COVER STORY

Rethinking efficiency

UT Austin takes a creative approach to unprecedented campus growth.

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The Dell Medical School at The University of Texas at Austin is, according to its slogan, “Rethinking Everything,” from how medical care is taught to how it is delivered to the community. As the first medical school in nearly 50 years to be built from the ground up at a top-tier U.S. research university, Dell will be located in a new medical district under construction on the southeastern corner of the UT Austin campus. The project promises to revolutionize many aspects of health care delivery and create an entirely new approach to academic medicine. The new school will welcome its inaugural class of students in June 2016.

As part of this groundbreaking effort, the university has also recently rethought how it delivers energy through its campus district energy/combined heat and power system.

Though the existing power system has some spare capacity, the new building loads created by the planned medical district additions would push campus existing CHP systems beyond the most efficient operating points. The demands of meeting additional heating, cooling and power loads with the existing district energy/CHP systems also would reduce reserve power capacity, potentially exposing the university to a higher standby rate from the local electric utility if an outage were to occur.

Therefore, it was clear that significant district energy/CHP upgrades were needed. The university wanted to ensure that utilities serving the new medical district would build on past high performance standards with an innovative system that would set even higher standards for overall efficiency. And just as crucial, the expanded district energy system would need to be operational ahead of the new medical building construction for dry-in purposes. Creative design solutions coupled with an expedited project delivery method would be required to get the district energy expansion built and operating ahead of the oncoming wave of load growth.

RETHINKING PROJECT APPROACH

In November 2012, Travis County voters approved a ballot measure to fund a portion of the UT Austin medical district construction costs. From that point, all phases of the project began moving ahead rapidly. The university’s Utilities and Energy Management group quickly recognized that a fast-track approach to upgrading its systems was needed.

The university produces and delivers power via a CHP system and microgrid and provides thermal utilities in the form of chilled water and steam. The power and thermals are delivered to 160 buildings and more than 17 million sq ft of classroom, office and critical lab space with overall efficiencies among the highest in the industry.

With schedule and budget flex-

The University of Texas at Austin's new Chilling Station No. 7 and thermal energy storage tank will be completed by June 2016.

ibility as top priorities, the university utilities team began exploring design-build project delivery as an option. Though design-build has not been commonly utilized at UT Austin, the utilities team wisely concluded this would be the best method to expedite the project and allow budget flexibility through an open-book approach. After an open RFP process, the university selected the team of Flintco and Burns & McDonnell to design and construct a new chilling station (Chilling Station No. 7), which would also house the primary heating plant; the connecting portion of the thermal distribution; and a backup steam-fired heating plant (Hot Water Plant No. 1).

LARGEST, MOST CONCENTRATED AMOUNT OF GROWTH

The new medical school campus and district energy system were master-planned and designed in parallel. Currently, all buildings as well as the civil and thermal utility systems are being constructed simultaneously. Phase 1 of the project is anchored by the $295 million, 500,000-sq-ft Dell Seton Medical Center teaching hospital, which will replace the existing University Medical Center Brackenridge as the Level 1 trauma center serving the community's underprivileged population. In addition, a new Education and Administration Building, research and medical office buildings, a parking garage and Chilling Station No. 7 round out the remaining construction footprint, totaling more than 1.1 million sq ft. (fig. 1).

These projects account for approximately $800 million of new construction within two city blocks. Elsewhere on campus, another $500 million in construction projects is under way, including an Engineering, Education and Research Building, Rowling Hall and the McCombs School of Business building. Together, all these ongoing projects represent the largest and most concentrated amount of growth the university has ever experienced.

From a utility load standpoint, the Phase 1 growth adds 4,500 tons of chilled water, 52 MMBtu of heating hot water and 4 MW of electrical demand. Following completion of Phase 1 and removal of the existing hospital, Phase 2 will include student housing and several additional academic and research buildings. Details are yet to be determined, but the total load increase due to the medical district (Phases I and II) is projected to be 10,000 tons of cooling, 95 MMBtu of heating hot water and 6 MW of electrical demand.

