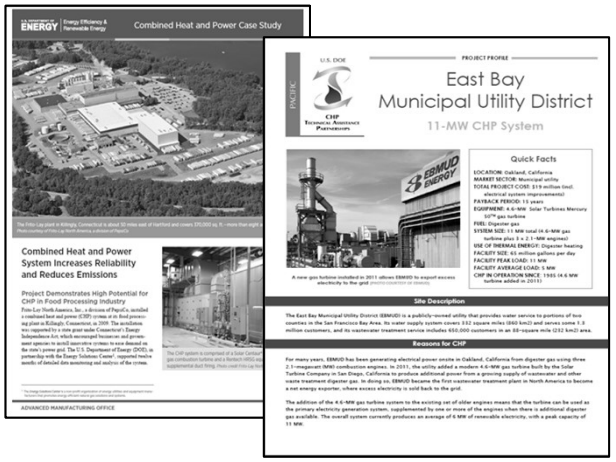
1. Better Plants
2. ISO 50001/SEP
3. Combined Heat and Power
4. Industrial Assessment Centers
5. Technologist in Residence

- ✓ **Validate the performance and energy impacts of established advanced manufacturing technologies and identify opportunities for further development or commercialization by the private sector.**
- ✓ **Foster feedback from stakeholders on critical technology challenges that might be addressed by follow-on, early-stage applied R&D.**

U.S. DOE CHP Deployment Program Mission & Scope

- **Mission**
  - Provide stakeholders with the resources necessary to identify CHP market opportunities
  - Support implementation of cost-effective CHP systems in industrial, commercial, institutional, and other applications
- **Scope**
  - CHP Technical Assistance Partnerships (CHP TAPs)
  - CHP Market and Project Resources
  - Packaged CHP eCatalog
  - Packaged CHP Accelerator





www.energy.gov/chp

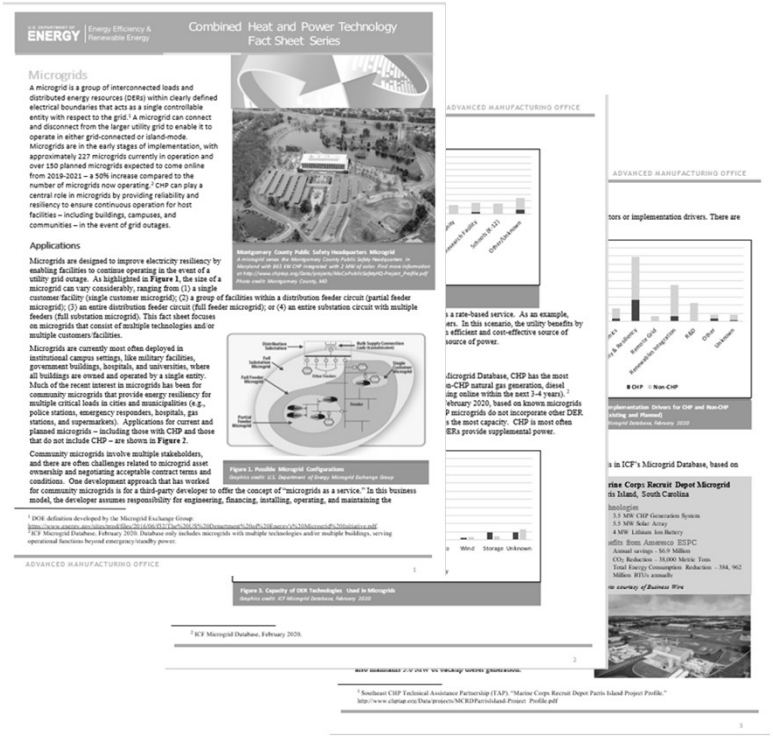
CHP Deployment Support Resources

Objective:

- Resources, tools, analyses and technical materials to support CHP TAP mission;
- Educate state and local policy makers, regulators, end users, trade associations, and CHP stakeholders;
- Inform DOE Deployment and R&D program planning
- energy.gov/chp

Materials include:

- CHP installation database
- Market analysis and tracking
- CHP regulatory and policy trends
- Technology information and industry trends
- Screening/evaluation tools
- Case studies and project profiles
- Fact Sheets
- Specific issue research and reports
- Program metrics and evaluation



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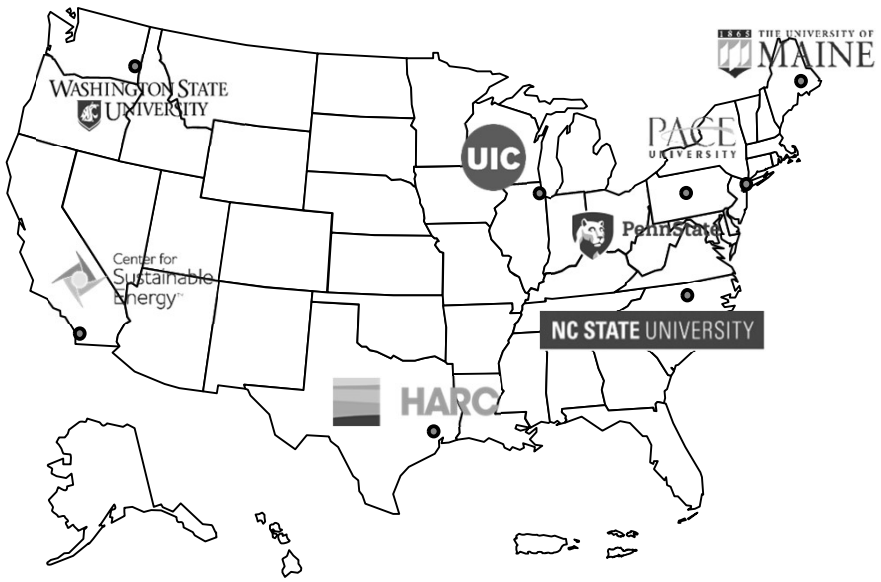
CHP Technical Assistance Partnerships (CHP TAPs):

Leveraging innovations in CHP technologies, packages and assessment tools, the regional CHP TAPs provide fact based, unbiased information on CHP, district energy, and microgrids through:

- **Technical Services**: The CHP TAPs work with sites to screen for CHP opportunities and provide advanced services to maximize the economic impact and reduce the risk of CHP from initial CHP screening to installation.

- Partner with strategic **End Users** in the Commercial, Industrial, Federal, Municipal, Education, and Healthcare Sectors to advance technical solutions using CHP as a cost effective and resilient energy efficiency measure.

