U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

International District Energy Association (IDEA) Annual Conference 2019

U.S. Department of Energy Resilience Tools

U.S. Department of Energy (DOE) CHP for Resiliency Accelerator

Tarla Toomer, DOE
Anne Hampson, ICF

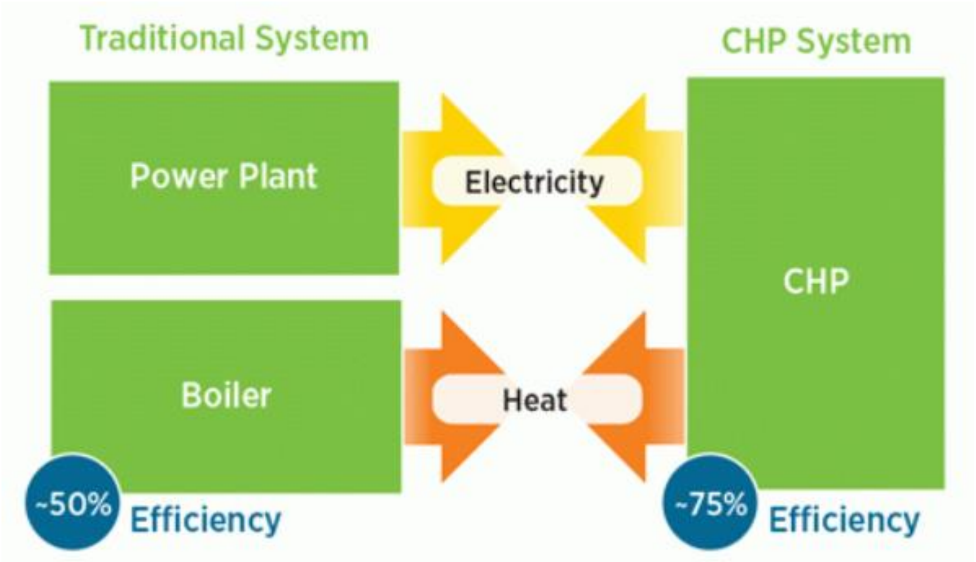
What is CHP and How Does it Increase Resilience?

What is CHP?

- CHP, or cogeneration, is the production of electricity and capture of waste heat to provide useful thermal energy for space heating, cooling, DHW, or industrial processes (recip. engines, steam turbines, microturbines, fuel cells)

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 for Resiliency Accelerator

Purpose:

- Incorporate consideration of CHP into resiliency planning efforts at the city, state, and utility levels
- Collaborate with Partners to:
  - Assess opportunities for CHP to maintain critical operations
  - Document Partner process for replicability

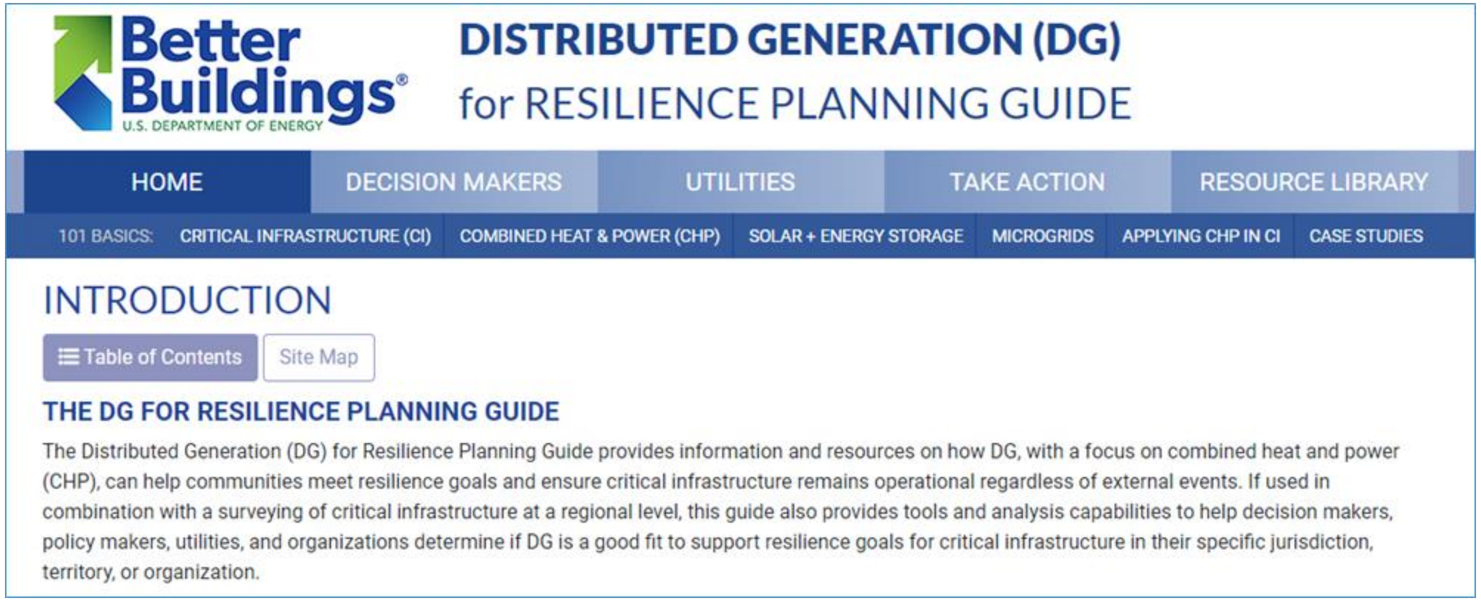
Key Materials Developed:

