

U.S. DEPARTMENT OF  
**ENERGY**

Office of  
ENERGY EFFICIENCY &  
RENEWABLE ENERGY

# CHP/DE Portfolio Meeting – Day One

*Bob Gemmer, CHP Program Lead*

*EERE Advanced Manufacturing Program*

*San Antonio, Texas*

*June 9, 2022*



# *Welcome!*

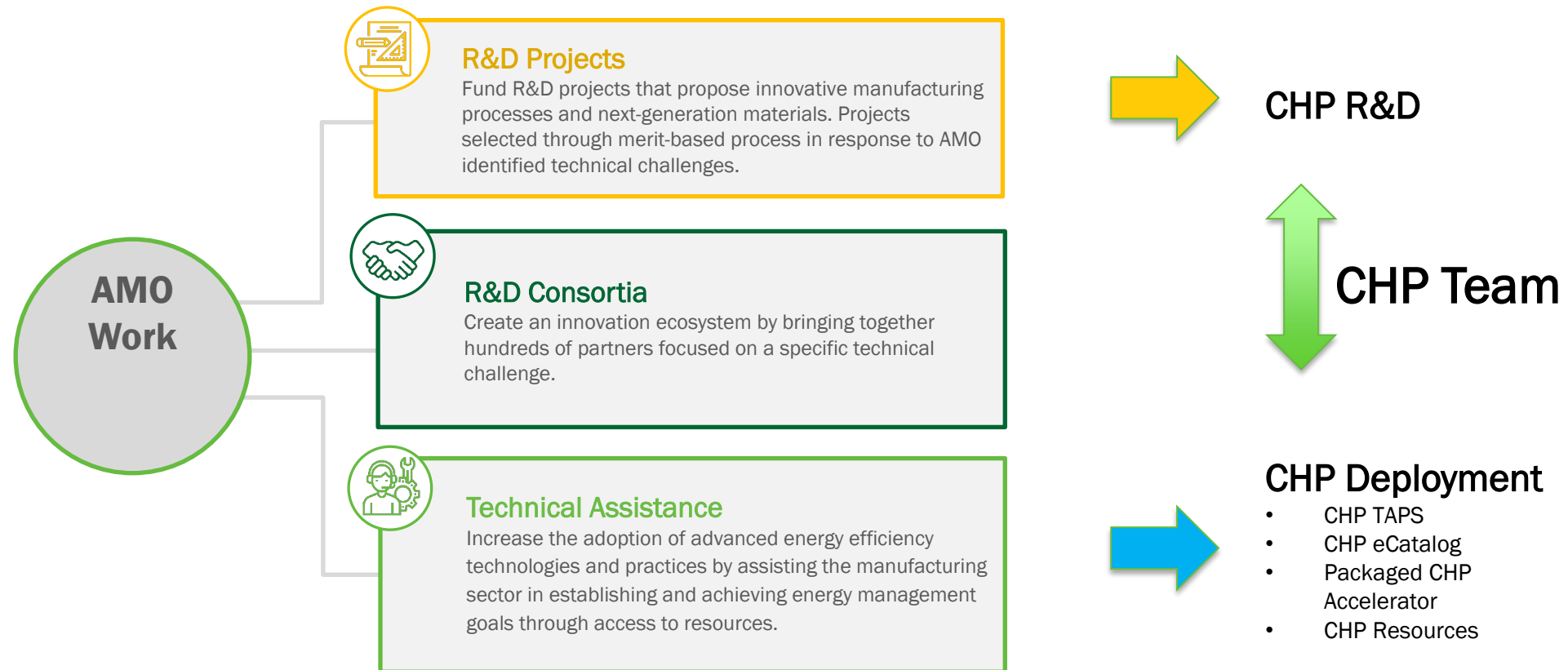
**SwRI introduction slides can be inserted here**

# Meeting Agenda

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- **Day One**
  - AMO CHP Program Overview
  - CHP Markets and Decarbonization
  - Flexible CHP R&D and Demonstrations
- **Day Two**
  - National Laboratory Projects
  - High Power to Heat Ratio CHP Systems R&D
  - Tour of SwRI
- **Day Three**
  - District Energy Systems Modeling and Verification/Validation

# CHP Is an Integral Part of the AMO Program



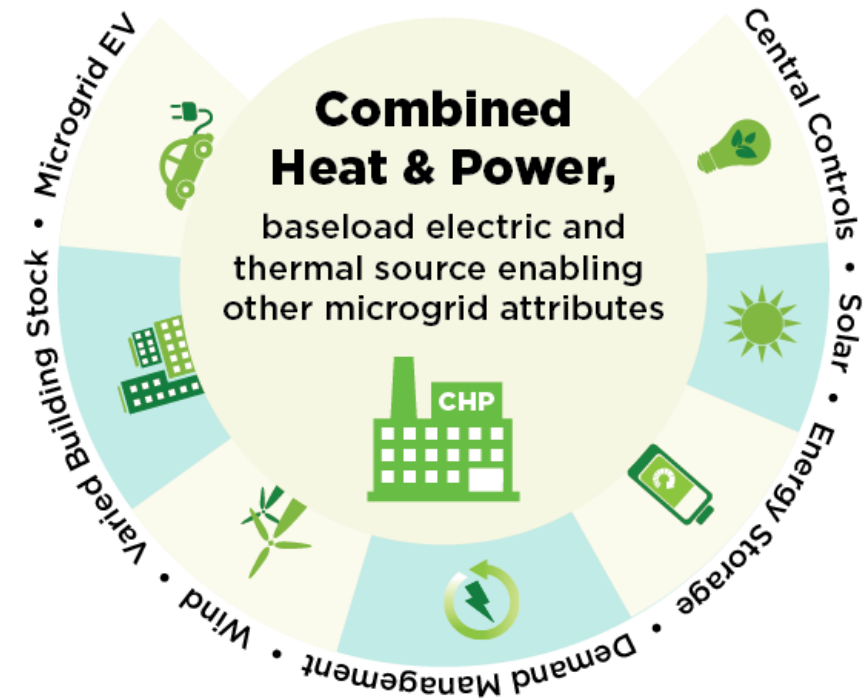
# CHP Benefits

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- **More efficient than separate generation of electricity and heating/cooling**
  - Lower carbon and other pollutant emissions
  - Lower operating costs (but requires capital investment)
- **Works with any fuel, including carbon neutral fuels**
  - Efficiency becomes more important as fuels become scarce
- **Increases energy reliability and resiliency**
- **Reduces grid congestion and avoid distribution costs**
  - Complements intermittent renewable resources

