COMBINED HEAT AND POWER: FREQUENTLY ASKED QUESTIONS

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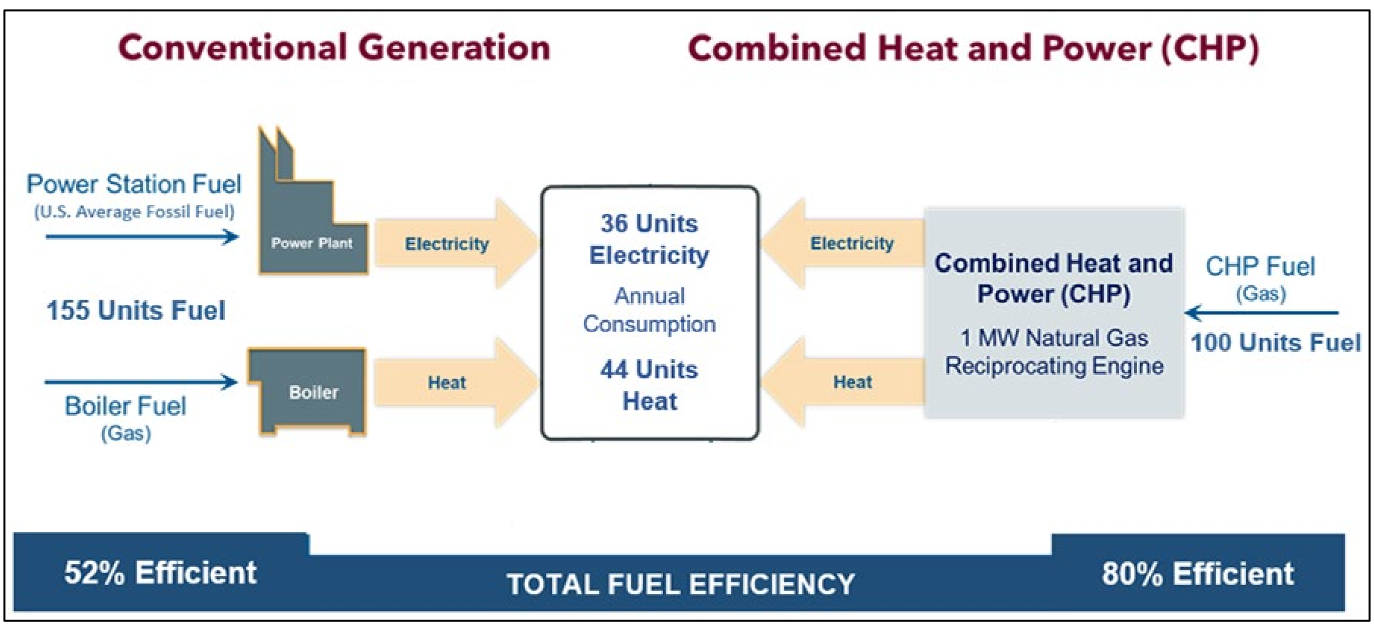
What is combined heat and power?

Combined heat and power (CHP), sometimes referred to as cogeneration, is an efficient and clean approach to generating onsite electric power and useful thermal energy (e.g., steam, hot water) from a single fuel source. CHP can use several different technologies and a variety of fuels. When evaluated against comparable separate heat and power options, CHP reduces emissions of greenhouse gases and other air pollutants by avoiding the need for grid-based electricity generation, transmission, and distribution, as well as use of an onsite boiler to meet thermal needs.

CHP can be located at an individual facility or building, or it can be a district energy, microgrid, and/or utility resource that provides power and thermal energy to multiple end users. CHP equipment can provide resilient power 24/7 in the event of grid outages, and it can be paired with other distributed energy technologies like solar photovoltaics and energy storage.

During conventional separate power and heat generation, nearly two-thirds of energy is wasted in the form of heat discharged to the atmosphere. Additional energy is wasted during the distribution of electricity to end users. By capturing and using heat that would otherwise be wasted and by avoiding distribution losses, CHP can achieve a total system efficiency of over 80 percent, compared to 50 percent for typical technologies (i.e., conventional electricity generation and an onsite boiler). Because of this increased efficiency, CHP systems can emit less carbon than separate heat and grid power. See the figure below for additional information.

Conventional Generation vs. CHP: Overall Efficiency



CHP can play several roles in the clean energy market, including:

- Reducing emissions while the grid transitions toward cleaner energy.

- Supporting solar and wind power resources in microgrids to increase onsite reliability and resiliency.
- Reducing emissions in sectors that are hard to decarbonize.

How does CHP work?

- Every CHP application involves the recovery of otherwise wasted thermal energy to produce useful thermal energy or electricity. CHP can be configured either as a topping or bottoming cycle.
- In a typical topping cycle system, fuel is combusted in a prime mover such as a gas turbine or reciprocating engine to generate electricity. Energy normally lost in the prime mover's hot exhaust and cooling systems is instead recovered to provide heat for industrial processes (e.g., food processing, paint drying), hot water (e.g., laundry, dishwashing), or for space heating, cooling, and dehumidification.
- In a bottoming cycle system, also referred to as "waste heat to power," fuel is combusted to provide thermal input to a furnace or other industrial process and heat rejected from the process is then used for electricity production.

Why is CHP more efficient than conventional electricity generation?