1. DG for Resiliency Planning Guide
2. CHP for Resiliency Screening Tool
3. DER Matrix – Issue Brief
4. Partner Profiles

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

The Distributed Generation (DG) for Resilience Planning Guide

Web-based guide that provides information and resources on how distributed generation (w/a focus on CHP), can help communities meet resilience goals and ensure critical infrastructure remains operational regardless of external events



Available at: https://resilienceguide.dg.industrialenergytools.com/

Two Main Sections to the Guide

Stakeholder Take Action Pages

- Information and resources for resiliency planners to actively use to incorporate CHP/DERs in their planning process
  - Decision Makers
  - Utilities
  - Take Action
  - Resource Library

101 Background Information Pages

- Background information on critical infrastructure, DERs, and how to apply in end-use sectors
  - Critical Infrastructure
  - Combined Heat and Power
  - Solar + Energy Storage
  - Microgrids
  - Applying CHP in Critical Infrastructure
  - Case Studies

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

DG for Resilience Planning Guide: Take Action

- Provides user with an efficient approach to quickly assess a critical infrastructure portfolio for potential DG deployment, and/or;
- Provide a framework for reviewing existing resiliency strategies and policies, and developing new programs.

Steps 1 & 2: Identify and Rank CI Sectors and Subsectors Conducive to DG Technologies

Provides users with criteria for identifying and prioritizing CI sectors conducive to DG technologies

Step 3: Individual Site Assessments and Next Steps

Individual Site Assessments: Tools that can be used to perform individual site assessment of DG technologies are provided for users: CHP Site Screening Tool, Solar + Storage Screening Tool , Microgrid Modeling Tools

Table 2. Critical Infrastructure Sub-Sectors Conducive to CHP

CI Sector	Sub-sector Conducive to CHP
Transportation	Airports
Information Technology	Data Centers
Government Facilities	College/Universities Schools Prisons Military Bases
Emergency Services	Police Stations Fire Stations
Water and Wastewater Systems	Waste Water Treatment Plants
Food and Agriculture	Food Processing Food Distribution Centers Supermarkets
Commercial Facilities	Lodging Multi-Family Buildings
Healthcare and Public Health	Hospitals Nursing Homes
Healthcare and Public Health	Chemicals / Pharmaceuticals Food Processing

CHP for Resilience Screening Tool

Allows users to screen and rank individual sites or portfolios of buildings based on a variety of resilience metrics and their suitability for CHP

Resiliency Screening

- **Inputs:** User-defined critical infrastructure ranking criteria, as well as microgrid and load factor ranking assessments
- **Results:** Users receive a resiliency score, microgrid score, load factor score, historical CHP uptake, and combined total resilience score

CHP Screening

- **Inputs:** Resiliency score (from resiliency screening), site location, energy consumption data, and energy price data
- **Results:** Estimated CHP size and stoplight screening assessment (taking into account resiliency screening)