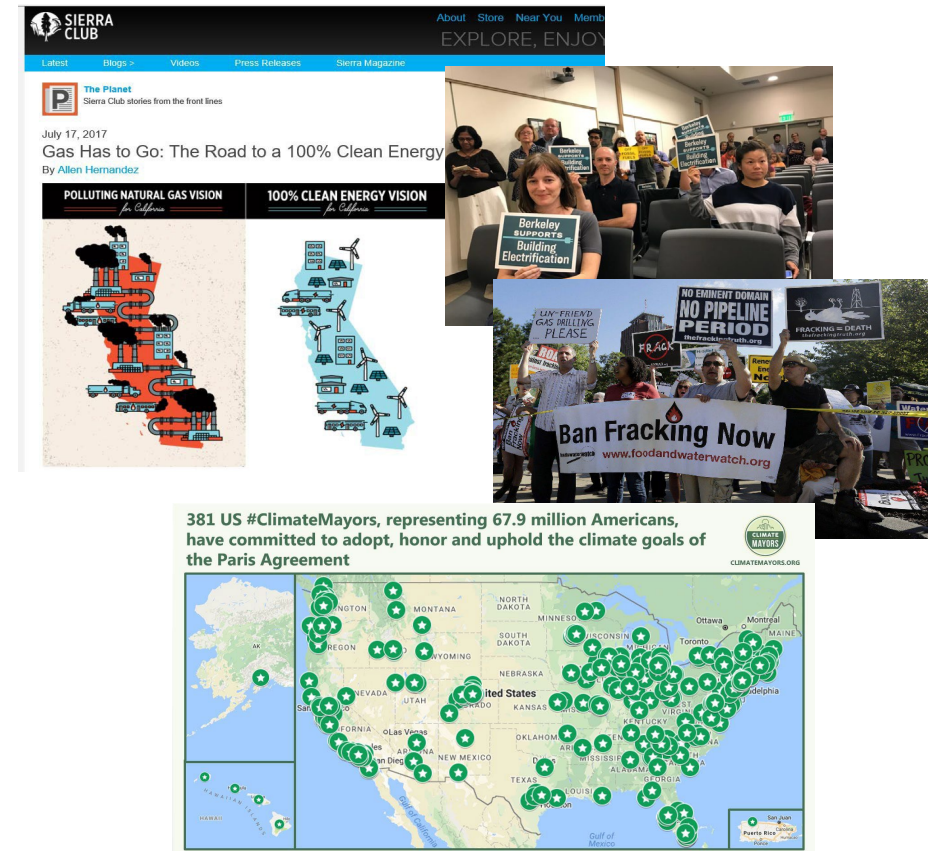
# CHP as a Resilient Anchor for Clean Microgrids

- 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 can be fueled by local resources where available

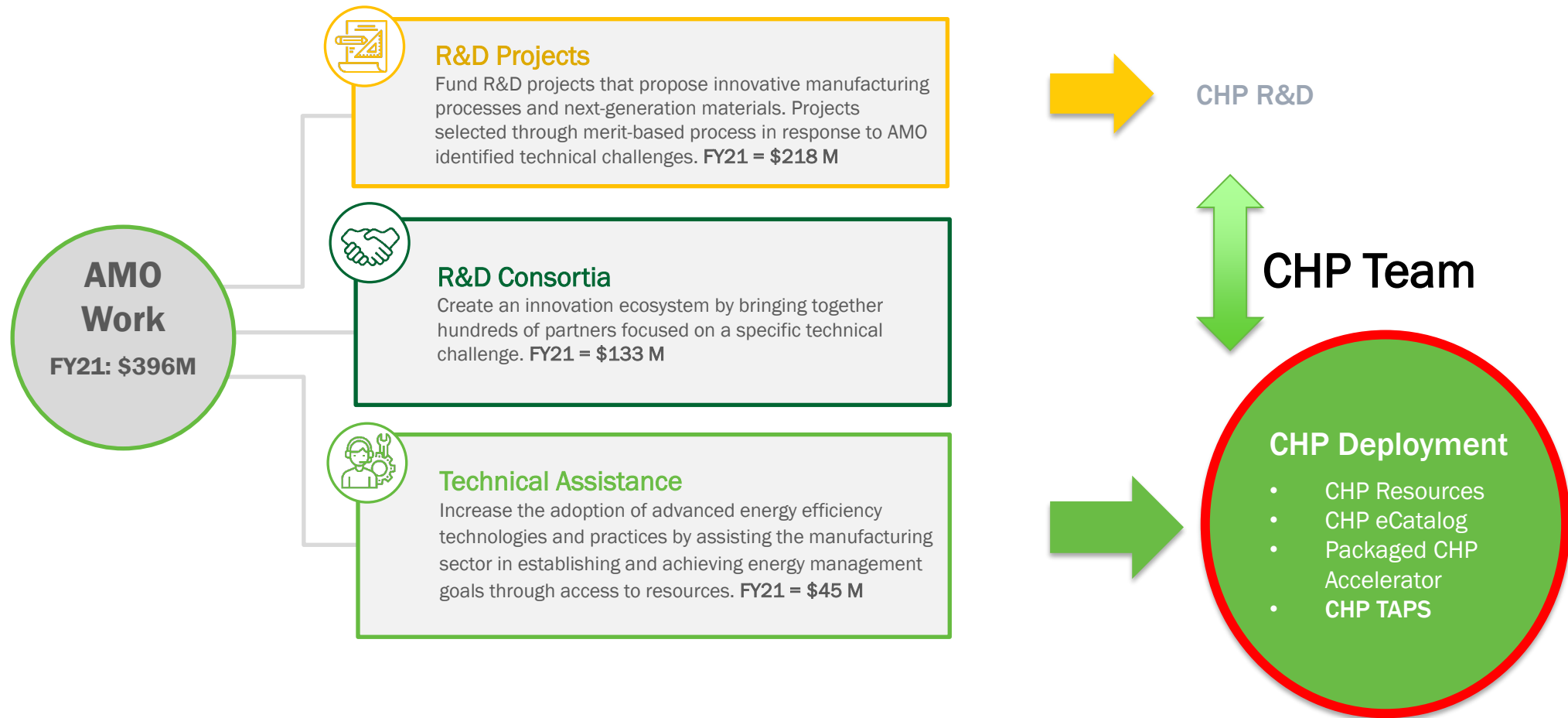


# Decarbonization

- Decarbonization is a major policy topic nationally
- Biden Administration priorities
  - Addressing climate change and building clean energy economy
  - Goal to reach net-zero carbon emissions by 2050
- CHP's contribution
  - Efficiency – can save carbon now
  - Fuel flexible
  - Complements intermittent renewable resources



# CHP Deployment Program



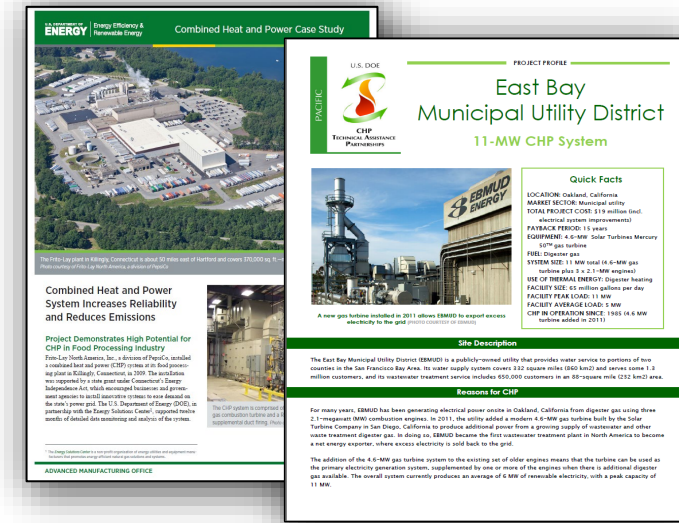
# U.S. DOE CHP Deployment Program Mission & Scope

## 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 Market and Project Resources
- Packaged CHP eCatalog
- Packaged CHP Accelerator
- CHP Technical Assistance Partnerships (CHP TAPs)



[energy.gov/chp](https://energy.gov/chp)

# CHP Deployment Support Resources

## Objectives:

Provide tools, analyses and technical materials to support CHP TAP mission;

