FACILITIES & MAINTENANCE

Water Heating Systems in Residence Halls: Key Considerations to Improve Energy Efficiency and Reduce Carbon Footprint

BY SHARON CHO AND HELEN RINGLE

College and university governing boards, presidents, chancellors, and other administrators from coast to coast are implementing decarbonization and energy-efficiency initiatives on their campuses to reduce their environmental impact. Those sustainability goals extend into the mechanical room, as facility managers are evaluating means to optimize domestic hot water systems to lower energy consumption, reduce emissions, and still meet demand, especially in high-use buildings such as residence halls.

Improving hot water systems can also impact the bottom line of higher education institutions, considering the usage volume. This is particularly true when the loads for residence halls (Figure 1) are considered. Residence halls demand constant access to hot water for the daily cleaning and cooking needs of thousands of students living on campus.

As part of their decarbonization and energy-efficiency goals, many decision-makers are considering building electrification—with heat pumps gaining much attention. The size required for a heat pump and accompanying storage tanks can be factored into the design for new construction. In retrofit projects, space is typically an overriding concern, as many older buildings do not have the footprint to accommodate heat-pump systems. Additionally, the significant up-front cost of a heat-pump system and the current capacity of the electrical grid are critical factors.

Once space, budget, and external constraints are considered, heat pumps may not always be realistic—or even the ideal solution. Instead, those projects may turn to a high-efficiency system that utilizes advanced gas-condensing water heaters and is properly designed—from sizing and piping to venting and water treatment—to help meet energy-efficiency goals. Doing so can help shrink a building's carbon footprint significantly and meet decarbonization goals in a cost-effective way, provided that the many site-specific aspects are fully considered.

Proper Sizing of Hot Water Systems

One main consideration is properly sizing the water heating system based on expected usage. Sizing water heaters for college and university campuses varies depending on the project. A one-system-fits-all approach is impossible. Decisions need to be made based on each building and its individual requirements.

This is especially true as it relates to residence halls, which have multiple variables. For example, when sizing the water-heater system, the occupancy of the hall is a main factor. Showers, sinks, kitchens, and laundry machines—often common areas for multiple uses—must also be considered. For example, a state university on the East coast has 16,000 students living in 140 buildings across four campuses. Those buildings range in occupancy from under 100 to more than 650 residents. Each residence hall has different requirements.

Load is another variable when sizing the system. Typically, high demand for on-campus residence halls is during the fall and spring months, when school is in full session. Hot water demands during these peak periods must be accurately determined to satisfy resident needs.

As outlined above, large campuses will have residence halls of various sizes, meaning load requirements will vary depending on the building. For this reason, it is beneficial to contract with a water-heater supplier that has a wide portfolio of models in numerous sizes and multiple footprints, as a single-source supplier helps simplify the project.

Benefits of System Redundancy

When designing the system and determining the size, redundancy must be considered. In a multi-unit redundant system, all water heaters are configured to work together, though at a lower rate than their maximum capacities. There are two main benefits to this type of design:

- **Maintenance and longevity:** Less strain is placed on the water heaters, reducing maintenance costs and extending the life of the units for greater lifetime value
- **Efficiency:** Because water heaters are operating at their peak performance, overall system efficiency is improved, lowering operating costs and supporting sustainability efforts.

Designing water heaters with sequence valves and advanced controls can help achieve optimal operation of a redundant system.

