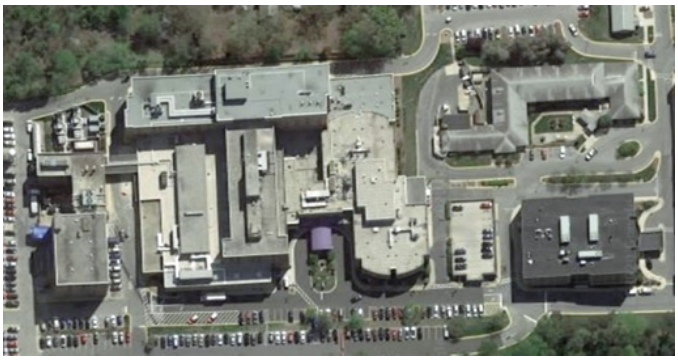
Better Buildings® U.S. DEPARTMENT OF ENERGY

Combined Heat and Power Fact Sheet Series

CHP MARKET SECTOR: HOSPITALS

CHP at Hospitals

Hospitals and healthcare systems are at the front line of responding to natural disasters, reducing mortality rates, and assisting with public health crises. It is imperative that these facilities, along with the patient health and critical life support systems they house, operate nonstop. Yet economic development continues to grow in regions that face extreme weather events—events whose intensity, duration, and geographic reach are on the rise. The trend affects even areas of the country not historically associated with severe weather. Furthermore, most communities are struggling with weak or outdated infrastructure. In the face of these natural hazards, healthcare organizations must improve the resilience of their facilities, including power delivery systems. One approach is the installation of combined heat and power (CHP) systems. Well suited to meet both resilience requirements and energy demands, CHP can provide electricity, hot water, and space heating and cooling during both normal operations and major outage events.



Doctors Community Hospital in Lanham, Maryland, installed two 600 kW reciprocating engines to provide 80% of the hospital's electrical load and 90% of the hospital's thermal load.

Photo courtesy of Doctors Community Hospital

Characteristics of Energy Use in Hospitals

A hospital is one of the most energy-intensive commercial building types, using more than three times the energy per square foot compared to a typical office building. Hospitals require continuous power for their operations and have significant thermal demands for heating, hot water, steam for sterilization, cooling, dehumidification, and laundry services.

These coincident thermal and electric loads make CHP a good fit to provide year-round critical power and thermal energy. Figure 1 (next page) shows average monthly hospital electric and gas loads, modeled using DOE Commercial Reference Buildings for two different weather regions.[2] Electric and gas loads are relatively consistent for facilities in both warm and cold climates, with some fluctuation due to space heating in winter and space cooling in summer. CHP can meet baseload thermal demand year-round and can provide cooling in warmer months, which could significantly decrease electricity costs and generate resilient space cooling on site.

HOSPITAL CHP QUICK FACTS

- Hospitals have **24–7 energy loads** and significant thermal requirements (hot water, space heating/cooling).
- **CHP's reliability** independent of the electric grid makes it a good match for hospital needs as **critical infrastructure** in the event of disasters.
- **Over a quarter** of all existing CHP systems at hospitals were installed after 2012.
- Hospitals spend an average of **$3.16 per square foot** on energy costs each year. CHP can help reduce these costs and free up resources for patient care.[1]
- The current average CHP installation size at a U.S. hospital is **~3.3 MW**.

Packaged CHP Systems eCatalog

Packaged CHP systems are standardized, prefabricated CHP systems built off site prior to installation, allowing customers to reduce installation time and cost. The Packaged CHP eCatalog from DOE provides tools for users to learn about, select, and compare packaged CHP systems and solutions that have been reviewed and recognized by DOE. The eCatalog is the product of a voluntary public–private partnership designed to validate packaged CHP technologies for growing commercial, institutional, multifamily, government, and light manufacturing markets. Visit the DOE CHP eCatalog at https://chp.ecatalog.lbl.gov/.

[1] Environmental Protection Agency. "CHP for Hospitals: Superior Energy for Superior Patient Care." Accessed 2020. https://www.epa.gov/chp/chp-hospitals-superior-energy-superior-patient-care.

[2] Data obtained from DOE Commercial Reference Buildings, modeled in EnergyPlus: https://www.energy.gov/eere/buildings/commercial-reference-buildings.

