

Distributed Generation (DG) for Resilience Planning Guide

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Introduction

The DG for Resilience Planning Guide

The Distributed Generation (DG) for Resilience Planning Guide provides information and resources on how DG, with a focus on combined heat and power (CHP), can help communities meet resilience goals and ensure critical infrastructure remains operational regardless of external events. If used in combination with a surveying of critical infrastructure at a regional level, this guide also provides tools and analysis capabilities to help decision makers, policy makers, utilities, and organizations determine if DG is a good fit to support resilience goals for critical infrastructure in their specific jurisdiction, territory, or organization.

With the guide, decision makers, state and local policy makers, and utilities can get up to speed on the role of DG and CI in resilience planning. Decision makers and policy makers can use the guide to learn how to determine where DG can be a good fit for critical infrastructure in their territories or organizations, what types of DG are best suited to certain types of CI applications, and how to incorporate DG into their resilience plans. Through the guide, utilities can also gain an understanding of how DG for CI can help utilities engage with customers and provide support to local grids. The guide provides users with a variety of background resources:

► **Critical Infrastructure (CI) 101**

This section provides general background information on the different critical infrastructure sectors defined by the Department of Homeland Security (DHS) and their National Infrastructure Protection Plan (NIPP), and why energy resilience for individual critical infrastructure facilities is important. It also provides critical infrastructure resiliency planning specific to the energy sector.

► **Combined Heat and Power (CHP) 101**

This section provides a general overview of CHP technologies, benefits compared to separate heat and power (SHP) generation, the historical and current market for CHP, and a variety of CHP resources.

► **Solar + Energy Storage 101**

This section provides a general overview of distributed solar and energy storage technologies, resilience benefits of solar + storage at CI facilities, and the current market for distributed solar and energy storage.

► **Microgrids 101**

This section provides details on microgrid basics, from technology configurations to potential ownership models. It also highlights the role that CHP can play in supporting microgrids and how microgrids can support resilience in CI operations.

► **Applying CHP in Critical Infrastructure 101**

This section highlights CHP's role in increasing the resiliency of critical infrastructure, as well as detailing CI sectors conducive to CHP deployment. It also provides information on how to value the reliability benefits of CHP when compared to traditional backup generation.

► **Case Studies**

This section highlight real world examples of microgrids and CHP, solar, and energy storage systems operating and providing resilience benefits (among others) to critical infrastructure sites.

The CHP for Resiliency Accelerator

The CHP for Resiliency Accelerator is a collaborative effort with states, communities, utilities, and other stakeholders with the goal of supporting and expanding the consideration of CHP solutions to keep critical infrastructure operational regardless of external events. This guide incorporates examples of how Accelerator Partners have:

- ▶ Examined the perceptions of CHP among resiliency planners,
- ▶ Identified gaps in current technologies or information relative to resiliency needs, and
- ▶ Developed plans for communities to capitalize on CHP's strengths as a reliable, high-efficiency, low-emissions source of electricity and thermal energy for critical infrastructure.

Decision Makers / Policy Makers

The DG for Resilience Planning Guide

The electric grid is increasingly under pressure from natural disasters and physical attacks that can have profound physical and financial consequences. Government officials, military leaders, decision makers, 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. After critical infrastructure sites have been identified for protection, an important next step is evaluating options available to enable a faster response to disasters when they occur, mitigate the extent of damage and suffering that communities endure, and speed the recovery of critical functions. Access to energy is a high priority for ensuring critical facilities can continue to deliver services and assist in recovery, especially in the event of an unplanned grid outage.

Most facilities currently rely on diesel generators for backup power in the event of a grid outage. They are the default for emergency backup power and have provided critical power and enhanced resilience for many facilities. However, there have been cases where diesel generators have not performed as expected for a variety of reasons. Generators have failed to start or experienced mechanical failures in emergency situations due to lack of regular use or ongoing maintenance. They are also limited by the amount of fuel that can be stored on-site or trucked in during a disaster. Energy-efficient distributed generation, such as CHP, and onsite renewables, can solve many of the challenges with traditional approaches to back-up generation. Distributed systems provide electricity at or near the point of use and can be equipped to ensure uninterrupted power during unexpected outages, which provides safety and security during emergencies. In general, distributed energy systems that run consistently throughout the year are more reliable in an emergency than a backup generator system that only runs during emergencies. Energy efficiency is also an important consideration for enhancing resilience and enabling the integration of distributed resources at critical facilities. By lowering overall demand and decreasing backup power needs, energy efficiency investments enable optimal sizing of distributed systems so they achieve the highest efficiencies and greatest cost savings, while improving energy resilience.

Resilience Planning

As identified in the National Academies report on Enhancing the Resilience of the Nation's Electric System, no single entity is responsible for, or has the authority to implement a comprehensive approach to assure the resilience of the nation's electric system and a local process is needed to develop an integrated perspective that addresses a number of needs at critical infrastructure. At the state and local level, and throughout the many U.S. federal facilities and military bases worldwide, many decision makers and policy makers already integrate resilience considerations in planning priorities across a number of existing functions, such as emergency preparedness, energy assurance plans, and hazard mitigation strategies. These efforts often prioritize critical infrastructure, as directed by federal guidelines for implementing the Nation's Infrastructure Protection Plan (NIPP) and developing plans to manage risk at critical infrastructure. Improving and advancing resilience requires coordination among a number of stakeholders including government emergency planners, facility operators, and the electricity sector. For stakeholders that are new to resiliency planning, several approaches are described in the following resources:

- ▶ [NASEO State Energy Assurance Guidelines¹](#): The National Association of State Energy Officials (NASEO), in collaboration with the National Association of Regulatory Utility Commissioners (NARUC), has produced Energy Assurance Guidelines that help states plan, organize and build response mechanisms on energy emergency preparedness and key critical infrastructure protection issues.
- ▶ [NIST Community Resiliency Planning Guide²](#): The National Institute of Science and Technology (NIST) provides a practical and flexible approach to help all communities improve their resiliency through a six-step planning process. The Guide helps users integrate consistent resiliency goals into their comprehensive, economic development, zoning, mitigation, and other local planning activities that impact buildings, public utilities, and other infrastructure systems.
- ▶ [NREL Resilience Roadmap³](#): The National Renewable Energy Laboratory (NREL) offers comprehensive guidance for federal, state, and local entities, to effectively convene at the regional level for resiliency planning. It outlines a step-by-step approach including intergovernmental preparation and coordination; planning and strategy development; and plan adoption, implementation, and evaluation.
- ▶ [Argonne State Energy Resilience Framework⁴](#): Argonne National Laboratory developed a five-step State Energy Resilience Framework, which enables state and local governments, in conjunction with energy utilities, to identify resilience concepts, challenges, and vulnerabilities to implement cost-effective and proven resilience enhancement options. State and local governments can use the framework to link broad level resilience concepts to implementation actions tailored to their individual resilience needs and capabilities.
- ▶ [NIBS Whole Building Design Guide⁵](#): The Whole Building Design Guide, a program of the National Institute for Building Sciences (NIBS), explores different aspects of resilience management, with a focus on strategies for planning and designing buildings to help reduce the costs of manmade and natural hazards and make critical infrastructure and communities more resilient.
- ▶ [Energy Planning for Resilient Military Installations Workshop⁶](#): The International District Energy Association (IDEA) provides a variety of resources to its members and the public through workshops, conference proceedings, webinars, and reports. A recent workshop focused on resilient energy planning for military installations provides a wide variety of presentations and resources that can be used by decision makers in military organizations.

Some states, local governments and military institutions have initiated resiliency planning from a post-disaster point of view, developing strategies for providing recovery and relief after a significant disruption. Other approaches to resiliency planning have focused on pre-disaster planning and preparedness, providing guidelines for enhanced preparation and response for all types of natural and man-made emergencies. While not all planning exercises address the same factors, the examples below demonstrate

¹ <https://www.naseo.org/eaguidelines>

² <https://www.nist.gov/topics/community-resilience/planning-guide>

³ https://www.nrel.gov/tech_deployment/resilience-planning-roadmap/

⁴ <https://energy.gov/epsa/downloads/state-energy-resilience-framework>

⁵ <https://www.wbdg.org/resources/building-resiliency>

⁶ <https://www.districtenergy.org/resources/conference-proceedings/energy-planning-for-resilient-military-installations-workshop>

how a few states and cities are identifying and addressing the resiliency issues most important to them within a planning process:

- ▶ [Resilient New Orleans](#)⁷: The City of New Orleans has created a resiliency plan, outlining disaster preparedness procedures while also focusing on transforming city energy, transportation, and communications systems in order to provide residents with a more connected, innovative, and resilient city.
- ▶ [A Stronger, More Resilient New York](#)⁸: New York City's resiliency framework contains recommendations for rebuilding communities affected by Hurricane Sandy and plans for increasing citywide resiliency focused on coastal protection, energy systems and utilities, critical infrastructure, and community preparedness.
- ▶ [2017 Draft Connecticut Comprehensive Energy Strategy](#)⁹: This planning document includes a number of resiliency related objectives that apply to the Connecticut's electricity sector, including promoting more distributed generation with programs that would keep critical facilities and core services in cities and towns operating when the grid goes down.

Key Policy Considerations for Enhancing Resiliency Through Distributed Generation

A number of market and regulatory factors at the state and utility service territory level impact how and where distributed generation is deployed during normal operations. Consideration from policymakers in the fundamental areas described below can help encourage the use of distributed technologies generally, and lead to increased opportunities to enhance resiliency of critical infrastructure. Several of these key policies are common across most distributed generation technologies, such as the ability to interconnect to the grid, how utility rates and tariffs are applied, and opportunities to access financial incentives through clean energy programs. Other policies may apply only to CHP, such as air permitting requirements. The following section summarizes policies common to distributed generation and, in some cases, provides specific examples related to CHP. For more detailed information on each of these policy areas, including best practices examples and policy recommendations from leading states, see the [Next Steps](#)¹⁰ portion of the [Take Action](#)¹¹ section.

▶ Interconnection Standards

Interconnection is the process of connecting a distributed energy resource to the electric transmission or distribution grid, which gives facilities with onsite generation the option to purchase power from the grid or to use their onsite generation. Interconnection standards are procedures that must be followed by system owners and utilities to ensure the protection and safety of the larger distribution grid. Historically, utilities have managed the interconnection process and some require complex and costly studies that have discouraged distributed generation. However, many states have begun to require interconnection

⁷ <http://resilientnola.org/>

⁸ <https://www1.nyc.gov/site/sirr/report/report.page>

⁹ http://www.ct.gov/deep/lib/deep/energy/ces/2017_draft_comprehensiveenergystrategy.pdf

¹⁰

<https://resilienceguide.dg.industrialenergytools.com/takeAction#Next%20Steps:%20Contact%20DOE%20CHP%20TAP%20for%20Further%20Analysis>

¹¹ <https://resilienceguide.dg.industrialenergytools.com/takeAction>

procedures that promote broad participation by utilities and customers. For more general information, see the Regulatory Assistance Project's report, [Interconnection of Distributed Generation to Utility Systems: Recommendations for Technical Requirements, Procedures and Agreements, and Emerging Issues](#)¹². The American Council for an Energy-Efficient Economy (ACEEE) tracks [how interconnection standards apply to CHP](#)¹³ on a state-by-state basis and identifies best practices of leading states.

► Standby Rates

Standby rates are charges typically paid by commercial and industrial customers that operate onsite generation systems, but remain connected to the grid in order to access services from an electric utility such as supplemental, standby, and backup power. Without appropriately designed rate structures for these services, the financial viability of a distributed generation project can be significantly reduced. For example, standby rates that primarily use fixed customer charges or ratcheted demand charges, rather than energy charges, significantly reduce the financial viability of a CHP project. For more information, see the National Regulatory Research Institute's report, [Electric Utility Standby Rates: Updates for Today and Tomorrow](#)¹⁴ and the Regulatory Assistance Project's report, [Standby Rates for CHP Systems](#)¹⁵, which examines utility standby rates for CHP in five states.

► Net Metering

Net energy metering (NEM) is a method that adapts traditional monthly metering and billing practices to compensate owners of distributed generation facilities for electricity exported to the grid. The customer can offset the electricity they draw from the grid throughout the billing cycle. The net energy consumed from the utility grid over the billing period becomes the basis for the customer's bill for that period. The level of compensation varies by state, depending on the policies in place. For more general information about net metering, see NREL's technical assistance page on [Net Metering](#)¹⁶. [EPA's CHP Policies and Incentives Database](#)¹⁷ specifically details state net metering policies that apply to CHP.

► Portfolio Standards

Clean energy portfolio standards, such as Renewable Portfolio Standards (RPS), Energy Efficiency Resource Standards, and Alternative Energy Portfolio Standards, set goals for clean energy deployment and have promoted the use of distributed energy technologies. Due to its high efficiency, several states have included CHP in their portfolio standards. For more general information on renewable portfolio standards, see NREL's technical assistance page on [Renewable Portfolio](#)

¹² <http://database.aceee.org/state/interconnection-standards>

¹³ <http://www.raonline.org/wp-content/uploads/2016/05/rap-sheaffer-interconnectionofdistributedgeneration-2011-09.pdf>

¹⁴ http://www.michigan.gov/documents/energy/NRRI_Electric_Standby_Rates_419831_7.pdf

¹⁵ <http://www.raonline.org/knowledge-center/taking-a-deeper-look-at-utility-standby-rates-for-combined-heat-and-power-systems/>

¹⁶ <https://www.nrel.gov/state-local-tribal/basics-net-metering.html>

¹⁷ <https://www.epa.gov/chp/dchpp-chp-policies-and-incentives-database>

[Standards](#)¹⁸. The EPA CHP Partnership's report, [Portfolio Standards and the Promotion of Combined Heat and Power](#)¹⁹, details how portfolio standards can specifically encourage CHP.

► **State Efficiency and Clean Energy Programs**

A variety of incentives to encourage distributed energy and energy efficiency can be offered at the federal or state level. For example, some states offer tax credits based on a percentage of system costs. Others provide grants, low-interest loans, bonds, or other forms of financial assistance that help cover capital or other costs associated with deployment. For more information, the [Database of State Incentives for Renewables and Efficiency \(DSIRE\)](#)²⁰ provides information on programs that offer incentives for renewable distributed generation. EPA's [CHP Policies and Incentives Database](#)²¹ and ACEEE's [State and Local Policy Database](#)²² track significant state policies and financial incentives related to CHP. Some states also assist by organizing activities that help educate stakeholders about distributed technologies by hosting outreach events, leading workshops, and facilitating working groups.

► **Utility Incentive Programs**

Some utilities implement programs that help their customers save energy or generate clean energy by providing incentives, rebates, or technical assistance for distributed generation and energy efficiency. Depending on the utility's goals, programs may be designed specifically to encourage energy efficiency measures, CHP systems, or solar installation at their customer's sites, which help with cost savings or new generation options for both the customer and the utility. For example, [Baltimore Gas & Electric](#)²³ offers incentives for the design, installation, and production phases of CHP projects development for their customers.

► **Air Permitting**

Distributed generation systems that use prime mover technologies must also meet air permitting and other emissions requirements. Some states have [streamlined air permitting](#)²⁴ procedures that can help reduce the time and cost involved in permitting eligible technologies, such as CHP units, in recognition of its efficiency and environmental benefits. In addition, adopting [output-based emissions regulations](#)²⁵ are more effective ways to regulate air emissions from CHP than traditional input-based standards.

► **Local Project Permitting and Codes**

¹⁸ https://www.epa.gov/sites/production/files/2015-07/documents/portfolio_standards_and_the_promotion_of_combined_heat_and_power.pdf

¹⁹ <https://www.nrel.gov/state-local-tribal/basics-portfolio-standards.html>

²⁰ <http://www.dsireusa.org/>

²¹ <https://www.epa.gov/chp/dchpp-chp-policies-and-incentives-database>

²² <https://database.aceee.org/>

²³ <http://bgesmartenergy.com/business/chp>

²⁴ https://www.epa.gov/sites/production/files/2015-07/documents/approaches_to_streamline_air_permitting_for_combined_heat_and_power_permits_by_rule_and_general_permits.pdf

²⁵ https://www.epa.gov/sites/production/files/2015-07/documents/output-based_regulations_a_handbook_for_air_regulators.pdf

When installing distributed generation systems, facilities are required to obtain permits from local authorities to ensure the system is constructed and operated in compliance with local and state regulations. Coordination among agencies, such as the city or county planning agency, fire department/authority, building department, environmental health department, and others can be challenging and is important to project success. For more information, see EPA's guide to [CHP Siting and Permitting Requirements](#)²⁶.

Policy and Program Approaches for Enhancing Resiliency through Distributed Generation

States most directly affected by natural disasters have become good models for how to approach policies that enhance energy resiliency. For example, a series of storms including hurricanes and flooding have exposed significant vulnerabilities to infrastructure along the Gulf Coast, motivating Texas and Louisiana to develop legislation that would protect critical facilities from future disruptions. Similarly, several East Coast states impacted by Superstorm Sandy including Connecticut, Massachusetts, New Jersey, and New York have since initiated state programs aimed at increasing resiliency.

Many existing state policies focus on allocating funding for implementing energy resiliency projects, which is a strong driver because it helps compensate facilities for the additional costs associated with designing systems that can continue operating during a grid outage. However, other approaches such as [state energy assurance planning](#)²⁷, resiliency roadmap exercises, and stakeholder education and awareness-building, can also be effective strategies. The American Council for an Energy-Efficient Economy (ACEEE) identified several [Indicators for Local Energy Resiliency](#)²⁸, which may help decision makers set goals, inform plans, and develop policies to increase the energy resilience of their communities.

The following section briefly summarizes how some leading states have specifically addressed distributed generation technologies in their policies to enhance resiliency in critical infrastructure. For additional information on various approaches to developing resiliency policies and programs, see [Resilient Power: A Guide to Resilient Power Programs and Policy](#)²⁹.

► Connecticut

The Department of Energy and Environmental Protection (DEEP) has passed a number of bills to support distributed energy generation at critical facilities. Public Act No. 12-148 established a [Microgrid Grant and Loan Pilot Program](#)³⁰ to support the development of microgrids powered by CHP and onsite renewables. Many of these projects may also be eligible for financing from the [Connecticut Green Bank](#)³¹. Another law, Public Act 17-144, provides support for fuel cell projects that incorporate CHP and enhance the reliability and resiliency of the electric grid.

► Massachusetts

²⁶ https://www.epa.gov/sites/production/files/2015-07/documents/procurement_guide_chp_siting_and_permitting_requirements.pdf

²⁷ <http://www.naseo.org/energyassurance>

²⁸ <http://aceee.org/white-paper/indicators-local-resilience>

²⁹ <https://www.cleangroup.org/ceg-resources/resource/what-states-should-do-a-guide-to-resilient-power-programs-and-policy/>

³⁰ <http://www.ct.gov/deep/cwp/view.asp?a=4405&Q=508780>

³¹ <https://www.ctgreenbank.com/>

The [Community Clean Energy Resiliency Initiative](#)³² is a \$40 million grant program that supports the use of clean energy technology solutions to protect communities from interruption in energy services due to several climate events. Grants help cover a variety of costs, including the cost of adding black start and island mode capability to CHP systems located at critical public facilities. Funding for the program was provided by Alternative Compliance Payments, which are paid by electric retail suppliers with insufficient credits to meet their compliance obligations under the state's [Renewable and Alternative Portfolio Standard programs](#)³³.

► New Jersey

New Jersey launched the country's first [Energy Resilience Bank \(ERB\)](#)³⁴, a resiliency financing initiative aimed at funding distributed energy technologies, including CHP, at critical facilities. The bank was created using \$200 million of Community Development Block Grant-Disaster Recovery funds allocated to New Jersey by the U.S. Department of Housing and Urban Development (HUD). For CHP, the ERB financed all costs associated with resiliency, including black start components, interconnection costs, flood-proofing, and third-party service contracts. The first project to receive funding approval was the installation of a CHP system at St. Peter's University Hospital in New Brunswick. The program was fully subscribed and is no longer accepting applications.

► New York

The New York State Energy Research and Development Authority (NYSERDA) provides incentives to support CHP for resiliency through its [CHP Program](#)³⁵. Systems are required to have the ability to operate during grid outages in order to be eligible for funding. The base incentive through the program is increased by 10% if the CHP system is installed to support critical infrastructure. NYSERDA is also leading the [NY Prize](#)³⁶ Community Grid Competition, which provides funding to study the feasibility and implementation of microgrid projects, the majority of which include CHP systems integrated with other distributed energy technologies and energy efficiency.

