Combined Heat and Power (CHP) and Resilience - Keeping the Lights On

U.S. DOE CHP Deployment Program
CHP Technical Assistance Partnerships

May 9, 2019

Outline

- **CHP Overview**
- **The State of CHP**
- **Introduction to Resilience and Reliability with CHP**
- **Critical Infrastructure Resilience with CHP**
  - How CHP can provide resilience for critical infrastructure facilities
- **CHP in Critical Infrastructure**
  - Installations and Technical Potential
- **Resilience Planning**
  - Tools and techniques for critical infrastructure resilience planning
- **Policies and Incentives for Resilient CHP**
- **Case Studies** for Resilient CHP
- **Implementing a Project with CHP TAP**

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.

www.energy.gov/chp

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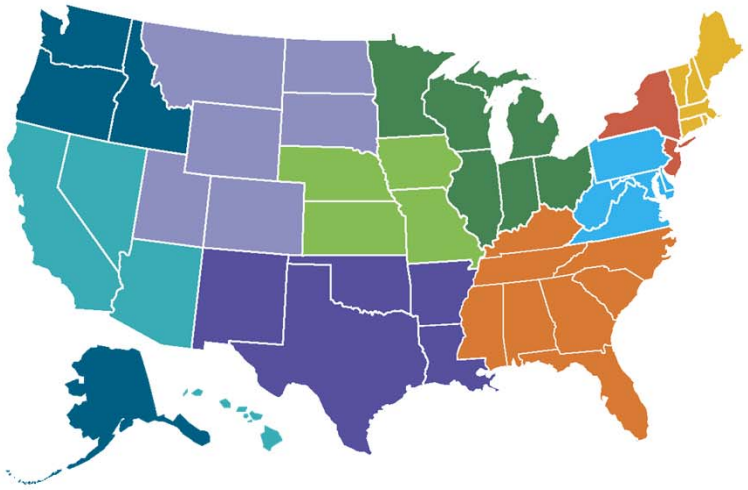

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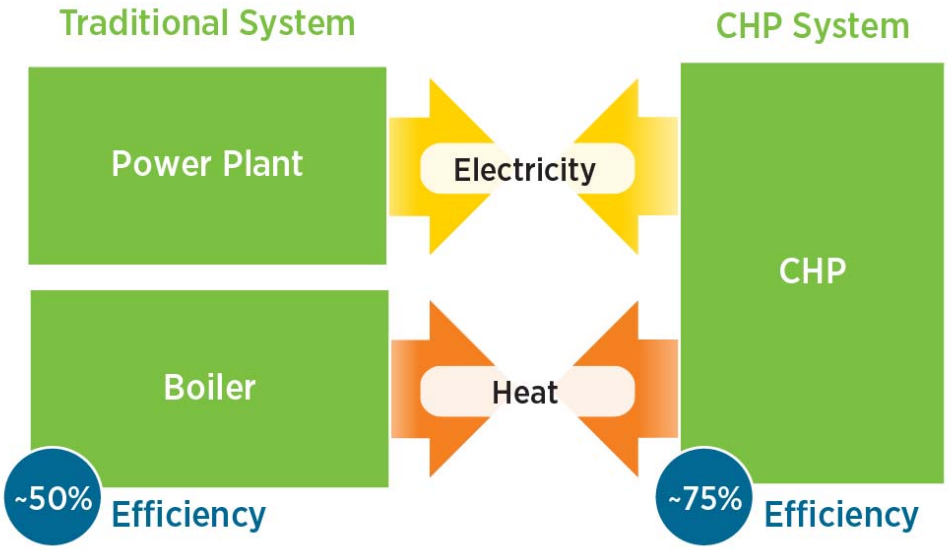
CHP Overview

CHP: A Key Part of Our Energy Future

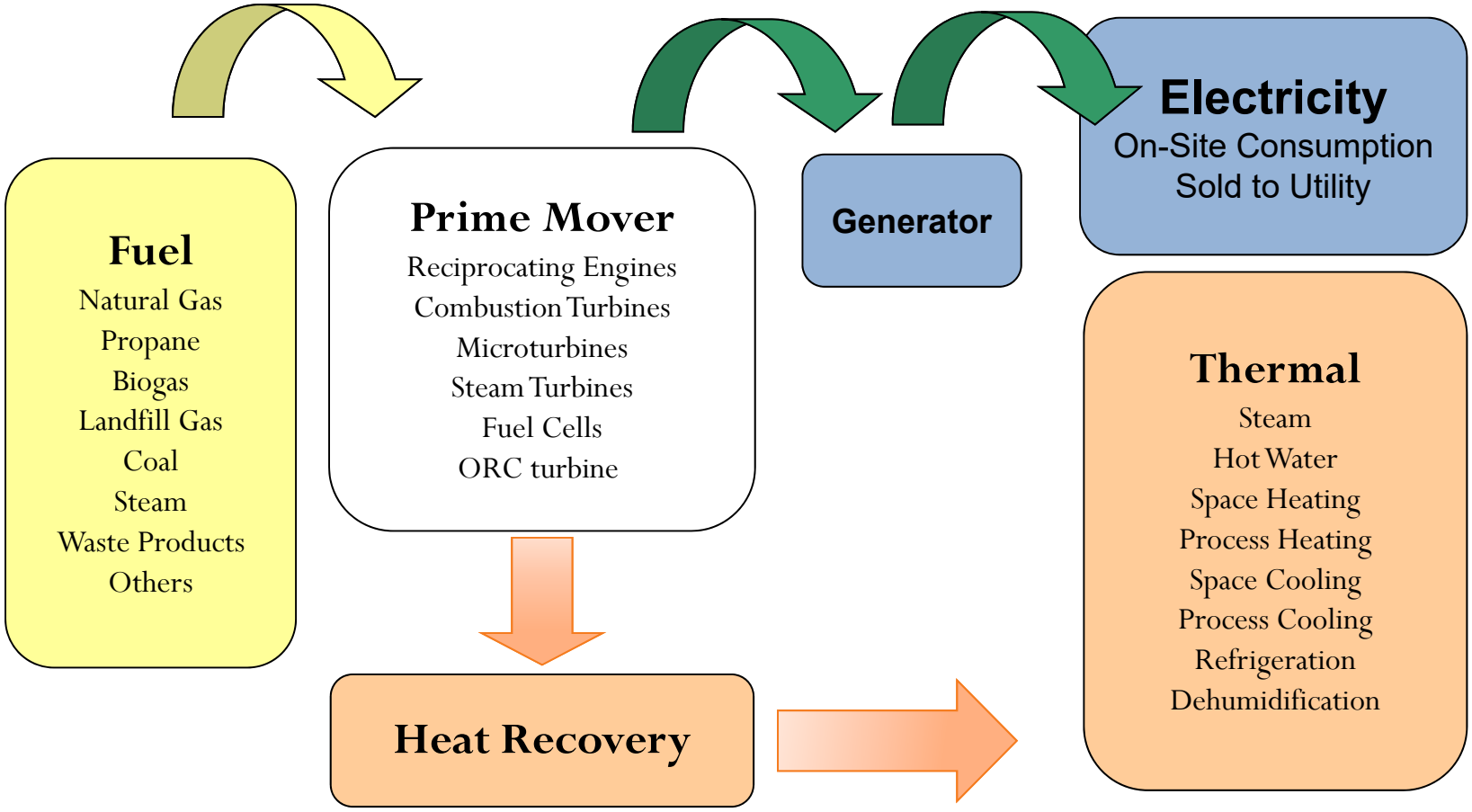
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
  - Space Heating / Cooling
  - Process Heating / Cooling
  - Dehumidification