Stoplight Screening Assessment

- This site has a high potential for CHP, contact your CHP TAP for more information
- This site has medium potential for CHP, contact your CHP TAP for more information
- Limited CHP Potential

CHP for Resilience Screening Tool

CHP for Critical Infrastructure Facility Priority Ranking Table

Using the ranking criteria above, select a facility type, and provide a score for each ranking (A-H)		Factor A	Factor B	Factor C	Factor D	Factor E	Factor F		Resiliency Total	Factor G			Factor H	Combined Total
Facility Identification	Facility Type	Government Continuity Ranking	Locational Ranking	Leverage/ Scalability	Life Safety	Economic Impact	Part of Microgrid	Microgrid Score	Resiliency Score	Question	Answer	Load Factor Score	Historic Uptake	Combined Score
Example Site 1	College or University	3	3	2	4	4	Yes	3	19	Student housing	Yes	5	5	29
Example Site 2	Hospital	4	4	4	5	5	Yes	3	25	> 50 beds	Yes	5	4	34
Example Site 3	Police Station	4	4	3	3	3	Yes	3	20			2	1	23
Example Site 4	Airport	4	2	1	3	5	No	0	15			5	3	23

Resiliency Screening

CHP for Critical Infrastructure Individual Site Resiliency Screening

Site Information (entered in the Resiliency Screening step)			Inputs - Enter individual values or choose from the drop-down options provided				
			1	2		3	4
The site information below has been transferred based on the information entered in the resiliency screening section. For each site indicated below, please move from left to right in this table in order to answer the following questions based on each individual site. Each question is numbered and has a description to help the user either select an answer based on a drop-down menu, or enter their own information.			Use the drop down list to select the appropriate state or territory	Select an option from the drop-down menu on the left below to either produce the default climate zone based on the state selected in question 1, or manually select the appropriate climate zone. Click here to view the climate zone map.		Use the drop down to select the appropriate utility that serves the facility within the state/territory selected in question 1.	Enter the kWh used during a typical year or multiply the average monthly kWh consumption by 12
Facility Identification	Facility Type	Combined Resiliency Score	*What state/territory is the facility located in?*	*What climate zone is the facility located in?*	Climate Zone	*What is the electric utility that serves the facility?*	*What is the annual electric use in kWh?*
Example Site 1	College or University	29	NJ	*Use the default climate zone*	Climate Zone 3 - Moderate	Jersey Central Power & Lt Co	85,000,000
Example Site 2	Hospital	34	WA	*Use the default climate zone*	Climate Zone 2 - Cold/Moderate	Orcas Power & Light Coop	17,500,000
Example Site 3	Police Station	23	IA	*Use the default climate zone*	Climate Zone 2 - Cold/Moderate	Western Iowa Power Coop	450,000
Example Site 4	Airport	23	RI	*Use the default climate zone*	Climate Zone 2 - Cold/Moderate	National Grid	5,000,000

CHP Screening

CHP Site Screening Results					
Site Summary Information (transferred based on the information entered in the resiliency screening section and input 1)			The results below include the estimated CHP size, a stoplight screening indicating the potential for CHP at the individual facility, and additional information to assist users in determining which sites should move forward in contacting their CHP TAP for further analysis and useful implementation resources.		
Facility Identification	Facility Type	State	CHP Size Range	Stoplight Screening	Additional Information
Example Site 1	College or University	NJ	9-10 MW	This site has a high potential for CHP, contact your CHP TAP for more information	New York-New Jersey CHP TAP
Example Site 2	Hospital	WA	2-3 MW	This site has a high potential for CHP, contact your CHP TAP for more information	Northwest CHP TAP
Example Site 3	Police Station	IA	25-50 kW	Limited CHP Potential	*If this building is still a critical facility, you should consider other resilient technologies or talk to your utility about additional rebates that may be available*
Example Site 4	Airport	RI	300-350 kW	This site has medium potential for CHP, contact your CHP TAP for more information	New England CHP TAP

Stoplight Screening Results

Resiliency Screening Factors: Government Continuity, Locational Ranking, Leverage/Scalability, Life Safety, Economic Impact, Microgrid, and Load Factor

Access the tool at the accelerator website under “Featured Resources”: https://betterbuildingsinitiative.energy.gov/accelerators/combined-heat-and-power-resiliency

