Combined Heat and Power as a Source of Resilience in Microgrids

Webinar

November 13th 2018

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

CHP Technical Assistance Partnerships
SOUTHCENTRAL

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Director of the DOE Southcentral CHP TAP

Carlos Gamarra
Energy Engineer with DOE Southcentral CHP TAP

Laxmi Rao - Moderator

Director, International District Energy Association

Partner

INTERNATIONAL
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ASSOCIATION

Agenda

- CHP Overview
- CHP Markets
- CHP Trends
- CHP Activity in the Southcentral Region
- CHP as a Source of Resilience in Microgrids
- Project Snapshots
- How to Implement a CHP Project with the Help of the 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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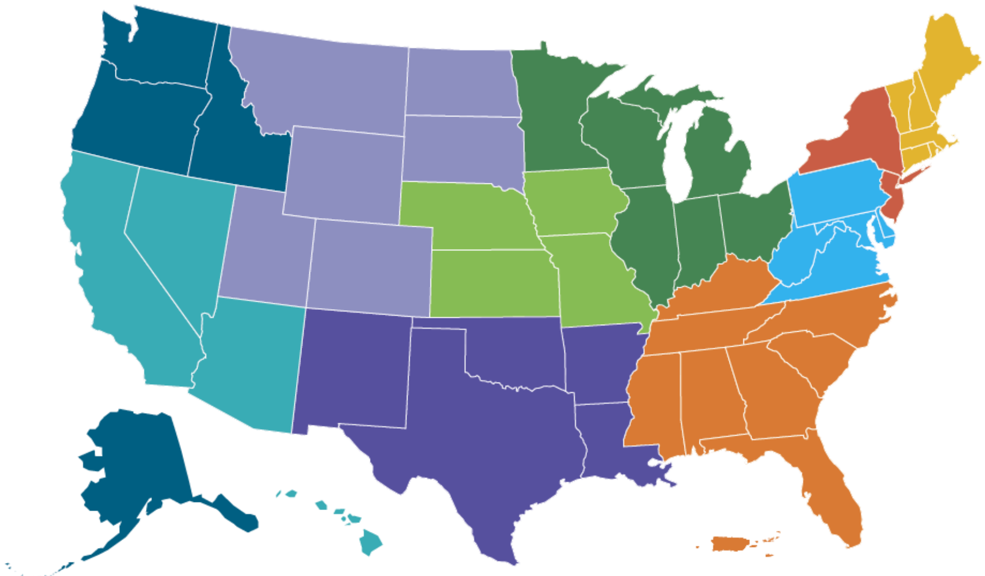

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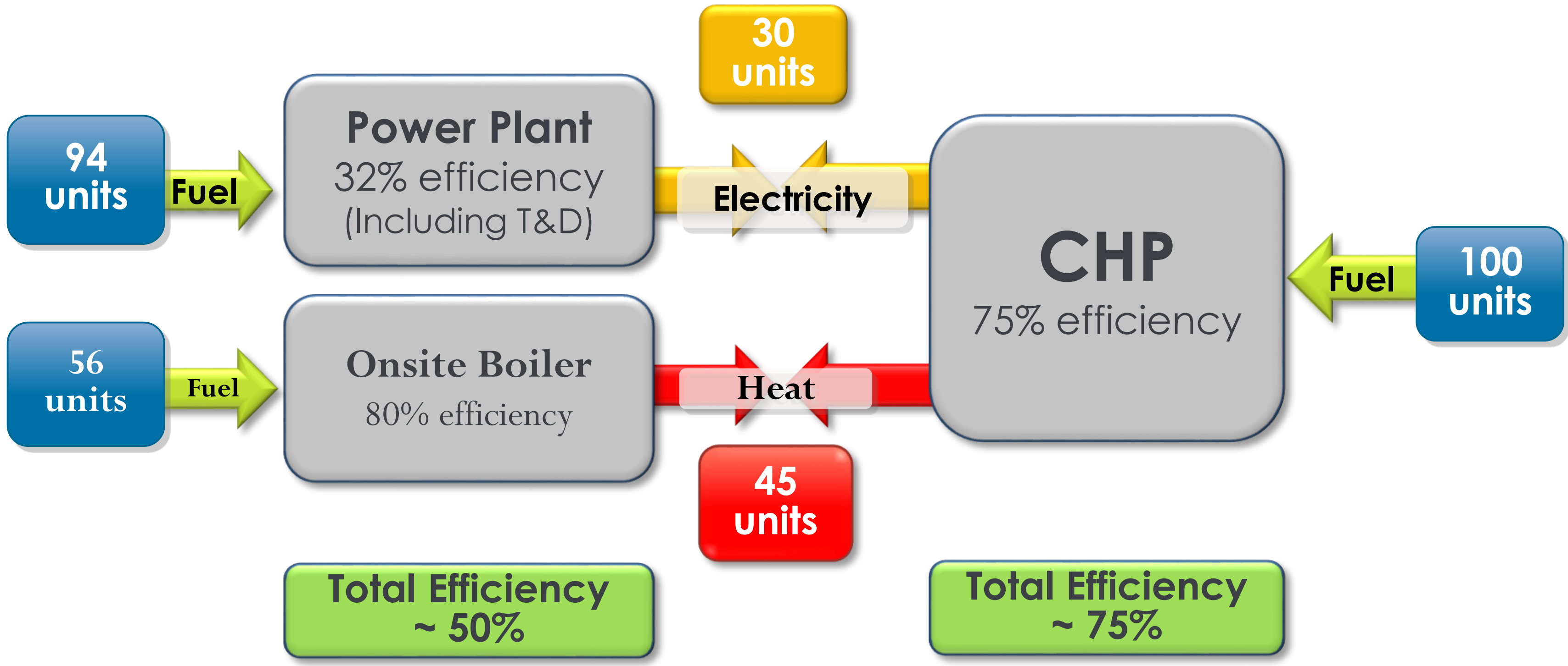
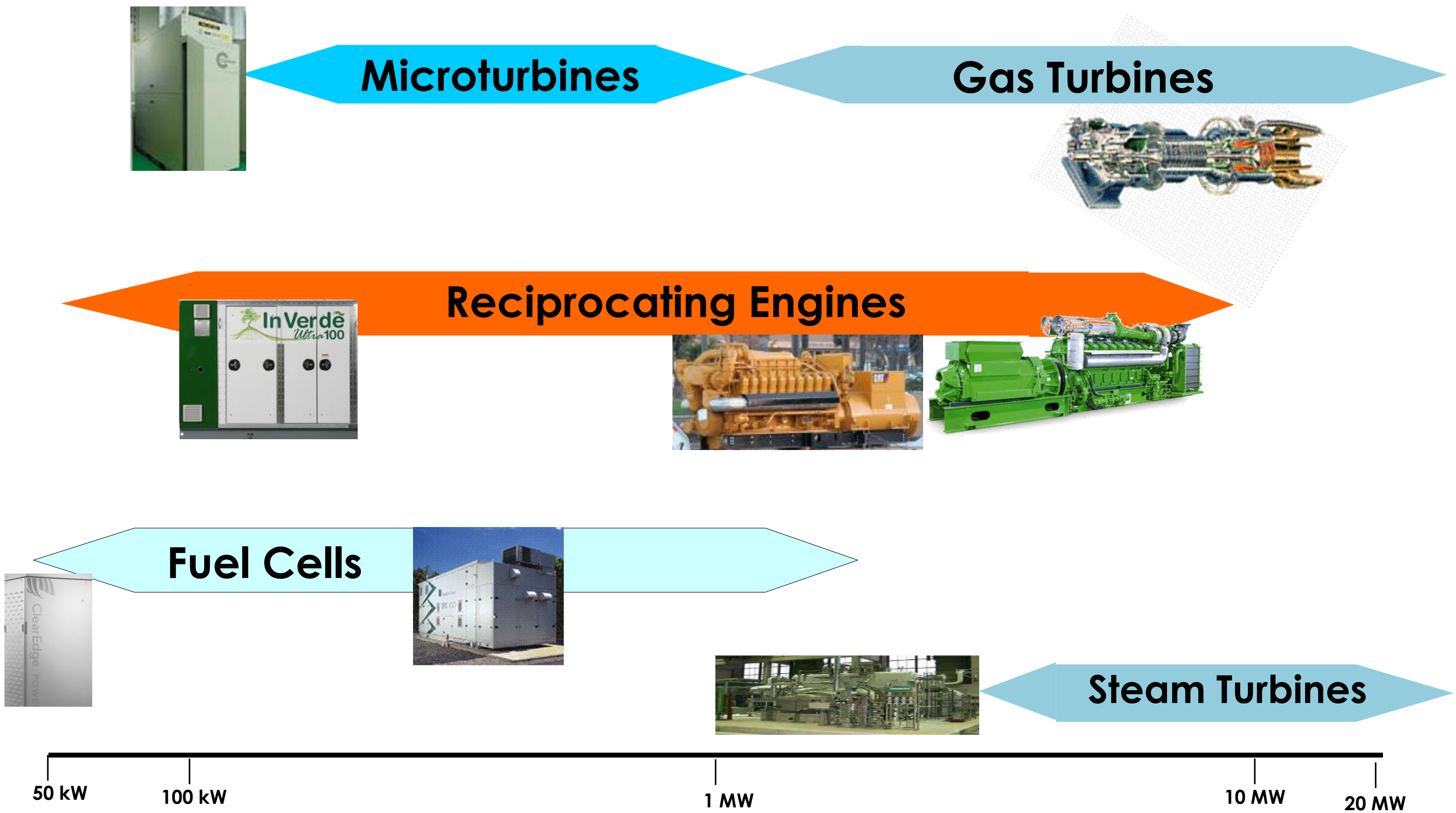
CHP Overview

CHP Recaptures Heat of Generation, Increasing Energy Efficiency, and Reducing GHGs

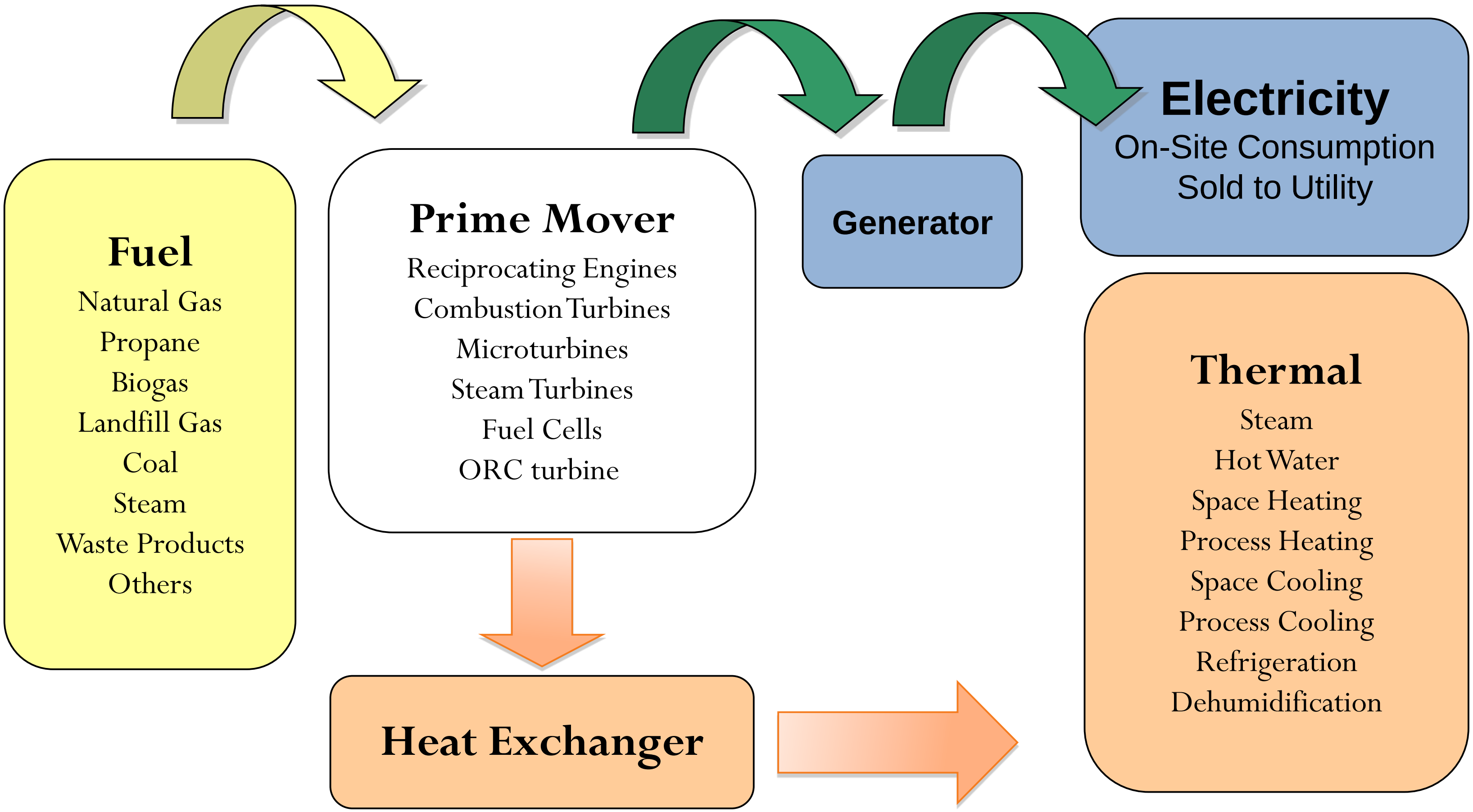


30 to 55% less greenhouse gas emissions

Common CHP Technologies



CHP System Schematic



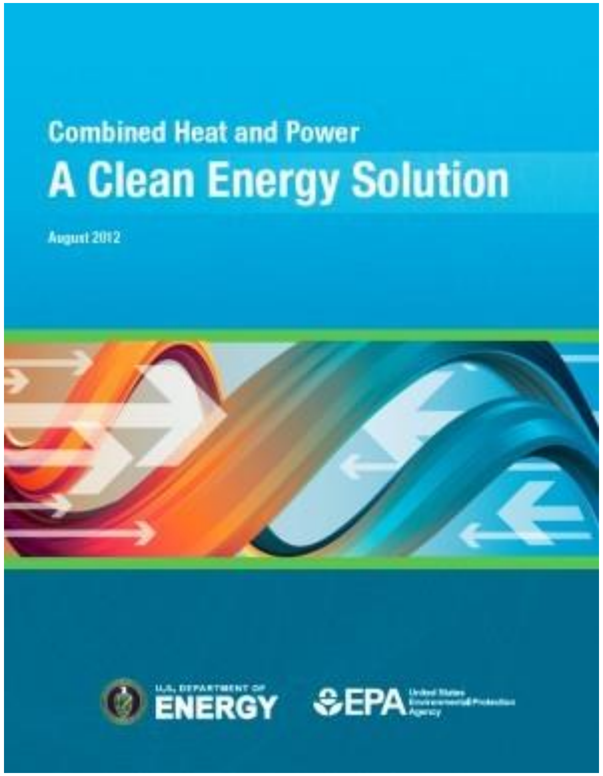
What Are the Benefits of CHP?

