Combined Heat and Power and Infrastructure Plans

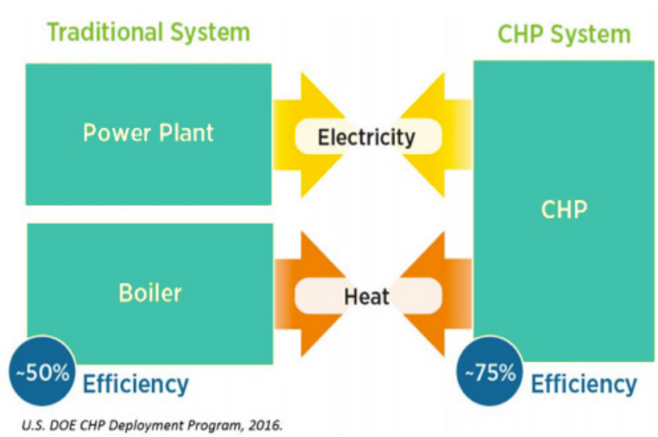
Introduction

Combined heat and power (CHP) systems can play an integral role in a wide array of infrastructure projects by reducing energy costs, improving community resiliency, increasing electric grid reliability, and reducing emissions. As such, CHP systems should be included in infrastructure planning, especially for facilities that require a consistent source of electric and thermal energy.

CHP technology uses a single fuel source, typically natural gas, to generate both heat and electricity. CHP systems are efficient electric and thermal energy generation units and deployed as a way to reduce energy costs. While the potential for lower energy bills is a clear benefit of CHP systems, this is not the only valuable attribute of CHP systems.

In addition to producing electric and thermal energy in a highly efficient manner, CHP systems can be deployed across sectors to improve the resiliency of critical infrastructure facilities and the communities they serve, increase the reliability of a modern electric grid, and reduce greenhouse gas and other emissions.

Figure 1: Energy Efficiency Advantage of CHP Compared to Traditional Energy Supply



This brief describes how **<u>including CHP in infrastructure planning can</u>**:

- Reduce energy costs
- Improve the resiliency of critical infrastructure and communities
- Increase the reliability of a modern electric grid
- Reduce greenhouse gas and other emissions

Types of infrastructure projects that can benefit from a CHP system:

- Airports
- Colleges and Universities
- Hospitals and Nursing Facilities
- Electric Grid
- Electricity Supply
- Emergency Response Facilities
- Microgrids
- Military Installations
- Municipal Buildings
- Wastewater Treatment Plants

Reduce Energy Costs

CHP systems are efficient electric and thermal energy generation units that can reduce energy costs. Improvements in CHP technology over time have resulted in properly designed CHP systems typically operating with an overall efficiency of 65-85%, compared to an overall efficiency of only 45-55% when electricity and thermal energy are provided separately.[1] Getting more energy outputs from the same fuel inputs reduces energy costs. In addition, since CHP systems are typically located close to where the electric and thermal energy will be used, savings are also achieved from reduced line losses, electricity that is typically lost during transmission and distribution from a central power plant to the end user.

Infrastructure that requires electric and thermal energy loads for operations may be able to reduce operational costs by installing a CHP system to efficiently produce electric and thermal energy on-site. Airports, wastewater treatment plants, hospitals, universities, and municipalities that install CHP systems may see their energy costs drop due to these increased efficiencies.

Case studies demonstrate how facilities can realize cost savings from CHP systems. For example, the University of Texas Medical Branch installed a 15 MW CHP system that saves the facility $3 million annually, with a five-year simple payback.[2] Eastern Michigan University, which serves over 21,000 students, upgraded its existing central heating plan with a new 7.8 MW CHP system with an estimated annual cost savings of $2.8 million and an estimated project payback of seven years.[3] Finally, a wastewater treatment facility in Tigard, Oregon took on a major upgrade that included a 1700 kW CHP system estimated to save the facility $800,000 per year in energy costs.[4] These examples demonstrate how infrastructure projects that are essential to our communities can reduce their energy costs by installing CHP systems.

While numerous facilities are already saving money with their CHP systems, there is a significant opportunity to capture additional energy savings through further CHP installations. In 2016, the U.S.