CHP is a form of distributed generation, which is located at or near the energy-consuming facility, whereas conventional electricity generation takes place in large, centrally located power plants. CHP's higher efficiency comes from recovering the heat normally lost in power generation or industrial processes to provide heating or cooling on site or to generate additional electricity. CHP's inherent higher efficiency and elimination of transmission and distribution losses from the central power plant results in reduced primary energy use and lower greenhouse gas emissions.

Is CHP widely used in the United States?

- The existing 82 gigawatts of CHP capacity at over 4,700 industrial, commercial, and institutional facilities represent approximately 8 percent of current U.S. electric generating capacity. Detailed information on each of these operational CHP systems is available on the U.S. Department of Energy's CHP Installation Database.
- CHP is used in every state (and Puerto Rico, the U.S. Virgin Islands, and Washington, D.C.) and is primarily found in areas with high concentrations of industrial and commercial activity, high electricity prices, and policies favorable to CHP. The EPA CHP Partnership offers information on policies that promote clean energy generation technologies such as CHP in its Database of CHP Policies and Incentives (*d*CHPP).

What kinds of facilities use CHP?

CHP can be utilized in a variety of applications that have significant electric and thermal loads. As of December 31, 2020, 78 percent of existing CHP capacity is found in industrial applications, providing electricity and steam to energy-intensive industries such as chemicals, paper, refining, food processing, and metals manufacturing. Commercial and institutional applications currently represent 16 percent of existing CHP capacity, providing electricity, steam, and hot water to hospitals, schools, university campuses, hotels, nursing homes, office buildings, and apartment complexes.

While industrial applications account for most of the installed capacity, nearly two-thirds of all operational CHP systems in the United States are located at commercial and intuitional facilities. With a rise in packaged CHP systems (i.e., pre-designed and fabricated systems) and their associated reductions in installation times and costs, the market has opened to small commercial and institutional facilities. Since 2016, 82 percent of CHP installations have been located at commercial and institutional facilities, with the leading applications being multifamily buildings, hospitals, wastewater treatment facilities, and colleges and universities.

What are the benefits of CHP for the United States?

- CHP reduces greenhouse gas emissions and other air pollutants by 40 percent or more.
- CHP consumes essentially zero water resources in generating electricity.
- CHP offers a low-cost approach to adding new electricity generation capacity.
- Onsite electric generation reduces grid congestion and improves the reliability of the electricity distribution system.
- CHP defers the need for investments in new central generating plants and new transmission and distribution infrastructure, helping to minimize increases in electricity costs.
- CHP uses highly skilled local labor and American technology.

How does CHP reduce energy costs?

CHP systems produce both electricity and thermal energy on site. Every kilowatt-hour of electricity generated with CHP is a kilowatt-hour that does not need to be purchased from the utility. Furthermore, when thermal energy from CHP equipment is utilized, onsite boiler or chiller fuel and electricity consumption is reduced. The difference between the cost to generate power on site with CHP and to the cost to purchase the equivalent amount of utility electricity is known as the "spark spread." EPA's CHP Screening Tool can help users determine the energy cost reduction and potential payback period for a CHP installation.

How does CHP produce electricity during grid outages?

When CHP systems are interconnected with the utility grid, there are two solutions that allow end users to continue operating during an extended power outage. The first option is shutting down and then restarting without a grid connection—a process known as a "black start." When the grid is back online, the CHP system may need to briefly shut down and restart to resynchronize and connect to the grid. Alternatively, CHP systems can be designed to ride through grid outages by applying transformers or energy storage systems that allow CHP to instantaneously disconnect, synchronize, and reconnect to the grid for continuous facility operation during utility outages. CHP can be paired with other technologies in microgrids or district energy systems (i.e., solar photovoltaics, energy storage, geothermal heat pumps) to efficiently produce resilient power and thermal energy for multiple end users.

Do CHP systems reduce carbon emissions?

Yes, current CHP systems fueled by natural gas will reduce carbon emissions compared to separate heat and grid power across the United States. This reduction occurs because CHP systems displace marginal electricity produced by the grid, which is typically in the form of fossil fuel generation (expected to continue in most U.S. locations for the coming years). Even when only half of the available thermal energy from CHP is utilized, net emissions from natural gas–fueled CHP are estimated to be lower than grid power (see EPA's analysis, *How CHP Reduces Greenhouse Gas Emissions on a Cleaner Grid*). Using renewable or zero-carbon fuels, such as renewable natural gas (RNG), provides further carbon reductions and is especially common for CHP systems with onsite access to these fuels, such as wastewater treatment plants and farms. As of December 2020, there are over 750 CHP installations using low-carbon fuels. In the future, as RNG and green hydrogen fuels become more widely available, zero-carbon CHP will be accessible to more end users. Emissions savings from CHP can be calculated with the EPA's CHP Energy and Emissions Savings Calculator.

What can CHP contribute in the future?

There is an additional 149 gigawatts of onsite capacity in technical potential for new CHP installations across the United States, which could provide resilient, reliable power with lower emissions for facilities (see the U.S.

Department of Energy's *Combined Heat and Power (CHP) Technical Potential in the United States*). Furthermore, renewable or zero-carbon fuels (e.g., RNG, hydrogen) can be used to further reduce emissions and ensure that CHP systems do not become net carbon emitters over time as future grids incorporate renewable or zero-carbon resources on the margin.