



**AIChE<sup>®</sup> 12<sup>th</sup>**  
**SOUTHWEST**  
PROCESS TECHNOLOGY  
CONFERENCE

**OCTOBER 1–2, 2020**



**VIRTUAL**

# CHP, Energy Resilience and Grid Reliability

Gavin Dillingham, PhD – Director – US DOE CHP TAP

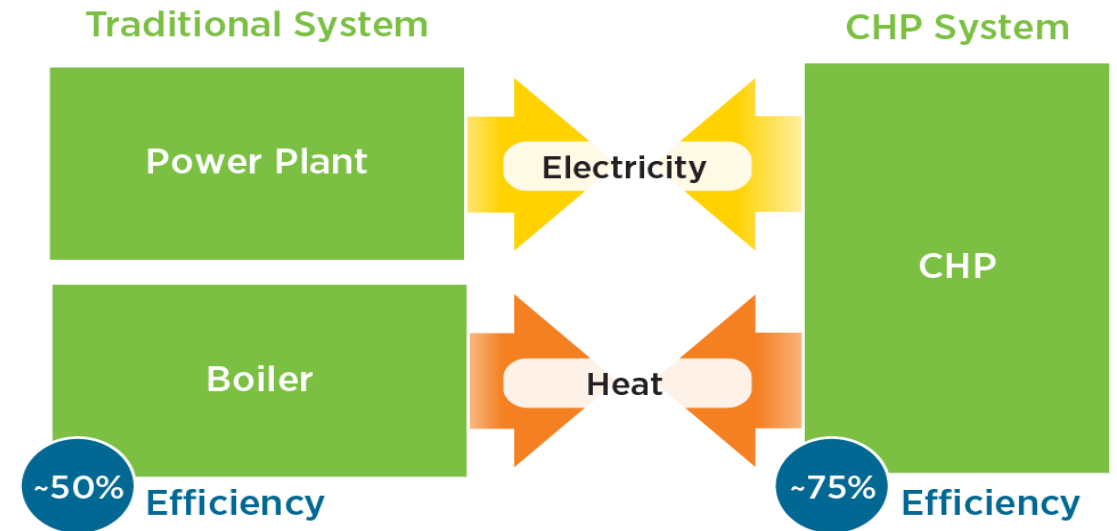
Carlos Gamarra, PhD, P.E. – Assistant Director – US DOE CHP TAP

# DOE CHP Technical Assistance Partnerships

- **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: A Key Part of Our Energy Future

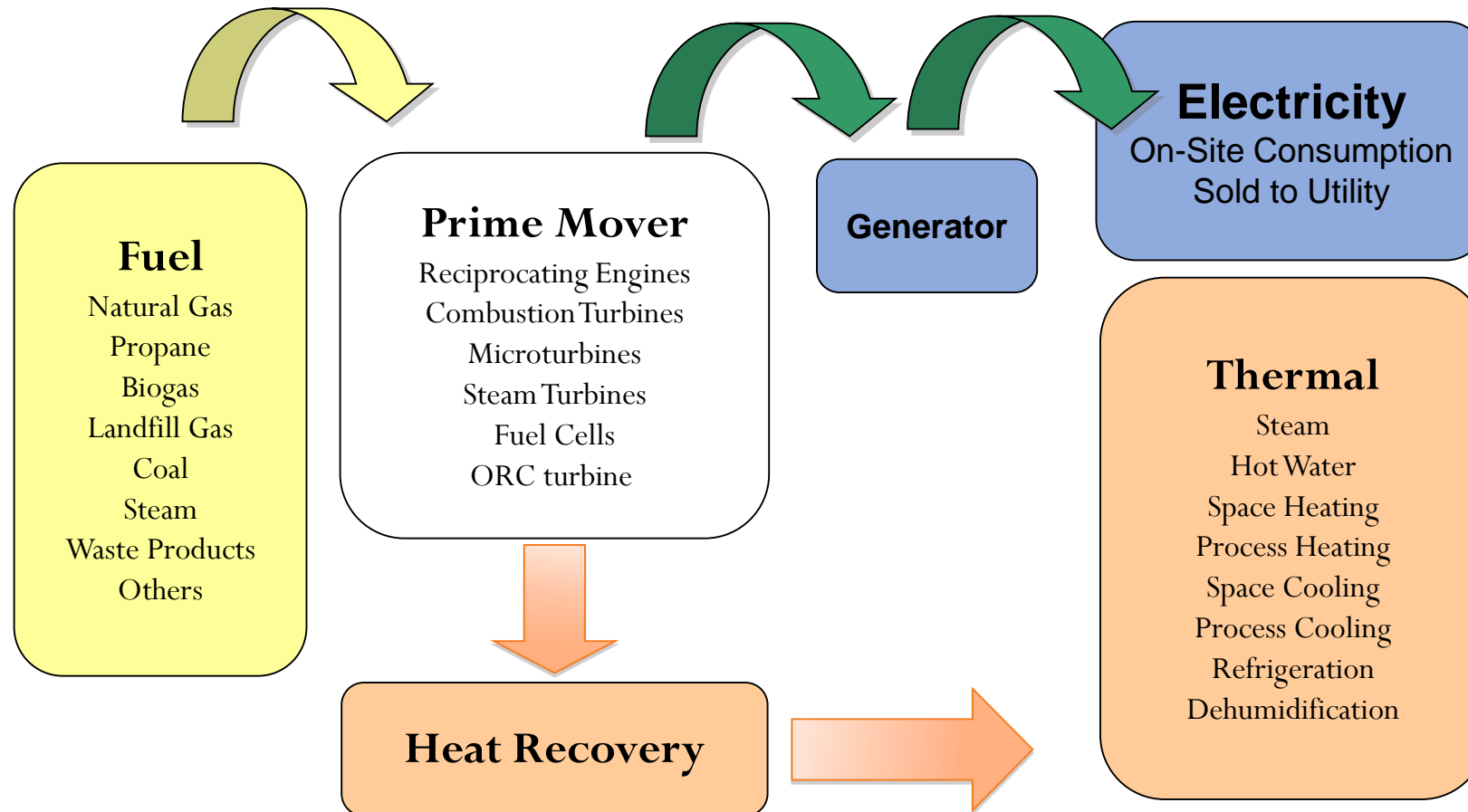
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