Table 1: CHP Technical Potential at Certain Types of Infrastructure Projects

	# of Sites	Total MW Capacity
Airports	346	973
Wastewater Treatment Plants	1,303	262
Hospitals and Nursing Homes	17,307	8,889
Colleges and Universities	5,285	13,932
Military	854	3,393
Government Buildings	9,760	4,460

Source: U.S. DOE, 2016, https://energy.gov/sites

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[1] United States Department of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States," Mar. 2016, p. 3-4. https://www.energy.gov/sites/prod/files/2016/04/f30/CHP Technical Potential Study 3-31-2016 Final.pdf

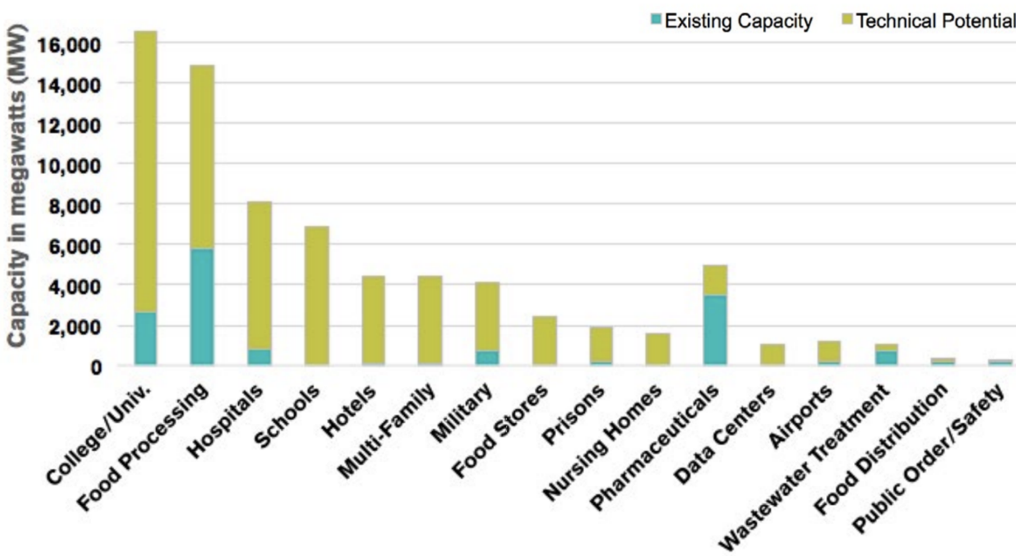
[2] U.S. DOE Southcentral CHP Technical Assistance Partnership, "Project Profile: University of Texas Medical Branch," Jan. 2019. http://www.chptap.org/Data/projects/UTMB-Project_Profile.pdf.

[3] U.S. DOE Midwest CHP Technical Assistance Partnership, "Project Profile: Eastern Michigan University," Jun. 2019. http://www.chptap.org/Data/projects/EasternMichiganUniversity-Project_Profile.pdf.

[4] U.S. DOE Northwest CHP Technical Assistance Partnership, "Project Profile: Durham Advanced Wastewater Treatment Facility," 2018. http://www.chptap.org/Data/projects/Durham_WWTF-Project_Profile.pdf.

Department of Energy (DOE) estimated that there was more than 240 GW[5] of CHP technical potential across all facility types.[6] Though progress to date is substantial, many facilities are leaving savings on the table.

Figure 2: CHP Capacity and Technical Potential Across Critical Infrastructure Sectors



Improve Resiliency of Critical Infrastructure Facilities and Communities

Distributed energy resources can also provide increased resiliency, not only for facilities that host such resources, but also for a host facility's surrounding community. Facilities that are critical infrastructure – assets, systems, and networks that, if incapacitated, would have a substantial negative impact on national security, economic security, or public health and safety[7] – are particularly well suited to utilize distributed energy resources as access to energy is a high priority for ensuring that critical facilities can continue to deliver services and assist in recovery.[8]

Many critical infrastructure customers such as hospitals, universities, and municipalities have successfully deployed CHP systems, increasing their resiliency against natural disasters, emergencies, or other events that may impact the electric grid. This can mitigate the impacts of

