

Oklahoma State University moves toward greater sustainability

OSU's main campus prepares for the future with a new central plant and local wind energy resources.

James W. Rosner, PE, CEM, Director of Energy Services, Facilities Management, Oklahoma State University-Stillwater; Brian Sauer, PE, CxA, LEED AP BD+C, Director of Mechanical Engineering, Frankfurt Short Bruza



Rendering of OSU's new Central Plant.

Source: Frankfurt Short Bruza.

Since 2007, Oklahoma State University (OSU)-Stillwater has been sharpening its focus on sustainability – in education, research and a variety of applications such as clean energy-fueled buses, energy management and conservation, recycling, composting and sustainable dining programs. Most recently, OSU embarked on a project to enhance the long-term sustainability of campus energy systems. The project incorporates Oklahoma's plentiful wind resources and includes construction of a new central steam and chilled-water plant to replace the Stillwater campus's aging Power Plant.

Built in 1947, the Power Plant produced electricity and steam with World War II-era surplus boilers and turbines. The plant increased its steam capacity in 1962 with a boiler addition and added chilled-water production in 1975. Now the 69-year-old steam and 41-year-old chilled-water operations have exceeded their life expectancy. Replacement parts are hard to find, and vendors are unable and unwilling to risk repairs. Additionally, compared with today's standards and technology, the existing plant equipment is inefficient.

OSU-Stillwater is experiencing exceptional growth, and the campus requires a plant capable of serving its needs for the next 20 years and beyond. Embracing the task of plant replacement, OSU chose to investigate a sustainable financial, operational, energy and environmental solution.

UTILIZING LOCAL GREEN ENERGY

Oklahoma, "where the wind comes sweeping down the plain," has abundant wind energy that supplied more than 18 percent of the state's generated power last year. In 2011, when considering options for replacing the Power Plant, OSU President Burns Hargis and the university's Board of Regents chose to utilize this local, renewable natural resource. That year, OSU entered into a power purchase agreement with Oklahoma Gas and Electric (OG&E) and committed to annually purchase 110 million kilowatt-hours of wind-generated energy – roughly 67 percent of the Stillwater campus's need – from the new Cowboy Wind Farm near Blackwell, Okla. The 26-turbine wind farm, commissioned in December 2012, spans 5,000 acres.

Wind power was selected over combined heat and power because of concerns over rising natural gas prices, additional capital costs for a CHP plant and the unknowns of what clean air and power legislation was on the horizon.

This wind power purchase agreement provided better electrical rate

Figure 1. Rendering of the OSU Central Plant Observation Room.



The Central Plant Observation Room provides students, faculty and visitors views of the boiler and chiller rooms through windows as well as monitors displaying the components of the heating and cooling systems, showing graphics of the output and operations of the equipment in real time.

Source: Frankfurt Short Bruza.

predictability for OSU, allowed reduction of staff in the Power Plant and made the university a better environmental steward. Among the agreement's stipulations, OG&E would construct a second electrical substation to serve campus needs. OSU agreed to no longer generate power and to build a new Central Plant (fig. 1).

Once these energy and environmentally sustainable goals were satisfied, OSU sought a sustainable operational and financial model for plant replacement within the contract's timeline and began investigating utilities privatization as a means to increase organizational efficiency.

FINANCIAL AND ORGANIZATIONAL SUSTAINABILITY

A utilities privatization analysis began in January 2012 and was completed in September 2013. The university's goals were to develop reliable, economical utility services; realize long-term savings; monetize infrastructure; and reduce debt. In short: create a sustainable utility operation with sustainable economic impact. A request for proposal was advertised in August 2012 to solicit private companies to operate and maintain the utilities production and distribution systems, and three com-

panies responded. The respondents' proposals were compared against the university's operational and financial plan – called OSU's "most efficient organization" (MEO) – to provide its own utility services. The knowledge gained through this evaluation process included a catalog and analysis of the entire utility system, identification of system deficiencies and comprehension of the university's financial health.

THE RESULTS OF THE EVALUATION SHOWED IT WAS IN THE UNIVERSITY'S BEST INTEREST NOT TO PRIVATIZE BUT TO RETAIN ALL UTILITIES FUNCTIONS.

The results of the evaluation showed it was in the university's best interest not to privatize but to retain all utilities functions for three primary reasons. First, it was determined that any concession payment would be on-the-books financing and therefore would increase the university's debt ratio. Second, the university was able to finance at much lower interest rates than the respondents. Finally, the nearest respondent's pro-

posal was 5 percent more expensive than the university's cost and would have resulted in large, multiyear utility rate increases. Upon the decision not to privatize, OSU began implementation of the plans developed in the MEO – one of which was selecting an architectural and engineering firm to assist in developing a utility master plan (UMP).

