Winning with Water Source Heat Pumps in Mixed Use Commercial Developments

Use Diversity of Energy Demand to your Advantage

- By **Naveen Halbhavi, P.E, ClimateMaster Inc.**

Mixed use buildings and campuses have been one of the hottest growing markets in the construction industry. As GenYers move out of their parents' basements and Boomers look for no maintenance environments, they are embracing mixed use developments that are convenient, upscale and where everything is walkable. According to the National Association of REALTORS® *2013 Community Preference Survey*, 60 percent of respondents favor a neighborhood with a mix of houses, stores, and other businesses that are within walking distance, rather than neighborhoods requiring driving between home, work, and recreation.

This presents challenges to developers from obtaining permits for mixed use development, working with local municipalities to rezone land for mixed use projects, traffic planning and meeting energy efficiency mandates. For architects, the problems are having to design spaces that are functional to both residents and commercial property owners while still retaining the aesthetics of an overall space that residents can call home. For engineers, they need to tackle issues related to power distribution, noise reduction, plumbing and overall heating and cooling strategies for a mixed tenant base comprising of retail, office and homeowner tenants.

One of the best time tested technologies that can address issues related to energy efficiency, mixed use heating and cooling demand, and providing aesthetically appealing exteriors and interiors are water source heat pumps.

Introduction

A heat pump is a refrigeration circuit that can cool spaces during warm weather and heat spaces during cool weather. With a heat pump, you can cool or heat a space by only using electricity. By not burning fuel for heating, as in a traditional central furnace, a flammability risk is eliminated.

Commercially available heat pumps can be categorized into two broad types:

- An air-source or air-cooled heat pump
- A water-source heat pump (WSHP)

An air-source or air-cooled heat pump is a type of heat pump that operates by rejecting heat to outside air during the summer or by absorbing heat from outside air during the winter. A WSHP is a type of heat pump that operates by rejecting heat to a water-pipe system (or water loop) during the summer or by absorbing heat from the same water loop during the winter. When multiple units of WSHPs are installed, they are all serviced by a common water loop system (or header) to keep system costs low.

With WSHPs, since the heat is transferred into a pipe carrying water, the operation is much quieter and the system is also space efficient since water is more efficient and has larger capacity for carrying away heat air does. With traditional air cooled heat pumps, designers of mixed use developments must find a place to house multiple air condensing coils that are not only noisy but also distract from the outdoor aesthetics. These air condensing coils require a lot of real estate footprint and free ambient space to be able to reject the heat. With a multi-unit WSHP installation, heat exchange can be accomplished with a single central evaporative cooling tower or dry cooler located on the ground or the rooftop. The individual WSHP units themselves can be placed in dropped ceilings or hidden away in mechanical rooms or utility closets away from occupied spaces. Placing the units in ceilings, nearer the point of use in a decentralized architecture, also results in less ductwork and less fan energy consumption. Fan energy consumption can be among the largest energy components of a HVAC system and good system designers will acknowledge it and attempt to minimize this.

Diversity of Energy Demand in Mixed Use Developments

Depending on the orientation of the buildings and the demands of different kinds of tenants in a multi-use location, it is normal for some of the occupants to be demanding cooling while some others are in heating demand. Or there is demand for hot water in a restaurant while the gym next door is demanding cooling. Even within a single office building, for example in winter, there is usually need for heating at the perimeter that is exposed to the elements and cooling needed at the core of the building due to heat given off by occupants and equipment.

This diversity of energy demand exists everywhere. Wouldn’t it be the most efficient use of resources if we could take the heat out of an area that is rejecting it and use it in another area that is demanding it? This is where the water source heat pumps excel. Water is non-flammable, non-toxic and an ideal medium to transport energy without any of the negative consequences of using a synthetic or flammable refrigerant to move energy, especially in the vicinity of occupied spaces. What gives the WSHP this unique ability to achieve this safely and efficiently?