CHP for Resilience Screening Tool: Valuing Resilience

Provides a framework for users to assign a value of resilience to individual sites, and understand the affects on overall potential

One-time Resilience Payment ($)

- Estimates the impact of placing a simple monetary value on resilience
- **The University of Texas Medical Branch (UTMB)** – Identified 6 CHP options compared to a base-case standby generators and assigned a premium cost for CHP based on resilience

Energy Resilience Value ($/kWh)

- Cost of downtime to the facility, or the extra portion of electricity prices they would be willing to pay for assured resilience
- **Downtown Cleveland Microgrid** – Cleveland Thermal and Cuyahoga County are considering a 48 MW downtown microgrid, and are estimating paying 5 cents/kWh more for electricity for increased energy resilience

Capacity Resilience Value ($/kW)

- Similar to capacity incentives for CHP systems, this determines the value of resilience based on system size
- **Clemson University** – Currently installing a 15 MW CHP system w/black start capability, and expecting to pay additional $12,500/month on extra facilities charges for upgraded electrical equipment

Issue Brief – Examining the Performance of Different DERs in Disaster Events

- Explores how different DERs are impacted by various types of natural disasters (flooding, high winds, extreme temperature, etc.)
- Goal: To assist stakeholders in evaluating the technology options best able to meet their resilience priorities

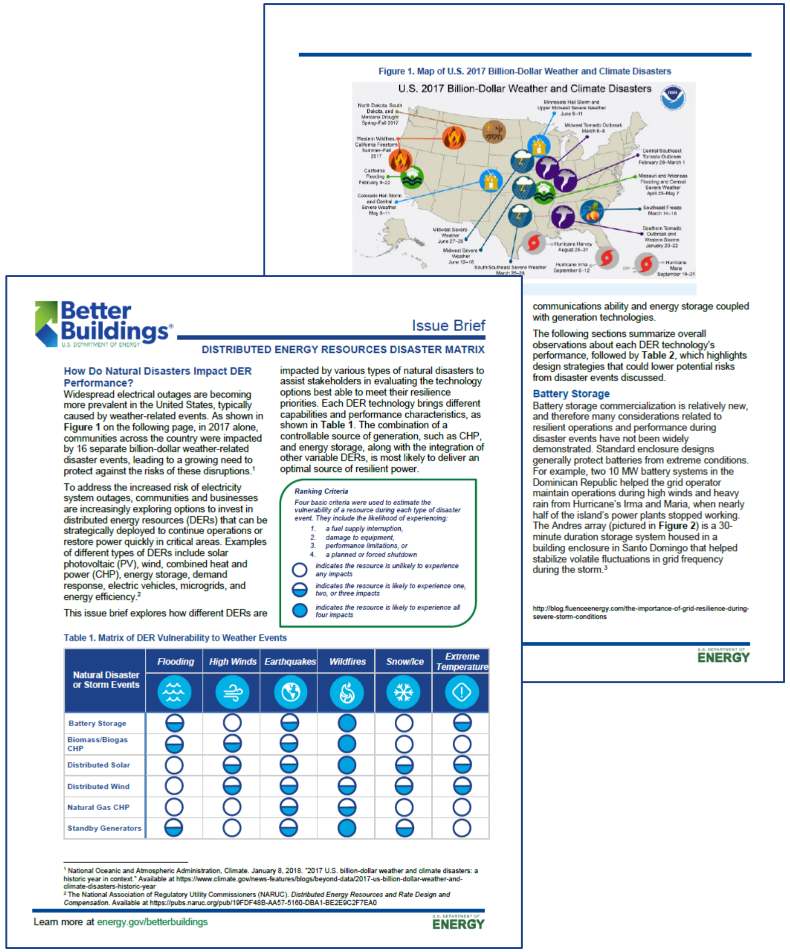


Figure 1. Map of U.S. 2017 Billion-Dollar Weather and Climate Disasters

U.S. 2017 Billion-Dollar Weather and Climate Disasters

Better Buildings U.S. DEPARTMENT OF ENERGY

Issue Brief

DISTRIBUTED ENERGY RESOURCES DISASTER MATRIX

How Do Natural Disasters Impact DER Performance?
Widespread electrical outages are becoming more prevalent in the United States, typically caused by weather-related events. As shown in **Figure 1** on the following page, in 2017 alone, communities across the country were impacted by 16 separate billion-dollar weather-related disaster events, leading to a growing need to protect against the risks of these disruptions.[1]