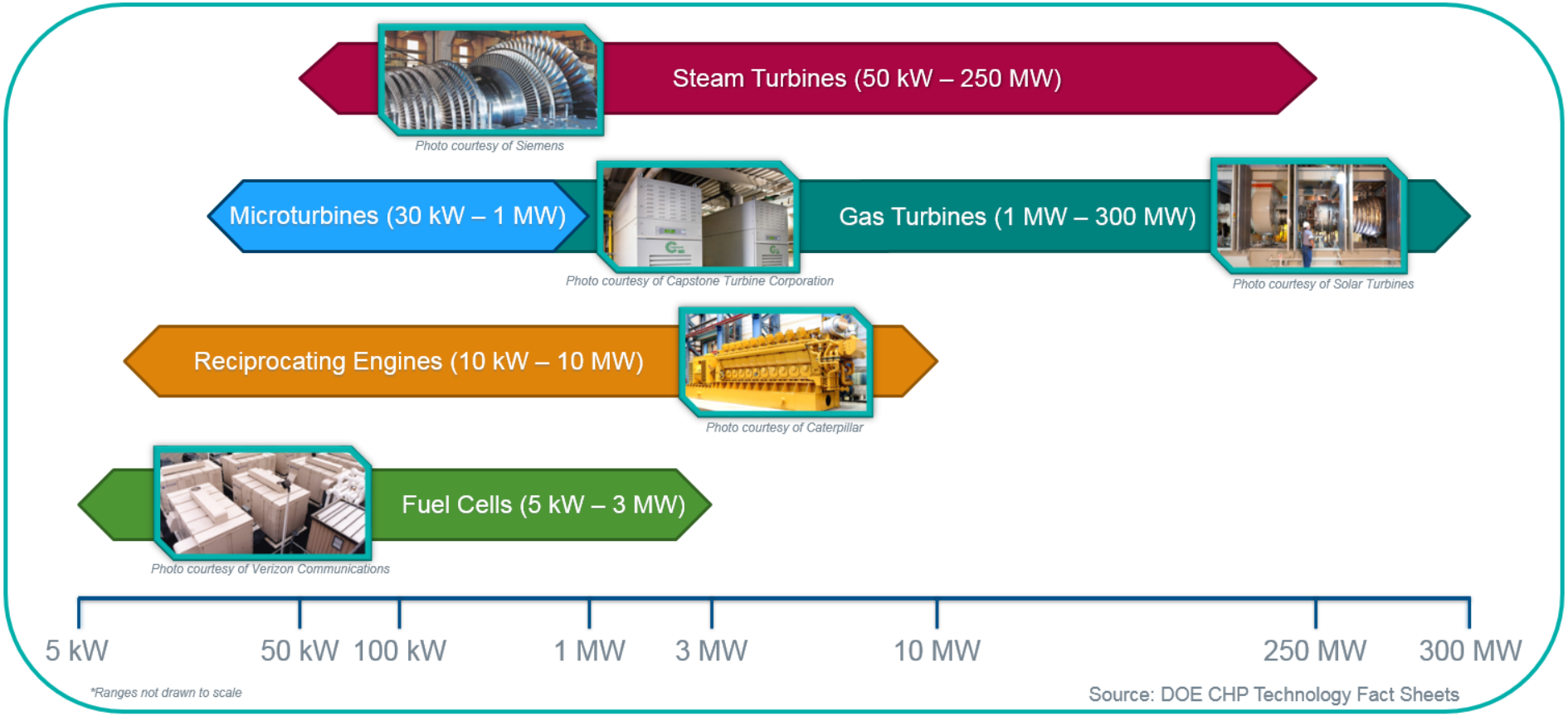
CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Source: www.energy.gov/chp

CHP System Schematic



Common CHP Technologies and Capacity Ranges

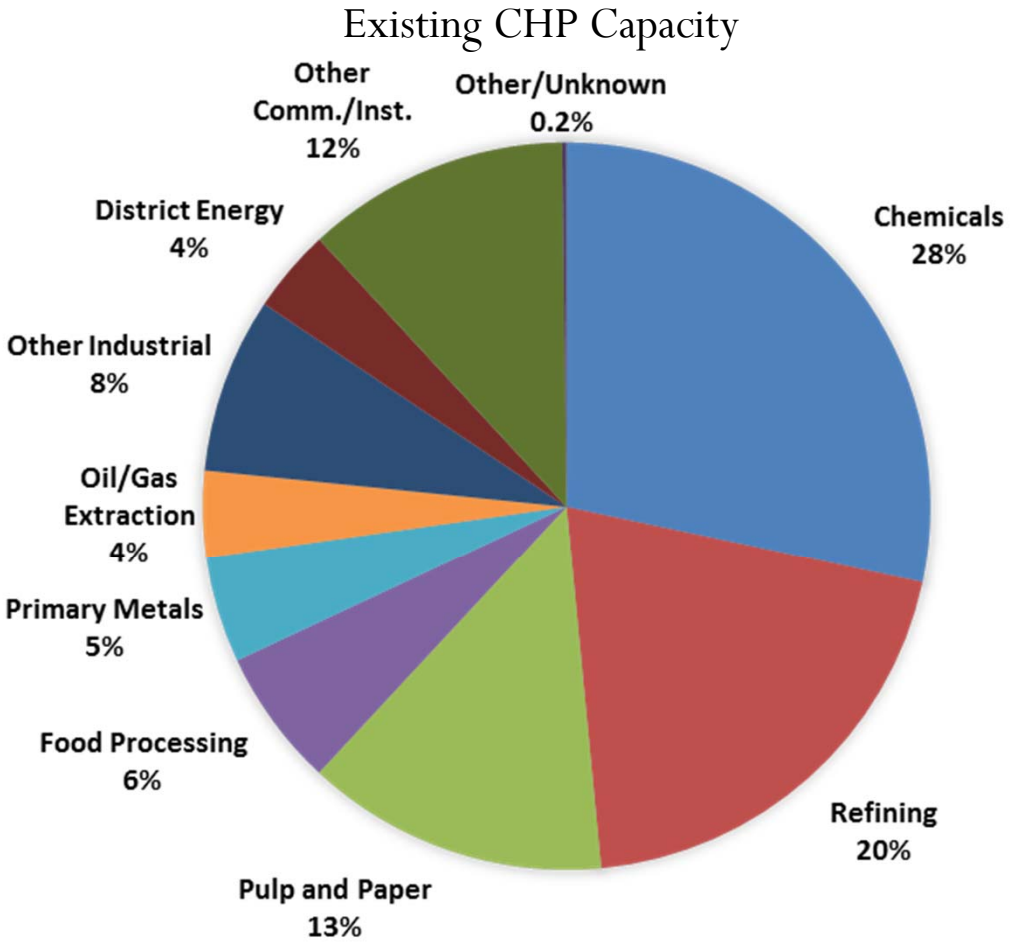


What Are the Benefits of CHP?

- 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 resiliency** and enhance power quality
- On-site electric generation can **reduce grid congestion** and avoid distribution costs.