- 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.

Emerging National Drivers for CHP

- Benefits of CHP recognized by policymakers
  - State Portfolio Standards (RPS, EEPS), Tax Incentives, Grants, standby rates, etc.
- Favorable outlook for natural gas supply and price in North America
- Opportunities created by environmental drivers
- Utilities finding economic value
- Energy resiliency and critical infrastructure

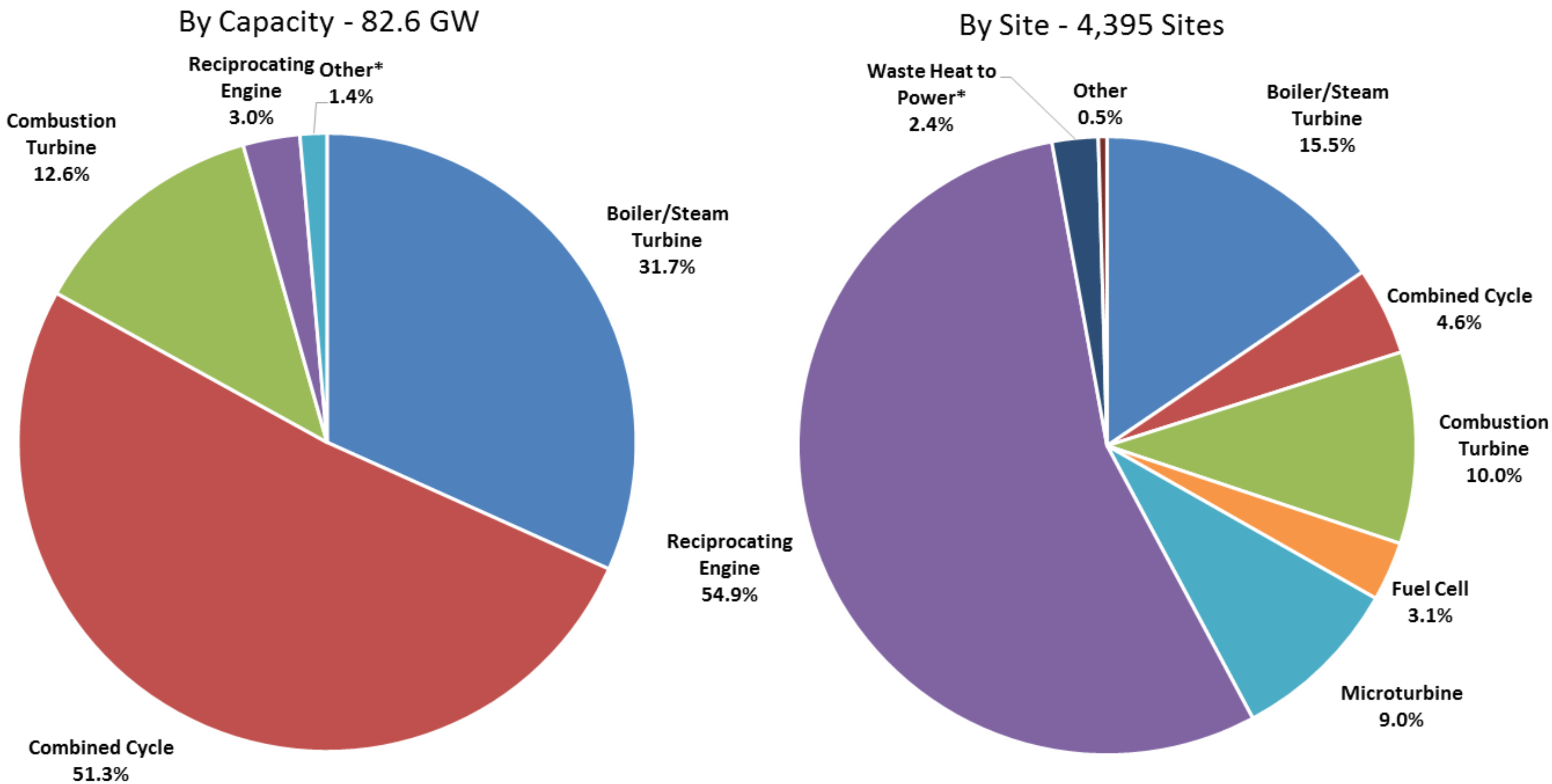
DOE / EPA CHP Report (8/2012)



http://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_clean_energy_solution.pdf

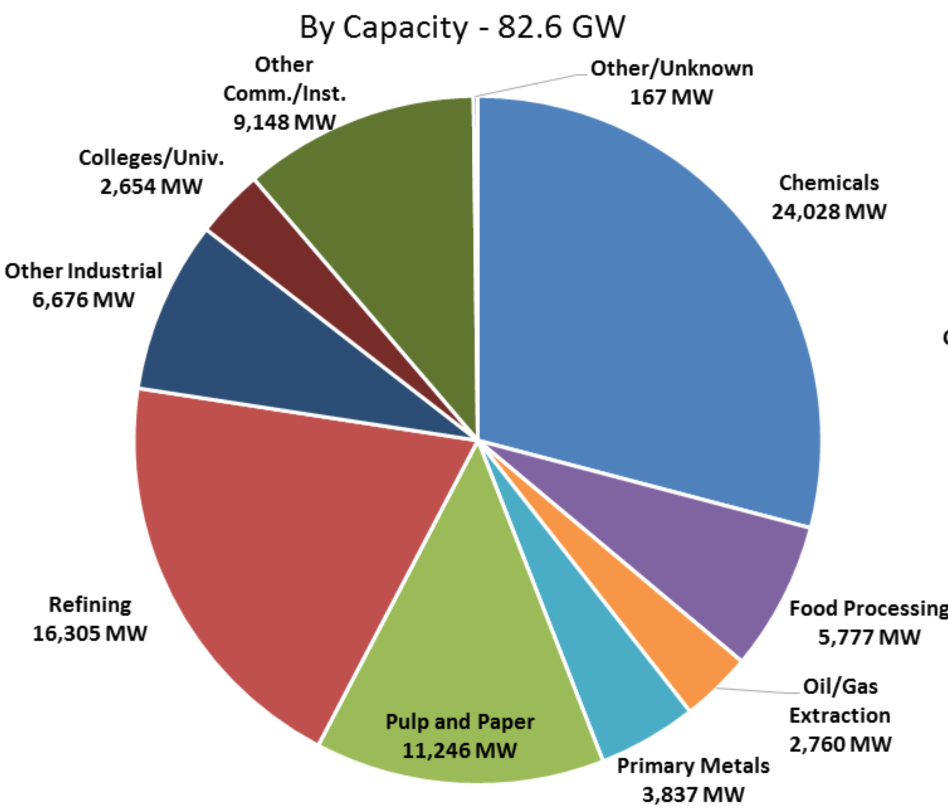
CHP Markets

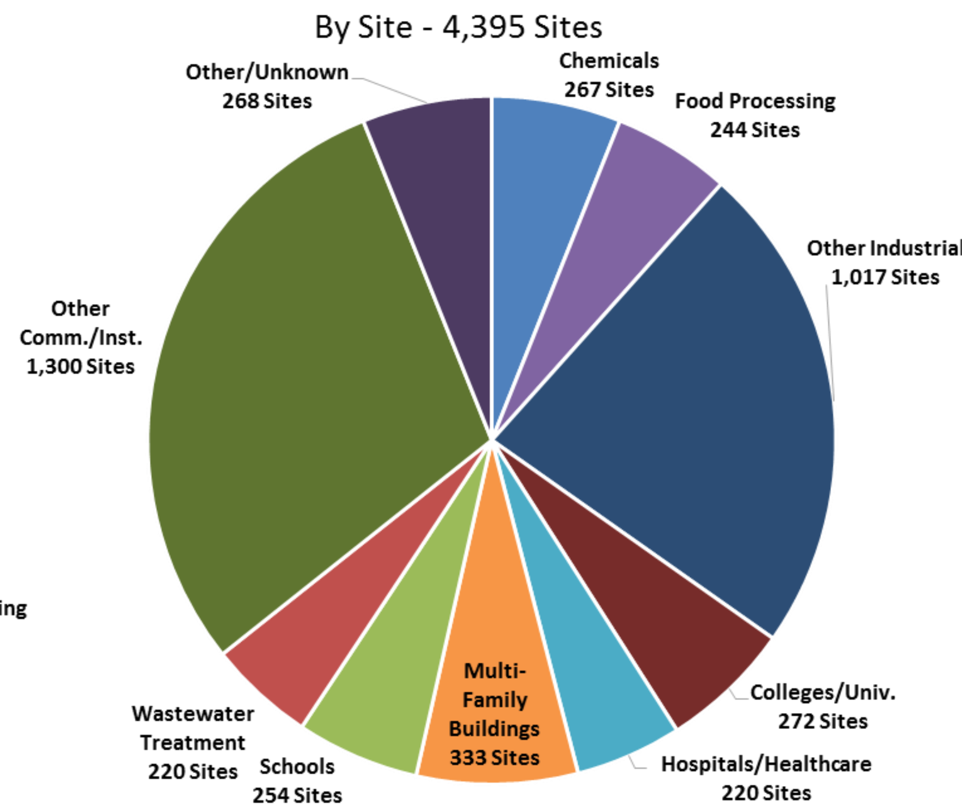
Existing CHP Installations in the U.S.



Source: DOE CHP Installation Database (U.S. installations as of December 31, 2016)

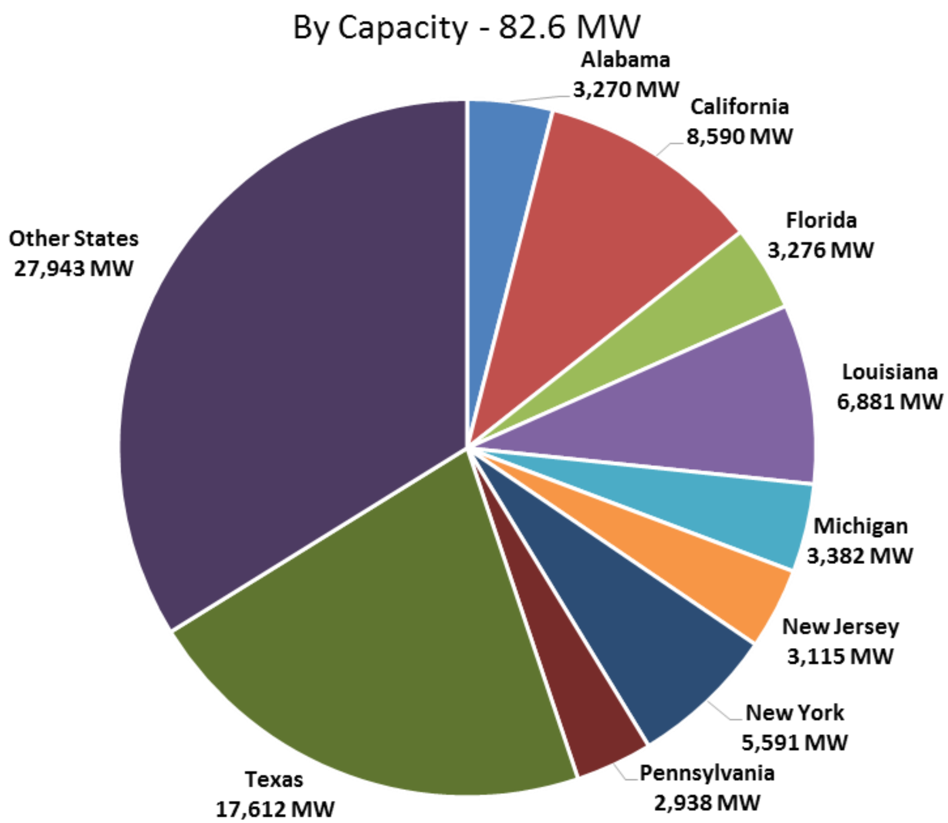
Total CHP by Application

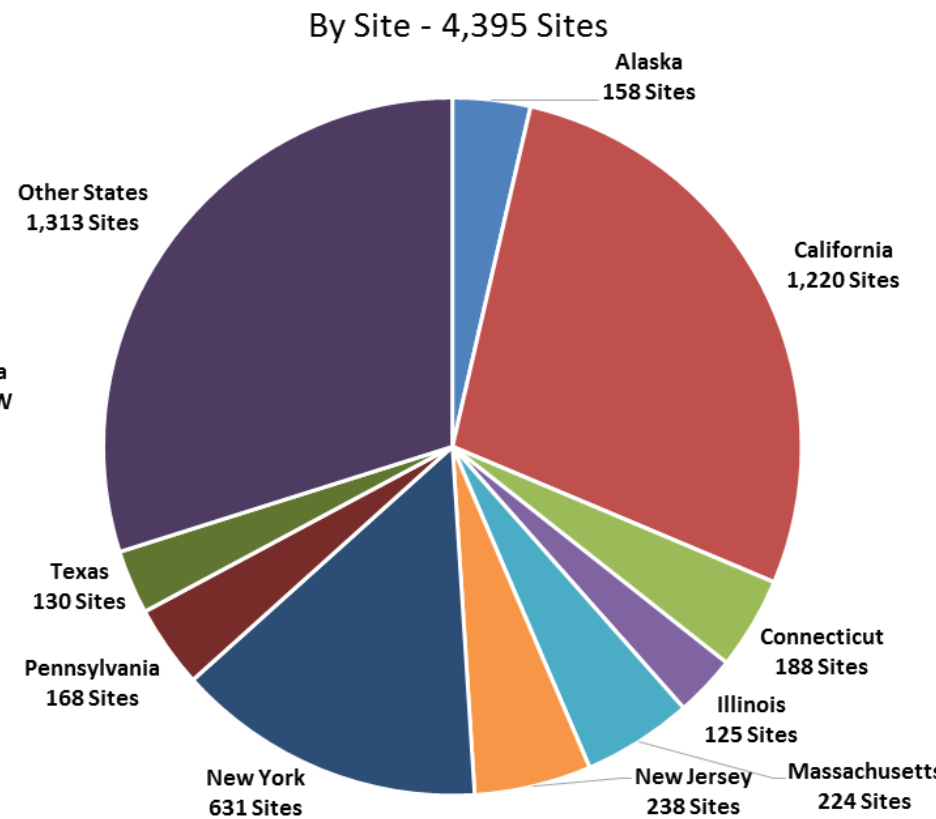




Source: DOE CHP Installation Database (U.S. installations as of December 31, 2016)

