Wet Heat Performs Well When Put to the Test

By Nicole Krawcke
Of *The NEWS* Staff

When applied properly, wet heat technology can help significantly reduce energy consumption and increase energy savings. Below are three working examples of how wet heat technology helped a large college apartment building reach Leadership in Energy and Environmental (LEED)-Silver certification, a Kentucky high school save up to 35 percent in monthly utility costs, and a local pizza restaurant go green.

Steve Moruzzi, Laars territory service manager, tests the operating efficiency of a Laars NeoTherm.

Redstone Lofts

In 2012, the University of Vermont broke ground on the Redstone Lofts — two on-campus student apartment buildings. Now, in their second winter, the apartments have achieved LEED-Silver certification and have been rated by students as one of the institution's best places to live.

Matt Blair, Redstone Lofts maintenance manager, tests the variable frequency drive for Taco circulators that serve remote hydronic zones. The apartment complexes have been rated very highly by University of Vermont students.

At Redstone Lofts, the south building's mechanical room includes Taco FI Series loop water system pumps, the glycol reserve tank and its expansion tank, the large plate and frame heat exchanger, and cooling loop tower pumps.

Following strict LEED guidelines, both of the new buildings were heavily insulated and provided each living unit with its own HVAC system. The buildings also have high-albedo roofs designed to reflect sunlight and heat, reducing roof temperatures. All 144 living units are fully furnished and range from one to four bedrooms in size. They also feature abundant natural light, which helps reduce electric costs (separately monitored so that occupants pay utility costs for their living unit), and low-emissive windows, which are said to further reduce energy consumption by up to 24 percent.

Water-source heat pump systems provide efficient zone-controlled heating and cooling throughout each building by circulating water in a closed-loop piping system to move and exchange thermal energy. The many separate heat pumps in each building are connected to transfer Btu with greater efficiency.

Individual heat pumps add or remove heat from the air within each zone as required to meet its unique heating or cooling loads. During zone heating, they extract needed heat (thermal energy) from the common water loop. During zone cooling, heat is rejected into the water loop, where it can then be shared with all other heat pumps throughout the building. It's in this way that rejected heat, which is wasted to the outdoors in many HVAC systems, is fully utilized before any new energy source is used to heat or cool the buildings.

The heat pump systems also operate efficiently under part-load conditions such as when a small portion of the building remains occupied after hours. Only the required zone heat pumps are used, unlike systems that must keep a large central plant in operation at scaled-back capacity in order to serve a small portion of the load.

"Each building's mechanical room is equipped with two 95 percent, 1 MBtu Laars NeoTherm boilers, which serve as the main source of heat for fully integrated water-source heat pump systems,"

explained Tod Hebert, regional sales manager, Laars.

Large Baltimore Aircoil Co. cooling towers serve as the source of heat rejection during warmer months to cool the heat pump loop and provide air conditioning.

"One of the more interesting facets of the mechanicals is the hydronic system," said Ed Pearson, president, Pearson and Associates Inc., the Redstone Lofts' mechanical, electrical, and plumbing engineering firm. "The boilers are connected to an outdoor reset control, which monitors outdoor temperatures during the winter months to determine firing rates and frequencies."

David Cohen, territory manager of Stoughton, Massachusetts-based rep firm Sales Marketing & Service Inc., said he prefers the NeoTherms because they are easy to operate.

"They've got an advanced, intuitive control with a touchscreen right on the face of the boiler that tells users all about system operation and conditions within the buildings."

"Paired with the Laars M4 controller mounted on the wall next to each boiler, the heating and hot water operations in the building are performed almost automatically. Very little has to be done to keep them going," explained Steve Moruzzi, territory service manager, Laars.

"I'm the only full-time maintenance tech, and, with more than 400 tenants, the automated systems are a huge help," said Matt Blair, technician, Redstone.

There are a total of 156 heat pumps ranging in size from 1 1/2- to 2-ton for the apartments and up to 6 ton for common areas. Each heat pump has its own compressor with a reversing valve, making them the sole providers for heating and cooling needs in each apartment. In each of the mechanical rooms are six 120-gallon indirect water heaters to meet domestic hot water demand for each building. The boilers serve these as priority zones. "There's a readily available source of domestic hot water at all times, which is extremely important during the winter conditions we experience," said Blair.

For system heat, as needed during the winter months, hot water is injected into a flat plate heat exchanger that heats system fluids and then circulates the fluids to individual heat pumps. The temperature of the boiler water is reset according to the outdoor air temperature. When system fluids hit 50°-55°F, sensors activate the boiler. A Taco circulator then moves the Btu out to any zones calling for heat.

