CHP for Resiliency in Critical Infrastructure

The U.S. electric power system is vast and complex, with thousands of miles of high-voltage cables that serve millions of customers around the clock, 365 days per year. Aging grid infrastructure and major storm events have increased the need to build a more resilient, modern grid that can keep communities safe and protect businesses if an outage occurs. When the grid goes down due to a storm or other event, hospitals experience more difficulty serving patients, industrial sites must suspend operations, and emergency services become challenging to deliver.

Combined heat and power (CHP) is an efficient way to produce both electricity and thermal energy from a single source, with the ability to keep operating separate from the grid. By operating independently from the grid, CHP can continue to provide services to a user during grid outages.

Protecting Critical Infrastructure with CHP

Government officials, policy makers, and disaster preparedness planners have become increasingly aware of the need to protect critical infrastructure facilities and to better prepare for energy emergencies. Critical infrastructure collectively 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.[1] These facilities may deliver essential services and functions during natural disasters, emergency events, or grid outages, and CHP systems can be configured to allow operations to continue uninterrupted at these sites.

How Does CHP Increase Resiliency?

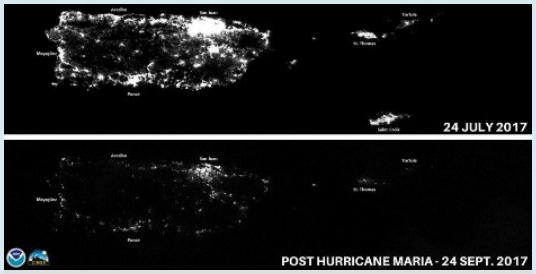
- Keeps the lights on
- Allows continuous supply of thermal energy
- Enhances grid stability and relieves grid congestion
- Withstands long, multi-day outages
- Enables microgrid deployment for a diverse generation mix

Brays Bayou next to the Texas Medical Center CHP installation under normal conditions in October 2012 (left), and during flooding caused by Hurricane Harvey In August 2017 (right).
Photo courtesy of Thermal Energy Corporation.

CHP systems have proven effective during and after natural disasters, as CHP has played a vital role in ensuring that the appropriate emergency response services are available and critical infrastructure remains operational. In August 2017, while much of Houston, Texas, and surrounding areas were faced with uncertainty about how infrastructure would withstand Hurricane Harvey's landfall, hospital staff at the Texas Medical Center were prepared to continue patient care without interruption by relying on CHP. The hospital's 48 MW natural gas-fueled CHP system sustained a variety of energy services, including electricity, air conditioning, refrigeration, heating, sterilization, laundry, and hot water, throughout the storm.[2] Although several major storms during the 2017 hurricane season left millions without power, facilities like the Texas Medical Center and others were able to power through due to onsite CHP.[3]

Economic Effects of Hurricanes Harvey, Irma, and Maria

Hurricanes Harvey, Irma, and Maria resulted in considerable damage to infrastructure and disruption to businesses. The economic research firm Moody's Analytics estimates Harvey and Irma combined will cost the U.S. $20-30 billion in economic output, whereas Maria could cost an additional $40 billion in lost economic output due to impassable roads and remote locations losing power.



Power outages in Puerto Rico during Hurricane Maria.
Photo courtesy of NOAA.

1 Patriot Act of 2001 Section 1016(e).

2 US DOE. "CHP Installation Keeps Hospital Running During Hurricane Harvey." September 8, 2017.

3 ICF. "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities." March 2013.

Critical Facilities with CHP Today

The DOE CHP Installation Database tracks CHP installations across the country, including those located at critical facilities. **Table 1** shows CHP installations that currently support critical infrastructure in sub-sectors that typically have coincident power and thermal loads and are conducive to CHP. More than 15 GW of CHP is installed at over 2,000 sites identified as critical infrastructure.

The majority of critical facility sites with CHP systems are currently multi-family buildings, college and university campuses, and schools, which can serve as important places of refuge and often house medical and research facilities. A large number of CHP sites are located at hospitals and healthcare facilities, which provide important emergency services and patient care, and at water and wastewater treatment plants, which provide drinking water and prevent dangerous pollution from entering local waterways.