ROAD MAP: UTILITY MASTER PLAN

Through a competitive selection process, the firm of Frankfurt Short Bruza of Oklahoma City was selected to develop the UMP, and a notice to proceed was issued May 1, 2014. The purpose of OSU's UMP was to solve the existing deficiencies identified in the privatization analysis and create a living framework to be updated over time based on an ever-changing and dynamic campus environment.

In order to avoid obsolescence, the UMP contains dynamic models using geographic information systems (GIS) for the steam, chilled-water and electrical distribution systems on campus. These models evaluated future growth of the campus and resulted in the analysis of the load for a new Central Plant and the impact of its location on the systems. Once size and location were determined, the UMP provided five- and 20-year plans for steam, chilled-water and electrical systems to serve campus, accounting for system age, condition and growth. The UMP is the definitive road map for planning OSU campus utilities over the next 20 years and beyond.

PROJECTING CAMPUS AND LOAD GROWTH

The UMP incorporates information from the OSU Campus Master Plan with regard to future utility needs. Campus growth projections were used to size the new Central Plant and predict when additional capacity would be needed. The load analysis included 21 new buildings, four building additions and eight demolished buildings, all scheduled over the next 20 years and increasing the campus square footage by 24 per-

cent – a total of 2,971,000 sq ft. Based on projected growth, the current five- and 20-year peak demands are as follows:

Chilled-water load

- Current campus peak demand as of 2016: 15,300 tons
- Estimated five-year campus peak demand: 15,469 tons
- Estimated 20-year campus peak demand: 18,992 tons

Steam load

- Current campus peak demand as of 2016: 136,000 lb/hr
- Estimated five-year campus peak demand: 150,000 lb/hr
- Estimated 20-year campus peak demand: 190,000 lb/hr

Electrical load

- Current campus peak demand as of 2016: 31,995 kW
- Estimated five-year campus peak demand: 32,647 kW
- Estimated 20-year campus peak demand: 38,291 kW

With future load estimates determined (fig. 2), the models created for chilled-water, steam and electrical distribution systems aided in the selection of the best site for a new plant.

CENTRAL PLANT SIZE AND LOCATION

Constructing a new Central Plant and demolishing the old Power Plant frees up valuable campus real estate,

as the existing location is highly visible and desired by the university for other purposes including an opportunity to showcase new university buildings. Also, commissioning the new Central Plant before demolition of the existing plant alleviates the problem of having to make temporary cooling and heating provisions for the campus.

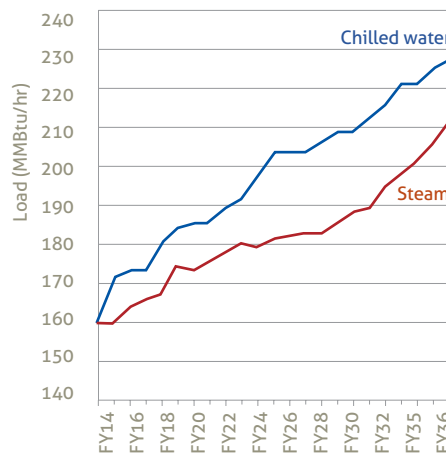
Frankfurt Short Bruza and the OSU Energy Services team met to determine possible sites for a new central steam and chilled-water plant. Any location on the campus map appearing to have even a remote potential for siting the new Central Plant was identified. Ultimately, nine sites were identified and presented to the OSU Board of Regents for final selection. On Oct. 24, 2014, the board approved the site directly north of the current Power Plant – the most favorable site economically and hydraulically for connection to the existing distribution systems. The system models also showed that this site required negligible increases to the distribution system capacity over the 20 years of the UMP. With plant size and location selected, complete design was able to begin.

EFFICIENT PLANT DESIGN

Full design of the Central Plant commenced March 9, 2015, and was completed Nov. 10, 2015. The plant's location at the prominent north entrance to campus required specific attention be paid to architectural features to create a utility plant that did not resemble a utility plant. Designed to blend with OSU's characteristic Neo-Georgian-style architecture, the plant bears similarities to an adjacent parking and transit structure, incorporating corner glass stairwells and OSU's signature red brick.