- Engage with strategic **Stakeholders**, including state energy offices, regulators, utilities, and policy makers, to identify and reduce the barriers to using CHP.



energy.gov/chptap

Nationwide DOE CHP TAP Contacts and Locations

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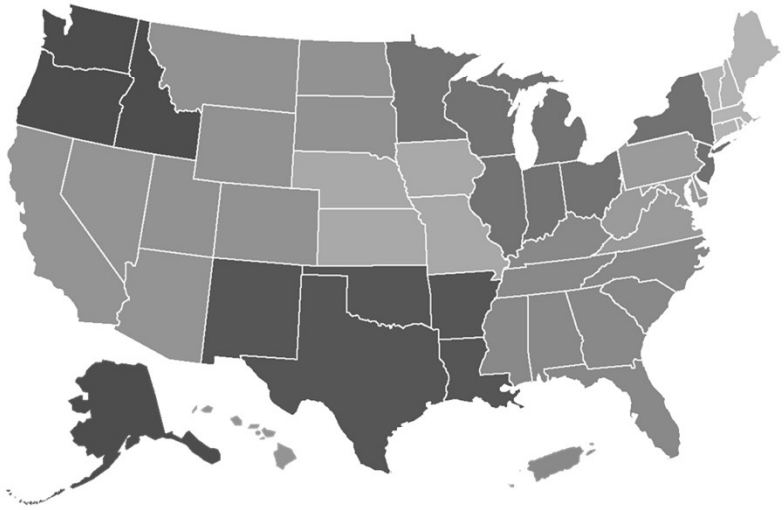

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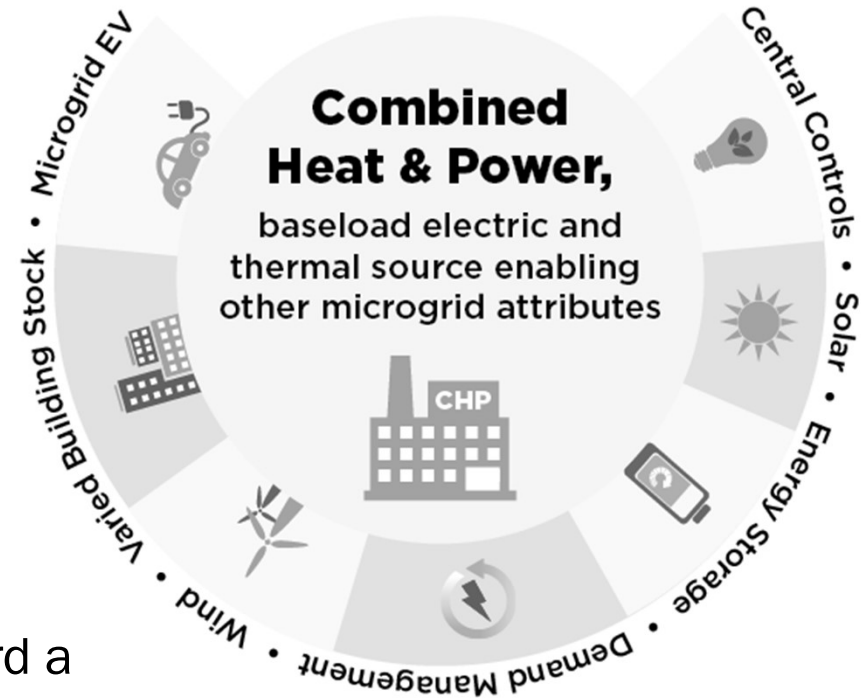
CHP as a Resilient Anchor for Clean Microgrids

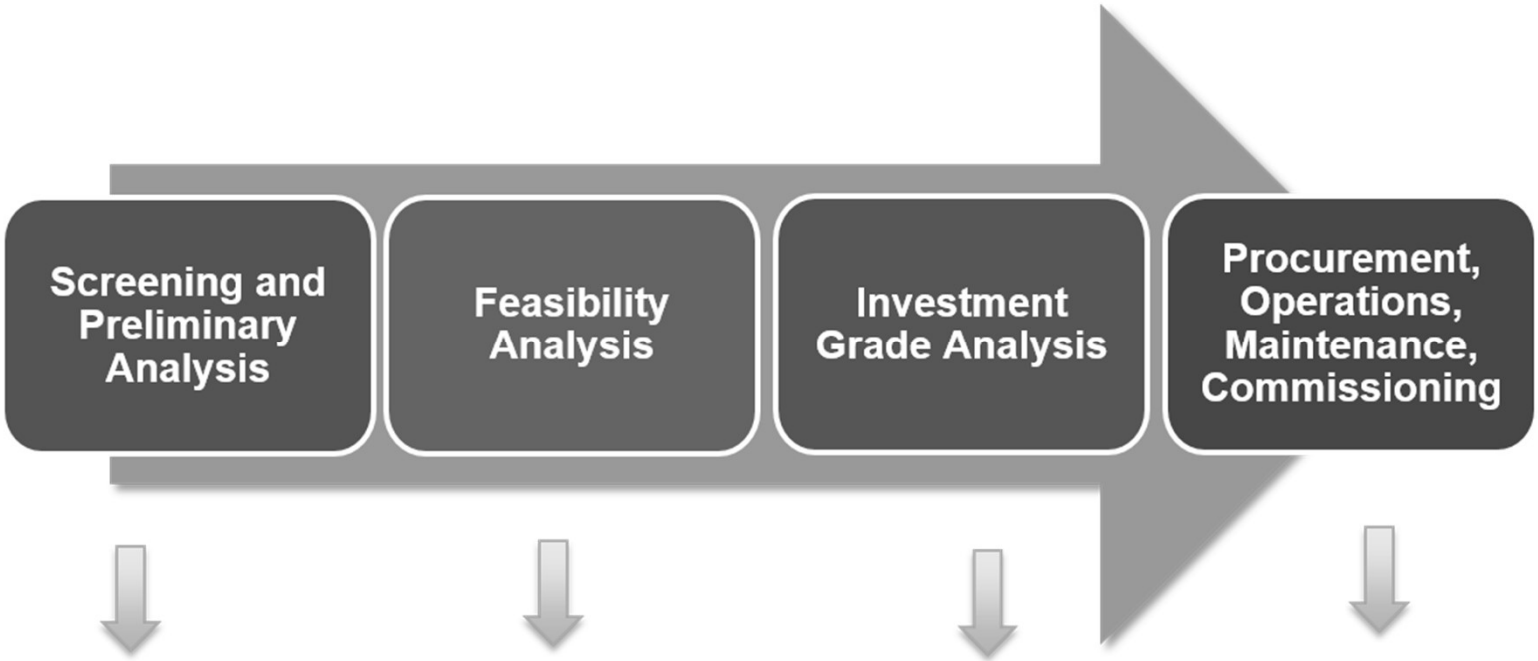
- CHP provides efficient, resilient, baseload power and localized thermal energy
- CHP supports increased integration of renewable energy sources
- Storage adds additional flexibility and can help optimize CHP sizing and operation
- CHP supports the move toward a resilient, distributed, more renewable grid