The BTUs of cooling load and the heat of compression in the refrigeration circuit of a traditional air source unit is rejected to the atmosphere through the condensing coil. The quality of heat is low and it is not economical in an air source heat pump to recover this energy. This energy is wasted. In a water source heat pump, these BTUs are rejected into a common water loop and the water loop acts as a reserve of this energy that can be easily transported to the place that is demanding heating. As water is physically moved by means of a pump to different areas of the same building, or a group of buildings, thermal energy is also being transported. Even though the quality of heat is low, it is efficiently captured and transported to where it is needed.

Indeed this is one of the biggest advantages of a WSHP - thermal energy can be efficiently and safely transported to wherever water can be pumped. Now contrast this with a VRF system with its limited ability to transport energy over long distances since it uses refrigerant in copper pipes as the transport medium. If there is a refrigerant leak anywhere along the path, it is extremely difficult to detect, isolate, re-braze, re-vacuum and reinstate the system. With a WSHP, normal plumbing systems are used. This is much safer and easier to maintain.

WSHP Implementation in Mixed Use Developments

A typical WSHP implementation in a mixed use development consists of several WSHPs that are installed close to the areas of demand and fed by a common water header. The cooling tower, pumps and boiler are located away from occupied spaces resulting in quieter surroundings. (Figure 1)

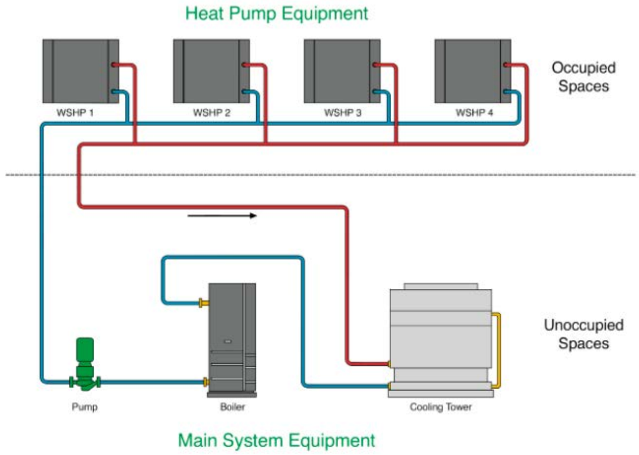

Fig 1: Multiple WSHPs are connected to a common loop or pipe header. This common loop is connected to a boiler and to a cooling tower. Water is then pumped around the loop using pumps. This picture shows a 2-pipe system which is the most common.

The small quantity of Freon charge needed in a WSHP is contained completely within the unit. Again contrast this with a VRF system that requires much higher quantities of Freon charge. In a VRF system, Freon is not only used within the central units and their internal multisplit units but also is present in the extensive pipework between all these internal and external units. Some VRF systems need two or three pipe networks to accomplish this and all these pipes are carrying Freon. This complex maze of copper piping presents increased safety and maintenance risks due to the higher refrigerant charge in the system and the hazard it poses if there is a leak. As the industry considers moving to flammable refrigerants to meet the low GWP refrigerant requirements driven by climate change concerns, the safety considerations of using VRF become more acute.

In a WSHP implementation, the control schemes generally limit the water loop temperature to be in the range of 60F to 95F depending on the season. Keeping the water loop temperature in this range is a matter of economics and engineering judgement. The heat pumps can operate with water temperatures outside this range but their efficiency will be lower. For example, the heat pump has to work harder in heating mode with the water loop temperature at 55F than at 60 F. Is it more economical to let the heat pumps work harder at 55 F (consuming more electricity) or using the gas fired boiler to raise the temperature of the loop to 60 F? The answer depends on the relative costs of gas and electricity as well as the relative efficiencies of the boiler and heat pumps at these operating points.

When both heating and cooling loads are present, the WSHPs extract the heat from areas rejecting it and provides it to the WSHPs that are demanding this heat through the common water loop. When the loads are able to offset each other, small temporary imbalances between heating and cooling loads are taken care of by allowing the water loop temperature to float within the 60F to 95F range. In this scenario, there is no need for any net inputs to the system of either heating BTUs or cooling BTUs and both the cooling tower and boiler can be turned off to improve system efficiency (Figure 2). Due to the large specific heat of water in the loops, a 35 degree F range in water loop temperature implies there is a large amount of thermal energy available to take care of demand imbalance. Just one thousand feet of 6” pipe can hold 875 KBTU of thermal energy over a 35 F span of temperature. Over a one hour period, this equates to over 70 tons of refrigeration that can be moved around.

