AIChE® 12th SOUTHWEST PROCESS TECHNOLOGY CONFERENCE

VIRTUAL

OCTOBER 1–2, 2020

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CHP, Energy Resilience and Grid Reliability

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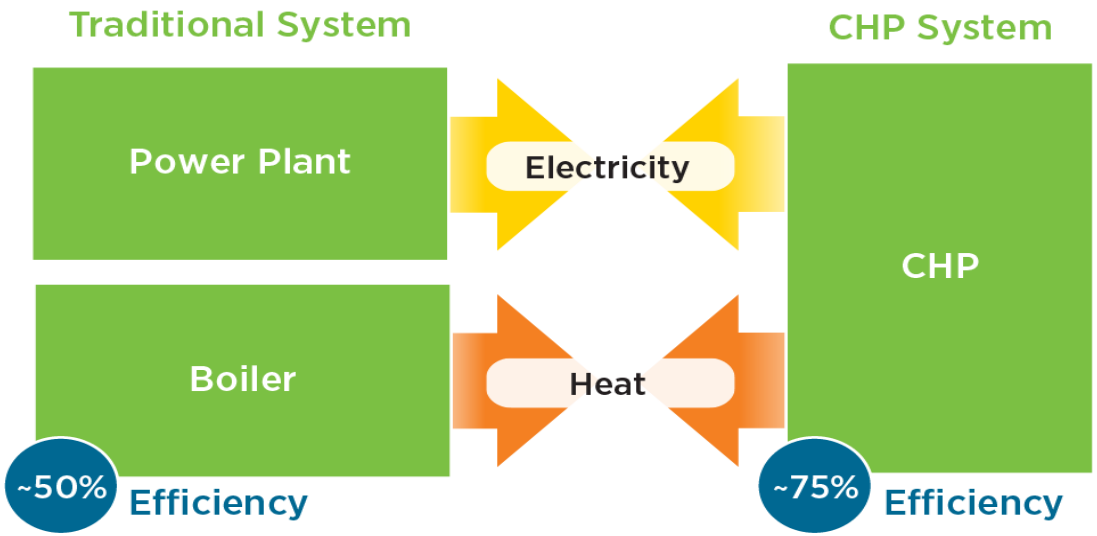
DOE CHP Technical Assistance Partnerships