The ultimate buildout of the medical district and surrounding area is also planned to include a 240,000-sq-ft psychiatric hospital; 150,000-sq-ft cancer center; another parking structure; and a new 51,000-sq-ft Travis County medical examiner's office. While these will not be university-owned buildings, they will be invited to connect to the district energy system, which will likely require further expansion at that time to maintain adequate redundancy.

RELENTLESS PURSUIT OF EFFICIENCY

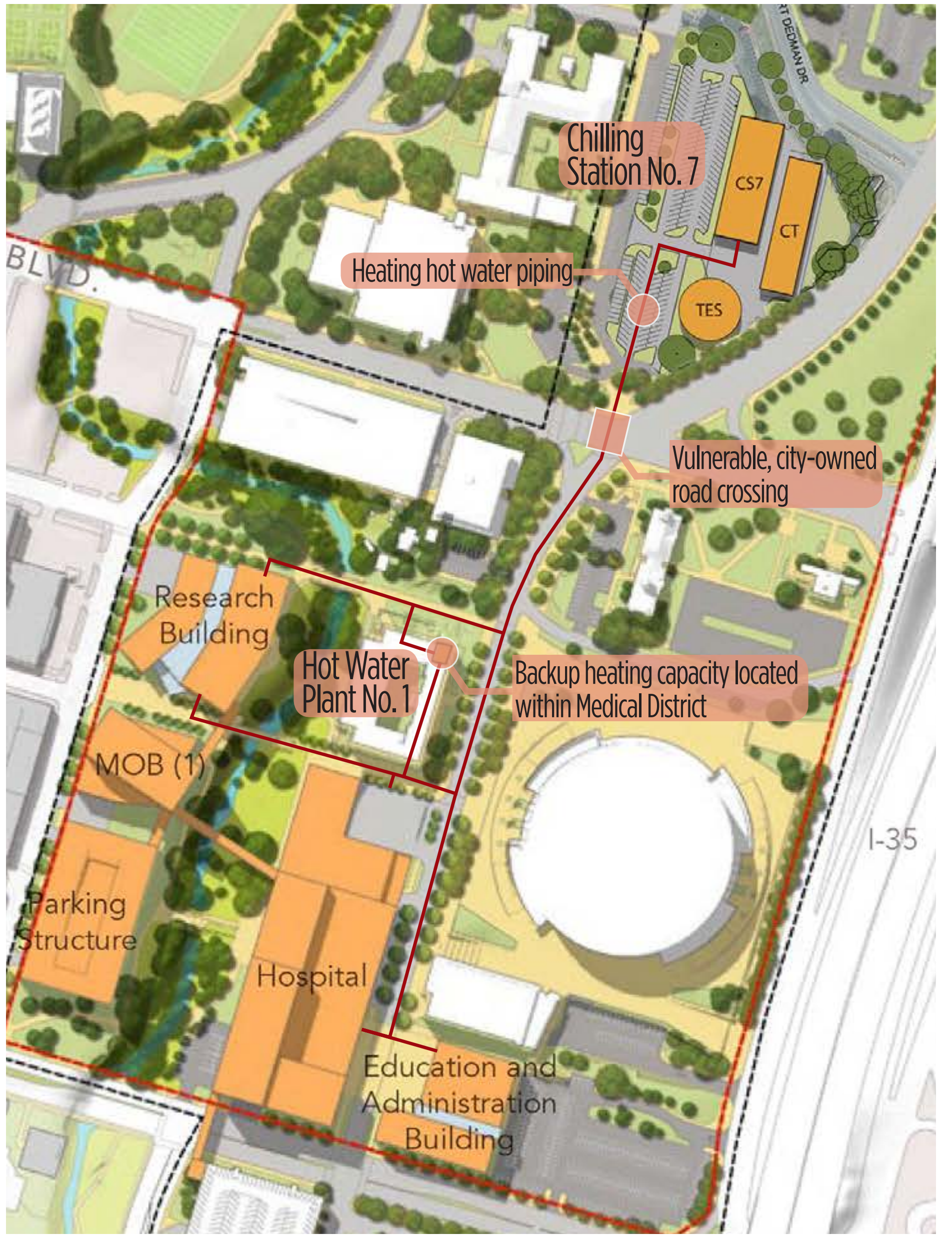
UT Austin's district energy system is already one of the most efficient in the country. Combining sound operational practices with the industry's latest technologies, the university has maintained annual systemwide chilled-water production and distribution efficiency at 0.62 kW/ton for the past three consecutive years and an overall power and thermal efficiency of 87 percent. Though meeting the needs of the new medical district within the proposed schedule presented a tremendous challenge, the university recognized this as an opportunity to make its entire system even more efficient.