"The circulation and control systems permit 'self-serve' operation of the heat pumps as warmth or cooling is needed within the zones they serve," explained Blair.

The heat pump loop is the key source of constantly circulating Btu. Loop water temperature ranges from 55° in the winter to 90° during the summer months.

Paul Christy, superintendent, Clark County Public Schools, said the new high school's dedicated outdoor air system (DOAS) and active chilled beams combination saved the district thousands of dollars within its first four months of operation.

Each heat pump has its own zone valve that opens and closes to either pick up or reject heat into the main loop. When heat pumps are not calling for heating or cooling and the zone valve closes, the variable frequency drive (VFD)-controlled Taco pump slows down, which saves building energy.

"The boilers interact with the loop water to keep the temperature in the required operating range for the heat pumps," added Blair. "Each heat pump operates as its own zone, drawing in or rejecting Btu from the loop as needed."

In each mechanical room, four Taco 1900 Series pumps — each dedicated to a boiler — circulate system fluids. A 1.5-hp Taco KV Series pump governs domestic hot water circulation. Taco 2400 Series circulators were installed as backups for the hot water circulation pumps. Both the loop system and cooling system pumps are Taco FI Series pumps.

Eight Taco iWorx controllers act as the backbone for each building's mechanical system, controlling the automation for all pumps and allowing the system to operate fluidly as a whole.

"iWorx makes maintaining and monitoring the mechanical systems a simple task. I can log in online with an IP [Internet protocol] address and see how each mechanical system is running," explained Blair. "I don't even have to step into the mechanical room to make changes to heat pump operation. I can be in my office or out in the field; if anything goes wrong — a pump shuts off, there's higher static pressure that may indicate the need to replace a filter, or a sensor goes above a set point — I receive an email alarm that goes directly to my phone."

In cases such as these, Blair can log in on his smartphone, turn pumps on or off, raise or lower temperatures, or perform a series of diagnostic procedures immediately. "In most instances, we learn about problems before there's any noticeable change of conditions within the living spaces, long before they're real problems."

Although the polar vortex wreaked havoc all across the U.S., student tenants at Redstone Lofts had luxurious comfort, thanks to state-of-the-art technology.

"Not once have we received a complaint about loss of heat or hot water," said Blair. "Even though last winter was one of the coldest we'd seen in a long time, the systems kept up with the heating and hot water demands effortlessly."

The energy savings are attributed to a 50 percent airflow reduction that chilled beam technology offers versus conventional forced-air distribution methods as well as better humidity control and higher set point temperatures with no trade-off of indoor air comfort.

Chilled beams don't require filters or any moving parts, which reduces the number of maintenance-related classroom interruptions.

George Rogers Clark High School

George Rogers Clark High School (GRCHS), located in Winchester, Kentucky, features a new green design that reduced monthly utility costs approximately 35 percent while providing improved IAQ and comfort.

One reason for the increased efficiency is a hybrid HVAC design featuring a geothermal well field that supplies active chilled beams, dual-wheel outdoor air dehumidification systems, and other cutting-edge technologies, according to Paul Christy, superintendent, Clark County Public Schools. Christy, the county schools' former director of operations, oversaw the 300,000-square-foot high school's HVAC design team that included engineer, Charles Wade, vice president, KTA Engineers, Lexington, Kentucky; Mark Saunier, president, Comfort & Process Solutions (CPS), Lexington; and engineers from Semco LLC, a Columbia, Missouri-based manufacturer of chilled beams and heat recovery outdoor air equipment. D.W. Wilburn Construction Co., Somerset, Kentucky, oversaw the construction and HVAC installation.

Originally specified as a conventional 200-foot, 80-well geothermal field with just ground-source heat pumps (GSHPs), Christy opted for enhancing the design by replacing

the proposed 350 heat pumps with 542 active chilled beams and six Semco Pinnacle Series dedicated outdoor air (DOAS) heat recovery systems. Christy's decision was based on visiting a similar system at Greenville, South Carolina-based Furman University and reviewing an 18-page building energy simulation report prepared by Semco.

The report, which was completed by using the Carrier Hourly Analysis Program (HAP), in conjunction with SEMCO's supplemental Pinnacle hourly energy analysis module, compared the estimated annual energy consumption of the high school's three most-likely HVAC approaches:

- A DX-based outdoor air system, including a total energy recovery wheel and hot gas reheat capabilities, preconditioning the outdoor air delivered directly to the classroom spaces served by individual GSHPs;
- A DOAS incorporating both energy recovery and passive dehumidification wheels, served by a GSHP to precondition outdoor air delivered directly to the classroom spaces served by individual GSHPs; or
- A DOAS and active chilled beams combination, all served by a GSHP chiller, to condition the media center and all classrooms.

