BEST PRACTICES 2013

CSU Stanislaus Central Plant and Chilled/Hot Water Optimization

A systematic commissioning process led to a combination of capital improvements and control modifications that realized central plant electricity savings of 24 percent, slashing chilled water flow and distribution energy, and reducing the number of hot water pumps required by half.

Award Category

HVAC Design/Retrofit

Green Features

Altered piping design to reduce bypass

Replaced three-way valves with two-way valves

Improved temperature differential and reduced chilled and hot water volume

Improved secondary chilled water pump control

Utilized chiller plant energy simulation

Optimized sequences for cooling tower and chiller staging

Annual Energy and Cost Savings

213,998 kWh/yr

$39,000

Size

700,000 ft²

Cost

$235,777

Completion Date

2012

Since the early 1990s, the CSU Stanislaus campus has been proactive about undertaking energy efficiency improvements, from lighting and HVAC upgrades to construction projects meeting LEED criteria. In 2012 a comprehensive optimization of the chilled and hot water systems for the entire campus was identified as the most beneficial upgrade in terms of simple payback and maintenance savings. The central plant includes a 24 MMBtu hot water plant and two 2,600-ton chillers serving 13 buildings and 700,000 ft^2 of occupied space.

For the optimization project the campus energy management team identified three interrelated issues which are fairly typical of older chilled water systems. First was the need to increase the amount of temperature differential or "delta-T," for both the chilled and hot water loops, so that water entering the building loops would be as hot or cold as possible, thereby reducing the volume of water and associated pumping energy required to meet demand. The next objective was to optimize the operation of the chilled water loop for varying loads, locking in potential savings from the increased delta-T. The team's third objective was to ensure that multiple plants could be used simultaneously in order to accommodate a growing campus.

By improving the temperature differential in the campus chilled water loop, the system can now meet peak demand with dramatically reduced flow rates.

For a facilities team already engaged in optimizing energy on campus, finding the right partners to facilitate a comprehensive process was critical. The campus hired EnerNOC, an energy services firm specializing in retro-commissioning, to manage the entire process in close collaboration with campus staff. EnerNOC had previously completed several similar chilled water plant projects for other CSU and UC schools. "The low delta-T was typical" said Robin Liu, project manager from EnerNOC. The major cause for the low delta-T was also fairly typical but particularly extreme in this case — previous practices included piping connections and valves that allowed water to bypass the main loop connections, causing excessive mixing between supply and return, thereby degrading the delta-T.

Central pumps for hot and chilled water present opportunities for significant energy savings. Image: Geng Liu, CSU Stanislaus.

The project began with a walk-through in which the team systematically identified a number of savings opportunities, both in capital improvements and control sequences. In the central plant they re-designed the bypass between primary and secondary loops for both chilled and hot water systems, including a new check valve, to provide better control of mixing between the two lines. Throughout campus the team also replaced three-way valves between supply and return lines with two-way valves, which effectively enable each system to meet demand by varying flow rather than temperature. The team also capped or removed open bypasses between supply and return piping in seven buildings.

To capture the benefits of these piping modifications, several control issues had to be corrected related to the secondary chilled-water pumps. These pumps were previously

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Contacts

Associate Vice President of Facilities Services:
Melody Maffei
209.667.3624
mmaffei@csustan.edu

Team

Project Manager:
Geng Liu, CSU Stanislaus Campus Energy Manager

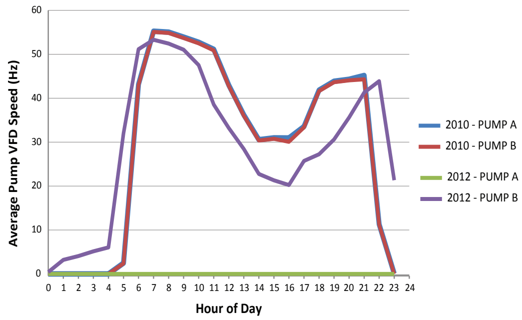
Commissioning Agent:
Robin Liu, Manager of Engineering, EnerNOC

More Information

http://www.csustan.edu/FS/EnergyManagement.html

http://www.csustan.edu/FS/Publications/CSUSSustainableEnvironment.pdf

operating at constant speed, regardless of demand. Although these pumps were equipped with variable frequency drives, the control sequences were not enabling them to modulate speeds. Similarly, the control logic for the pumps in the central plant and the building tertiary pumps was modified to include a pressure set-point reset so that they ran only as fast as needed, as opposed to operating based on a constant differential pressure setpoint.



Hot water pump chart shows the reduction from two pumps operating simultaneously to one operating at a reduced speed. Image: EnerNOC.

The combination of reducing required flow by increasing delta-T, and ensuring that all pumps operate at that reduced flow, illustrates a systematic approach to identifying and implementing measures. Together the improvements cut electricity use for chilled water distribution by 80 percent, and for hot water distribution by 35 percent, saving the campus $39,000 per year. All measures combined reduced total central plant electricity use by 24 percent and reduced peak demand by 65 kW. In fact, where two hot water pumps were operating at full speed before the project, only one running at a reduced speed now meets the same demand.

The team further optimized controls for the entire campus cooling system by creating an energy simulation model to develop new control sequences. This required machine-specific performance data from the chiller manufacturer in order to simulate the chillers correctly. “Because manufacturers don’t have a vested interest in helping you out, gathering this data can be very hit or miss,” Robin Liu points out. In this case getting the right data required persistence from the project team.

Transparent operation sequences allowed the campus to see the modifications being made to central plant operations.

Using the calibrated simulation model, EnerNOC developed and trained operators regarding optimum setpoints for chilled water plants under various operation scenarios. The simulations also helped optimize staging sequences of the two chillers with an auxiliary plant, to maintain savings under changing and expanding loads. Overall the improvements to the piping and control sequences were welcomed by building operators, and the increased automation and improved delta-T have required fewer manual fixes than were previously common, and that resulted in excessive energy use, cost, and staff time.

LESSONS LEARNED

Robin Liu notes that “everyone was working for a common goal and was interested in solving the problem, so the campus was very responsive and open to our ideas.” She points out that an energy service consultant must be able to understand the concerns of the facilities team, and work with the team to collectively identify problems. EnerNOC succeeded by focusing on inherent challenges in the design of the system, rather than operational shortcomings. Likewise, the project allowed plant operators to understand changes through transparent control sequences, and involved them in verification and training. She also says that controls contractors would ideally be active team member from earlier in the process, to improve collaboration and allow all parties to bring ideas to the table.

Best Practices case studies are coordinated by the Green Building Research Center, at the University of California, Berkeley.

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