SAMSUNG

Chiller White Paper

The Benefits of Modular Chillers

Executive Summary

Chiller technology made its debut nearly 100 years ago when the first centrifugal chiller was patented (1). This essential technology has become widespread in commercial buildings and industrial sites ever since. However, not all chillers are created equal. For example, while modular heat pump chillers have been around for decades, they are not as widely used as water-cooled chillers (cooling-only) or packaged air-cooled chillers with natural gas-fired boilers to satisfy the heating demand in the building. Yet these modular heat pump chillers offer numerous benefits: hot water generation using an all-electric system, easily scalable, and a small footprint per module. This white paper explores the advantages of modular heat pump chiller technology.

An Introduction to Packaged Air-Cooled vs. Modular Heat Pump Chillers

For small- to mid-sized applications, both air-cooled chillers with natural gas-fired boilers and modular heat pump chillers can effectively satisfy a building's cooling and heating demand. However, it's important to recognize that because both types are based on different engineering system designs, they have separate performance outcomes. For new construction or retrofit applications, each system design should be evaluated carefully for its compatibility with the design and operating parameters.

Packaged Air-Cooled Chillers –
These are typically sized for 50-400 tons and use an air-cooled condenser for heat transfer. Because the large unit is placed on a roof or the side of a building by crane, its concentrated weight must be considered. This type of chiller only produces chilled water, so a separate natural gas-fired boiler for hot water is required. This necessitates the addition of a rooftop mechanical room or installation in a basement to protect the boiler from the elements. Appropriate venting is required to ensure that the combustion products are safely removed from the building.

Modular Heat Pump Chillers –
These generally have a module size between 10-60 tons and use an air-cooled condenser section to transfer heat like a traditional air-cooled chiller. They also have the ability to work in reverse via a reversing valve to switch the condenser coil into an evaporator coil, producing hot water instead of cold water. The system is comprised of a series of modules that are connected by a water piping header. Due to their modular configuration, they can be headered together separately to create multiple heating and cooling systems. Their compact footprint makes them easy to transport and install without heavy machinery. They can be moved with pallet jacks and transported in a freight elevator, eliminating the need for a crane. Chillers can be grouped in one location or distributed throughout a property.

Performance Advantages of Modular Heat Pump Chillers

Because the life expectancy of an air-cooled chiller is 15+ years, it is critical to select systems that offer lasting performance benefits. This is equally true for new construction and retrofit applications. A modular heat pump chiller offers three distinct advantages over using a packaged air-cooled chiller and natural gas-fired boiler: all-electric hot water production, capacity flexibility, and fossil fuel independence.

Hot Water Production

One of the key benefits of a modular heat pump chiller is its ability to make hot water, which a packaged air-cooled chiller is unable to do on its own. Depending on the hot water temperature requirement of the system, a heat pump chiller could eliminate the need for a separate boiler and all the associated upfront, utility, and maintenance expenses. This is a significant advantage as many states are restricting or moving away from natural gas. A heat pump chiller allows commercial properties to comply with mandates and reduce greenhouse gas emissions without sacrificing hot water supply.