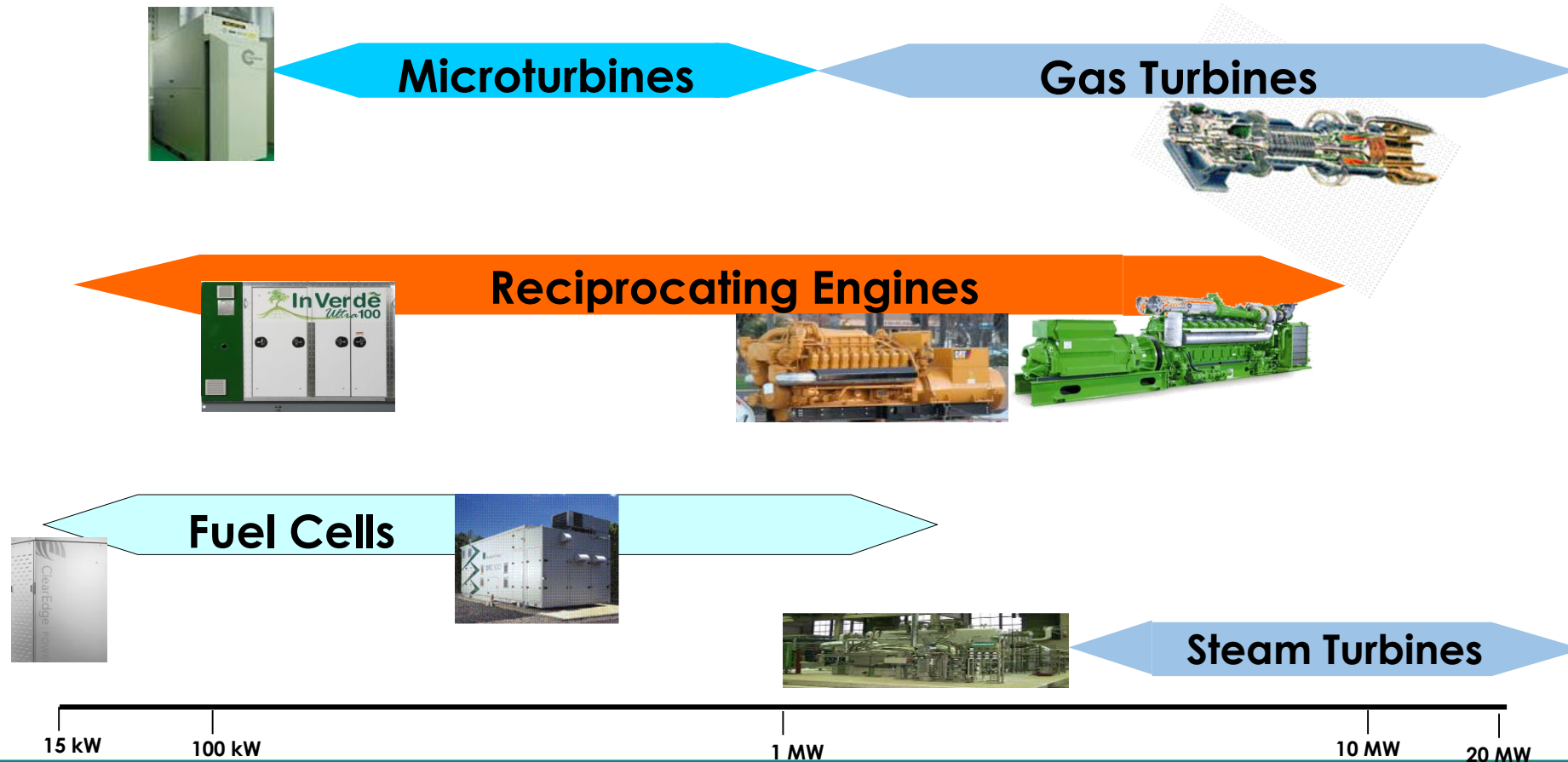
CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Source: [www.energy.gov/chp](http://www.energy.gov/chp)