- **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

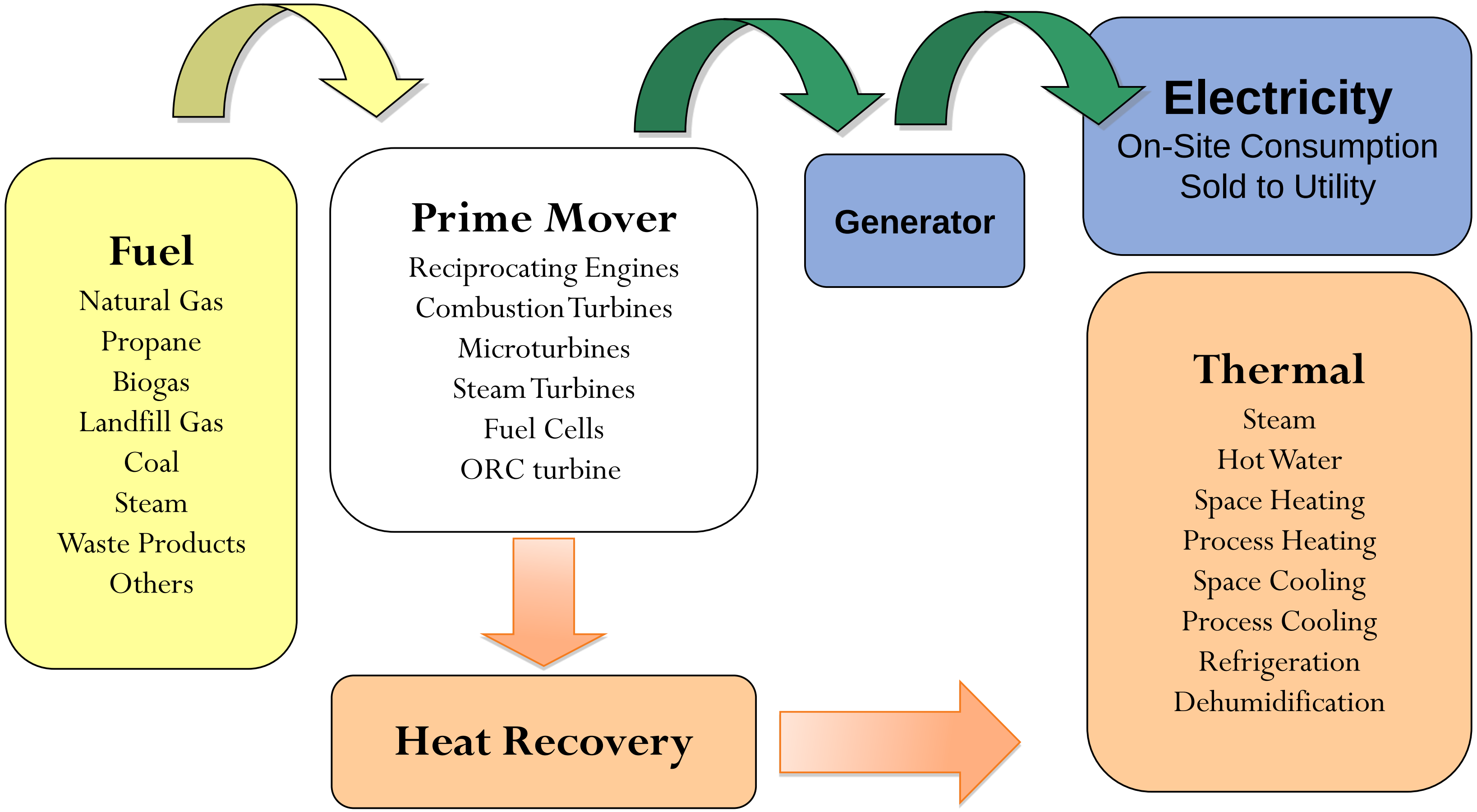
- Form of Distributed Generation (DG)
- An integrated system
- Located at or near a building / facility
- Provides at least a portion of the electrical load and
- Uses thermal energy for:
    - Space Heating / Cooling
    - Process Heating / Cooling
    - Dehumidification