Figure 1. Monthly Hospital Electric and Gas Consumption (Modeled) for Different Weather Regions

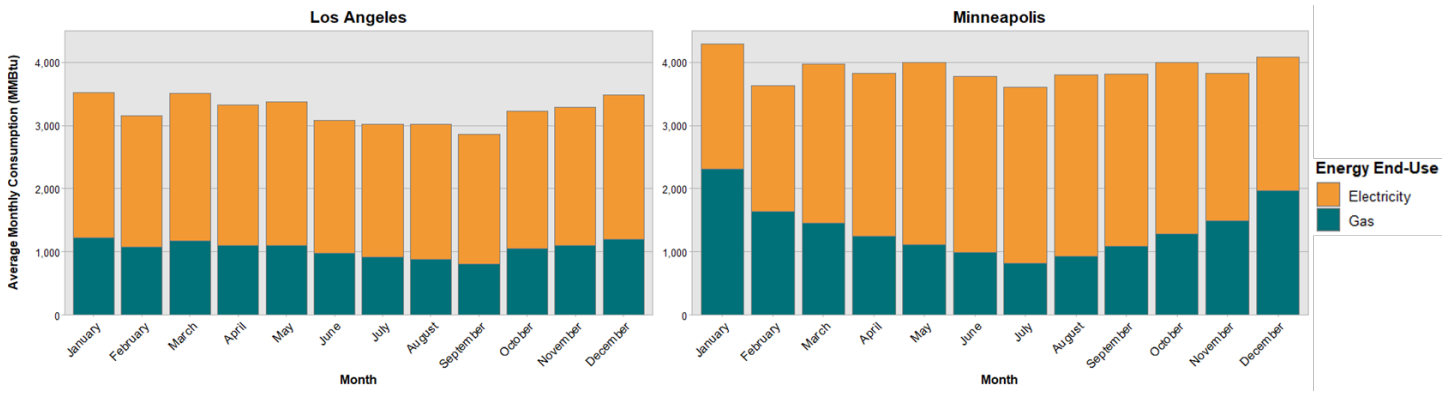
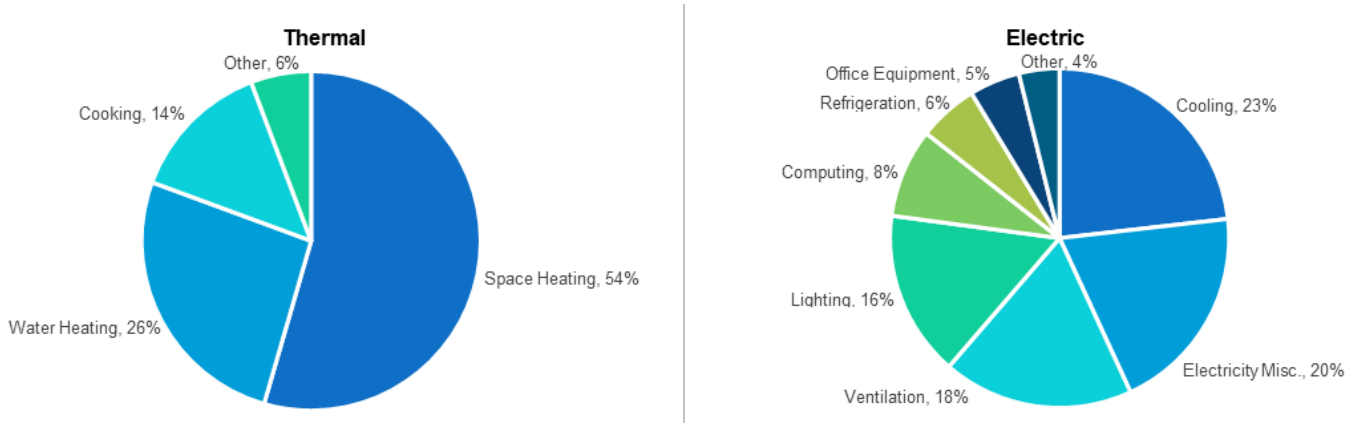


Figure 2 shows the electricity and gas consumption for various uses in hospitals. Nearly one-quarter of total electricity consumption is used for cooling applications. CHP can meet these needs when configured with absorption or steam-turbine-driven chillers.[3] Hospitals that elect to use CHP to fulfill all thermal needs, not just space heating, can further reduce grid electricity purchases and enhance energy resilience.

