The cost and availability of natural resources have become concerns for colleges and universities nationwide. This is no less true at The University of Alabama at Birmingham (UAB), a rapidly growing campus of more than 17,000 students. Twenty-five years ago, water was abundant in Birmingham. However, within the past decade – especially the past five years – water has become an expensive and scarce commodity. Factors contributing to this include summer droughts that have led to water use restrictions and interstate legal fights over water consumption rights for the rivers flowing through multiple states.

Reliable water supply is essential to UAB, where a central chilled-water system cools approximately half the campus building space – much of it critical-care hospital units and research labs. Among its water conservation efforts, UAB has implemented a creative strategy to recover and utilize condensate water from the fins of air handler coils.

Mission-Critical Cooling

In addition to educating students from every U.S. region and some 100 countries, UAB is a renowned research university and among the largest academic medical centers in the nation. The UAB Health System comprises UAB Hospital, the I.M. Pei-designed Kirklin Clinic, Callahan Eye Foundation Hospital and several other medical facilities. With more than 18,000 employees, UAB is Alabama's largest employer and the single-largest contributor to Birmingham's and central Alabama's economies, with an annual impact exceeding $5 billion.

The UAB campus is home to more than 200 buildings totaling approximately 16 million sq ft of space spread over more than 86 city blocks, taking up much of the southern half of the city. Approximately half the building space at UAB – 8 million sq ft – is connected to the campus chilled-water system.

This system consists of three chiller plants housing a total of 31 centrifugal chillers (ranging from 2,000 to 4,000 tons each) with a capacity of 38,000 tons. Peak cooling load is 28,000 tons, and the minimum winter load is 5,500 tons. Operating around the clock, 365 days a year, the plants are equipped with programmable logic controller (PLC) systems to maximize efficiency. Chilled water produced at the plants is delivered to buildings via a 4.5-mile closed-loop distribution system, approximately 70 percent of which is underground. Each building is connected to the distribution system with a flow meter and is billed monthly for MMBtu usage.

Fifty-two of UAB's key buildings utilize this cooling system – all spaces where chilled-water service reliability is critical. Sixty percent of these buildings are acute-care hospital facilities. For life-support patients in the 1,132-bed UAB medical center, maintaining levels throughout temperature-dependent surgical suites and intensive-care units is imperative. Forty percent of the buildings on the campus cooling system are research labs, including facilities with specialized procedural labs, animal housing and labs with research stored in freezers.

(The UAB campus also has a new central steam system that will open in February 2013. Previously, the university purchased steam for heating and instrument sterilization from a district system owned and operated by Alabama Power Co., which is discontinuing steam service. The UAB system,
which will also include installation of a condensate return system, will provide 400,000 lb/hr of steam to 30 critical buildings totaling 6 million sq ft of space.)

Sustainability: A High Priority

The largest single-site employer in Alabama, UAB strives to be a good steward of its resources and is an established sustainability innovation leader. Among UAB’s sustainability initiatives have been the energy and water conservation efforts of its campus chilled-water system.

Alabama experiences around 100 days of extremely hot weather annually, and the heat and humidity result in heavy air-conditioning need. UAB’s central chilled-water system is a major energy consumer, responsible for nearly one-third of total campus electrical use. The power demand at UAB has increased with the university’s growth: 2011 electricity consumption was up 20 percent from 2006, despite effective conservation efforts. Recent programs to reduce chilled-water system energy use included the removal of all three-way valves, increasing delta T and raising overall system efficiency; replacing old 78 degree F wet-bulb cooling towers with new high-efficiency 80 F wet-bulb towers; and improving average chiller efficiency to 0.59 kW/ton.

Due to ongoing campus expansion, UAB requires more and more water to sustain operations. During peak summer months, the UAB central chilled-water system requires more than 1.2 million gal of cooling tower makeup water daily due to evaporative and blowdown losses. UAB has had ongoing concerns about water use and conservation – especially in light of its need to deliver cooling to more than 86 blocks of campus buildings.

