

CHP MARKET SECTOR: MULTIFAMILY HOUSING

When Hurricane Sandy struck the eastern coast of the United States in 2012, several multifamily apartment complexes in affected areas continued operations due to their combined heat and power (CHP) systems, even as the electric grid was down. Over the last 10 years, the multifamily housing sector has installed the most CHP systems of any sector in the country, improving the resiliency of critical infrastructure in the face of extreme weather events.¹ Multifamily housing can include single buildings with a few tenants up to large campuses of high-rise buildings housing thousands of tenants. Multifamily housing buildings consist primarily of living spaces for residents but can also include lobbies, common spaces for gatherings, laundry facilities, pools, and fitness centers. CHP is an efficient way to provide electricity, hot water, and space heating/cooling to multifamily housing buildings, allowing residents to live comfortably while reducing energy expenses. Master-metered multifamily housing buildings with central domestic hot water are best suited for CHP installations, as electricity and hot water from the CHP system can be delivered to tenants while building owners recover their investment via electric and gas bill savings. CHP offers the additional benefit of allowing these facilities to operate during extended grid outages, helping to ensure the safety and wellbeing of their residents.



The Sea Park apartment complex in Brooklyn, New York, installed 300 kW of CHP to reduce costs through energy efficiency improvements. CHP provides approximately 1/4 of the buildings' electricity needs. Photo courtesy of U.S. Department of Energy (DOE) New York-New Jersey CHP Technical Assistance Partnership (CHP TAP).

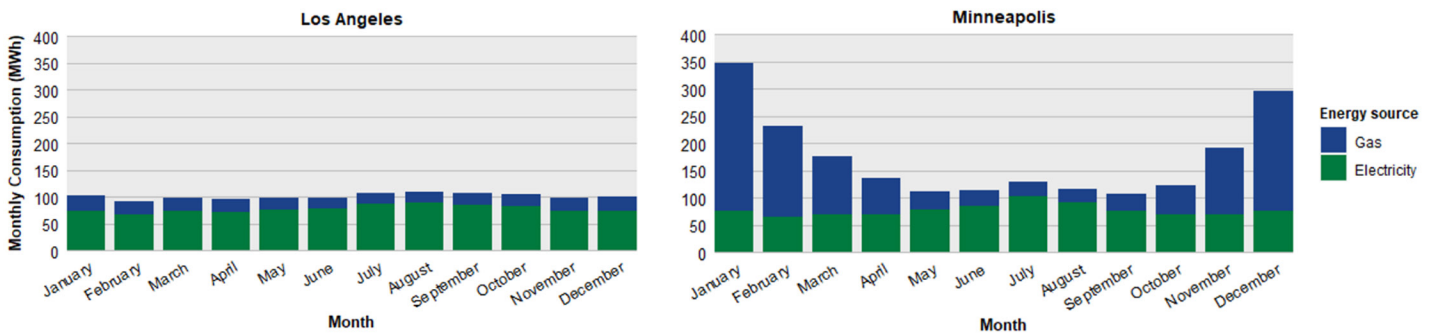
Characteristics of Energy Use at Multifamily Housing

Multifamily housing buildings require electricity and thermal energy around the clock, but the magnitude of these loads, as well as their seasonal variability, depends on many factors, including location, building size, and amenities provided. Figure 1 shows average monthly multifamily housing electric and gas loads for a 135,000 sq. ft. apartment complex consisting of four mid-rise apartment buildings, modeled using U.S. Department of Energy (DOE) Commercial Reference Buildings for two different climate regions.² Electric loads are relatively consistent for complexes in both warm and cold climates, with some variation due to space cooling in summer months. Gas loads in multifamily buildings include a relatively constant demand for thermal energy for domestic hot water year round, making them an especially good candidate for CHP. Gas loads are significantly higher in the winter months in Minneapolis, owing to high space heating needs.