To address the increased risk of electricity system outages, communities and businesses are increasingly exploring options to invest in distributed energy resources (DERs) that can be strategically deployed to continue operations or restore power quickly in critical areas. Examples of different types of DERs include solar photovoltaic (PV), wind, combined heat and power (CHP), energy storage, demand response, electric vehicles, microgrids, and energy efficiency.[2]

This issue brief explores how different DERs are impacted by various types of natural disasters to assist stakeholders in evaluating the technology options best able to meet their resilience priorities. Each DER technology brings different capabilities and performance characteristics, as shown in **Table 1**. The combination of a controllable source of generation, such as CHP, and energy storage, along with the integration of other variable DERs, is most likely to deliver an optimal source of resilient power.

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*

Table 1. Matrix of DER Vulnerability to Weather Events

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	◐	○	◐	●	◐	○

[1] National Oceanic and Atmospheric Administration, Climate. January 8, 2018. "2017 U.S. billion-dollar weather and climate disasters: a historic year in context." Available at https://www.climate.gov/news-features/blogs/beyond-data/2017-us-billion-dollar-weather-and-climate-disasters-historic-year
[2] The National Association of Regulatory Utility Commissioners (NARUC). *Distributed Energy Resources and Rate Design and Compensation.* Available at https://pubs.naruc.org/pub/19FDF48B-AA57-5160-DBA1-BE2E9C2F7EA0

Learn more at energy.gov/betterbuildings

U.S. DEPARTMENT OF ENERGY

communications ability and energy storage coupled with generation technologies.

The following sections summarize overall observations about each DER technology's performance, followed by **Table 2**, which highlights design strategies that could lower potential risks from disaster events discussed.

Battery Storage
Battery storage commercialization is relatively new, and therefore many considerations related to resilient operations and performance during disaster events have not been widely demonstrated. Standard enclosure designs generally protect batteries from extreme conditions. For example, two 10 MW battery systems in the Dominican Republic helped the grid operator maintain operations during high winds and heavy rain from Hurricane's Irma and Maria, when nearly half of the island's power plants stopped working. The Andres array (pictured in **Figure 2**) is a 30-minute duration storage system housed in a building enclosure in Santo Domingo that helped stabilize volatile fluctuations in grid frequency during the storm.[3]

http://blog.fluenceenergy.com/the-importance-of-grid-resilience-during-severe-storm-conditions

