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Chiller System Optimization Platform SAVES ENERGY AT UNIVERSITY OF TULSA

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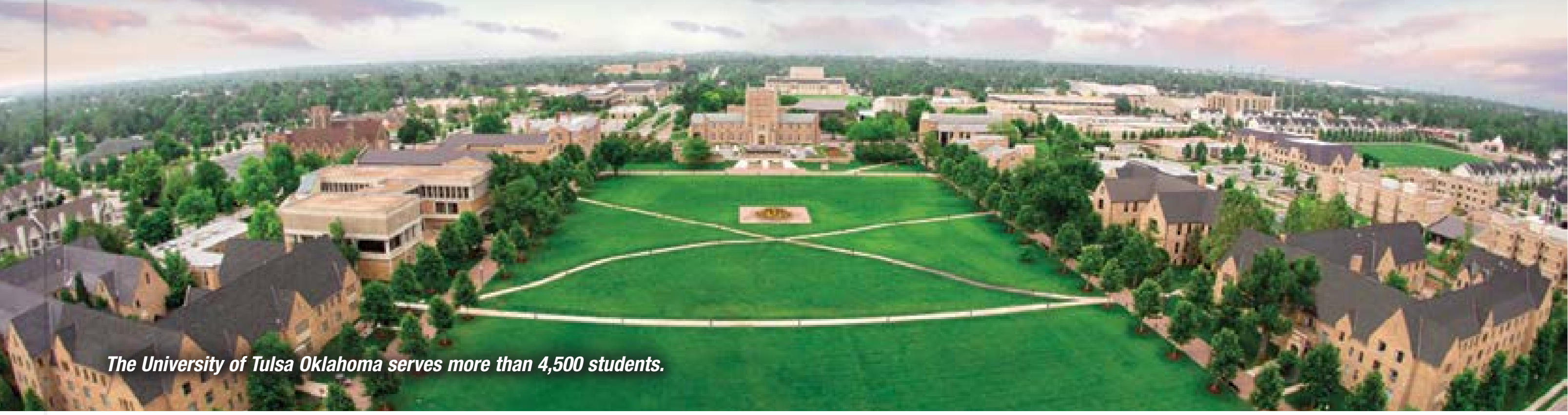

The University of Tulsa Oklahoma serves more than 4,500 students.

The University of Tulsa (TU) places a premium not only on education but the judicious use of energy for the growing campus. It's why TU installed an optimization software platform on its central chiller plant, which allowed it to reduce the kilowatt (kW) per ton of cooling capacity of three water-cooled chillers by 25% – resulting in an annual savings of $51,000. The system also eliminated the unplanned shutdown of the chillers, allowing the university to avoid as much as $300,000 in costs to restore them to their original design condition.

Chiller Efficiency a Top Priority

Founded in 1894 and located on 200 acres in Tulsa, Oklahoma, TU is a private educational institution serving more than 4,500 students. It also employs more than 1,200 faculty and staff and has experienced steady growth. The university's central plant houses equipment used to heat and cool campus facilities, comprised of more than 100 buildings, including classrooms, labs, residence halls and sports facilities, as well as Gilcrease Museum.

> "By the third year of operation, the kW/ton of cooling capacity of the three inefficient chillers improved by 25% for a savings of $51,000 per year in energy costs."
>
> — Senthil Kumar, CEM, Derrick Shoemake, Riyaz Papar, PE, CEM, Fellow ASHRAE, Hudson Technologies

As TU continues to grow, administrators wanted to ensure the institution's utility infrastructure efficiently delivers heating and cooling in support of its sustainability goals. Managing peak load and optimizing energy usage of is a cornerstone of these efforts.

The need to pay close attention to the university's central chiller plant has always been a priority given the energy required to power the chillers, said Michael Bolien, Manager of Central Plant Operations, University of Tulsa. At TU, seven water-cooled chillers provide 7,000 tons of cooling capacity to all university facilities.

"Over the past five years, TU has had a 17% increase in cooling load, based on the square footage of new buildings. Because our central chiller plant is our biggest energy user, optimizing its operations is our first line of defense," said Bolien.

More Chiller Monitoring and Measurement Needed

The ability to gain chiller efficiencies – while meeting the need for more chilled water – isn't without its challenges, driving the need to address the chillers' existing control system.

TU uses a Building Automation System (BAS) and a separate chiller control system to operate its chillers. At most industrial and commercial facilities, these systems work together to ensure optimal chiller performance. The university, however, only used the legacy BAS system to turn equipment on and off and make setpoint changes. The chiller control system also didn't have the ability to collect or interpret data needed to continually improve chiller performance. Additionally, existing monitoring equipment didn't provide accurate sensor data necessary for fault detection and diagnostics, making system optimization difficult.

Another challenge, which is common for many, was the need to collect and assess data without requiring unnecessary time and attention given a lean operations staff.

Calculated Part Load Value (CPLV) Curve Reveals Inefficiencies

To support TU's need for better chiller system control and data acquisition, Hudson Technologies Global Energy Services installed its SMARTenergy OPS® optimization platform to provide real-time continuous monitoring of the chiller system and gain access to key data points to improve system performance.