► Texas and Louisiana

Texas ([HB 1831](#)³⁷; [HB 1864](#)³⁸) and Louisiana (SR 171) passed legislation requiring consideration of CHP for public buildings and critical facilities during times of upgrade or new construction. These policies do not provide funding for projects, but they require building owners to conduct feasibility assessments and evaluate the cost-effectiveness of CHP at critical sites.

► Puerto Rico

³² <http://www.mass.gov/eea/energy-utilities-clean-tech/renewable-energy/resiliency/resiliency-initiative.html>

³³ <https://www.mass.gov/service-details/program-summaries>

³⁴ [http://www.njeda.com/erb/erb-\(1\)](http://www.njeda.com/erb/erb-(1))

³⁵ <https://www.nyserda.ny.gov/All-Programs/Programs/Combined-Heat-and-Power-Program>

³⁶ <https://www.nyserda.ny.gov/All-Programs/Programs/NY-Prize>

³⁷ <http://www.legis.state.tx.us/tlodocs/81R/billtext/html/HB01831F.HTM>

³⁸ <https://capitol.texas.gov/tlodocs/83R/billtext/html/HB01864F.HTM>

Puerto Rico's energy commission [opened a docket](#)³⁹ to investigate ways to encourage distributed generation, energy storage, and microgrids as part of the island's strategy for restoring and rebuilding its electric system after Hurricane Maria. To encourage deployment, the commission developed and proposed a regulatory framework, [Regulation on Microgrid Development](#)⁴⁰, outlining a set of rules and terms related to the rights, responsibilities and obligations of owners, operators and customers of a microgrid.

³⁹ <http://energia.pr.gov/wp-content/uploads/2017/11/Investigacio%CC%81n-Post-Mari%CC%81a-CEPR-eng-.pdf>

⁴⁰ <http://energia.pr.gov/wp-content/uploads/2018/01/Proposed-Regulation-on-Microgrid-Development-CEPR-MI-2018-0001-2.pdf>

Utilities

Enhancing Resiliency for Utility Customers

Maintaining the operational reliability of the electric grid is of paramount importance to electric utilities, who are mandated to provide reliable service. By facilitating onsite generation, utilities can help customers with critical loads maintain their operations when the utility grid goes down. When critical infrastructure is made more resilient through energy planning processes that ensure electricity will still be accessible during an outage, these facilities can serve as a place of refuge for the community while the utility works to restore power in other areas. Investments in distributed generation can also help limit service disruptions and unplanned outages during normal operations. For more information on the need for a more resilient power system, see [EPRI's 2016 report, Electric Power System Reliability](#)⁴¹. It discusses resiliency planning from a utility perspective and describes how utilities are following resiliency plans to assess and fix system vulnerabilities.

Some utilities have developed their own energy resiliency plans that outline investment strategies for hardening the grid's infrastructure and protecting against unplanned outages. Customer solutions, including installation of distributed generation and CHP at critical facilities, can be prioritized in these plans. For example, [ConEdison](#)⁴² undertook a long-term planning process to ensure that their system is less susceptible to storms and more responsive to customer needs in three distinct ways: (1) hardening their systems; (2) improving the information provided to customers; and (3) strengthening partnerships. The plan specifically describes strategies for maximizing distributed generation, including using CHP and solar generation. For example, ConEd is expanding efforts to use customer-sited CHP to upgrade the distribution system, give grid operators more options for restoring service to feeders, and supply supplemental power during outages. The utility is also exploring solutions that would enable its solar customers to rely on their solar energy sources in the event of a system outage.

Utilities should collaborate with state emergency planners and other policy makers about resiliency planning activities. The City of New York developed a [utility chapter](#)⁴³ within their resiliency plan, [A Stronger, More Resilient New York](#)⁴⁴, which proposes more than 20 different strategies for partnering with utilities and regulators to address system reliability, including during extreme weather events. To learn more about how cities and states are approaching efforts to enhance resiliency through distributed generation, visit the policymakers section of this tool.

Utility Involvement in Enhancing Resiliency Through Distributed Generation

Customers have very similar needs and concerns when it comes to enhancing the resiliency of critical infrastructure, but differences in state regulatory structures impact how utilities are involved in addressing those needs. Electric utilities have not historically been incentivized to support distributed generation, but new regulatory models are leading to greater utility involvement in deploying onsite generation at their

⁴¹ <https://www.epri.com/#/pages/product/000000003002007376/>

⁴² https://www.coned.com/-/media/files/coned/documents/services-outages/post_sandy_enhancement_plan.pdf

⁴³ http://www.nyc.gov/html/sirr/downloads/pdf/final_report/Ch_6_Utillities_FINAL_singles.pdf

⁴⁴ <https://www1.nyc.gov/site/sirr/report/report.page>

customer sites. By considering the areas of opportunity and examples described below, utilities can gain value and benefit from improving resiliency with distributed generation. While many examples focus on CHP, similar opportunities exist for energy efficiency and other distributed technologies.

► **Improve Customer Relationships**

When utilities support investments in CHP, it creates an opportunity to increase the value they can offer to some of their larger customers. Working together to enhance onsite resiliency provides an opportunity for utilities to interact with customers and learn more about how to best serve their needs. Utilities that communicate with customers about technology options and assist with technical requirements and interconnection procedures for distributed generation can strengthen their long-term customer relationships.

In emergency situations, establishing strong relationships with customers with CHP systems can come in handy. South Oaks Hospital in Amityville, NY utilized its 1.25 MW, black-start-equipped CHP system to assist their utility, Long Island Power Authority (LIPA), in power restoration efforts after Hurricane Sandy. Even though LIPA was able to restore power to the substation serving the hospital within five days of the storm, the grid remained unstable and LIPA requested that South Oaks stay disconnected. While the utility continued resolving issues for the community, the hospital stayed isolated and continued to rely on their CHP system to provide critical services for two weeks after the storm. The South Oaks CHP system is integrated with a 47 KW rooftop solar PV system.

Utilities can also enter into partnerships with customers that are interested in CHP for resilience. In many cases, utilities are well-positioned to help reduce the upfront costs of CHP for their customers, while also providing a stable source of power for grid customers. For example, in Missouri, the [City of Macon entered into partnership with a local ethanol plant, POET Biorefining⁴⁵](#), to jointly invest in a 10 MW CHP system. The facility is located onsite and provide steam to meet 60% of the biorefinery's thermal requirement, but it is owned and operated by the City of Macon and provides electric power to serve the local grid. The ethanol plant and the municipal utility split the costs of purchasing natural gas to fuel the system, which decreases costs for both entities. Further, in the case of a grid outage, the CHP system is designed to disconnect from the grid and supply the full load of the ethanol plant. It has maintained plant operations during numerous outages since CHP operations began in 2003.

► **Increase Energy Efficiency**

Many utilities are required by states to meet energy efficiency savings targets, and CHP can help utilities achieve their goals. For example, Maryland made CHP an eligible technology to contribute energy savings toward efficiency targets established for utilities by [EmPOWER Maryland⁴⁶](#). As a result, utilities in Maryland now offer CHP programs that provide financial incentives and other assistance to encourage customers to deploy CHP systems and utilities count the energy savings toward their efficiency goals. Baltimore Gas & Electric (BGE), Pepco, Delmarva Power, and First Potomac provide incentives to support CHP projects with incentives for capacity (\$/kW) and for production (\$/kWh) and report savings achieved toward their targets. BGE provided a \$1.5 million incentive to support a 2 MW

⁴⁵ <http://www.midwestchptap.org/profiles/ProjectProfiles/POETandCityofMacon.pdf>

⁴⁶ <http://www.psc.state.md.us/electricity/empower-maryland/>

CHP system at the [University of Maryland Upper Chesapeake Medical Center and BGE](#)⁴⁷ estimated that savings from this system and additional CHP projects would contribute 19.5% of the utility's total commercial and industrial (C&I) savings for the 2015 - 2017 program year.

In Massachusetts, a similar energy efficiency resource standard recognizes CHP as an eligible technology and electric and gas utilities in the state administer a [CHP program through the MassSave initiative](#)⁴⁸ to help meet their savings targets. Launched in 2010, the program provides incentives based on CHP system size and efficiency requirements. Utilities provide three tiers of incentives and each tier provides a greater reward to systems that are designed to achieve ideal performance and cost effectiveness.

► Upgrade Grid Infrastructure

Several utilities are beginning to develop strategies that encourage deployment of distributed generation and other “non-wires alternatives” in targeted areas with distribution or capacity needs. By siting distributed energy resources at strategic locations on the grid, utilities can help address distribution system constraints and unload the grid in areas where congestion is causing reliability issues. Supporting CHP at critical facilities that are also located in constrained areas is a win-win-win for the utility, the customer, and all users of the electric grid.

A good example is Con Edison’s Brooklyn Queens Demand Management (BQDM) Program, which targets deployment of distributed energy resources in an area where the utility grid was constrained due to major demand growth. To encourage commercial-building owners and industrial facilities to install CHP in this targeted area, [ConEdison matched state incentives for CHP](#)⁴⁹ already offered by NYSERDA, effectively doubling the incentive levels for CHP in the BQDM zone. Through initiatives like BQDM, utilities can have greater control over how and where distributed generation is deployed within their service territory. In this way, CHP and other technologies can provide an opportunity for utilities to mitigate investments in new grid infrastructure, gain access to grid services such as power quality and voltage management, and improve overall system security and resiliency as part of a targeted strategy.

► Build, Own, and Operate Resilient Assets

Some utility companies have found new value in building, owning, and operating distributed generation and CHP located at customer facilities. Some critical facilities may be good candidates for CHP, but have not been able to justify deploying limited capital for an energy investment that is not related to their core business. In this case, the utility could be a good partner, capable of stepping in to install CHP as a rate-based asset to help these customers become more resilient. Traditionally regulated utilities, or those operating in vertically integrated markets, should be able to follow existing regulatory procedures for owning a CHP system and recovering their costs. For distribution utilities operating in deregulated markets, it can be more complicated. In these states, utilities are typically prohibited from owning

⁴⁷ <https://www.businesswire.com/news/home/20140812006282/en/BGE-Teams-University-Maryland-Upper-Chesapeake-Health>

⁴⁸ <https://www.masssave.com/en/learn/business/combined-heat-and-power/>

⁴⁹ <https://www.coned.com/-/media/files/coned/documents/save-energy-money/rebates-incentives-tax-credits/rebates-incentives-tax-credits-for-commercial-industrial-buildings-customers/commercial-and-industrial-program/combined-heat-and-power-program.pdf?la=en>

generation assets, but some regulators have recognized the value of allowing utilities to own distributed energy resources when they are in the public interest, classifying them as transmission and distribution upgrades that improve the reliability of the electric grid.

A good example of utility-owned CHP is the [Eight Flags Energy CHP Plant⁵⁰](#), a 21.7 MW system, owned and operated by Florida Public Utilities (FPU) and located at an industrial customer site on Amelia Island, Florida. The CHP system has the ability to support critical services to the residents of Amelia Island, who are especially vulnerable to severe weather and outages. Reliability and resiliency were strong drivers for FPU's investment and the CHP system is designed to survive a category 4 storm surge. During normal operations, electricity from the CHP system is a source of reliable baseload electricity for approximately 16,000 of FPU's customers, while thermal energy is supplied as steam and heated water to the host facility, a large paper mill. The Florida Public Service Commission was supportive of FPU's involvement and [applauded the project as a "creative solution"⁵¹](#) for regulators and other states to consider.

Duke Energy has also pursued ownership of CHP at its customer sites and included the model as a strategy in its integrated resource planning (IRP) activities. [A proposal⁵²](#) for a 16 MW CHP project at Clemson University was [approved in 2017⁵³](#). The system will provide electric service to Duke retail customers and thermal energy to supply the Clemson campus. In the event of a major grid outage, the CHP system will be capable of islanding to supply power to the University. For Clemson, the project comes at a time when the campus is upgrading and replacing sections of its aging electrical infrastructure to improve system reliability. For Duke Energy, the project is part of its plan to meet energy needs in its service territory by installing smaller, highly efficient, distributed gas generation as part of their grid resources. The [utility's IRP for the Carolina's⁵⁴](#) also notes that investments in CHP can result in CO2 emissions reductions, deferral of T&D investments, and economic development opportunities for the state.

► **Boost Reliability Performance**

Electric utilities measure their own reliability performance using indicators like the System Average Interruption Duration Index (SAIDI) and System Average Interruption Frequency Index (SAIFI). They are an average measure of how long and how often customers experience interruptions and are typically expressed in minutes. Critical facilities and communities served by utilities that perform poorly on SAIDI and SAIFI measures are likely to be more motivated to invest in onsite generation. By supporting these customers in deploying resilient distributed generation assets, the utility can ensure reliable service to their most at-risk customers. Additionally, the resulting reduction in demand for grid electricity can help utilities improve reliability performance for all of their customers, especially in congested areas.

► **Develop Procedures that Support Distributed Generation**

⁵⁰ http://www.chptap.org/Data/projects/eight-flags-Project_Profile.pdf

⁵¹ <https://www.youtube.com/watch?v=2aE9bovMpx8>

⁵² <https://dms.psc.sc.gov/Attachments/Matter/0bcba62a-4b68-48dd-b466-c677f4006919>

⁵³ <https://dms.psc.sc.gov/Attachments/Order/d3f96088-7206-4ef5-9515-172d45874782>

⁵⁴ http://www.energy.sc.gov/files/view/DEC_IRP_2016_Corrected_10-2016_Clean_Copy.pdf

Utilities play a role in several key policy issues that can impact the implementation of customer-sited DG and CHP. Some policies, such as standby rates and interconnection standards, can be streamlined in order to reduce perceived barriers to distributed generation. Utilities can also offer incentives for DG and CHP installations as part of resiliency initiatives and energy efficiency programs, and include consideration of distributed generation in integrated resource planning exercises. When developing procedures and policy frameworks, utilities should value the resiliency attributes of distributed energy resources where possible, and take these considerations into account when assessing the range of costs and benefits associated with different distributed technologies.

Take Action

Identify Opportunity for DG in Critical Infrastructure

In order to identify opportunities for DG in critical infrastructure, it is important to first determine the most important CI sectors across the state, local jurisdiction, or utility territory, and then identify which are most conducive to different DG technologies based on sector characteristics. Ultimately, selected facilities within these defined CI sectors can be analyzed and ranked based on prioritization and the potential for installing CHP, solar + storage, or implementing a microgrid.

The objective of this section is to quickly assess a CI portfolio through a series of filters that is designed to yield high priority candidate facilities for further assessment. Users may choose to utilize only a portion of this step-by-step guide, or start from Step 1 and move all the way through to assess the potential for different DG technologies at host CI facilities. For example, states may find it useful to rank the most important CI sectors in their state (Step 1) and assess which of these sectors are the most conducive to different DG technologies (Step 2), and then move on to assessing what types of programs or policies could enable DG or CHP in these CI sectors. Cities and utilities may find it useful to move through all of the detailed steps to screen specific CI sites for individual DG technologies, such as CHP feasibility and cost-effectiveness.

Step 1: Identify and Rank Critical Infrastructure

The first step is to identify and rank the key CI sectors in the targeted region. This typically involves working with various stakeholder groups to determine a set of metrics to prioritize critical infrastructure sectors, with a vulnerability or risk assessment. Critical facilities can include both public and private sector buildings, which is often a consideration in the approach as well. Although approaches and metrics for each jurisdiction will differ depending on resiliency goals, the critical infrastructure sectors outlined by DHS offer a good starting point and provide information on which services are most important to maintain during an extended outage event. Users can use DHS sectors as starting point, and apply resiliency goals and criteria to each sector to help rank top CI sectors. The following table is an example of how NYSERDA approached evaluating the most critical sub-sectors to maintain during an emergency.

Consequence Category	Measurement Criteria
1. Human Impact	Measured in terms of the fatalities or injuries that could result if the critical asset is degraded or incapacitated by the worst reasonable case power outage
2. Economic Impact	Measured in terms of the direct and indirect effects on the economy (e.g., cost to rebuild asset, cost to respond to and recover from disaster, downstream costs resulting from disruption of product or service, long-term costs due to environmental damage) that could result if the critical asset is degraded or incapacitated by the worst reasonable case power outage
3. Impact on Public Confidence or Psychological Consequences	Measured in terms of the effect on public morale and confidence in national economic and political institutions that could result if the critical asset is degraded or incapacitated by the worst reasonable case power outage
4. Impact on Government Continuity	Measured in terms of the reduction in the ability of state and local governments to deliver minimum essential public services, ensure public health and safety, and carry out national security-related missions if the critical asset is degraded or incapacitated by the worst reasonable case power outage

The following list is an example of how a community might rank a list of top CI sectors, as a result from applying resiliency goals and criteria to the DHS CI sectors. (see Table 1 below).

DHS Critical Infrastructure Sectors

Chemicals	Financial Services
Commercial Facilities	Food & Agriculture
Communications	Government Facilities
Critical Manufacturing	Healthcare & Public Health
Dams	Information Technology
Defense Industrial Base	Nuclear Reactors, Materials/Waste
Emergency Services	Transportation Systems
Energy	Water & Wastewater

Table 1. Example of Critical Infrastructure Sector Ranking

Ranking	Critical Infrastructure Sector
1	Healthcare & Public Health
2	Water & Wastewater Treatment
3	Government Facilities
4	Energy
5	Financial Services

*Note: This is an example of what ranking CI sectors could look like and would likely be different for each user.

Examples of processes individual states have used to identify key CI sectors are shown below:

► Rhode Island Emergency Management Agency (RIMEA)

The Rhode Island Emergency Management Agency (RIMEA) used the framework developed by DHS to identify key critical infrastructure sectors in their [Rhode Island Critical Infrastructure Program Plan \(RCIPP\)](#)⁵⁵. RIMEA prioritized six lifeline sectors, created Sector-Specific Plans (SSPs) to identify interdependencies between sectors, and is currently creating a database of critical facilities throughout the state.

► Minnesota Department of Public Safety

Minnesota has developed a [Critical Infrastructure Protection Program](#)⁵⁶ through the Minnesota Department of Public Safety in order to protect, strengthen, and maintain critical infrastructure assets. The Homeland Security and Emergency Management (HSEM) division has prioritized five lifeline sectors in order to increase the safety and resiliency of assets within these sectors.

Step 2: Identify Critical Infrastructure Sub-Sectors Conducive to CHP, Solar + Storage, and Microgrids

The second step is to take the CI sector list in Step 1 and to identify the specific CI sub-sectors in that list that have the technical characteristics (e.g., potential electric and thermal loads) to support CHP, solar + storage, and/or microgrids, and eliminate other sectors/sub-sectors that do not. While most facilities currently rely on diesel generators for backup power in the event of a grid outage, there have been cases where diesel generators have not performed as expected for a variety of reasons. Therefore, this section will focus on technologies that can operate continuously and/or provide different types of benefits to CI facilities, such as CHP. Diesel generators can still provide the required backup power if engineered and configured correctly, but are not analyzed in this context.

⁵⁵ http://www.riema.ri.gov/resources/business/prepare/preparednessconference/files/Session_4_Critical_Infrastructure_Brief_for_August_Conference.pdf

⁵⁶ <https://dps.mn.gov/divisions/hsem/homeland-security/Pages/critical-infrastructure-key-resources.aspx>

► Sub-Sectors Conducive to CHP

The list of CI sub-sectors that generally have electric and thermal loads and other technical site characteristics conducive to CHP are listed in Table 2 below.

Table 2. Critical Infrastructure Sub-Sectors Conducive to CHP

Consequence Category	Measurement Criteria
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

Once the list of CI sub-sectors conducive to CHP has been determined, users can narrow it down further by identifying CHP opportunities at individual CI facilities in Step 3.

Step 3: Individual Site Assessment

The third step is to perform an individual site assessment for potential CI sites based on the conducive sub-sectors identified in Steps 1 & 2 above. The following tools can be used to screen individual CI sites for their potential to deploy CHP, solar + storage, and/or a microgrid for increasing energy resilience.