## CHP System Schematic



# CHP Technologies



# What are the benefits of CHP?

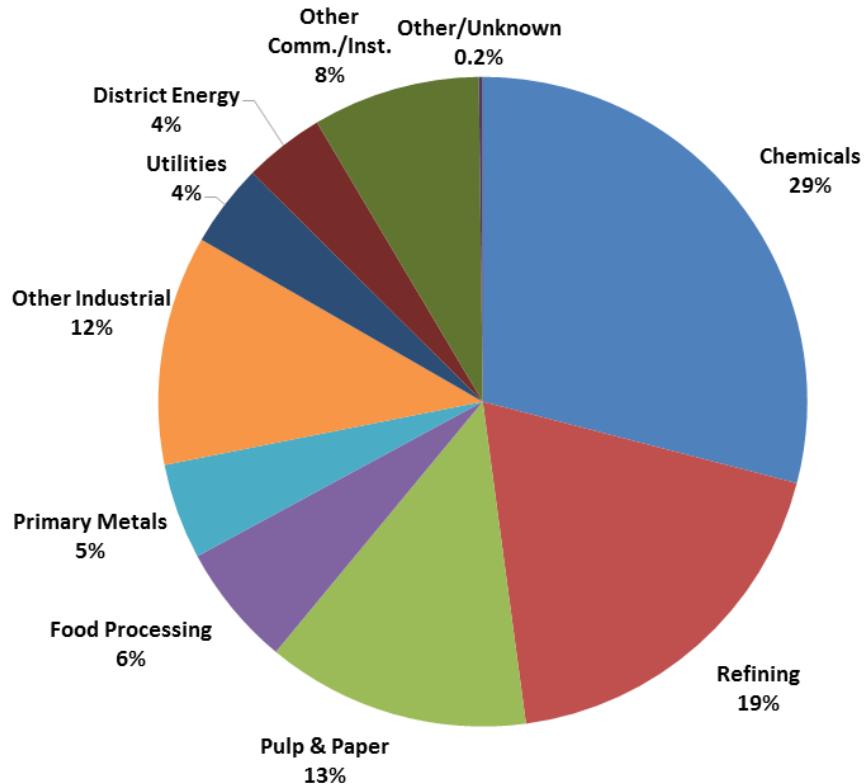
- CHP is more efficient than separate generation of electricity and heating/cooling
- Higher efficiency translates to lower operating costs (but requires capital investment)
- Higher efficiency reduces emissions of pollutants
- CHP can also increase energy reliability and enhance power quality
- On-site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

# CHP Integration with Renewables and Storage

- CHP + Solar PV - solar seldom meets the entire electricity load, making room for CHP to supply thermal loads and electricity when PV electricity is insufficient or unavailable
- CHP + Battery Storage – 1) dampen daily demand swings; 2) Shift power usage from off peak to on-peak periods; 3) enhanced resiliency and availability; and 4) enhance grid value-stacking capabilities (voltage support, T&D deferral, reserve capacity, reliability, over-generation management)
- CHP in a Microgrid – 1) efficient measure to serve thermal load; 2) backup power during extended outages; 3) supplements generation from PV & storage
- CHP is a Flexible Generation Resource – most CHP technologies can be powered down or off when renewable supply exceeds demand
- CHP Powered by Renewable Gas (biogas, hydrogen) - would enable CHP to partially or completely utilize renewable fuel either by piping non-pipeline quality biogas to the CHP site; using directed renewable gas; or purchasing pipeline gas that that has been blended with renewable gas