Educate policymakers, regulators, end users, trade associations, and other CHP stakeholders;

Inform DOE CHP Deployment and R&D program planning

## Expertise:

Market analysis and tracking  
CHP regulatory and policy trends  
Technology information and industry trends

## Materials:

# CHP Installation Database

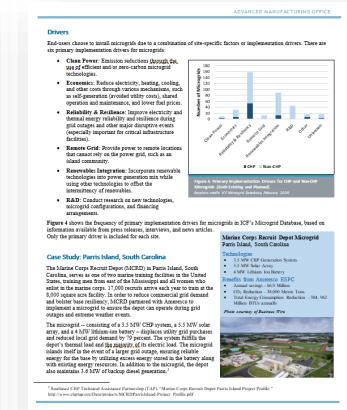
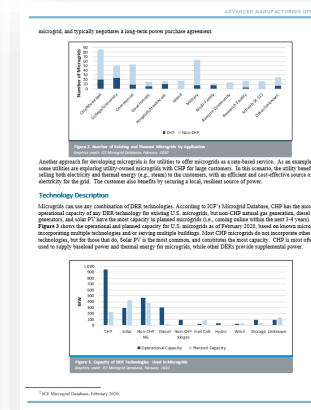
## Upcoming: Microgrid Installation Database

## CHP TAP screening/evaluation tools

## CHP project and policy/program profiles

## Fact sheets

## Topic issue briefs and reports



[energy.gov/chp](https://energy.gov/chp)

# DOE Packaged CHP eCatalog

A national web-based searchable catalog of DOE-recognized packaged CHP systems and suppliers with the goal to reduce risks for end-users and vendors through partnerships with:

**CHP Packagers** that assemble and support recognized Packaged CHP Systems

**Solution Providers** that install, commission and service packaged CHP systems

**CHP Engagement Partners** that provide CHP market deployment programs at the state, local and utility level

**Pre-engineered and tested packaged CHP systems that meet DOE performance requirements**

**eCatalog audience:** end-users, consulting engineers, utilities, state energy offices, regulators, federal agencies, and project developers.

**Users 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**

The screenshot displays the DOE Packaged CHP eCatalog website. The header includes the U.S. Department of Energy logo and navigation links for SEARCH eCATALOG, SITE GUIDE, BENEFITS, FINANCING, PACKAGERS, SOLUTION PROVIDERS, CUSTOMER ENGAGEMENT PARTNERS, and CHP TAPS. A 'Contact Us' button and a 'Sign In' link are also present. The main content area features a large image of industrial piping and a search sidebar on the left. The sidebar contains filters for 'QUICK START', 'FIND CHP PACKAGES', 'PRIMARY SITE LOCATION' (with a Zip Code input), 'SUPPLIER PRIORITY' (with radio buttons for Packagers, Solution Providers, and Assurance Plans), 'POWER OUTPUT' (with a kW input), 'OUTDOOR INSTALLATION' (with a Required checkbox), 'FUEL TYPE' (with radio buttons for Natural Gas, Propane, and Digester Gas), 'GRID CONNECTION TYPE' (with radio buttons for Grid Parallel Only, Grid Island, and Black Start), 'THERMAL OUTPUT' (with radio buttons for Hot Water Only, Hot Water and Chilled Water, Steam Only, Steam and Hot Water, and Steam, Hot Water, and Chilled Water), and 'PRIME MOVERS' (with radio buttons for Reciprocating engines, Combustion turbines, and Microturbine). A 'FIND PACKAGES' button is at the bottom of the sidebar. The main content area has a heading 'PACKAGED CHP SYSTEMS: RIGOROUS RECOGNITION PROCESS' and buttons for 'SHOP THE eCATALOG' and 'LEARN MORE'. Below this is a 'Getting Started: REGISTER' button. The text explains that the eCatalog is a voluntary public/private partnership designed to increase deployment of CHP in commercial, institutional, and multi-family buildings and manufacturing plants. It also mentions that the core of the eCatalog are CHP Packagers who commit to provide pre-engineered and tested Packaged CHP systems that meet or exceed DOE performance requirements and CHP Solution Providers who commit to provide responsible installation, commissioning, maintenance and service of recognized Packaged CHP systems and also provide a single point of project responsibility. A section titled 'CUSTOMER ENGAGEMENT PARTNERS: INCENTIVIZING CHP IN YOUR AREA' discusses the importance of energy efficient technologies and the role of customer engagement partners. Finally, a section titled 'eCATALOG PACKAGED CHP SYSTEM PERFORMANCE' explains that the data is standardized and presented for comparison, based on engineering data and available performance test data submitted by the Packagers. Emissions data is based on either third-party emissions test results when available, or prime mover manufacturer's emissions certification data, both using standard EPA test methodologies or equivalent. When evaluating CHP performance for a particular project, it is important to use final performance data from the Packager or Solution Provider that reflects specific site conditions such as actual fuel characteristics, ambient temperatures and altitude, and thermal load temperatures or pressures. As an example, hot water thermal capacity ratings in the eCatalog are based on a standard hot water supply temperature of 180 F, with packager specified return temperatures for each system. Actual hot water available from a packaged CHP system for a project will depend on the specific temperature requirements of the hot water supply and return at the site, and may vary from data presented in the eCatalog.

# Packaged CHP eCatalog



**FOCUS YOUR RESULTS**

reset | save search | favorites

**PRIMARY SITE LOCATION**

20001

Selected: Washington, DC

**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.

**OUTDOOR INSTALLATION**

- ☐ Required (174)

**FUEL TYPE**

- ☐ Natural Gas (231)
- ☐ Propane (1)
- ☐ Digester Gas (26)

**GRID CONNECTION TYPE**

- ☐ Grid Parallel Only (57)
- ☐ Grid Island, Black Start, Auto Transfer (189)

**THERMAL OUTPUTS**

- ☐ Hot Water Only (240)
- ☐ Hot Water and Chilled Water (1)
- ☐ Steam Only (1)
- ☐ Steam and Hot Water (13)
- ☐ Steam, Hot Water, and Chilled Water (3)

**PRIME MOVERS**

- ☐ Reciprocating engines (175)
- ☐ Combustion turbines (1)
- ☐ Microturbine (82)

DISPLAYING: 258 Packages ordered by Relevance

Available Solution Provider Assurance Plan Local Support Outdoor Install Within Footprint U.S.A. Packaged Installed Favorite

**JMC 416**

- Power Output: 1,109 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 1x Reciprocating engine
- Grid Connection: Black Start, Auto

AV SP AP US 26

FULL MATCH (100%)

**C800S-1CHP HPNG DM MAX EFFICIENCY**

- Power Output: 800 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 4x Microturbine
- Grid Connection: Black Start, Auto

AV SP AP US 0

FULL MATCH (100%)

**CG132B-16 POWER HEAT MAX CONTAINER NG**

- Power Output: 784 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 1x Reciprocating engine
- Grid Connection: Black Start, Auto

AV US 0

FULL MATCH (100%)

**CHP12V4000GS1MNAT**

- Power Output: 1,127 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 1x Reciprocating engine
- Grid Connection: Black Start, Auto

AV SP AP US 0

FULL MATCH (100%)

**AEGIS POWER THERM 75**

- Power Output: 73 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 1x Reciprocating engine
- Grid Connection: Parallel Only

AV SP AP US 293

FULL MATCH (100%)