MULTIFAMILY HOUSING CHP QUICK FACTS

- ▶ Multifamily housing buildings maintain steady **24/7 energy loads** and significant thermal requirements to meet resident needs.
- ▶ Potential for CHP is strongest for multifamily housing buildings that have **over 100 units, central domestic hot water, and master-metered electricity**.
- ▶ Over the last 10 years, **more CHP systems** have been installed in multifamily housing buildings than in any other building type.
- ▶ **Packaged CHP installations** represent many of the new CHP installations for multifamily housing buildings, offering a standardized modular approach to CHP design.

Figure 1. Monthly Multifamily Housing Complex Electric and Gas Consumption (Modeled) for Different Climate Regions

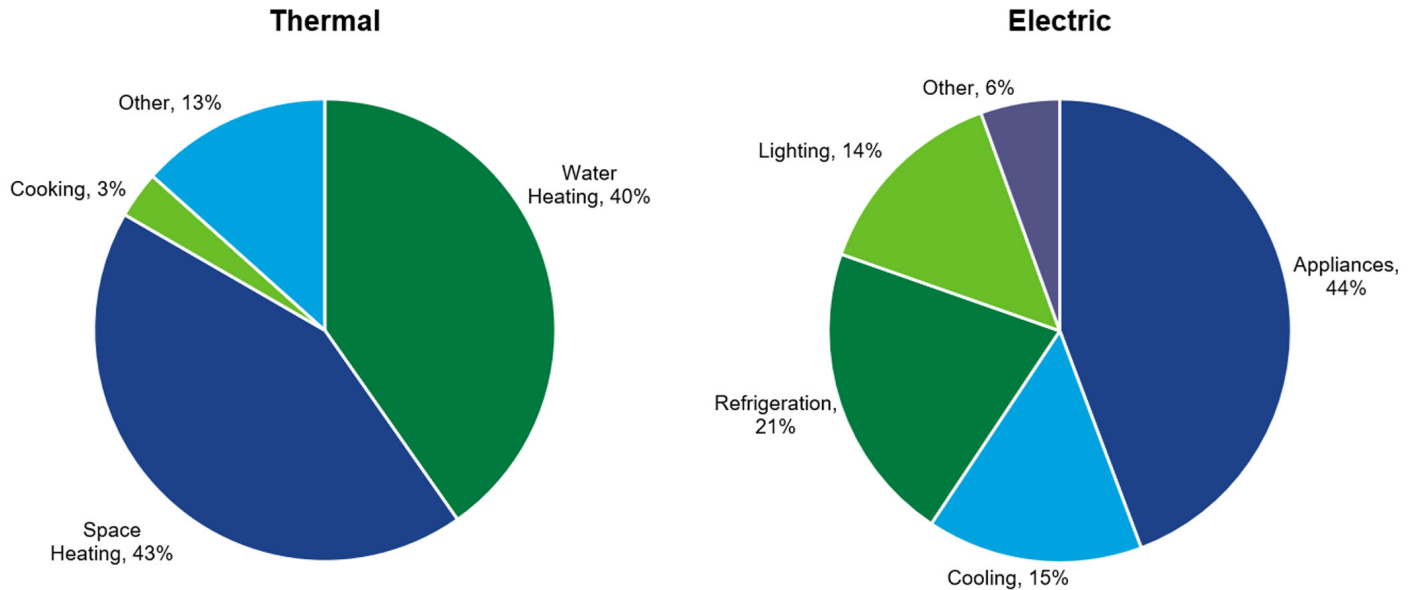


1 U.S. Department of Energy CHP Installation Database (U.S. installations as of December 31, 2020). <https://doe.icfwebservices.com/chp>.

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

Figure 2 shows breakouts for average energy end uses in the multifamily housing sector in the United States.³ End uses are split between loads that can be covered by a CHP system’s thermal and electric outputs. Thermal energy from CHP can be applied to central domestic water heating year round, but space heating may be limited to winter months. Absorption chillers can be used to meet cooling loads with CHP thermal output, especially in warm climates and in the summer months, allowing for larger CHP system sizes, improved CHP thermal utilization, and increased CHP electric generation.