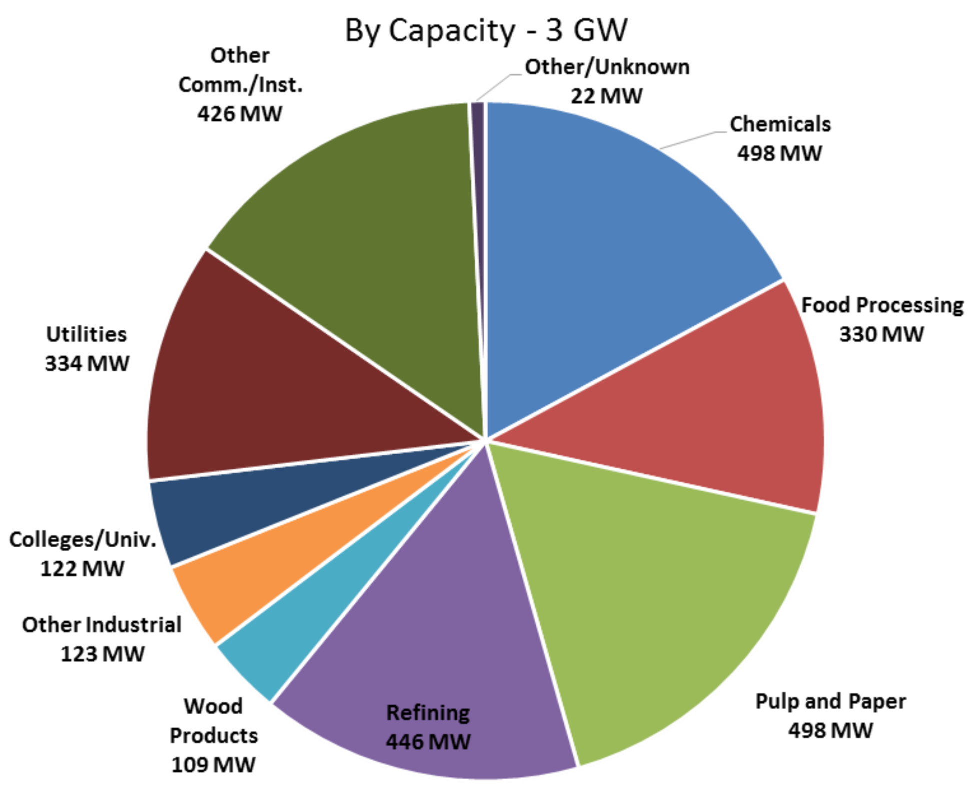
Total CHP by State

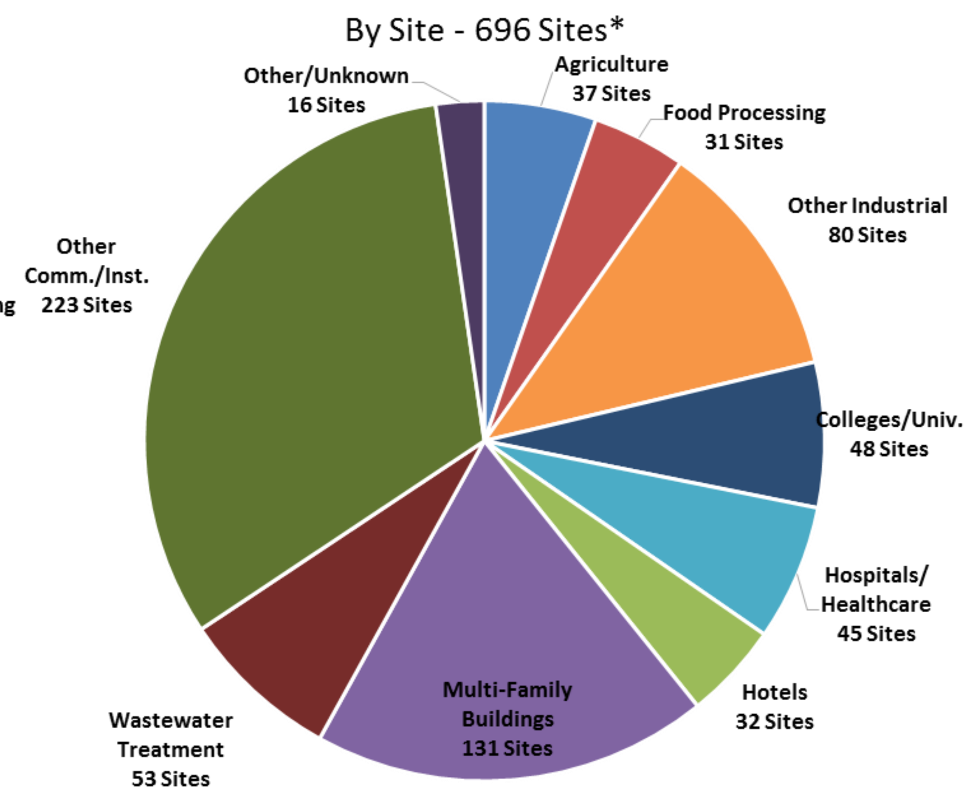




Source: DOE CHP Installation Database (U.S. installations as of December 31, 2016)

CHP Additions by Application (2013-2016)





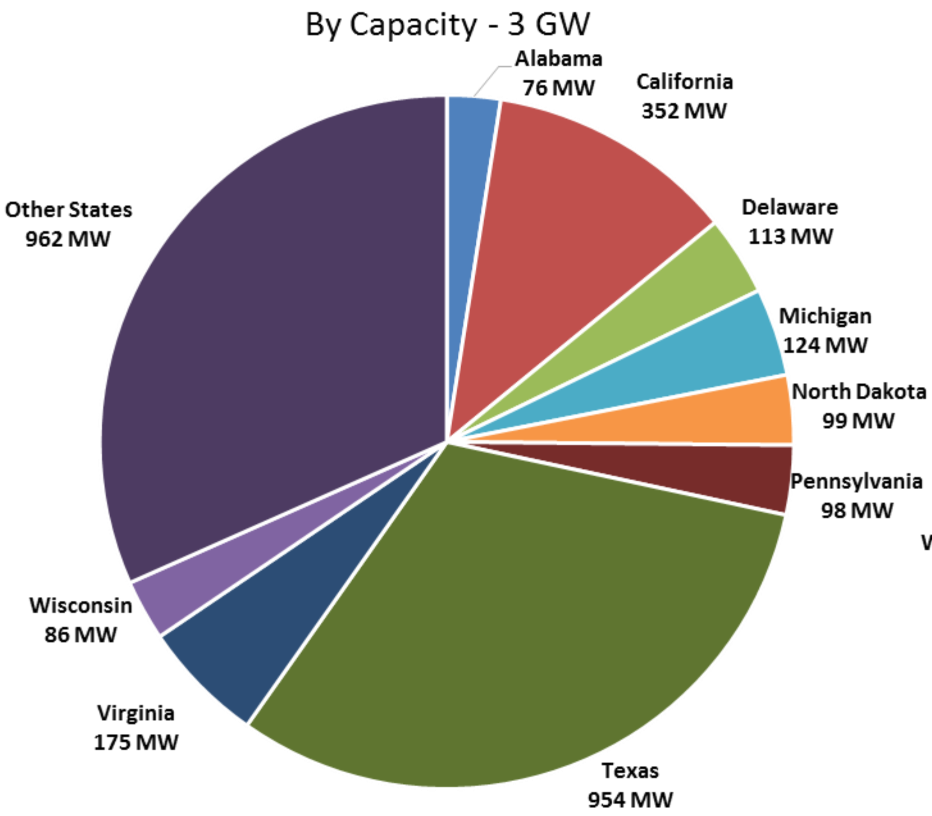
Source: DOE CHP Installation Database (U.S. installations as of December 31, 2016)

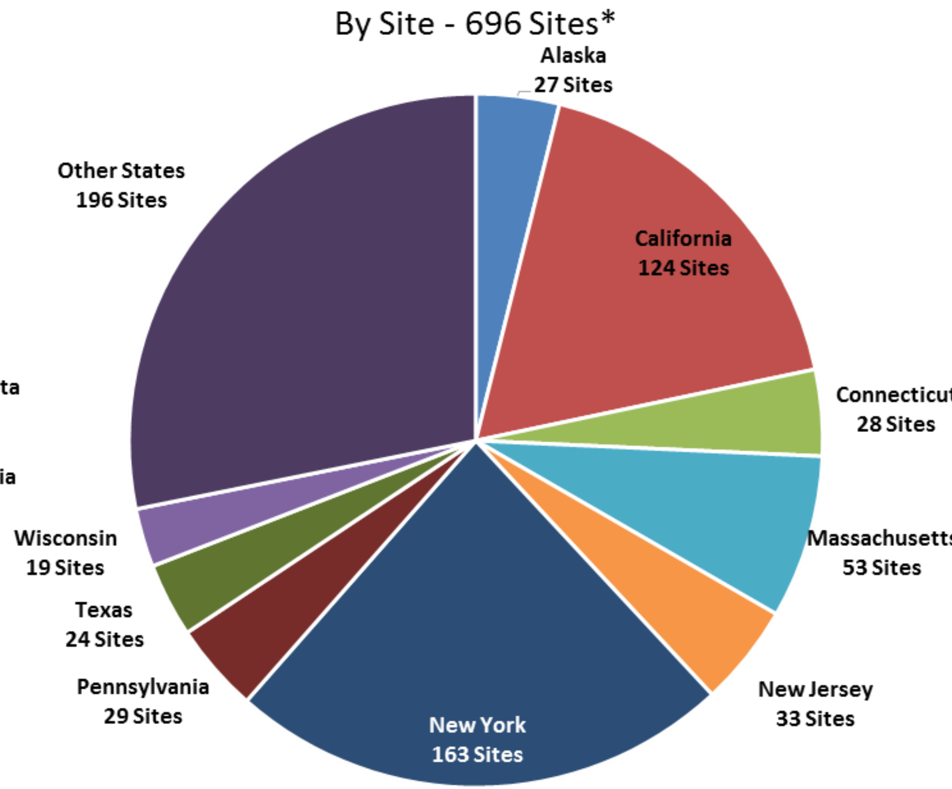
CHP Technical Assistance Partnerships SOUTHCENTRAL

*This includes 91 expansions to existing CHP systems

Slide prepared on 5-30-17

CHP Additions by State (2013-2016)





Source: DOE CHP Installation Database (U.S. installations as of December 31, 2016)

CHP Technical Assistance Partnerships
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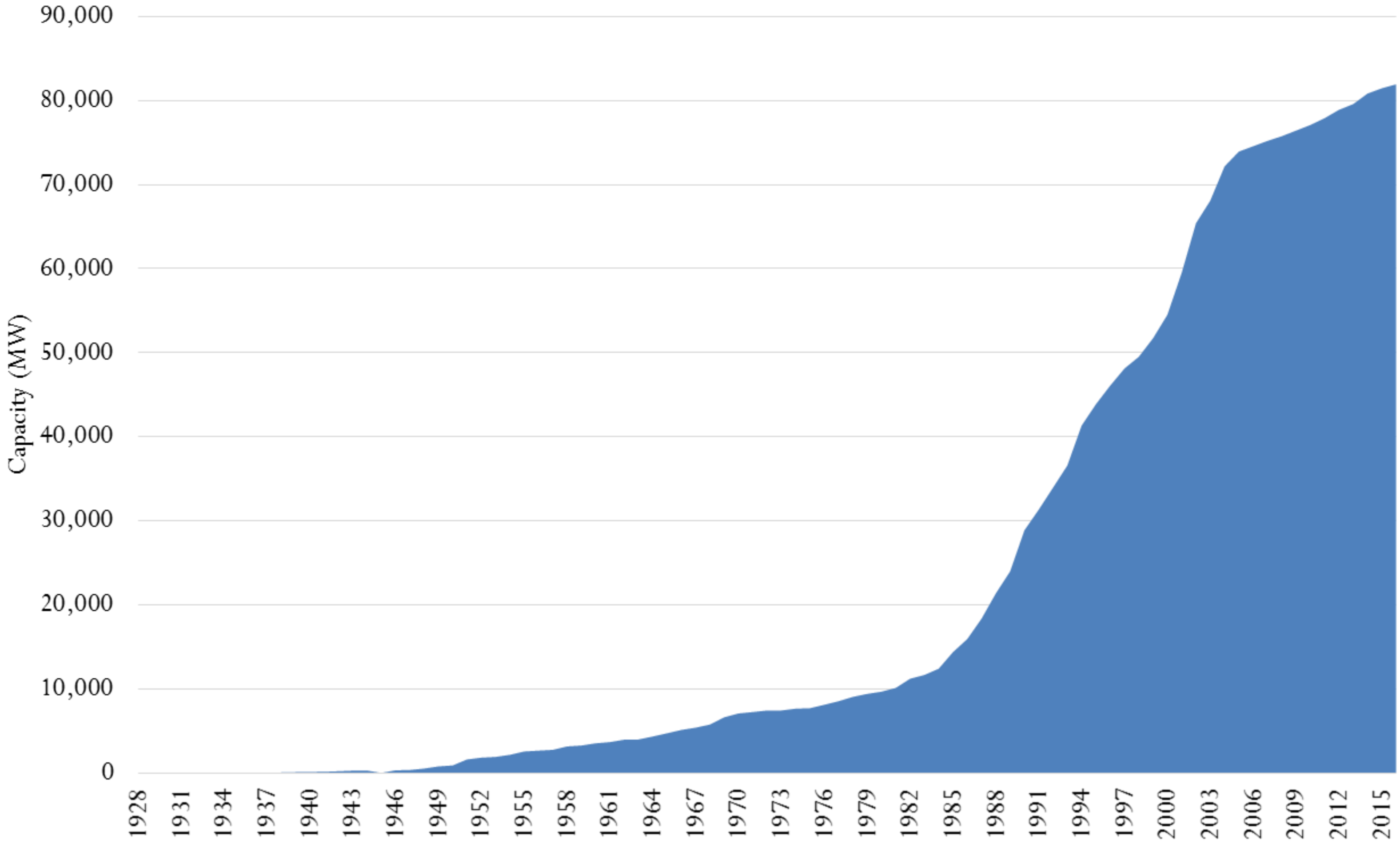
*This includes 91 expansions to existing CHP systems