The State of CHP

CHP Today in the United States

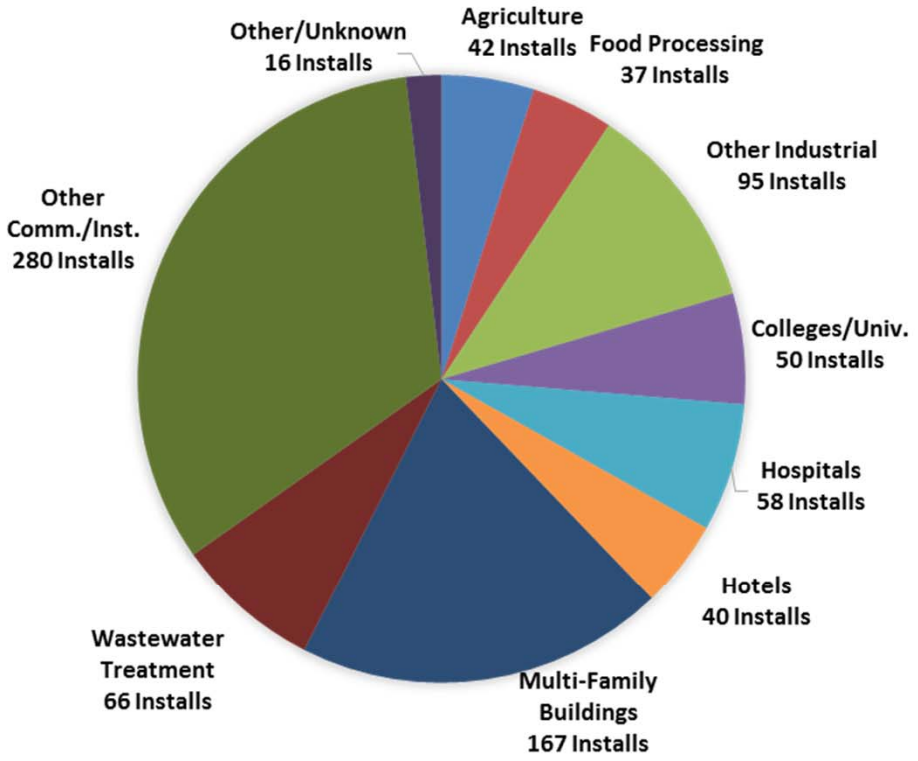


- **81.3 GW** of installed CHP at more than 4,400 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO_2** compared to separate production

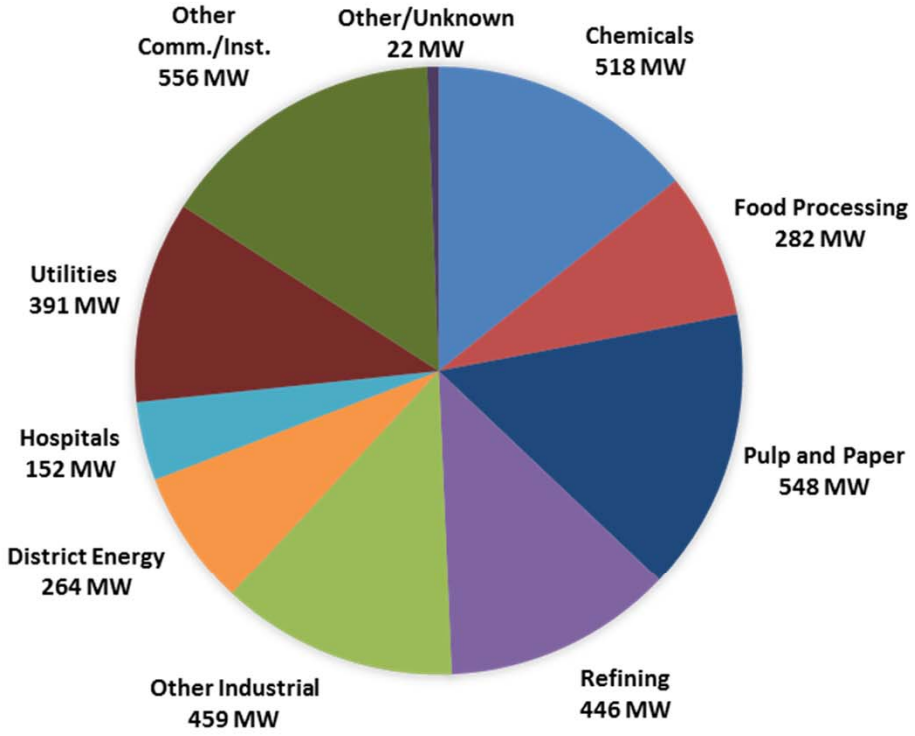
Source: DOE CHP Installation Database (U.S. installations as of December 31, 2017)

CHP Additions by Application (2013-2017)

By Installations – 851 Installs



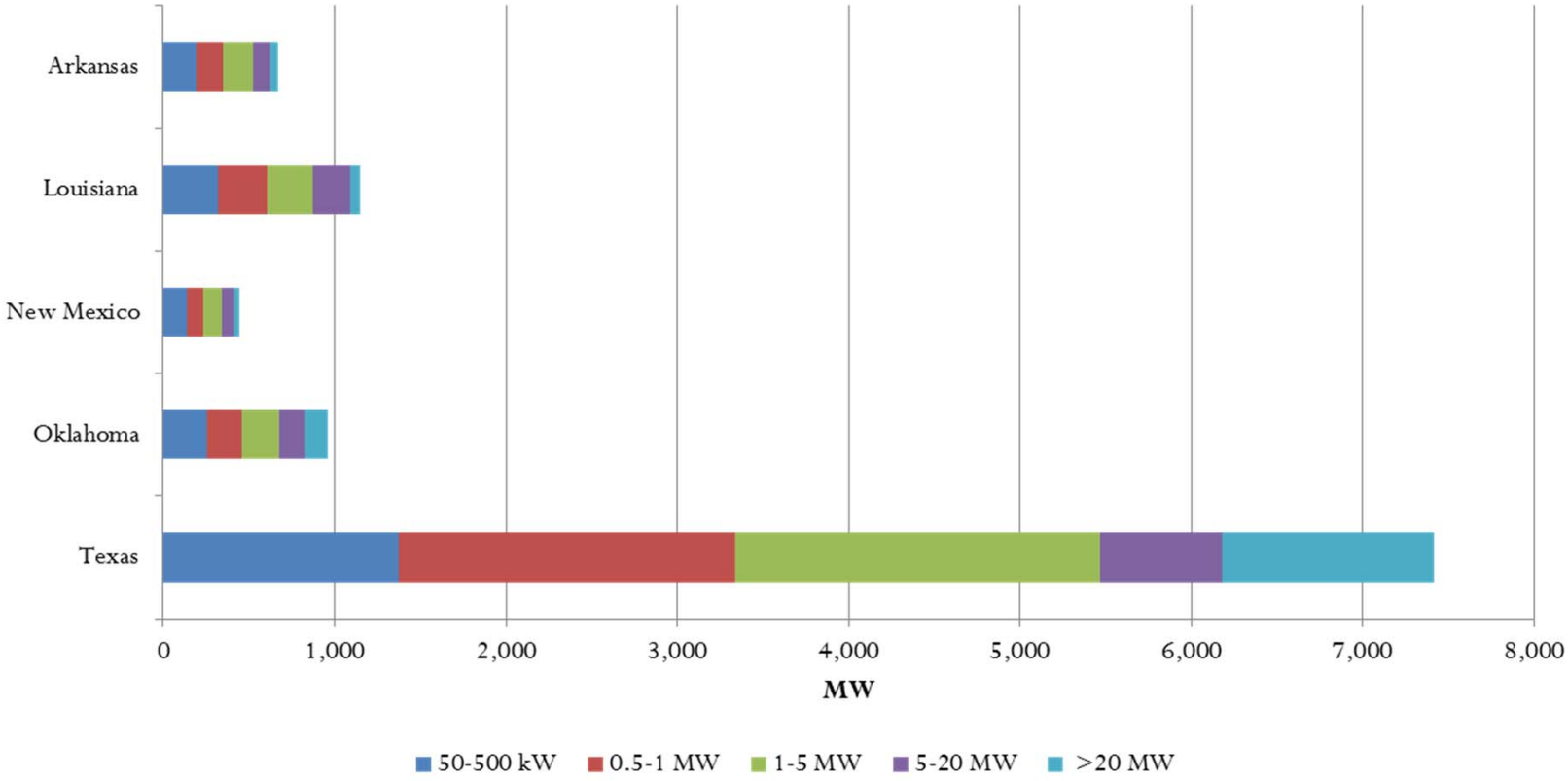
By Capacity – 3.6 MW



Source: DOE CHP Installation Database (U.S. installations as of December 31, 2017)

Where are the Southcentral Opportunities for CHP?