U.S. DEPARTMENT OF ENERGY

Matrix of DER vulnerability to weather events

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	◒	○	◒	●	◒	○

Design considerations and other strategies to increase resilience of DERs

Natural Disaster or Storm Event	Flooding	High Winds	Earthquakes	Wildfires	Snow/Ice	Extreme Temperature
Resource						
Battery Storage	• Elevate equipment above flood and storm surge levels • Use NEMA-rated enclosures that protect against water damage • Factor equipment repair or replacement in O&M plans	• Use NEMA-rated enclosures to minimize exposure to debris • Design EMS or protection systems to shut down at harmful wind speeds or conditions.	• Utilize shock-mount system enclosures to maintain integrity of individual system components	• Use built-in fire suppression system	• Design enclosures to withstand snow/ice loads • Design with sealings and venting to address moisture • Use NEMA-rated enclosures to minimize exposure to moisture	• Design protection or EMS to withstand extreme temperatures • Design system to shut down to protect component integrity
Biogas/Biomass CHP	• Elevate equipment and biomass stockpiles above flood levels • For biogas, coordinate with the wastewater treatment on potential planned shutdowns	• For biogas, use rigid covers to protect digester tanks • For biomass, cover or protect onsite fuel supply stockpiles	• Maintain industry standards for facilities sited near seismic activity	• For biomass, use enclosures, fire protection, or containment strategies for fuel supply.	• Design with proper freeze protection • Protect biomass stockpiles from excess snow and ice	• Use heating jackets designed for optimal temperatures and adequate thermal management systems • Ensure systems are designed for regional temperature ranges
Distributed Solar	• Design systems and framing for easy runoff and drainage, especially for commercial rooftop systems with flat roofs • For ground mount, avoid siting in flood zones	• Use secure, flush-mounted systems for rooftop solar • Use flexible racking and anchoring systems • Maintain ASCE standards for rooftop systems based on expected wind loads	• Ensure roof mount design meets ASCE building code for seismic areas	• If ground-mount, site in open areas away from flammable material (trees, shrubs, etc.)	• Manually remove snow/ice to clear panels • Automonous mechanical cleaning (tiled removal) • Install bifacial systems capable of absorbing irradiance on the back or front of panels	• Site systems in applicable weather conditions • Enhance design to maximize cooling and airflow in order to ensure optimal temperature conditions for modules and electrical components (inverters)
Distributed Wind	• Design foundation for conditions in high water table • Elevate controls and electronics above flood and storm surge levels • Use site drainage strategy	• Include design features and braking procedures to withstand hurricane force winds (feather blades, lock rotors, change orientation, etc.)	• Design systems for ground acceleration rating based on typical seismic activity	• Extend gravel apron around base of turbine	• Install electro-thermal ice protection systems • Use ice-resistant coating on blades	• Design uninterruptible power supply to operate within adequate temperature range • Add on "cold weather packages"
Natural Gas CHP	• Elevate equipment above flood and storm surge levels	• Locate systems indoors or protect with containers designed to withstand high wind and debris	• Shock-mount system enclosures • Maintain industry standards for pipelines sited near seismic activity	• Use fire protection systems for above-ground facilities associated with gas delivery networks	• No additional design consideration needed	• To ensure fuel availability, purchase "firm supply" to avoid curtailment
Standby Generators	• Elevate equipment above flood and storm surge levels • Store enough fuel onsite to avoid delivery issues	• Locate systems indoors or protect with containers designed to withstand high wind and debris	• Purchase an earthquake-resistant model (IBC certified; subject to shake table testing)	• Avoid siting in areas prone to wildfire • Store enough fuel onsite to avoid delivery issues	• Store enough fuel onsite to avoid delivery issues	• Check generator batteries during cold weather • Enclose the system to protect from temperatures. • Store "winter diesel" fuel in cold climates with additives to prevent gelling

Partner Profiles

- Summary of individual partner achievements throughout the accelerator and future plans
- Short profiles containing:
  1. Partners’ approach to resiliency planning
  2. Program or project implementation related to CHP/DG
  3. Lessons learned and future plans
  4. Additional resources and information

CHP FOR RESILIENCY ACCELERATOR PARTNER PROFILES

The partner summary table highlights key partner accomplishments, initiatives, and strategies related to resilience planning, and implementing CHP or DG programs or projects. Please click on an individual partner to see more information in their individual partner profile. Partner profiles were completed through multiple interviews with each partner listed below and focus on 4 aspects: 1.) Resilience Planning, 2.) Program or Project Implementation, 3.) Lessons Learned, and 4.) Additional Information.

Partner Name	Partner Type	Key Accomplishments
City of Boston	City	Coordinated a pilot project for a multi-user CHP district energy microgrid and Community Energy Study
Healthcare Without Harm	Non-Profit Organization	Helped develop toolkits and initiatives focused on resilient healthcare facilities for the US Department of Health and Human Services’ (HHS)
Hoboken, NJ	City	Completing a feasibility study for the development of a city-wide microgrid to connect and power critical and community facilities
International District Energy Association (IDEA)	Non-Profit Organization	Organizes stakeholder engagement events that highlight the importance of CHP, microgrids, and district energy in increasing energy resilience
Maryland Energy Administration	State Agency	Administers a CHP grant program designed to encourage the growth of CHP to improve end-user resilience throughout the state
Massachusetts Department of Energy Resources	State Agency	Provided project implementation support to add resiliency capabilities to clean energy technologies at hospitals
Miami-Dade Water and Sewer Department	City	Increasing the capacity of cogeneration units at two wastewater facilities studying of individual facilities to evaluate CHP and DER options
Missouri Department of Economic Development, Division of Energy	State Agency	Collaborated with Spire on several initiatives, such as co-hosting CHP summits focused on energy resiliency for critical facilities
Montgomery County, MD	County	Leading implementation of two pilot projects to enhance resiliency of individual facilities and the electric system with CHP
National Grid	Utility	Facilitated the interconnection of 900 MW of DERs for customers, and examining the feasibility of community microgrids in New York