The installation of the Managed Software as a Service (MSaaS) solution included the use of nine calibrated sensors for collecting data on a wide range of operating fields, including pressure, temperature, flows and electrical power of each individual chiller. With the installation of sensors, Hudson Technologies collected data to establish an accurate operating chiller plant baseline kW/ton.

The data includes a Calculated Part Load Value (CPLV) curve to illustrate chiller efficiency across varying loads based on the difference between the actual operating kW/ton and CPLV kW/ton. The CPLV curve demonstrates the maximum efficiency achievable by a chiller under any operating condition – including part-load, not just full load. The ability to assess efficiency in all conditions is important since more than 95% of the time the chillers run at part-load conditions. This means that without access to the part-load data from the chiller manufacturer, the efficiency of a given chiller won't be known more than 95% of the time. The use of a CPLV curve also offers the ability to identify mechanical, heat transfer, and fluid chemistry issues within a chiller system and quantify the associated energy penalty.

An analysis of the data generated based on proprietary algorithms showed the loss of

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efficiency in three of the university's seven chillers. The CPLV curve also identified the need for critical maintenance to address a plugged heat exchanger inlet on each of the three chillers. If not addressed, the inlet could result in an unplanned shutdown of 42% percent of the chiller system capacity. This would lead to unscheduled chiller system downtime and a disruption to the university's functions.

Heat Exchanger Cleaning Improves Chiller Performance

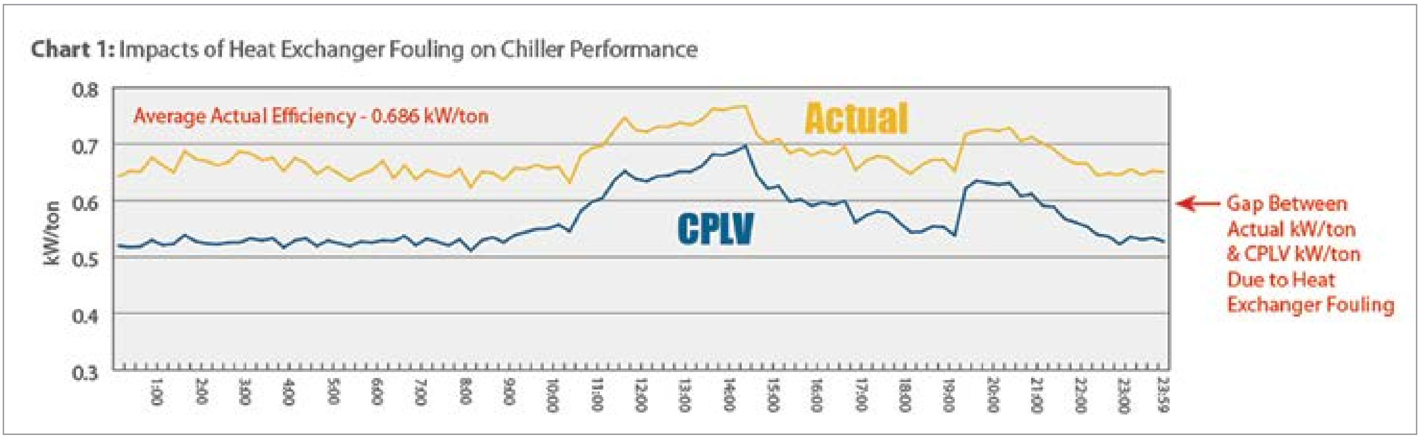
Hudson Technologies recommended a plan of action to improve chiller efficiency at all times of operation including peak loads – while also avoiding the potential to alarm or shut down any chillers should performance fall too far outside established operating parameters.

In addition to adjusting water flows and changing a variety of setpoints, Hudson Technologies advised the university to brush the tubes of heat exchangers on the three chillers that were operating inefficiently. TU staff subsequently rotated the chillers out of operation to perform the needed proactive maintenance. Brushing the heat exchangers eliminated fouling inside the evaporator of each chiller and increased the overall heat transfer co-efficient, which allowed for a higher refrigerant temperature – and in turn – reduced compressor lift to achieve energy savings.