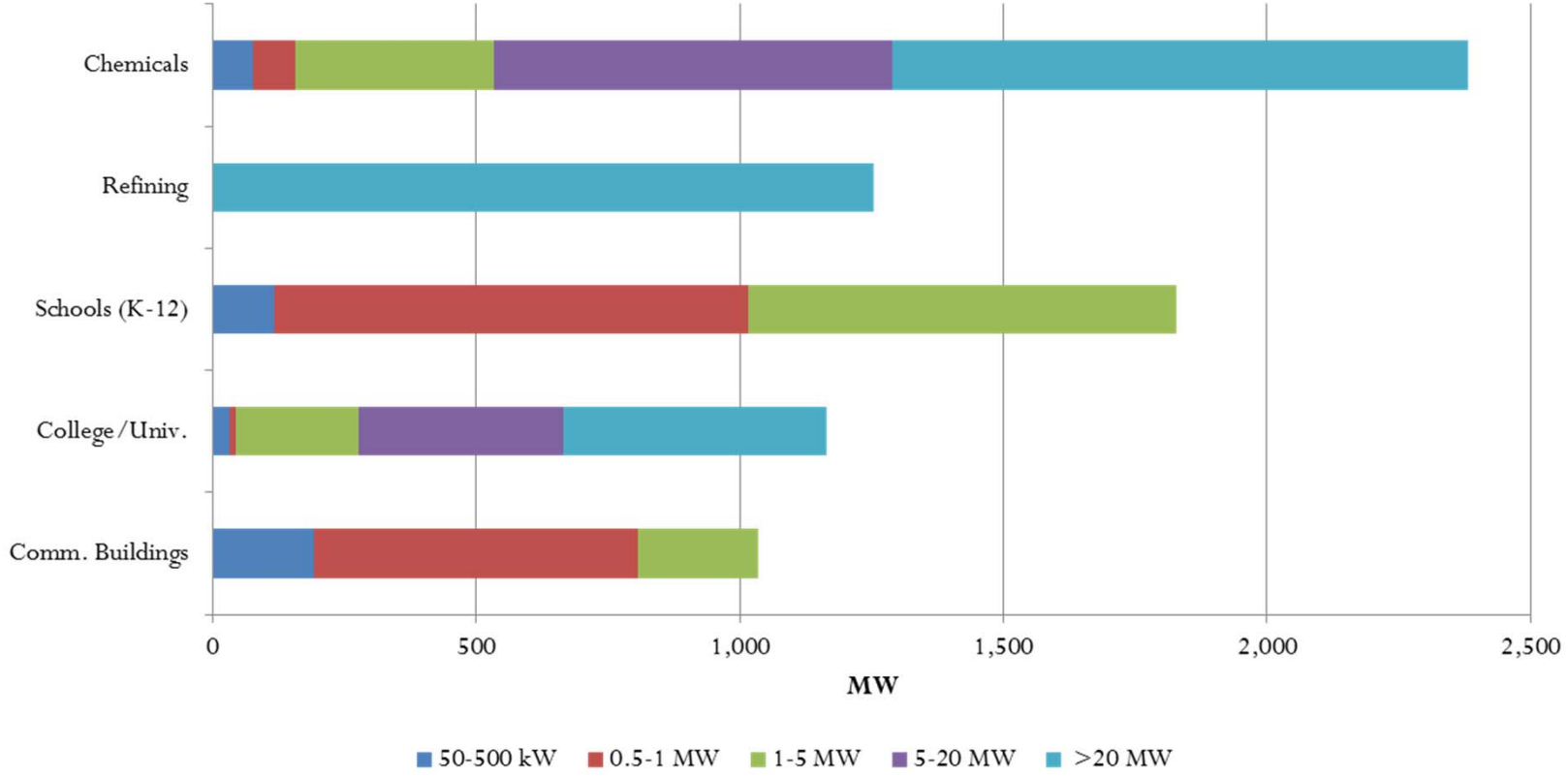
(10,637 MW of CHP Potential at 27,426 sites)



Source: U.S. Dept. of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States", March 2016.

Where are the CHP Opportunities in Texas?

(14,062 MW of CHP Potential at 20,855 sites)



Source: U.S. Dept. of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States", March 2016.

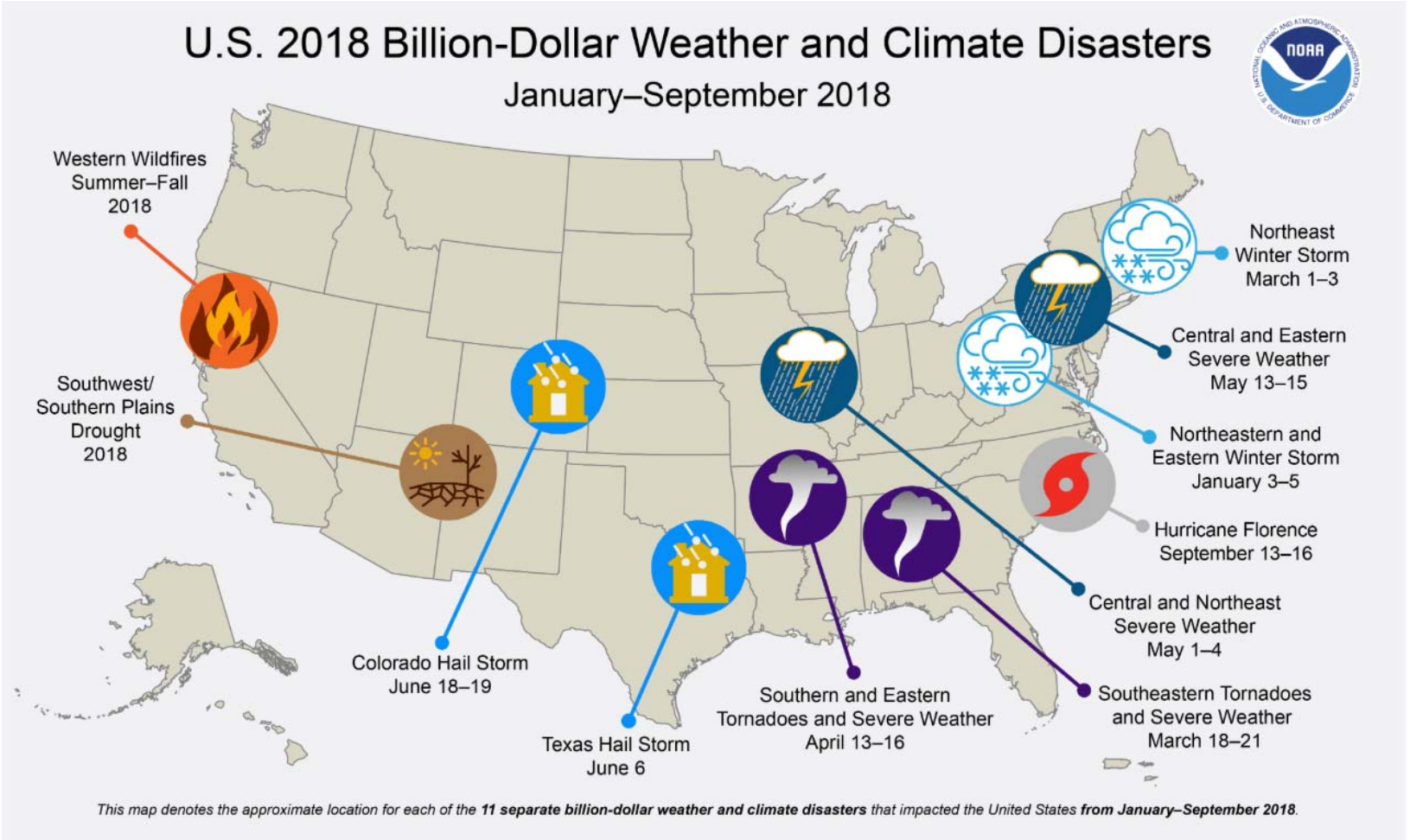
Introduction to Resilience and Reliability