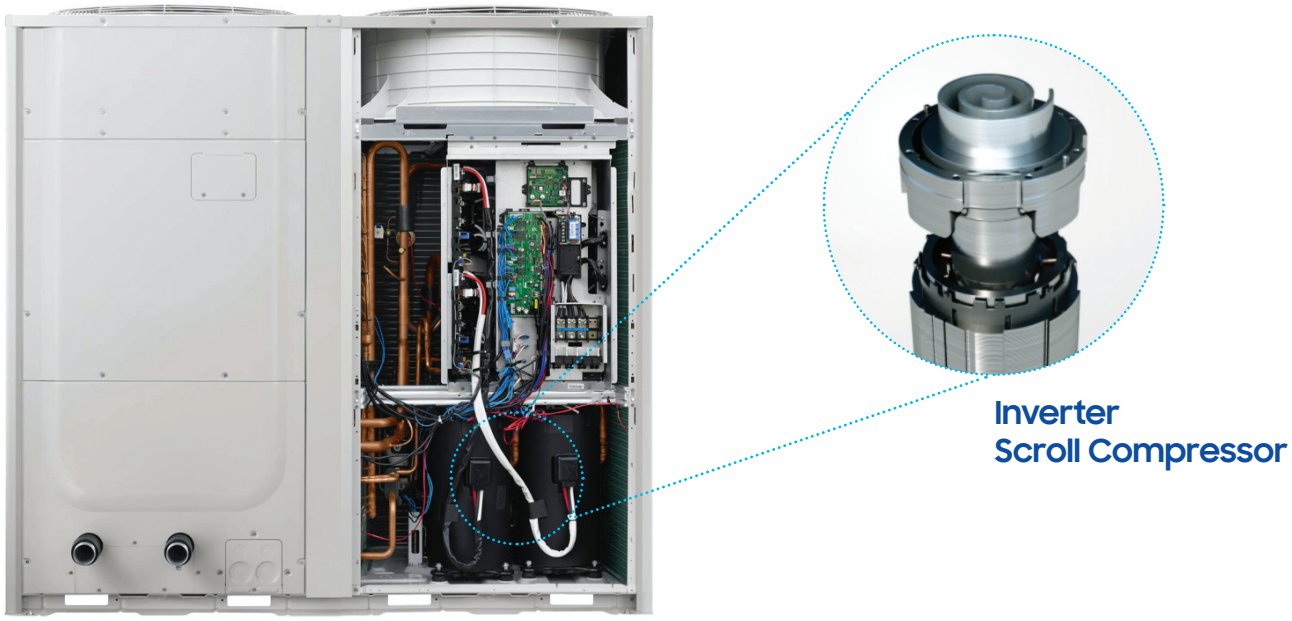
Hot water generation from modern heat pump chillers has come a long way. Heat pumps of the past would start to derate as outside air temperatures dropped below freezing. But with flash injection technology and variable frequency drives or inverter driven compressors, they can now make over 130°F (54.4°C) water down to 28°F (-2.2°C) outside temperature, over 120°F (48.9°C) water down to 5°F (-15.0°C) outside temperature, and 105°F (40.6°C) water down to -13°F (-25.0°C) outside temperature. Based on building needs, additional modules can be designed to overcome derates and still meet load on a project's given design-day requirements.

Hot water can be used to heat spaces through radiant floors or hydronic air handling units as well as serve process load needs. When using for domestic hot water applications, a heat exchanger must be employed to ensure that the system water doesn't contaminate the domestic hot water.

Capacity Flexibility

The turndown rates of modular heat pump chillers have a significant advantage over packaged air-cooled chillers, which typically only have a 25% turndown. Both chillers use staging, but modular chillers can shut off all but one of their modules and then turn that single module down to 10% capacity. The reason packaged air-cooled chillers aren't as nimble is due to their compressor sizes, compressor quantity, and staging methodology.

For example, a 150-ton packaged air-cooled chiller system would typically turn down to 25%, or 37.5 tons, before the compressors start cycling on and off. The same size system with ten 15-ton modules could turn off all but one 15-ton module. It would then ramp that module down to 10%, or 1.5 tons, before compressors start cycling on and off.



Modular heat pump chillers also make it simple to add incremental capacity by adding another unit – an option that is impossible with a large packaged air-cooled chiller system. There are scenarios where a property outgrows its original capacity. For example, a 200-ton packaged air-cooled chiller was configured for a summer design-day of 83°F (28.3°C), but the new average highs are closer to 91°F (32.8°C). This system would be undersized and unable to effectively deliver cooling at those higher temperatures. Unfortunately, there's no option to change the chiller's capacity even by a few tons when using only a single packaged air-cooled chiller system. But with modular chillers, this can be achieved by simply adding units until the desired capacity has been met.

This capability is a significant advantage for any property that is increasing capacity in stages. For example, a new high-rise office plans for 50% occupancy in the first year with 20% increases each following year. With modular chillers, a property can add units whenever occupancy rates increase. This saves on upfront installation costs and capital expenses can be phased in over time.

Modular chillers are also a benefit for sites that expand their footprint or demand. For example, vineyards use chillers to air condition barrel rooms and chill fermentation tanks; as production increases, the wine producer can add a modular chiller at any time to keep pace with its new demand. The same is applicable to offices that experience frequent renovations. While switching from an open layout with 300 square feet per person to cubicles with 140 square feet per person allows a company to add more people to the same space, there's also a corresponding need for additional heating and cooling. A building can even experience an internal load change by adding or expanding a server room. Increasing the total tonnage of a modular chiller bank is the easiest way to satisfy higher demand.

Natural Gas Replacement

The first American city to prohibit natural gas infrastructure in new buildings was Berkeley, CA in 2019 (2). Dozens of other cities across the country have since followed suit. This includes a number of states that have adopted 100% electricity or renewable energy targets, such as Maine and Washington, D.C. (3, 4). This growing concern over fossil fuels and greenhouse gas emissions is pushing building owners and developers to find alternatives to natural gas.