In addition to these sub-sectors, industrial manufacturing facilities and other subsectors may be identified as critical infrastructure and can provide essential services during emergencies. For example, Sikorsky Aircraft's manufacturing facility in Stratford, Connecticut *(pictured below)*, was able to continue operations during Superstorm Sandy because of its 10 MW CHP plant. In addition to maintaining normal operations, Sikorsky offered free helicopter transport services for disaster relief personnel and ferried water, first aid kits, snacks, diapers, flashlights, and other necessities. Furthermore, the manufacturing center's campus provided a place for meals, showers, and cell phone charging to its employees and their families during the storm's aftermath.[4]

Sikorsky Aircraft facility in Stratford, CT.
Photo courtesy of NRDC.

Table 1. CHP in Critical Infrastructure Installations by Sub-Sectors Conducive to CHP

Application Type	Sites	Capacity (MW)
Multifamily Buildings	333	141
College/Universities	270	2,653
Schools	253	65
Food Processing	244	5,777
Hospitals	220	819
Wastewater Treatment	220	740
Nursing Homes	148	24
Lodging	139	141
Police/Fire Stations	46	168
Military Bases	42	712
Prisons	39	165
Supermarkets	34	11
Pharmaceuticals	29	3,479
Airports	14	187
Data Centers	11	16
Food Distribution Centers	8	161
Total	**2,050**	**15,260**

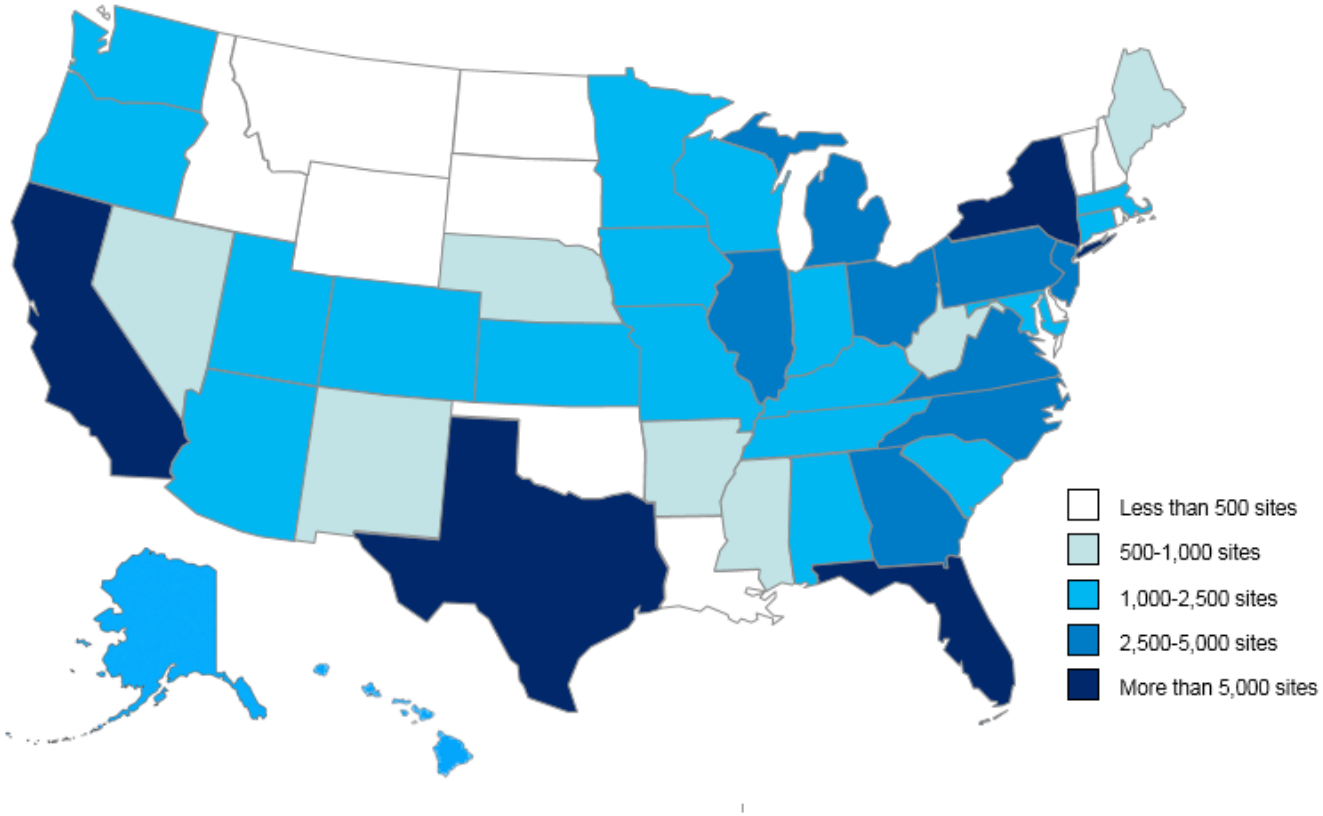
Potential for CHP at Critical Infrastructure Facilities

