As its energy system aged, DePauw University saw opportunity

How Ecosystem Energy Services helped a midwestern campus modernize its heating and cooling network

By Rick Kinsinger

In 2017, utility managers at DePauw University took a hard look at the Greencastle, Indiana, campus's aging infrastructure and—instead of seeing only problems—recognized an opportunity to decrease energy costs, address deferred maintenance needs and lay the groundwork for future growth.

DePauw began its energy modernization initiative with a Campus Energy Master Plan implemented beginning in 2019. The project, which was completed in 2021, is expected to reduce campus energy use by 33% and annual greenhouse gas emissions by more than 7,300 tons (a reduction of about 25%).

Founded in 1837, DePauw is a liberal arts college in west-central Indiana. The 190-acre campus includes student residences, classroom buildings and a major performing arts center. The university owns and maintains approximately 140 buildings with a total of nearly 2 million square feet in both older and more modern structures.

As recently as 2017, the Central Heating Plant provided most campus heat through a network of buried piping. Inefficiencies in the four 25-year-old boilers and the similarly aged piping systems meant that only 55% of the energy created by burning natural gas was being delivered as steam. Additionally, the steam network and the Central Heating Plant were each requiring at least one major repair per year. And although steam was being distributed across most of the campus, only two buildings used it directly—in all others, steam was converted to hot water at building entry points.

Chilled water, produced by a mix of water-cooled and air-cooled chillers, was distributed through five separate networks with no connections between them. Some existing chillers had been decommissioned, and several others were operating past their normal life expectancies. Buildings not connected to one of the five networks were cooled with a variety of building-specific systems such as DX split systems, air-cooled chillers and heat pumps.

The condition of these disparate and aging systems, which almost universally had maintenance and reliability

Minimizing disruptions to street and foot traffic was a priority during construction, which included replacing about a mile of underground piping.

issues, called for an approach that would save energy, reduce maintenance costs and improve reliability while positioning DePauw for future growth and innovation.

Following a competitive RFP process, Ecosystem Energy Services was selected to work with members of DePauw's Facilities Management team to first develop an actionable master plan. Work began with two questions: What were the inefficiencies in the system, and how could they be best addressed in a way that would provide a foundation for future energy-saving projects?

It quickly became apparent that the old steam boilers and the unreliable condensate return system were major sources of energy inefficiency. With network losses adding up to about 45% of produced steam, the heating system was in desperate need of renovation or replacement. Several solutions were considered, and project leaders ultimately decided to replace the steam network with a hot-water network.

Switching from district steam heating to hot water also was seen as a step toward future greenhouse gas (GHG) reductions. Lowering the heating distribution temperature from 275°F to 160-190°F would allow for the use of technologies other than boilers, such as solar-heated hot water, geothermal sources, heat pumps, CHP, and potentially other applications that could be added. Thermal efficiencies would also be gained from installing higher-efficiency hot water boilers and by virtually eliminating the amount of makeup water required.

Reimagining heating distribution also was seen as a way to allow for connecting bigger loads that will likely come from the anticipated redevelopment of on-campus housing.

DePauw and Ecosystem took a similar tack in reimagining the cooling network. Inefficiencies and aging infrastructure also needed to be addressed there, alongside the need for greater future capacity.

As with most large-scale campus energy projects, lighting was also analyzed by the project team. Both LED retrofits and upgraded lighting controls were added to the scope of the CEMP. Special attention was given to areas like indoor tennis courts and swimming pools, where metal halide and inefficient indirect lighting fixtures were in use. Ecosystem prepared models that showed how properly laid out LED fixtures could provide consistent coverage and reduce energy usage.

UNIFIED DISTRIBUTION

Working with local contractors, Ecosystem in June 2019 began to bury a new four-pipe network (supply and return piping for both hot water and chilled water networks). The network tied the heating and cooling plants with all of the buildings in the core campus area. It also allowed for future connections by providing piping stubs into some not-yet-connected buildings and locating piping tees in the proximity of others.

Various direct-bury piping solutions were considered. Ultimately, because of the limited corrosion potential and speed of installation, the team selected a cross-linked polyethylene (PEX) pipe.

BEFORE THE MAKEOVER, SIX DIFFERENT CHILLED WATER NETWORKS PROVIDED COOLING TO THE CORE CAMPUS AREA.

Minimizing disruptions to street and foot traffic was a priority, as was protecting a campus named by Conde Nast Traveler as one of the 50 most beautiful in the U.S. An awareness campaign, deploying a combination of banners and lawn signs, kept campus users informed of the progress of the project and of its long-term benefits. The use of PEX piping meant fewer joints had to be made in the field, so trenches were open for a shorter time. Trenching was carefully planned to be completed in the course of one summer.

While the COVID-19 pandemic kept students and staff off campus for many months during construction—creating an advantage of sorts—it required the team to be agile in dealing with staffing shortages and equipment delays.

One example of how the project played out can be seen in the 80,000-square-foot Richard E. Peeler Art Center, which is DePauw's hub for visual arts and houses exhibition and studio spaces, offices and an auditorium. Originally, the building, commissioned in 2002, had steam heating coils in AHUs (air-handling units), HW reheat coils, HW perimeter heating, and steam re-heat coils in AHUs serving areas without VAVs. Converting all coils to HW would have been very costly.