Finding the Best Candidates:
Some or All of These Characteristics

- High and constant thermal load
- Favorable spark spread
- Need for high reliability
- Concern over future electricity prices
- Interest in reducing environmental impact
- Existing central plant
- Planned facility expansion or new construction; or equipment replacement within the next 3-5 years

CHP TAP Role: Technical Assistance



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.

DOE TAP CHP Screening Analysis

- High level assessment to determine if site shows potential for a CHP project
  - **Quantitative Analysis**
    - Energy Consumption & Costs
    - Estimated Energy Savings & Payback
    - CHP System Sizing
  - **Qualitative Analysis**
    - Understanding project drivers
    - Understanding site peculiarities

Annual Energy Consumption		
	Base Case	CHP Case
Purchased Electricty, kWh	88,250,160	5,534,150
Generated Electricity, kWh	0	82,716,010
On-site Thermal, MMBtu	426,000	18,872
CHP Thermal, MMBtu	0	407,128
Boiler Fuel, MMBtu	532,500	23,590
CHP Fuel, MMBtu	0	969,845
Total Fuel, MMBtu	532,500	993,435
Annual Operating Costs		
Purchased Electricity, $	$7,060,013	$1,104,460
Standby Power, $	$0	$0
On-site Thermal Fuel, $	$3,195,000	$141,539
CHP Fuel, $	$0	$5,819,071
Incremental O&M, $	$0	$744,444
Total Operating Costs, $	$10,255,013	$7,809,514
Simple Payback		
Annual Operating Savings, $		$2,445,499
Total Installed Costs, $/kW		$1,400
Total Installed Costs, $/k		$12,990,000
Simple Payback, Years		**5.3**
Operating Costs to Generate		
Fuel Costs, $/kWh		$0.070
Thermal Credit, $/kWh		($0.037)
Incremental O&M, $/kWh		$0.009
Total Operating Costs to Generate, $/kWh		**$0.042**

General ESCO Process: 4 Phases

Preliminary Assessment Phase

A Business Development Manager (BDM) will make contact with potential clients. The BDM will engage an Energy Engineer (EE) to develop a Preliminary Assessment showing the energy conservation measures with savings and cost estimates. BDMs and EEs Sales people need to understand:

- Is this building a candidate for CHP
- What issues can a CHP system address for this location
- How do I develop a preliminary assessment for cost and savings estimates

General ESCO Process cont.

Investment Grade Audit Phase

The owner has signed an agreement with the ESCO to develop a project with investment-level costs and savings. This document will form the foundation of the construction contract and guaranteed savings agreement. The document is created by close collaboration of the BDM, EE and a Project Manager. The team needs to understand:

- How do I select the right contractor to install the CHP
- How do I select the right CHP System
- How do I finalize the savings for the CHP System
- How do I understand the long-term cost of ownership issues

General ESCO Process cont.

Construction Phase

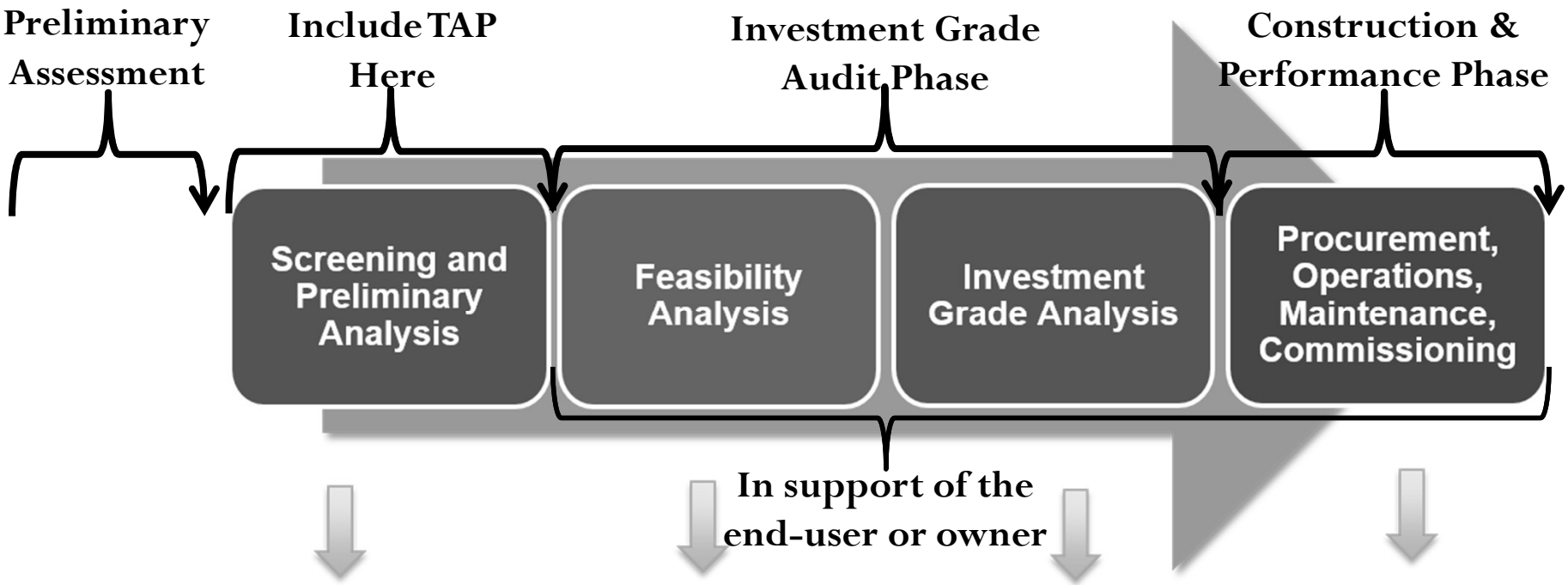
Now that we have a construction agreement, the team needs to understand:

- What are the critical aspects of construction I need to be aware of
- By whom and how should the CHP system be commissioned

Performance Phase

After construction and during the guarantee term of 10-20 years, what should I be concerned about now?