Slide prepared on 5-30-17

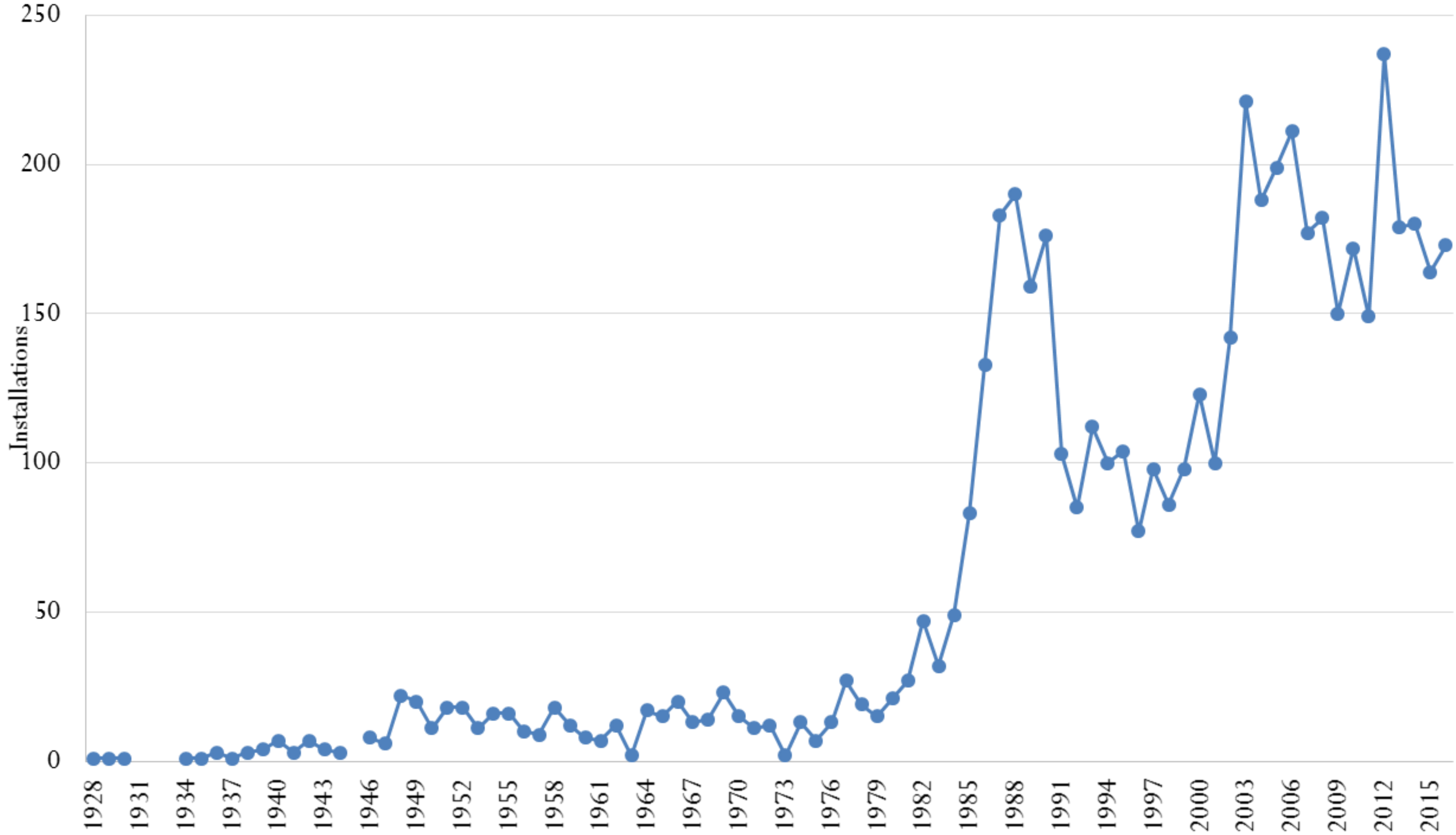
CHP Trends

CHP Cumulative Capacity per Year



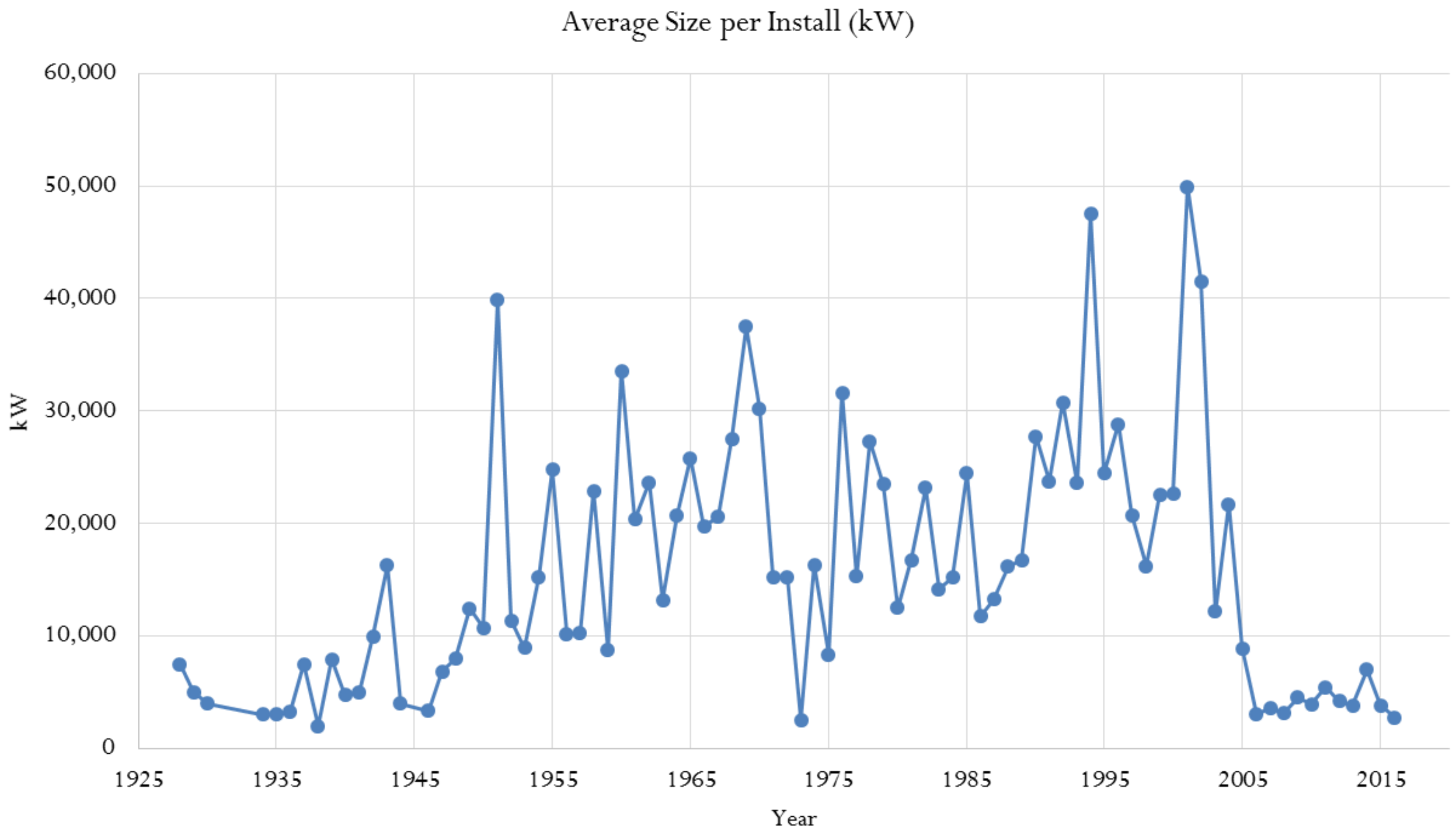
Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2016)

Total CHP Installations per Year



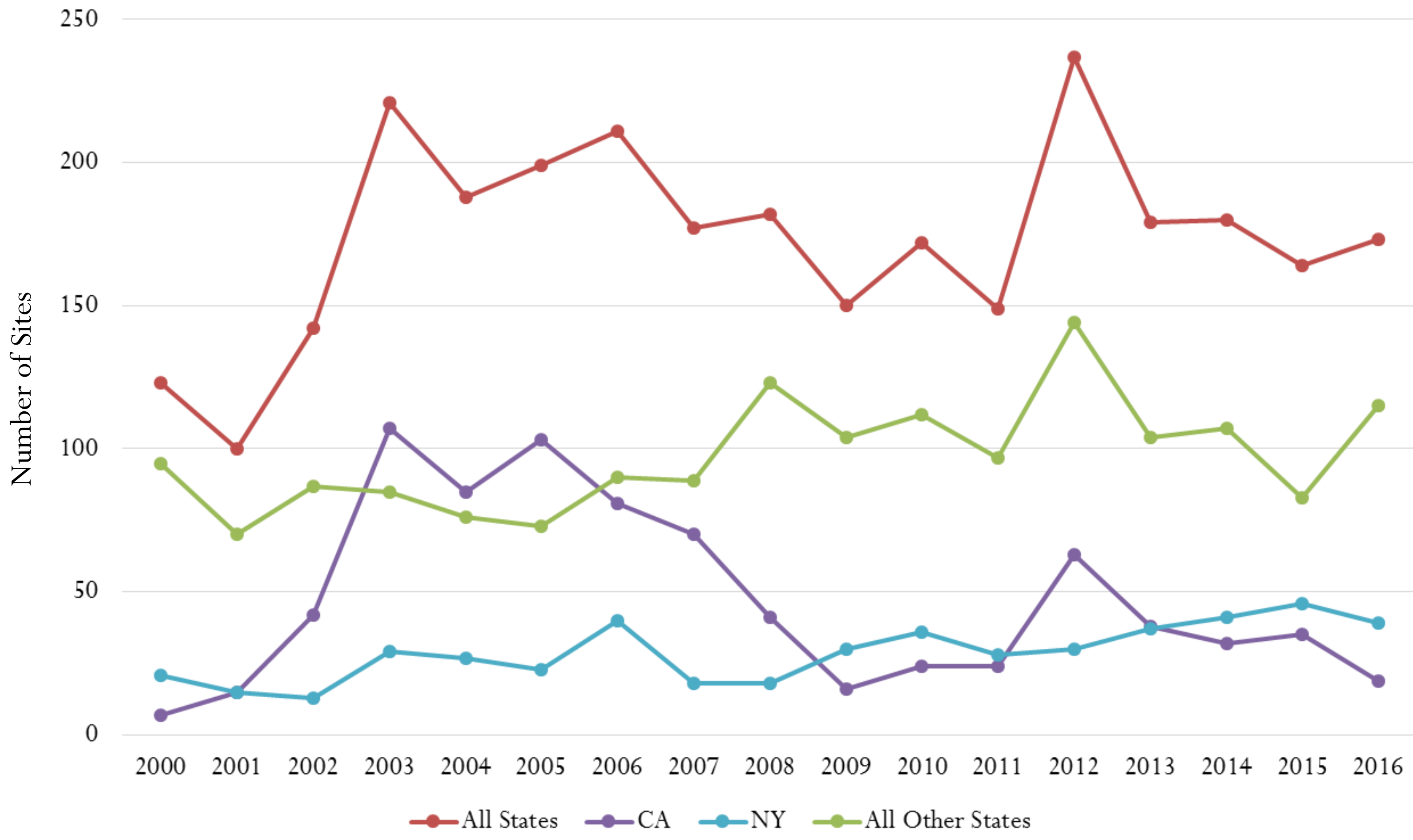
Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2016)

Average Size of CHP Installations per Year



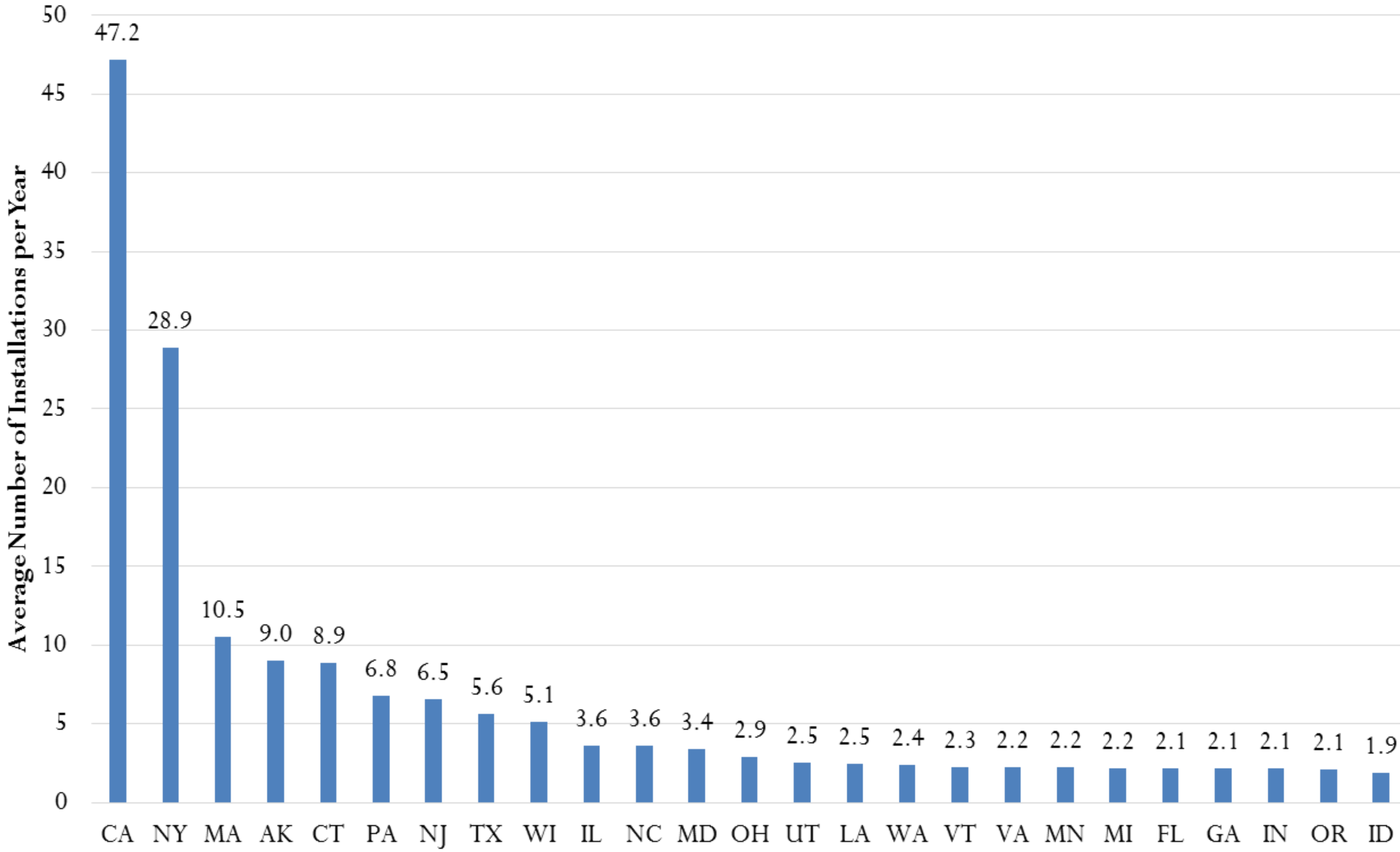
Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2016)

Total CHP Installations - 2000 to 2016



Source: DOE CHP Installation Database, US Installations as of December 31, 2016)

Average Number of Installations per Year by State - 2000 to 2016



Source: DOE CHP Installation Database, US Installations as of December 31, 2016)