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

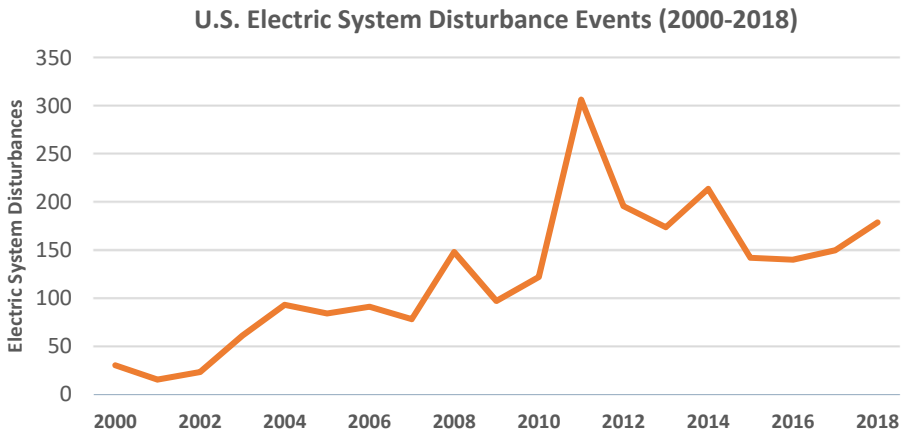
Source: State Energy Resilience Framework, Argonne National Laboratory (2017)

Power Outages are Costly

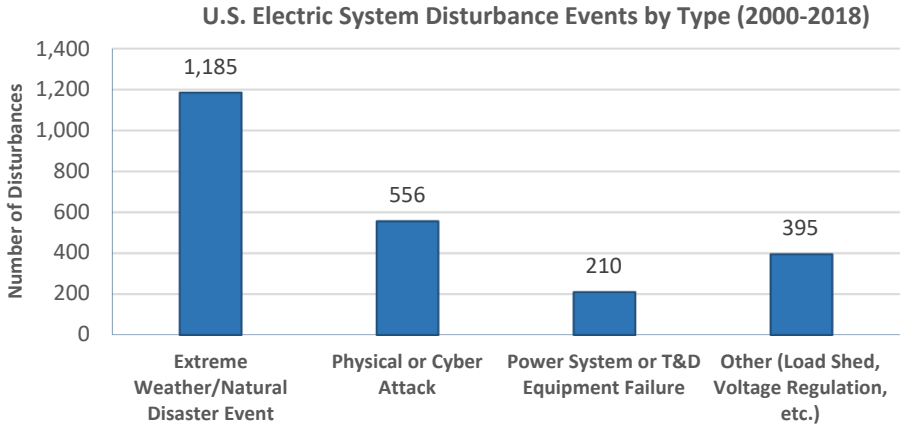


Electric System Disturbances

Electric system outages are increasingly frequent...

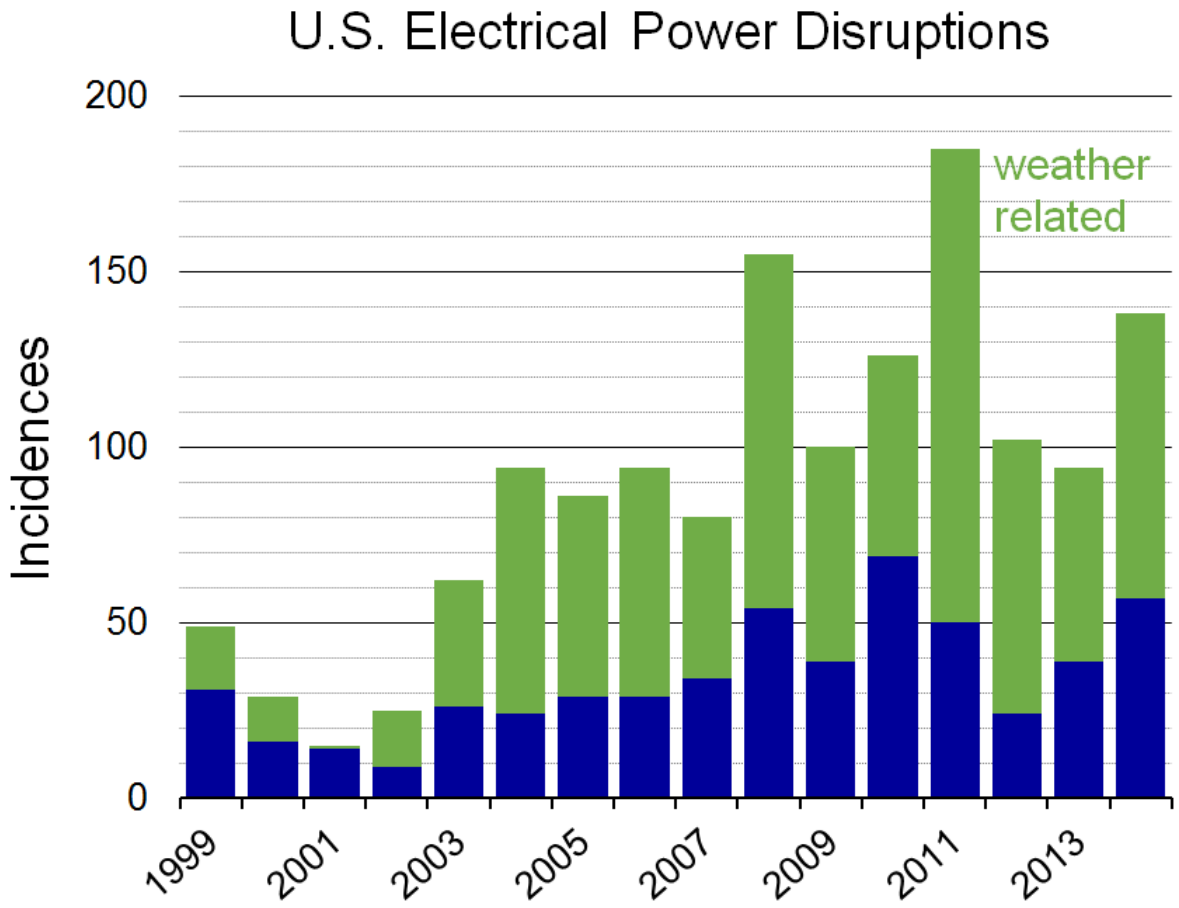


And outages are increasingly caused by natural disasters and storm events



Source: U.S. DOE Office of Cybersecurity, Energy Security, and Emergency Response, Electric Disturbance Events (OE-417) Annual Summaries

Weather Related Disturbances



Natural gas infrastructure has demonstrated robust resilience in the face of most weather events.