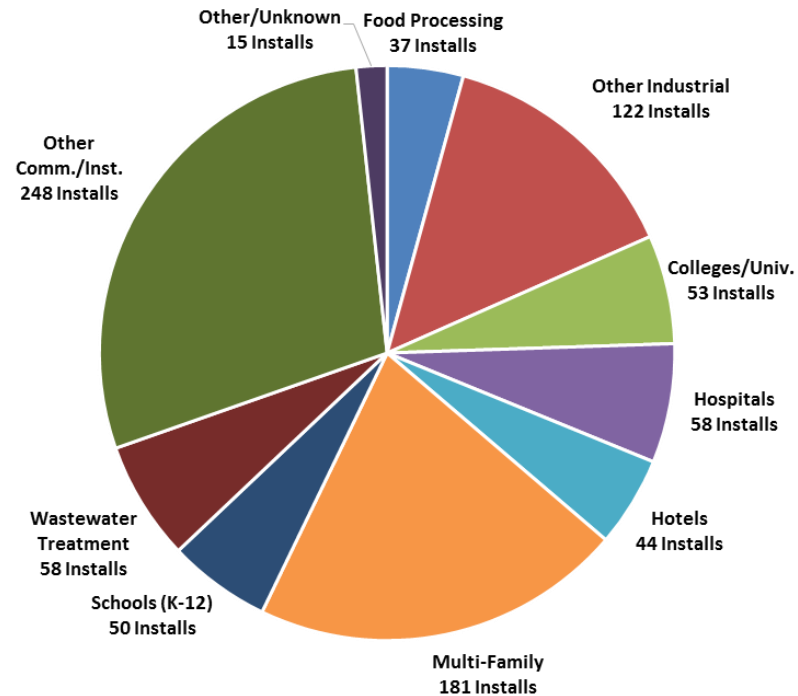
# CHP Today in the United States



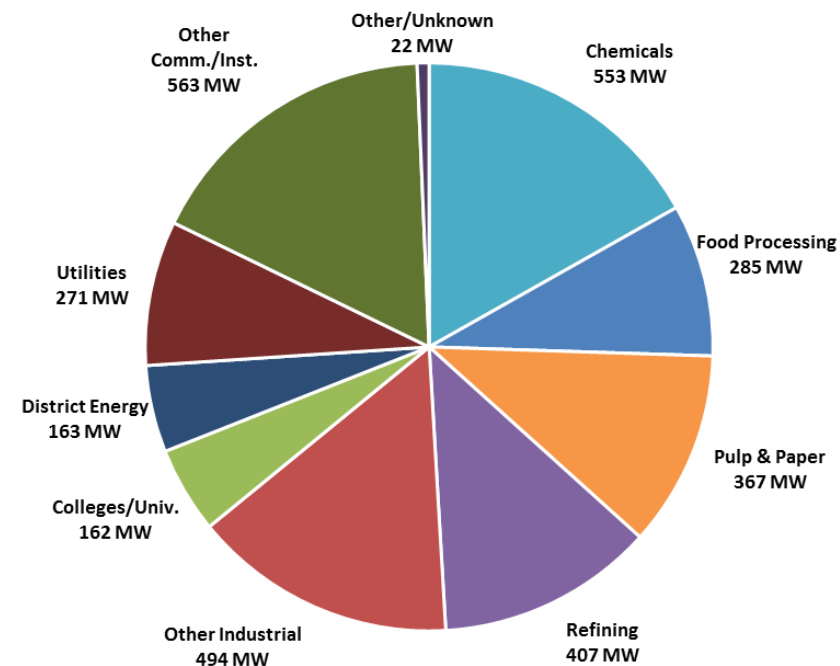
- **81.1 GW** of installed CHP at more than 4,500 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO<sub>2</sub>** compared to separate production

# CHP Additions by Application (2014-2018)

By Installations – 866 Installs



By Capacity – 3.3 GW



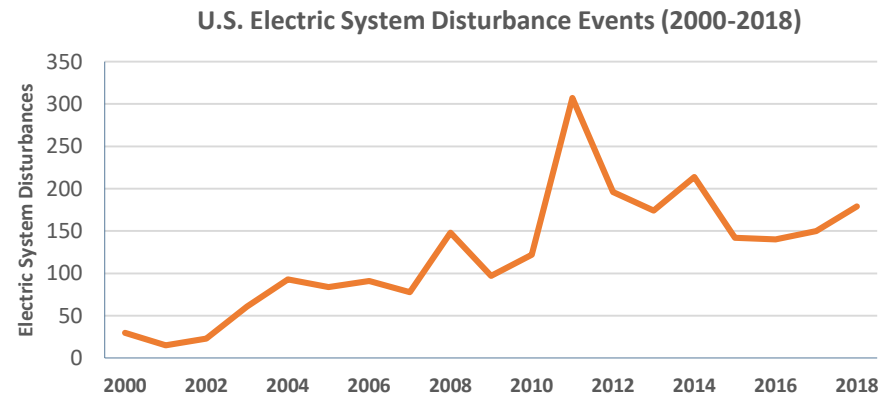
# Defining Resilience and Reliability

- Resilience: the ability of an entity—e.g., asset, organization, community, region—to anticipate, resist, absorb, respond to, adapt to, and recover from a disturbance
  - Reducing the magnitude and duration of energy service disruptions
- Reliability: the ability of the electric power system to deliver the required quantity and quality of electricity demanded by end-users

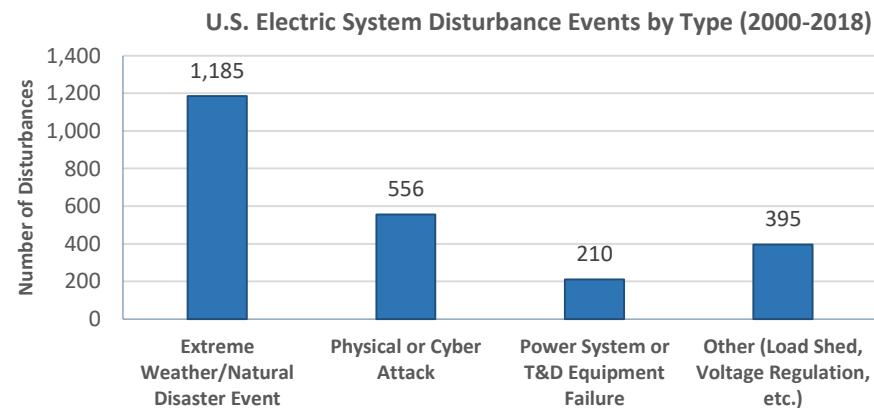


# Electric System Disturbances

*Electric system outages are increasingly frequent...*



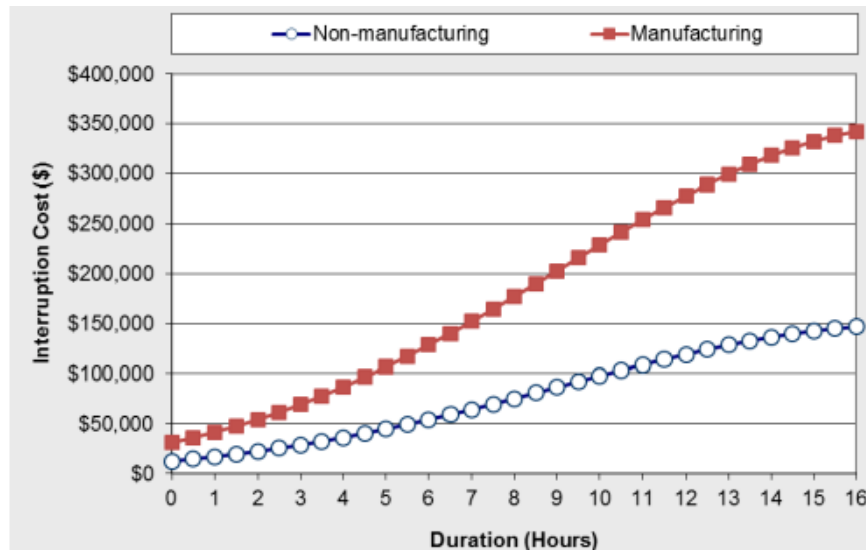
*And outages are increasingly caused by natural disasters and storm events*