Chilling Station No. 7

The bulk of the university's existing chilled-water load is shouldered by Chilling Station No. 6 (CS6), a highly efficient 15,000-ton facility comprising three 5,000-ton variable-speed chillers that operate under an optimization program. The new Chilling Station No. 7 (CS7) will join CS6 as an all-variable-speed optimized plant on campus (fig. 2), supporting the medical district growth as well as other new loads on the south side of campus. The campus's two thermal energy storage tanks will be dispatched strategically to cover high demand periods and the remaining three chilling stations will run as necessary to cover higher summertime peaks. To mitigate pressure-balancing issues between multiple plants, CS7 will be controlled on a flow setpoint, as it is on the edge of campus and has a smaller effect on the main campus differential pressure. CS6 is more centrally located and better suited to maintain stable control of the campus differential pressure sensors.

Rather than employ a field-erected chiller similar to those at CS6, CS7 was intentionally designed with more capacity steps: six (and ultimately eight) 2,500-ton units versus the much larger 5,000-ton machines at CS6. This produces a wider best-efficiency range

Figure 1. Map of medical district buildings and new thermal energy utilities, The University of Texas at Austin.



Source: The University of Texas at Austin.

Figure 2. Architect's rendering of the new Chilling Station No. 7 and thermal energy storage tank at The University of Texas at Austin.

Source: Stantec.

that can be leveraged to deploy the station very efficiently at a variety of flow setpoints and system conditions. To ensure the best operation from both optimized facilities, multiple-plant "sweet spot" control will be employed to keep both chilled-water stations loaded to their lowest energy points. The optimization program will continuously monitor efficiency at both stations and adjust the flow set-point from CS7 to keep the entire system operating at the lowest possible overall kilowatts per ton.

Aside from the smaller capacity steps, CS7 also differs from all other campus stations in its cooling tower selection. Following an extensive lifecycle cost analysis comparing several plant configurations, including series-counterflow chillers, the best-performing option was determined to be an upgraded cooling tower capable of delivering a 5 degree F approach at design conditions. The upgraded tower provides colder water back to the chillers – making the largest energy user in the plant much more efficient every hour of the year. The larger tower footprint was negotiated within the site constraints, resulting in a slightly higher first cost. This option provided very attractive efficiency gains and payback without the added complexity of a series-counter-flow piping and valve arrangement.

View of the new thermal distribution trench excavated within solid limestone subgrade. The trench will contain both hot and chilled-water piping.

Thermal energy storage

The university-owned medical district buildings will be served by the existing campus microgrid and power generation equipment. The new higher peak electricity demand, in particular the peak summer cooling energy required, was projected to strain the existing power generation assets beyond their best efficiency point.

Instead of building more costly power generation, the university once again chose an innovative approach to the challenge. A new 5.5-million-gal thermal energy storage tank – the second tank in the campus system – will provide 52,000 ton-hr of storage and allow 10,000 tons of chilled water-producing equipment to shut down during peak hours of the day. The ability to shift nearly 6 MW in demand to the off-peak hours provides a significant leveling effect, allowing the combustion turbines to maintain stable and more efficient operation. While primarily an economic measure, the tank also provides flexible chilled-water capacity that can be deployed to cover both planned and unplanned equipment outages.