Ecosystem's modernization solution was to create an automatic building switchover system, where both heating and cooling networks were interconnected

Working in existing facilities can be challenging, and the installation of this chiller was no exception, requiring well-planned rigging and the removal of two walls.

to the existing cooling coils in AHUs. As cold-water coils are much larger, they can operate with a lower HW setpoint than the remaining systems. This allowed for the creation of a cascade system in which hot water would first serve the perimeter and VAV (variable air volume) reheat coils and then be used in the AHUs.

The cascade design allows for a much higher building delta T, improving central plant efficiency. The existing perimeter heating pumps were also re-used for summer AHU reheat coils to reduce the amount of equipment required to be installed. The entire system was automated using only a small number of two-way valves, making it simple to operate and maintain.

STEAM TO HOT WATER

When the systemwide project began, DePauw's heating plant had four boilers producing 100 psi steam that was reduced to 30 psi for distribution at 275 F through the in-ground piping. These were replaced with four near-condensing boilers and one condensing boiler producing 180 F hot water. The condensing boiler was sized to provide heating needed during the summer months. The thermal efficiency of the near-condensing boilers was a significant improvement over the existing steam boilers.

System snapshot: DePauw University

	Hot water or steam or steam/ combined heat and power system	Chilled-water system
Startup year	HW system, 2020	Original mini networks – commissioning over several decades Updated interconnected CW system, 2020
Number of buildings served	20	19
Total square footage served	1,350,00	1,325,000
Plant capacity	40.8 MMBtu/hr hot water	3,800 tons [TK]ton-hours chilled-water storage
Number of boilers/chillers	5 boilers	5 electric chillers
Fuel types	Natural gas with diesel backup	Electric
Distribution network length	1 mile/trench mile	1 mile/trench mile
Piping type	Direct buried PEXGOL	Direct buried HDPE
Piping diameter range	90mm (3.5") to 355mm (14")	3" to 14"
System pressure	Network max 100 psi, operating max 70 psi	Network max 100 psi operating max 70 psi
System temperatures	190-170F	45-55F

Source: Ecosystem Energy Services

The power of planning

DePauw University, which has been a signatory for well over a decade to the American College & University Presidents' Climate Commitment, issued an RFP in 2016 for an energy master plan with specifics that included:

- A 25% reduction in energy costs within three years;
- A long-term energy infrastructure strategy that would support growth;
- Optimal management of deferred maintenance and life-cycle costs across campus energy assets;
- A meaningful carbon-footprint reduction to put the campus on a path toward carbon neutrality.

Ecosystem proposed a plan to present the university's management team with options. Rather than pushing for a detailed picture of campus energy infrastructure improvement that could have been seen as outdated as soon as it was printed, the Ecosystem proposal was designed to be a basis of discussions for the design, implementation, costs, and timeline for each phase of proposed work. Stakeholder engagement and alignment was seen as a central aspect of the process—presenting and explaining ideas and plans (with associated financial implications for each) is a critical step in aligning stakeholders ahead of a project's launch.

The result was a specific and actionable set of recommendations. Using an analysis of then-current conditions to lay the groundwork, Ecosystems called for an integrated group of initiatives built around a core project that would make optimum use of capital and would actually exceed the university's goals. Thus was born what is now the DePauw Campus Energy Master Plan.

Key to executing this portion of the project was the phasing of the replacement of the boilers, by which time the hot water network had been installed and the connected buildings were ready to receive hot water from the district. Working with DePauw's facilities management team, Ecosystem developed a plan to remove all but one of the steam boilers while new hot water boilers were installed in their places. During this time, the remaining boiler fed the old steam network. A steam-to-HHW (heating hot water) heat exchanger in one of the larger buildings was used to generate hot water and feed it into the new hot water distribution piping. This arrangement met the heating demands of the connected buildings into the fall.

The new hot water boilers were operational in time for the winter heating season, at which point the remaining steam boiler was removed and the condensing hot water boiler installed.

Minimal in-building modifications were needed. Where local steam was necessary for humidification or other processes, the source of the steam was changed to small on-demand electric generation.

REIMAGINING HEATING DISTRIBUTION WAS SEEN AS A WAY TO ALLOW FOR CONNECTING BIGGER LOADS.

Before the makeover, six different chilled water networks provided cooling to the core campus area: The North Plant and the South Plant both had multiple water-cooled chillers with cooling towers. Most of these chillers were near or past the typical usage-life expectancies.

The system had three chiller yards with air-cooled chillers. These served residence halls and generally were without backup or redundancy. A single large building had its own air-cooled chillers.

The project kept only the two best performing water-cooled chillers and installed three additional ones. The air-cooled chiller yards were decommissioned while the North and South chiller plants were connected to the new piping network.

Combining all chilled water networks into a single one proved advantageous on several points. First, it allowed for the necessary capacity redundancy to be shared, rather than having to provide redundancy at each plant (each chiller plant has enough additional capacity to make up for any single chiller outage at the other plant.) Additionally, by feeding the entire network with both plants, more options exist for matching campus cooling load with the most efficient combination of both partially and fully loaded chillers and their associated cooling towers.

DePauw's energy modernization project was developed to deliver on ambitious goals that included energy savings, maintenance-cost reductions, the replacement of aging equipment and, finally, the creation of a system that is responsive to future growth, all while respecting the university's requirements for fiscal responsibility. By starting with a formal master plan and then taking a holistic approach toward a solution, all of these goals have been achieved.

The project has been recognized with an Innovation Award Honorable Mention from the International District Energy Association, the Indiana Department of Environmental Management's Governor's Award for Environmental Excellence, and Duke Energy's Power Partner Award.

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