CHP Technical Assistance Partnerships (TAPs) Are Here to Help

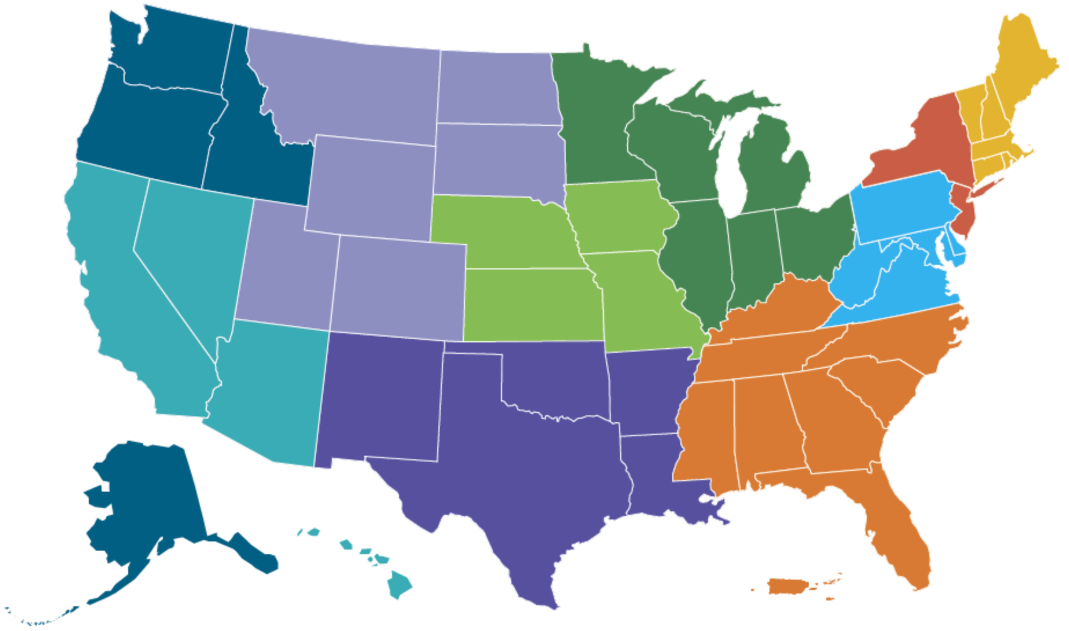
Northwest WA, OR, ID, AK
www.northwestCHPTAP.org
David Van Holde, P.E.
Washington State University
360-956-2071
VanHoldeD@energy.wsu.edu

Upper-West UT, CO, WY, MT, ND, SD
www.upperwestCHPTAP.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.org

Midwest MN, WI, MI, IL, IN, OH
www.midwestCHPTAP.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefk1@uic.edu

New England VT, NH, ME, MA, RI, CT
www.newenglandCHPTAP.org
David Dvorak, Ph.D., P.E.
University of Maine
dvorak@maine.edu
207-581-2338

New York-New Jersey NY, NJ
www.newyorknewjerseyCHPTAP.org
Tom Bourgeois
Pace University
914-422-4013
tbourgeois@law.pace.edu



Mid-Atlantic PA, WV, VA, DE, MD, DC
www.midatlanticCHPTAP.org
Jim Freihaut, Ph.D.
The Pennsylvania State University
814-863-0083
jdf11@psu.edu

Southeast KY, TN, NC, SC, GA, FL, AL, MS
www.southeastCHPTAP.org
Isaac Panzarella, P.E.
North Carolina State University
919-515-0354
ipanzarella@ncsu.edu

Western CA, NV, AZ, HI
www.westernCHPTAP.org
Gene Kogan
Center for Sustainable Energy
858-633-8561
gene.kogan@energycenter.org

Southcentral TX, NM, OK, AR, LA
www.southcentralCHPTAP.org
Gavin Dillingham, Ph.D.
HARC
281-216-7147
gdillingham@harcresearch.org

Central NE, IA, KS, MO
www.centralCHPTAP.org
Cliff Haefke
University of Illinois at Chicago
312-355-3476
chaefk1@uic.edu

Questions?

?

Anne Hampson
Anne.Hampson@icf.com
703-934-3324

Tarla Toomer
Tarla.Toomer@ee.doe.gov
202-586-7989