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[5] 1 GW is equal to 1000 MW.
[6] United States Department of Energy, "Combined Heat and Power (CHP) Technical Potential in the United States," at 21.
[7] Uniting and Strengthening America by Providing Appropriate Tools Required to Intercept and Obstruct Terrorism (USA PATRIOT ACT) Act of 2001. Pub. L. 107-56 at Sec. 1016(e). 26 Oct. 2001. https://www.congress.gov/bill/107th-congress/house-bill/3162/text.
[8] United States Department of Energy Better Buildings, "Distributed Generation (DG) for Resilience Planning Guide," January 2019, p. 4. https://betterbuildingsinitiative.energy.gov/sites/default/files/attachments/DG%20for%20Resilience%20Planning%20Guide%20-%20report%20format.pdf.

an emergency by keeping critical facilities operational until power is restored. In addition to providing power and heat to a host facility to keep the facility operational, such host facility may also be able to provide services to their local community to aid in the recovery effort.

In addition to the general benefits of distributed energy resources, CHP systems provide further benefits in that they typically run and are maintained continuously, avoiding the need to call a generator into operation that may not have been used recently. These systems also provide a consistent source of heat and power, unlike intermittent resources such as wind and solar. In addition, CHP systems frequently run on natural gas delivered directly via pipelines, avoiding the need for a fuel delivery as well as the resulting increased emissions from diesel or oil.[9]

Learn more about how CHP makes these types of infrastructure projects more resilient:

- **Airports**
- **Colleges and Universities**
- **Hospitals**
- **Wastewater Treatment Plants**

Case studies demonstrate the benefits of CHP systems during severe weather events that result in electric grid service disruption. During and after Superstorm Sandy in the northeast United States, numerous facilities with CHP systems were able to remain operational. For example, South Oaks Hospital in New York was able to provide critical services for two weeks relying solely on its CHP system and admitted displaced patients, offered refrigeration of vital medicines to those who had lost power, and welcomed the local community to recharge phones and electronic devices at its facility.[10] In New Jersey, the Bergen County Utilities Authority's wastewater treatment plant has a CHP system that allowed the facility to process sewage for its 47 municipalities and approximately 550,000 customers during and after Superstorm Sandy.[11] Louisiana State University has also benefitted from a CHP system, the university never lost power during Hurricane Katrina, allowing the school to continue to operate and permit administrative offices of other institutions to relocate to the main campus.[12]

Resilient infrastructure makes for resilient communities. By including CHP systems in infrastructure plans, the facilities described above, and many others like them, have been able to continue to provide crucial services to their communities during electric grid disruptions. Maintaining these services during times of emergency helps communities to withstand a severe event and move quickly into a recovery phase.

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[9] United States Environmental Protection Agency, "Valuing the Reliability of Combined Heat and Power," Jan. 2007, p. 2. https://www.epa.gov/sites/production/files/2015-07/documents/valuing_the_reliability_of_combined_heat_and_power.pdf.
[10] ICF International, "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," Mar. 2013, p.13. https://www.energy.gov/sites/prod/files/2013/11/f4/chp_critical_facilities.pdf.
[11] Better Buildings, U.S. Department of Energy, "Distributed Generation (DG) for Resiliency Planning Guide," Jan. 2019, p. 66. https://betterbuildingssolutioncenter.energy.gov/sites/default/files/attachments/DG%20for%20Resilience%20Planning%20Guide%20-%20report%20format.pdf.
[12] ICF International, "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," Mar. 2013, p. 24. https://www.energy.gov/sites/prod/files/2013/11/f4/chp_critical_facilities.pdf.