There is significant opportunity to increase protection of critical infrastructure by installing CHP at a greater number of facilities. More than 148 GW of technical potential for new CHP exists across all sectors in the U.S., and much of this potential is found in critical infrastructure, including colleges and universities, hospitals, and schools. **Figure 1** *(top of next page)* shows states with technical potential to install CHP at critical infrastructure facilities in terms of number of sites.[5]

4 United Technologies. "Sikorsky Aircraft Delivers Supplies to Staten Island, Victims of Hurricane Sandy." November 13, 2012.

5 ICF. CHP Technical Potential Database. December 2016.

Figure 1. CHP Technical Potential at Critical Infrastructure Sites



Increasing interest in resiliency has also led government planners in many states and cities to look for opportunities to connect more than one critical load into a single, resilient community microgrid. In some locations, a number of critical facilities such as hospitals, fire and police stations, emergency shelters, and gas stations can be connected and configured to operate in isolation from the larger utility grid, even during extended outages. CHP is currently the main source of generation in microgrids, and it is expected to continue to be a key technology in future microgrid design.[6]

Fairfield, CT, Community Microgrid

The town of Fairfield, CT, experienced energy outages caused by several storms, including Superstorm Sandy, and has since invested in a community microgrid to improve the resiliency of the town's critical facilities. The microgrid consists of a 300 kW natural gas-fired generator, 47 kW of solar PV, and a 60 kW natural gas-fired CHP reciprocating engine as the connected system's anchor. The microgrid serves the fire station, police station, an emergency communications center, a public shelter, and a cell phone tower. It has the ability to isolate from the electric grid in case of an outage event, and can keep the connected critical facilities operational during weather and other emergency events.

The public shelter, Operation Hope Fairfield, will be energized 24/7 because of the microgrid. *Photo courtesy of Schneider Electric.*

Economic Impacts of Grid Outages

In addition to increasing resiliency for public health and safety, it is also important to protect against the economic impacts of grid outages, which can have significant effects on overall facility operations. Whether the facility is a hospital that must serve its patients or a manufacturing plant that cannot afford several days of down time, major grid outages can be extremely costly for a business or organization. A 2012 study estimated the economic costs of weather-related electric grid outages between $20 billion and $55 billion annually for the entire U.S. economy. Other studies have provided estimates for the economic impacts of grid outages from all sources at anywhere between $20 billion and $209 billion annually.[7]

6 GTM Research. "U.S. Microgrids 2016: Market Drivers, Analysis and Forecast." August 2016.

7 Campbell, R. 2012. Weather-Related Power Outages and Electric System Resiliency. Congressional Research Service (CRS).

Matosantos Commercial Corp. – Industrial CHP for Resilience

The Matosantos Commercial Corporation owns and operates a specialty meat products facility in Vega Baja, Puerto Rico, that includes a processing facility and large cold storage warehouse. In 2015, the site installed a 2 MW propane-fueled reciprocating engine CHP system in order to provide power as well as steam and hot water to the facility for processing, clean up, and sterilization. During Hurricane Maria and in the months following, the local power grid was not stable enough to support the continuous operation of the plant, so the CHP system provided critical power and thermal energy for food processing and cold storage needs. The facility was able to run independent of the grid for months after the storm, because propane supplies were not interrupted. The facility has also been storing milk and other perishables for local plants that are only receiving partial power from the grid, even causing one nearby milk processor to begin evaluating the feasibility of installing its own CHP system. A new anaerobic digester is currently under construction at the processing facility to provide renewable fuel from waste products for the CHP system.[8]

The Rimco Cat CG170-20 generator is providing 2 MW of power to the processing facility and warehouse.
Photo courtesy of Caribbean Business.