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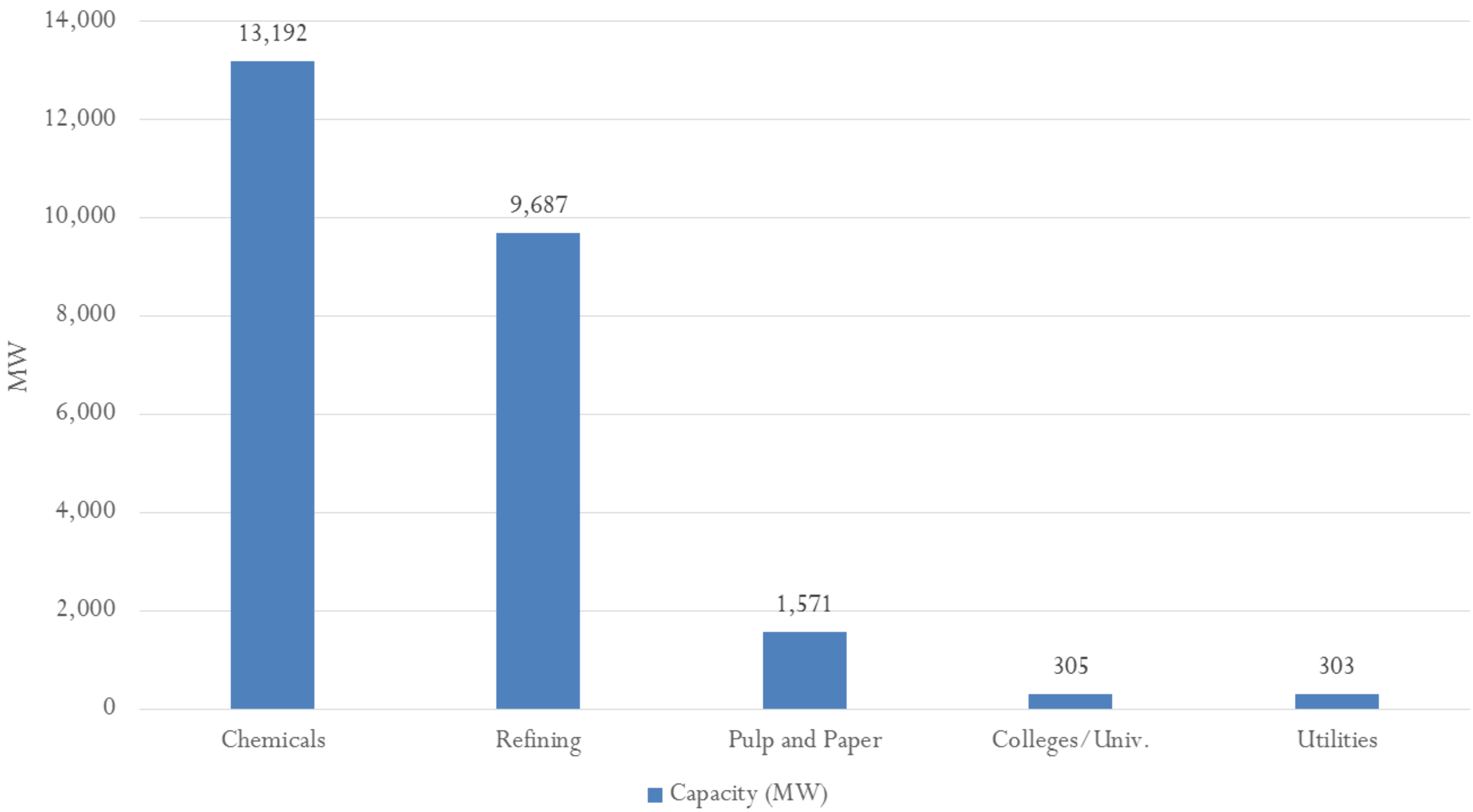
CHP Activity in the Southcentral Region

CHP by Prime Mover - Southcentral

Prime Mover Type	# of CHP Systems	Capacity (MW)
Boiler/Steam Turbine	73	4,225
Combined Cycle	46	18,417
Combustion Turbine	59	3,065
Fuel Cell	1	0.3
Microturbine	4	4
Reciprocating Engine	39	106
Waste Heat to Power	8	69
Other	1	6
Total	**231**	**25,892**

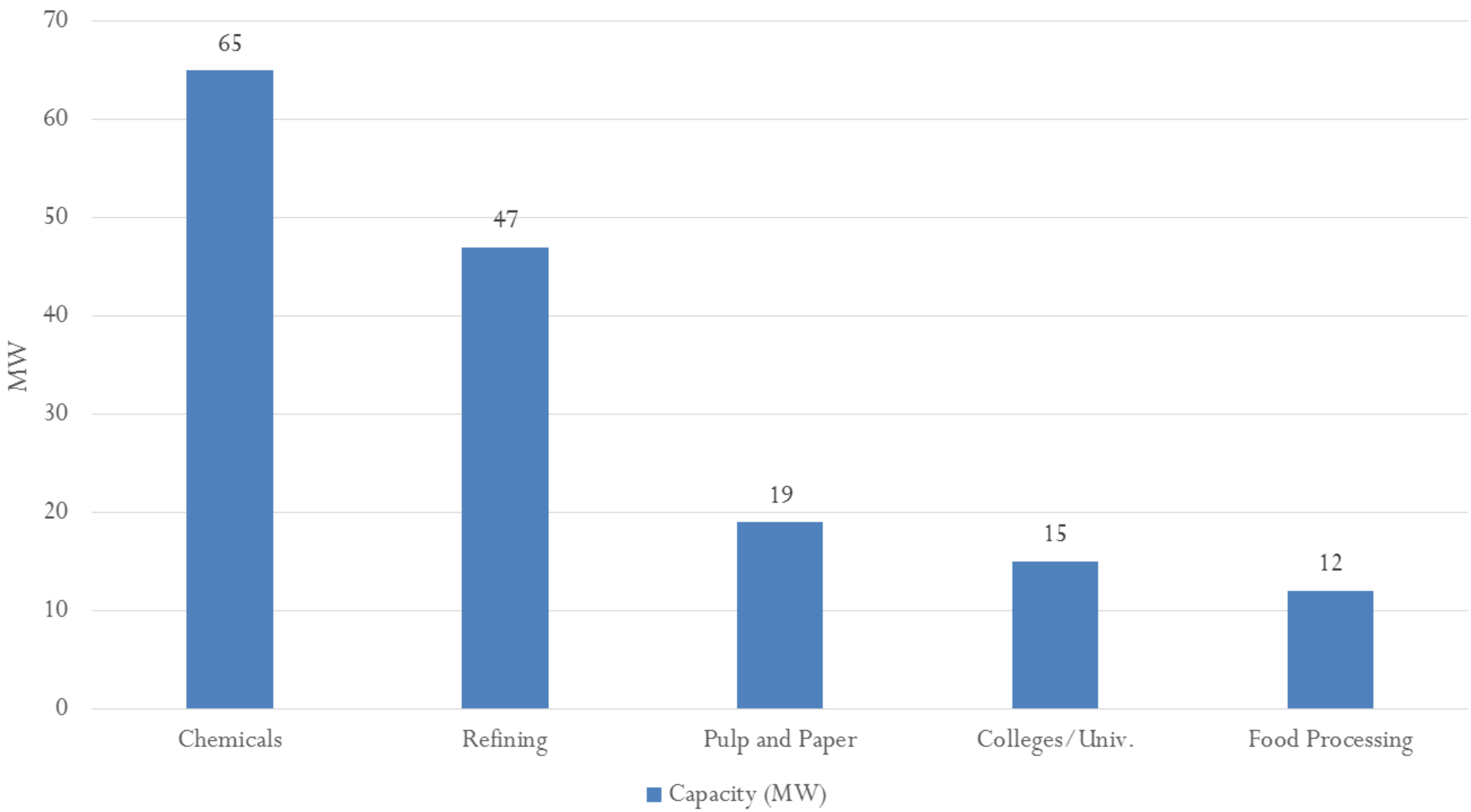
Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2016)

Top Applications by CHP Capacity (MW) - Southcentral



Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2016)

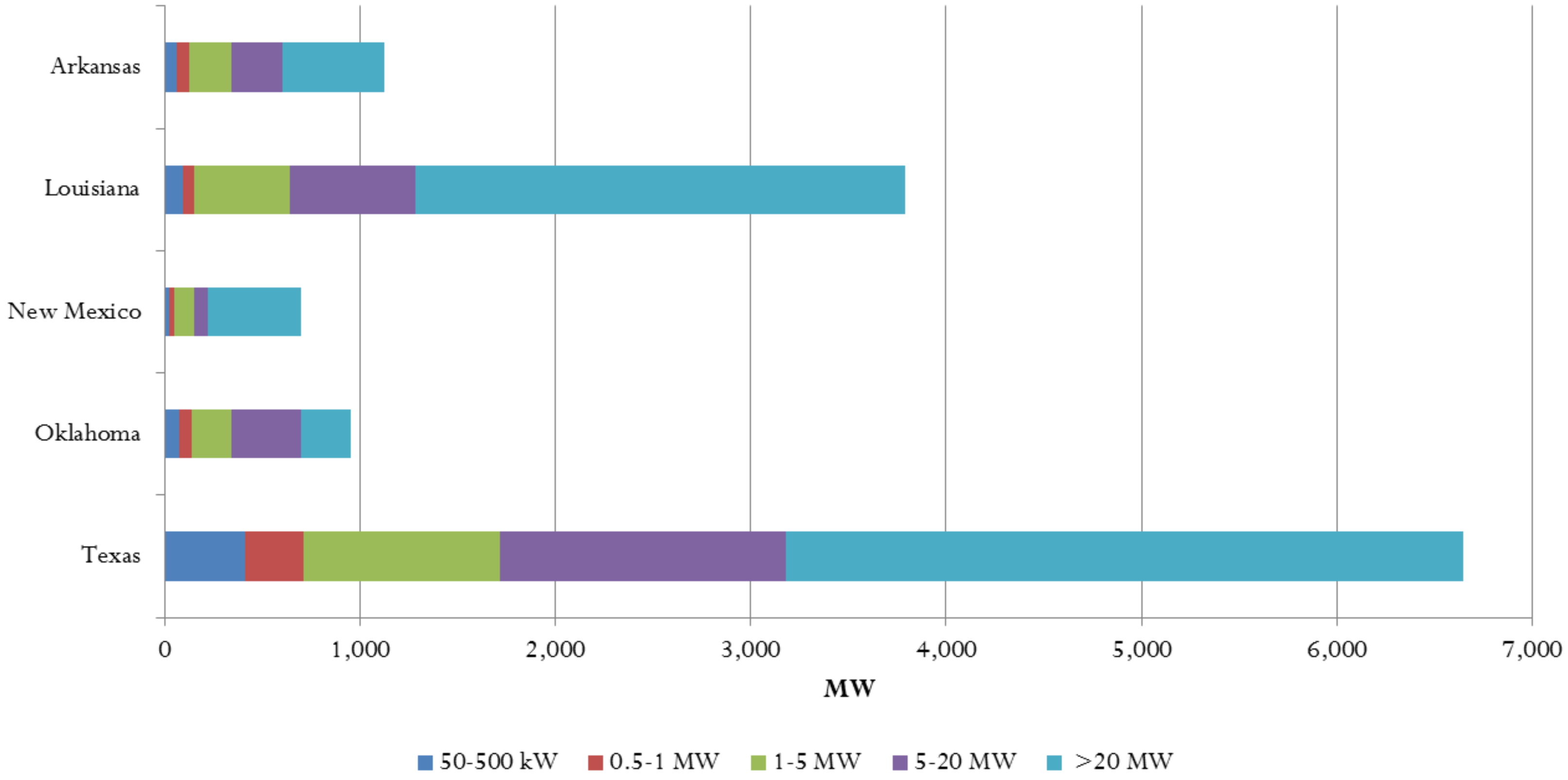
Top Applications Number of Systems - Southcentral



Source: DOE CHP Installation Database (U.S. installations as of Dec. 31, 2016)

Where are the Southcentral Opportunities for Industrial CHP?

(13,222 MW of CHP potential at 5,669 sites)



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

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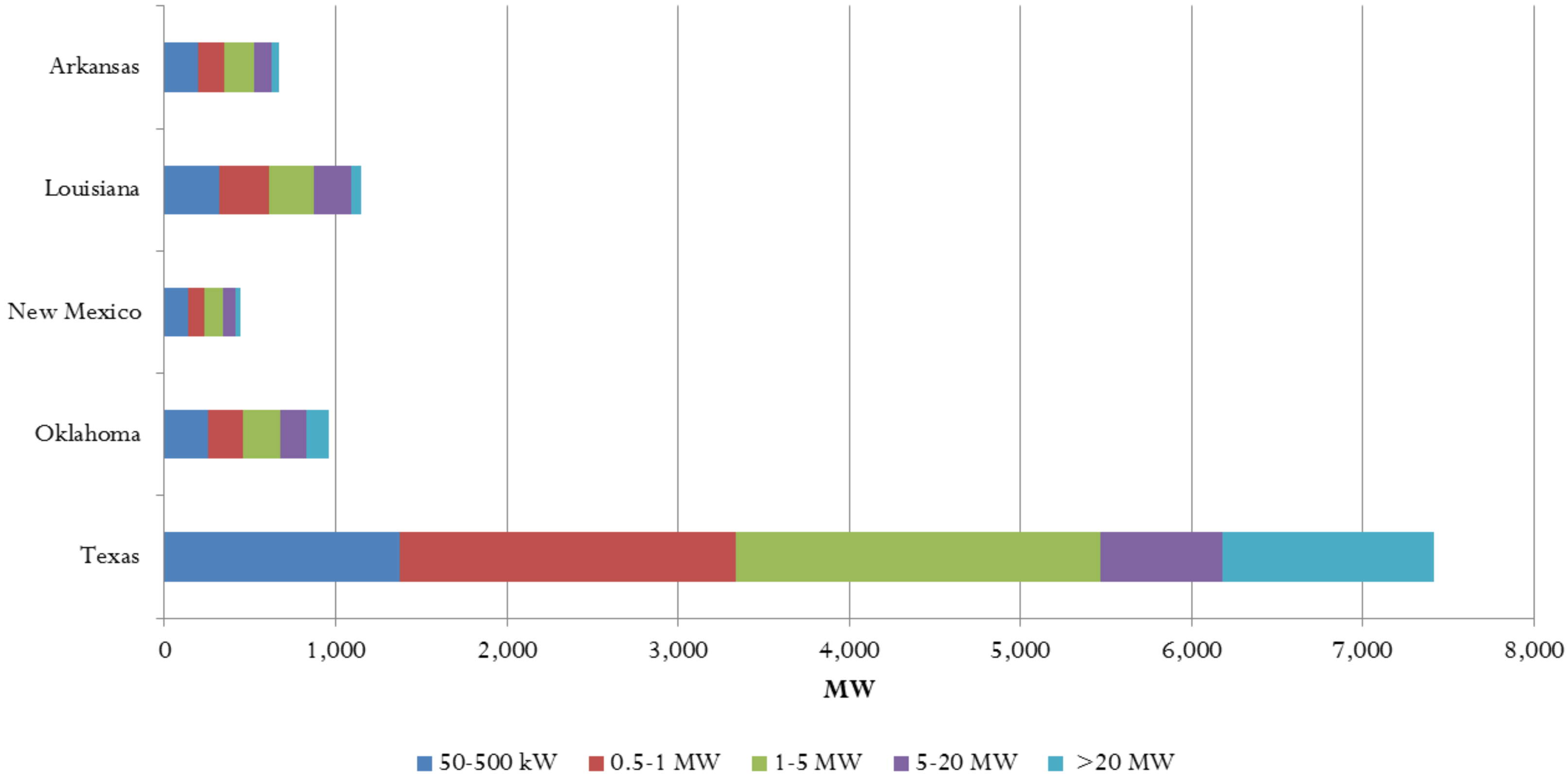
Where are the Southcentral Opportunities for Commercial CHP?