The Solution

In summer 2010, UAB considered recovering and using the millions of gallons of high-quality condensate water from the fins of the air handler coils, which was being wasted down the drain. UAB and others had collected this condensate before on a small scale at individual buildings. Such projects were limited, however, in their ability to reuse the condensate, often due to the high cost of installing piping to transfer the water to remote areas for utilization.

At UAB, the main obstacle was that most of the condensate would be collected in buildings far from the cooling towers where the water was needed. Digging up the streets in downtown Birmingham to install a distribution system to pipe the air handler condensate back to the chilled-water plants’ cooling towers was not viable. However, a simple solution was already in place: The existing chilled-water distribution system piping could be used to move the condensate from the buildings to the main plants.

The central chilled-water distribution system has long been considered solely a closed loop running throughout the campus. With its new water recovery concept, UAB viewed the central chilled-water distribution system like a mass transit subway network, where people enter and exit at different locations. Everything was in place near the areas where water needed to be put in and taken out: The existing
lines of the chilled-water distribution system were already near the condensate drains and the plant cooling tower water return lines.

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**The existing chilled-water distribution system piping could be used to move the condensate from the buildings to the main plants.**

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UAB installed its first fin water recovery system in May 2011 in a group of large research buildings. Throughout 2011, five other systems were installed. By fall 2012, a total of eight large research buildings had condensate recovery systems in place (fig. 1).

At each building in the program, two to five small condensate recovery tanks were installed in the main mechanical room to collect the condensate water. (The condensate drains by gravity into the tanks). Each tank has a small standard sump pump to move the condensate to a large centrally located collection tank, typically holding 250 or 500 gal each. These larger tanks can generally handle the condensate from two to four small tanks. Water from the large collection tanks is pumped through a filter into the main chilled-water return. Water meters are on all points of feed into the chilled-water return.

At the central plant, the chilled-water return line is overpressurized by the condensate water pumped into the system at the building locations. The return line is typically maintained at 76 psig, so the control valve has a setpoint of 76 psig to bleed water into the cooling tower system.

As a safety precaution, the controls are programmed to keep closed the fin water control valve that relieves into the cooling towers in the event any makeup pump is running. Also, there is a remote safety in place to limit pressure by stopping all condensate pumps if the pressure in the return line exceeds the setpoint with a maximum of 80 psig.

**Project Concerns**

With this project, UAB was entering uncharted territory for condensate transport, so some concerns existed at the start. They included the possibility of overpressurization, flooding in collection areas, water chemistry changes and increased maintenance.

To ensure system reliability, several safeties and redundancies were installed. Besides the high-pressure safety setpoint in the PLC system, these include protecting against power outage or pump failure by having all collection and pumping tanks drain by gravity. In addition, the discharge temperature of the water at each pumping location is monitored with resistance temperature detectors that indicate water is actually being pumped (i.e., a temperature increase indicates water is not flowing).

UAB also faced the following water chemistry problems in implementing its condensate recovery project:

- Fin water is basically pure distilled water and therefore more corrosive than Birmingham city water, which was previously used as makeup.
- Fin water is oxygen-rich, having been freshly aerated at the air handler coils; this adds to the corrosion loading.
- Fin water at some air handlers is "dirty," creating a filtration need.
- Fin water is not sterile, making it important to create an effective biological control program for the chilled water that is not corrosive to the system metallurgy.
- Any chemistry used in the chilled water must be compatible with the cooling tower chemistry as the two programs commingle in the tower system.
- The first two water chemistry problems required a stronger corrosion inhibition package that would not rely on oxygen scavenging as a corrosion inhibition mechanism. To accomplish this, UAB evaluated corrosion inhibition technology and did significant laboratory research on a proprietary blend of silicates, azoles and polymers (for which a patent application has been submitted). Adding this blend to the cooling system water resulted in excellent corrosion inhibition while providing the benefit of compatibility with the cooling towers' ongoing treatment regime. The corrosion rate for mild steel averaged less than 0.015 mils per year (mpy), and copper averaged less than 0.025 mpy. Of note is the fact that these rates are better than what is normally achieved using traditional chemistries. Corrosion rates were monitored continuously using Rohrback model 9020 dual-channel corraters and confirmed with corrosion coupons.