Users may choose to perform individual site screening assessments using the tools detailed (below), or learn more about individual DG technologies and the potential resilience benefits they may provide to individual CI sites (right).	Learn more about CHP⁵⁷ for Resilience
	Learn more about Solar + Storage⁵⁸ for Resilience
	Learn more about Microgrids⁵⁹ for Resilience

Individual Site Assessment Tools

- [CHP Site Screening Tool⁶⁰](#): The CHP Site Screening Tool is an excel-based tool that can provide an individual site screening assessment for CHP based on a variety of user inputs and pre-determined metrics.

⁵⁷ <https://resiliencyguide.dg.industrialenergytools.com/chp>

⁵⁸ <https://resiliencyguide.dg.industrialenergytools.com/solar>

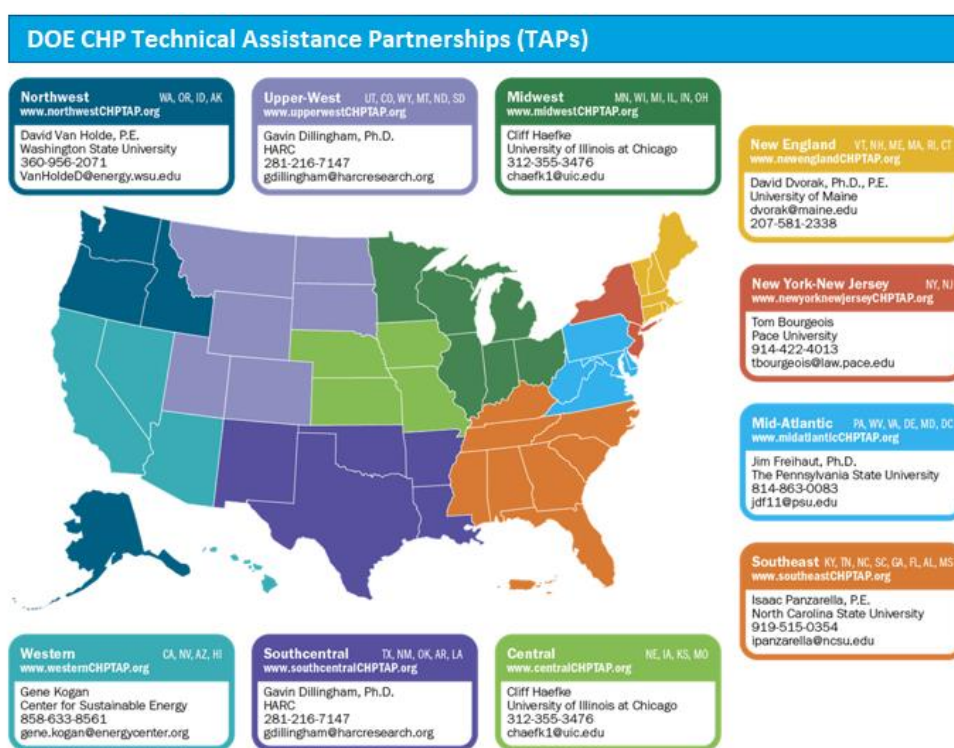
⁵⁹ <https://resiliencyguide.dg.industrialenergytools.com/microgrids>

⁶⁰ https://resiliencyguide.dg.industrialenergytools.com/CHP_for_Resilience_Screening_Tool.xlsm

- ▶ **Solar + Storage Screening Tool⁶¹**: NREL's REopt model is used to optimize energy systems for buildings, campuses, communities, and microgrids.
- ▶ **Microgrid Modeling Tools**: The CHP Site Screening Tool is an excel-based tool that can provide an individual site screening assessment for CHP based on a variety of user inputs and pre-determined metrics. ([HOMER Energy⁶²](#), [DER-CAM⁶³](#), [RETScreen⁶⁴](#))

Next Steps: Contact DOE CHP TAP for Further Analysis

Contact your CHP TAP⁶⁵ with sites identified for further analysis. If your facility received a payback of under 10 years and qualified as having either high (green) or medium (yellow) CHP potential, you should contact your CHP TAP. CHP TAPs can provide a more in-depth analysis and additional services, such as a qualification screening or feasibility analysis for individual sites. CHP TAPs can also provide additional resources for individual project implementation.



**DOE CHP Deployment
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www.energy.gov/chp-contacts

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⁶¹ <https://reopt.nrel.gov/tool>

⁶² <https://www.homerenergy.com/index.html>

⁶³ <https://building-microgrid.lbl.gov/projects/der-cam>

⁶⁴ <http://www.nrcan.gc.ca/energy/software-tools/7465>

⁶⁵ <https://energy.gov/eere/amo/chp-technical-assistance-partnerships-chp-taps>

Next Steps: Review Existing Policies and Develop New Programs

Now that you've defined which critical facilities are the highest priority, there are several ways you can take action to ensure state policies and programs support CHP deployment at these sites. By reviewing statutes and/or regulations already in place, state and local policymakers can ensure that policies are consistent with objectives to enhance the resiliency of critical infrastructure with CHP. States may also consider designing new programs targeting critical infrastructure applications. In this step, we provide policymakers and utility regulators with best practice policy recommendations to assist them in aligning key state policies to support CHP.

- ▶ Interconnection Standards
- ▶ Standby Rates
- ▶ Portfolio Standards
- ▶ State Efficiency and Clean Energy Programs
- ▶ Utility Incentive Programs
- ▶ Air Permitting
- ▶ Local Project Permitting and Codes

Interconnection

Standardized interconnection rules typically address the technical requirements and the application process for DG systems, including CHP, to connect to the electric grid. Most CHP systems are sized to provide a portion of the site's electrical needs, and the site continues to remain connected to the utility grid system for supplemental, standby, and backup power services, and, in select cases, for selling excess power.

A key element to the market success of CHP is the ability to safely, reliably, and economically interconnect with the existing utility grid system. Uncertainty in the cost, timing, and technical requirements of the grid interconnection process can be a barrier to increased deployment of CHP. While developing state standards or revising existing standards, the following elements have been used successfully by states across the country:

- ▶ **Appropriate interconnection fees.** High application and technical study fees associated with interconnection, along with high insurance requirements, can easily impair CHP project economics. Thus, some states have turned to a more effective approach—setting upper and lower bounds on application and study fees commensurate with the size of the system and potential safety impacts on the grid, and sometimes waiving application fees for small CHP systems completely. In general, interconnection fees should be just and reasonable and reflect the true costs of interconnection.
- ▶ **Streamlined procedures with decision tree screens (allowing faster application processing for smaller systems and those unlikely to produce significant system impacts).** A criticism of some state interconnection standards is the lengthy approval process and complicated application requirements. To facilitate rapid application turnaround, successful state interconnection standards have well-defined application processing timelines and simple decision trees that show, based on the system size and other characteristics, which interconnection procedures apply. For example, Colorado has a

streamlined process for systems up to 2 MW that involves several different screens to determine if more detailed review is needed. If a proposed project fails one of the screening tests the owner may have to pay for additional tests or move to the next level analysis.

- ▶ **Standardized Technical Requirements.** Standardization of technical and safety requirements ensures consistent safety for the utility, lessens the complexity of the interconnection process, and helps reduce costs for some project developers by alleviating the need to hire expert consultants. States commonly specify technical requirements based on national safety standards—IEEE 1547 and UL 1741—or use these two standards as a basis for developing their own requirements. These two standards focus on the technical specifications for, and testing of, the interconnection itself. They provide guidelines relating to the performance, operation, testing, safety considerations, and maintenance of the interconnection and form the basis of many state standards.
- ▶ **Standardized, simplified application forms and contracts.** Providing standardized and readily accessible interconnection application and contract forms to end-users and project developers is important. Standardized forms used by all utilities in the state helps state regulators assess the interconnection process and handle disputes, and also make it easier for project developers to comply with requirements. For example, Maryland’s interconnection application forms are limited to eight pages. Massachusetts proposed the creation of a uniform on-line interconnection application form, and California has a model interconnection application in investor-owned utilities to adopt.
- ▶ **Defined process to address disputes.** A defined process to address interconnection disputes between an end-user and a utility if an impasse is reached is important. Con Edison appointed a Distributed Generation Ombudsperson in 2002 in response to increased customer interest and the role was formalized in a 2005 order (CASE 04-E-0572) from the New York State Department of Public Service. Massachusetts has proposed requiring that an arbitrator is hired to resolve any disputes in its interconnection process. Other states have dispute resolution clauses in their interconnection standards including Hawaii, Colorado, and Maryland.
- ▶ **The ability for larger CHP systems and those not captured under net metering rules to qualify under the interconnection standards.** Some states only allow for relatively small systems to interconnect under streamlined standards, often assuming that smaller DG systems are more likely to produce power primarily for their own use. In states with a multi-tiered interconnection process, small systems that meet IEEE and UL standards or certification generally pass through the interconnection process faster, pay less in fees, and require less protection equipment because there are fewer technical concerns. However, restricting capacity limits for streamlined interconnection standards to only small systems does not help facilitate broad investment in all sizes of CHP in applications where it makes economic sense. State regulators can consider the size threshold for streamlined standards that is appropriate for their states.
- ▶ **Allow CHP systems to interconnect to both radial and network grids.** Network grids are present in many large cities where a significant amount of CHP potential exists. Interconnection, particularly in network or local distribution networks, present protection and grid operational challenges to address inadvertent back feed into the local grid that can cause safety concerns and failure to serve loads. However, with careful operational planning and system protection review, DG can be accommodated. It

is important to allow interconnection to both radial and network grids, with protections in place to minimize system impacts, in order to realize the full potential of CHP.

Interconnection Resources

- ▶ [SEE Action Guide to Successful Implementation of State CHP Policies](#)⁶⁶. Chapter 3 of this Guide, prepared by the State and Local Energy Efficiency Action Network (SEE Action), co-facilitated by the US DOE and the US EPA, provides an overview of issues associated with interconnection standards and provides additional detail on the key elements and approaches described above.
- ▶ [Interstate Renewable Energy Council’s Model Interconnection Procedures](#)⁶⁷. IREC’s Model Interconnection Procedures synthesize a number of best practices in the evolution of safe and reliable connecting to the utility grid. It is a free resource intended for states to use as they develop and/or refine their own rules for interconnection. The goals of the model procedures are to “streamline the regulatory process, save state resources, and avoid the need to reinvent the wheel on interconnection.”
- ▶ [Freeing the Grid: Best Practices in State Net Metering Policies and Interconnection Procedures](#)⁶⁸. Produced by IREC and Vote Solar, “Freeing the Grid” is an annual report card that rates all 50 states on net metering and interconnection standards. It is an online resource that includes best practice guidelines and an interactive map with state grades and recommendations designed to help state policy makers, regulators, advocates and other stakeholders easily understand and improve their policies.

Standby Rates

Standby rates are charges typically paid by commercial and industrial customers that operate onsite generation systems, but remain connected to the grid in order to access services from an electric utility such as supplemental, standby, and backup power. Without appropriately designed rate structures for these services, the financial viability of a CHP project can be significantly reduced.

The following features can be incorporated into a standby rate regime consistent with standard ratemaking principles, avoiding cost shifting from CHP customers to other customers, providing appropriate incentives to operate CHP facilities in a manner most efficient for the utility system as a whole, and aligning the economics for the CHP facility with the cost to serve that customer:

- ▶ **Reflect load diversity of CHP customers in charges for shared delivery facilities.** Charges for transmission facilities and shared distribution facilities such as substations and primary feeders should reflect that they are designed to serve customers with diverse loads. Load diversity can be recognized by designing demand charges on a coincident peak demand basis as well as the customer’s own peak demand and by allocating demand costs primarily or exclusively to usage during on-peak hours.
- ▶ **Allow the customer to provide the utility with a load reduction plan.** The plan should demonstrate its ability to reduce load within a required timeframe and at a specified amount to mitigate all, or a

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https://www4.eere.energy.gov/seeaction/system/files/documents/publications/chapters/see_action_chp_policies_guide_chap_3.pdf

⁶⁷ <http://www.irecusa.org/publications/model-interconnection-procedures/>

⁶⁸ <http://freeingthegrid.org/>

portion of, backup demand charges for local facilities. This allows the standby customer to use demand response to meet all, or a portion of, its standby needs.

- ▶ **In states with retail competition, offer a self-supply option for reserves.** This can be in the context of the load reduction plan discussed above, through utility-controlled interruptible load, or some other means that can both save costs for the customer and avoid costs for the utility. The self-supply plan can be structured to reflect actual performance of the customer over time.
- ▶ **Offer daily, or at least monthly, as-used demand charges for backup power and shared transmission and distribution facilities.** Moving away from annual ratcheted charges gives the CHP customer a chance to recover from an unscheduled outage without eroding savings for an entire year. Daily charges encourage customers to get their generators back online as quickly as possible.
- ▶ **In states with retail competition, allow customer-generators the option to buy all of their backup power at market prices.** The customer can avoid any utility reservation charge for generation service because the utility is relieved of the obligation to acquire capacity to supply energy during unscheduled outages of the customer's CHP unit.
- ▶ **Schedule maintenance service at nonpeak times.** In general, because this service can be scheduled for nonpeak times, it creates few additional or marginal costs to the utility's system, and tariffs can be structured to exempt the customer from capacity-related costs (e.g., reservation charges or ratchets, for either generation or delivery).
- ▶ **Provide an opportunity to purchase economic replacement power.** During times of the year when energy prices are low, the utility can provide on-site generators energy at market-based prices at a cost that is less than it costs to operate their CHP systems, and at no harm to other ratepayers. Such arrangements must be compatible with the structure of retail access programs, which the CHP customer may otherwise be relying on, and should allocate any incremental utility costs of purchasing such power (including general and administrative fees) to the CHP customer.

Standby Rates Resources

- ▶ [SEE Action Guide to Successful Implementation of State CHP Policies⁶⁹](#): Chapter 2 of this Guide, prepared by the State and Local Energy Efficiency Action Network (SEE Action), co-facilitated by the US DOE and the US EPA, provides a detailed explanation of what standby rates are, how they are designed, and how they can be improved. It explains successful implementation approaches by utilities operating in different states including Pacific Power (Oregon), ConEdison (New York), and Georgia Power (Georgia).
- ▶ [5 Lakes Energy "Apples to Apples" Standby Rate Analyses⁷⁰](#): 5 Lakes Energy has conducted several analyses of standby rates for Ohio, Minnesota, Michigan, and Pennsylvania that compares monthly bills across a variety of outage scenarios to demonstrate the impact of widely varying standby tariffs on

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https://www4.eere.energy.gov/seeaction/system/files/documents/publications/chapters/see_action_chp_policies_guide_chap_2.pdf

⁷⁰ <http://5lakesenergy.com/5-lakes-energy-apples-to-apples-standby-rate-analyses/>

current and potential CHP customers. [One of the studies](#)⁷¹ found that a Pennsylvania company with a 2 MW CHP system with no outages would be required to pay standby fees ranging from roughly \$5,200 to over \$11,500 each month in standby fees, depending on where the system is located. Findings from these studies have been considered by state regulators exploring best practices in standby rate design.

- ▶ [National Regulatory Research Institute's report, Electric Utility Standby Rates](#)⁷²: Updates for Today and Tomorrow. This paper reviews current practices for standby tariffs and presents options and recommendations about how to determine an appropriate standby rate, reflecting differences among generators (such as size and type of generator) and how the generators are regularly operated. In particular, it explores and reports on standby rates and differences between vertically integrated monopoly and competitive electricity markets.
- ▶ [Standby Rates for Customer-Sited Resources](#)⁷³: Issues, Considerations and the Elements of Model Tariffs. This report was prepared by Regulatory Assistance Project and ICF International for the U.S. Environmental Protection Agency's CHP Partnership. It provides a primer on the basics of electric service and rate design and a detailed assessment of the effects of three tariff existing designs on a prototype CHP facility in Oregon, New York, and Massachusetts. The report suggests features and approaches to standby rates that provide appropriate savings to DG customers and appropriate cost recovery to the utility.
- ▶ [Standby Rates for Combined Heat and Power Systems](#)⁷⁴: Economic Analysis and Recommendations for Five States. This report, prepared for Oak Ridge National Laboratory, presents the results of an analytical assessment of the rates, terms, and conditions for standby service for CHP systems in five states: Arkansas, Colorado, New Jersey, Ohio, and Utah. It sets forth options to improve tariffs analyzed and estimate the impact of these improvements for a set of utility customers with CHP systems.

Clean Energy Portfolio Standards

Clean energy portfolio standards, including energy efficiency resource standards and renewable energy portfolio standards, can be used by states to successfully increase the use of clean energy. A number of states have explicitly included CHP as an eligible resource within a portfolio standard, including renewable portfolio standards (RPS), energy efficiency resource standards (EERS), and alternative portfolio standards.

- ▶ **Renewable portfolio standard (RPS)** is the most common form of a portfolio standard and is usually focused on traditional renewable energy such as wind, solar, and biomass projects. This type of portfolio standard may incorporate other technologies and fuel types in addition to renewable energy and may have separate tiers or target mandates based on the form of generation. Connecticut is an example of a state with CHP included in an RPS.

⁷¹ https://alliance4industrialefficiency.org/wp-content/uploads/2017/06/AIE_Pennsylvania-PUC-Comments_Docket-M-20152518883_5.31.2017.pdf

⁷² http://www.michigan.gov/documents/energy/NRRI_Electric_Standby_Rates_419831_7.pdf

⁷³ https://www.epa.gov/sites/production/files/2015-10/documents/standby_rates.pdf

⁷⁴ <https://info.ornl.gov/sites/publications/files/pub47558.pdf>

- ▶ **Energy efficiency resource standards (EERS)** require utilities to save a certain amount of energy every year. To do this, utilities implement energy efficiency programs to help their customers save energy in their homes and businesses. Some states include CHP and other efficient distributed generation technologies. Many states have an EERS and a separate RPS, but some combine an RPS and EERS into one comprehensive portfolio standard program. Michigan is an example of a state with renewable energy standard (RES) that combines targets for renewable energy generation and energy savings requirements.
- ▶ **Alternative energy portfolio standards (APS)** often set targets for a certain percentage of a supplier's capacity or generation to come from alternative or advanced energy sources such as CHP, coal with carbon capture and storage (CCS), coal co-fired with biomass, or municipal solid waste projects. These standards are often market-based and credit eligible projects with alternative energy credits or some other form of credit, which can then be purchased by electricity suppliers to meet compliance obligations. Examples of states with APS' that include CHP are Massachusetts and Pennsylvania.

State regulators should focus on the following three implementation approaches when implementing CHP as a resource within a clean energy portfolio standard:

- ▶ **Qualifying resources definition—how CHP is defined.** A key component of CEPS is the definition of technologies and fuels that qualify towards compliance with the standard. This decision may be made in legislation or by the utility commission as part of implementing the standard, or by other policymakers. How CHP is defined in a CEPS varies by state. For instance, some state CEPS only allow for bottoming cycle CHP systems (waste heat recovery or waste heat to power) to qualify, some states allow for all types of CHP regardless of fuel type, whereas other standards may only allow for renewable-fueled CHP to qualify.
- ▶ **Minimum efficiency requirements or performance-based metrics.** An efficiency threshold for CHP projects is an important feature of incorporating CHP in CEPS. An appropriate eligibility threshold for CHP systems is one that is set high enough so that it is clear the CHP is achieving energy savings compared to separate heat and power, but not at a level that many CHP systems considered to be “high efficiency” would be excluded. Connecticut, Ohio, and Washington are examples of states with minimum efficiency requirements. As an overlay or as a stand-alone policy, progressive incentives for greater energy efficiency requirements in CEPS can also serve as a market driver for the development of systems with greater efficiency. For example, the Massachusetts Alternative Portfolio Standards uses a performance-based metric instead of a minimum efficiency threshold to encourage highly efficient CHP systems.
- ▶ **Separate, distinct targets for CHP and other technologies.** Establishing separate targets or tiers for different categories of resources ensures that a certain class of resource is not encouraged to the detriment of others. If a policy goal is to encourage diversity of supply, this can also help achieve the goal. The following are two state implementation approaches that have proven effective:
 - ▶ To set a separate tier for CHP and related energy efficiency technologies and require a specified percentage of the target to be met by each of these tiers (Connecticut's Class III and Pennsylvania's Tier II).

- ▶ To establish a separate portfolio standard program (distinct from the RPS) which is devoted to CHP and/or other energy efficiency technologies (Massachusetts' APS and Michigan's Energy Optimization Savings Standard).