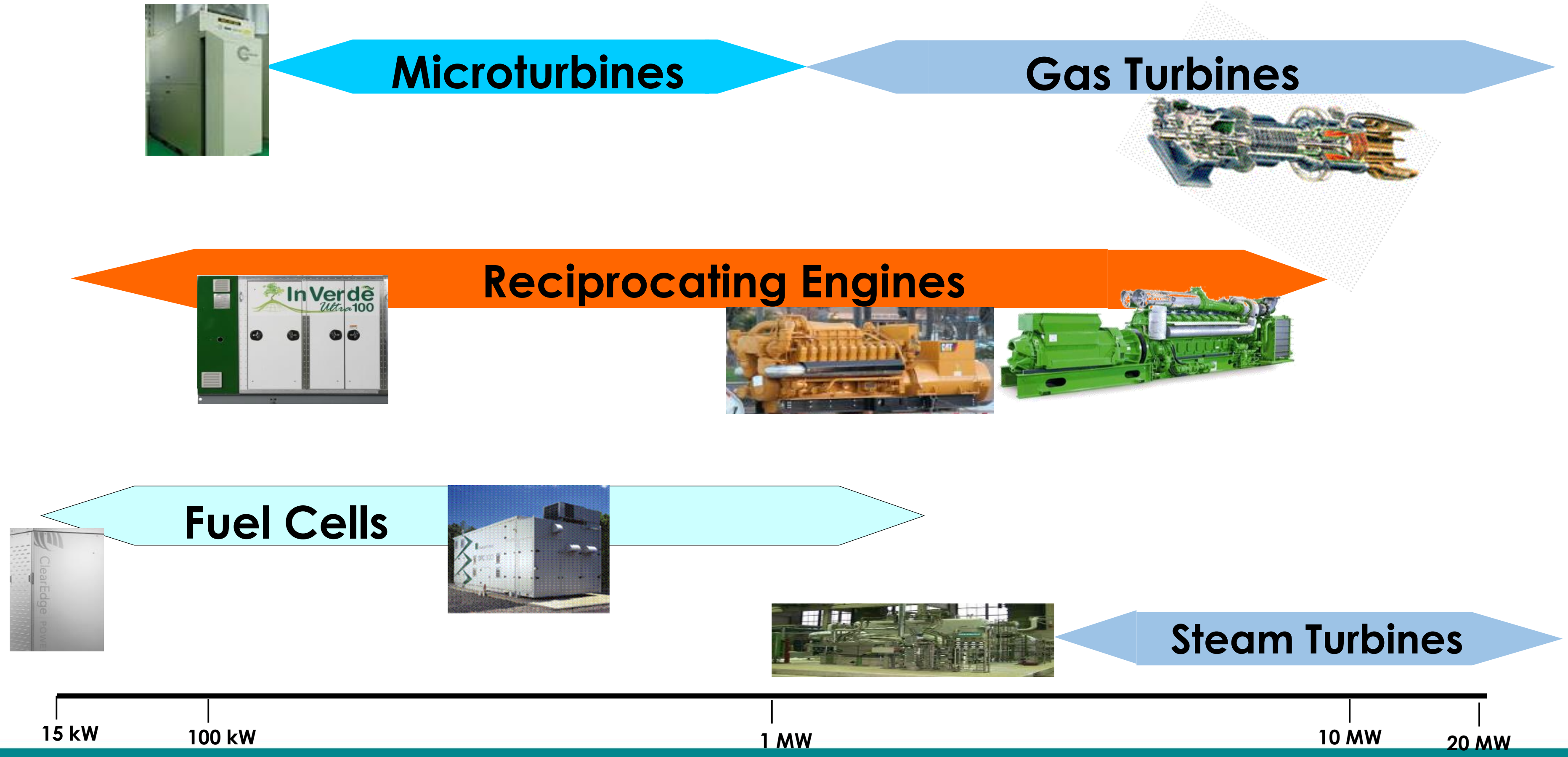
CHP provides efficient, clean, reliable, affordable energy – today and for the future.

Source: www.energy.gov/chp

CHP System Schematic



CHP Technologies



What are the benefits of CHP?

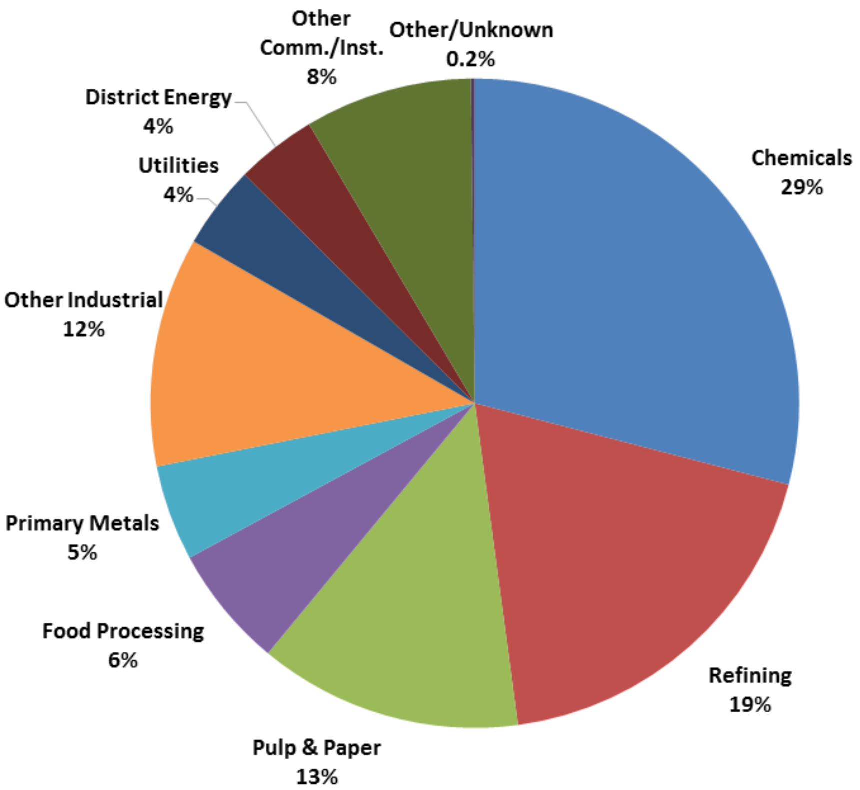
- CHP is more efficient than separate generation of electricity and heating/cooling
- Higher efficiency translates to lower operating costs (but requires capital investment)
- Higher efficiency reduces emissions of pollutants
- CHP can also increase energy reliability and enhance power quality
- On-site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