Coordination between the two thermal energy storage tanks and their power generation system will allow the university to take further control of its electrical demand to keep the gas turbines operating at their most efficient point at all times. This is a significant win for the university, as it allows a vast addition of square footage to the campus microgrid without adding any expensive power generation equipment.

COORDINATION BETWEEN THE THERMAL ENERGY STORAGE TANKS AND POWER GENERATION SYSTEM WILL ALLOW THE UNIVERSITY TO FURTHER CONTROL ELECTRICAL DEMAND TO KEEP GAS TURBINES OPERATING MOST EFFICIENTLY.

Heat pump chiller and hot water system

Another significant energy efficiency measure was the selection of a heat pump chiller residing within CS7 that will simultaneously provide heating hot water and chilled water to the new district. The choice to introduce a hot water system to the primarily steam-heated campus was driven by extensive lifecycle cost analysis of multiple options. Ultimately, extension of the steam tunnel system and installation of expensive steam-generating equipment was deemed to be cost-prohibitive compared to the direct-buried heating water system that was selected. Strategically designed to operate at low temperatures during the summer as well as higher temperatures with a very wide temperature differential in the winter, the hot water system will minimize pumping energy while maximizing the prime opportunity for heat recovery.

In general, moving heat between sinks is far more efficient than creating new heat from a fired source. The heat pump chiller harnesses thermal energy that would normally be rejected to the atmosphere through a cooling tower. It then boosts that heat through a second stage of refrigeration compression to achieve higher-temperature water that is usable for space and domestic water heating.

The heat pump operates most efficiently at lower lift conditions or by keeping heating water temperatures to a minimum. Close coordination with the medical building designers ensured the building heat exchangers were selected appropriately to match the heat pump's capabilities. With temperatures matched to the building systems and strategically sized to meet the anticipated minimum summer heating load, the heat pump chiller is intended to run year-round to maximize its return on investment.

Accounting for all the useful energy delivered, the heat pump chiller can achieve a net heating-cooling coefficient of performance efficiency of up to 6.0, which results in a $177,000 savings per year versus conventional boilers and chillers. The plant is capable of expanding to three more heat pumps, which will only magnify the savings as the campus grows. An added benefit is the offset cooling tower operation, reducing chemical use, minimizing PM10 emissions (particulate emissions up to 10 micrometers in size) and saving approximately 17 million gal of water per year.

During winter when the campus heating load exceeds the heat pump capacity or if higher temperatures are needed, CS7 also features a fleet of three 85 percent efficient water-tube boilers capable of contributing 37 MMBtu of heating hot water capacity at supply temperatures up to 180 F. The heat pump chiller and boilers are arranged in a series configuration within a robust variable primary-variable secondary pumping scheme that ensures stable flow delivery to the campus while allowing for pump energy savings and operational flexibility within the plant.

As a new critical heating water system and distribution network are being created with this project, UT Austin recognized that geographic diversity would be necessary to ensure consistent service to the new Dell Seton Medical Center and support buildings. Strategically located within an enlarged section of tunnel below an existing nursing school building, Hot Water Plant No. 1 will provide 40 MMBtu of backup steam-fired heating water capacity to the medical district using steam from the campus CHP system.

REMOTE OPERATIONS

Similar to its drive for better energy efficiency, the university also seeks to optimize the efficiency of its operations and maintenance staff. The robust programmable logic controller system is designed to operate the new plants with zero permanent staff on-site. UT Austin will build on its existing campus control network with three additional PLC controllers for CS7 and one additional controller for the hot water plant – all of which will be remotely operable from the control room in CS6. Several high-definition surveillance cameras will be strategically located around these facilities. In addition to their use for security purposes, the cameras will have the resolution and zooming capability with which the staff can confirm actual conditions in the plants from afar. For instance, operators can remotely check for leaks or even confirm if the local pipe gauges are in agreement with the associated instrument signal displayed by the control system.