Building a More Resilient Future with CHP

According to the US DOE's database of grid disturbance incidents, national trends indicate that grid outages have become more prevalent since 2000 and are most often caused by weather-related events.[9] With the increased need to protect against the risks of future outages, a number of resources exist to help state and local agencies build a more resilient future.

Through the *Advanced Manufacturing Office* and its *CHP Technical Assistance Partnerships (CHP TAPs)*, DOE provides support to local agencies and companies, including critical facilities, to explore feasibility of CHP for improving resiliency. In addition, the *Better Buildings CHP for Resiliency Accelerator* provides tools and analysis capabilities to help policy makers, utilities, and organizations determine if CHP is a good fit to support resiliency goals for critical infrastructure in their specific jurisdiction or territory.[10] ■

8 Caribbean Business. "Rimco Cat Cogeneration." June 2, 2017.

9 U.S. Department of Energy (DOE). Office of Electricity Delivery and Energy Reliability. EIA Form OE-417.

10 CNBC. "Harvey and Irma economic hit could total $200 billion: Moody's." September 2017.

11 Schuett, J. Energy Security on a Barrier Island. Presented to Energy Master Planning for Resilient Military Installations. Dec, 2017.

12 *https://energy.gov/eere/amo/articles/chp-installation-keeps-hospital-running-during-hurricane-harvey*

13 *https://ir.capstoneturbine.com/press-releases/detail/3561/capstone-microturbines-continue-to-power-through-hurricane*

14 *http://www.businesswire.com/news/home/20171018006493/en/Arensis-Off-Grid-Power-System-Delivered-Victims-Hurricane*

15 *https://ufhealth.org/node/52008*

16 *http://chpassociation.org/wp-content/uploads/2017/08/2017-Policy-Forum-Slides.pdf*

17 *http://caribbeanbusiness.com/prma-special-commercial-coverage-rimco-cat-cogeneration/*

Examples of Sites that Remained Operational by CHP During Hurricanes Harvey, Irma, and Maria

- University of Texas Medical Branch, Galveston, TX – A 6 MW combustion turbine operated in island mode throughout and after Harvey even though the site's two utility feeders were down due to excessive flooding.[11]
- Texas Medical Center, Houston, TX – The 48 MW combustion turbine was able to provide critical power and thermal energy for hospital patients and staff during Harvey.[12]
- Wyndham Hotel St. Thomas, Smith Bay, VI – The Wyndham Hotel, powered by a 1.7 MW microturbine, operated throughout Maria and was the only resort in the area with both power and water after the storm.[13]
- Fajardo Sports Complex, Fajardo, PR – The sports complex was used as an emergency shelter and relief center after Maria; it was provided electricity and thermal energy by a 120 kW reciprocating engine.[14]
- Shands Medical Center, Gainesville, FL – A 4.3 MW combustion turbine allowed the medical center to maintain near-normal operations throughout Irma, house facility staff and families, and operate a hurricane relief command center during the storm.[15]
- Hospital De La Concepción, San Germán, PR – The 167-bed facility was able to operate throughout Hurricanes Irma and Maria using a propane-fueled 1.2 MW reciprocating engine.[16]
- Matosantos Commercial Corp., Vega Baja, PR – The food processing facility was able to operate independently from the power grid for months after Maria with a 2 MW propane-fueled reciprocating engine, which was installed in 2015.[17]

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For more information, visit the CHP Deployment Program at energy.gov/chp or email us at CHP@ee.doe.gov

DOE/EE-1771 • May 2018