Figure 2. Average Multifamily Housing Thermal and Electric Consumption by End Use*



*Percentages do not add up to 100% due to rounding.

PROJECT SNAPSHOT: CHP Keeps the Lights On



The Brevoort in Manhattan, New York, was able to maintain power and heating for its 720 residents during Hurricane Sandy. The residents of the housing cooperative did not lose power because the onsite 400 kW CHP plant was configured to continue operating during a utility power outage. The cooperative acted as a refuge during the storm, doubling its occupancy and providing shelter for the surrounding community.

Photo courtesy of the U.S. Environmental Protection Agency.

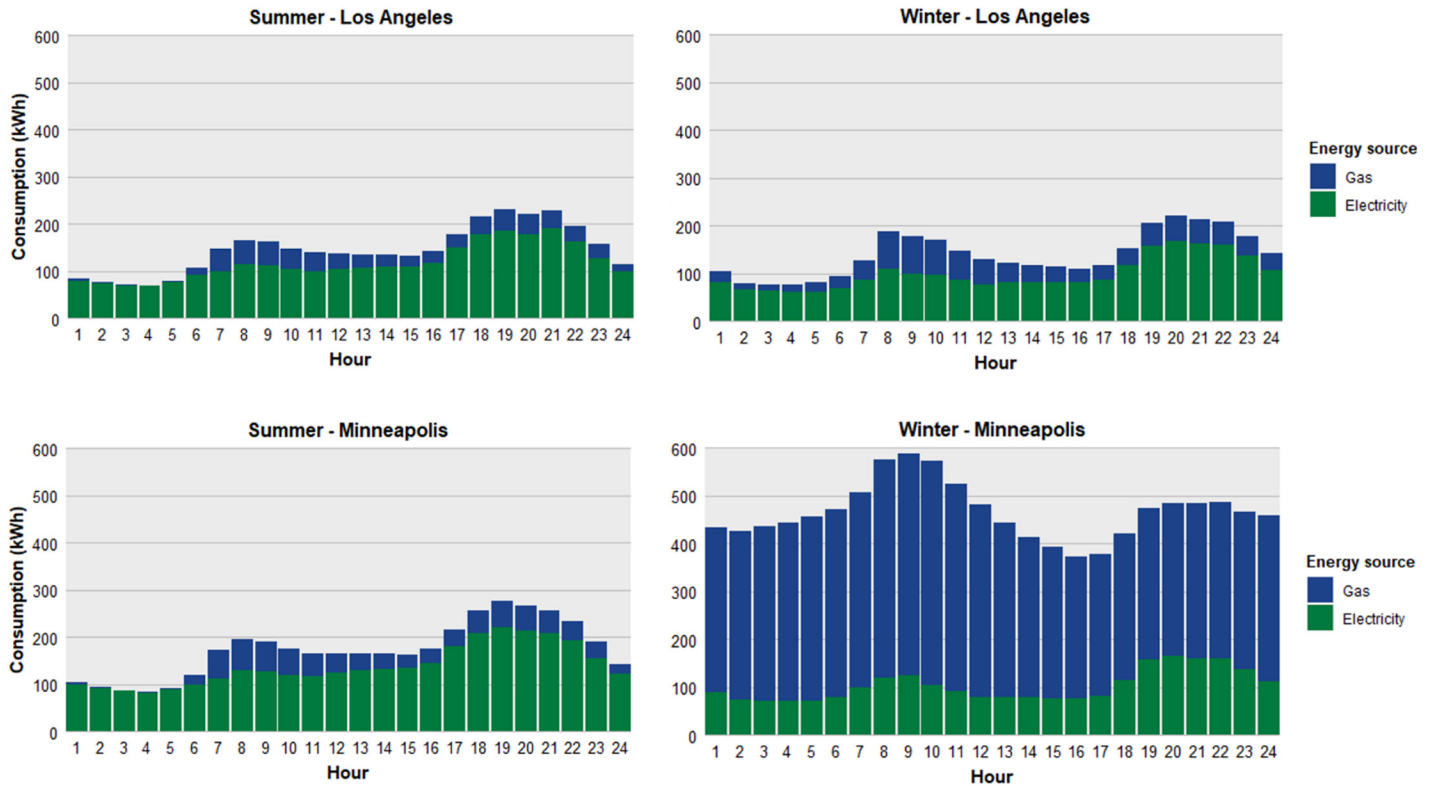
DOE Packaged CHP eCatalog

The eCatalog is a voluntary public/private partnership designed to increase deployment of efficient CHP systems in a wide range of applications, including manufacturing plants, commercial buildings, institutional facilities, and multifamily housing. The eCatalog is a searchable web-based system that hosts commercially available DOE-reviewed packaged CHP systems with comparable performance data from DOE-recognized CHP suppliers. End users, consulting engineers, utilities, state energy offices, federal agencies, and project developers can benefit from the data available in the eCatalog. In addition to an extensive database of packaged CHP products, the eCatalog provides information on CHP benefits, project financing considerations, and current events and news. Visit the DOE CHP eCatalog [here](https://www.eia.gov/consumption/commercial/).

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

Figure 3 shows 24-hour average electric and gas loads in a complex of mid-rise multifamily housing buildings for a typical day in the summer and winter for both climate regions. The charts below illustrate that electricity and gas consumption are typically highest in the early morning and evening