Because modular chillers are all electric and produce hot water, they are a viable replacement to natural gas-fired boilers. They can help secure points or credits under green building systems such as LEED or Living Building Challenge as well. When paired with renewable energy, their demand is also offset.

Even if a state or city doesn't ban natural gas, there are budget reasons to avoid natural gas-fired boilers. There are jurisdictions that require a licensed operator for high-pressure boilers; New York City is one such example (5). While this trained professional performs a number of critical functions, such as testing equipment and handling maintenance, their required presence is an additional payroll expense. Switching to a modular electric chiller eliminates this labor cost.

4 Reasons to Switch to Modular Heat Pump Chillers

1) Eliminate Gas Connections or Service

Because modular chillers are electric, they reduce or even eliminate gas utility bills. If there are no other gas appliances, connections can even be removed from new construction plans. With no gas meter or piping necessary, building owners will reduce material as well as installation costs.

2) Gain Design Flexibility

Modular chillers free up space by eliminating the need for a separate boiler and mechanical room. Due to their unobtrusive profile, modular units are also easy to camouflage in a design. This is a bonus for buildings where the rooftop is an extension of the workplace; the aesthetics of patio spaces or vegetation can take precedence over mechanical equipment.

Modular chillers aren't limited to rooftop installation either. They can be placed in a parking garage, basement, or at ground level. It is also not a requirement to group a modular chiller bank in one location – they can be distributed throughout a site. By clustering chillers closer to end devices, piping can be shortened and pump sizes can be decreased, resulting in energy and material cost savings.

Another benefit of modular heat pump chillers is that overall system tonnage can be reduced, saving on initial expense. For example, a project may consist of a 200-ton packaged air-cooled chiller and a 2M BTU boiler. This is 400 tons of equipment that will never be operated simultaneously at full load. After determining a project's maximum heating and cooling peak loads as well as simultaneous peak load, it may be possible to downsize the plant to 200-300 tons of modular heat pump chillers because they can serve both hot water and chilled water headers with proper valving.

3) Increase Compressor Redundancy

A typical packaged air-cooled chiller has one to six compressors. If one goes down, the system can lose a good portion of capacity or goes completely offline. With modular chillers, however, a lost compressor isn't as catastrophic. If there are ten modular units and one compressor goes offline, only 10% of generation is lost and the remaining 90% capacity should be able to handle demand on most days.

This is possible with modular systems because the refrigerant circuit contained per module is completely independent. A contaminated system as a result of a compressor failure would only affect that module while the other modules would continue to operate normally. In a packaged air-cooled chiller, however, compressors typically share a common refrigerant circuit. Thus, a compressor failure could put debris into the circuit, requiring that the entire system be cleaned and all compressors be replaced. In this instance, the entire chiller may become inoperable.

This redundancy is especially important in critical environments. A hospital, for example, might have a 100-ton chiller in active use as well as a backup of equal size. Having an idle backup chiller is an enormous expense in the rare event that the main chiller experiences a failure. Modular chillers are far simpler to achieve redundancy – add an extra chiller module. Because each unit has its own set of compressors, one lost compressor isn't a major failure like it would be in a packaged air-cooled chiller. A 10-ton backup modular chiller is significantly less costly and requires less space than a 100-ton backup packaged air-cooled chiller.

4) Supplement a Packaged Air-Cooled System

An overlooked capability of modular chillers is that they can be added to an existing chiller plant as supplemental cooling or to act as a pony chiller. There are situations where an existing chiller plant is lagging behind demand by a small but impactful amount. Especially if the equipment is in the middle of its lifecycle and otherwise functions well, it doesn't make financial or environmental sense to replace it. Adding 10 to 60 tons of modular chillers is a cost-effective way to compensate for lost performance due to system degradation over time.

Another situation is when the load demands are less than the main packaged air-cooled chiller can turn down to during off peak times. To save on wear and tear of the compressors cycling, modular heat pump chillers could be used to satisfy those loads. This leaves the main packaged air-cooled chiller off, only to be used when the larger tonnages are needed by the building.

Samsung's DVM Chiller is a modular heat pump chiller that provides a chilled water solution for replacement and new design solutions. By combining the benefits of chiller and VRF technology, the DVM Chiller provides performance, efficiency, and incredible space savings. Visit SamsungHVAC.com or watch our product overview video to learn more.

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