Natural Gas Distribution Service Reliability

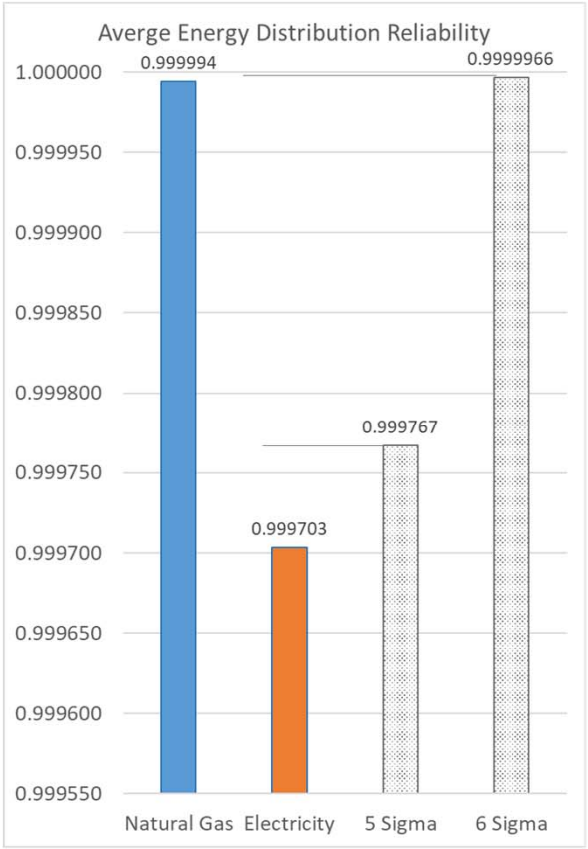
Survey Overview

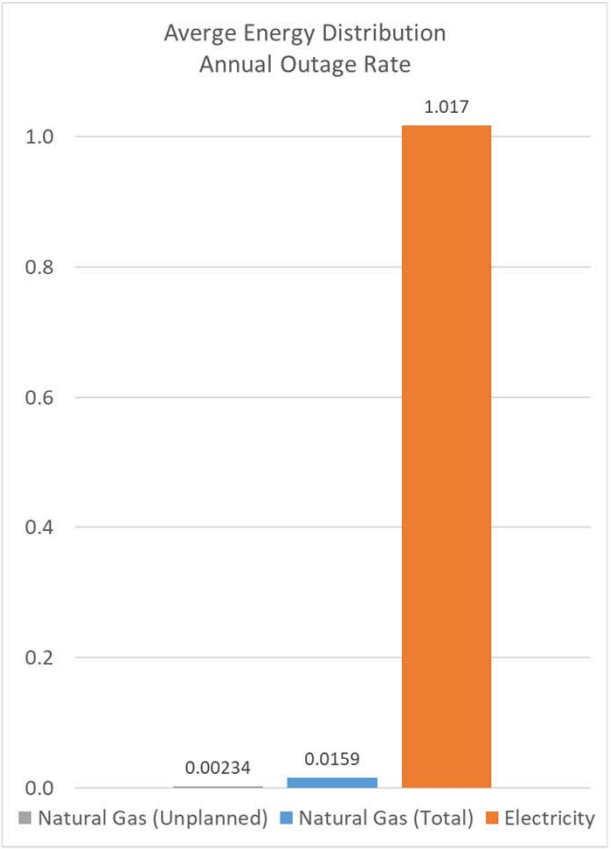
- **GTI conducted a survey of several North American natural gas distribution companies to obtain data on:**
  - **Distribution service reliability/availability. That is, the percent of time in any given year when natural gas service might not be available.**
  - **Annual outage rates. That is, the likelihood in a year time period that a customer could expect a disruption in natural gas service**
- **These data were compared with representative data from electric distribution service, using metrics that align with IEEE 1366 Electric Distribution Reliability Indices**

Energy Distribution Service Reliability

Summary of Survey Results

- **Electric distribution approaches "five sigma" reliability with demonstrably higher annual outage rates (mainly unplanned)**
- **Natural gas distribution achieves "six sigma" reliability levels and exceptionally low outage rates**
  - **Most outages are due to planned maintenance**
  - **Third-party excavation leading cause of unplanned outages**





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

Critical Infrastructure Resilience with CHP

- Critical infrastructure refers to assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, economic security, or public health and safety
- Many critical infrastructure facilities have consistent electric and thermal loads that can support CHP
- CHP offers many benefits to critical infrastructure:
  - Improve power quality, reliability, and resiliency
  - 24/7 power and heat with continuous benefits and cost savings
  - Can continue to operate during utility outages, providing uninterrupted electricity and heating/cooling to host facility

CHP Can Meet Critical Infrastructure Power Reliability Requirements

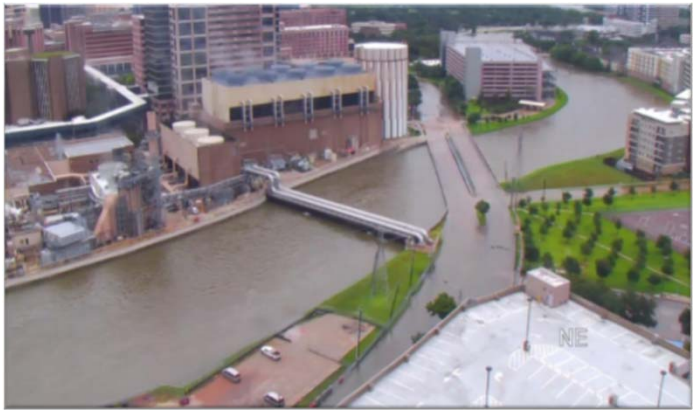
- If the CHP system is connected to the grid, it should:
  - Be designed to disconnect and keep operating following a power disturbance, and
  - Should cover the critical loads of the facility.

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.

Source: Guide to Using Combined Heat and Power for Enhancing Reliability and Resiliency in Buildings, U.S. DOE. 2013.

Design is Critical for Resilient CHP Systems

- Design criteria can significantly impact the resilience of CHP systems during severe weather events
- Key design considerations include:
  - Elevation of equipment above flood and storm surge levels
  - Utilize containerized or indoor systems to protect from high winds and debris
  - Utilize shock-mount systems enclosures in earthquake-prone areas
  - Equip with fire protection systems for above-ground gas delivery systems



The Texas Medical CHP system remained operational throughout Hurricane Harvey despite significant flooding in the Brays Bayou area (https://www.energy.gov/eere/amo/articles/chp-installation-keeps-hospital-running-during-hurricane-Harvey)

CHP vs. Status Quo

CHP vs. Backup Generation

Metric	CHP	Backup Generation
System Performance	• Designed and maintained to run continuously • Improved performance and reliability	• Only used during emergencies
Fuel Supply	• Natural gas infrastructure typically not impacted by severe weather	• Limited by on-site storage – finite fuel supply
Transition from Grid Power	• May be configured for "flicker-free" transfer from grid connection to "island mode"	• Lag time may impact critical system performance
Energy Supply	• Electricity • Thermal (heating, cooling, hot/chilled water)	• Electricity
Emissions	• Typically natural gas fueled • Achieve greater system efficiencies (80%) • Lower emissions	• Commonly burn diesel fuel