hours. Gas consumption is higher in the winter months owing to space heating requirements. The approach to designing CHP for multifamily properties will influence system size. Sizing to meet domestic hot water loads results in smaller CHP systems that cover a portion of the facility's electric load. Alternatively, sizing to meet space heating and cooling requirements results in larger CHP systems and greater coverage of electric loads. These larger systems can provide more energy resilience in the event of a grid outage.

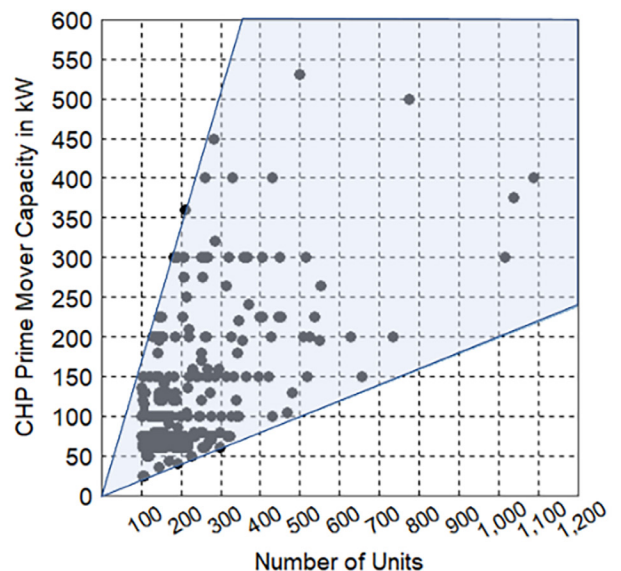
Figure 3. Average Hourly Multifamily Housing Complex Electric and Gas Consumption (Average Winter and Summer Days)



Current Multifamily Housing CHP Installations

The U.S. Department of Energy CHP Installation Database identifies 448 multifamily housing buildings with CHP, totaling 160 MW of installed electric capacity.⁴ The most common technology is the reciprocating engine applied in 86% of sites, followed by microturbines at 12% of sites. Almost all CHP systems in this sector are fueled by natural gas. To the extent that zero-carbon fuels like renewable natural gas and hydrogen become more economic and available in the future, the ability of CHP systems to adapt and be modified would enable them to increasingly use these fuels and further reduce greenhouse gas emissions from multifamily housing buildings. Figure 4 shows the CHP system capacities installed at a subset of multifamily apartment buildings in the U.S. Department of Energy CHP Installation Database as a function of the number of housing units. CHP sizing strategies vary depending on the following factors: 1) location/climate, 2) electric rates and metering of tenant electricity, 3) presence of central heating/cooling, and 4) cost/benefit of adding absorption chillers. As a result, some CHP systems have a low capacity per number of housing units while others are much higher.