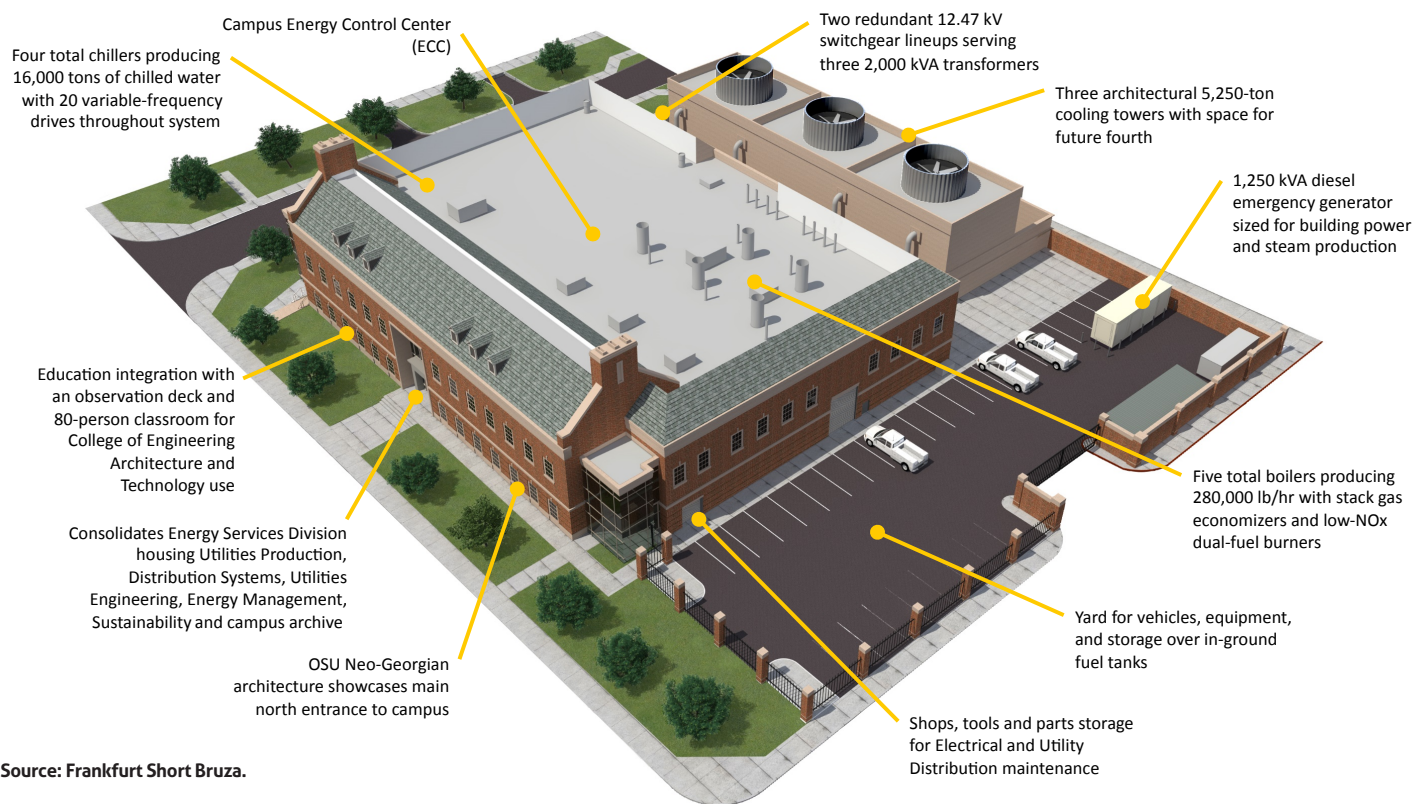
While OSU does not currently certify buildings using the Leadership in Energy and Environmental Design system, the Central Plant has been designed and will be constructed with a sustainable performance equal to that of LEED Silver standards. New preinsulated direct-buried piping, high-

Figure 2. OSU-Stillwater campus cooling and heating load growth, FY2014-FY2036.



Source: Oklahoma State University.

Figure 3. OSU's Central Plant layout.



Source: Frankfurt Short Bruza.

efficiency chillers and boilers, variable-speed pumping and comprehensive metering will allow future campus buildings to be more easily certified in the event OSU chooses to adopt the LEED green building rating system.

The new plant is also designed to tie into education. Beyond offering tours of the facility, which occur throughout the academic year, the new Central Plant has an 80-person classroom for architecture, engineering and technology students. Other majors may potentially use this classroom too, as most every discipline can associate with at least one aspect of the plant – be it the economics of utility production, consumption and conservation of natural resources, sustainability and efficiency, or even manpower requirements of an operating facility.