Clean Energy Portfolio Standard Resources

- ▶ [SEE Action Guide to Successful Implementation of State CHP Policies](#)⁷⁵. Chapter 5 of this Guide, prepared by the State and Local Energy Efficiency Action Network (SEE Action), co-facilitated by the US DOE and the US EPA, provides an overview of portfolio standards and how states can use them to increase adoption of clean energy technologies, including CHP. It provides additional detail on the key elements and approaches described above, including a table detailing states with CHP eligibility in RPS, EERS, or APS and the characteristics of the policy.
- ▶ [Portfolio Standards and the Promotion of Combined Heat and Power](#)⁷⁶. This report, prepared for EPA's CHP Partnership, discusses the different ways CHP is incorporated in portfolio standards. It presents the basic portfolio standard design approaches, identifies key CHP-related issues for policymakers to consider when revising or developing portfolio standards, and provides state-specific information on existing standards that allow for CHP.
- ▶ [EPA's CHP Policies and Incentives Database \(dCHPP\)](#)⁷⁷. EPA's CHP Partnership maintains an online database that allows users to search for CHP policies and incentives by state, including portfolio standards. Entries include only those standards that specifically include CHP, which can help users find out if CHP is eligible for a portfolio standard in their state.

State Efficiency and Clean Energy Programs

States have used a number of policy instruments to provide financial support for distributed generation and CHP deployment. Policy and program options can include tax credits, bonds, loans or loan guarantees, project grants, and property assessed clean energy (PACE) programs. State efficiency and clean energy programs that are designed with broad applicability are most likely to encourage CHP and policymakers should consider developing eligibility criteria that can apply to a range of system sizes, allow all fuel types, and are not restricted to a single sector. The following describes each policy option and offers basic state examples.

- ▶ **Tax credits:** State or federal tax credits or favorable tax treatment can support CHP projects or activities, either specifically or where eligibility includes CHP. For example, in Florida, the purchase of eligible CHP equipment is exempt from the state's sales and use tax.
- ▶ **Bonds:** State or federal bonds can support CHP projects or activities by establishing a means to borrow capital for CHP projects at a fixed and often lower interest rate. For example, New Mexico's Clean Energy Revenue Bond Program, enacted in 2005, authorizes up to \$20 million in bonds to financing

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https://www4.eere.energy.gov/seeaction/system/files/documents/publications/chapters/see_action_chp_policies_guide_chap_5.pdf

⁷⁶ https://www.epa.gov/sites/production/files/2015-07/documents/portfolio_standards_and_the_promotion_of_combined_heat_and_power.pdf

⁷⁷ <https://www.epa.gov/chp/dchpp-chp-policies-and-incentives-database>

clean energy projects in state government agencies and schools, paid back to the bonding authoring using savings on energy bills.

- ▶ **Loans or loan guarantees:** State or federal loans can support CHP projects or activities (either specifically or where eligibility includes CHP) by financing the purchase of CHP systems and equipment, often at very low interest rates. For example, Connecticut's low-interest loan program, in effect since 2006, provides loans at a subsidized interest rate of 1 percent below the applicable rate or no more than the prime rate to customers for the installation of distributed generation systems, including CHP, with a capacity range of 50 kW or greater.
- ▶ **Grants:** State or federal grants can support CHP projects or activities by financing the development and purchase of CHP systems and equipment. For example, the Maryland Energy Administration provides grants up to \$500,000 per project to encourage the implementation of CHP at industrial and critical infrastructure facilities, including healthcare, wastewater treatment, and essential state and local government facilities. This state grant program is in addition to the utility incentive programs offered by Maryland electric utilities.
- ▶ **C-PACE:** Commercial Property Assessed Clean Energy (PACE) programs allow building owners to receive financing for eligible energy-saving measures that can include CHP, repaid as property tax assessments over a period of years. For example, San Francisco has a commercial PACE program called GreenFinanceSF, which offers loans of up to 10 percent of the assessed value of a property to eligible CHP systems.

State Efficiency and Clean Energy Programs Resources

- ▶ [EPA's Energy and Environment Guide to Action](#)⁷⁸. Chapter 6 of this guide provides in-depth information about CHP policies and programs that states are using to meeting their energy, environmental, and economic objectives. Table 6.1 summarizes each type of CHP-related policy, including incentives, currently in place in many states and classifies them into four categories: environmental, energy, financial, and utility.
- ▶ [EPA's CHP Policies and Incentives Database \(dCHPP\)](#)⁷⁹. EPA's CHP Partnership maintains an online database that allows users to search for CHP policies and incentives by state, including specific categories on bonds, C-PACE, grants/rebates, loans, and tax incentives. Entries include only those standards that specifically include CHP, which can help users find out if CHP is eligible for any of the state efficiency or clean energy programs described above.
- ▶ [Database of State Incentives for Renewables and Efficiency \(DSIRE\)](#)⁸⁰. The N.C. Clean Energy Technology Center administers an online database funded by DOE, providing comprehensive information on incentives and policies that support renewable energy and energy efficiency in the US. Users can select their state to identify what policies are in place and which technologies are eligible.

⁷⁸ <https://www.epa.gov/statelocalenergy/energy-and-environment-guide-action-chapter-6-policy-considerations-combined-heat>

⁷⁹ <https://www.epa.gov/chp/dchpp-chp-policies-and-incentives-database>

⁸⁰ <http://www.dsireusa.org/>

Utility Incentive Programs

States can encourage utilities to develop and implement CHP-specific incentive programs within their portfolio of energy efficiency programs. Many utilities consider CHP as an available efficiency measure in their “custom” programs for commercial and industrial (C&I) customers. However, this approach may not be sufficient to significantly encourage the adoption of CHP. CHP is typically more capital-intensive than other C&I efficiency measures and involves more complex procedures like environmental permitting, interconnection applications, feasibility assessments and other procedures that simpler measures do not require. Expertise in navigating this complex process is key to CHP adoption, which is why some states have encourage their utilities to develop standalone CHP programs that can provide this focused expertise.

There are a number of different CHP program incentives structures, eligibility requirements, and design parameters, but utilities with specific CHP programs in their energy efficiency portfolio share several common incentive structures. Utilities typically offer two major types of incentives for CHP programs; capacity incentives and production incentives.

- ▶ **Capacity incentives.** Capacity incentives are typically issued on a \$/kW basis to help buy down the initial capital outlay for a customer. Systems must typically meet a minimum efficiency requirement to qualify for the incentive. Utilities may offer capacity incentives of different amounts at different stages throughout project development:
 - ▶ *Design Phase* – Design capacity incentives are issued upon submission of a commitment letter and review of system design specifications. This model helps to not only lower the initial capital outlay for a customer, but also lower the project risk. This type of incentive is the simplest to administer, as it requires only a review of design specifications and performance estimates. For example, ComEd, the largest electric utility in Illinois, offers a few interesting variations on a standard design incentive, for example, offering to pay 50% of the cost of a feasibility assessment and 50% of an interconnection fee—up to a cap.
 - ▶ *Installation Phase* – Installation capacity incentives are issued upon system commissioning and inspection. These incentives are typically issued in a tiered system based on project size. For example, Baltimore Gas & Electric (BG&E) and Pepco are two utilities in Maryland that offer this incentive. Separating the design and installation incentives into two parts adds some administrative complexity, but ensures that the system is installed according to the design specifications.
- ▶ **Production incentives.** Production Incentives are issued on a \$/kWh basis for electricity that is produced for a certain period of time after the system is operational. Typical timeframes for production incentives are in the range of 18 months to 5 years. These incentives help ensure that the system is operated efficiently and properly maintained. While production incentives do not help with the barrier of high upfront capital investments for CHP, they do provide a guaranteed cash flow for the project after it becomes operational and meets the measurement and verification requirements.

More than 20 utilities currently administer CHP incentive programs, including:

- ▶ [AEP Ohio⁸¹](#)

⁸¹ <https://www.aepohio.com/save/business/programs/CombinedHeatandPower.aspx>

- ▶ [Baltimore Gas and Electric](#)⁸²
- ▶ [Commonwealth Edison](#)⁸³
- ▶ [Consolidated Edison](#)⁸⁴
- ▶ [Delmarva Power](#)⁸⁵
- ▶ [Dayton Power and Light](#)⁸⁶
- ▶ [Eversource](#)⁸⁷
- ▶ [FirstEnergy's Pennsylvania Utilities](#)⁸⁸
- ▶ [National Grid \(Massachusetts\)](#)⁸⁹
- ▶ [National Grid \(Rhode Island\)](#)⁹⁰
- ▶ [Nicor Gas](#)⁹¹
- ▶ [PECO](#)⁹²
- ▶ [Pepco](#)⁹³
- ▶ [Pacific Gas and Electric](#)⁹⁴
- ▶ [Philadelphia Gas Works](#)⁹⁵
- ▶ [PPL Electric Utilities](#)⁹⁶
- ▶ [Puget Sound Energy](#)⁹⁷
- ▶ [Southern California Edison](#)⁹⁸

⁸² <http://bgesmartenergy.com/business/chp>

⁸³ <https://www.comed.com/WaysToSave/ForYourBusiness/Pages/factsheets/CHPFactSheet.aspx>

⁸⁴ <https://www.coned.com/-/media/files/coned/documents/save-energy-money/rebates-incentives-tax-credits/rebates-incentives-tax-credits-for-commercial-industrial-buildings-customers/commercial-and-industrial-program/combined-heat-and-power-program.pdf?la=en>

⁸⁵ <https://cienergyefficiency.delmarva.com/CombinedHeat.aspx>

⁸⁶ <https://www.dpandl.com/save-money/business-government/custom-rebates/chp-rebates/>

⁸⁷ <https://www.masssave.com/en/learn/business/combined-heat-and-power>

⁸⁸ <https://energysavepa-business.com/combined-heat-power/>

⁸⁹ <https://www.masssave.com/en/learn/business/combined-heat-and-power>

⁹⁰ <https://www.nationalgridus.com/RI-Business/Energy-Saving-Programs/Cogeneration>

⁹¹ <https://www.nicorgasrebates.com/your-business/custom-incentive/Combined-Heat-and-Power>

⁹² <https://www.peco.com/WaysToSave/ForYourBusiness/Pages/CombinedHeatPower.aspx>

⁹³ <https://cienergyefficiency.pepco.com/combinedHeat.aspx>

⁹⁴ https://www.pge.com/en_US/business/solar-and-vehicles/your-options/solar-programs/self-generation-incentive-program/self-generation-incentive-program.page?WT.mc_id=Vanity_sgip

⁹⁵ <https://www.pgworks.com/business/fueling-the-future/combined-heat-power>

⁹⁶ <https://www.pplelectricbusinesssavings.com/rebates/combined-heating-and-power>

⁹⁷ <https://www.pse.com/rebates/combined-heat-and-power>

⁹⁸ <https://www.sce.com/procurement/solicitations/chp>

- ▶ [San Diego Gas and Electric](#)⁹⁹
- ▶ [Southern California Gas Company](#)¹⁰⁰
- ▶ [Southwest Gas](#)¹⁰¹
- ▶ [UGI Utilities](#)¹⁰²

Utility Incentive Program Resources

- ▶ [Utility Combined Heat and Power Programs—the Hot New Trend in Efficiency](#)¹⁰³. This whitepaper prepared by ICF International helps explain why a utility should consider including CHP as part of an energy efficiency portfolio and describes different program and design options available to utilities. In addition, it provides an example utility CHP program structure and shares ideas about how a utility can go about setting up a program.
- ▶ [EPA’s report on Utility Incentives for CHP](#)¹⁰⁴. This report describes the results of EPA’s research and analysis into utility incentives for CHP. It provides information about utility-initiated policies, programs, and incentives. It was prepared in 2008 and may provide useful historical information.
- ▶ [EPA’s CHP Policies and Incentives Database \(dCHPP\)](#)¹⁰⁵. EPA’s CHP Partnership maintains an online database that allows users to search for CHP policies and incentives by state, including a specific category on grants/rebates, which includes disbursements of money from utilities. Entries include only those standards that specifically include CHP, which can help users to find out if any utilities are offering CHP programs in their state.

Air Permitting

To ensure CHP systems are in compliance with air quality standards, a facility, in consultation with the state or local permitting agency, reviews air permitting requirements and must obtain a permit before the system is installed and operated. The process for obtaining air permits can be time-consuming and resource-intensive, so several states have introduced procedures to simplify and speed up the permitting process for certain types of CHP units. Another tool for encouraging CHP deployment is the development of output-based emissions regulations, which recognize the efficiency and environmental benefits of CHP when regulating their emissions. States should consider the following options for air permitting policy options that can support CHP:

- ▶ **Streamlined permitting procedures.** States may choose to develop alternatives to conventional air permits that streamline the permitting process for both the permitting authority and the facility being regulated. The purpose is to reduce the time and cost involved in permitting for eligible CHP units by consistently applying requirements that are predetermined by the state, although they may not apply to

⁹⁹ <https://www.sdge.com/2015-request-offers-seeking-chp-power-purchase-agreements>

¹⁰⁰ <https://www.socalgas.com/for-your-business/power-generation/self-generation-incentive>

¹⁰¹ <https://www.swgas.com/en/rebate/arizona-combined-heat-and-power-program-business>

¹⁰² <https://www.ugi.com/gas-for-business/gas-equipment/chp/>

¹⁰³ <https://www.icf.com/resources/white-papers/2017/utility-combined-heat-and-power-programs-the-hot-new-trend-in-efficiency>

¹⁰⁴ https://www.epa.gov/sites/production/files/2015-07/documents/utility_incentives_for_combined_heat_and_power.pdf

¹⁰⁵ <https://www.epa.gov/chp/dchpp-chp-policies-and-incentives-database>

all CHP prime movers and fuel types. There are two approaches to streamlining permitting procedures – permits-by-rule and general permits – which are designed similarly but implemented differently.

- ▶ *Permits-by-rule (PBRs)* - PBRs are established as part of a state's regulations. Facilities that elect to obtain a PBR notify the permitting authority that they are utilizing the PBR and agree to comply with all of the requirements of the PBR. There is no permit application, no permit development process, and no public notice period. Sources are not issued a PBR; instead, they construct and operate under the requirements of the regulation. A source constructed and operated under a PBR is required to notify or register with the permitting authority. Procedures vary, and at times, an approval is not necessary.
- ▶ *General permit (GPs)* - GPs are developed according to procedures found in state regulations and can be expeditiously approved to permit a specific system. However, sources applying for a GP may need to wait for approval depending on the state permit jurisdiction.
- ▶ **Output-based emissions regulations (OBRs).** States have found that OBRs can be effective tools for promoting CHP by relating emissions to the productive output of the energy-consuming process, instead of the amount of fuel burned. OBRs define emissions limits based on the amount of pollution produced per unit of useful output, accounting for the unit's efficiency (e.g., pounds of sulfur dioxide per MWh of electricity). By contrast, input-based regulations are based on the amount of fuel burned and do not reflect a unit's efficiency. Electricity generation technologies, including CHP, have traditionally been subject to input-based emissions regulations, but OBR can be used to credit all of the useful energy generated. For CHP system owners, OBR can provide greater flexibility and lower compliance costs by accounting for both the thermal and electric energy they produce. As of December 2014, 19 states have adopted some form of output-based regulation. The steps for developing an output-based emission standard are:
 - ▶ *Develop the output-based emission limit.* The method that is used will depend on whether or not measured energy output data are available.
 - ▶ *Specify a gross or net energy output format.* Net energy output more comprehensively accounts for energy efficiency, but can increase the complexity of compliance monitoring requirements.
 - ▶ *Specify compliance measurement methods.* Output-based standards require designating methods for monitoring electrical, thermal, and mechanical outputs. Instruments to continuously monitor and record energy output are routinely used and are commercially available at a reasonable cost.

Air Permitting Resources

- ▶ [EPA's Fact Sheet on "Approaches to Streamline Air Permitting for CHP: Permits by Rule and General Permits."](#)¹⁰⁶ This fact sheet provides background and a description of the process for developing streamlined air permitting through permit by rule and general permits. It summarizes the permit by rule and general permit programs developed in Connecticut, New Jersey, and Texas based on interviews

¹⁰⁶ https://www.epa.gov/sites/production/files/2015-07/documents/approaches_to_streamline_air_permitting_for_combined_heat_and_power_permits_by_rule_and_general_permits.pdf

with representatives from those states. Research documents reasons for developing expedited permitting programs, the processes they followed to develop them, the requirements they established, and observations on the process and outcomes achieved.

- ▶ [EPA's Handbook for Air Regulators on Output-Based Regulations](#)¹⁰⁷. The EPA's CHP Partnership developed this handbook to assist air regulators in developing emission regulations that recognize the pollution prevention benefits of energy-efficient generation and renewable energy technologies. It describes output-based regulations, explains the benefits, shows how to develop an output-based standard or how to comply with one, and provides a catalogue of the current use of output-based regulations for combustion sources.

Local project Permitting and Codes

When installing a CHP system, facilities are required to obtain permits from local authorities to ensure it is constructed and operated in compliance with local and state regulations. The number of permits and approvals will vary depending on project characteristics such as the size and complexity of a project, the geographic location, the extent of other infrastructure modifications (e.g., gas pipeline, distribution), and the potential environmental impacts of construction and operations. Coordination with local agencies, such as the city or county planning agency, fire department/authority, building department, environmental health department, and others is needed. However, many local agencies have limited to no experience with CHP projects, which can create delays or difficulties in the CHP project development process. Policy makers can help streamline CHP installations by including education about CHP during permitting codes and inspector training.

Local project Permitting and Codes Resources

- ▶ [EPA's Procurement Guide: CHP Siting and Permitting Requirements](#)¹⁰⁸. The EPA's CHP Partnership developed this guide to help explain the essential steps in permitting and siting CHP systems. It documents the typical types of permits or approvals that are required, describes the overall permitting process and goes in depth in several key areas. Section 5 focuses on "Local Zoning/Planning Requirements," and discusses the local regulatory agencies that may be involved in permitting a CHP project.

¹⁰⁷ https://www.epa.gov/sites/production/files/2015-07/documents/output-based_regulations_a_handbook_for_air_regulators.pdf

¹⁰⁸ https://www.epa.gov/sites/production/files/2015-07/documents/procurement_guide_chp_siting_and_permitting_requirements.pdf

Resource Library

U.S. DOE CHP Deployment Program

This program from the Department of Energy's Advanced Manufacturing Office provides technical assistance and information on CHP markets, applications and technologies. Read about the key services of DOE's CHP Deployment program in this [fact sheet](#)¹⁰⁹.

U.S. EPA CHP Partnership

The EPA hosts a voluntary [partnership program](#)¹¹⁰ to promote the use of CHP in order to reduce air pollution and water usage associated with electric power generation. The website contains several documents and tools, including a database of policies and incentives for CHP.

CHP Project Development Resources

There are several steps in the process of developing a CHP project, from making a preliminary assessment to actually building and operating a system. The following resources provide additional information about the CHP project development process:

- ▶ [DOE's CHP Technical Assistance Partnerships \(CHP TAPs\)](#)¹¹¹ – The CHP TAPs assist end-users with project development from initial CHP screening to installation.
- ▶ [EPA Project Development Guide](#)¹¹² – EPA's CHP Partnership offers a guide to development of CHP projects with a detailed description of each of the five steps in the process including: qualification, level 1 feasibility analysis, level 2 feasibility analysis.
- ▶ [DOE's CHP Project Profiles](#)¹¹³ – DOE maintains a database of two-page summaries profiling real world CHP projects with detailed information about system design, project costs, annual energy savings, environmental benefits and more.
- ▶ [CHP in CI Case Studies](#)¹¹⁴ – Selected case studies are highlighted to identify examples of CHP providing benefits to critical infrastructure facilities.