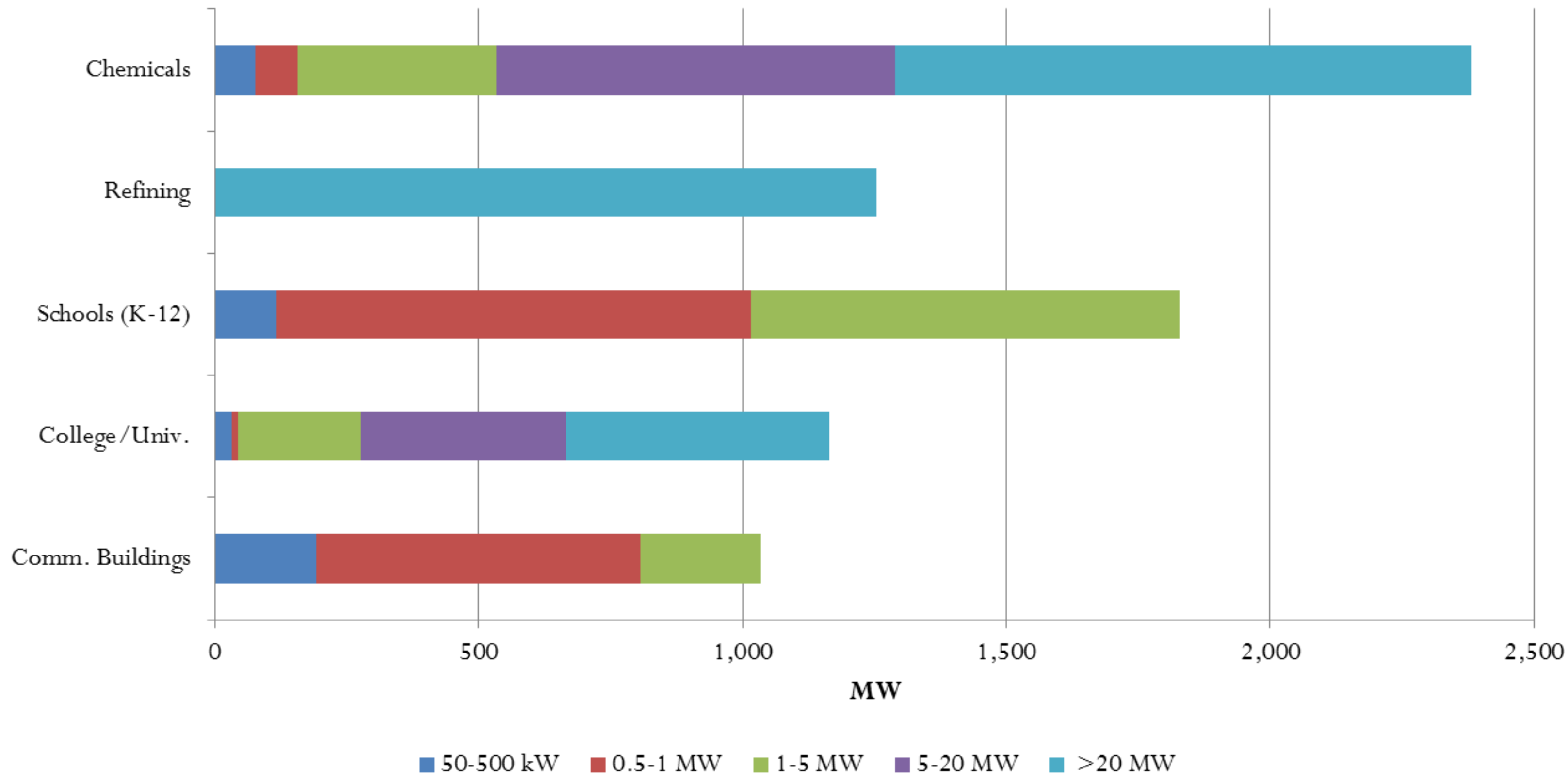
(10,637 MW of CHP Potential at 27,426 sites)



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.

CHP as a Source of Resilience in Microgrids

Power Outages Are Costly

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

Source: ACEEE (2017) Valuing Distributed Energy Resources: Combined Heat and Power and the Modern Grid

CHP Design for Resilience

- One estimate states that over $150 billion per year is lost by U.S. industries due to electric network reliability problems
- CHP systems designed for reliability will incur additional costs ($45 - $170/kW depending on complexity of system)
- CHP (if properly configured):
  - ✓ Can generate energy savings in your daily operations
  - ✓ Offers the opportunity to improve CI resiliency, supplying electricity and heating/cooling to the host facility during a disaster.

Source: https://www1.eere.energy.gov/manufacturing/distributedenergy/pdfs/chp_critical_facilities.pdf

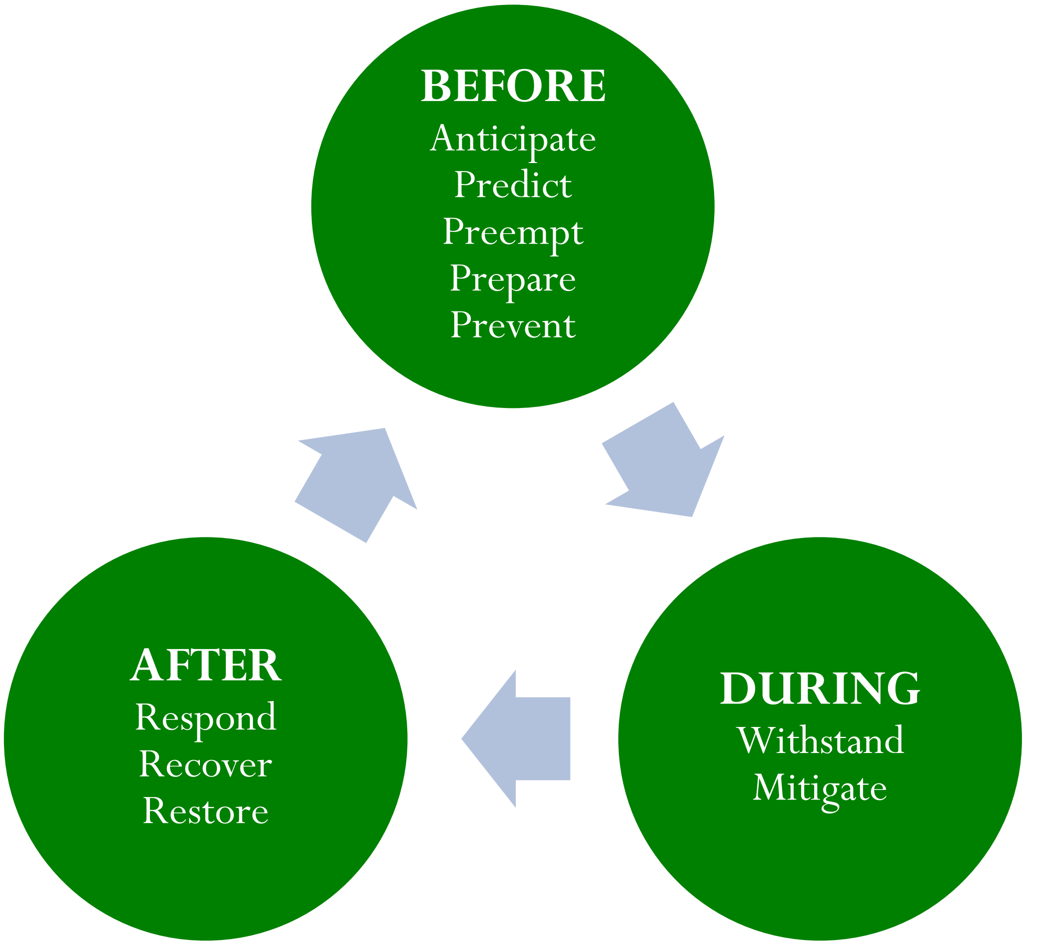
CHP: Proven to be Resilient

- Hurricane Harvey
  - University of Texas Medical Branch (UTMB), Galveston, TX, 2 7.5 MW gas turbines
  - Texas Medical Center, Houston, TX (owned and operated by Thermal Energy Corporation), 48 MW gas turbines
- Hurricane Irma and Maria
  - University of Florida- Shands Medical Center – Gainesville, FL, 4.3 MW CHP gas turbine
  - Baptist Medical Center South, Jacksonville, FL – 3.5 MW reciprocating engine CHP system and backup generators
  - Hospital De La Conception, San German, Puerto Rico, 1.2 MW reciprocating engine
  - Matosantos Commercial Corp., Vega Baja, PR – food processing facility - 2 MW propane fueled reciprocating engine

Infrastructure Resilience

What is RESILIENCE?

- ***Resilience (engineering)*** *is the ability to absorb or avoid damage without suffering complete failure.*
- ***Human resilience (psychology) is the capacity to make realistic plans and take steps to carry them out.***



Distributed Energy Resources Disaster Matrix

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*

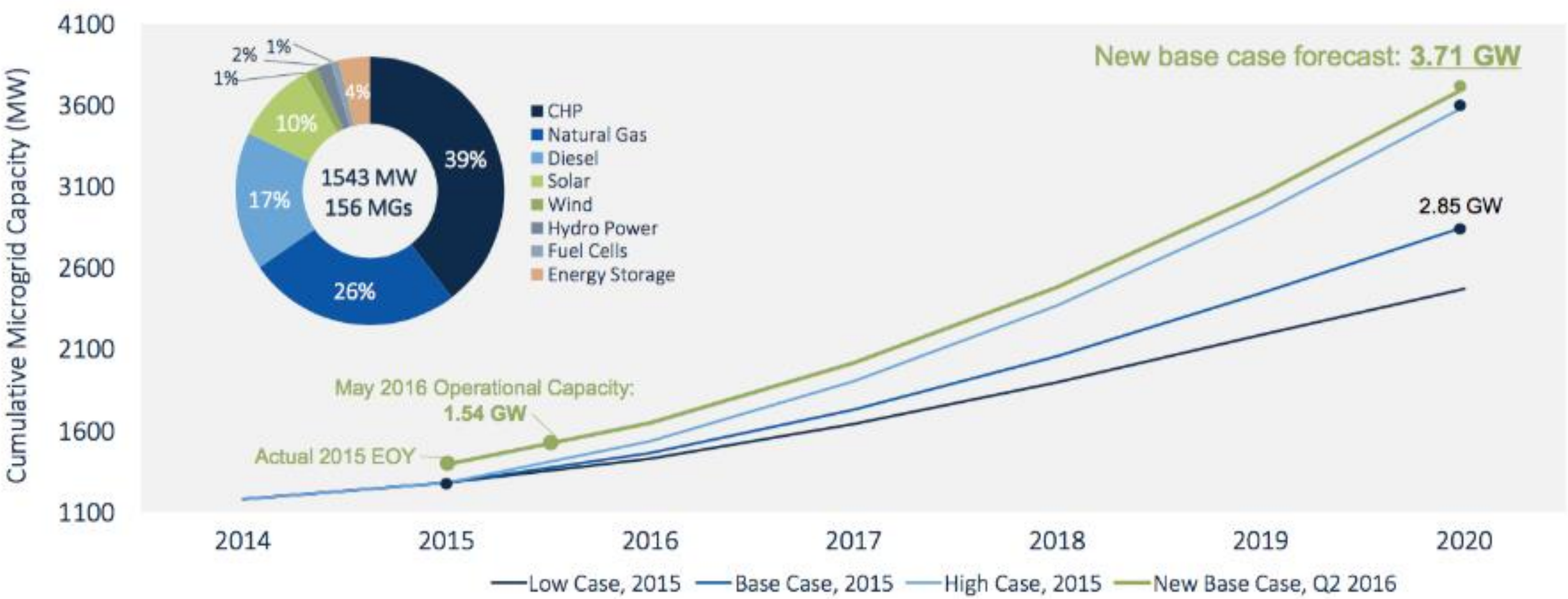
● *indicates the resource is likely to experience all four impacts*

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	◒	○	◒	●	◒	○

Source: DOE Better Buildings (2018). Issue Brief: Distributed Energy Resources Disaster Matrix

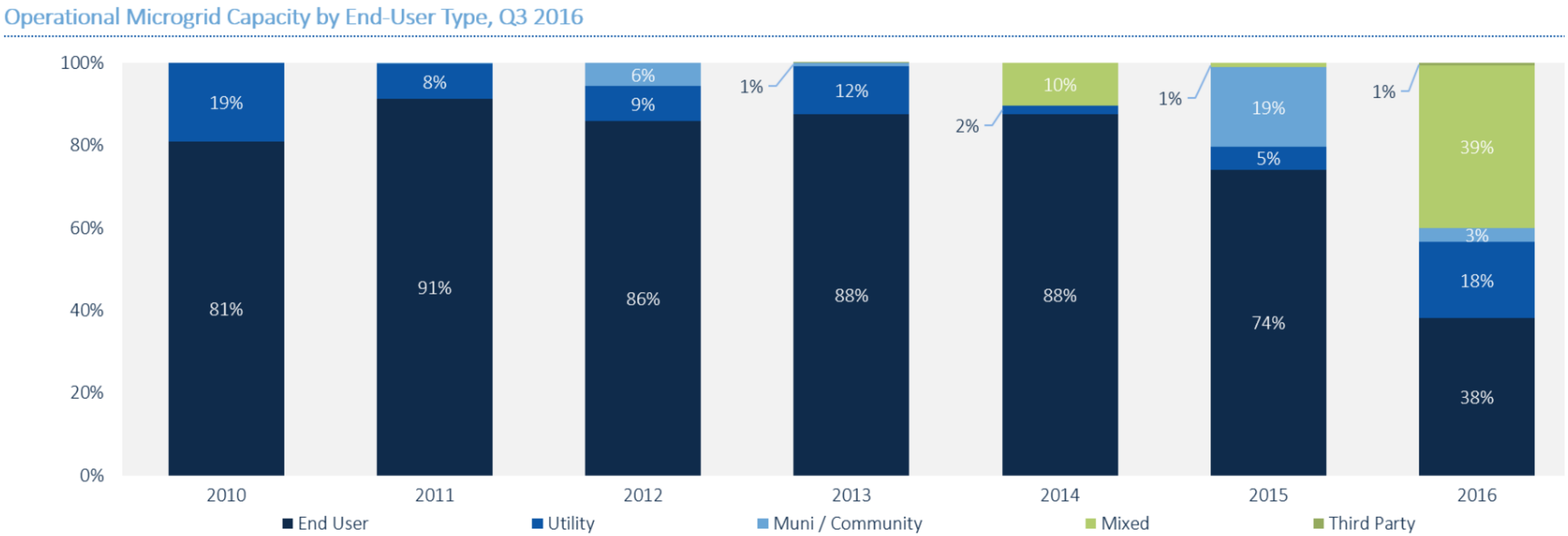
US MG Market Evolution

- Market research companies are updating their forecasts.
- The MG market is expected to reach 3.71 GW of operational capacity in 2020.
- **In 2Q 2016 39% of the existing microgrids are based on CHP systems.**