# Valuing Resiliency and Reliability

Study author	Parameters	Annual cost
Galvin Electricity Initiative (Rouse and Kelly 2011)	Cost of losses due to power outages	\$150 billion (about 4 cents for every kWh consumed nationwide)
Lawrence Berkeley National Laboratory (LaCommare and Eto 2006)	Cost of poor energy reliability and poor power quality	\$79 billion
Hartford Steam Boiler and Atmospheric and Environmental Research (AER and HSB 2013)	Cost of power outages	\$100 billion
Executive Office of the President (2013)	Cost of weather-related outages over five minutes	\$18–33 billion
Institute of Electrical and Electronics Engineers (Bhattacharyya and Cobben 2011)	Cost of poor power quality	\$119–188 billion
Electric Power Research Institute (EPRI) (Hampson et al. 2013)	Cost of outages to “industrial and digital economy” businesses	\$45.7 billion
EPRI (Hampson et al. 2013)	Cost of outages to entire US economy	\$120–190 billion
US Congressional Research Service (Campbell 2012)	Cost of weather-related outages longer than five minutes	\$25-70 billion

# Reliability and Resilience: C&I Outage Costs by Sector



Cost figures in 2013\$. Source: Sullivan, Schellenberg, Blundell 2015.

Sector	Momentary	30 min.	1 hour	4 hours	8 hours
<b>Medium and large C&amp;I</b>					
Agriculture	\$4,382	\$6,044	\$8,049	\$25,628	\$41,250
Mining	\$9,874	\$12,883	\$16,366	\$44,708	\$70,281
Construction	\$27,048	\$36,097	\$46,733	\$135,383	\$214,644
Manufacturing	\$22,106	\$29,098	\$37,238	\$104,019	\$164,033
Telecommunications & utilities	\$11,243	\$15,249	\$20,015	\$60,663	\$96,857
Trade & retail	\$7,625	\$10,113	\$13,025	\$37,112	\$58,694
Finance, insurance, real estate	\$17,451	\$23,573	\$30,834	\$92,375	\$147,219
Services	\$8,283	\$11,254	\$14,793	\$45,057	\$71,997
Public administration	\$9,360	\$12,670	\$16,601	\$50,022	\$79,793
<b>Small C&amp;I</b>					
Agriculture	\$293	\$434	\$615	\$2,521	\$4,868
Mining	\$935	\$1,285	\$1,707	\$5,424	\$9,465
Construction	\$1,052	\$1,436	\$1,895	\$5,881	\$10,177
Manufacturing	\$609	\$836	\$1,110	\$3,515	\$6,127
Telecommunications & utilities	\$583	\$810	\$1,085	\$3,560	\$6,286
Trade & retail	\$420	\$575	\$760	\$2,383	\$4,138
Finance, insurance, real estate	\$597	\$831	\$1,115	\$3,685	\$6,525
Services	\$333	\$465	\$625	\$2,080	\$3,691
Public administration	\$230	\$332	\$461	\$1,724	\$3,205

Cost figures in 2008\$. Source: Sullivan et al. 2009.

Manufacturing facilities generally experience higher outage costs than other Large C&I customer segments.

# How Does CHP Increase Resilience

- For end users:
  - Provides continuous supply of electricity and thermal energy for critical loads
  - Can be configured to automatically switch to “island mode” during a utility outage, and to “black start” without grid power
  - Ability to withstand long, multiday outages
- For utilities:
  - Enhances grid stability and relieves grid congestion
  - Enables microgrid deployment for balancing renewable power and providing a diverse generation mix
- For communities:
  - Keeps critical facilities like hospitals and emergency services operating and responsive to community needs



# CHP Meets Critical Infrastructure Power Reliability Requirements

If the CHP system is connected to the grid, it should:

- Be designed to disconnect and keep operating following a power disturbance, and
- Should cover the critical loads of the facility.

## Requirements for Critical Infrastructure Power Reliability

### Black-start capability

The CHP system must have an electrical signal from a battery system or onsite backup generator to provide “black-start” capability when there is a grid outage.

### Generator capable of operating independently of the grid

The CHP electric generator must be able to continue or maintain operation without a grid power signal. High frequency generators (microturbines) or DC generators (fuel cells) need to have inverter technology that can operate independently from the grid.

### Ample carrying capacity

The facility must match the size of the critical loads to the CHP generator.

### Parallel utility interconnection and switchgear controls

The CHP system must be able to properly disconnect itself from the utility grid and switch over to providing electricity to critical facility loads.