CHP Technologies

For more information on CHP technologies, benefits, and other key details, please see the resources listed below:

- ▶ **CHP Technology Fact Sheet Series from the DOE CHP Deployment Program**
 - ▶ [Reciprocating Engine Fact Sheet](#)¹¹⁵

¹⁰⁹ https://energy.gov/sites/prod/files/2017/05/f34/CHP_deployment_program_fact_sheet_051117_compliant.pdf

¹¹⁰ <https://www.epa.gov/chp>

¹¹¹ <https://energy.gov/eere/amo/chp-technical-assistance-partnerships-chp-taps>

¹¹² <https://www.epa.gov/chp/chp-project-development-steps>

¹¹³ https://www1.eere.energy.gov/manufacturing/distributedenergy/chp_database/

¹¹⁴ <https://resilienceguide.dg.industrialenergytools.com/caseStudies>

¹¹⁵ <https://energy.gov/eere/amo/downloads/reciprocating-engines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

- ▶ [Gas Turbine Fact Sheet¹¹⁶](#)
- ▶ [Microturbine Fact Sheet¹¹⁷](#)
- ▶ [Fuel Cell Fact Sheet¹¹⁸](#)
- ▶ [Steam Turbine Fact Sheet¹¹⁹](#)
- ▶ [Absorption Chiller Fact Sheet¹²⁰](#)
- ▶ [Catalog of CHP Technologies¹²¹](#) – This report provides an overview of how CHP systems work and the key concepts of efficiency and power-to-heat ratios. It also provides information and performance characteristics of five commercially available CHP prime movers.
- ▶ [Calculating CHP Emissions Reductions¹²²](#) – The EPA’s CHP Energy and Emissions Savings Calculator is an Excel-based tool that can be used to estimate the energy and emissions savings associated with any U.S. CHP installation.
- ▶ [Calculating CHP Efficiency¹²³](#) – EPA describes two methods for calculating CHP efficiency: total system efficiency and effective electric efficiency.

CHP Policy Resources

- ▶ [EPA CHP Policies and Incentives Database¹²⁴](#) – The EPA maintains a database of policies and incentives that are applicable to CHP.
- ▶ [SEE Action Guide to Successful Implementation of State Combined Heat and Power Policies¹²⁵](#) – Informs state utility regulators and other state policymakers with actionable information to assist them in implementing key state policies that impact CHP.
- ▶ [ACEEE Policies and Resources for CHP Deployment¹²⁶](#) – Provides technical resources and practical information to help states address key CHP policy factors.

¹¹⁶ <https://energy.gov/eere/amo/downloads/gas-turbines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹¹⁷ <https://energy.gov/eere/amo/downloads/microturbines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹¹⁸ <https://energy.gov/eere/amo/downloads/fuel-cells-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹¹⁹ <https://www.energy.gov/eere/amo/downloads/steam-turbines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹²⁰ <https://energy.gov/eere/amo/downloads/absorption-chillers-chp-systems-doe-chp-technology-fact-sheet-series-fact-sheet>

¹²¹ <https://www.epa.gov/chp/catalog-chp-technologies>

¹²² <https://www.epa.gov/chp/chp-energy-and-emissions-savings-calculator>

¹²³ <https://www.epa.gov/chp/methods-calculating-chp-efficiency>

¹²⁴ <https://www.epa.gov/chp/dchpp-chp-policies-and-incentives-database>

¹²⁵ <https://www4.eere.energy.gov/seeaction/publication/guide-successful-implementation-state-combined-heat-and-power-policies>

¹²⁶ <http://aceee.org/sector/state-policy/toolkit/chp>

Energy Planning Resources

- ▶ [Microgrid Design Toolkit \(MDT\)](#)¹²⁷ - A software tool that assists microgrid designers in the preliminary stages of microgrid design. The model uses user-defined objectives focused on the cost, performance, and reliability of various DERs.
- ▶ [Distributed Energy Resources Customer Adoption Model \(DER-CAM\)](#)¹²⁸ - A customer adoption model of DER based on economic, technical, and environmental metrics. The model aims to minimize the cost of operating distributed generation resources, including CHP.
- ▶ [Interruption Cost Estimator](#)¹²⁹ - Developed by LBNL, the ICE tool is designed for reliability planners, but can provide estimates for the cost per interruption of an outage event and the total cost of sustained electric power interruptions.
- ▶ [RETScreen](#)¹³⁰ - Developed by Natural Resources Canada, software system that provides project feasibility and energy performance analysis for energy efficiency, renewable energy, and cogeneration projects.
- ▶ [2015 Energy Sector-Specific Plan](#)¹³¹ - This section of the DHS NIPP provides information with regards to resilience planning for critical infrastructure facilities specific to the energy sector.

Resilience Planning Resources

- ▶ [NIPP Critical Infrastructure Plan](#)¹³² – This report provides information about critical infrastructure sectors that are of concern to national security, and a vision, mission, and goals focused on risk management to influence future critical infrastructure security and resiliency planning.
- ▶ [2015 Energy Sector-Specific Plan](#)¹³³ - This section of the DHS NIPP provides information with regards to resilience planning for critical infrastructure facilities specific to the energy sector.
- ▶ [City of New Orleans Resilience Plan](#)¹³⁴ - The City of New Orleans is assessing the risks of energy outages to critical infrastructure systems and conducting feasibility studies for backup generation or microgrids as part of its plan, Resilient New Orleans.
- ▶ [Connecticut Comprehensive Energy Strategy](#)¹³⁵ - The state of Connecticut addresses a number of resilience objectives in its Comprehensive Energy Strategy, including promoting programs that would keep critical facilities and core services in cities and town.

¹²⁷ <http://www.sandia.gov/CSR/tools/mdt.html>

¹²⁸ <https://building-microgrid.lbl.gov/projects/der-cam>

¹²⁹ <https://icecalculator.com/home>

¹³⁰ <http://www.nrcan.gc.ca/energy/software-tools/7465>

¹³¹ <https://www.dhs.gov/publication/nipp-ssp-energy-2015>

¹³² <https://www.dhs.gov/sites/default/files/publications/national-infrastructure-protection-plan-2013-508.pdf>

¹³³ <https://www.dhs.gov/publication/nipp-ssp-energy-2015>

¹³⁴ <http://resilientnola.org/>

¹³⁵ http://www.ct.gov/deep/lib/deep/energy/ces/2017_draft_comprehensiveenergystrategy.pdf

Healthcare Sector Resources

- ▶ [DHS Best Practices Guide](#)¹³⁶ – DHS developed a best practice guide to assist healthcare providers in pursuing resilient infrastructure options, which highlight CHP and other onsite generation options to increase energy security and reliability.
- ▶ [Healthcare Without Harm Resilience Report](#)¹³⁷ - Healthcare Without Harm's report details resilience changes that healthcare providers could make to be better prepared for future natural disasters and stronger storms.

Additional Resources

- ▶ [CHP Technical Potential in the US](#)¹³⁸ – This market analysis report provides data on the technical potential in industrial facilities and commercial buildings for “topping cycle” CHP, waste heat to power CHP (WHP CHP), and district energy CHP in the U.S.
- ▶ [CHP Installation Database](#)¹³⁹ – The DOE maintains a comprehensive database of all U.S. CHP installations, updated monthly.

¹³⁶ [https://toolkit.climate.gov/sites/default/files/SCRHCFI Best Practices Report final2 2014 Web.pdf](https://toolkit.climate.gov/sites/default/files/SCRHCFI%20Best%20Practices%20Report%20final2%202014%20Web.pdf)

¹³⁷ [https://noharm-uscanada.org/sites/default/files/documents-files/5146/Safe Haven.pdf](https://noharm-uscanada.org/sites/default/files/documents-files/5146/Safe%20Haven.pdf)

¹³⁸ <https://www.energy.gov/eere/amo/downloads/new-release-us-doe-analysis-combined-heat-and-power-chp-technical-potential>

¹³⁹ <https://energy.gov/chp-installs>

Critical Infrastructure (CI) 101

Critical Infrastructure Background

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. The Department of Homeland Security (DHS) has identified [16 critical infrastructure sectors](#)¹⁴⁰, each consisting of multiple sub-sectors, which provide security and safety services. The importance of resilience in these sectors and their sub-sectors is compounded by the interdependencies between them. For example, hospitals and nursing homes, which are significant components of the Public Health Sector, are dependent on the Chemical Sector for pharmaceuticals. The Chemical Sector is dependent on the Transportation Sector to move supplies and products. The Transportation Sector is dependent on the Energy Sector for fuel, and each of the 16 sectors is in some way dependent on the Energy Sector for electricity. Many examples confirm these interdependencies among critical infrastructure sectors, which is why the resilience of the assets, systems, and functions in these sectors is so important. The DHS has developed [sector-specific plans](#)¹⁴¹ for assessing, analyzing, and managing risks in each of the 16 sectors. Resilience plans vary across the sectors and subsectors depending on their unique attributes and requirements.

The DHS critical infrastructure sectors are detailed below:

Chemicals

The chemicals sector converts various raw materials into more than 70,000 diverse products that are essential to modern life. Based on the end product produced, the sector can be divided into five main segments: basic chemicals, specialty chemicals, agricultural chemicals, pharmaceuticals, and consumer products.

Commercial Facilities

The Commercial Facilities Sector includes a diverse range of sites that draw large crowds of people for shopping, business, entertainment, or lodging. It consists of eight subsectors: entertainment and media, gaming, lodging, outdoor events, public assembly, real estate, retail, and sports leagues.

Communications

The Communications Sector is a diverse, competitive, and interconnected industry using terrestrial, satellite, and wireless transmission systems. The transmission of these services has become interconnected; satellite, wireless, and wireline providers depend on each other to carry and terminate their traffic and companies routinely share facilities and technology to ensure interoperability.

Critical Manufacturing

The Critical Manufacturing Sector consists of four subsectors: primary metals, machinery, electrical equipment, appliance and components, and transportation equipment. Products made by these manufacturing industries are essential to many other critical infrastructure sectors.

¹⁴⁰ <https://www.dhs.gov/critical-infrastructure-sectors>

¹⁴¹ <https://www.dhs.gov/2015-sector-specific-plans>

Dams

The Dams Sector delivers critical water retention and control services in the United States, including hydroelectric power generation, municipal and industrial water supplies, agricultural irrigation, sediment and flood control, river navigation for inland bulk shipping, industrial waste management, and recreation.

Defense Industrial Base

The Defense Industrial Base Sector is the worldwide industrial complex that enables research and development, as well as design, production, delivery, and maintenance of military weapons systems, subsystems, and components or parts, to meet U.S. military requirements.

Emergency Services

The Emergency Services Sector includes geographically distributed facilities and equipment in both paid and volunteer capacities organized primarily at the federal, state, local, tribal, and territorial levels of government. The Emergency Services Sector is composed of five distinct disciplines: law enforcement, fire and rescue services, emergency medical services, emergency management, and public works.

Energy

The Energy Sector consists of infrastructure assets in electricity, oil, and natural gas. Virtually all industries and critical infrastructure assets rely on electric power and fuels for critical power and energy needs.

Financial Services

The Financial Services Sector includes thousands of depository institutions, providers of investment products, insurance companies, other credit and financing organizations, and the providers of the critical financial utilities and services that support these functions.

Government Facilities

The Government Facilities Sector includes a wide variety of buildings, located in the United States and overseas, that are owned or leased by federal, state, local, and tribal governments. These facilities include general-use office buildings and special-use military installations, embassies, courthouses, national laboratories, and structures that may house critical equipment, systems, networks, and functions.

Healthcare and Public Health

The Healthcare and Public Health Sector includes not only acute care hospitals and ambulatory healthcare, but also the vast and complex public-private systems that finance that care. It incorporates a large system of private sector enterprises that manufacture, distribute, and sell drugs, vaccines, and medical supplies and equipment, as well as a network of small businesses that provide mortuary services.

Information Technology

The Information Technology Sector is comprised of small and medium businesses, as well as large multinational companies. The IT Sector is a functions-based Sector that comprises not only physical assets such as data centers, but also virtual systems and networks that enable key capabilities and services in both the public and private sectors.

Nuclear Reactors, Materials, and Waste

The Nuclear Reactors, Materials, and Waste Sector includes 99 active and 18 decommissioning power reactors, 31 research and test reactors, and 8 active nuclear fuel cycle facilities.

Transportation Systems

The Transportation Systems Sector includes a variety of assets and organizations that comprise the nation's transportation system. It consists of seven subsectors: aviation, highways and motor carrier, maritime transportation, mass transit and passenger rail, pipeline systems, freight rail, and postal and shipping.

Waste and Wastewater

The Water and Wastewater Sector includes assets vital to providing safe drinking water and properly treating wastewater. This sector includes public drinking water systems and wastewater treatment plants.

Some definitions of critical infrastructure are narrower than the DHS NIPP, and may focus on public health and safety at the state or local level, rather than national and economic security. To that end, many cities and states have created their own resilience plans that also include specific strategies to address critical infrastructure. For example, the City of New Orleans is assessing the risks of energy outages to critical infrastructure systems and conducting feasibility studies for backup generation or microgrids as part of its plan, [Resilient New Orleans](#)¹⁴². Similarly, the state of Connecticut addresses a number of resilience objectives in its [Comprehensive Energy Strategy](#)¹⁴³, including promoting programs that would keep critical facilities and core services in cities and towns operating when the grid goes down. Additional information and examples of critical infrastructure resilience planning strategies can be found in under the [Resilience Planning](#)¹⁴⁴ section of the [Decision Makers](#)¹⁴⁵ page.

One key sector that has increased its focus on enhancing overall resilience in buildings and campus settings is the healthcare industry. The U.S. DHS provided a [best practices](#)¹⁴⁶ document in 2014 to assist healthcare providers in pursuing resilient healthcare infrastructure options, which highlight DG and CHP options to increase energy security and reliability. Healthcare Without Harm also recently published a [report](#)¹⁴⁷ detailing resilience changes that healthcare providers could make to be better prepared for future natural disasters and stronger storms.

Critical Infrastructure Planning in the Energy Sector

In addition, the [2015 Energy Sector-Specific Plan](#)¹⁴⁸, created by DOE, provides information for critical infrastructure resilience planning specific to the energy sector. The report details the energy sector's security and resilience goals and identifies strategic partnerships and risk management strategies for critical energy infrastructure in the future. The report also identifies approximately 170 activities and

¹⁴² <http://resilientnola.org/>

¹⁴³ http://www.ct.gov/deep/lib/deep/energy/ces/2017_draft_comprehensiveenergystrategy.pdf

¹⁴⁴ <https://resiliencguide.dg.industrialenergytools.com/decisionMakers#Resilience%20Planning>

¹⁴⁵ <https://resiliencguide.dg.industrialenergytools.com/decisionMakers>

¹⁴⁶ https://toolkit.climate.gov/sites/default/files/SCRHCFI_Best_Practices_Report_final2_2014_Web.pdf

¹⁴⁷ <https://noharm-uscanada.org/sites/default/files/documents-files/5146/Safe%20Haven.pdf>

¹⁴⁸ <https://www.dhs.gov/publication/nipp-ssp-energy-2015>

programs that could be useful for individuals and/or stakeholders interested in improving critical energy infrastructure. The activities and programs support the national critical energy infrastructure goals and have been developed by a variety of public and private organizations across the country.

The National Association of State Energy Officials (NASEO) [Energy Security Committee on Energy Assurance Planning](#)¹⁴⁹ also provides a number of resources on protecting and hardening critical energy infrastructure, energy assurance planning, and enhancing grid resilience efforts.

¹⁴⁹ <http://www.naseo.org/energyassurance>

Combined Heat and Power (CHP) 101

CHP Basics

Combined heat and power (CHP), also known as cogeneration, produces both electricity and thermal energy on-site, replacing or supplementing electricity provided from a local utility and fuel burned in an on-site boiler or furnace. CHP systems can be designed to operate independently from the electric grid providing reliable power and thermal energy to keep critical facilities running during grid outages. CHP systems increase energy security by producing energy at the point of use, and are generally 40% to 60% more efficient than non-CHP energy. The [deployment of CHP¹⁵⁰](#) is driven by several factors, including:

CHP User Benefits	CHP National/Regional Benefits
Decreases energy costs	Typically utilizes abundant domestic natural gas or opportunity fuels, such as biogas or wood waste
Enhanced energy resiliency	Increases energy resiliency of critical infrastructure and operations
Reduced risk from volatile energy prices	Enhances electric grid reliability
Increased economic competitiveness	Supports local economic growth and competitiveness

Combined heat and power (CHP) systems are a highly efficient form of distributed generation, typically designed to power a single large building, campus, or group of facilities. These systems comprise on-site electrical generators (primarily fueled with natural gas, but biomass-fed systems may be feasible in some locations) that achieve high efficiency by capturing heat, a byproduct of electricity production that would otherwise be wasted. The captured heat can be used to provide steam or hot water to the facility. Capturing and using the waste heat allows CHP systems to reach fuel efficiencies of 75% or higher, compared to about 50% for the combination of utility-delivered power and an on-site boiler (see Figure 1). This efficient operation is both environmentally and economically advantageous. CHP systems can use the existing, centralized electricity grid as a backup source to meet peak electricity needs and provide power when the CHP system is down for maintenance or in an emergency outage. If the electricity grid is impaired, a properly configured CHP system will continue to operate, ensuring an uninterrupted supply of electricity and thermal services to the host facility. More information on CHP basics and benefits can be found through the [DOE's CHP Deployment Program¹⁵¹](#) and the [EPA's CHP Technical Assistance Partnership¹⁵²](#).

¹⁵⁰ <https://energy.gov/eere/amo/chp-deployment>

¹⁵¹ <https://energy.gov/eere/amo/chp-deployment>

¹⁵² <https://www.epa.gov/chp>

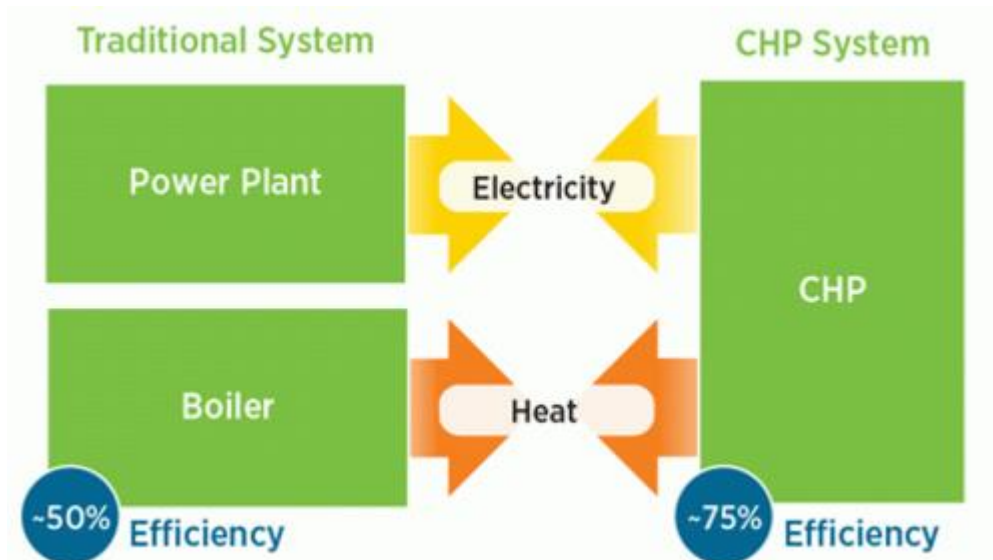


Figure 1: CHP Efficiency Compared to Separate Heat and Utility Power

CHP technology can be deployed quickly, cost-effectively, and with few geographic limitations. It has been employed for many years, mostly in industrial, large commercial, and institutional applications. There are currently about 4,400 CHP systems installed throughout the country generating up to 82 GW of electricity. The [DOE CHP Installation Database](#)¹⁵³ provides information on the location, size, technology, and fuel type of these systems. Figure 2 shows the locations of U.S. CHP installations. The International Energy Agency's (IEA) [CHP and DHC Collaborative](#)¹⁵⁴ report for the U.S. provides an overview of the current CHP and district heating and cooling (DHC) market in the U.S., and well as information on the recent trends in CHP deployment.



Figure 2. Locations of U.S. CHP Systems

¹⁵³ <https://energy.gov/chp-installs>

¹⁵⁴ https://www.iea.org/publications/insights/insightpublications/US_CountryScorecard_FINAL.pdf

In addition to current CHP installations, a recent [DOE CHP Technical Potential Report¹⁵⁵](#) identifies the estimated market size for CHP in the U.S., constrained by only technological limits. The report outlines market drivers for future CHP growth, as well as identifying CHP technical potential for 20 industrial and 24 commercial/institutional application types by state and estimated CHP size range.