Another design feature is that the layout of the new Central Plant (fig. 3) incorporates efficiencies identified in the MEO for increasing operational sustainability by consolidating the majority of Energy Services staff in

one location. (Energy Services encompasses utilities production, distribution systems, utilities engineering, energy management and sustainability, and geospatial systems.) This allows remotely located departments to be brought under one roof and facilitates improved communication and training; and it reduces the campus footprint of the department by 42 percent (table 1).

The new plant design has a central control room that will serve as a

hub for improved controls integration between plant systems and campus building systems. This new control room will also serve as an after-hours emergency call center since the facility will be manned 24 hours a day. In addition, the new plant has space to serve as the Facilities Management Operations Center, ensuring business continuity and operations during power outages, natural disasters and special events.

As the new Central Plant has been designed to meet future needs as dictated by the growth of campus over the next 20 years, it is being built with the following production capabilities:

Chilled-water production

- 12,000 tons (8,000 tons firm)
- Three 4,000-ton chillers
- Space for a fourth 4,000-ton chiller

Steam production

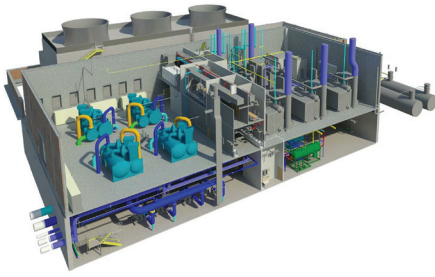
- 220,000 lb/hr (160,000 lb/hr firm)
- One 40,000-lb/hr boiler (with enough turndown for summer load) and three 60,000-lb/hr boilers
- Space for a fourth 60,000-lb/hr boiler

Table 1. Breakdown of Energy Services Division-occupied area, existing vs. consolidated at new plant.

Energy services area	Existing sq ft	Proposed sq ft
Building	67,283	64,973
Site equipment	9,275	12,400
Equipment yard	81,000	22,400
Substation	15,580	0
Power distribution center	0	3,750
Total	173,138	103,523

Source: Oklahoma State University.

Figure 4. OSU Central Plant equipment view.



Source: Frankfurt Short Bruza.

Future heating hot water production

- 25 MMBtu/hr (20 MMBtu/hr firm)
- Space for five 5-MMBtu/hr steam-to-hot-water heat exchangers
- Beginning in 2019, a hot water loop will be developed in six phases to serve north and west campus areas where no steam service exists. Steam from the new boilers will be utilized to provide the heating hot water.

The steam and chilled-water equipment has been meticulously arranged to make the most efficient use of the square footage available. The first floor houses the primary pieces of equipment with the basement containing the distribution pumps and piping for steam and chilled water (fig.4).

Connection of the new Central Plant to the existing infrastructure is no small feat, set to take place in fall and winter 2016. More than 12,000 total linear ft of steam, condensate return and chilled-water lines are required for the thermal system and over 8,027 linear ft of electrical duct bank for the electrical distribution network. In addition, 21 vaults are required to make the plant operational. In two separate locations, distribution has to cross one of the most prominent roads in the city of Stillwater – Hall of Fame Avenue. Creative design and phasing plans have been essential in addition to a creative and flexible construction plan.

PLANT CONSTRUCTION

Early into the schematic design, the process to select a construction



Courtesy Oklahoma State University Work Zone Team
Construction of OSU's new Central Plant, for which ground was broken in fall 2015, is under way with service to campus expected to begin in December 2017.

manager at risk brought Flintco LLC of Tulsa, Okla., onto the project team to provide preconstruction services and to build the Central Plant and associated distribution. Individual bid packages were fast-tracked, enabling phases of the project to begin while the full design was being finalized. Construction of the Central Plant itself comprised three packages, with site demolition and mass excavations first, foundations and structural steel second and building completion third. Electrical distribution construction and thermal utilities distribution construction were bid as two complete, separate packages. OSU decided it was in its best interest to “owner-purchase/contractor-install” the large-equipment portions of the project. The boilers, cooling towers, chillers, deaerator, surge tank, emergency generator, chilled- and condenser water pumps, associated variable-frequency drives, transformers and switches have all been purchased by the university.