CHP TAP Role: Technical Assistance



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Attractive CHP Markets:

Industrial
Chemicals
Refining
Food processing
Petrochemicals
Natural gas pipelines
Pharmaceuticals
Rubber and plastics
Pulp and paper
Manufacturing
Lumber/wood products

Commercial
Data centers
Hotels and casinos
Multi-family housing
Office buildings
Refrigerated warehouses
Restaurants
Supermarkets
Retail
Green buildings

Institutional
Hospitals
Schools (K–12)
Universities & colleges
Wastewater treatment
Landfills
Correctional facilities
Government buildings
Airports

Agricultural
Dairies
Concentrated animal feeding operations
Greenhouses
Wood waste (biomass)

Black = Attractive CHP Market
Blue = Traditional CHP Market for ESCO's
Red = Developing CHP Market for ESCO's

Project Snapshot:

DOE and ESCO Cooperation

Savannah River National Laboratory

Aiken, SC

Application/Industry: Federal Government

Capacity: 20 MW

Prime Mover: Steam Turbine

Fuel Type: Biomass

Thermal Use: Process Steam

Installation Year: 2012

Energy Savings: $34.3 Million, projected $944 Million throughout life of project.

Highlights:

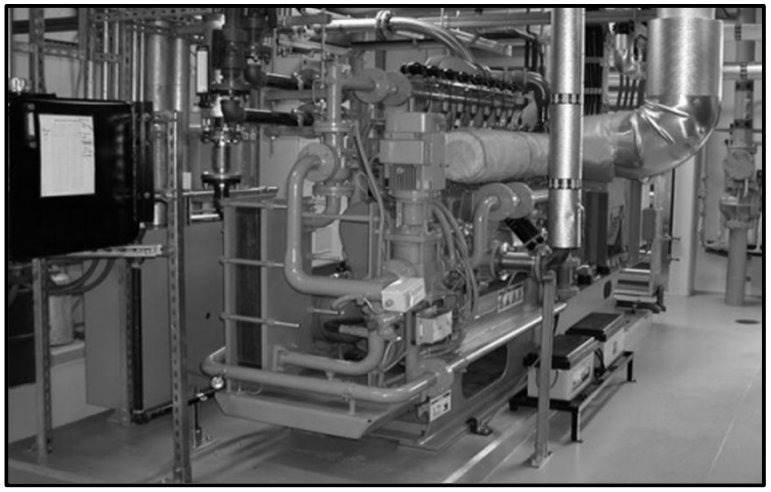
In 2009, the U.S. Department of Energy awarded Ameresco, a leading energy efficiency and renewable energy company, an Energy Service Performance Contract (ESPC) to finance, design, build, operate, and maintain a 20 MW biomass CHP facility as well as two smaller biomass steam plants at the Savannah River Site. This was the largest renewable ESPC project in U.S. history.

Source: https://chptap.lbl.gov/profile/195/doe-savannah-river-Project_Profile.pdf

Project Snapshot:

ESCO Cooperation

Budd Inlet Wastewater Treatment Plant
Olympia, WA
Application/Industry: Municipalities
CHP Capacity: 335 kW
Prime Mover: GE reciprocating engine
Fuel Type: Bio-methane, natural gas
Thermal Use: District heating, digester/sludge treatment
Installation Year: 2009
Annual Savings: $150,000-$180,000



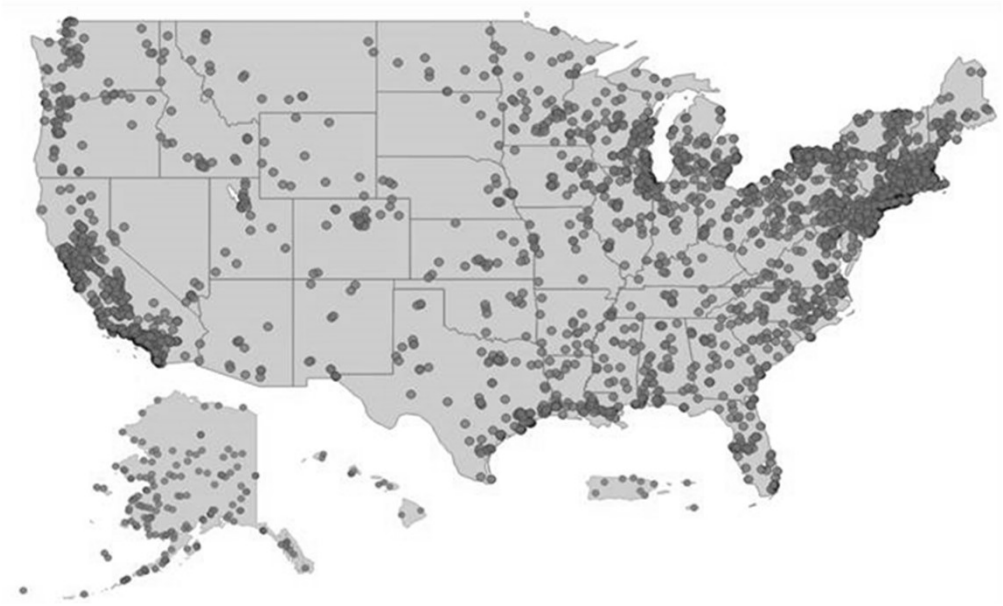
Highlights:
As a municipality-owned utility, the Lacey, Olympia, Tumwater, and Thurston (LOTT) County Alliance was able to take advantage of an ESPC through the Washington State Department of Enterprise Services. This contract provided the following benefits:

- A way to use utility savings to pay for some or all project costs.
- Guaranteed energy savings, determined by the ESCO, were also used to help with project financing; shortfalls in savings were guaranteed to be paid by the ESCO to the facility owner.
- As part of the contract, the client also received a guaranteed maximum project cost, guaranteed equipment performance, and open book pricing for project costs.
- LOTT did not have to publish an RFP, develop a contract with an ESCO, negotiate scope and cost of the project, or review invoices, all of which represented a significant investment in time and expense.