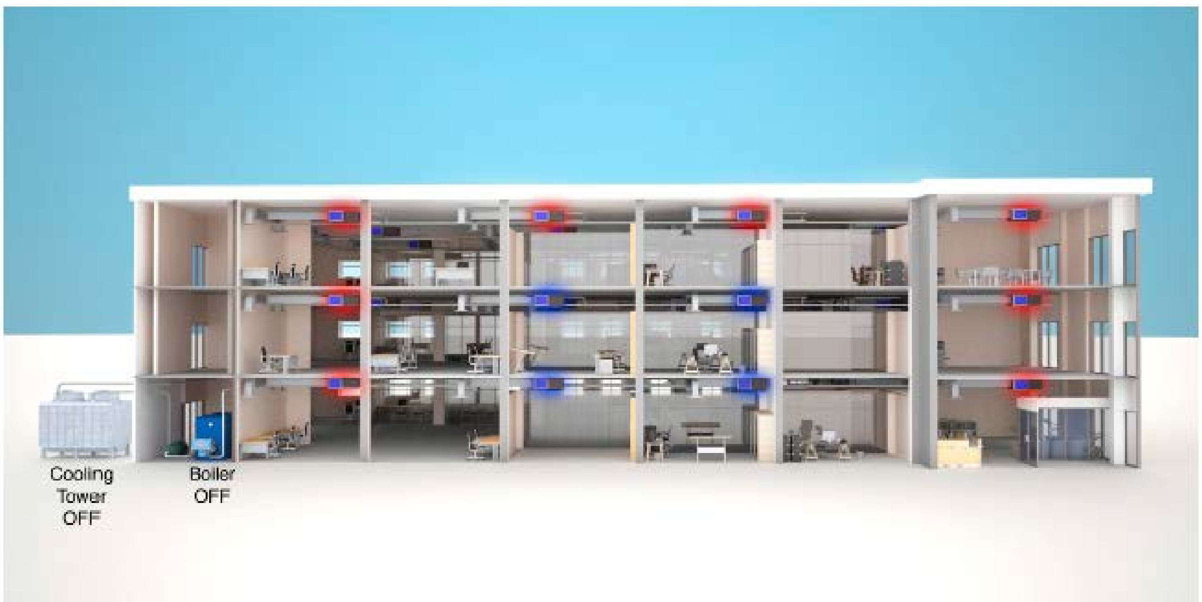

Fig 2: **The heating and cooling loads are able to offset each other in this scenario. The heat rejected by units in cooling mode is carried away to the heat pumps that are in heating mode. Both the boiler and cooling tower are turned off.**

In cases where there are predominantly cooling loads, in summer for example, a central cooling tower is provided to provide only the net cooling to keep the water loop temperature from exceeding 95F (Figure 3). Alternately, the excess BTUs can simply be used to generate hot water using a water-to-water WSHP.