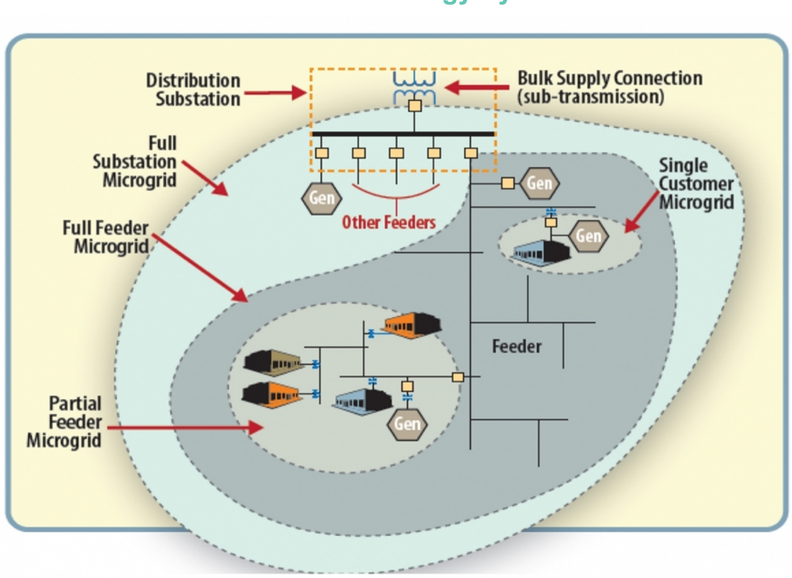
Increase the Reliability of a Modern Electric Grid

In recent years, the nation's electric grid has seen a shift in where and how electricity is generated. Historically, power has been produced at large central generation stations and moved to customers through a transmission and distribution system. More recently, however, power is generated at more locations that are situated throughout the grid system, and frequently is generated in smaller quantities at each location. In addition, an increasing amount of intermittent generation resources – those that only produce power some of the time – are being added to the electric grid, including renewables such as solar and wind.

The reliability of the electric grid – the ability to get power where and when needed – depends on grid operators ensuring that sufficient generation resources are available to meet demand. As more intermittent resources such as solar and wind are added to the grid, operators will have to balance these resources with those that can provide a consistent source of power. CHP systems typically run continuously and generate a consistent amount of power. As such, they could be called upon by grid operators to send electricity into the grid when renewable supply is unable to meet demand. In this way, CHP systems can improve the reliability of the larger power grid while supporting the addition of renewables.

CHP systems can also provide reliable power to a local community by being connected to a microgrid, allowing several buildings or facilities to keep the lights on during a grid outage. When a traditional electric grid has an outage or needs to be repaired, all users of the grid are impacted. A microgrid is a local energy grid that can disconnect from the traditional grid and operate on its own during a traditional grid outage.[13] To function independently, a microgrid requires either battery storage or a form of distributed generation such as CHP. CHP systems provide 39% of the energy in existing microgrids.[14]

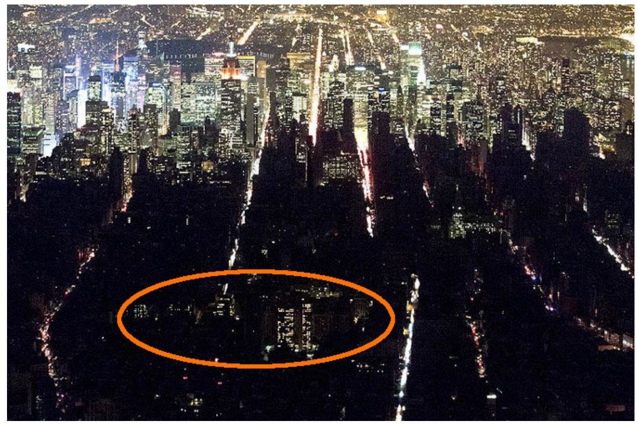
The Role of Microgrids in Helping to Advance the Nation's Energy System



[13] United States Department of Energy, "How Microgrids Work," Jun. 17, 2014. https://www.energy.gov/articles/how-microgrids-work.
[14] Greentech Media, "US Microgrid Growth Beats Estimates: 2020 Capacity Forecast Now Exceeds 3.7 Gigawatts," Jun. 1, 2016. https://www.greentechmedia.com/articles/read/u-s-microgrid-growth-beats-analyst-estimates-revised-2020-capacity-project#gs.fmnot7GL.