Existing CHP Capacity

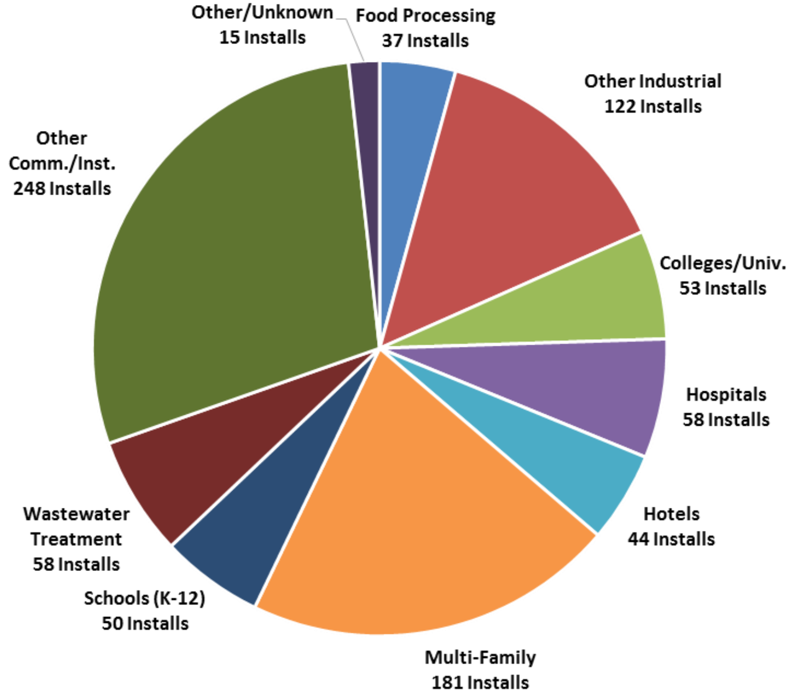


- **81.1 GW** of installed CHP at more than 4,500 industrial and commercial facilities
- 8% of U.S. Electric Generating Capacity; 14% of Manufacturing
- Avoids more than **1.8 quadrillion Btus** of fuel consumption annually
- Avoids **241 million metric tons of CO_2** compared to separate production

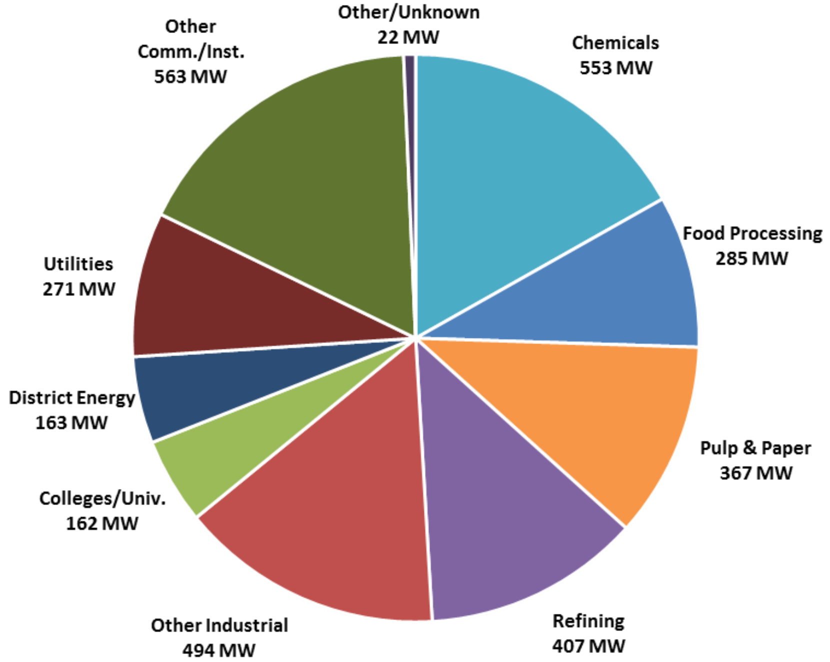
Source: DOE CHP Installation Database (U.S. installations as of December 31, 2018)