The Most Common CHP System Configurations

- ▶ Reciprocating engine with heat recovery unit
- ▶ Combustion turbine with heat recovery steam generator
- ▶ Boiler with steam turbine

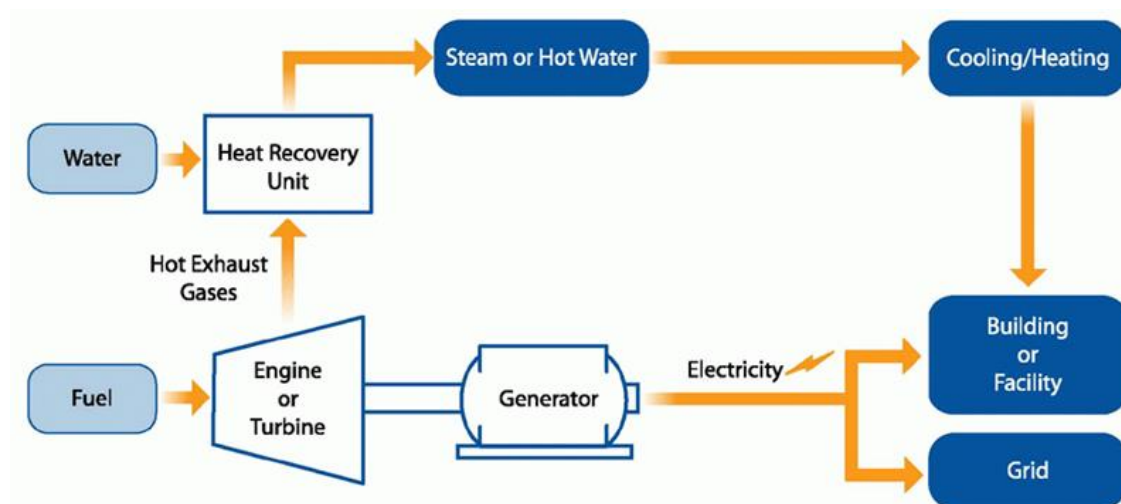


Figure 3. Combustion Turbine or Reciprocating Engine with Heat Recovery

In the configuration shown in Figure 3, the engine or turbine combusts fuel (typically natural gas, oil, or biogas) to generate electricity while heat is recovered and converted into useful thermal energy, usually in the form of steam or hot water.

¹⁵⁵ [https://www.energy.gov/sites/prod/files/2016/04/f30/CHP Technical Potential Study 3-31-2016 Final.pdf](https://www.energy.gov/sites/prod/files/2016/04/f30/CHP_Technical_Potential_Study_3-31-2016_Final.pdf)

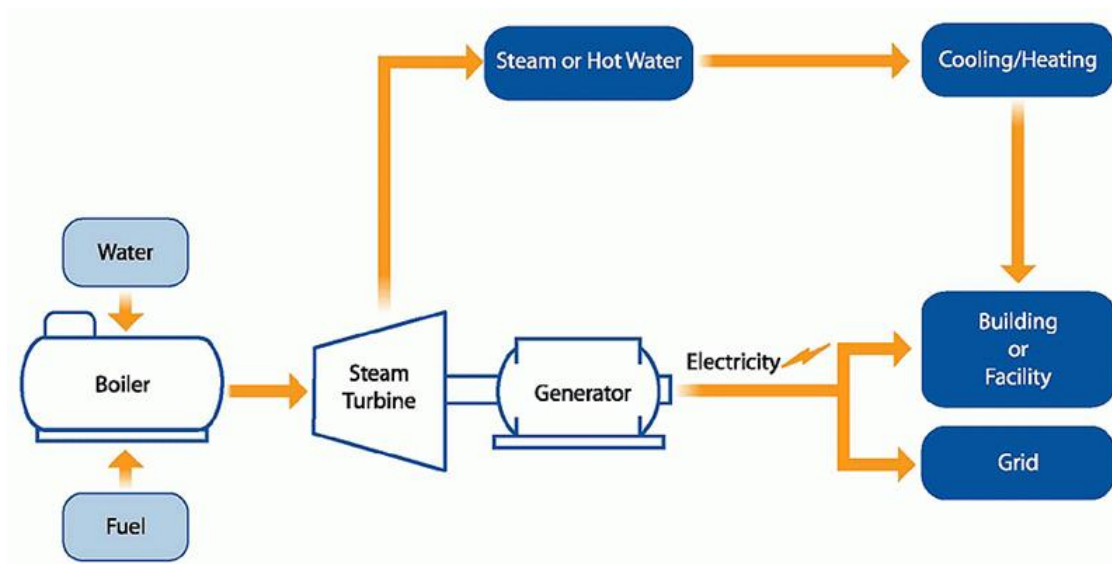


Figure 4. Boiler with Steam Turbine

In a boiler/steam turbine CHP configuration, fuel is burned in a boiler to produce steam, which is then used to generate electricity and useful thermal energy for the host facility. Boilers can use a variety of solid, liquid and gaseous fuels.

More Information

The [DOE CHP Technology Fact Sheet Series](#)¹⁵⁶ can provide more information on individual CHP technologies and a comparison of CHP characteristics for typical systems. Links to the individual technology fact sheets are listed below:

- ▶ [Reciprocating Engine Fact Sheet](#)¹⁵⁷
- ▶ [Gas Turbine Fact Sheet](#)¹⁵⁸
- ▶ [Microturbine Fact Sheet](#)¹⁵⁹
- ▶ [Fuel Cell Fact Sheet](#)¹⁶⁰
- ▶ [Steam Turbine Fact Sheet](#)¹⁶¹
- ▶ [Absorption Chiller Fact Sheet](#)¹⁶²

¹⁵⁶ https://energy.gov/sites/prod/files/2017/12/f46/CHP_Overview-120817_compliant_0.pdf

¹⁵⁷ <https://www.energy.gov/eere/amo/downloads/reciprocating-engines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹⁵⁸ <https://energy.gov/eere/amo/downloads/gas-turbines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹⁵⁹ <https://energy.gov/eere/amo/downloads/microturbines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹⁶⁰ <https://energy.gov/eere/amo/downloads/fuel-cells-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹⁶¹ <https://www.energy.gov/eere/amo/downloads/steam-turbines-doe-chp-technology-fact-sheet-series-fact-sheet-2016>

¹⁶² <https://energy.gov/eere/amo/downloads/absorption-chillers-chp-systems-doe-chp-technology-fact-sheet-series-fact-sheet>

EPA's [Catalog of CHP Technologies](#)¹⁶³ also provides an overview of how CHP systems work and the key concepts of efficiency and power-to-heat ratios. It also provides information and performance characteristics of five commercially available CHP prime movers.

For more information on CHP technologies, project development guides, policy documents, and a variety of other resources, please visit the CHP for Resilience Planning Guide [Resource Library](#)¹⁶⁴ page.

¹⁶³ <https://www.epa.gov/chp/catalog-chp-technologies>

¹⁶⁴ <https://resilienceguidе.dg.industrialenergytools.com/resourceLibrary>

Solar + Energy Storage 101

Solar Basics

Solar photovoltaics (PV) are the main solar energy technology used in distributed solar generation. Photovoltaic (PV) materials and devices convert sunlight into electrical energy. A single PV device is known as a cell, which typically produces about 1-2 watts of power. PV cells are typically connected in chains to form larger units known as modules or panels, which can increase system capacity and power output of PV cells. Modules can be used individually, or several can be connected to form arrays. One or more arrays can then be used as a standalone system or connected to the electrical grid as part of a complete PV system. PV systems can be configured to meet a variety of power needs due to their modular design. Systems also include mounting structures that direct panels toward the sun, and components such as inverters that convert the direct (DC) produced by a PV system into alternating current (AC) that can be used at an individual site or supplied directly onto the electric grid. The DOE Solar Energy Technologies Office [Solar Energy Technology Basics website](#)¹⁶⁵ can provide additional detail into solar energy technologies and configurations.

Solar PV can offer benefits to critical infrastructure facilities and increase resilience for local communities by providing a backup power supply in the case of a utility outage or natural disaster event. Distributed solar installations have also allowed utilities to defer costly capital investments for distribution-level equipment, and can be useful in shifting peaks to increase overall grid reliability. Given the variable nature of solar energy generation, standalone solar PV systems may not be able to provide critical backup power and resilience capabilities at all times for communities and critical infrastructure facilities. However, when combined with energy storage, these types of distributed energy systems can provide backup power to a wide variety of facilities and communities that require a reliable source of energy.

Energy Storage Basics

One of the distinctive characteristics of the electric power sector is that the amount of electricity that can be generated is relatively fixed over short periods of time, although demand for electricity fluctuates throughout the day. Energy storage technologies can manage the amount of power required to supply customers at peak times when demand is highest. At the distribution level, energy storage can assist in smoothing the variable output of renewable energy and other DERs, making them more dispatchable. They can also help balance microgrids to achieve a good match between generation and load, and can provide a number of ancillary services for the grid, such as frequency regulation and voltage control.

Distribution level energy storage includes technologies such as batteries, fuel cells, compressed air energy storage, and flywheel storage systems. Battery storage systems are the most common technology combined with solar PV to create distributed systems capable of providing continuous reliable power to critical facilities or communities. There are a wide variety of different battery types and design configurations that can be utilized at the distribution level or combined with solar PV. The Energy Storage Association's (ESA) page on [Energy Storage Technologies](#)¹⁶⁶ can provide additional detail on the different types of energy storage technologies and use cases. A Sandia National Laboratory report: [Energy Storage](#)

¹⁶⁵ <https://www.energy.gov/eere/solar/articles/solar-energy-technology-basics>

¹⁶⁶ <http://energystorage.org/energy-storage-1>

[Procurement Guidance Documents for Municipalities](#)¹⁶⁷ in 2016 that was aimed at supporting the Massachusetts Department of Energy's Community Clean Energy Resilience Initiative can also be a useful tool for any municipality looking to incorporate energy storage into resilience planning.

Solar + Energy Storage for Resilience

In order to provide resilient power to critical facilities or a community microgrid, distributed solar + storage resources must be capable of islanding from the grid and operating independently during outages and storm events. If solar + storage resources are carefully designed and equipped with the appropriate transfer or disconnect switches, a critical load panel, smart inverters, and sufficient control systems, they can together act as a uniform and reliable distributed resource with islanding capabilities. During normal operations, the solar PV can provide power to the facility or community and charge the battery with the excess energy generated, and the battery can discharge during times of low solar irradiance or when grid power prices are high. In the event of a grid outage, the system can disconnect from the grid and can continue to operate in island mode, utilizing the solar when available, and discharging the battery when necessary. For extended outages, the system may be limited to the amount of solar resource available over that time, but the power output of the system can be configured to only serve critical loads when islanded.

A report from the Clean Energy Group, [Solar+Storage 101: An Introductory Guide to Resilient Power Systems](#)¹⁶⁸ provides a general overview of the benefits that distributed solar + storage systems can offer, along with basic technical details of system configurations. In addition to the resilience benefits that solar + storage systems can provide, there are a number of other factors that can make a distributed solar + storage system beneficial compared to traditional backup generation when serving facility or community critical loads:

Reliability: Solar + storage systems operate continuously and are not just used in emergency conditions, reducing potential startup failures similar to that of diesel generators	Operations & Maintenance: Solar + storage systems have limited ongoing O&M costs, and typically only require visual inspections or light maintenance work periodically
Financial & Economic: Solar + storage systems can capitalizing on arbitrage opportunities in electricity markets, limit peak charges for customers, and storage can also participate in ancillary services markets	Safety & Environmental: Solar + storage systems can significantly reduce GHG emissions, and do not require onsite fuel storage, which can pose safety risks

Many of current standalone and combined solar + storage systems are designed for providing economic benefits to the end-user or utility, or providing a solution to electric grid challenges or constraints. These systems are specifically configured to operate in a way that maximizes these economic or technical benefits, but designing a solar + storage system for resilience may require an entirely different approach. A recent analysis from [NREL and the Clean Energy Group](#)¹⁶⁹ has identified considerations for sizing a solar + storage system specifically for resilient operations, which are highlighted below:

Current Electricity Costs	Time of Day When Outages Occur
Building Load Profile	Time of Year When Outages Occur

¹⁶⁷ <https://www.sandia.gov/ess-ssl/publications/SAND2016-8544O.pdf>

¹⁶⁸ <https://www.cleangroup.org/wp-content/uploads/Energy-Storage-101.pdf>

¹⁶⁹ <https://www.nrel.gov/docs/fy18osti/70679.pdf>

Average Duration of Outages	Critical Loads
Average Cost of Outages	Other Uses for Battery

When pursuing a solar + storage project for resilient onsite power, understanding not only the resiliency value that these system can provide, but also the additional technical and economic benefits that they offer is important to overall project implementation and ultimate performance. There are a number of solar and energy storage resources highlighted below that can provide additional details on technical specifications for solar and energy storage, solar + storage programs, and other resources that may help decision makers or utilities pursue solar + storage opportunities.

More Information

The U.S. Department of [Energy Solar Energy Technologies Office](#)¹⁷⁰ supports early-stage research and development to improve the affordability, reliability, and performance of solar technologies on the grid.

DOE's Office of Electricity (OE) [Energy Storage Program](#)¹⁷¹ performs research and development on a wide variety of storage technologies, collaborates with utilities and state energy organizations on storage research and programs, and supports analytical studies on the technical and economic performance of storage technologies.

The National Renewable Energy Laboratory (NREL) offers a number of [tools, maps, and calculators](#)¹⁷² specific to distributed solar resources and applications, such as the [PVWatts Calculator](#)¹⁷³ and [Solar Maps](#)¹⁷⁴ highlighting solar potential throughout the U.S.

A report from NREL, [Valuing the Resilience Provided by Solar and Battery Storage Systems](#)¹⁷⁵, provides an assessment of the potential resilience values that can be attributed to solar + storage systems, and also highlights a number of considerations when designing a solar + storage system for resiliency.

The Federal Energy Management Program (FEMP) through the DOE recently published two reports: one providing [Procurement Specifications Templates for Onsite Solar PV](#)¹⁷⁶ and the other an [ESPC Energy Sales Agreement Toolkit](#)¹⁷⁷. Both can be useful for municipalities or state governments seeking to implement renewable energy projects.

San Francisco's [Solar Resilient](#)¹⁷⁸ project is aimed at creating a pathway for deploying solar + storage systems for resilience by minimizing the regulatory, financial, and technical barriers that currently exist. Funded by a grant from the DOE's Solar Market Pathways Program, they are looking to solar + storage

¹⁷⁰ <https://www.energy.gov/eere/solar/solar-energy-technologies-office>

¹⁷¹ <https://www.energy.gov/oe/activities/technology-development/energy-storage>

¹⁷² <https://www.nrel.gov/gis/solar.html>

¹⁷³ <http://pvwatts.nrel.gov/>

¹⁷⁴ <https://www.nrel.gov/gis/solar.html>

¹⁷⁵ <https://www.nrel.gov/docs/fy18osti/70679.pdf>

¹⁷⁶ https://www.energy.gov/sites/prod/files/2017/01/f34/solar_pv_procurement.pdf

¹⁷⁷ <https://www.energy.gov/eere/femp/downloads/energy-savings-performance-contract-energy-sales-agreement-toolkit>

¹⁷⁸ <https://sfenvironment.org/solar-energy-storage-for-resiliency>

systems to increase overall community resiliency by integrating them into the City's emergency response plans.

Microgrids 101

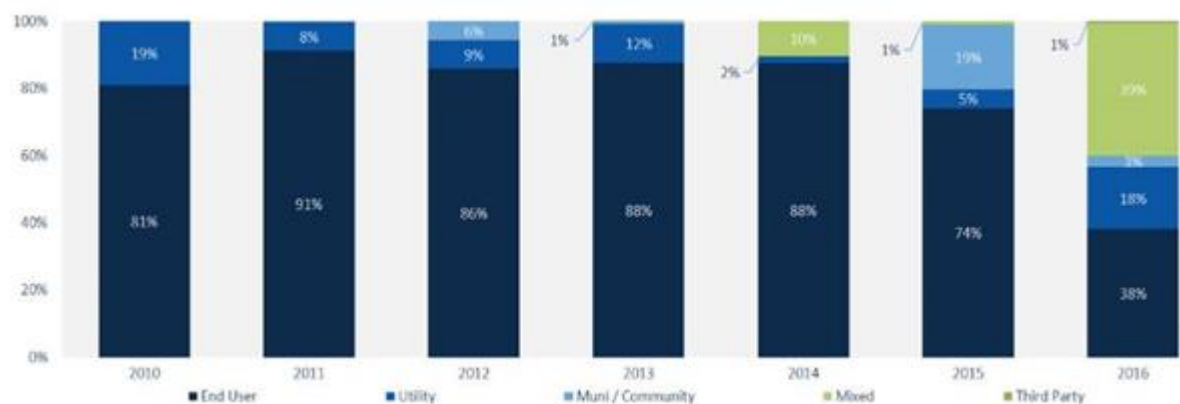
Microgrid Basics

Microgrids are localized grids that can disconnect from the traditional grid to operate autonomously. Because they are able to operate while the main grid is down, microgrids can strengthen grid resilience and help mitigate grid disturbances as well as function as a grid resource for faster system response and recovery. Hospitals, military bases, and campuses have traditionally been the primary users for microgrids given their needs for round the clock energy and required energy loads. However, microgrids, are increasingly being included in community resiliency planning because of their ability to provide continuous power to critical infrastructure and limit the impact of outages by localizing power generation close to critical services. To be most cost-effective, microgrids that are developed to support critical infrastructure have a cluster of critical facilities that will all be serviced by the microgrid in the case of an emergency.

- ▶ **Woodbridge, CT** - Fuel-cell [microgrid](#)¹⁷⁹ servicing the town hall, library, fire house, police station, public works, high school, and senior center.
- ▶ **Montgomery County, MD** - Multiple [microgrids](#)¹⁸⁰ servicing public safety headquarters and correctional facilities, and other proposed community microgrids.
- ▶ **Pittsburgh, PA** - Microgrid [concept](#)¹⁸¹ that will serve hospitals, fire and police stations, and places of refuge during outage events.

The three examples above illustrate that microgrids can be formed with different ownership models and technologies to meet needs and policy goals. The traditional microgrid ownership model has been single end-user ownership but there has been a recent shift to multi-stakeholder projects, which helps with overall project economics. More information on ownership models can be found [here](#), and see below for a breakdown in microgrid ownership models by GTM.

Operational Microgrid Capacity by End-User Type, Q3 2016



¹⁷⁹ <https://microgridknowledge.com/woodbridge-connecticut-takes-next-step-install-municipal-microgrid/>

¹⁸⁰ <https://www.montgomerycountymd.gov/dgs-oes/Microgrids.html>

¹⁸¹ <https://microgridknowledge.com/grid-of-microgrids-pittsburgh-webinar/>

In 2016, CHP was the main source of generation in microgrids, and is expected to continue to be a key technology in future microgrid design (Figure 5). In many resiliency projects, a technology like CHP is needed to reliably sustain power over an extended period, supplemented with solar generation. CHP can be an ideal anchor for microgrid systems because of its ability to withstand heavy storms and long outages, while also serving as an enabling technology for integrating renewable energy. As storage costs continue to decline, solar + storage will likely become a stronger candidate for more complex microgrid projects. Several jurisdictions are exploring solar and storage in resiliency and have created supportive resources, such as the [roadmap created by New York City](#)¹⁸²:

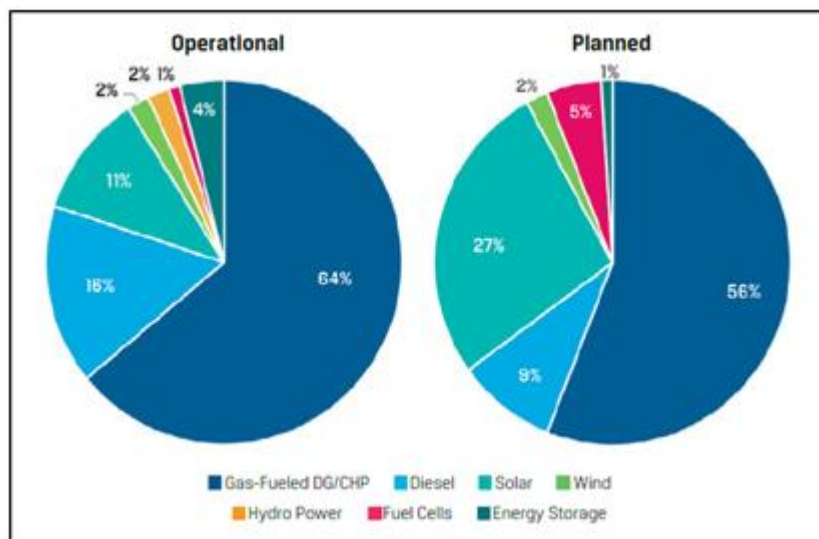


Figure 5. Existing and Planned Microgrid Capacity by Resource

Microgrids for Critical Infrastructure

Nationally, states and local governments are exploring how microgrids can help meet resiliency goals within the existing regulatory framework. Approaches include developing reports considering key concerns, developing a task force to provide recommendations on how to incorporate microgrids in resiliency planning, creating funding opportunities to incentivize microgrid developments, and developing pilot projects.