**CPT - SOLAR TURBINE - TAURUS 70**

- Power Output: 7,501 kW
- Thermal Output: Steam Only
- Fuel: Natural Gas
- Prime Mover: 1x Combustion turbines
- Grid Connection: Black Start, Auto

AV US 2

FULL MATCH (100%)

**CP35D1-TNUG**

- Power Output: 35 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 1x Reciprocating engine
- Grid Connection: Black Start, Auto

AV 6

FULL MATCH (100%)

**MEG S1000N-HW**

- Power Output: 988 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 1x Reciprocating engine
- Grid Connection: Black Start, Auto

AV SP AP US 0

FULL MATCH (100%)

**INV-E+ 125**

- Power Output: 123 kW
- Thermal Output: Hot Water Only
- Fuel: Natural Gas
- Prime Mover: 1x Reciprocating engine
- Grid Connection: Black Start, Auto

AV US 615

FULL MATCH (100%)

# DOE Packaged CHP Accelerator

**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 efficiency program implementors committed to promoting packaged CHP via CHP deployment and/or incentive programs

**CHP Supplier Partners:** CHP packagers and solution providers participating in the Packaged CHP eCatalog

## Planned Products:

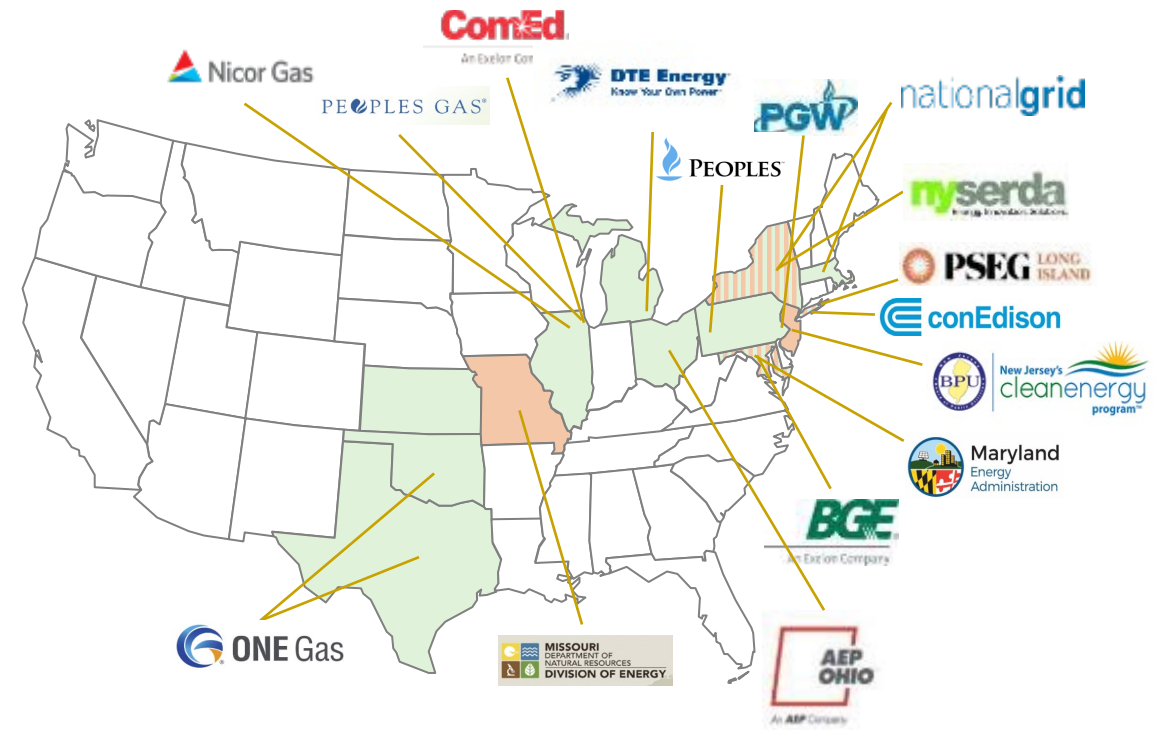
Engagement Partner Roadmaps

Topical Webinar Series

Market Sector Fact Sheets

Verification of Packaged CHP System deployment

## Current CHP Engagement Partners



<https://betterbuildingsolutioncenter.energy.gov/accelerators/packaged-chp>

# CHP Technical Assistance Partnerships (CHP TAPs)

- **End User Engagement**

Partner with strategic Manufacturers and other 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 policymakers, 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.



**Above:** National Manufacturing Day 2019 at the University of Illinois at Chicago

# CHP Technical Assistance Partnerships Activities

Through May 2022, the CHP TAPs:

- Completed over 905 Technical Assistance Activities
- Completed 462 end-user partner engagements
- Completed 353 stakeholder partners engagements
- Completed 129 Project Profiles
- Completed 90 Policy/Program Profiles

## CHP TAP ROLE FOR TECHNICAL ASSISTANCE:



### Screening and Preliminary Analysis

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

### Feasibility Analysis

Perform 3<sup>rd</sup> party reviews of site feasibility assessments: Estimates on savings, installation costs, simple paybacks, equipment sizing, and type.

### Investment Grade Analysis

Perform 3<sup>rd</sup> party reviews of engineering analysis. Review equipment sizing and choices.

### Procurement, Operations, Maintenance, Commissioning

Review specifications and bids.