CHP Additions by Application (2014-2018)

By Installations – 866 Installs



By Capacity – 3.3 GW



Source: DOE CHP Installation Database (U.S. installations as of December 31, 2018)

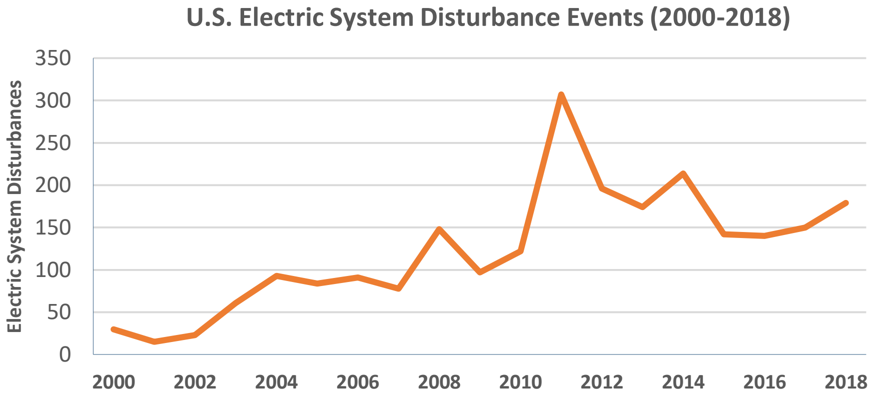
Defining Resilience and Reliability

- 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

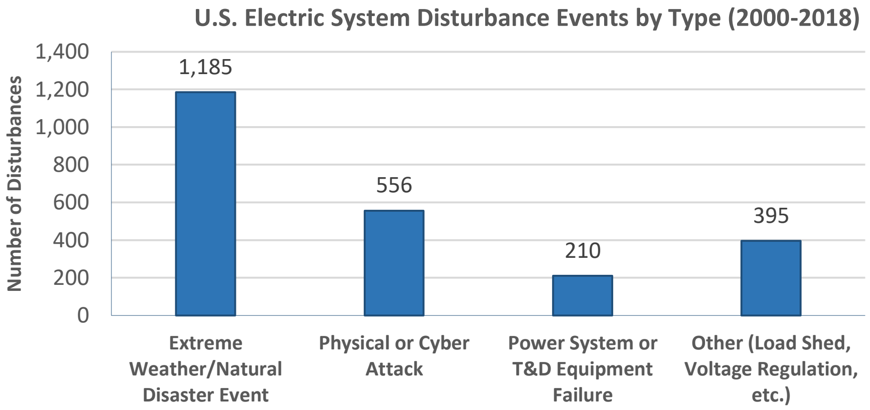
Source: State Energy Resilience Framework, Argonne National Laboratory (2017)