Based on an electric rate of 7 cents per kilowatt hour, the estimated annual HVAC energy cost for each of the three systems was $73,490 (53 cents per square foot), $56,670 (41 cents per square foot), and $45,175 (33 cents per square foot), respectively.

"The [GRCHS] mechanical system was installed for $19.5 per square foot, which is the same or less than water-source heat pumps or variable refrigerant volume (VRV) ground-source systems currently in Kentucky," said Saunier, whose company offers building automation, HVAC service, and energy-efficiency products.

The 1960s-era, 199,492-square-foot high school building featured a four-pipe boiler/chiller system with fan coil units and was averaging annual utility costs of approximately $194,040 (97 cents per square foot). "In the first four months of operation, the new building's preliminary utility bill figures were $41,800 less than our old building during the same period," said Christy, who oversees 11 county schools.

The savings comes primarily from better humidity control and subsequently higher set point temperatures with no trade-off of indoor air comfort. The system's comparably lower 43°F dew point temperature allows for greatly reduced air volume due to the superior humidity control from dual-wheel dehumidifiers that control both latent and sensible humidity, according to Saunier, who helped convert the original design from conventional heat pumps to Christy's requested chilled beam concept.

Other Clark County schools with conventional HVAC systems typically operate at 70°F amidst occasional "too warm" complaints in spring, summer, and fall. GRCHS's temperature complaints have occured less frequently due to better humidity control, even though set points average five degrees warmer at 75°. "We've had to educate teachers that set point classroom temperatures they may have previously perceived as being too warm, are now a more comfortable temperature due to this building's superior humidity control," Christy said.

The IQHC chilled beams, which are supplied by a water-to-water GSHP by ClimateMaster Inc., have a 12-slot nozzle that's field-adjustable for areas with excessive solar gain or heat loss. CPS' service department is training the GRCHS maintenance staff to adjust volume and up to a 45-degree angle directional airflow for hotspots with each chilled beams' easily accessed hand-operated levers for the greatest airflow flexibility efficiency. The nozzle adjustment additionally provides a unilateral, disproportional, or equal air volume from each side. It allows ideal room coverage and flexible distribution possibilities without relocating the device.

The chilled beams never develop condensation because five rooftop DOAS units ranging 3,700- to 14,500-cfm supply them with semi-neutral, dry air. There is one 7,000-cfm DOAS that resides in a mechanical room. Some areas with high ceilings that aren't ideal for chilled beams, such as the cafeteria and gym, use their own DOAS to distribute cooling and heating via the GSHP loop.

The DOAS units feature variable frequency drives (VFD), integrated GSHPs, and dew point discharge controls that are all interfaced with the school's building automation system by Delta Controls. The control system runs through each DOAS unit's wintertime supply temperature control stages that use the enthalpy wheels' heat recovery to minimize the onboard mechanical heat pump's runtimes. The system also saves energy by maintaining humidity with a recirculation mode during unoccupied periods, which lessens ramp-up time heating or cooling when the school opens each day.

Besides energy savings, GRCHS also realized additional benefits, including saving 2,000 square feet of storage space that would have been consumed by heat pumps in two mechanical rooms that are now used for storage and other uses; reduced maintenance, because chilled beams require no filters and moving parts, thus eliminating any periodic classroom-interrupting maintenance tasks; quieter classroom environments, because chilled beams are approximately 10- to 15-db quieter than heat pumps; and better temperature and humidity control by independently controlling each load.

"We like the idea of constant air movement at low velocities from a comfort and noise perspective," said Ron Murrell Jr., principal, Rosstarrant Architects, Lexington, Kentucky, an architect firm that designs educational facilities exclusively. "Chilled beams provide a quieter learning atmosphere as opposed to the considerably noisier method of mechanical units cycling on and off in or near the classroom."

"When we told a state education representative that our outdoor air system wouldn't shut off because it actually drives the chilled beams, he was excited because some conventional Kentucky school buildings suffer poor IAQ when school operators shut off outdoor air to eliminate high indoor humidity," said Saunier.

The building meets the energy requirements for LEED-Platinum certification; however, the school district chose to instead use the application money for educational programs, according to Saunier.

Christy also boasts 0.53 percent student attendance increases the first five months of operation in the 2013 fall semester versus the same period the previous year, which he attributed partially to superior IAQ and humidity control.