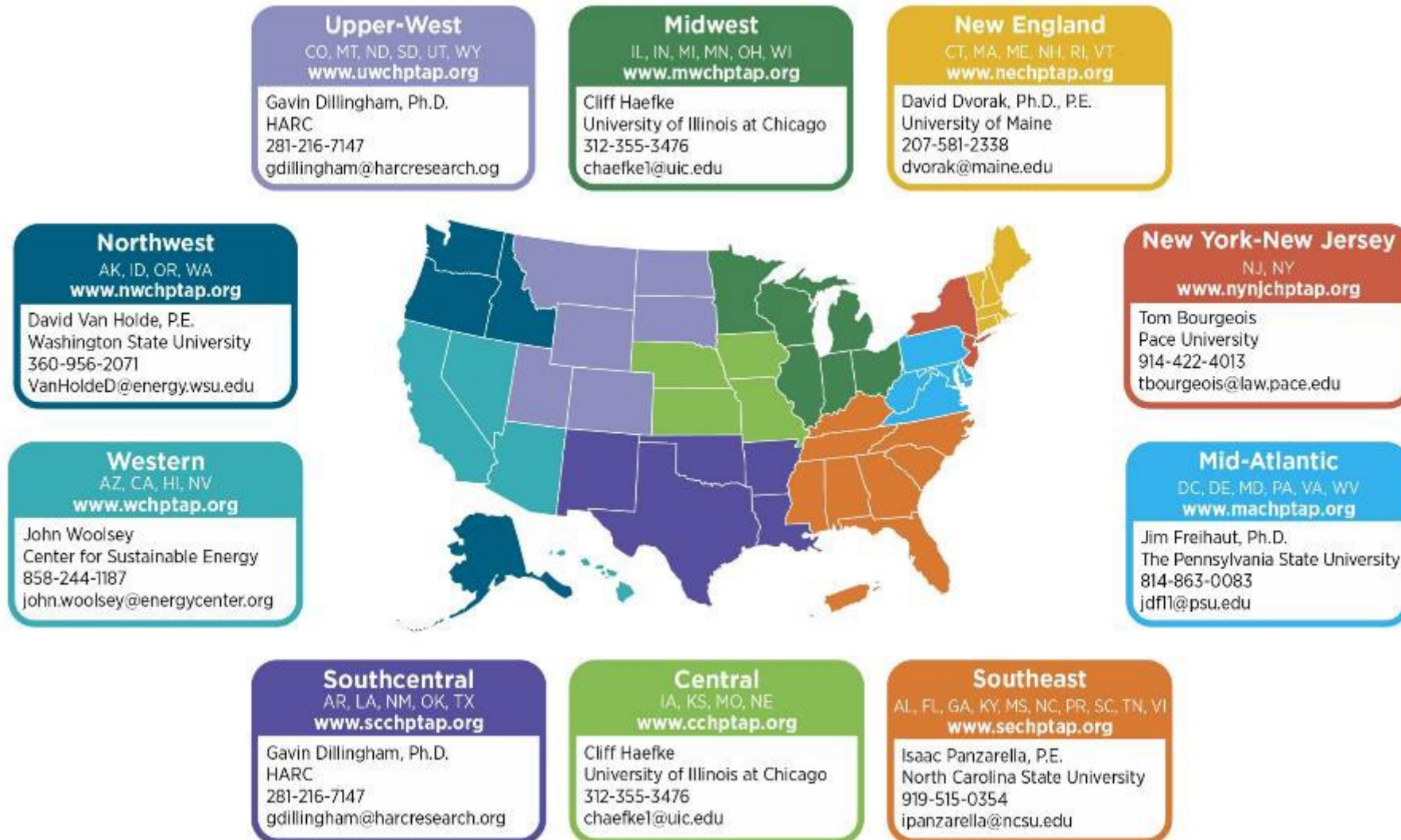
## End-User & Stakeholder Engagements

- Workshops
- Webinars
- One-on-one Meetings
- Presentations
- Booths at conferences
- Project and Policy/Program Profiles
- Education – NOT Advocacy

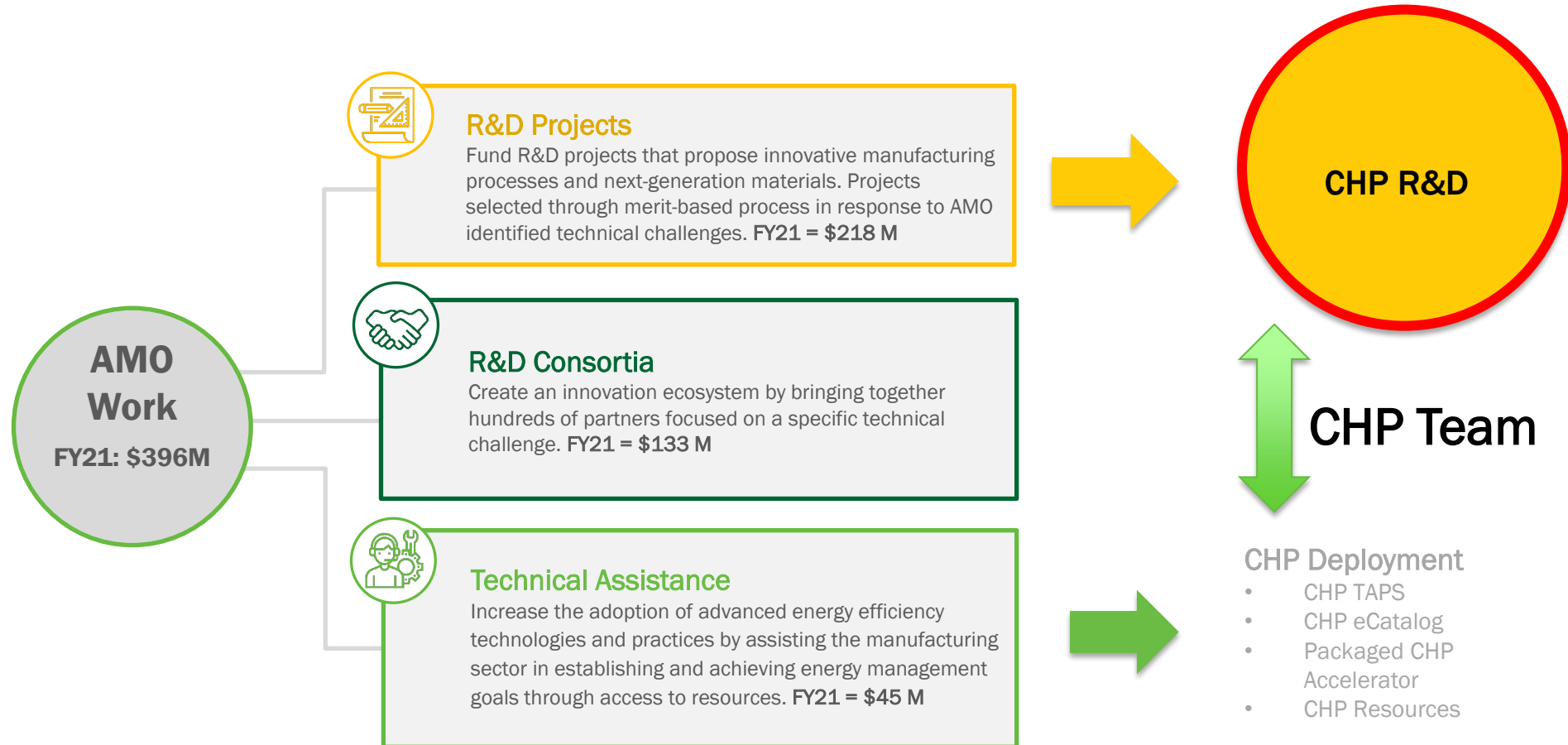
## Technical Services

- Screening Technical Assistance
- Advanced Technical Assistance
- Portfolio Reviews