Electric System Disturbances

Electric system outages are increasingly frequent…



And outages are increasingly caused by natural disasters and storm events

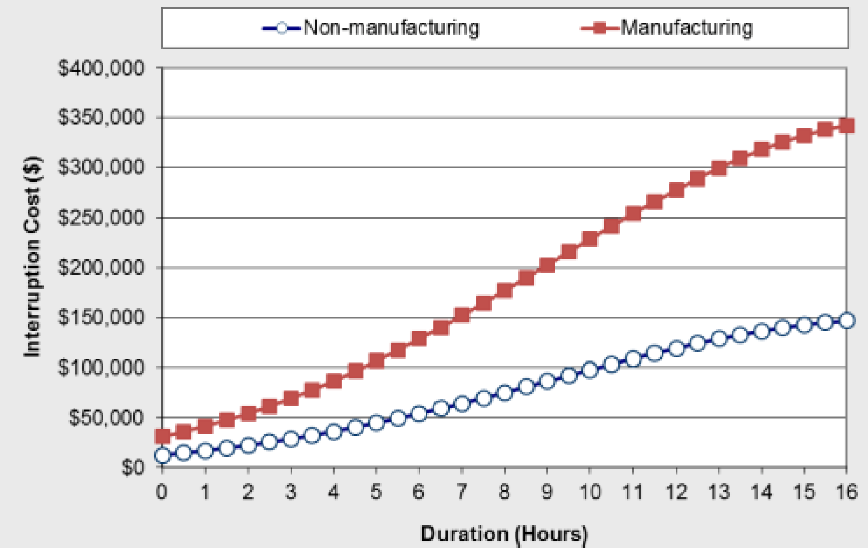


Source: U.S. DOE Office of Cybersecurity, Energy Security, and Emergency Response, Electric Disturbance Events (OE-417) Annual Summaries

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
Medium and large C&I					
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
Sector	Momentary	30 min.	1 hour	4 hours	8 hours
Small C&I					
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.

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.

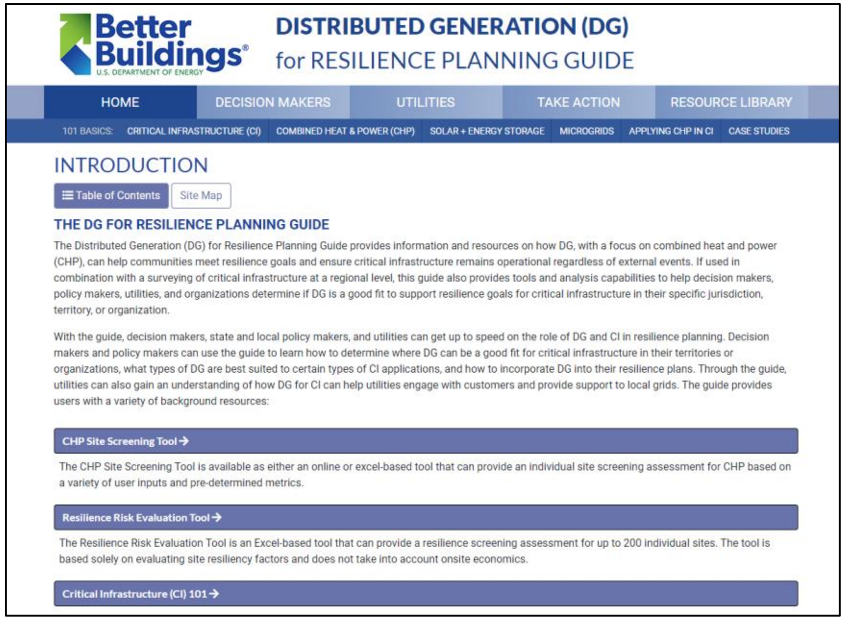
Resilience Planning with DOE Resiliency Accelerator