SOURCES: www.greentechmedia.com/articles/read/u.s.-microgrid-growth-beats-analyst-estimates-revised-2020-capacity-project

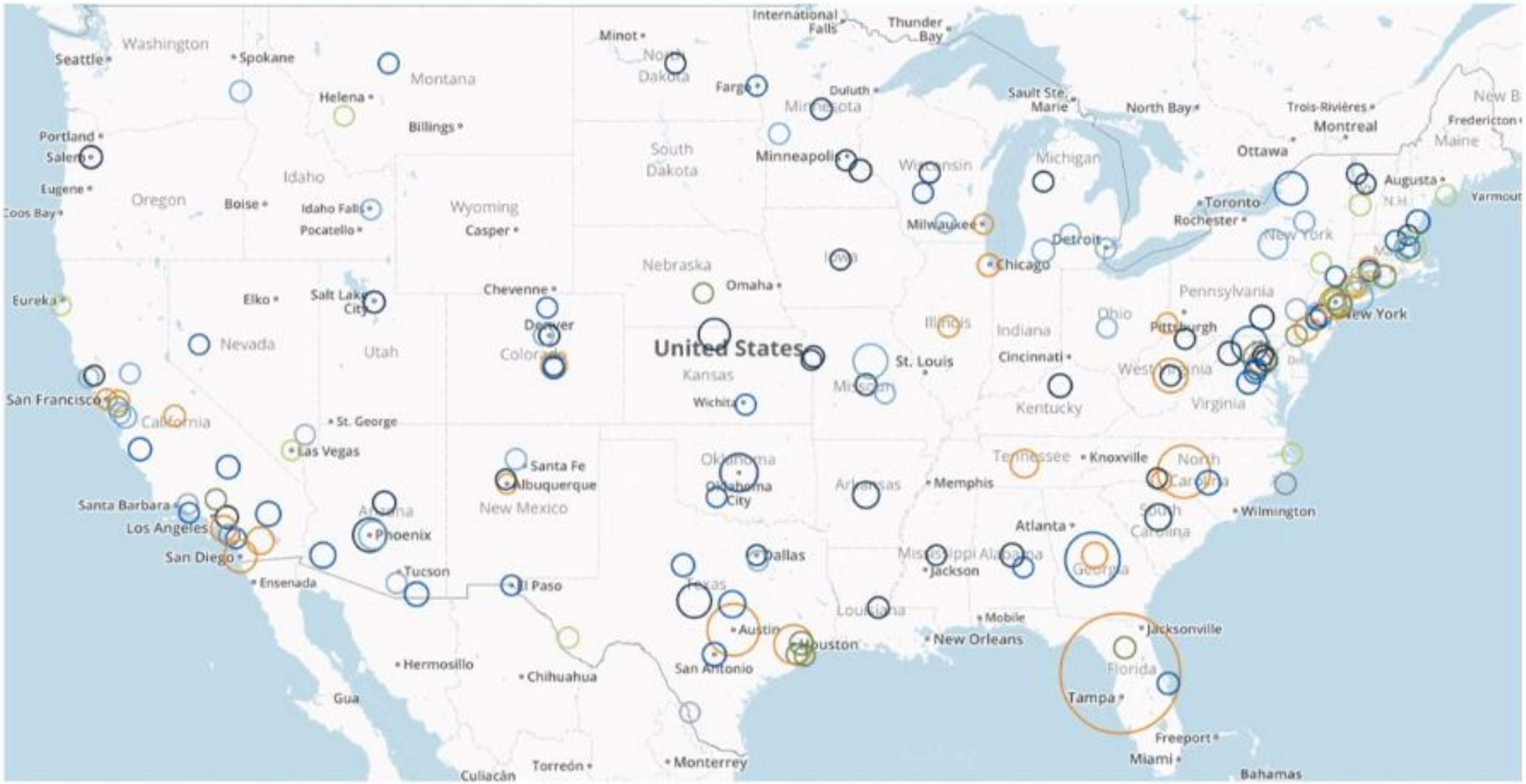
US MG Market Evolution



SOURCES: www.greentechmedia.com/articles/read/US-Installed-Microgrid-Capacity-to-Grow-115-And-Reach-4.3-GW-Over-Next-Fiv

US MG Market Evolution

Map of Operational Microgrid Deployments by End-User Type Across the Continental U.S.*



■ Commercial ■ Military Installation ■ University/Research Facility ■ City/Community ■ Public Institution ■ Island ■ Remote Community ■ Multiple End User Types**

Source: GTM Research, U.S. Microgrid Tracker Q3 2017

* The size of the bubbles correspond with the total capacity (MW) installed in that location.
** Microgrids are mapped based on city location; when multiple microgrids are in the same city they may get the multiple end user designation. In some cases for data privacy, data is given at a state or national level. In these cases, the microgrids are mapped at the center of the state.

The role of microgrids in the future power grid

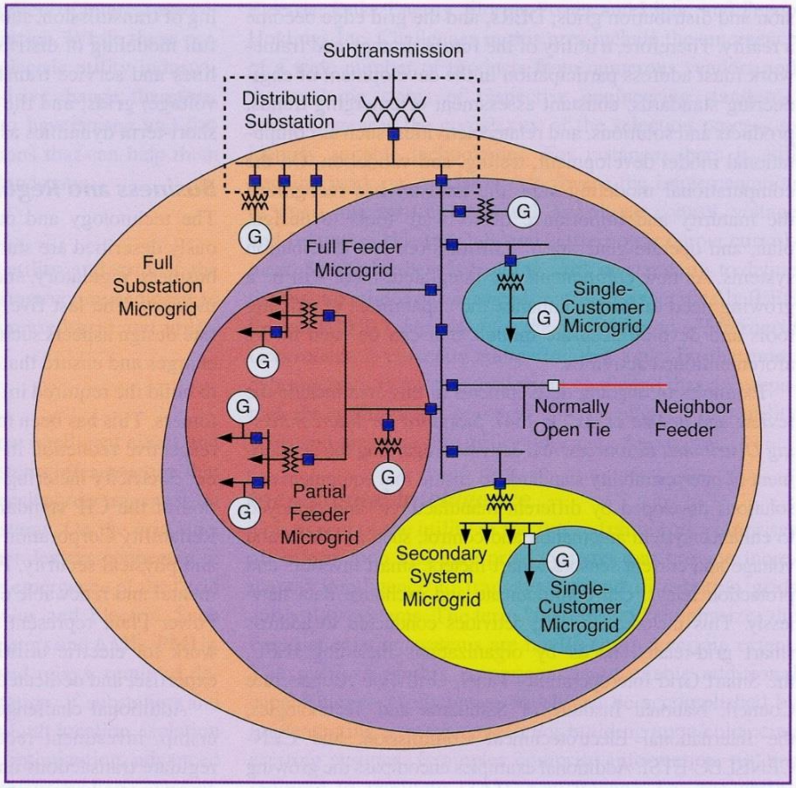
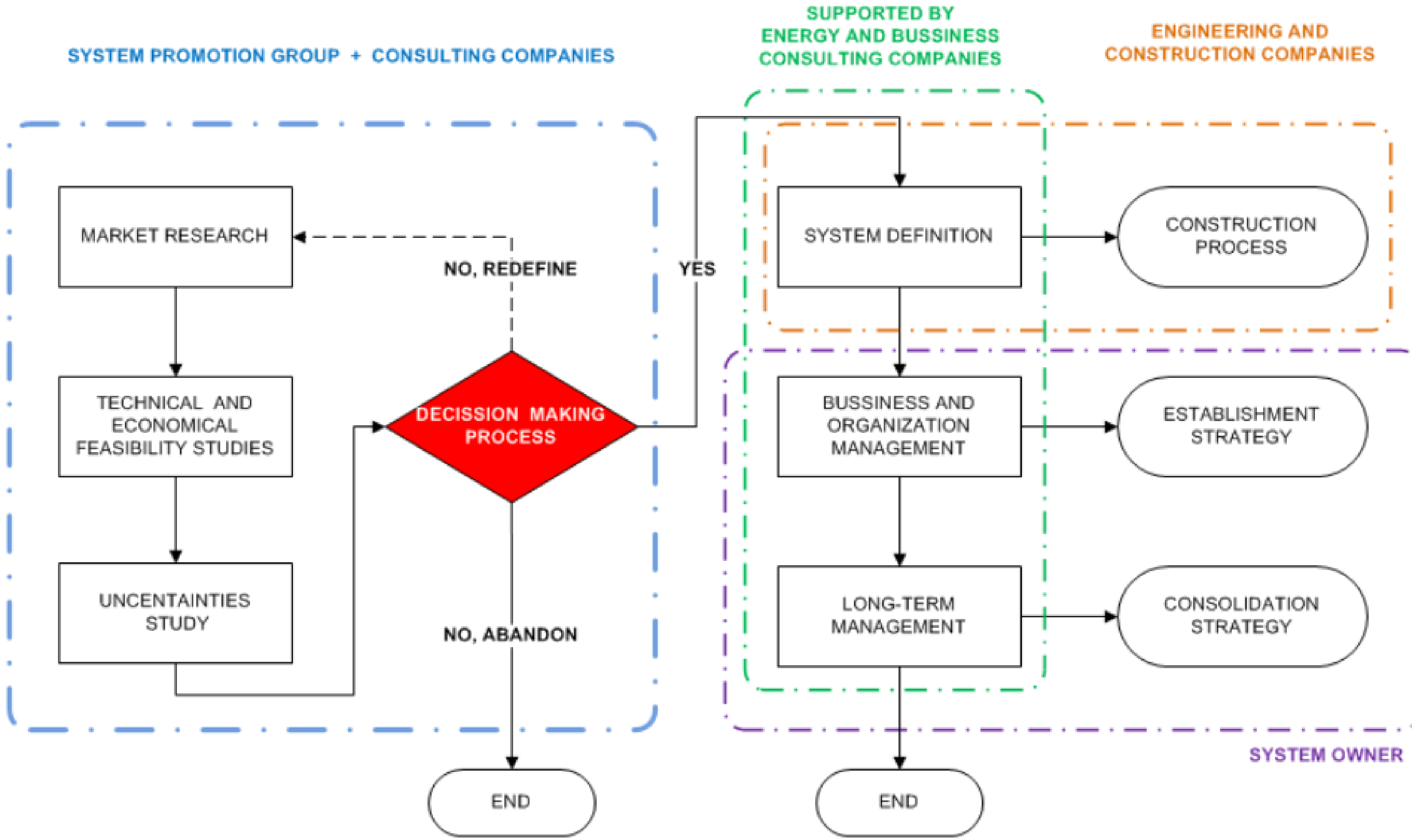


figure 3. This hierarchical microgrid is an example of the grid architectures being explored to enable the highly distributed grid concept and maximize reliability and resiliency under a wide variety of contingency conditions and locations as well as DER and load-balance scenarios. (Source: Sandia National Laboratory.)

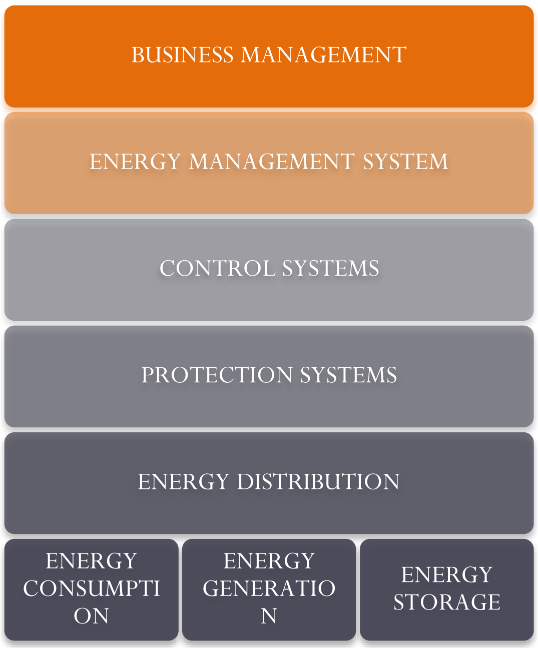
SOURCE: *IEEE POWER & ENERGY. Vol.*14, Number 5, September/October 2016

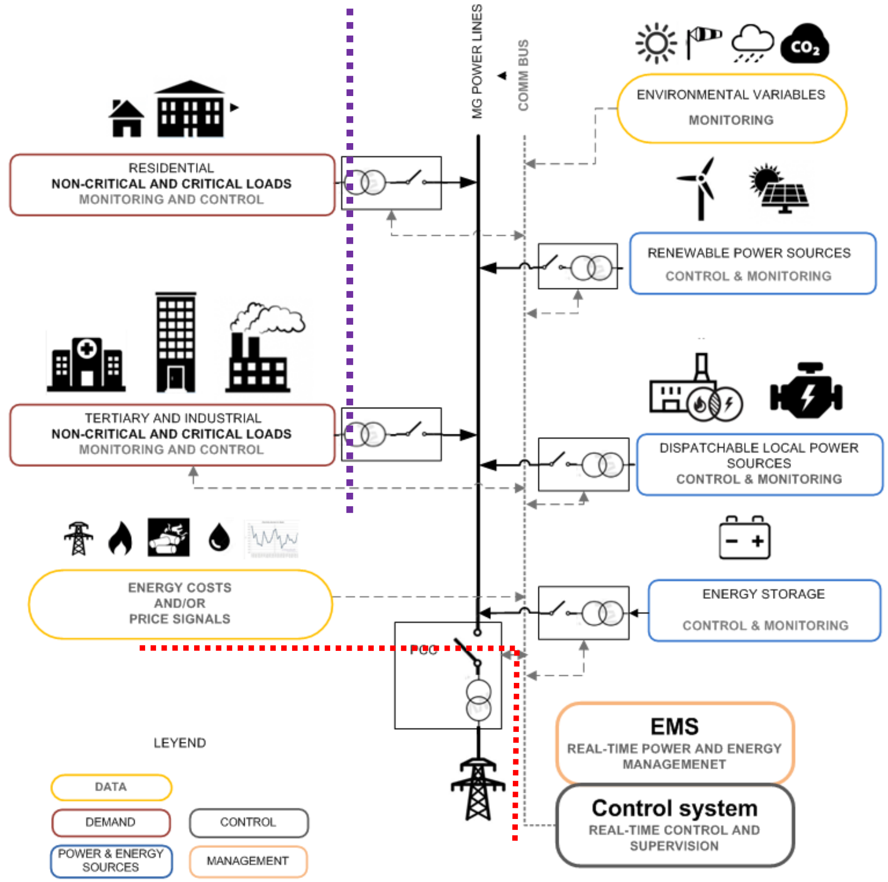
- Regarding the other power systems A MICROGRID can:
  - Coexist: as individual power systems
  - Cooperate: take part of other microgrids or work as part of the distribution grid
  - Compete: as individual power system
- No massive establishment: only those based on competitive advantages or added value proposals.
- Is there a microgrid for every company? YES
- Is it worth exploring your possibilities to have a MG? YES
- Make sense for every company to have their own microgrid? NO