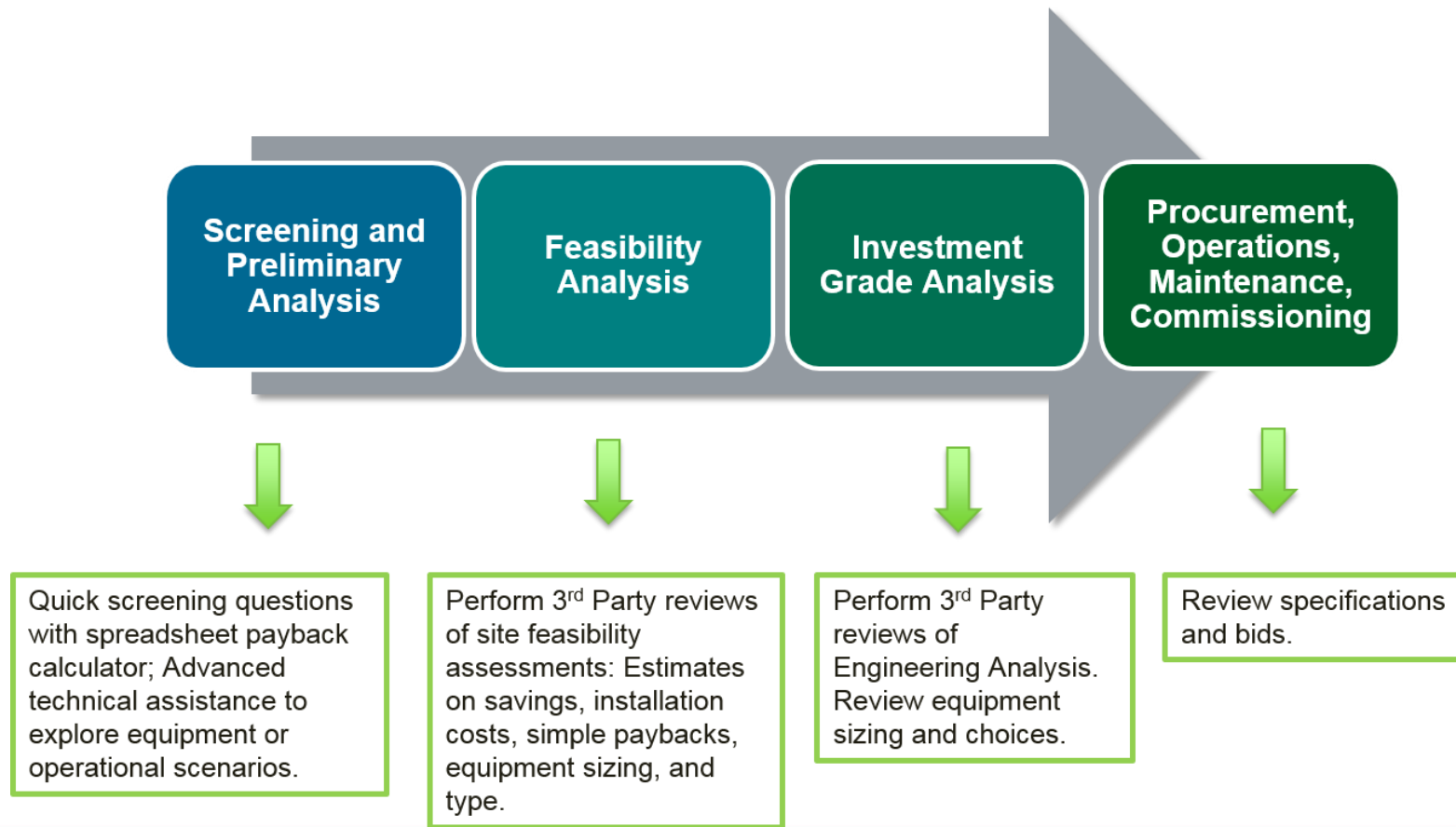


 VIRTUAL

OCTOBER 1-2, 2020

# How to Implement a CHP Project with the Help of the CHP TAP

# CHP TAP Role: Technical Assistance

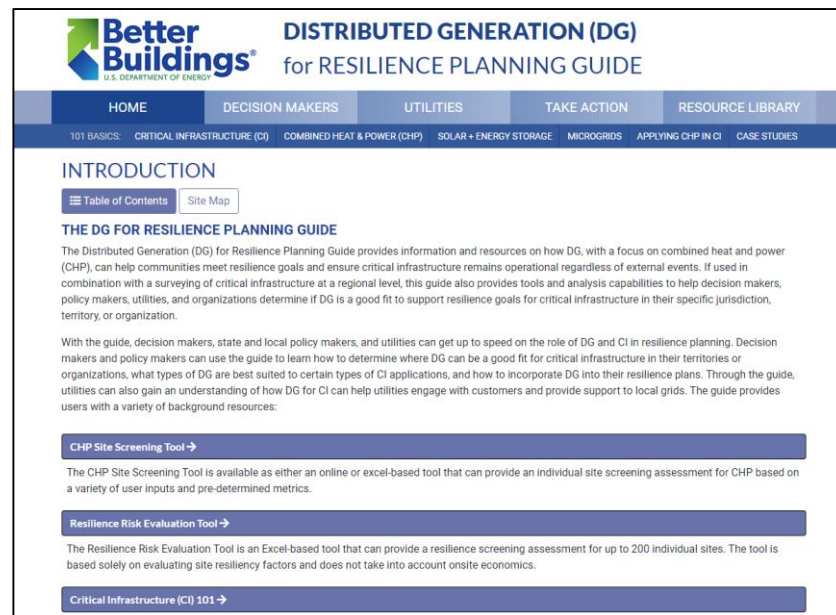


## Resilience Planning with DOE Resiliency Accelerator

- The [DOE CHP for Resiliency Accelerator](#) includes resources and tools designed to assist with resilience planning efforts
  - Distributed Generation for Resiliency Planning Guide
  - CHP for Resilience Screening Tool
  - Issue Brief on Performance of DERs in Disaster Events
  - Partner Profiles