Figure 2. Average Hospital Thermal and Electric Consumption by End Use



PROJECT PROFILE: CHP Keeps the Lights On

Montefiore Medical Center (MMC) was the first hospital in New York City to install a CHP system, beginning operation of a 5 MW system in 1993. An additional 4.5 MW was added in 2001. This CHP system enabled MMC to remain open during the Northeast blackout in 2003 and Hurricane Sandy in 2012. During Hurricane Sandy, MMC accommodated patients who were evacuated from other hospitals that lost electricity during the storm.[6]

Photo courtesy of Montefiore Medical Center

[3] Data obtained from the Energy Information Administration's Commercial Building Energy Consumption Survey (CBECS): https://www.eia.gov/consumption/commercial/.

Based on DOE Commercial Reference Buildings data, daily electric and gas loads at hospitals are also relatively stable, as shown in Figure 3. This graph uses Pacific region weather data to illustrate that hospitals have a relatively stable daily and seasonal energy demand and consistent coincident demand for thermal energy and electricity. These daily, monthly, and annual energy use characteristics indicate that CHP installations are suitable and cost-effective options for hospitals with long operating hours.

Figure 3. Average Hourly Hospital Electric and Gas Consumption (Average Winter and Summer Days)

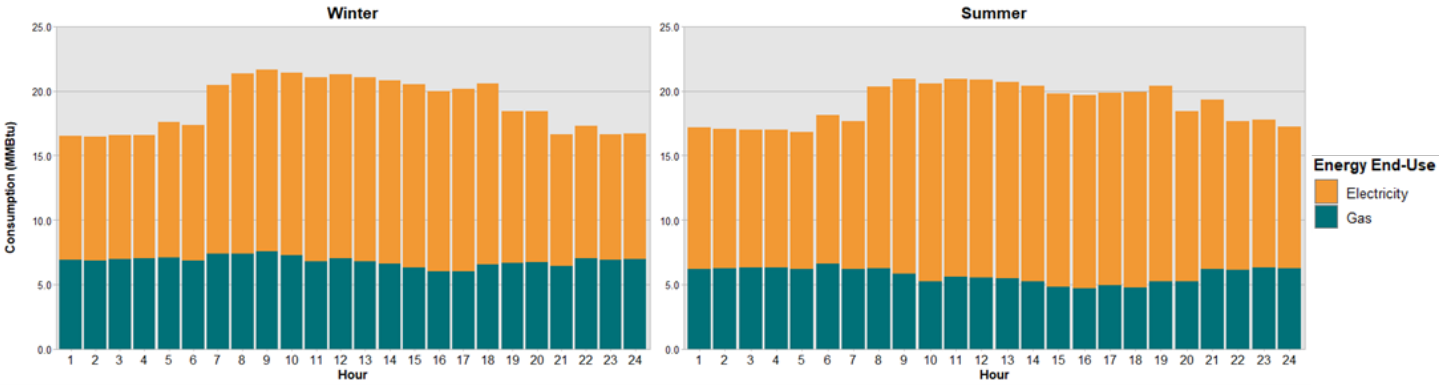
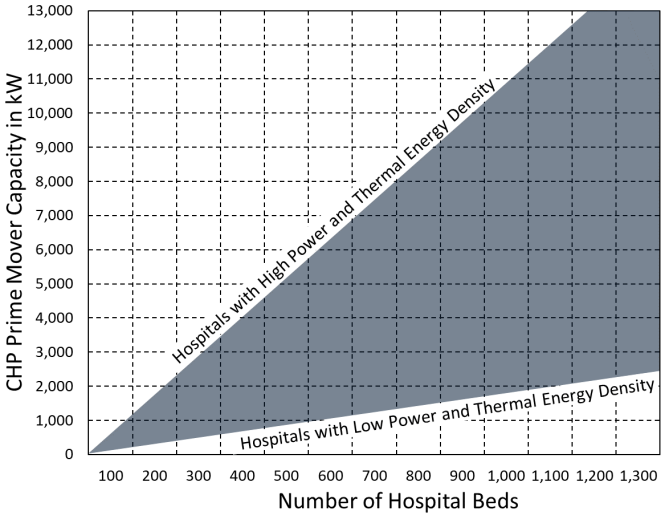


Figure 4 compares the CHP system capacities installed at 120 hospitals in the U.S. Department of Energy CHP Installation Database[4] as a function of the number of licensed beds and shows a range of power and thermal energy densities based on patient services provided. CHP system sizes range from 2 kW/bed to nearly 10 kW/bed. The former metric represents local hospitals without teaching or research facilities that therefore have lower power and thermal energy density needs. Regional medical centers are on the higher end, as they have high simultaneous electric and thermal energy needs driven by high-power-density equipment, extensive operating facilities, and an urgent need for air conditioning and research refrigeration during power outages.