CHP systems can be paired with renewable resources, such as solar, as well as battery storage to provide a consistent source of power in a microgrid. Microgrids are used by universities, military installations, municipalities, and public institutions, helping to maintain the reliability of their electric and thermal energy supply and to improve their resiliency against extreme weather and power outages.[15] In some locations, a number of critical facilities such as hospitals, fire and police stations, emergency shelters, and gas stations can be connected and configured to operate in isolation from the larger utility grid, even during extended outages.[16]

NYU's Microgrid Provided an Island of Light During Hurricane Sandy



A CHP system can also assist a utility in restoring service to the larger eclectic grid. For example, during Superstorm Sandy, the College of New Jersey was able to disconnect from the electric grid for a week and the campus continued to operate using its 5.2 MW CHP system, despite the grid disruption.[17] In addition, the College's equipment was used to assist the state's largest utility in reestablishing service after the grid outage: the utility was able to use the College's equipment to back-feed one of its power lines to bring it back in service.[18] In this way, the College's CHP system helped to restore reliable electric service to the greater community.

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[15] Greentech Media, "US Microgrid Growth Beats Estimates: 2020 Capacity Forecast Now Exceeds 3.7 Gigawatts," Jun. 1, 2016. https://www.greentechmedia.com/articles/read/u-s-microgrid-growth-beats-analyst-estimates-revised-2020-capacity-project#gs.fmnot7GL.

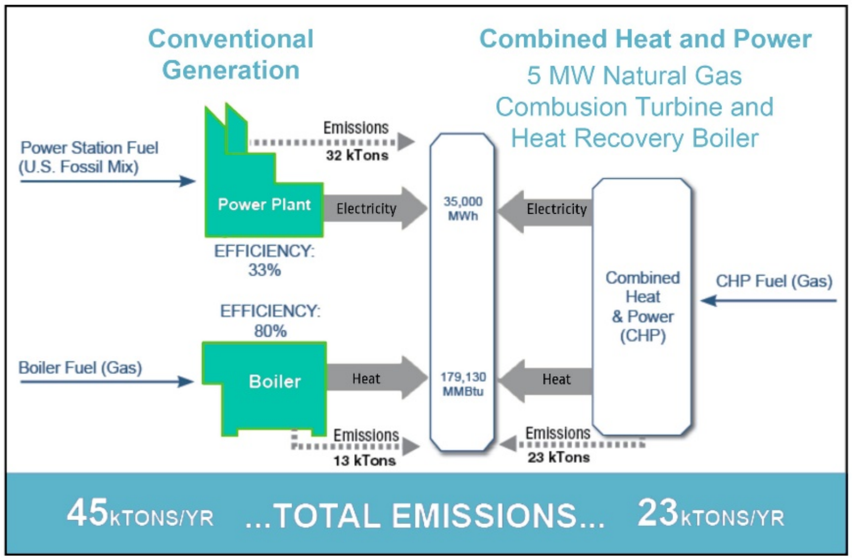
[16] United States Department of Energy, "CHP for Resiliency in Critical Infrastructure," May 2018, p. 3. https://betterbuildingsinitiative.energy.gov/sites/default/files/attachments/CHP_Resiliency.pdf.

[17] ICF International, "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," Mar. 2013, p.18. https://www.energy.gov/sites/prod/files/2013/11/f4/chp_critical_facilities.pdf.

[18] ICF International, "Combined Heat and Power: Enabling Resilient Energy Infrastructure for Critical Facilities," Mar. 2013, p.18. https://www.energy.gov/sites/prod/files/2013/11/f4/chp_critical_facilities.pdf.

Reduce Greenhouse Gas and Other Emissions

Figure 3: CO_2 Emissions – 5 MW CHP Versus 5 MW of Separate Heat and Power Production



Source: U.S. EPA, 2015, [https://bit.ly/2E2IByK.](https://bit.ly/2E2IByK)

The efficiency that CHP systems are able to achieve allows them to also reduce emissions. Because CHP systems combust less fuel to provide the same energy services, they reduce all types of emissions, including greenhouse gases, criteria pollutants, and hazardous air pollutants. As a consequence, natural gas-fired CHP can produce electricity with about one-quarter of the GHG emissions of an existing coal power plant. In a joint DOE and United States Environmental Protection Agency (EPA) report, the agencies stated that installing just an additional 40 GW of CHP would eliminate over 150 million metric tons of carbon dioxide emissions each year – the equivalent of the emissions of over 25 million cars.[19] CHP systems are commercially available and immediately deployable, providing an immediate path to lower emissions through increased energy efficiency.[20]