A Potentially Complex Planning Process…



A Potentially Complex Planning Process…

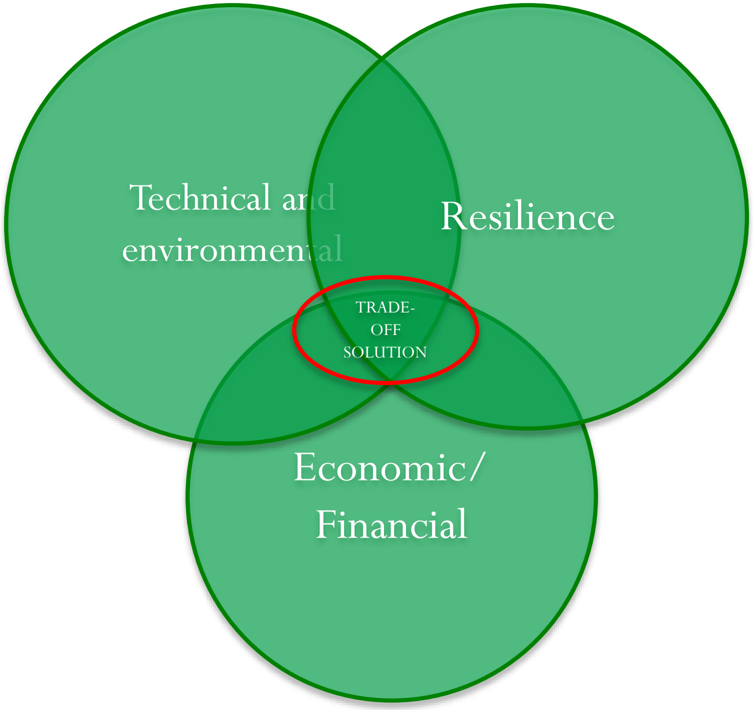


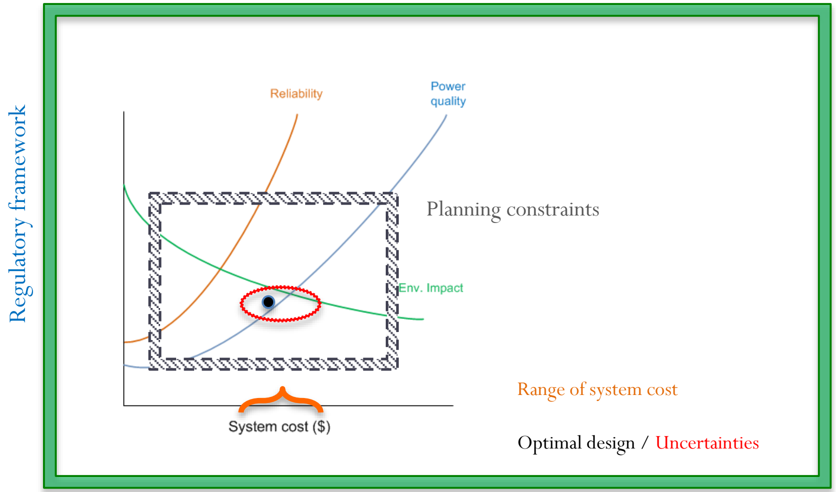


Frontier points

purple dotted line	Customer/MG system
red dotted line	MG system / Utility

...With Not a Single Solution





Trends in microgrid planning

- A microgrid planning process is a study of present and future profitability scenarios.
- Design and planning stages must be strongly focused around specific goals: save money, save energy, save environmental emissions, improve resilience, etc.
- Specific competitive advantages must be the basis of the planning process.
- Incentives will support the system only in the short-term.
- Tailored solutions vs modular MG.
- Data mining and machine learning based design and management strategies
- Planning tools not available for ever kind of microgrid → **tailored models**

Project Snapshots

Project Snapshot:
Energy Security, Resiliency, Federal Mandates

White Oak FDA Campus
Silver Spring, MD

Application/Industry: Federal

Capacity: 26 MW

Prime Mover: Reciprocating engine, gas turbine

Fuel Type: Natural gas

Thermal Use: Heating and cooling

Installation Year: 2004

Emissions Savings: 50,000 metric tons CO2 - equivalent

Highlights: The current CHP system:

- Has 26 MW power supply (currently being expanded to 55 MW to handle the site's peak load)
- Works in parallel with the utility under a three-party interconnect agreement
- Participates in demand response events
- Utilizes spinning reserve to maintain energy reliability
- Can island and operate mission critical functions independent from the grid
- Can match load to supply

Project Snapshot:
Energy Cost Savings – Microgrid

Marine Corps Air Ground Combat Center Twentynine Palms (MCAGCC)

Twentynine Palms, CA

Application/Industry: Military Base

Capacity: 7.2 MW (9.2 MW expansion)

Prime Mover: Gas turbines

Fuel Type: Natural gas, diesel

Thermal Use: Heating and cooling

Installation Year: 2003, 2014

Emissions Savings: Reduces CO_2 emissions by 19,700 tons/year

Highlights: The 7.2 MW CHP system earned the 2012 Energy Star CHP Award. The base decided to add another 9.2 MW of CHP in 2014 that is all tied to a microgrid that incorporates CHP, solar PV, fuel cells, backup generators, and storage, meeting 90% of the base's power requirements.

Source: http://www.pewtrusts.org/en/about/news-room/news/2014/04/22/us-marines-take-lead-in-deploying-clean-energy

CHP Technical Assistance Partnerships
SOUTHCENTRAL

Slide prepared 6/2017

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

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

Investment Grade Analysis

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

Procurement, Operations, Maintenance, Commissioning

Review specifications and bids.

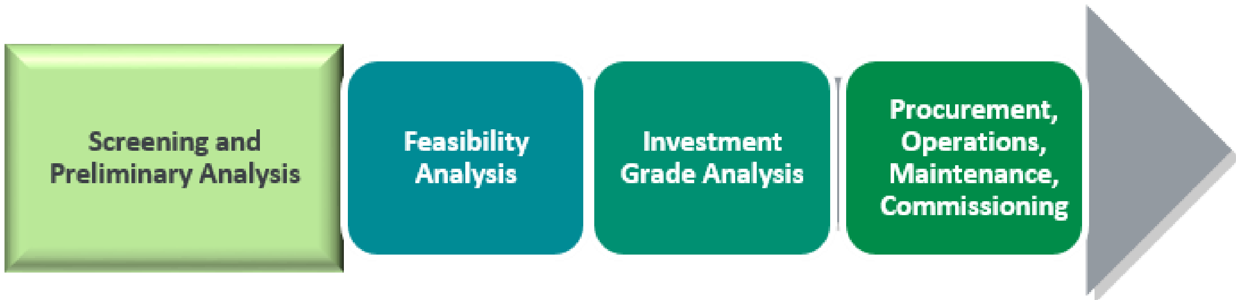
DOE TAP CHP Screening Analysis

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

CHP Technical Assistance Partnerships
SOUTHCENTRAL

Screening Questions



- **Do you pay more than $.06/kWh on average for electricity (including generation, transmission and distribution)?**
- **Are you concerned about the impact of current or future energy costs on your operations?**
- **Are you concerned about power reliability?**
  What if the power goes out for 5 minutes… for 1 hour?
- **Does your facility operate for more than 3,000 hours per year?**
- **Do you have thermal loads throughout the year?**
  (including steam, hot water, chilled water, hot air, etc.)

Screening Questions (cont.)

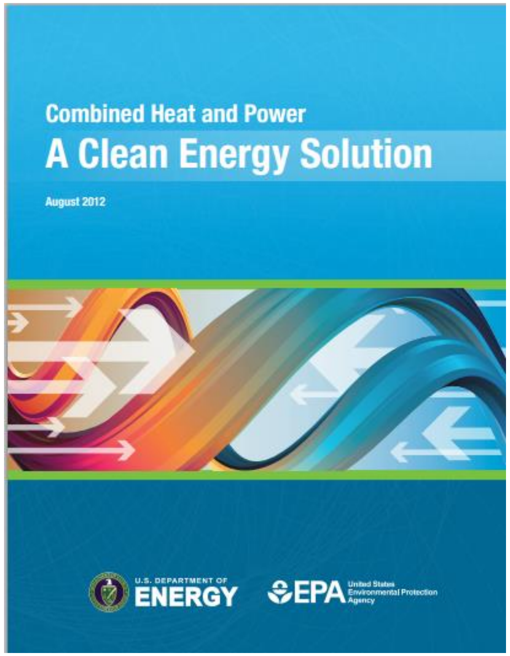
- Does your facility have an existing central plant?
- Do you expect to replace, upgrade, or retrofit central plant equipment within the next 3-5 years?
- Do you anticipate a facility expansion or new construction project within the next 3-5 years?
- Have you already implemented energy efficiency measures and still have high energy costs?
- Are you interested in reducing your facility's impact on the environment?
- Do you have access to on-site or nearby biomass resources?
  (i.e., landfill gas, farm manure, food processing waste, etc.)

CHP Project Resources

DOE CHP Technologies Fact Sheet Series

www.energy.gov/chp-technologies

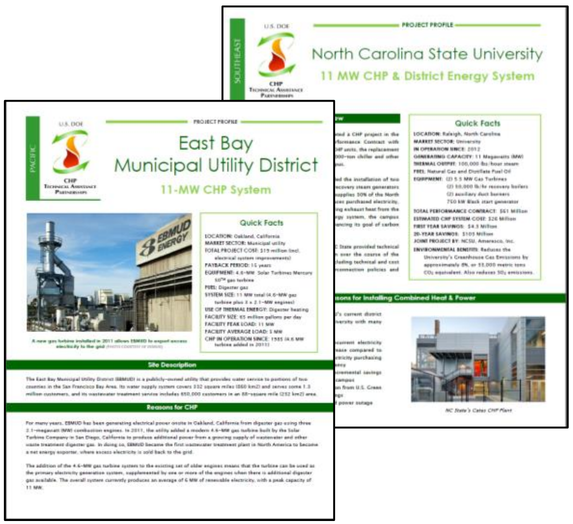
Good Primer Report



www.eere.energy.gov/chp

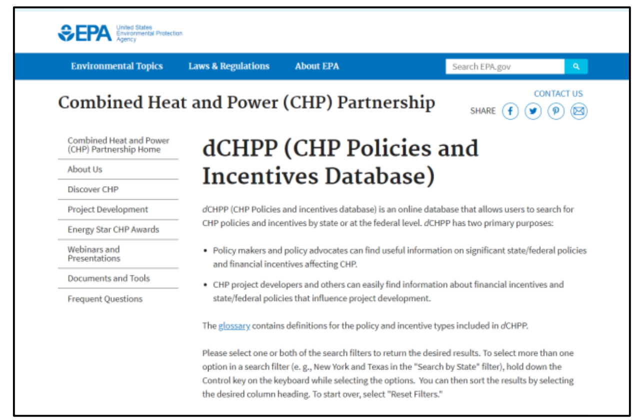
CHP Project Resources

DOE Project Profile Database



energy.gov/chp-projects

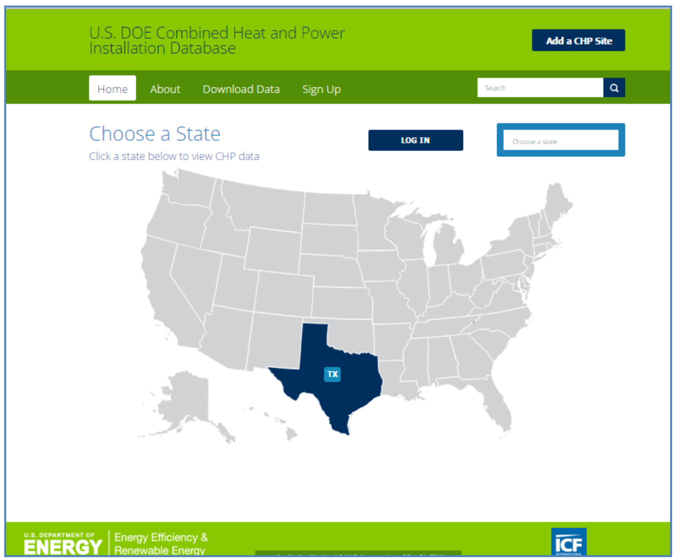
EPA dCHPP (CHP Policies and Incentives Database



https://www.epa.gov/chp/dchpp-chp-policies-and-incentives-database

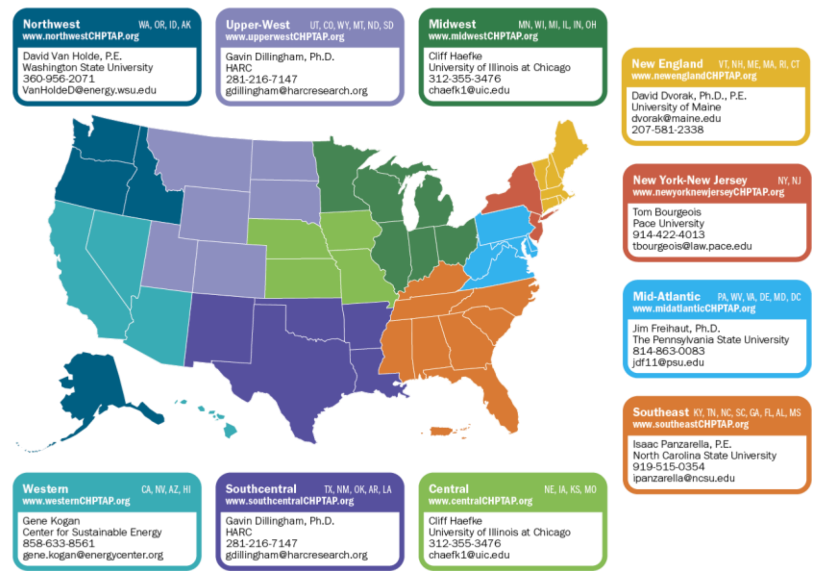
CHP Project Resources

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



energy.gov/chp-installs

Low-Cost CHP Screening and Other Technical Assistance from the CHP TAP



energy.gov/CHPTAP

Summary

- CHP gets the most out of a fuel source, enabling
  - High overall utilization efficiencies
  - Reduced environmental footprint
  - **Reduced operating costs**
- CHP can be used in different strategies, including **critical infrastructure resiliency** and emergency planning
- **Proven technologies** are commercially available and cover a full range of sizes and applications

Next Steps

Contact Sountcentral CHP TAP for assistance if:

- ✓ Interested in having a Qualification Screening performed to determine if there is an opportunity for CHP at your site
- ✓ If you already have an existing CHP plant and interested in expanding it
- ✓ Need an unbiased 3rd Party Review of a proposal

Thanks to our Partner

INTERNATIONAL DISTRICT ENERGY ASSOCIATION

Thank You!

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