The next challenge was that the fin water at many of the air handlers was contaminated with dust, dirt and other debris. This was resolved by installing filtration at the main collection points and filtering the water before adding it to the main chilled-water distribution system. UAB used Harmsco filter bodies with Watts Co. 100-micron filter cartridges.

The final challenge was biological control for the chilled-water system. Far greater quantities of water would now be
added into the chilled-water system – a natural and productive breeding ground for bacteria – without the benefit of residual chlorine (as found in city water).

Based on the projected amount of fin water to be recovered and the pass-through rate to the cooling towers, traditional nonoxidizing biocides were dismissed for performance and economic reasons. Traditional halogen (oxidizing) chemistries were also rejected due to potential for increased corrosion. Chlorine dioxide emerged as the preferred biological control agent. Recent advances in ClO₂ technology made this approach safe, economical and effective. Due to the loop’s size, three Pureline model HP-10 ClO₂ generators were installed (each producing 10 lb of ClO₂ daily). UAB selected Pureline units because they use a single chemical precursor, thereby reducing the potentially hazardous chemicals on-site.

Since ClO₂ did not have to be fed continuously to the chilled-water system, excess ClO₂ was available for feed to the cooling towers, which allowed UAB to eliminate bromine feed. Chlorine dioxide residuals were measured and controlled using 12 SensoreX low-range ClO₂ probes. One probe was installed in the main chilled-water line in each of the three central plants, plus one in the cooling tower water supply line to each of nine condensers. Biological activity in the closed chilled-water systems and the three tower systems was monitored using both alternate test procedure testing and standard dip slides. Results in all systems were excellent. It is notable that after initial control of ClO₂ levels was achieved, both test methods showed levels of biological activity that were essentially below the tests’ detection limit.

Projected Economic Benefits

UAB calculates return on investment on a per-building basis. The fin water projects completed in the heavy research buildings have an ROI of approximately three to three and a half years (see sidebar for example). These buildings use 100 percent outside air and typically have 25-40 air exchanges per hour.

The chilled-water loop makeup rate is 500 gph, which totals 4.38 million gal/year. Previously, the makeup water came in at 65 degrees F. Currently, the makeup demand is completely met with the recovered fin water at 45 F. This is a savings of 20 Btu/lb, which is 730 MMBtu/year, for another $10,000 per year. Additionally, the cold water makeup to the cooling tower increases the approach by approximately 1 degree, resulting in additional savings.

The first fin water project at the Bevill Biomedical Sciences Research Building in 2011 resulted in over $30,000 in savings. In addition to the Bevill Biomedical Sciences Research Building, additional fin water projects have been completed at the John R. Sims Biomedical Research Building, the School of Medicine, the School of Public Health, the Jones School of Molecular Medicine, the Comprehensive Cancer Research Building, the Omohundro Building, and the School of Medicine.

Future Projects

UAB’s fin water projects have a return on investment of approximately three and a half years. With condensate recovery systems in place at eight buildings, UAB expected to collect more than 10 million gal of fin water in 2012. Plans call for another air handler condensate recovery system to be installed this winter at the Shelby Interdisciplinary Biomedical Research Building.

Benefits of the fin water recovery system are both economic and ecological. By recovering the fin water, UAB has reduced the amount of domestic water usage and wastewater while conserving a valuable natural resource. Although the amount of collected and recycled condensate water varies seasonally, the water is most abundant during warmer months when the need for makeup to the cooling towers peaks. Furthermore, the cold condensate provides additional cooling to the cooling tower, circulating water free of cost.

UAB’s goal is to recover more than 20 million gal of condensate annually within the next three to five years. Future construction of new buildings will incorporate plans for a corresponding fin water recovery system during the design phase. From now on, as UAB’s campus grows and expands, so will its innovative fin water recovery system.