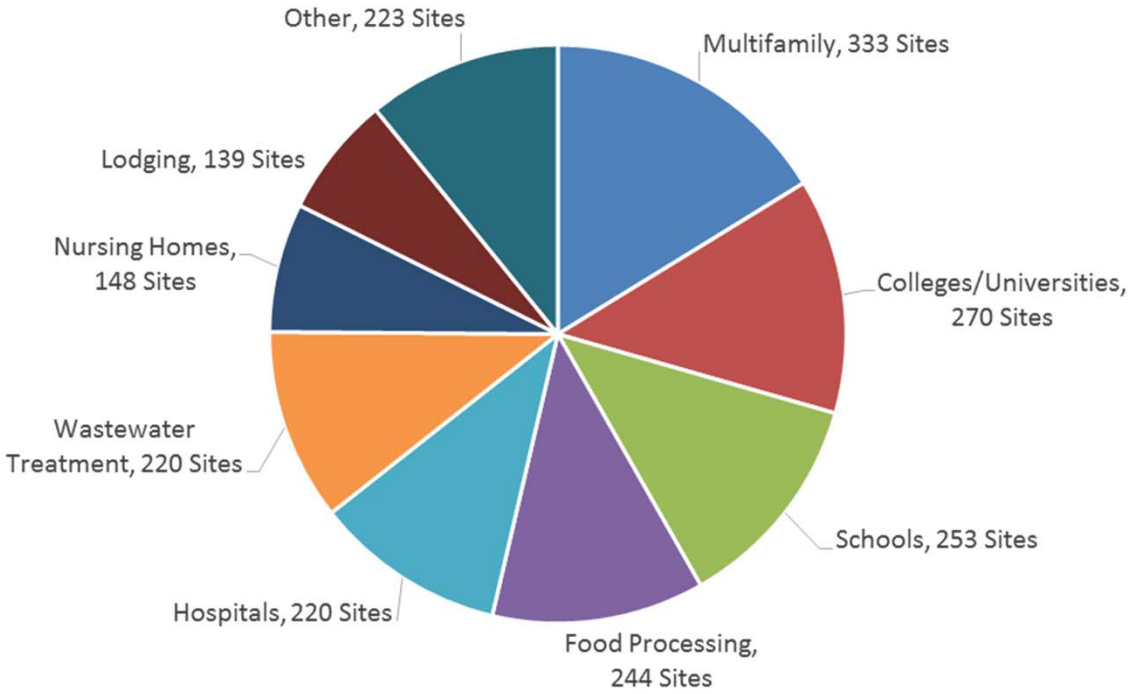
Source: DER Disaster Matrix, Issue Brief, U.S. DOE CHP for Resiliency Accelerator. 2018; Natural Gas Systems: Reliable & Resilient, The Natural Gas Council. 2017; Case Studies of Natural Gas Sector Resilience Following Four Climate-Related Disasters in 2017, ICF Prepared for SoCalGas. 2018.

Critical Infrastructure Sectors Conducive to CHP

- Host facilities must have a consistent electric and thermal demand, and a reliable source of fuel (pipeline natural gas, anaerobic digester gas, etc.)

Who Can Use CHP?				
Airports	Chemicals & Pharmaceuticals	Colleges & Universities	Critical Manufacturing	Datacenters
Distribution Centers	Fire Stations	Food Processing	Food Sales & Supermarkets	Government Facilities
Hospitals & Healthcare	Hotels & Lodging	Laundries	Military Bases	Multifamily
Nursing Homes	Police Stations	Prisons	Schools	Wastewater Treatment Plants

CHP in Critical Infrastructure Installations by Sub-Sectors



More than 8.5 GW of CHP is installed at over 1,300 sites identified as critical infrastructure

Source: CHP Installation Database, 2018 - https://doe.icfwebservices.com/chpdb/

Project Snapshots

Resilience and Reliability with CHP

Project Snapshot:

Power Reliability

Evonik Industries
Garyville, LA

Application/Industry: Chemicals
Capacity: 5 MW
Prime Mover: Gas turbine
Fuel Type: Natural gas
Thermal Use: Process steam
Installation Year: 2012

Highlights: Evonik decided to invest in a CHP system to improve both their electric power and steam reliability. The system provides 100% of the facility's electric needs for most of the year and eliminated Evonik's dependency on their previous steam supplier, minimizing disruptions that were out of their control.

Source: Evonik, Garyville, LA
http://corporate.evonik.com/en/Pages/default.aspx

Project Snapshot:

Environmental Benefits

SABIC Innovative Plastics

Mt. Vernon, IN

Application/Industry: Plastics

Capacity: 80 MW

Prime Mover: Gas turbine

Fuel Type: Natural gas

Thermal Use: Steam

Expected Installation Year: 2016

Highlights: SABIC's new CHP facility is expected to reduce annual emissions by an amount equivalent to 110,000 automobiles. The site was impacted by Boiler MACT emissions standards.

Source: http://www.industrysourcing.com/articles/286116.aspx
https://www.sabic-ip.com/gep/en/NewsRoom/PressReleasePrint/december_03_2013_sabicsinnovativeplastics.html

Project Snapshot:

3rd Party Build, Own, and Operate

Atlantic Power Cogeneration Plant
(LyondellBasell Ethylene Plant)
Morris, Illinois

Application/Industry: Chemicals

Capacity: 200 MW

Prime Movers: Combustion turbines and condensing steam turbine

Fuel Type: Natural gas

Thermal Use: Steam for ethylene plant

Installation Year: Combustion turbines in 1998; steam turbine in 2000

Highlights: Under a long term contract between Atlantic Power and LyondellBasell, steam and power is supplied to the ethylene production process. This consists of up to 350,000 lbs/hr of high pressure / high temperature steam and up to 57 MW of electrical power.

Project Snapshot:

Utility–Industry Partnership, Critical Infrastructure Resiliency

Eight Flags Energy Center
Chesapeake Utilities /
Florida Public Utilities Corp
Fernandina Beach, FL

Application/Industry: Utility/Industrial
Capacity: 22 MW
Prime Mover: Gas turbine
Fuel Type: Natural gas
Thermal Use: Steam for Rayonier plant
Installation Year: 2014
Efficiency: 78%
Net Annual Savings: $7.3 million

Testimonials: *"We're excited to launch the Company's first CHP plant as we continue to expand our footprint and develop smart energy offerings, further diversifying our business."*
- Michael P. McMasters, President and Chief Executive Officer, Chesapeake Utilities Corporation

"The Eight Flags Energy CHP system is a welcome addition to the Fernandina plant, improving our reliability and the robustness of our operations."
- C.A. McDonald, Plant Manager, Rayonier Advanced Materials

Source: http://www.chpk.com/eight-flags-energy/

Project Snapshot: University of Texas Medical Branch at Galveston

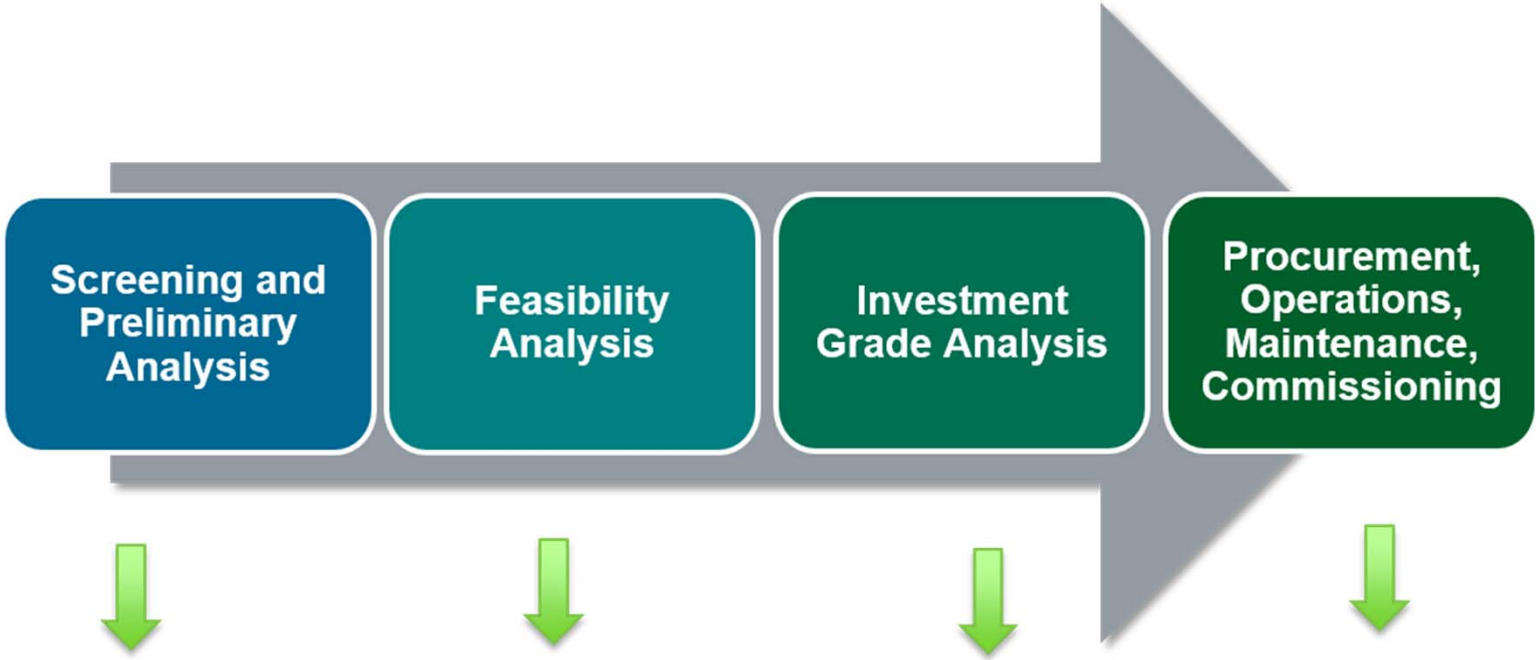
- **Location:** Galveston, TX
- **Application/Industry:** Hospital
- **Capacity:** 11.9 MW
- **Prime Mover:** Combustion turbine
- **Fuel Type:** Natural gas
- **Thermal Use:** Steam for steam, DHW
- **Installation Year:** 2016
- **Resilience Benefits**
  - Hurricane Ike severely damaged UTMB campus and energy/steam infrastructure
    - Hospital unable to operate for 90 days, $2 million loss of business revenue/day, lost research materials, etc.
  - Converted buildings to DHW, distributed steam overhead to buildings, elevated boilers and chillers, and built flood wall around CHP system
  - During Harvey, CHP system operated throughout in island mode, and all infrastructure was well protected