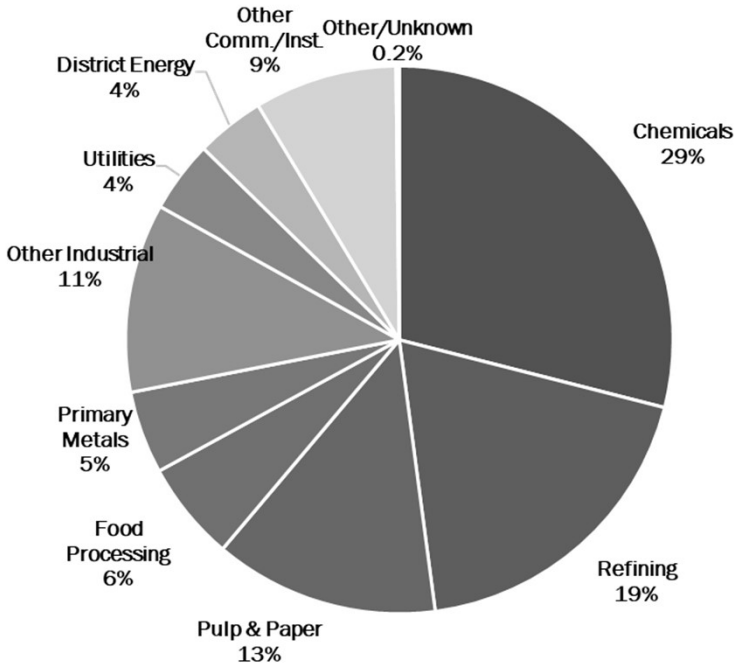
Source: https://chptap.lbl.gov/profile/27/BuddInletWWTF-Project_Profile.pdf

CHP Today in the United States

CHP Installations in the U.S.



Existing CHP Capacity

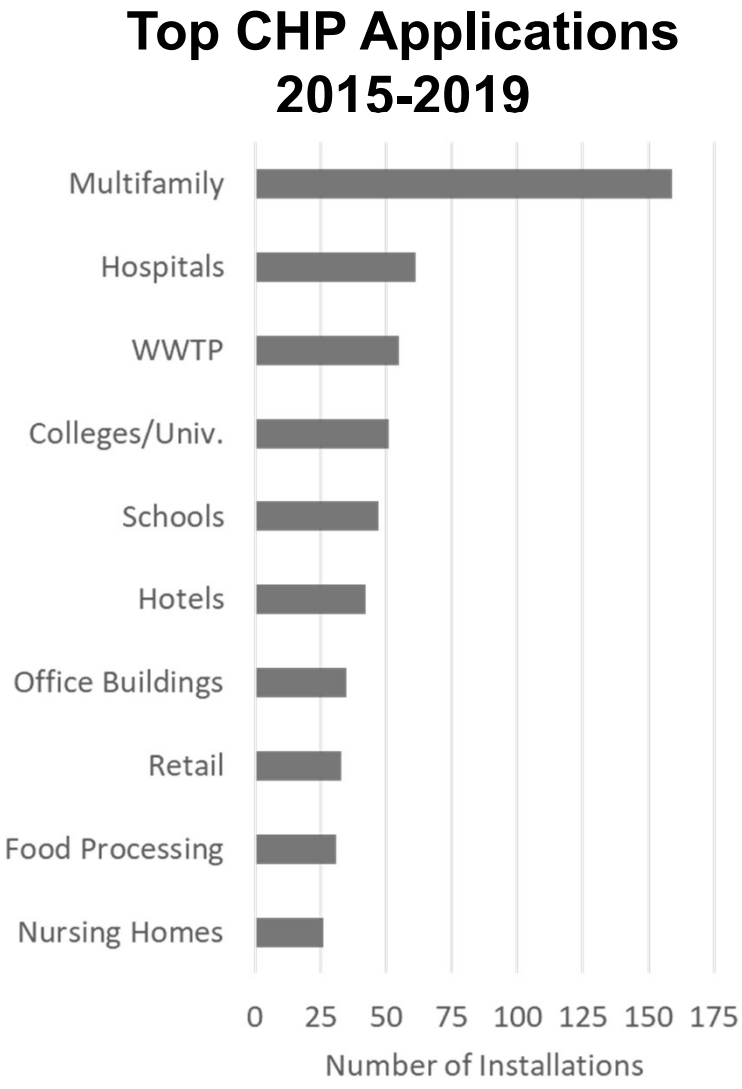


- 80.7 GW of installed CHP at more than 4,600 industrial and commercial facilities
- 82% of existing CHP capacity is in industrial applications
- 65% of capacity is gas turbine based
- 72% natural gas fueled; 15% biomass, biogas, and municipal and process waste fueled

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

CHP Market Trends – The Last Five Years

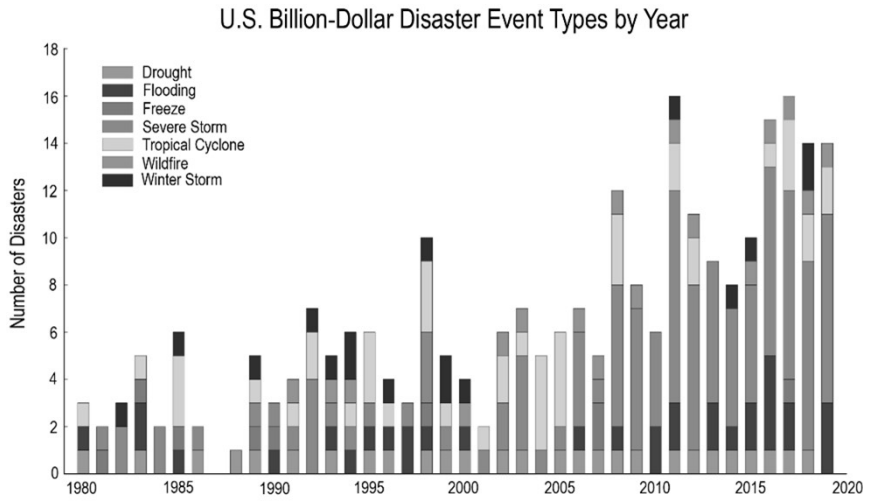
- Significant capacity continues to be installed in industrial applications – 61% of capacity
- Growing activity in non-traditional CHP markets (light industrial, commercial, institutional, multi-family) – 88% of installs
- Move toward smaller CHP installations - recip engines and microturbines make up 77% of installs
  - ✓ Increase in packaged CHP system offerings
- Natural gas continues to be the dominant fuel - 77% of new capacity
- Increasing interest in hybrid systems that integrated CHP with renewables and energy storage
- Prioritizing CHP for resilience with focus on critical infrastructure applications and microgrids