Reports Exploring Microgrid Options

- ▶ [Microgrids for Critical Facility Resiliency in New York State](#)¹⁸³: This report was commissioned by the New York State Legislature for the purpose of developing recommendations for the establishment of microgrids. Several state agencies including New York State Energy Research and Development Authority (NYSERDA), the New York State Department of Public Service (DPS), and New York State Division of Homeland Security and Emergency Services (DHSES) collaborated to prepare the report.
- ▶ [Maryland Resiliency through Microgrids Task Force](#)¹⁸⁴: This report shares the results of a task force established by the Governor's office to study the statutory, regulatory, financial, and technical barriers to

¹⁸² https://nysolarmap.com/media/1727/roadmap_final_final_228.pdf

¹⁸³ <http://nyssmartgrid.com/wp-content/uploads/Microgrids-Report-Summary.pdf>

¹⁸⁴ http://energy.maryland.gov/documents/MarylandResiliencyThroughMicrogridsTaskForceReport_000.pdf

the deployment of microgrids in Maryland. It includes a roadmap for action to pave the way for private sector deployment of microgrids across the state.

- ▶ [Resilient Microgrids for Rhode Island Critical Services](#)¹⁸⁵: This report was prepared for the Rhode Island Office of Energy Resources (OER) in response to their request for support for the design of a program to enhance energy assurance of critical infrastructure through deployment of distributed resources. It describes technologies, procurement strategies, and policies that can contribute to microgrid development.
- ▶ [Connecticut Microgrid Program](#)¹⁸⁶: Connecticut was the first state in the nation to deploy a statewide Microgrid Pilot Program in 2013. Today, the state runs a full-scale microgrid program offering incentives for microgrid projects at critical facilities. Funding is typically applied to design, engineering, and interconnection costs.

Resiliency goals will have an impact on technology choices and required load in microgrid design for critical infrastructure. For instance, relying exclusively on renewable energy resources cannot provide electric power during grid outages with the level of reliability required for emergency loads for an extended period. A beginning step for designing a microgrid is collecting data across all of the facilities on the site to determine the energy needs and assets, as well as determining which critical facilities may already have backup generation systems. A number of technologies are considered to form the optimal generation including combined heat and power systems, renewables, smart grid technologies, energy storage, and traditional backup generators. Microgrids that are designed for resiliency that have black start capability and meet the needs of all critical infrastructure on site during an islanded incident may require additional generation than needed to ensure power in the case failure of one or more generators.

Despite these additional challenges, microgrids have already proven to provide consistent power during times of emergency. The [Hurricane Sandy Rebuilding Task Force](#)¹⁸⁷ identifies microgrid systems as a means of mitigating the sprawling impacts of weather related disaster. Examples include:

- ▶ With a 15 megawatt (MW) combined heat and power generator as well as 5.3 MW of solar, **Princeton University's** microgrid kept its campus live for three days while power was cut during Hurricane Sandy.
- ▶ **South Oaks Hospital**, a 245-bed healthcare facility on Long Island, remained disconnected from the grid for fifteen days after Sandy with the help of its 1.25 MW combined heat and power generator and 47 kilowatts (kW) of solar. The hospital accepted patients from other sites that lost power during the storm.
- ▶ TECO's CHP plant at **Texas Medical Center** in Houston, the world's largest medical center, improves the center's ability to operate in an emergency. The CHP system was able to provide all of the power and thermal energy to the campus during a hot summer day in 2010, when the Texas grid experienced all-time high energy demand and faced numerous grid disruptions.

¹⁸⁵ <http://www.energy.ri.gov/documents/SRP/RI-microgrid-exec-summary-170331.pdf>

¹⁸⁶ <http://www.ct.gov/deep/cwp/view.asp?a=4405&Q=508780>

¹⁸⁷ <https://portal.hud.gov/hudportal/HUD?src=/sandyrebuilding>

As with all distributed generation with large load profiles, microgrids require electrical, communication and controls infrastructure that can add costs to the project. Depending on the size and complexity of the microgrid, specialized protection equipment may also be needed. NYSERDA has developed a [benefit-cost assessment \(BCA\)](#)¹⁸⁸ model for assessing the economic viability of microgrids at critical facilities based on the specific attributes of each site and taking into account the benefits and costs of providing essential services during a prolonged emergency. The model also estimates a range of other potential benefits, including energy cost savings; savings in the development of energy generation, transmission, or distribution capacity; power quality benefits; and environmental benefits (see Figure 6 below).

Results Summary		
Cost or Benefit Category	Present Value Over 20 Years (2014\$)	Annualized Value (2014\$)
Costs		
Initial Design and Planning		
Capital Investments		
Fixed O&M		
Variable O&M (Grid-Connected Mode)		
Fuel (Grid-Connected Mode)		
Emission Control		
Emissions Allowances		
Emissions Damages (Grid-Connected Mode)		
Total Costs		
Benefits		
Reduction in Generating Costs		
Fuel Savings from CHP		
Generation Capacity Cost Savings		
Distribution Capacity Cost Savings		
Reliability Improvements		
Power Quality Improvements		
Avoided Emissions Allowance Costs		
Avoided Emissions Damages		
Major Power Outage Benefits		
Total Benefits		
Net Benefits		
Benefit/Cost Ratio		
Internal Rate of Return		

Figure 6. Excerpt from NY Prize Spreadsheet Model for Community Microgrid Cost Benefit Analysis

This benefit-cost framework is also detailed in the [Evaluation of New York Prize Stage 1 Feasibility Assessments](#)¹⁸⁹ final report. This report highlights the objective of the NY Prize microgrid feasibility studies, provides background on the technical approach used in the analysis, and also outlines fundamental considerations for microgrid planning. These considerations can provide high-level guidelines on the key factors to identify when considering and moving forward with a microgrid project. This information all feeds into the benefit-cost analysis and project-specific technical issues, which provide more detailed information that can be used in later stages of specific microgrid projects.

The 2014 NYSERDA report [Microgrids for Critical Facility Resiliency in New York State](#)¹⁹⁰ also highlights the key attributes that generally lead to a successful microgrid project. These attributes may be highly sought after in certain microgrid deployments, but not all owners may benefit equally. These can be useful in the initial stages of project formulation, and are shown in the table below:

¹⁸⁸ <https://www.nyserderda.ny.gov/-/media/NYPrize/files/Cost-Benefit-Analysis-Tool-User-Guide.pdf>

¹⁸⁹ <https://www.nyserderda.ny.gov/All-Programs/Programs/NY-Prize/Feasibility-Studies>

¹⁹⁰ <http://nyssmartgrid.com/wp-content/uploads/Microgrids-for-Critical-Facility-NYS.pdf>

Attribute	Advantage
Clustering of CI sites in close proximity	Reduced infrastructure costs
Existing electric or thermal distribution infrastructure that can be re-utilized	Reduced infrastructure costs
A consistent and significant need for electrical energy	High degree of asset utilization improves economic return (e.g., generators never sit idle)
Capacity limitations in the zone or network area of the microgrid	Demand (capacity) savings that benefits the macrogrid
Requirement for distribution capital expenditures that can be deferred or avoided by this microgrid	Distribution utility capital expenditure savings
The ability of the microgrid to provide ancillary services (NYISO market)	Lowering the capital and operating costs of the transmission system
The ability of the microgrid to provide distribution level services (voltage control, feeder loading relief)	Lowering the capital and operating costs of the distribution system

Table 3: Attributes Favoring a Successful Microgrid Project

Additional Microgrid Resources

- ▶ [Distributed Energy Resources Customer Adoption Model \(DER-CAM\)](#)¹⁹¹ - A customer adoption model of DER based on economic, technical, and environmental metrics. The model aims to minimize the cost of operating distributed generation resources, including CHP.
- ▶ [Microgrid Design Toolkit \(MDT\)](#)¹⁹² - A software tool that assists microgrid designers in the preliminary stages of microgrid design. The model uses user-defined objectives focused on the cost, performance, and reliability of various DERs.
- ▶ [Hybrid Optimization of Multiple Energy Resources \(HOMER\)](#)¹⁹³ - A software package that provides a framework for optimizing a set of distributed energy resources in order to simplify the process for identifying least-cost options for microgrids.
- ▶ [RETScreen Clean Energy Management Software \(RETScreen\)](#)¹⁹⁴ - A software system that provides project feasibility and energy performance analysis for energy efficiency, renewable energy and cogeneration projects.

¹⁹¹ <https://building-microgrid.lbl.gov/projects/der-cam>

¹⁹² <http://www.sandia.gov/CSR/tools/mdt.html>

¹⁹³ <https://www.homerenergy.com/products/index.html>

¹⁹⁴ <http://www.nrcan.gc.ca/energy/software-tools/7465>

Applying CHP in CI 101

How Does CHP Support Critical Infrastructure

During and after recent Hurricanes Harvey, Irma, and Maria in 2017, and Hurricane Sandy in 2012, combined heat and power (CHP) enabled a number of critical facilities to continue their operations when the electric grid went down. Time and again, CHP has proved its value as an alternative source of power and thermal energy (heating and cooling) during emergencies, and demonstrated how it can be a cost-effective and reliable choice in making energy infrastructure more resilient in the face of extreme weather events.

CHP can effectively contribute to state and local planning efforts to build resiliency for both critical facilities and microgrids. CHP systems allow facilities to remain functional in the event of a disaster, and for non-critical loads to resume functionality as quickly as possible (e.g. CHP systems with back start capability and that meet other technical requirements, can ensure seamless operation during a grid outage). Key facilities across sectors can be protected from disruptions to the electricity grid through the use of CHP and other forms of distributed energy. Compared to backup generators, CHP systems run daily and are typically highly reliable.

A 2013 [report prepared for Oak Ridge National Laboratory \(ORNL\)](#)¹⁹⁵ provides details on the reliability benefits of CHP and how to effectively integrate CHP for reliability purposes. It also highlights key state and local policies designed to promote CHP in CI applications.

Who Can Use CHP?

Not every CI facility is a good fit for CHP. In order to efficiently and economically utilize the outputs from a CHP system, a facility must have a consistent demand for both electricity and thermal energy. The facility also needs to have reliable access to fuel, usually in the form of pipelined natural gas. CHP is a good fit for critical infrastructure sub-sectors such as hospitals, food sales and food processing facilities, nursing homes, prisons, universities, chemical plants, and water treatment facilities. In some cases, CHP systems may also be appropriate for places of refuge and chemical and pharmaceutical facilities. CHP may not be an ideal solution for smaller facilities with limited thermal demand, such as police stations, emergency responders, telecommunications and office buildings. However, if these buildings are in CI clusters, there may be opportunities for a microgrid that is anchored by a CHP system. Smaller facilities may also want to explore options other generation technologies.

The 2013 [“Guide to Using Combined Heat and Power for Enhancing Reliability and Resiliency in Buildings”](#)¹⁹⁶ from DOE and EPA offers a detailed look at the opportunities for CHP to provide resiliency and reliability benefits and the factors determining the successful implementation of CHP at critical facilities. Below is a list of the identified CHP conducive subsectors and brief descriptions for each:

¹⁹⁵ <https://energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

¹⁹⁶ <https://energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

Airports - These facilities are often in NO_x nonattainment areas and face significant emissions pressure from both regulators and the community. Airports have large space conditioning and electrical loads with long hours of operation, and are often well suited to add CHP to their district energy systems. Airport CHP installations vary widely in size depending on the size of the airport and the addressable thermal loads, but the most common technology is a reciprocating engine fueled by natural gas.

Chemicals / Pharmaceuticals - Pharmaceutical manufacturing facilities have consistent heating, cooling, and power loads, and typically operate 24/7. They require a reliable power supply for their core business that can be served well by CHP. Most pharmaceutical CHP installations use larger CHP systems and can range from 1 MW to over 100 MW. Combustion turbines and steam turbines are the most prominent prime movers for CHP installations at pharmaceutical facilities, and natural gas is the primary fuel for these systems.

Colleges/Universities - Due to their large thermal loads and desire for reliable power, CHP is a good fit for colleges and universities. A number of college and universities use CHP to provide steam and some power to key campus facilities. Having a heated pool on campus presents an even greater opportunity for CHP implementation. The majority of CHP systems at colleges/universities are natural gas-fired, and most institutions use a boiler/steam turbine or gas turbines. A number of college and university CHP systems have been designed to be able to run independently of the grid. This has enabled colleges and universities to continue many of their normal operations during storm events, and has helped increase interest in the use of CHP in this market sector.

Critical Manufacturing - Critical manufacturing facilities are ideal candidates for CHP due to their coincident power and thermal loads and high number of operational hours per year. Facility and plant managers of critical manufacturing facilities are well equipped to pursue CHP opportunities as industrial facilities currently make up about 86% of existing CHP capacity in the U.S. Like many other industrial applications, critical manufacturing facilities have consistent heating, cooling, and power loads, and typically operate 24/7. They also require a reliable power supply that can be served well by CHP. Combustion turbines and steam turbines are the most prominent prime movers for CHP installations at critical manufacturing facilities, and natural gas is the primary fuel for these systems.

Data Centers - Data centers require high quality, reliable power for extended periods of time and have large thermal loads for space cooling. CHP systems at data centers must be able to easily integrate with other energy generation and storage systems, and they range in size from a few hundred kilowatts up to 10MW. The majority are fueled by natural gas and use microturbines as prime movers.

Distribution Centers - Distribution centers or refrigerated warehouses can incur significant costs in the case of power outages and typically require year-round space cooling and refrigeration from absorption chillers, and consistent, reliable electric power generation. Distribution center CHP system sizes can vary widely depending on the building size, but they are nearly all fueled by natural gas and are reciprocating engines or combustion turbines.

Fire Stations - Fire stations have coincident thermal and electric loads, requiring space heating and cooling, domestic hot water (DHW), lighting, and plug loads. Similar to police stations, fire stations typically have lower capacity requirements than other CHP candidates, so 24/7 operation or on-site housing is typically required for CHP implementation. Currently, there is a limited amount of CHP installations at fire stations, but most utilize small microturbines or fuel cells, no more than 100 kW in size. If located close to other

government buildings such as police stations, multiple building loads can be served by a single CHP system, forming a small microgrid anchored by CHP.

Food Processing - Food processing facilities comprise a wide variety of plants and process ranging from local dairies to large wet mill corn processing facilities that resemble chemical plants. Natural gas is the preferred fuel for CHP in this sector unless the plant has processing waste available or is used to handling large amounts of solids in their operations. Expanding markets for CHP include animal/poultry slaughtering, flour and rice milling, breweries, soft drink manufacturing, animal food manufacturing, fruit and vegetable canning, fluid milk, beet sugar, soybean processing and cereal manufacturing.

Food Sales/Supermarkets - Similar to distribution centers or refrigerated warehouses, refrigeration and lighting are the two largest electricity/thermal loads in the supermarket industry, creating a good fit for CHP. Supermarket CHP systems can provide the electricity and chilling needed to satisfy the high energy demands and reliability requirements. CHP systems at supermarkets are typically on the smaller side, with no systems larger than 1 MW, and nearly all are reciprocating engines or fuel cells.

Government Facilities - Most government CHP systems consist of combined cycle/gas turbine configurations or reciprocating engines. Natural gas is used to a lesser extent in these CHP applications as compared to other commercial markets, although the majority of capacity comes from natural gas-fired systems. CHP systems can help meet government objectives such as reducing greenhouse gas (GHG) emissions and can help operations remain up and running during emergency events. Government facilities that operate 24/7 and have coincident thermal and electric loads are good candidates for CHP.

Hospitals/Health Care - Hospitals, nursing homes and other healthcare facilities are good candidates for CHP based on their thermal loads and the need for reliable power. Most hospital CHP systems consist of gas turbines, and reciprocating engines, and 84 percent of existing hospital/healthcare CHP capacity is natural gas. Many healthcare CHP systems are designed so that they can operate independently of the grid, in case of weather events or other incidents that may cause grid outages. Interest in CHP at healthcare facilities, especially in densely populated areas that are more prone to natural disasters, has increased in recent years due mainly to CHP's reliability benefits.

Hotels/Lodging - Most CHP systems located at hotels are smaller systems typically less than 5 MW and use natural gas-fired reciprocating engines. Nearly all hotel CHP capacity is fueled by natural gas. Hotels have large thermal loads for hot water, and use CHP to provide hot water for guest use and laundry facilities. Larger hotels that have multiple restaurants, provide spa services and have heated swimming pools typically make the best candidates for CHP.

Laundries - Laundries typically consume large amounts of hot water and electricity for their cleaning processes, and also have long operational hours compared to other commercial facilities. Reciprocating engines are primarily used in laundry CHP applications, using recycled heat to produce hot water. CHP systems at laundry facilities are usually on the smaller side at less than 1 MW, while many of the older systems installed at laundry facilities are under 100 kW.

Military Bases - Much like colleges, military base CHP systems are typically installed at sites with large campuses that have a significant power and thermal loads for barracks, office buildings, training facilities, medical centers, and other staff support buildings. Military bases are also often served by a large central

plant that enables easier CHP integration. CHP systems on military campuses range in size from a few kilowatts to several dozen megawatts, though most systems are under 20 MW. The majority of systems are natural gas-fired and use boiler/steam turbines or reciprocating engines as prime movers.

Multifamily - Multifamily facilities looking to incorporate CHP require central hot water and space heating systems, and buildings that have no sub-metering. Sized appropriately, CHP systems at multifamily residences such as coop buildings, apartments, and condominiums can meet all of the building's steam and power needs. Ninety-nine percent of existing CHP capacity located at multi-family residences is fueled by natural gas. The majority of multi-family CHP systems are gas turbines and reciprocating engines.

Nursing Homes - Hospitals, nursing homes and other healthcare facilities are good candidates for CHP based on their thermal loads and the need for reliable power. Most hospital CHP systems consist of gas turbines, and reciprocating engines, and roughly 80% of existing hospital/healthcare CHP capacity is natural gas. Many healthcare CHP systems are designed so that they can operate independently of the grid, in case of weather events or other incidents that may cause grid outages. Interest in CHP at healthcare facilities, especially in densely populated areas that are more prone to natural disasters, has increased in recent years due mainly to CHP's reliability benefits.

Police Stations - Police stations have coincident thermal and electric loads, requiring space heating and cooling, domestic hot water (DHW), lighting, and plug loads. Because police stations have lower capacity requirements than most CHP candidates, 24/7 operation or holding cell facilities on site are typically required for CHP implementation. The majority of CHP installations at police stations are small reciprocating engines, microturbines, or fuel cells, with the largest systems no more than a few megawatts. If located close to other government buildings such as fire stations, multiple building loads can be served by a single CHP system, forming a small microgrid anchored by CHP. Nearly all police station CHP systems are fueled by natural gas.

Prisons - Prisons and large correctional facilities represent a significant amount of potential for CHP systems because they generally have a significant coincident thermal and electric loads to serve space heating, domestic hot water (DHW), laundry, cooking, space cooling, lighting, and plug loads. Facilities that operate 24/7 and have on-site housing or holding cells present an even greater opportunity for CHP. CHP systems at prisons vary in size from under 100 kW to over 40 MW, depending on the size of the institution. The majority of prison CHP installations utilize reciprocating engines as their prime movers, but larger facilities use combustion or steam turbines.

Schools - CHP systems are increasingly common in schools due to their consistent cooling and electric loads and ability to serve as places of refuge, and most CHP systems at schools required heated pools to make the installation economically viable. These CHP systems are small, less than 1 MW systems and most schools use reciprocating engines as their prime mover. Roughly 80% of school CHP capacity is fueled by natural gas. Since schools often serve as places of refuge for the community during storm events, CHP systems have become increasingly popular due to their ability for the school to have lighting and other essential services during power outages.

Water Treatments Plants - Water treatment plants that have anaerobic digesters and operate 24 hours a day are prime candidates for CHP. Most CHP systems at wastewater treatment plants are between 100kW and 10MW. The majority are fueled by anaerobic digester gas produced on site, or natural gas. Nearly 70%

of wastewater treatment facilities use reciprocating engines as their prime mover, with microturbines also making up nearly 20% of the CHP wastewater treatment CHP installations.