utmb Health

The UTMB CHP systems protected by a flood wall, photos courtesy of Affiliated Engineers

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

CHP TAP Role: Technical Assistance



Resilience Planning with DOE CHP for 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

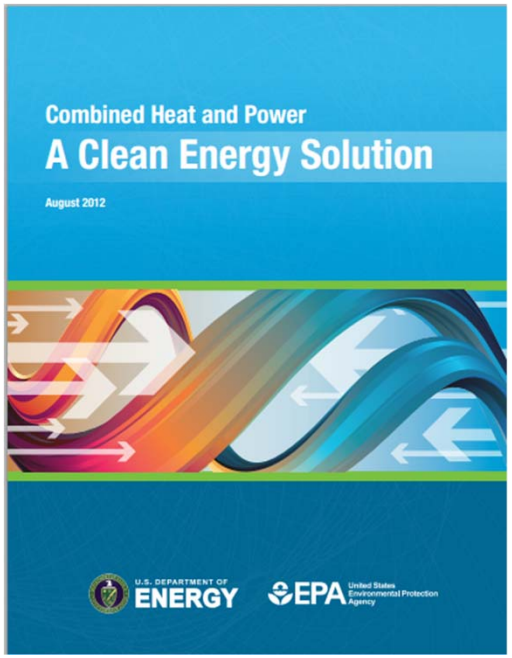
https://betterbuildingsinitiative.energy.gov/accelerators/combined-heat-and-power-resiliency

CHP Project Resources

DOE CHP Technologies Fact Sheet Series

www.energy.gov/chp-technologies

Good Primer Report



www.eere.energy.gov/chp

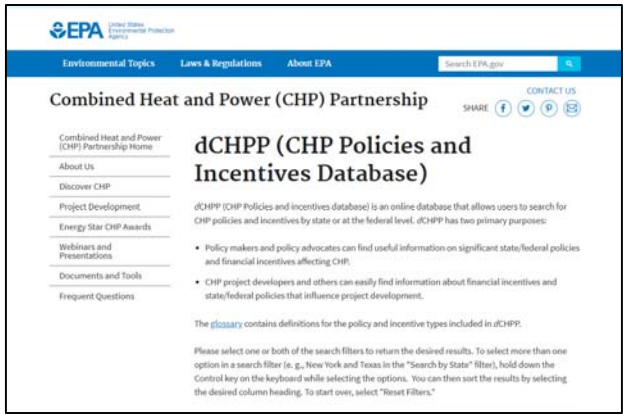
CHP Technical Assistance Partnerships
SOUTHCENTRAL

CHP Project Resources

DOE Project Profile Database

energy.gov/chp-projects

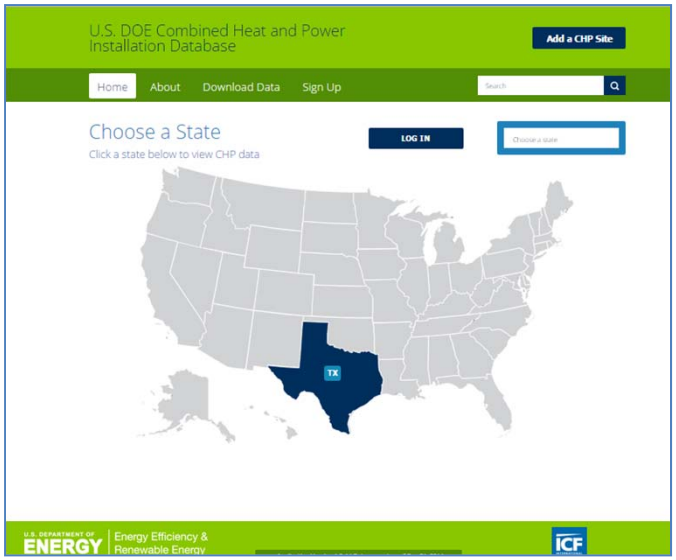
EPA dCHPP (CHP Policies and Incentives Database



www.epa.gov/chpdchpp-chp-policies-and-incentives-database

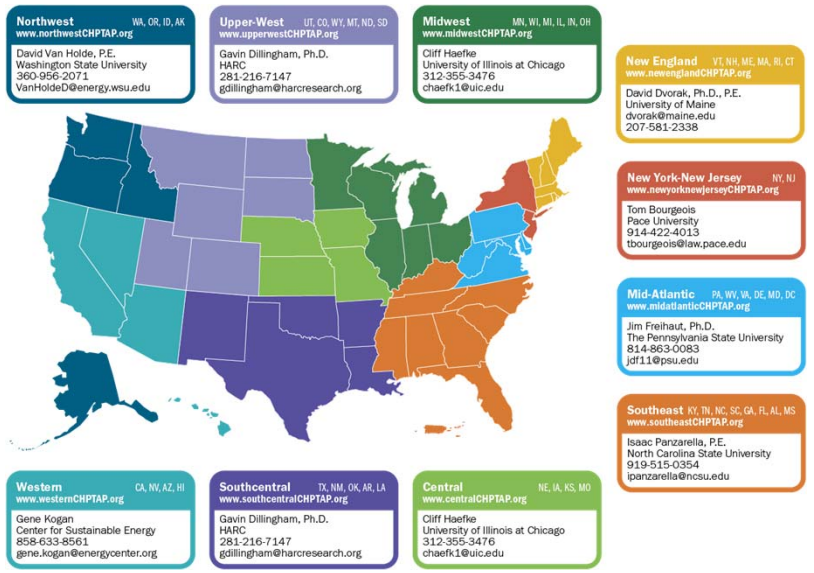
CHP Project Resources

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



https://doe.icfwebservices.com/chpdb/

And of course… No Cost CHP Screening and Other Technical Assistance from the CHP TAP



Next Steps

Resources are available to assist in developing CHP Projects.

Contact the Southcentral CHP TAP to:

- Perform CHP Qualification Screening for a particular facility
- Ask for a resiliency screening of your buildings
- Identify existing CHP sites for Project Profiles
- Advanced Technical Assistance

Summary

- 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 example exist to learn more how other data centers have incorporated CHP
- Engage with the US DOE Southcentral CHP TAP to learn more about the technical assistance offerings in evaluating CHP in your date center.

Thank You!

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