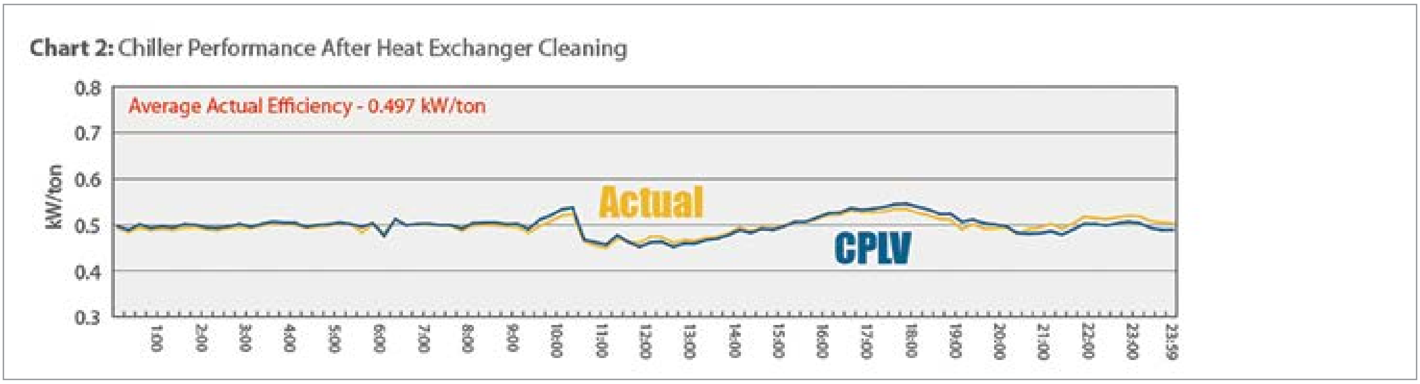
After the heat exchanger cleaning, the average efficiency of each chiller improved from 0.686 kW/ton to 0.497 kW/ton as shown in Figure 2. This translates into cost and energy savings of almost 27% per chiller.

By the third year of operation, the kW/ton of cooling capacity of the three inefficient chillers improved by 25% for a savings of $51,000 per year in energy costs. Addressing fouled heat exchangers also prevented the need to shut down the chillers for an extended period of time and spend an estimated $300,000 to restore them to their design condition. The cost for restoration would have included re-tubing/replacement of the heat exchanger bundles, full refrigerant recovery and reclamation possibly due to water leakage, etc. TU also improved the performance of the chillers by:

- Adjusting chiller sequencing: Higher efficiency chillers are given priority to run always to meet the load rather



A gap between the actual kW/ton and the kW/ton of a CPLV curve points to inefficient operation of a chiller due to a fouled heat exchanger.



Shown is improved chiller performance following the cleaning of the chiller's heat exchanger.

than running all chillers equalizing operating run time on each of them.

- Reducing Entering Condenser Water Temperature: This allows the system to take advantage of cooler ambient temperatures. Doing so lets the cooling tower provide a lower water temperature to the condenser, thereby allowing for lower compressor lift and energy savings.

- Load balancing: Running the chillers as close to their optimal operating conditions provides the highest efficiency. This requires the total load be divided (balanced) among the running chillers for optimal chiller plant efficiency. BP

About the Authors

Riyaz Papar is Director, Global Energy Services, Hudson Technologies. Papar, with more than 20 years of experience in industrial energy systems and best practices, is a U.S. Department of Energy (DOE) Steam Best Practices Senior Instructor and a U.S. DOE Steam Energy Expert. Additionally, he is a steam, waste heat recovery and refrigeration/chiller system expert. A registered Professional Mechanical Engineer and a Certified Energy Manager, Papar has completed Ph.D. level coursework with a research emphasis on optimization of operation of energy assets (boilers, turbines, chillers, etc.) in industrial plants. His graduate-level education specialized in the area of thermal engineering (heat transfer, energy conversion, refrigeration, etc.).

Senthil Kumar is Product Lead for SMARTenergy OPS in Hudson Technology's Global Energy Services division, tel: 845 512 6000 ext. 6073, email: skumar@hudsontech.com. Kumar is a Certified Energy Manager (CEM) and is also a U.S. DOE Best Practices Qualified Steam System and Process Heating Specialist. He has more than 10 years of experience in industrial energy assessment and auditing, data collection, development of energy efficiency measures and energy efficiency calculations. He is also highly skilled in data trending, building custom system models, performance monitoring and optimization of steam and chilled water system.

Derrick Shoemake is the IT Lead for SMARTenergy OPS, Hudson Technologies. He has over 35 years computer programming experience. He also has more than 15 years of experience in chiller efficiency, data collection, energy efficiency measures, energy efficiency calculations, and technical report writing. Additionally, Shoemake has more than 10+ years in building automation programming.

Hudson Technologies extends it appreciation to Michael Bolien, Manager of Central Plant Operations, University of Tulsa, for his contributions to this article.

About Hudson Technologies

Hudson Technologies, Inc. is a refrigerant services company providing innovative solutions to recurring problems within the refrigeration industry. Its products and services are primarily used in commercial air conditioning, industrial processing and refrigeration systems, and include refrigerant and industrial gas sales, refrigerant management services, consisting primarily of reclamation of refrigerants and RefrigerantSide® services, consisting of system decontamination to remove moisture, oils and other contaminants. In addition, the company's SMARTenergy OPS® service is a web-based real time continuous monitoring service applicable to a facility's refrigeration systems and other energy systems. Its Chiller Chemistry® and Chill Smart® services are also predictive and diagnostic service offerings. It also participates in the generation of carbon-offset projects. The company operates principally through its wholly owned subsidiaries, Hudson Technologies Company and Aspen Refrigerants, Inc., formerly known as Airgas-Refrigerants, Inc. For more information, visit www.hudsontech.com.

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