WATER CONSERVATION

Cooling facilities of this magnitude depend on vast amounts of water as much as they do the electricity that powers the pumps and compressors. With prolonged drought conditions and water prices spiking in other areas of the country, the writing is on the wall: Designers can no longer treat these systems as if water prices will not escalate and fresh, clean water is an infinite resource. To ensure water supply resiliency, four independent water sources are piped to the new chilling station that are each deployed on an economic basis.

The first source deployed is recovered water, which is made up largely from campus air-handling unit coil condensate gathered into the tunnel system and reclaimed by the station. This system represents tremendous foresight by the university, as it has recovered countless gallons of usable water that would have been sent to sanitary drain over the decades it has been in service. Following that lead, CS7 is also equipped with a separate recovery system fed by hub drains strategically located around the facility to receive equipment and header drains during maintenance activities. This cold, chemically treated water can be used internally or pumped to other chilling stations.

The second source deployed is reclaimed water from the city of Austin. Lightly treated, pressurized and less expensive than potable alternatives, this gray water source is ideal for cooling tower makeup – though design considerations must be given to tower filtration, blowdown and chemical treatment systems.

The third and fourth sources are domestic water from the city of Austin and the university-owned system. These provide additional redundancy but are used only as backups to the other sources. Again, loss of water to this type of facility would mean almost immediate shutdown, so having several contingencies is good practice.

FAST-TRACKED, ON SCHEDULE

The Dell Medical School project at The University of Texas at Austin is moving at an unprecedented speed. From November 2012, when Travis County voters bought into the idea, the entire new medical district campus has been master-planned and designed and is on track for completion this spring. Through expedited master planning and a design-build project delivery method, Chilling Station No. 7 is on schedule for substantial completion in June 2016 and is poised to support the final stages of the medical district construction.

Seizing this challenge as an opportunity for further improvement, the university set extremely high efficiency goals, driving the design process and optimization sequences. Chilling Station No. 7 simulations anticipate a total plant annual efficiency of 0.55 kW/ton, which will further improve on the university's exceptionally high energy performance. Considering that performance estimate includes the heat pump chiller input energy, the system will also contribute 75,000 MMBtu of "free" heating.

Fitting for a medical school rethinking health care education, the new district energy system is also redefining expectations for total system efficiency.

Reclaimed water program yields cost savings

In May 2013, The University of Texas at Austin began using reclaimed water – instead of valuable potable water – in the campus condenser water system to make up for water lost through evaporation in cooling towers. That first year, the university used 68,061,947 gal of reclaimed water, followed by 51,916,080 gal in 2014. The move has reduced campus cooling system water costs and helped conserve a precious resource in a state that has seen moderate-to-severe drought conditions in recent years.

Previously, the university had been buying water from the city of Austin at cost of $13.45/1,000 gal – $5.22 for fresh water and $8.23 to discharge it to the sewer. As an alternative, however, the city offered highly treated wastewater at $1.50/1,000 gal. UT Austin opted to bring the reclaimed water to campus, initially for trial use at Chilling Station No. 5. Around 80 million gal of potable water were replaced there at a savings of nearly $300,000 annually.

Before committing to a reclaimed water program, UT Austin partnered with U.S. Water to study the potential challenges presented by this water source. The company developed a water treatment plan for Chilling Station No. 5, designed to decreased corrosion rates in distribution lines, heat transfer stations and refrigeration units; eliminate fouling that could impede desired temperature control; minimize water losses from rust-damaged lines; minimize microbiological corrosion; and extend the life of seals, pumps and heat exchangers.

After nearly two years of successful reclaimed water use at Chilling Station No. 5, UT Austin is also moving ahead with plans to use reclaimed water for cooling tower makeup at the new 15,000-ton Chilling Station No. 7, now under construction.

Editor's note: *We would like to thank U.S. Water for the use of material from its case study on the UT Austin project. Read the full case study at http://tinyurl.com/hglxeje.*

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