# CHP TAPs Provide Assistance Across the U.S. and Puerto Rico



# CHP R&D Program



# Fall 2020 CHP Workshop – Key Takeaways

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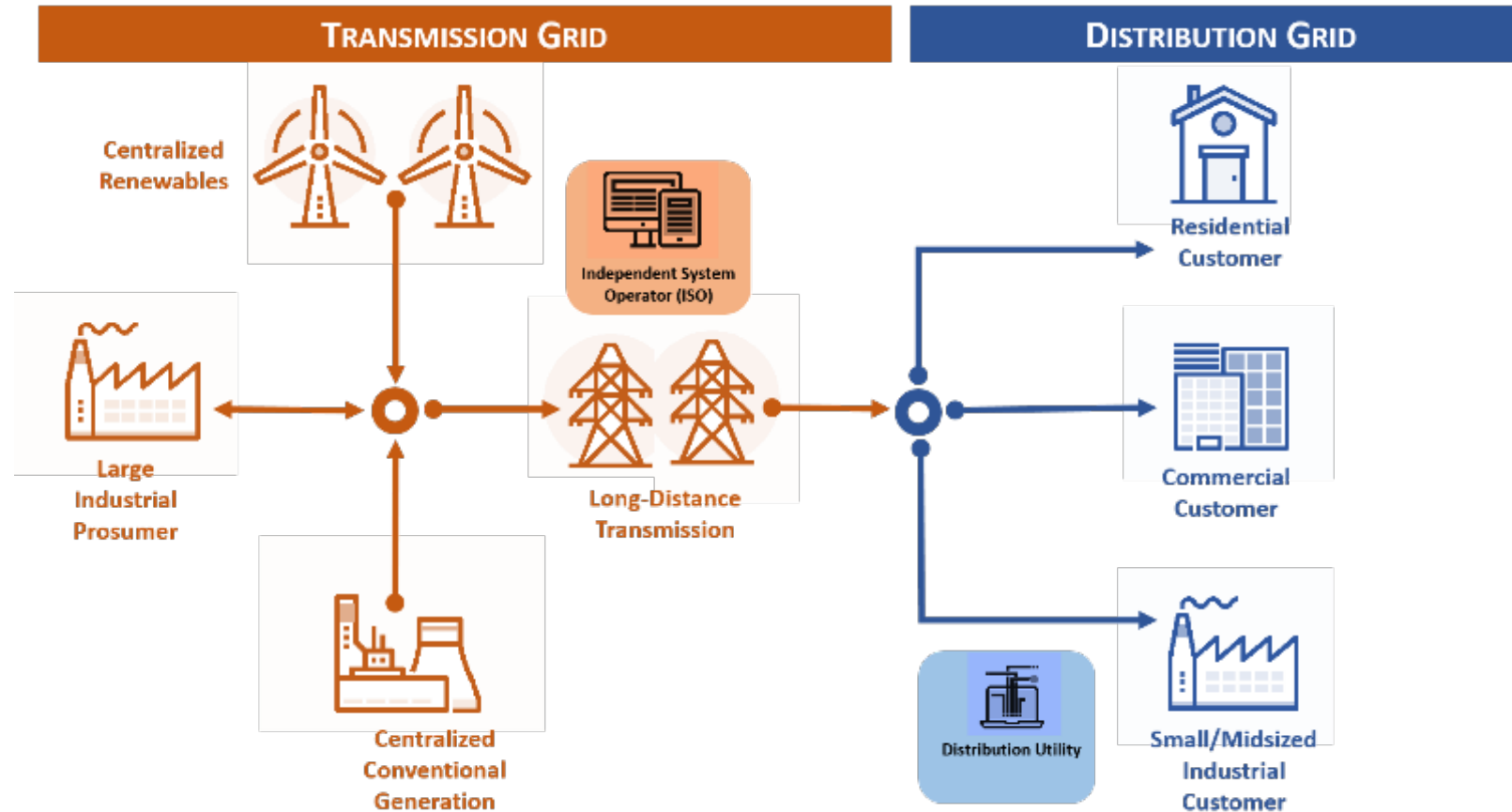
- **Trends impacting CHP technology development**
  - Electrification and decarbonization
  - Move toward distributed energy resources
  - Need and demand for more diverse fuel sources for CHP
  - Need and demand for energy storage, including thermal storage
  - Need for easy integration with renewables, microgrids, and district energy systems
  - Need for flexibility and resilience

# CHP R&D Program

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- **Mid-to-Longer Term Focus**
- **Decarbonization and electrification**
  - Enabling further integration of renewables
  - Utilization of renewable and other alternative fuels
- **Flexible CHP systems supporting the grid**
  - Increasing resilience and distributed energy resources
  - Energy storage integration, thermal and electrical
- **High power-to-heat ratio CHP systems**

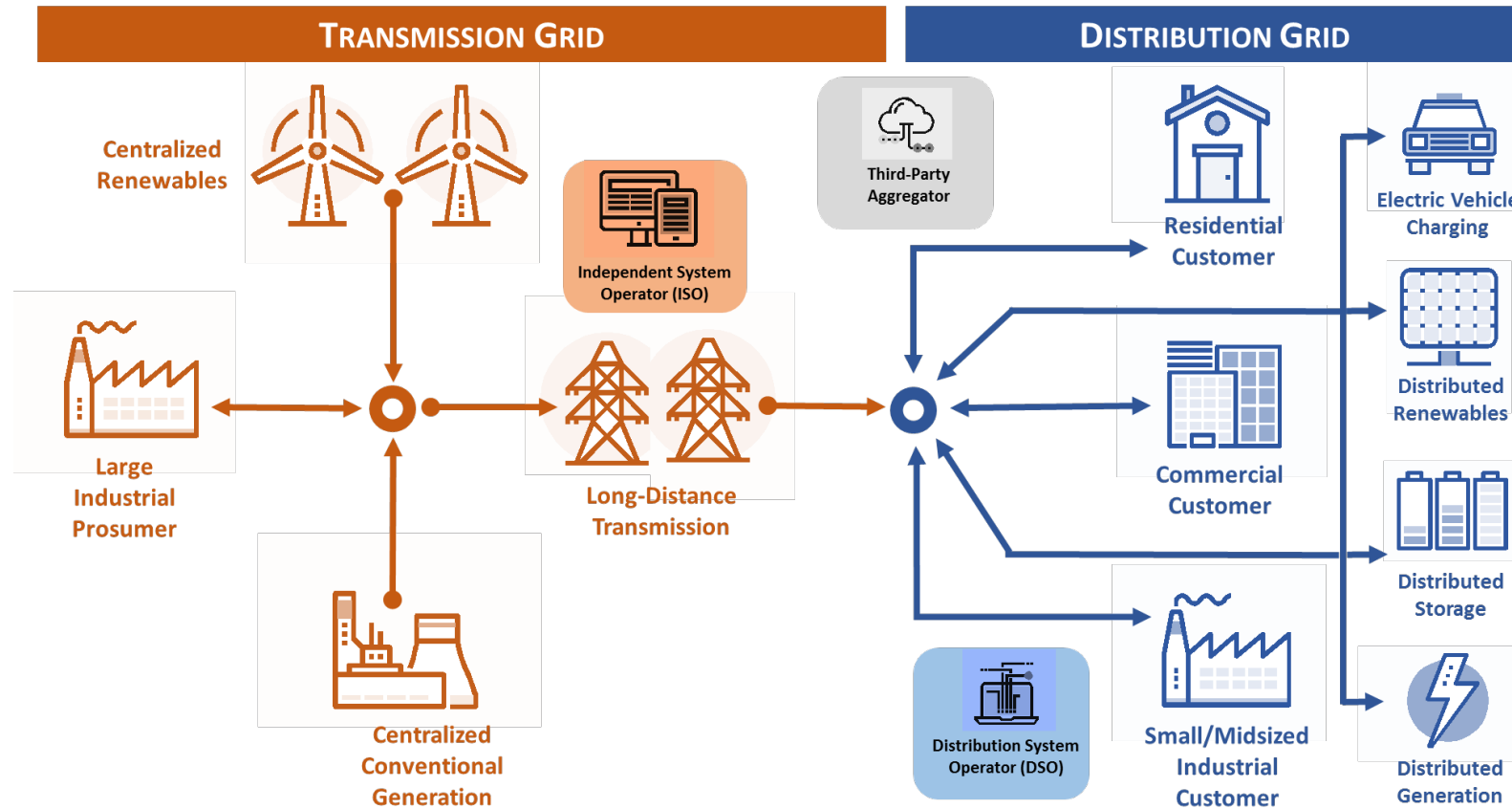
# Traditional Electricity Grid



**Traditional power grid: electricity is produced by centralized power plants and moved to the customer over a long-distance transmission network**

- Power flows are generally one-way (from generator to customer)
- Large industrial customers can export power, but small and midsized industrial customers do not provide services to the electric grid
- Generation and load are separated, and coordination between customers and load-serving entities is limited