What is Required for CHP to Deliver CI Power Reliability?

The requirements for a CHP system to deliver power reliability, as in a CI facility, are fairly straightforward, but they may add some costs relative to CHP in a non-critical facility. In order to ensure uninterrupted operation during a utility system outage, the CHP system must have the following features:

1. **Black start capability** – The CHP system must have a battery powered starting system.
2. **Generator capable of operating independently of the utility grid** – The CHP electric generator must be able to continue operation without the grid power signal. High frequency generators (microturbines) or DC generators (fuel cells) need to have inverter technology that can operate the grid independently.
3. **Ample carrying capacity** – The facility must match the size of the critical loads to the CHP generator.
4. **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.

Valuing the Reliability of CHP

Power reliability is a critical issue for many customers, especially at critical infrastructure facilities where power disruptions represent a significant safety and health risk to their operations. These risks often compel customers to install back-up or emergency diesel generator sets, which can be unreliable in an actual emergency. CHP can be a reliable and cost-effective alternative to installing back-up generators to provide protection against extended outages. A CHP system is typically selected for a facility due to its ability to reduce operating costs and overall emissions. However, power outage protection can also be designed into a CHP system that efficiently provides electricity and thermal energy to the site on a continuous basis. CHP systems can be configured meet the specific reliability needs and risk profiles of various customers, and to offset the capital cost investment for traditional back-up power measures.

Backup generators are seldom used and are sometimes poorly maintained, so they can encounter problems during an actual emergency (Table 1). More information on CHP vs. backup emergency generator sets can be found in the Midwest TAP's (formerly Clean Energy Application Center) [CHP Resource Guide for Hospitals](#)¹⁹⁷.

Table 1. CHP vs. Backup Generation

Metric	CHP	Backup Generation
System Performance	Designed and maintained to run continuously Improved performance reliability	Only used during emergencies

¹⁹⁷ http://www.midwestchptap.org/archive/pdfs/ushospitalguidebook_111907.pdf

Metric	CHP	Backup Generation
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

CHP systems are a more reliable, cleaner, efficient, and cost effective onsite power supply, which provides electricity and heating/cooling under both emergency and normal operating conditions.

A [2007 EPA report¹⁹⁸](#) on valuing the reliability of CHP helps potential customers and relevant stakeholders understand how to value the various reliability benefits that CHP can provide compared to traditional backup power generation.

Current CHP in CI Installations

The [DOE CHP Installation Database¹⁹⁹](#) tracks CHP installations across the country, including those at CI facilities. With a focus on national security, health, and public safety, the sub-sectors listed in Table 1 have been flagged as critical infrastructure in the database. This does not include industrial manufacturing facilities (i.e. chemicals and food processing) or some other sectors identified as CI by the Department of Homeland Security. The database does not have information for which installations have black start capability. Data for CHP installations at critical infrastructure facilities is shown in Table 2, with a total of 5.5 GW from 1,023 sites.

Table 2. CHP Installations by Critical Infrastructure Sub-Sectors

Sector	Sites	Capacity (MW)
Airports	14	187
Colleges/Universities	270	2,653
Communications	20	41
Data Centers	11	16
Hospitals/Healthcare	220	819
Prisons/Police Station	46	168
Military/National Security	42	712

¹⁹⁸ <https://www.epa.gov/chp/valuing-reliability-combined-heat-and-power>

¹⁹⁹ <https://energy.gov/chp-installs>

Sector	Sites	Capacity (MW)
Nursing Homes	148	24
Energy/Utilities	32	188
Wastewater Treatment	220	740
TOTAL	1,023	5,548

Distributed Generation in CI Case Studies

DG in CI Case Studies

The DG case studies that follow highlight real world examples of microgrids and CHP, solar, and energy storage systems operating and providing resilience benefits (among others) to critical infrastructure sites. Case studies provide an excellent snapshot of how project challenges were overcome, and how individual facilities and end-users are maximizing the benefits from DG in order to enhance their overall facility or campus resilience. The DOE also maintains a [CHP Project Profiles Database](#)²⁰⁰ of two-page summaries profiling real world CHP projects with detailed information about system design, project costs, annual energy savings, environmental benefits and more, many of which are featured here.

Hospitals/Healthcare

Texas Medical Center (CHP)

The 48 MW CHP system at the Texas Medical Center provides electricity, steam and chilled water to 45 buildings comprising an area of 19.3 million square feet, roughly 85% of the Texas Medical Center campus. The CHP system has been in operation since 2010 and provides between \$6-12 million in energy cost savings per year. While much of Houston and the surrounding area was without power during Hurricane Harvey, the Texas Medical Center's CHP system was able to provide life sustaining power for air conditioning, refrigeration, heating, and a number of other services. Although much of the surrounding Brays Bayou area was flooded, the elevated design of the CHP system allowed it to operate throughout the storm. More information can be found in the U.S. DOE Southwest CHP TAP project profile [Texas Medical Center and TECO](#)²⁰¹ and the DOE AMO website [CHP Installation Keeps Hospital Running During Hurricane Harvey](#)²⁰².

Greenwich Hospital (CHP)

The Greenwich Hospital is a 175 bed, 500,000 sq ft medical center located in Greenwich, CT. Its CHP system, installed in 2008, consists of two 1,250 kW natural gas-fired reciprocating engines. The hospital also has a 2,000 kW backup generator. Following Hurricane Sandy, the area surrounding Greenwich Hospital lost power for approximately 7 days. When the hospital lost grid power, it went down for about 7 seconds before the backup generators kicked in and power was restored. The transition from using grid power to operating solely on the CHP system went as planned, with the CHP system shutting down and restarting in island mode, while power was supplied to the hospital by backup generators. The whole transition process takes approximately 5 minutes. Due to its CHP system, Greenwich Hospital was able to continue normal operations throughout the storm. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²⁰³.

²⁰⁰ <https://betterbuildingsinitiative.energy.gov/chp/solutions-at-a-glance/chp-project-profiles-database>

²⁰¹ http://www.chptap.org/Data/projects/Texas_Medical_Center-Project_Profile.pdf

²⁰² <https://www.energy.gov/eere/amo/articles/chp-installation-keeps-hospital-running-during-hurricane-harvey>

²⁰³ <https://www.energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

Mississippi Baptist Medical Center (CHP)

Located in Jackson, Mississippi, the Mississippi Baptist Medical Center experienced a complete electric grid outage for 52 hours during Hurricane Katrina in August 2005. The hospital's 4.6 MW CHP system allowed the facility to continue operations while providing shelter, food, and clothing to stranded local citizens and displaced patients from other area hospitals. As the grid became unstable during the hurricane, the Mississippi Baptist Medical Center shed some load, disconnected from the power grid, and continued operation with the CHP system providing all power. The hospital ran for more than 50 hours, and it was the only such facility in the Jackson metropolitan area to remain nearly 100% operational. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²⁰⁴.

South Oaks Hospital (CHP + Solar)

South Oaks Hospital, located in Amityville, NY on Long Island, has experienced significant energy cost savings and reliability benefits from their 1.3 MW CHP system and 47 kW solar PV array. The two dual-fuel reciprocating engines are able to supply all of the building's electricity needs, while the absorption chiller and two boilers have continued to supply steam for use in space heating and cooling, and domestic hot water production. The system has an overall efficiency of 82% and was able to pay itself back in under 5 years. During the 2003 blackout, South Oaks never lost power and was able to remain grid-isolated for 5 days, while the surrounding area lost power for 14 hours. Again, during Superstorm Sandy, the CHP system provided 100% of power. This allowed the facility to keep medications and food in freezers and refrigerators, provide service to patients from other facilities, and serve as a community center during the storm. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²⁰⁵.

Hospital De La Concepcion (CHP)

Hospital de la Concepcion, a 167-bed facility in San German, Puerto Rico installed a 2.8 MW CHP system in early 2017 in order to reduce energy costs and increase facility resiliency. The CHP system operates in 100% island mode and was able to provide critical power and thermal energy to the hospital throughout and after Hurricane Maria, serving life sustaining loads. The system is fueled by propane and is also equipped with a 250 ton absorption chiller that provides cooling and refrigeration services to the hospital. In addition to the critical services offered by the CHP system during and after Hurricane Maria, it is also anticipated to provide significant energy savings to the hospital in the future. More information can be found in the CHP Association's Policy Forum presentation on [CHP Resiliency Stories](#)²⁰⁶.

Universities/Schools

Princeton University (CHP + Solar)

The heart of Princeton's microgrid is a gas turbine CHP system capable of producing 15 MW. On sunny days, this power is supplemented by a 4.5-MW solar field (see Figure 2). Princeton's microgrid normally

²⁰⁴ Ibid.

²⁰⁵ Ibid.

²⁰⁶ <http://chpassociation.org/wp-content/uploads/2017/08/2017-Policy-Forum-Slides.pdf>

operates synchronized (connected) with the local utility. This benefits both the university and other local ratepayers. When the price of utility power is lower than Princeton's cost to generate, the microgrid draws from the utility grid. However, when Princeton's microgrid can produce power less expensively than the utility, it will run to meet as much of the electricity needs of the university as possible. When Princeton's microgrid can generate more than the university needs, and when the price of power on the utility grid is high, Princeton exports some power to earn revenues while lowering the net price of power for all other grid participants. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²⁰⁷.

Alaska Gateway School District – Tok School (CHP)

The Gateway School District in Tok, Alaska, installed a 120 kW boiler/steam turbine CHP system in 2013. The community of Tok is located approximately 200 miles east of Fairbanks and is surrounded by 8.5 million acres of forest in the Tok Management Area. Because of its remote location and small size (1,400 inhabitants), the high cost of fuel and electricity had a large impact on the local economy, especially the school. By installing a CHP system that could utilize the large amount of woody biomass fuel in the area, the school was able to provide 75% of the school's electricity needs at a fraction of the cost. Furthermore, the excess heat from the CHP system was used to heat the school's greenhouses, providing fresh produce year-round to the school and local community. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²⁰⁸.

University of California San Diego (CHP + Solar + Energy Storage)

The University of California San Diego microgrid is one of the most advanced microgrids in the world. It provides 92% of the electricity and 95% of the heating and cooling needs for its 13 million square foot campus. The microgrid consists of 30 MW of CHP generation, 1.5 MW of solar PV, 300 kW of solar thermal, a 2.8 MW fuel cell, and 2.5 MW of battery storage. The CHP system is comprised of two 13.5 MW gas turbines and one 3 MW reciprocating engine, and serves nearly 85% of the entire campus' annual electricity loads. The cogeneration system has reduced UC San Diego's energy costs by approximately \$8 million per year, increased overall system efficiency by limiting energy T&D losses, and relieved congestion on the surrounding San Diego Gas and Electric grid. More information can be found in the Lawrence Berkeley National Laboratory [microgrids webpage](#)²⁰⁹.

Prisons/Correctional Facilities

Santa Rita Jail (CHP + Solar + Storage)

The BCUA wastewater treatment plant installed a 2.8 MW biogas-fueled CHP system in 2008 in order to heat the five anaerobic digester tanks and provide the facility with roughly 90% of its electricity needs. The two Jenbacher JMS 420 engines are able to operate in parallel to the electric grid and are capable of running on either anaerobic digester gas or natural gas. The facility heavily relied on its CHP system during

²⁰⁷ <https://www.energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

²⁰⁸ Ibid.

²⁰⁹ <https://building-microgrid.lbl.gov/ucsd>

Sandy, which allowed the facility to process sewage for it 47 municipalities and roughly 550,000 customers during and after the storm. The facility is also able to aid in grid resiliency by participating in PJM's Interconnection Demand Response Program. More information on the BCUA CHP system can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²¹⁰.

Wastewater Treatment

Bergen County Utilities Authority (BCUA) (Renewable CHP)

The BCUA wastewater treatment plant installed a 2.8 MW biogas-fueled CHP system in 2008 in order to heat the five anaerobic digester tanks and provide the facility with roughly 90% of its electricity needs. The two Jenbacher JMS 420 engines are able to operate in parallel to the electric grid and are capable of running on either anaerobic digester gas or natural gas. The facility heavily relied on its CHP system during Sandy, which allowed the facility to process sewage for it 47 municipalities and roughly 550,000 customers during and after the storm. The facility is also able to aid in grid resiliency by participating in PJM's Interconnection Demand Response Program. More information on the BCUA CHP system can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²¹¹.

Multifamily

Breevort East (CHP)

The Breevort East high-rise co-op in Greenwich Village, NYC, installed a 300 kW CHP system in order to reduce electricity and thermal energy costs for the facility. Three natural gas-fired reciprocating engines are used to provide 300 kW of continuous power and 2,100 MBtu/h of thermal output for hot water. The recovered heat is also used to provide cooling via a 90 ton absorption chiller. The Brevoort was one of the only buildings in the lower third of Manhattan that was able to maintain power during the extended grid outages caused by the storm. The CHP system has also helped to provide the building with significant energy cost reductions. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²¹².

Data Centers

Public Interest Data Center (CHP)

The data center at Public Interest Network Services (PINS), located at 50 West 17th Street in Manhattan, provides hundreds of companies with office communications support. It is connected via three different fiber networks to multiple carriers for voice calls, provides multiple tier-1 Internet backbone operators, and is protected against power failure by a full-scale uninterruptible power supply (UPS) and CHP system. The 65 kW microturbine-based CHP system; fueled by natural gas, provides for all of the computer and office lighting electric loads. In addition, thermal energy is captured and used for space cooling through the use of

²¹⁰ <https://www.energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

²¹¹ Ibid.

²¹² Ibid.

absorption chillers. During Superstorm Sandy the power to the building and surrounding area was out for over two days; however, the data center was able to remain fully operational. No staff were at the building when the power went out; however, the automatic switch system transferred the data center load to a UPS (uninterruptible power supply) while the CHP system was transferring into island mode. The automated transition process took about one minute to complete. More information on the Public Interest Data Center can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²¹³.

Places of Refuge

Fajardo Sports Complex (Renewable CHP)

The Rafael Hernandez airport in Aguadilla, Puerto Rico originally installed a 120 kW CHP system as part of Lufthansa's operations. In the aftermath of Hurricane Maria, the CHP system was moved across the island to the city of Fajardo in order to provide emergency services for nearby residents. The CHP system is located at the Fajardo Sports Complex which serves as a refugee shelter and distribution center for local residents. The CHP system is fueled by local waste biomass resources, such as woody biomass, and is the first non-diesel power generation system in the region. The system has provided critical relief services and shelter for residents in the region. More information can be found at [BusinessWire](#)²¹⁴.

Salem Community College (CHP)

Salem Community College, in Carney's Point, New Jersey, installed a 300 kW CHP system in 2009 in order to reduce energy costs and increase power reliability for the campus. The CHP system was critical in providing heat and power for campus buildings, including an emergency relief shelter, during Hurricane Sandy in 2012. The American Red Cross operated a disaster relief shelter in Davidow Hall, which provided emergency shelter and disaster relief services to roughly 85 people during and after the storm. More information can be found in the EPA's [Guide to Using Combined Heat and Power for Enhancing Reliability and Resiliency in Buildings](#)²¹⁵.

Margaritaville Vacation Club - Wyndham St. Thomas (CHP)

The Margaritaville Vacation Club in St. Thomas, U.S. Virgin Islands was able to remain open during and after recent Hurricanes Irma and Maria because of the onsite power provided by the 1.8 MW CHP system. While most businesses and hotels will not be able to reopen for 3-6 months, the Margaritaville resort was able to power up its CHP system within hours after Hurricane Irma, and provide critical power to guests and emergency services to others on the island. The CHP system remains operational and the resort

²¹³ Ibid.

²¹⁴ <http://www.businesswire.com/news/home/20171018006493/en/Arensis-Off-Grid-Power-System-Delivered-Victims-Hurricane>

²¹⁵ https://www.epa.gov/sites/production/files/2015-07/documents/guide_to_using_combined_heat_and_power_for_enhancing_reliability_and_resiliency_in_buildings.pdf

continues to provide power and water to those in need. More information can be found in a recent Capstone Microturbine [press release](#)²¹⁶ about the 1.8 MW hotel CHP system.

Critical Manufacturing

Sikorsky Aircraft (CHP + Solar)

Sikorsky Aircraft Corporation, an aircraft manufacturer based in Stratford, Connecticut, installed a 10.7 MW gas turbine CHP system in 2011 to align with corporate sustainability goals. The CHP system provides the 2,000,000 square foot manufacturing facility with 84% of its electric and 85% of its thermal needs. Due to the reliability of the CHP system, the facility did not experience any interruptions during Superstorm Sandy, and was able to sustain normal operation during storm and aftermath. The facility also provided helicopter transport services for disaster relief personnel and supplies, and the manufacturing campus was opened as a place of refuge (meals, showers, phone charging) for the 6,650 employees and their families. Sikorsky has also deployed a number of other renewable energy and energy efficiency strategies, including installing 250 rooftop solar PV panels that produce roughly 106,250 kWh per year. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²¹⁷.

Houweling's Tomatoes - Food Processing (CHP)

Located in Camarillo, CA, Houweling's Tomatoes is a family-owned greenhouse tomato grower. In 2012, the facility installed a 12.5 MW reciprocating engine CHP system to provide electricity and greenhouse heating. Because of the high demand for heat at all times and electricity during the night, the greenhouse is a good setting for a CHP system. By setting up a Power Purchase Agreement with the local utility, the greenhouse can run the CHP system at all times, exporting excess electricity to the grid during the day and utilizing it onsite at night. Houweling's Tomatoes now sees an annual energy savings of \$4.3 million after installing the CHP system, and has also incorporated 1 MW of solar PV into its operations. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²¹⁸.

Pfizer – Andover, MA - Pharmaceuticals (CHP)

In 1999, Pfizer installed a CHP system at their biotechnology campus in Andover, MA. The 10 MW natural gas-fueled turbine system provides electricity and thermal energy to the campus 24/7. The 70-acre site, seven-building campus houses some of the company's R&D and manufacturing facilities, which require electricity and steam at all times. In order to provide a reliable power source, Pfizer turned to a CHP system that provides electricity, heat, and steam to the manufacturing campus. The system was designed so that Pfizer can temporarily separate from the grid in instances of anticipated outage. The CHP system

²¹⁶ https://dl1io3yog0oux5.cloudfront.net/_adflf50b177db5b5c6e1ebb0f86e98d1/capstoneturbine/db/198/6621/pdf_article/St+Thomas_Irma+Writeup_15Sept2017_FINAL.pdf

²¹⁷ <https://www.energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

²¹⁸ <https://www.energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

also allows Pfizer to meet its sustainability goals and to significantly reduce its energy costs. More information can be found in the Oak Ridge National Laboratory report [Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities](#)²¹⁹.

Other

Community Microgrid - Fairfield, CT (CHP + Solar)

The town of Fairfield, CT experienced significant energy outages during Superstorm Sandy, and decided to invest in a community microgrid in order to improve the resiliency of 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 reciprocating engine as the microgrid 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 will greatly improve the resiliency of the connected facilities during future weather and emergency events. More information can be found at Connecticut's [Department of Energy and Environmental Protection](#)²²⁰ website.

Utility Microgrid - Sacramento Municipal Utility District (SMUD) (CHP + Solar + Storage)

The Sacramento Municipal Utility District (SMUD) is a public utility that provides electricity to Sacramento County, California. SMUD commissioned its microgrid project in 2012 at the corporate headquarters campus in order to demonstrate real world microgrid operation and integration of different resources and technologies. A 300 kW CHP system serves as the microgrid anchor, and also provides heating and cooling to the campus buildings through a 128 ton absorption chiller and chilled water storage. The microgrid also incorporates 10 kW of solar PV, which works in tandem with the CHP system through a number of smart inverters and the microgrid controller. The project not only demonstrates how microgrids can efficiently incorporate different generation technologies, but also increase power quality and reliability and interconnect with the bulk power system. More information can be found in SMUD's [Microgrid Demonstration Project](#)²²¹ report.

²¹⁹ <https://www.energy.gov/eere/amo/downloads/chp-enabling-resilient-energy-infrastructure-critical-facilities-report-march>

²²⁰ <http://www.ct.gov/deep/cwp/view.asp?a=4120&Q=508780>

²²¹ <https://www.smud.org/assets/documents/pdf/research-microgrid-demonstration-project.pdf>