The success of the project has led the school district's design team to consider chilled beams and DOAS in an upcoming school retrofit. "Because of space restrictions in a retrofit, we see chilled beams as a space-saving, air-comfort solution," Christy said.

Mellow Mushroom

The Mellow Mushroom already stands out from your average pizza place. With names like Kosmic Karma and Magical Mystery Tour, the national chain's pizza choices make an impression. The Eneref Institute recently highlighted the Asheville, North Carolina, restaurant for its recently installed solar thermal hot water system as part of its Efficient Heating and Cooling Initiative.

While Mellow Mushroom is a franchise, Jeremias Prenatt, manager of the Asheville location, explained the small, locally owned restaurant is run like an independent eatery. The location orders local produce and recently installed a solar heating system to supply hot water for the restaurant's dishwashing machines, kitchen sinks, and customer bathrooms.

When most people think of solar energy, they imagine solar photovoltaic cells (PV). Solar heating panels are different than PV in that solar heating works on the basic principle of converting solar radiation, or sunlight, into heat rather than electricity. Solar water heating systems simply circulate liquid through rooftop panels heated by the sun. The liquid, food-grade antifreeze or water, transfers the heat to storage tanks that feed heated water into the conventional hot water system. The technology is already quite common in both Europe and Asia.

Mellow Mushroom has gone "as green as possible for profit," said Prenatt. Owner Gerry Mahon and his restaurant partners have begun other green initiatives. The restaurant began a compost coalition that costs Mellow Mushroom a little bit more than standard waste dis-

posal, but "sends out a ton of less waste," Prenatt explained. When the franchise asked Sundance Power Systems, a local solar installation company, about installing a solar heating system, the numbers confirmed the wisdom of the restaurant's decision.

As Dave Hollister, founder of Sundance, said, Mellow Mushroom's owners saw they had "the ability to create a triple win for the business — you've got the marketing advantage, the tax advantage in the short term, and a long-term financial hedge against rising energy prices."

Mellow Mushroom's solar heating system consists of six 4-by-10-foot collectors and a 120-gallon storage tank, which produces about 240,000 Btu per day. The system included a differential control pump and also included a heat level monitor. The system was sized to produce 20 percent of the restaurant's hot water consumption in a day and can be expanded to provide more in the future. Capturing the savings that North Carolina has to offer, and considering the fuel costs, the system has a great payback. Because the restaurant's water needs are heavy and constant, its storage needs were relatively low, and required only a 120-gallon storage tank. The collectors increase the temperature of the water from 40°F to about 120°. To bring the water up to 160°, the higher temperature required for dishwashing, the restaurant uses natural-gas-powered water heaters located inside the building. The installation was quick and unobtrusive. The panels themselves are also low-profile. While the panels, manufactured by Alternate Energy Technologies LLC, are visible from other nearby locations, they can't be seen from the restaurant's patio seating. For curious customers, though, there are a few small signs in the restaurant to clue them in.

Mellow Mushroom, located in Asheville, North Carolina, installed a solar thermal hot water system as part of its Efficient Heating and Cooling initiative. The system was sized to produce 20 percent of the restaurant's hot water consumption in a day, and can be expanded to provide more in the future.

Mahon and the other owners of the franchise planned on a long life for the system. According to findings by Eneref Institute, a well-designed-and-installed system can last more than 25 years. Mahon chose to invest his own money to buy the system as opposed to a third-party power purchase agreement (PPA), "because they saw, in the long term, it's a great foundation on which to build their business," Hollister explained. Buying the system was made even easier because of state and federal incentives including the federal investment tax credits (ITCs). The state of North Carolina provided a 35 percent incentive, while the federal government provided an additional 30 percent ITC, which Hollister said helped tremendously.

In order to maximize the use of incentives and stay within budget, Sundance Power Systems and Mellow Mushroom chose to install the panels in two stages. Six panels were installed in the initial installation, and another six will be installed next year, earning additional tax credits with six panels installed each time instead of all 12 at once. Additionally, Mellow Mushroom was able to sell the renewable energy credits (RECs) it earned for creating its own hot water to Dominion Power, which is based in Virginia but has operations in North Carolina. The REC rules are different in each state, and the prices fluctuate greatly. Still, according to the Solar Energy Industries Association (SEIA), solar heating and cooling technologies have produced a strong return on investment for the public dollar, and more than 90 percent of Americans want their use to increase.

Prenatt said customers have noticed the panels, and he hopes they serve as an inspiration for other local businesses, as well. According to Prenatt, Mellow Mushroom is one of the highest-volume restaurants in downtown, and it succeeds not only in business, but on behalf of the environment, as well.