Current Hospital CHP Installations

According to the U.S. Department of Energy CHP Installation Database, there are 745 MW of installed electric CHP capacity at 229 hospitals across 35 states and territories. Massachusetts, Texas, and California have the most CHP capacity at hospitals, each with more than 100 MW. CHP projects in the hospital sector range from small engines suppling local clinics to large combustion turbines providing heat and power to medical campuses housing thousands of patients. The most common CHP technology used in hospitals is reciprocating engines, with installations at 128 sites. Other sites use combustion turbines (48), boiler/steam turbines (19), microturbines (18), and other prime mover technologies (16). Over 83% of hospital CHP systems use natural gas, while the remainder use waste heat or other fuels, such as biomass, biogas, and oil.[5]

Figure 4. Hospital CHP Capacity vs Beds



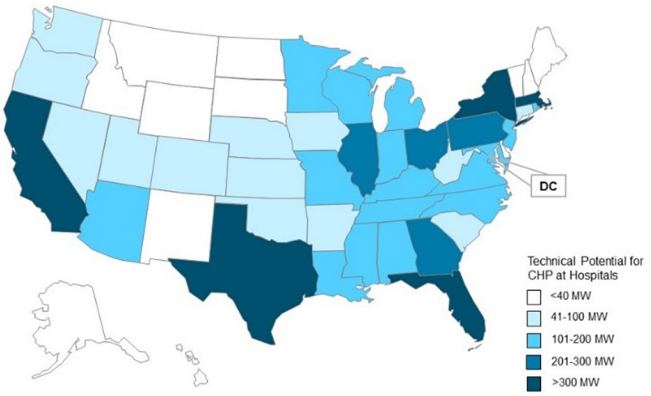
[4] U.S. Department of Energy CHP Installation Database. Accessed 2020. https://doe.icfwebservices.com/chpdb/.

[5] "U.S. installations as of July 31, 2020." U.S. Department of Energy CHP Installation Database. Accessed 2020. https://doe.icfwebservices.com/chpdb/.

Potential for New CHP Installations at Hospitals

Technical potential is an estimation of market size, constrained only by technological limits of existing hospitals (anticipated new construction is not considered). According to DOE studies, there is 7.3 GW of additional technical potential for CHP across over 6,000 hospitals in the United States. This potential includes a mix of configurations and sizes, as does the current fleet of CHP systems. Figure 5 shows that this potential is located across the country, with opportunities for CHP development found in most states, especially those with large population centers.

Figure 5. CHP Technical Potential at Hospitals by State



Source: DOE, "Combined Heat and Power (CHP) Technical Potential in the United States," March 2016.

PROJECT PROFILE: CHP for Sustainability

Constructed on a 30-acre brownfield site, Dell's Children's Medical Center in Austin, Texas, was designed with sustainability in mind. Through collaboration with Austin Energy, the hospital receives 100% of its energy needs from a 4.3 MW CHP system housed at the Muller Energy Center. The packaged CHP system, installed in 2007, operates at 65% efficiency, reducing emissions while supplying the hospital with electricity, steam for heating, and chilled water for cooling. Since the system's installation, the hospital's CO_2 emissions have decreased by 40%, SO_2 emissions by 99%, and NO_x emissions by 82%. Through its continued dedication to sustainability, the hospital became the first in the world to achieve LEED-Platinum certification.

Photo courtesy of Seton Healthcare Family

For More Information

For more information about CHP in hospitals, visit DOE's CHP Project Profiles Database,[6] a collection of more than 200 short studies of installations in various market sectors. The profiles, which are compiled by DOE's CHP Technical Assistance Partnerships, include details about equipment, project economics, environmental benefits, and more. The database currently contains more than 30 such descriptions of CHP systems installed at healthcare facilities across the country.

[6] DOE. "CHP Project Profiles Database." Accessed 2020. https://betterbuildingssolutioncenter.energy.gov/chp/solutions-at-a-glance/chp-project-profiles-database.