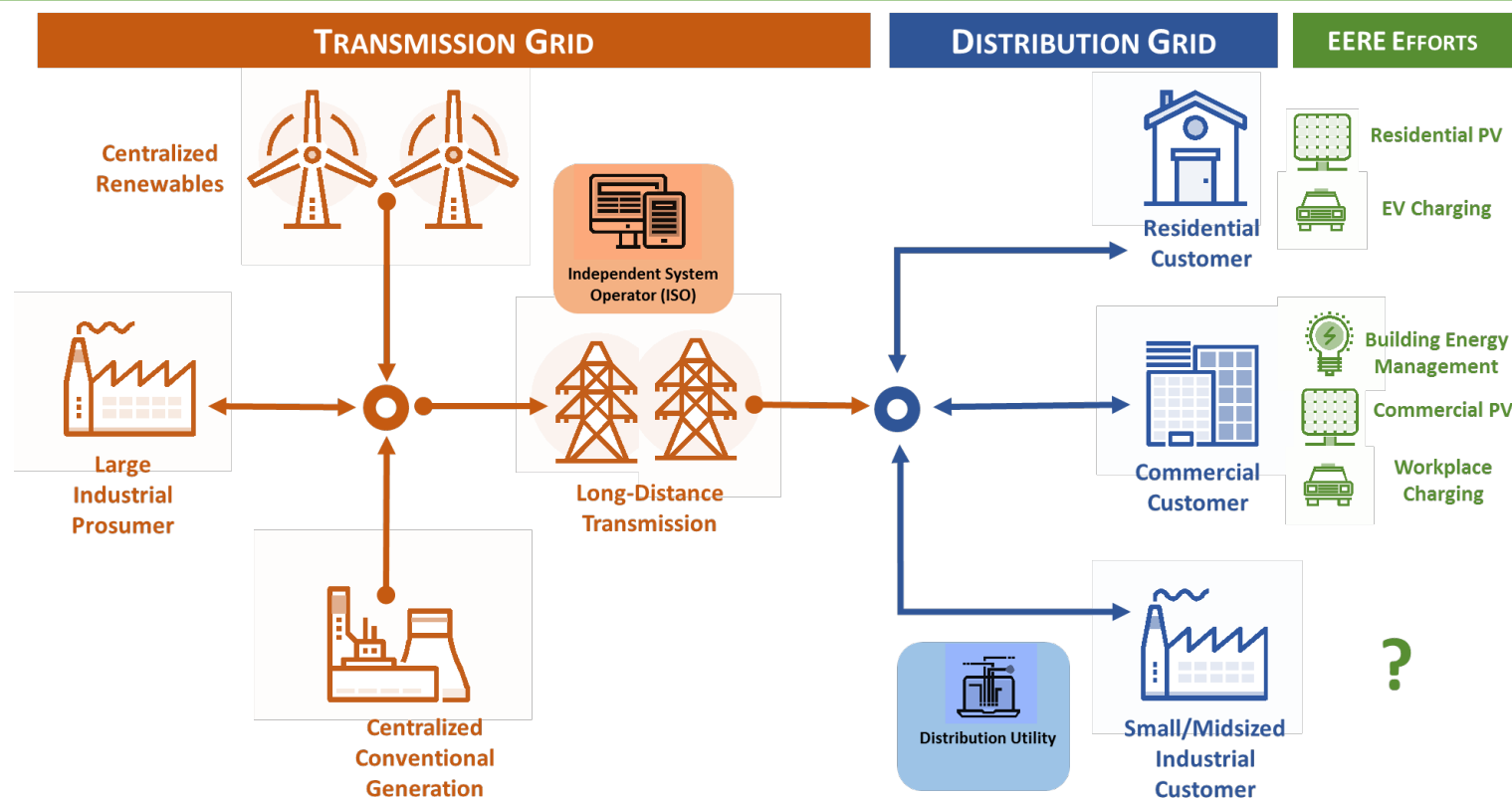
# Evolving Electricity Grid... the future



**Future power grid: electricity will be produced by a variety of resources, including renewable distributed energy resources with variable production that can export power to the distribution system**

- Power flows are bi-directional and managed by interconnected information and control systems
- Customers are “prosumers:” they consume electricity but also generate power to satisfy their own loads as well as to provide services to the grid (including energy to other customers)
- Generation and load are closely coordinated to optimize the performance of the system and reduce infrastructure costs

# R&D Opportunity: Role of Manufacturing

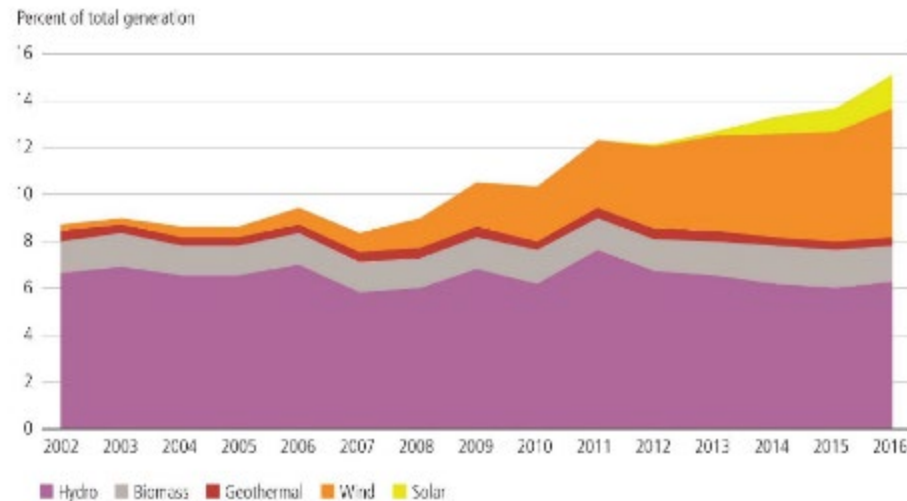


Small/midsized industrials are a large potential, not being address by other EERE programs, that integrate residential and commercial customers to tomorrow's distribution grid

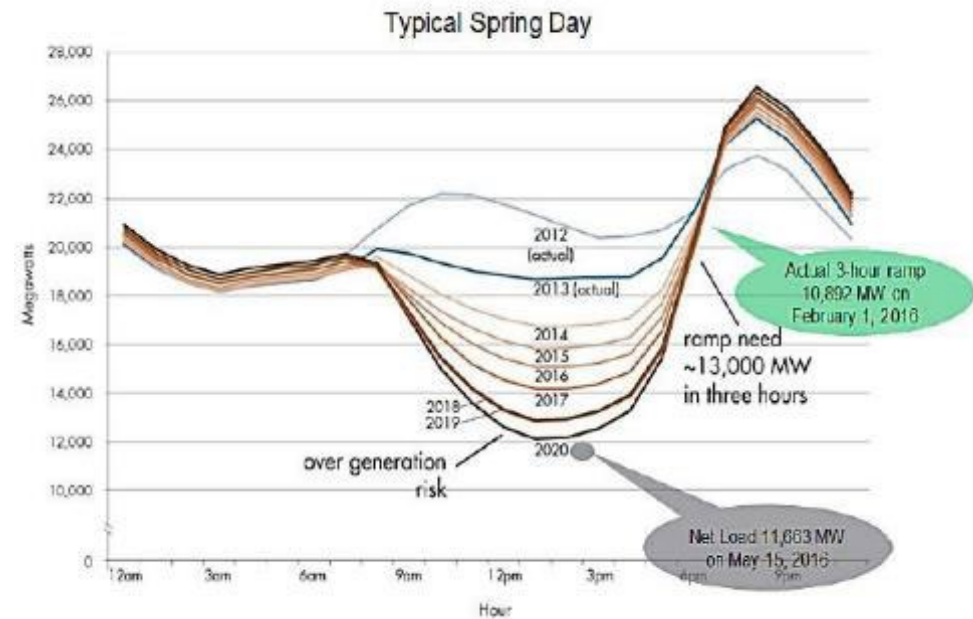
- Vehicles examples include a pathway for integration of vehicles with buildings, modeling and control software, and standard and interoperability systems research
- Buildings examples include data standardization to enable transactive services, hybrid inverter technology development, and load controls to support whole building response.
- Small/midsized industrials represent an important area of "white space" due to their substantial electric load (1-20MW) and familiarity with self-generation. But additional technologies are needed to integrate these generation resources to the grid.