# CHP in Resilience Resources

## DG for Resilience Planning Guide



**Better Buildings®** U.S. DEPARTMENT OF ENERGY  
**DISTRIBUTED GENERATION (DG) for RESILIENCE PLANNING GUIDE**

HOME DECISION MAKERS UTILITIES TAKE ACTION RESOURCE LIBRARY

101 BASICS CRITICAL INFRASTRUCTURE (CI) COMBINED HEAT & POWER (CHP) SOLAR + ENERGY STORAGE MICROGRIDS APPLYING CHP IN CI CASE STUDIES

### INTRODUCTION

[Table of Contents](#) [Site Map](#)

#### THE DG FOR RESILIENCE PLANNING GUIDE

The Distributed Generation (DG) for Resilience Planning Guide provides information and resources on how DG, with a focus on combined heat and power (CHP), can help communities meet resilience goals and ensure critical infrastructure remains operational regardless of external events. If used in combination with a surveying of critical infrastructure at a regional level, this guide also provides tools and analysis capabilities to help decision makers, policy makers, utilities, and organizations determine if DG is a good fit to support resilience goals for critical infrastructure in their specific jurisdiction, territory, or organization.

With the guide, decision makers, state and local policy makers, and utilities can get up to speed on the role of DG and CI in resilience planning. Decision makers and policy makers can use the guide to learn how to determine where DG can be a good fit for critical infrastructure in their territories or organizations, what types of DG are best suited to certain types of CI applications, and how to incorporate DG into their resilience plans. Through the guide, utilities can also gain an understanding of how DG for CI can help utilities engage with customers and provide support to local grids. The guide provides users with a variety of background resources:

**CHP Site Screening Tool →**

The CHP Site Screening Tool is available as either an online or excel-based tool that can provide an individual site screening assessment for CHP based on a variety of user inputs and pre-determined metrics.

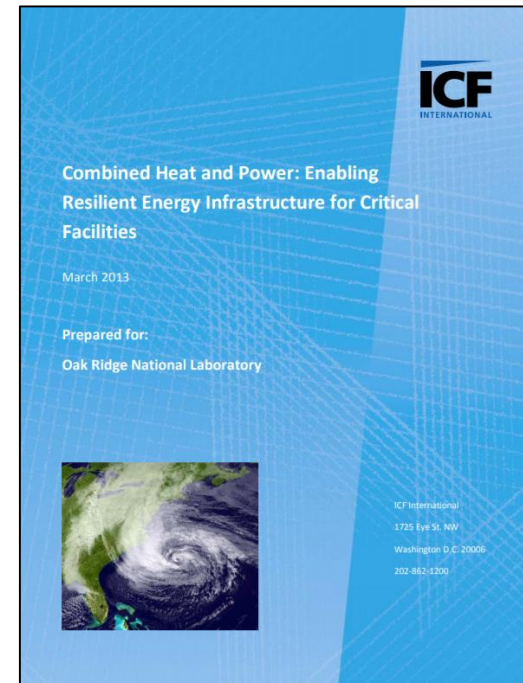
**Resilience Risk Evaluation Tool →**

The Resilience Risk Evaluation Tool is an Excel-based tool that can provide a resilience screening assessment for up to 200 individual sites. The tool is based solely on evaluating site resiliency factors and does not take into account onsite economics.

**Critical Infrastructure (CI) 101 →**

<https://dg.resiliencguide.lbl.gov/>

## CHP: Enabling Resilient Infrastructure for Critical Facilities



**ICF INTERNATIONAL**

### Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities

March 2013

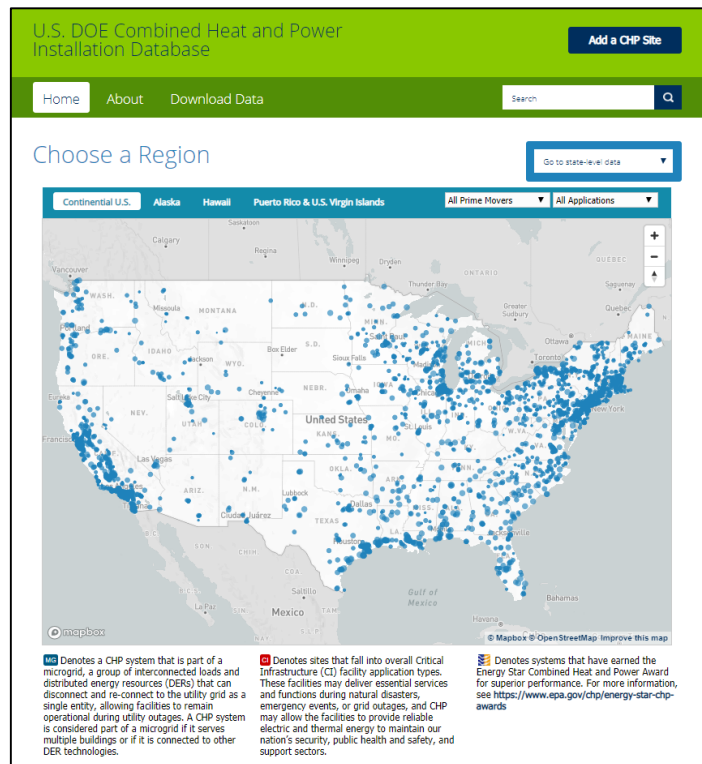
Prepared for:  
Oak Ridge National Laboratory