The first bid package was awarded Sept. 9, 2015, while the award of the first owner-furnished equipment was issued for the boilers Sept. 2, 2015, to English Boiler and Tube. This is remarkable, considering award of the first bid package was merely 184 days after the Central Plant design began and less than 18 months after the start of the UMP development! OSU broke ground for its new Central Plant Sept. 18 of last year. Currently, construction of the plant, electrical distribution and thermal utility distribution is under way with delivery of

the first boiler and chiller scheduled for the end of November and the first of December 2016, respectively. The plant is scheduled to start service to campus in December 2017.

SUSTAINABLE RESULTS

Replacing the 1947 Power Plant has already yielded and will continue to yield notable results. New Central Plant chillers are 31 percent more efficient and new boilers 21 percent more efficient than existing plant equipment, resulting in a projected \$350,000 reduction of annual campus energy costs. OSU's use of green power from Cowboy Wind Farm – annually averaging 70 percent of campus electrical usage – is reducing the university's annual carbon footprint by 89,000 metric tons. Besides the energy efficiency and environmental benefits, the new plant consolidates the majority of the Energy Services Division to a central location, reducing the group's campus footprint by 42 percent; and the facility also reinforces OSU's educational mission by providing opportunities for tangible applications of sustainability and engineering principles.

OSU's accomplishments have not gone unnoticed. Already in 2014, after beginning to tap wind energy the prior year, OSU won an Environmental Protection Agency Green Power Partner of the Year award. This year, OSU also ranks No. 8 on the EPA's Green Power Partnership Top 30 College & Universities list for green power usage (a list OSU has been on

since 2013) and No. 62 in the EPA's National Top 100 for leadership in renewable energy.

As OSU President Hargis has stated, "Through its sustainability practices, OSU seeks to more effectively and responsibly serve its university community, as well as the citizens of Oklahoma, our country and the world. OSU faculty, staff and students will advance all aspects of sustainability through instruction, research, outreach, administrative decision-making, innovative design and operation of our physical facilities, and our daily behavior."

OSU's replacement of its aging Power Plant with an efficient new Central Plant and renewable energy use most certainly reflects the type of innovative design and operation of facilities that President Hargis has in mind. Delivering the financial, operational, energy and environmental sustainability that OSU set out to

achieve, the new plant will soon be ready to start meeting campus utility needs for the coming decades. 

University of Denver starting Nov. 14, 2016. Rosner can be reached at james.rosner@okstate.edu



James Rosner, PE, CEM, is the director of energy services at Oklahoma State University in Stillwater, responsible for all utilities production, distribution, engineering, energy management, sustainability and facilities information services for a campus population of 33,600 and 631 facilities totaling 12.5 million sq ft. He is a certified energy manager and professional engineer and holds a Bachelor of Science degree in mechanical engineering from Colorado State University and a Master of Science degree in engineering management from the Air Force Institute of Technology. He has recently been selected as the associate vice chancellor for facilities management and planning for the



Brian Sauer, PE, CxA, LEED AP BD+C, is the director of mechanical engineering at Frankfurt Short Bruza. As the head of the firm's mechanical engineering group, Sauer plays a critical role in every company project, and he has extensive experience in the design of the complex mechanical systems required for a variety of clients. His responsibilities encompass the design of HVAC systems, central heating and cooling plants, building automation, energy recovery, fire protection, plumbing, compressed air and noise and vibration control engineering. Sauer is a licensed professional engineer, certified commissioning authority and LEED accredited professional. He can be reached at bsauer@fsb-ae.com.

System Snapshot: Oklahoma State University (Reflects new Central Plant systems on startup in December 2017)

	Steam system	Chilled-water system
Startup year	1948 – Power Plant begins steam service 2017 – New Central Plant to replace Power Plant, begin steam service	1976 – Chilled-water production added at Power Plant 2000 – West Chilled Water Plant added 2017 – New Central Plant to replace Power Plant, begin chilled-water service
Number of buildings served	75	90
Total square footage served	7,685,938 sq ft	8,542,743 sq ft
Central plant capacity	220,000 lb/hr	12,000 tons
Satellite plant capacity	NA	16,000 tons
Number of boilers/chillers	4 boilers	7 chillers (3 Central Plant, 4 West Chilled Water Plant)
Fuel types	Natural gas, backup No. 2 fuel oil	Electric
Distribution network length	10.9 miles	17.3 miles
Piping type	Carbon steel, stainless steel in tunnel	Direct-buried steel, transite, PVC, HDPE
Piping diameter range	2 to 12 inches	2 to 36 inches
System pressure	250 psi in power plant, 50 psi campus supply	65-90 psi
System temperatures	350 F	40-42 F supply/52-54 F return
System water volume	86,270 gal	1.2 million gal

Source: Oklahoma State University.