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

CHP Enhances Energy Resilience

- Higher reliability and power quality are needed to meet critical requirements
- Increased incidences of grid outages cause supply and production disruptions
- Consequences for health and safety of staff and clients, continuity of services, community support
- CHP can maintain power and heating/cooling during outages while providing financial benefits through operating savings every day



Source: NOAA

Natural Disaster or Storm Events	Flooding	High Winds	Earthquakes	Wildfires	Snow/Ice	Extreme Temperature
Battery Storage	◒	○	◒	●	○	◒
Biomass/Biogas CHP	◒	◒	◒	●	○	○
Distributed Solar	○	◒	◒	●	◒	◒
Distributed Wind	○	◒	◒	◒	◒	◒
Natural Gas CHP	○	○	◒	◒	○	○
Standby Generators	◒	○	◒	●	◒	○

Ranking Criteria

Four basic criteria were used to estimate the vulnerability of a resource during each type of disaster event. They include the likelihood of experiencing:

1. *a fuel supply interruption,*
2. *damage to equipment,*
3. *performance limitations, or*
4. *a planned or forced shutdown*

○ *indicates the resource is unlikely to experience any impacts*

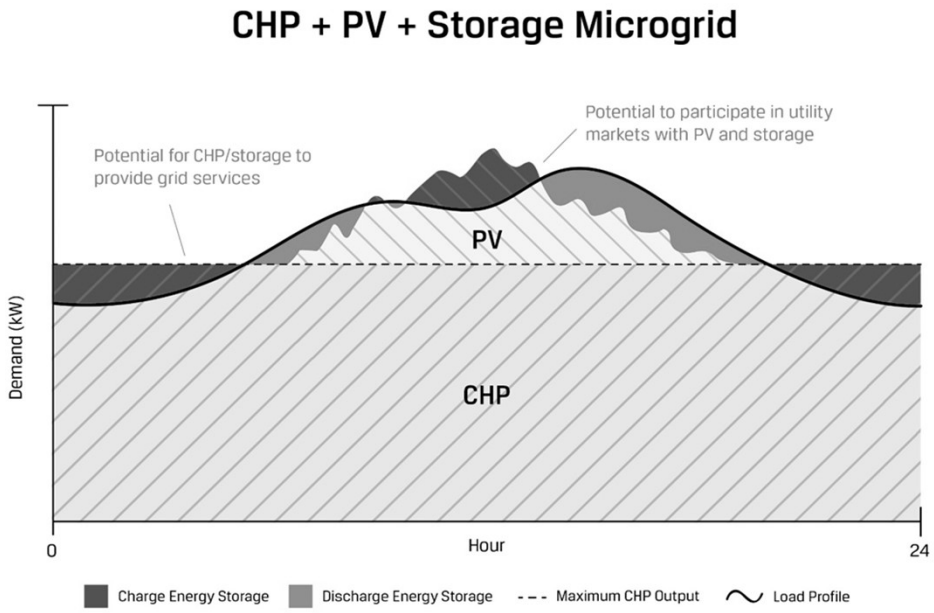
◒ *indicates the resource is likely to experience one, two, or three impacts*

● *indicates the resource is likely to experience all four impacts*

Source: https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/DER_Disaster_Impacts_Issue%20Brief.pdf

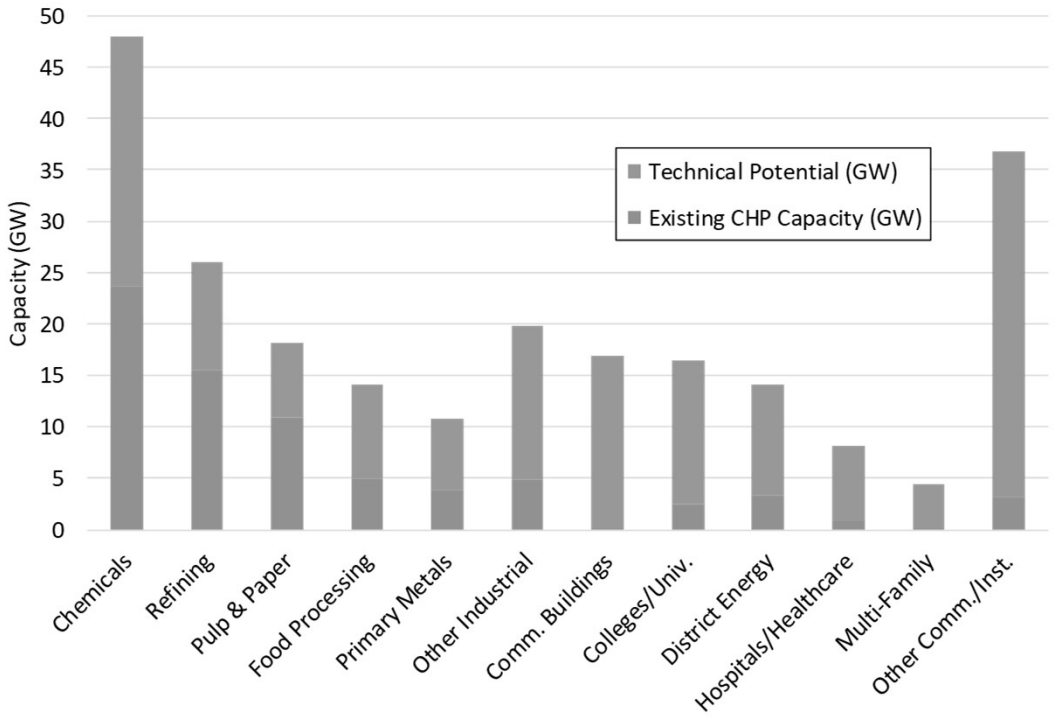
Hybrid Solar + Storage + CHP Solutions

- An optimized combination of solar, storage, and CHP can provide long-duration, on-site energy for sites with high resilience needs with the least possible carbon emissions
- CHP provides efficient, resilient, baseload power and thermal energy
- PV reduces grid demand and related emissions in peak hours
- Storage provides additional flexibility, helping to "firm" solar to meet peak loads
- Adding photovoltaic (PV) and storage lowers the required CHP size and further improves emissions compared to the grid



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

Packaged CHP Market

Packaged CHP systems are designed to increase deployment of CHP in key markets that are underdeveloped due to a variety of barriers that increase the perceived risks to end-users, engineers, equipment providers and project developers. These markets are served by smaller systems, generally less than 10 MW, which are also conducive to packaging and/or modularization.