ICF International  
1725 Eye St. NW  
Washington, D.C. 20006  
202-862-1200

[https://www.energy.gov/sites/prod/files/2013/11/f4/chp\\_critical\\_facilities.pdf](https://www.energy.gov/sites/prod/files/2013/11/f4/chp_critical_facilities.pdf)

# CHP Databases

## DOE CHP Installation Database (List of all known U.S. CHP systems)



U.S. DOE Combined Heat and Power Installation Database

Home About Download Data Search

Choose a Region

Continental U.S. Alaska Hawaii Puerto Rico & U.S. Virgin Islands All Prime Movers All Applications

mapbox

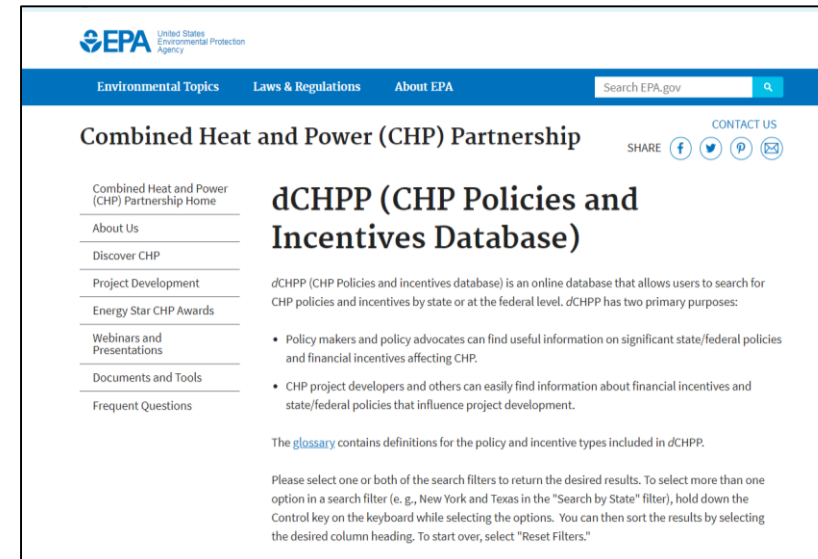
Denotes a CHP system that is part of a microgrid, a group of interconnected loads and distributed energy resources (DERs) that can disconnect and re-connect to the utility grid as a single entity, allowing facilities to remain operational during utility outages. A CHP system is considered part of a microgrid if it serves multiple buildings or if it is connected to other DER technologies.

Denotes sites that fall into overall Critical Infrastructure (CI) facility application types. These facilities may deliver essential services and functions during natural disasters, emergency events, or grid outages, and CHP may allow the facilities to provide reliable electric and thermal energy to maintain our nation's security, public health and safety, and support sectors.

Denotes systems that have earned the Energy Star Combined Heat and Power Award for superior performance. For more information, see <https://www.epa.gov/chp/energy-star-chp-awards>

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

## EPA dCHPP (CHP Policies and Incentives Database)



United States Environmental Protection Agency

Environmental Topics Laws & Regulations About EPA Search EPA.gov

CONTACT US SHARE

### Combined Heat and Power (CHP) Partnership

Combined Heat and Power (CHP) Partnership Home

About Us

Discover CHP

Project Development

Energy Star CHP Awards

Webinars and Presentations

Documents and Tools

Frequent Questions

### dCHPP (CHP Policies and Incentives Database)

dCHPP (CHP Policies and incentives database) is an online database that allows users to search for CHP policies and incentives by state or at the federal level. dCHPP has two primary purposes:

- Policy makers and policy advocates can find useful information on significant state/federal policies and financial incentives affecting CHP.
- CHP project developers and others can easily find information about financial incentives and state/federal policies that influence project development.

The [glossary](#) contains definitions for the policy and incentive types included in dCHPP.

Please select one or both of the search filters to return the desired results. To select more than one option in a search filter (e.g., New York and Texas in the "Search by State" filter), hold down the Control key on the keyboard while selecting the options. You can then sort the results by selecting the desired column heading. To start over, select "Reset Filters."

[www.epa.gov/chpdchpp-chp-policies-and-incentives-database](https://www.epa.gov/chpdchpp-chp-policies-and-incentives-database)

# In Summation

- CHP is a proven technology providing energy savings, reduced emissions, and opportunities for resiliency
- Emerging drivers are creating new opportunities to evaluate CHP and numerous examples exist to learn more how health care systems have incorporated CHP
- Engage with the US DOE Southcentral CHP TAP to learn more about the technical assistance offerings in evaluating CHP in your health care facility.



# Thank you

- Gavin Dillingham, PhD.  
Director of Southcentral and Upper West CHP TAPs  
[gdillingham@harcresearch.org](mailto:gdillingham@harcresearch.org)
- Carlos Gamarra, PhD, P.E.  
Assistant Director of Southcentral CHP TAP  
[cgamarra@harcresearch.org](mailto:cgamarra@harcresearch.org)