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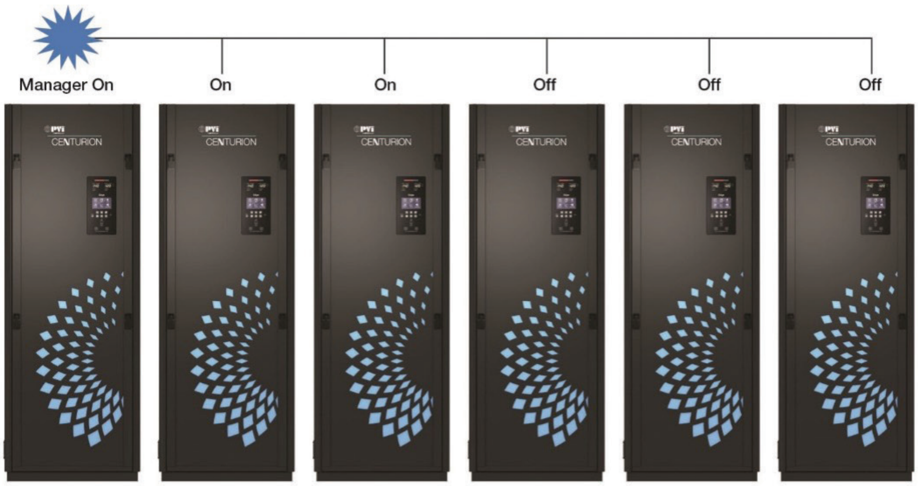

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Water heaters with multi-unit sequencing capability can efficiently string together numerous water heaters on the same system (Figure 2). Fire rates of all water heaters are sequenced by opening or closing a motorized valve, as required, to meet hot water demand. Only those units required to meet load demand are operating. Units in standby do not needlessly cycle to maintain a set point, minimizing system-standby losses as well as unit wear.

A Solution-Driven Approach

College and university administrators need to take a solution-driven system approach when planning their hot water solutions. Manufacturers with a broad portfolio of water heaters at various BTUs and footprint can provide multiple options along with a team of experienced engineers who can configure and customize the water heaters to provide a tailored solution that meets each building's specific needs.

This is particularly important for college and university campuses. Many buildings are not new constructions, so space is a premium. A manufacturer with various-sized units can configure and customize solutions to meet stated criteria. For example, smaller footprint, higher BTU/h, higher-recovery water heaters can meet the physical constraints of smaller-sized historical buildings, which are common on campuses, while also satisfying sustainability benchmarks.

High-Efficiency Design

Regardless of the configuration, system elements must be high efficiency. Selecting gas-fired condensing water heaters with low NOx can be 95 to 99 percent efficient. Water heaters with advanced combustion control systems can further improve operating efficiency by maintaining precise air/fuel ratios for greater uptime reliability and lower operating costs. If oxygen levels are too low, it can cause unstable combustion, resulting in faults and increased unscheduled maintenance. Conversely, if oxygen levels are too high, the dew point will be lower, and the water heater is less likely to condense.

Water heaters with a dedicWWated hot water re-circulation connection have the added advantage of improving overall operation. Circulation of hot water into the cold inlet on a condensing water heater lowers efficiency. A water heater with a dedicated connection to building return loops maintains two distinct temperature zones, so only the coldest water enters the lower-condensing zone of the water heater during a firing cycle. The result is higher efficiency.

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Water Quality and Scale Buildup

One often-overlooked component of designing a high-efficiency water-heating system is the quality of the water running through the pipes. It goes beyond obvious concerns regarding the health of building occupants. Poor water quality can cause scale buildup and corrosion within the water-heating system, which can negatively impact efficiency. It can also improve equipment lifespan dramatically, improving energy usage and maintenance and replacement costs. It is advisable to have the inlet water tested so a proper water-treatment plan can be factored into the design.

Hard-water scale is a common water-quality challenge facing campuses across the U.S., as it has corrosive effects on the water-heating system. By controlling scale formation at the source, facility management can maintain or improve the efficiency of a water-heating system in a very cost-effective way.

Water softeners are often used but may come with significant sustainability concerns related to water usage as well as harsh chemicals and salt released into the environment. An effective alternative is anti-scale systems that use Template Assisted Crystallization (TAC) technology. TAC controls the formation of scale in plumbing systems by transforming dissolved hardness minerals into harmless, passive microscopic particles without using salts or harsh chemicals—and with no wastewater.

These types of carbonization and energy-efficiency initiatives impact every aspect of campus operations. Taking a comprehensive approach to incorporate high-efficiency hot-water equipment and the load requirements of specific residence halls provides an effective means to shrink the carbon footprint by lowering water and electricity usage.

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