Catalog focus

Application	50-500 kW	0.5 - 1 MW	1 - 5 MW	5 - 10 MW	10 - 20 MW	> 20 MW	Total
Industrial	6,281	4,351	15,567	9,064	7,971	21,157	65,381
Commercial	20,068	18,100	20,284	5,504	3,948	8,026	75,930
Total	26,349	22,451	35,470	14,568	11,919	30,183	140,941

Source: US DOE *CHP Technical Potential* in the US, June 2017

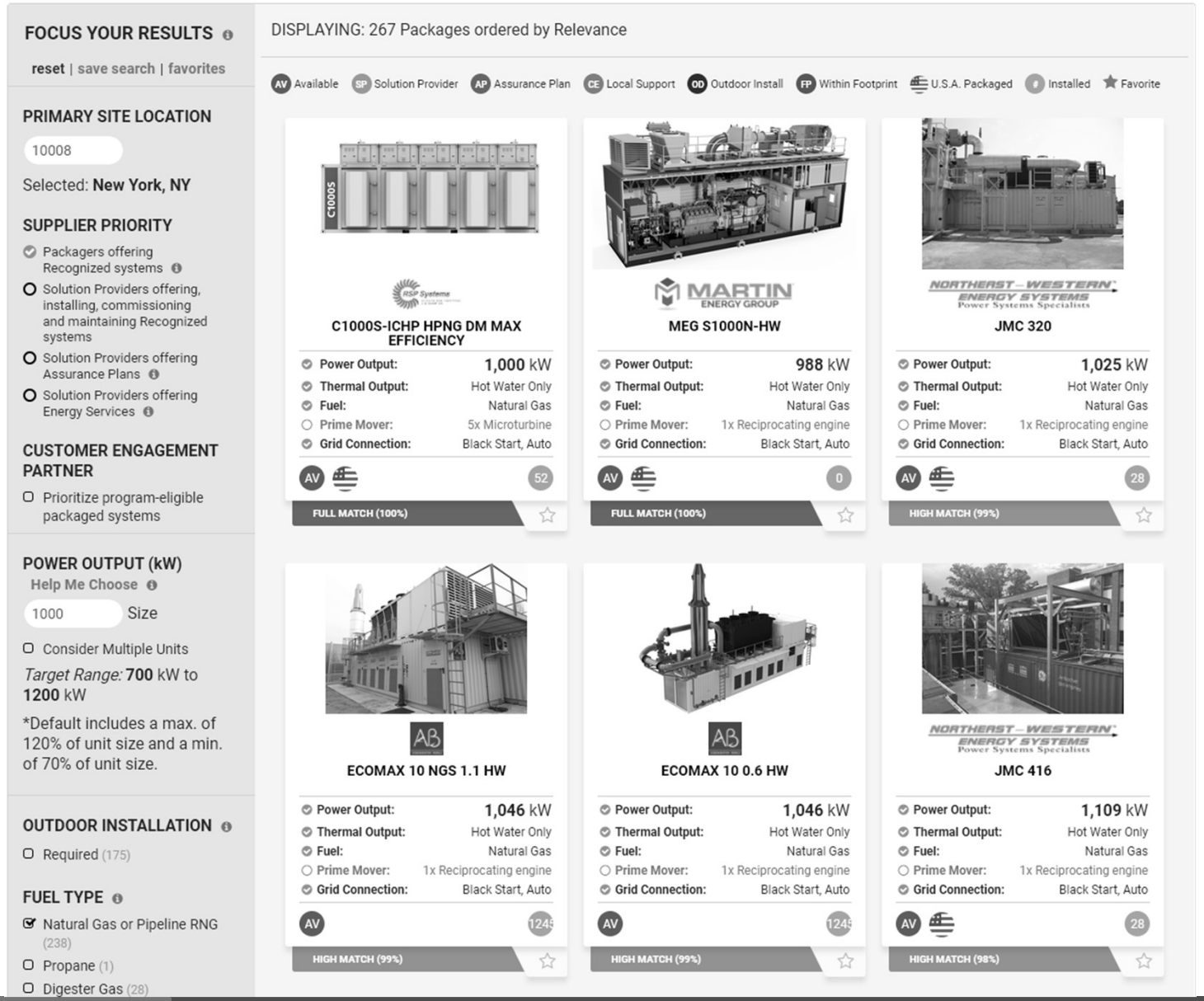
50 kW to 10 MW systems represent 99 GW of technical potential (70%)

DOE Packaged CHP eCatalog

- **Reduce risks for end-users and vendors through a national web-based catalog (*eCatalog*) of DOE-recognized packaged systems and suppliers, and a partnership with state/utility partners with CHP market engagement programs:**
  - *CHP Suppliers* that assemble, install and/or service packaged CHP systems
  - *CHP Engagement* partners that provide CHP market deployment programs at the state, local and utility level
- **DOE experts review packaged CHP system specifications**
- **End-users and design engineers search for applicable CHP system characteristics, and get connected to packagers, installers and CHP engagement programs**
- **Allows users to compare technology options on a common basis**

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

Searching the CHP eCatalog . . .



CHP System Information in e-Catalog

OVERVIEW

JMC 320

PACKAGED CHP SYSTEM HIGHLIGHTS

CHP Packager	Northeast Energy Systems
Model	JMC 320
Thermal Outputs	Hot Water
Assurance Plan	Depends on location
Grid Connection Type	Grid Parallel and Stand-alone Transition: Automatic
Outdoor Placement	Standard Option

KEY PERFORMANCE DATA

Prime Mover	Reciprocating engines Jenbacher j 320 GS-D802
Number of Prime Movers	1
Net Power Output $(kW)_2$	1,025
Fuel	Natural Gas or Pipeline RNG

INSTALLATION EXPERIENCE

28	-	8	6
Total Company Installs	**Total Company Installs In NY**	**Installs Of This Package**	**Company Installs Of This Package**
Total CHP systems installed by Northeast Energy Systems	Total CHP systems installed by Northeast Energy Systems in NY	Total number of this model Packaged CHP system installed	Installs of this model by Northeast Energy Systems

Note: Installations of Packaged CHP Systems may include systems outside the USA, and some may be 50 hertz applications.