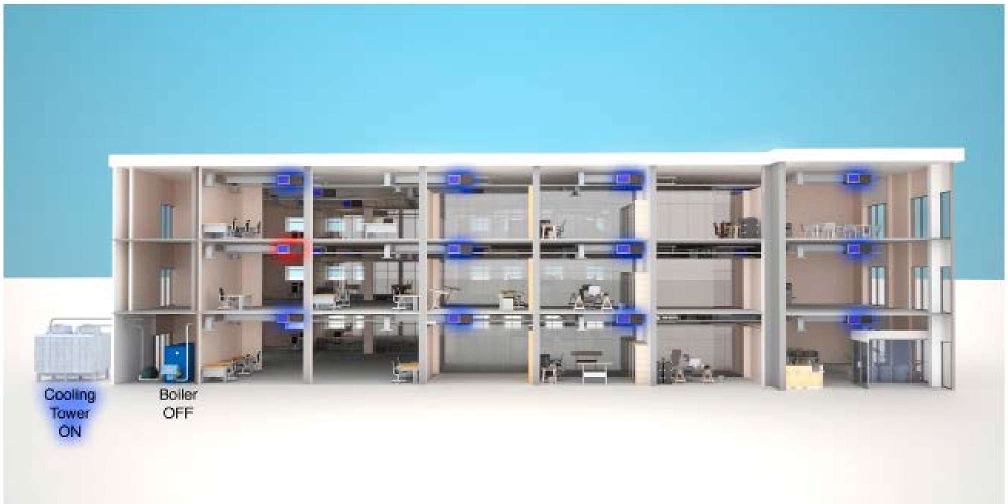

Fig 3: Most of the units are in cooling mode. The cooling tower is on and the boiler is turned off.

The reverse is true in winter when the heating demands exceed the cooling demands: a central boiler is provided to add BTUs to the water loop to make sure that the water loop temperature does not go below 60F (Figure 4). Since the cooling tower and boiler are sized to handle only the maximum net cooling and heating demand, as opposed to sizing for maximum total cooling and heating demand, their sizes can be reduced resulting in cost savings.

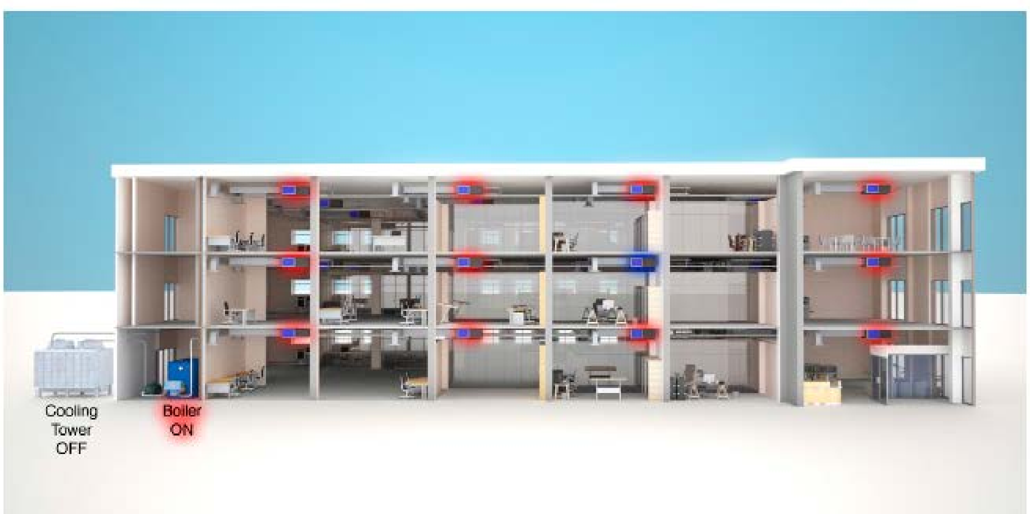

Fig 4: Most of the units are in heating mode. The cooling tower is off and the boiler is turned on.

The WSHP industry continues to make strides in improving efficiency, even at part load conditions. Technologies like microchannel heat exchangers, variable speed compressors, wireless thermostats and occupancy sensors are being tested or have already been implemented to further reduce energy usage and stay at the higher end of the efficiency spectrum.

Conclusion: WSHPs are a time tested solution that has been effectively deployed in large multi-use developments. They are especially effective in reducing energy consumption where there is diversity in energy demand and result in smaller sizes of cooling towers and boilers. By using water as a heat transport medium in a common water loop, WSHPs can move thermal energy across large distances safely and efficiently compared to alternative solutions on the market. They are smaller and quieter and offer design flexibility by allowing the placement of towers, boilers and pumps in locations remote from occupied spaces. WSHPs eliminate flammability risk associated with furnace heating and they accomplish highly efficient operation using much smaller quantities of refrigerant compared to VRF systems.

Naveen Halbhavi, P.E is Director of Marketing at ClimateMaster Inc, a leader in Water Source Heat Pumps. He has worked in roles of process engineering, project management, plant operations, product management and general management.