# Two Key Issues as Grid Resources Evolve

- Non-dispatchable renewables (particularly wind and solar) are increasing rapidly on the U.S. grid
- Evolving load changes at peak demand periods require additional fast-reacting grid resources



RENEWABLE GENERATION AS A PERCENTAGE OF TOTAL  
U.S. ELECTRICITY GENERATION

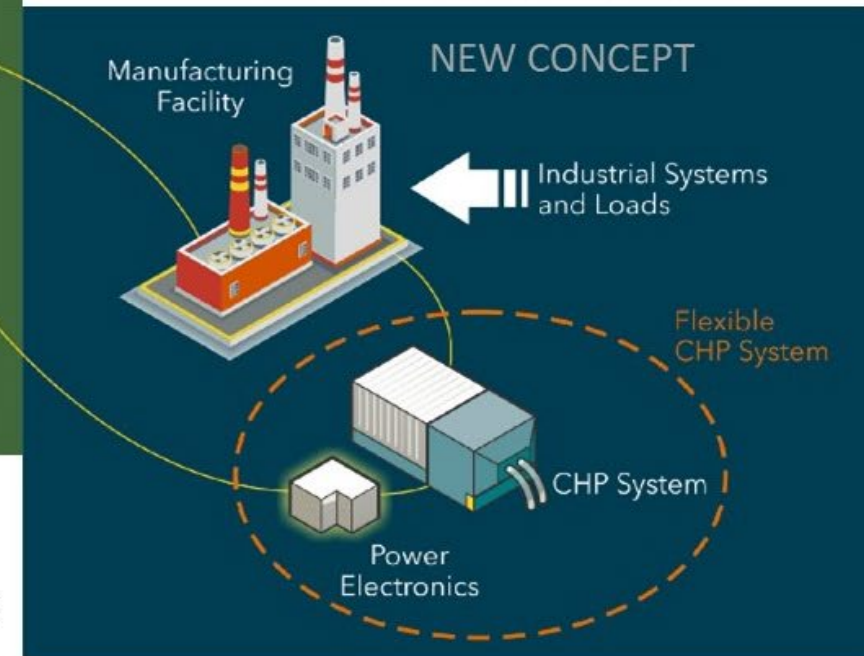
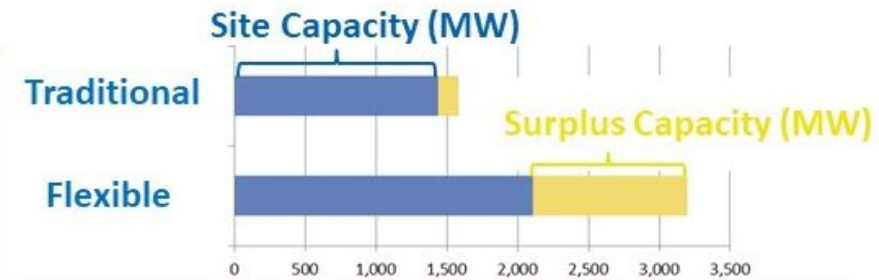


CALIFORNIA'S "DUCK CURVE"

# Flexible CHP Systems: Concept



A cost-effective, **flexible CHP system** that **seamlessly connects** to the grid and **provides needed grid services** would offer a **win-win** solution for manufacturers and grid operators.



Graphic credit: U.S. Department of Energy and Virginia Tech

- Improve grid reliability and resiliency, along with providing economic benefits to manufacturing facilities
- Technology advancements (R&D) are needed to achieve its full potential

# Flexible CHP on the Grid: Modeling of the California Market

## Three scenarios modeled: Added flexible CHP systems on the CA grid in 2024:

- **Baseline:**  
33% renewables on grid, 3,400 MW existing CHP for site loads
- **Traditional CHP:**  
Serves site loads + 10% capacity for grid services  
<500 hr/yr
- **Advanced CHP:**  
Serves site loads + large flexible capacity for grid services
- **Combined Scenario:**  
Selects most profitable option (between traditional and advanced) at each site

## Key findings:

- **Reduced Grid Operating Costs:**  
All scenarios reduce grid operations by \$1 Billion or more.
- **Increased Generation Capacity:**  
Alleviates need for new centralized power plants.
- **Lowers Site Energy Costs and Provides Additional Revenue Stream:**  
Sites average additional revenue of receive \$40,000 - \$780,000 / MW surplus capacity
- **Reduction in Grid Stress:**  
Eliminates hours when reserves may not be met or transmission ratings exceeded

FOA Objective: Research on enabling technologies for CHP systems (focusing on 1-20 MWe systems) that are specifically designed to provide cost-effective support to the electric grid

## Area of Interest 1 – Power Electronics

- Research, develop, and test CHP components such as power electronics and control systems needed to enable the cost-effective use of new and existing CHP systems to provide support to the grid.

## Area of Interest 2 – Electricity Generation Components (Prime Movers)

- Research and develop the electricity generation components of a 1-20 MWe CHP system capable of two operating configurations—a baseload mode where it is running at half its rated capacity and is designed to perform in a conventional CHP manner, and a second, at full rated capacity, where it is designed to maximize its ability to support the electric grid.

# FY18 FOA Projects

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## Area of Interest 1 – Power Electronics

- University of Tennessee
- Virginia Tech
- GE Global Research Center
- Clemson University

## Area of Interest 2 – Electricity Generation Components (Prime Movers)

- Southwest Research Institute
- Siemens
- ElectraTherm

# FY20 Multi-Topic FOA Projects

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

- **Caterpillar Inc.**
  - Flexible Natural Gas/Hydrogen Fuel CHP System
- **Clemson University**
  - Megawatt Scale, Multi-source Heat Recovery System with a Flexible Grid Interconnect

# Future is Strong for CHP

- **Focus Activities on CHP as a Decarbonization Solution**
  - As a baseload for renewably fueled microgrids
  - Transition to carbon neutral fuels
    - Low BTU value renewable gas
    - Hydrogen – either pure or in combination with renewable gas
      - Combustion technologies
      - Argonne smart hydrogen sensor

# Day 1 Meeting Overview

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- **Day One**
  - Flexible CHP R&D
    - Modeling the value of Flexible CHP
    - Prime Mover Development – three projects
    - Power Electronics Development – four projects
  - Flexible CHP Demonstrations
    - Two projects
  - Waste Heat Recovery Project
    - Legacy project



# Questions?