Figure 4. Multifamily Housing CHP Capacity vs. Units

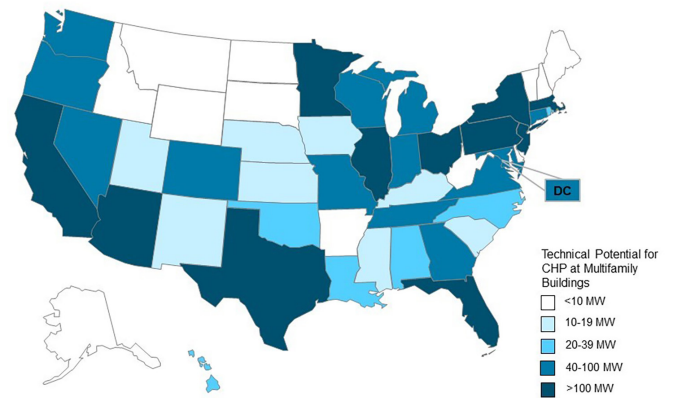


4 U.S. Department of Energy CHP Installation Database (U.S. installations as of December 31, 2020). <https://doe.icfwebervices.com/chp>.

Potential for New CHP Installations at Multifamily Housing

In 2016, DOE conducted a study of CHP's technical potential in the United States, estimating CHP market size in a sector based on existing facilities (i.e., not considering anticipated new construction), with that potential constrained only by technological limits (not economic or market factors). This study identified over 4.3 GW of additional technical potential for CHP across over 19,000 multifamily buildings in the United States.⁵ Just like the current fleet of CHP systems, this potential includes a mix of configurations and sizes. Technical assistance paired with policies designed to overcome market barriers could help expand CHP installations to capture more of their technical potential. Figure 5 shows that this potential is located across the country, with opportunities for CHP development concentrated in states with large populations.

Figure 5. CHP Technical Potential at Multifamily Housing Buildings by State



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

PROJECT SNAPSHOT: Small CHP System Reduces Energy Costs



The Towers Two apartment complex in Rexburg, Idaho, serves as housing for students at Brigham Young University-Idaho. The building houses 244 students and a residence manager. The building also contains common spaces and underground parking. The owners of The Towers Two installed CHP to make the housing facility less expensive for students by reducing their energy bills. The CHP systems are made up of two reciprocating engines, 10 kW and 5 kW. Electricity from the systems serves common spaces, while waste heat is used to produce hot water and heat a snow melt system for the building's walkways.

Photo courtesy of Blake Willis.

For More Information

For more information about CHP at multifamily housing, visit the DOE [CHP Project Profiles Database](https://betterbuildingsolutioncenter.energy.gov/resources/combined-heat-and-power-chp-technical-potential-united-states), a collection of more than 200 descriptions of installations in various market sectors compiled by DOE CHP Technical Assistance Partnerships (CHP TAPs). The database contains profiles of CHP systems installed at multifamily buildings across the country, including details about equipment, project economics, environmental benefits, and more. The CHP TAPs can also assist facility owners and stakeholders with opportunity screenings and technical analysis for proposed CHP installations. Contact your regional [CHP TAP](#) for additional details.

5 DOE, "Combined Heat and Power (CHP) Technical Potential in the United States," March 2016, <https://betterbuildingsolutioncenter.energy.gov/resources/combined-heat-and-power-chp-technical-potential-united-states>.