When additional power is needed, either to supply the electric grid when demand is high or to provide backup power during a grid outage, generation units fueled by coal, oil, or diesel are frequently brought into service, increasing emissions. In the same circumstances, a CHP system fueled by natural gas can produce fewer emissions than these other types of generation units, avoiding the increased emissions from coal, oil, or diesel.[21]

In addition to reducing emissions now, CHP systems have the potential to reduce emissions even further in the future as renewable fuels are developed and used. CHP systems can run on renewable fuels such as biomass – forest and crop residues, wood waste, or food-processing residue – or biogas – manure biogas, wastewater treatment biogas, or landfill gas. Renewable

[19] United States Department of Energy and United States Environmental Protection Agency, "Combined Heat and Power: A Clean Energy Solution," Aug. 2012, p. 5. https://www.energy.gov/sites/prod/files/2013/11/f4/chp_clean_energy_solution.pdf

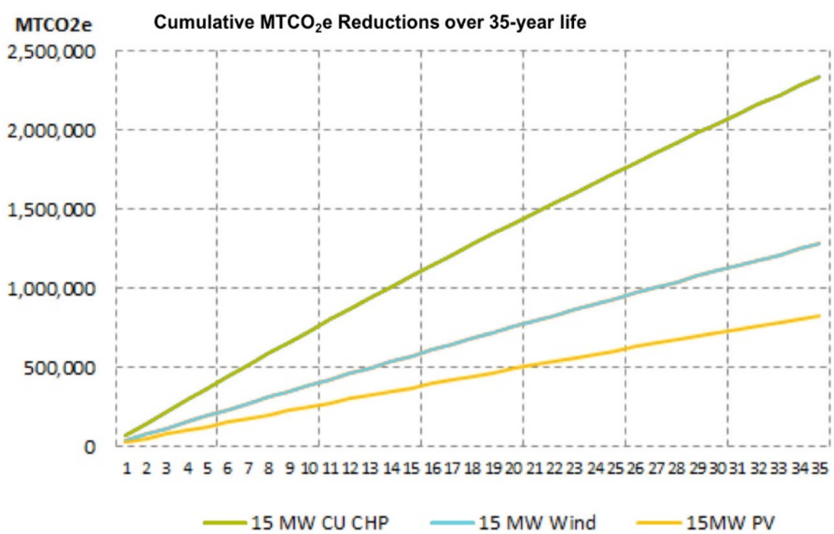
[20] United States Department of Energy and United States Environmental Protection Agency, "Combined Heat and Power: A Clean Energy Solution," Aug. 2012, p. 5. https://www.energy.gov/sites/prod/files/2013/11/f4/chp_clean_energy_solution.pdf

[21] United States Environmental Protection Agency, "Valuing the Reliability of Combined Heat and Power," Jan. 2007, p. 2. https://www.epa.gov/sites/production/files/2015-07/documents/valuing_the_reliability_of_combined_heat_and_power.pdf.

natural gas (RNG), or biomethane, is a pipeline-quality gas that is fully interchangeable with natural gas and compatible with U.S. pipeline infrastructure and can be used to fuel CHP systems. Over time, CHP systems can evolve and use different types of fuel. A system using natural gas today may run on RNG in the future.

As technologies advance, CHP systems will be able to utilize renewable fuels to even further reduce emissions. Moreover, CHP will likely be the most efficient way to use renewable fuels, maximizing the amount of energy output that can be gleaned from the fuel inputs, and thereby maximizing emissions reductions.

Figure 4: Cumulative Emissions Reductions over 35-year Life: CHP, Wind, Solar PV



Note: Calculated using EPA eGRID data for a hypothetical unit at a university in the Southeast, from 2020 to 2035, demonstrating specific unit emissions displaced by year.

Source: Sterling Energy Group, LLC, 2018

Conclusion

CHP systems should be included in infrastructure planning, especially for facilities that require a consistent source of electric and thermal energy because they can reduce energy costs, improve the resiliency of critical infrastructure facilities and the communities they serve, increase the reliability of a modern electric grid, and reduce greenhouse gas and other emissions.