- 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

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

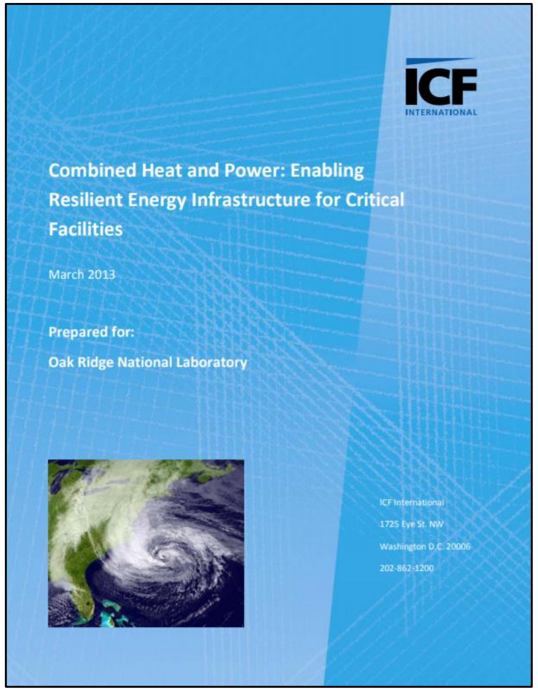
CHP in Resilience Resources

DG for Resilience Planning Guide



https://dg.resilienceguide.lbl.gov/

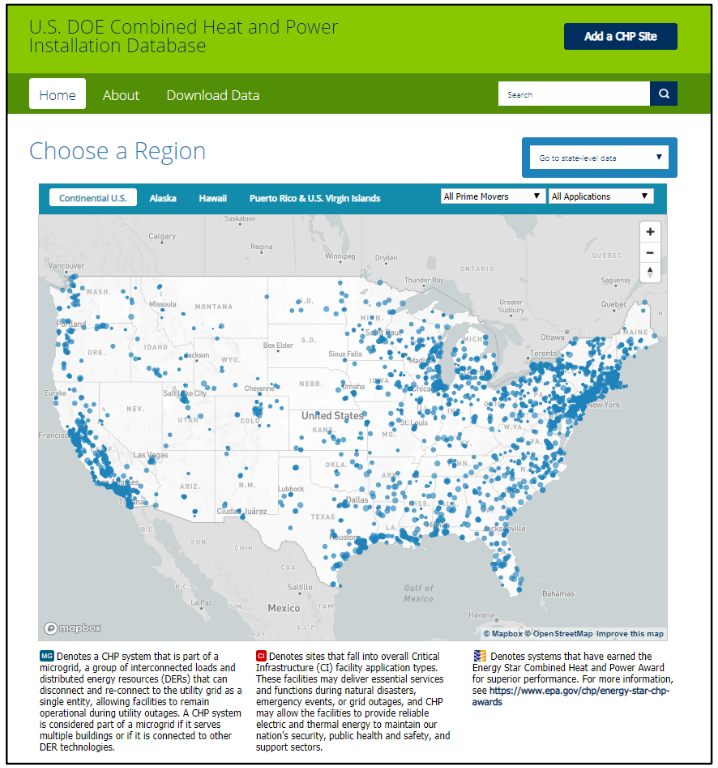
CHP: Enabling Resilient Infrastructure for Critical Facilities



https://www.energy.gov/sites/prod/files/2013/11/f4/chp_critical_facilities.pdf

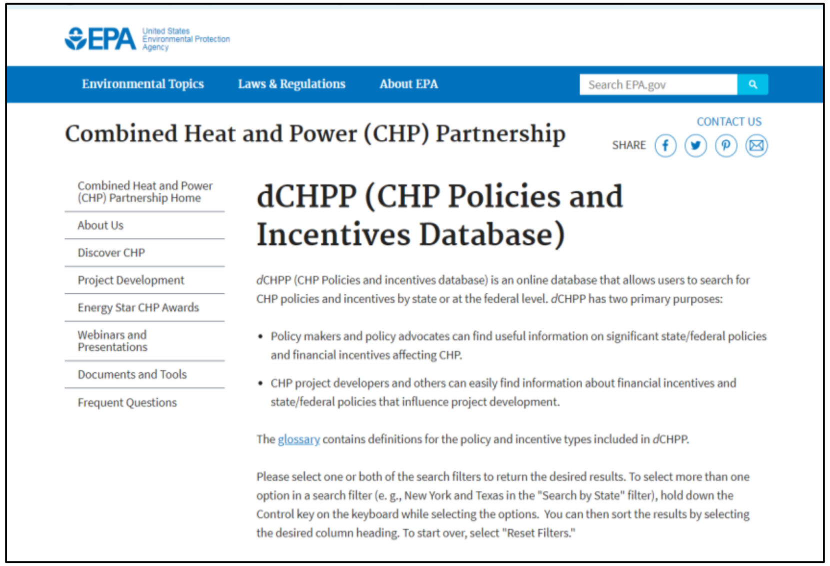
CHP Databases

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



energy.gov/chp-installs

EPA dCHPP (CHP Policies and Incentives Database



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 example 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

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