- PERFORMANCE DATA
- GENERATOR/INTERCONNECTION
- THERMAL RECOVERY SYSTEMS
- SOUND
- FOOTPRINT
- PACKAGED CHP SYSTEM SIMPLIFIED SCHEMATIC

Also Included:

- Assurance plan
- Packager & Solution Provider Description
- Manufacturer certifications
- Contact info for manufacturer and nearest TAP

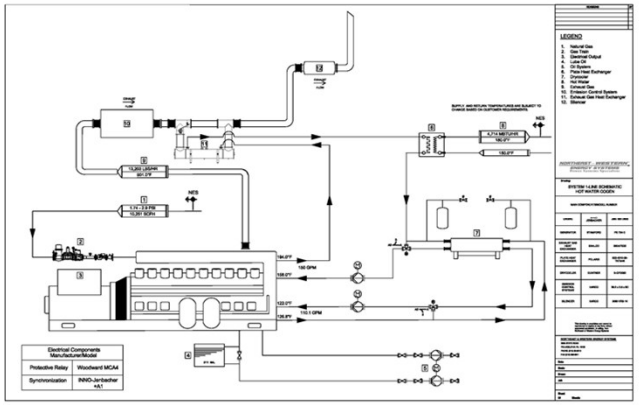
CHP Performance Data

PERFORMANCE DATA

Performance data presented below is based on capacity that is available at the respective prime mover load conditions. Performance data in Higher Heating Value (HHV). Note that when multiple thermal capacities are presented e.g. hot water, steam, chilled water and/or ORC kW, these capacities are based on using all the thermal heat available from the prime mover and should be viewed and independent and not concurrent with other thermal capacities. Note, for reciprocating engines steam production is generally using only exhaust heat so that hot water or chilled water capacity is concurrent with the steam capacity. In all cases, contact the Packager or Solution Provider for site specific details.

		100% GROSS POWER			75% GROSS POWER			50% GROSS POWER		
	Ambient Temperature	95°F	59°F	0°F	95°F	59°F	0°F	95°F	59°F	0°F
	CHP Fuel Input (MMBtu per hour HHV)	10.3	10.3	10.3	8.0	8.0	8.0	5.7	5.7	5.7
POWER	Gross Electricity Output (kW)	956	1,062	1,062	716	795	795	474	527	527
POWER	Net Electricity Output (kW)	923	1,025	1,025	689	765	765	453	503	503
POWER	Net Electric Efficiency % (HHV)	30.4	33.8	33.8	29.3	32.5	32.5	27.0	30.0	30.0
HOT WATER	Supply Temp to Site (°F)		180 °F			180 °F			180 °F	
HOT WATER	HW flow (GPM)	188	188	188	148	148	148	108	108	108
HOT WATER	Return Temp from Site (°F)	140	140	140	140	140	140	140	140	140
HOT WATER	Hot Water Capacity (MMBtu/hr)	3.77	3.77	3.77	2.98	2.98	2.98	2.17	2.17	2.17
HOT WATER	Thermal Efficiency % (HHV)	36.5	36.5	36.5	37.2	37.2	37.2	38.0	38.0	38.0

Be sure that the site thermal load will handle return water temperatures to the CHP system as stated. (e.g. 5 to 10 F below) Otherwise, hot water capacity will be less than stated. Contact the Packager/Solution Provider for details.

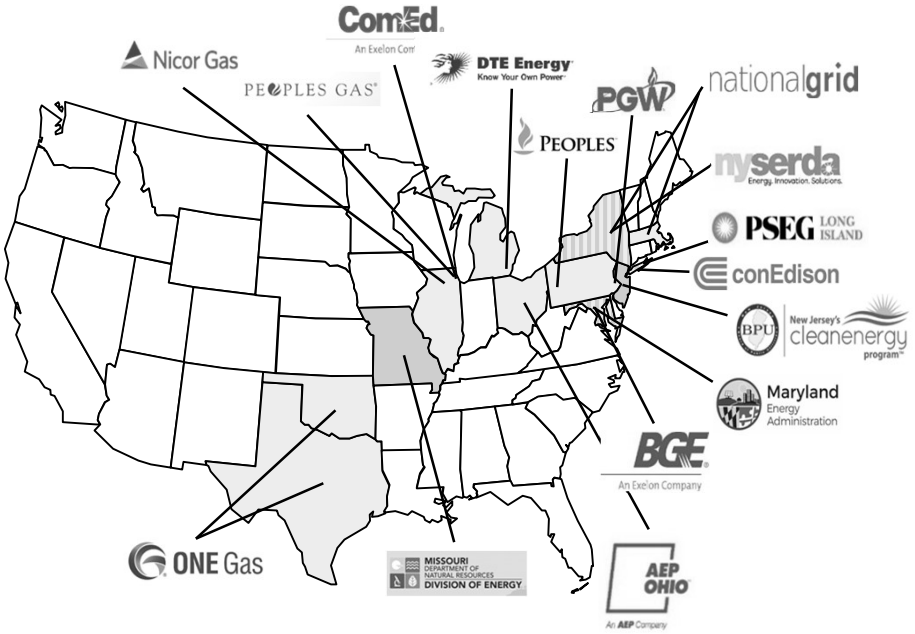


EMISSIONS	Emissions Aftertreatment	Lean-burn engine with no aftertreatment
EMISSIONS	NOx Emissions (lb/MWhe)	1.82
EMISSIONS	CO Emissions (lb/MWhe)	7.60
EMISSIONS	NMHC Emissions (lb/MWhe)	3.04

DOE Packaged CHP Accelerator

- **Better Buildings Accelerators** demonstrate innovative policies and approaches designed to accelerate investment in energy efficiency
- **Objective:** Populate, launch and publicize the eCatalog and promote packaged CHP
- **Goals:** Verify packaged CHP system performance in industrial, commercial, institutional and government markets
- **CHP Engagement Partners:** Utilities, states and federal agencies committed to promoting packaged CHP via CHP deployment and/or incentive programs
- **CHP Supplier Partners:** CHP packagers and solution providers participating in the national eCatalog

Current CHP Engagement Partners



https://betterbuildingssolutioncenter.energy.gov/accelerators/packaged-chp

Questions?

- U.S. DOE Technology Partnerships Program
- CHP Technical Assistance Partnerships (CHP TAPs)
- CHP Market Update
- Packaged Systems Accelerator and eCatalog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