Clemson University

Clemson, South Carolina

Renovated College Central Plant Creates Opportunities for Energy Research

"We were looking for new approaches in the energy market and were ready to consider a lot of new ideas." In this way Jeffrey Hinson of Clemson University in South Carolina describes the process followed by the university in establishing an innovative central electric generation and chilled water facility. Hinson is the director of utility services at the university.

Clemson is as deeply rooted in tradition as any American college. It stands on the site of the Fort Hill plantation home of statesman, congressman, and U.S. Vice President John C. Calhoun. The school was created from an 1889 gift of land and buildings by founder Thomas Green Clemson, Calhoun's son-in-law.

Alumni have fond memories of traditional sports rivalries, military drills, and the gracious wooded campus. Clemson's beloved Tigers compete in interscholastic sports in the prestigious Atlantic Coast Conference, of which Clemson was a charter member.

"We try and anticipate when that peak will occur..."

Above and right: Trane Duplex CenTraVac electric centrifugal chillers operate at exceptionally high efficiency and their low condensing water requirements allow the enlarged plant to continue to use the existing supply pipeline.

Yet along with its love of tradition, Clemson has always been an innovative school with an eye on the future of its students, its campus, and its region. From the time of its founding in 1893 as a men's military school that offered classes in agricultural and mechanical sciences, Clemson has had an outreach mission to upstate South Carolina.

In 1955 the university changed from an all-male college to a coeducational university with broad academic offerings. Today the school has an enrollment of 17,000, including over 3,000 in graduate programs. Clemson offers a broad range of programs in engineering, business, arts, architecture, health sciences, and education. The scenic campus in the city of Clemson encompasses 5.2 million square feet of space in 80 buildings.

Energy Plant Upgrade Needed

For decades, Clemson has operated a central plant facility to supply steam and chilled water for heating and cooling. In the late 1990s, the University Facilities group at Clemson recognized a need to upgrade its central plant with a more efficient and reliable steam and chilled water supply. At the same time, there was strong interest in installing an electric generation capability to carry at least a portion of the campus electric requirement.

The university's Central Energy Facility is also a key educational adjunct to the South Carolina Institute for Energy Studies (SCIES).

The Clemson campus is also the home for the South Carolina Institute for Energy Studies (SCIES), which in partnership with the university planned to create an Energy Systems Laboratory (ESL) adjacent to the existing Central Energy Facility. Lawrence Golan, director of SCIES, comments "Our goal was to make the campus a real-world energy laboratory. As the plans developed for the central plant improvements, we saw the opportunity to integrate this facility with the university's mission for research and teaching."

Clemson solicited proposals from engineers to design an integrated energy plant with combustion turbines for electric generation and a heat recovery boiler on the turbine exhaust to recover heat energy in the form of steam. The most urgent need was a new chiller plant to replace three older existing centrifugal chillers with equipment that could operate at much higher efficiency.

Plant Includes Learning Mission

The university encouraged submittal of designs which would allow the equipment to be closely observed by students, researcher and industrial partners from the Energy Systems Laboratory. The engineer selected to design the central plant facility was I.C. Thomasson of Tampa, Florida. Using the university's criteria, the integrated facility design included demolition of three of the four existing coal-fired boilers, leaving in place boiler number four, rated at 75,000 lbs/hr at 125 psig. A new natural gas fired boiler was specified to produce an additional 150,000lbs/hr, for a total system capacity of 225,000 lbs/hr.

Electric generation was to be provided by two natural gas-fired combustion turbines manufactured by Solar, rated at 4.2 and 4.8 megawatts (MW) each. The combined capacity of 9.0 MW represents about 40% of the university's summer peak electrical demand. One of the combustion turbines, the Solar Mercury 50, is an advanced recuperative cycle machine that was installed as a part of an energy technologies research project at the university.

The design uses a heat recovery boiler on the combustion turbine exhaust as a supplementary source of system steam. Steam from the heat recovery boiler reduces the need to purchase natural gas or coal and improves overall system efficiency.

The chilled water aspect of the design involved replacing three 30-year-old single-stage centrifugal chillers which had a nominal capacity of 6,000 tons with three new centrifugal chillers and a double-effect absorption chiller, providing a combined capacity of 6,400 tons. According to Jeffrey Hinson, the actual goal of the replacement was far greater than the slight increase from 6,000 to 6,400 tons. "Those old machines had already been dated because of

plugged tubes, and because of changes in the inlet temperature of the condenser cooling water."

He points out that the plant was designed to use water from nearby Lake Harwell for condenser cooling. "Because of the operation of the Oconee nuclear power plant upstream, we have seen an increase in the summer water temperatures from 65°F (18°C) to 80°F (27°C). Since our old chillers were designed for 65°F water, they suffered a major derate. We were unable to come close to meeting campus cooling loads. In fact, even though the nominal increase in capacity was only 7%, the actual increased cooling capability was more like 30%."

Minimal Condenser Water Flow Required

A key specification for the replacement chillers was that they be able to operate using the existing 20-inch buried pipeline carrying condenser cooling water from the lake to the central plant, a distance of over 1,000 feet. Hinson notes, "The expense of replacing this pipeline would have been phenomenal. Among other things, it runs under our football stadium."

He says, "Replacement just wasn't an option. We needed the new chillers to be able to continue to use the existing pipeline." According to Hinson, the engineer determined that the effective flow limit for the existing pipeline was 10,000 gpm, which meant that the electric chillers would need to be able to stay on line with flow rates as low as 1.5 gpm/ton.

The chillers ultimately selected for the project were three Trane Duplex CenTraVac™ chillers, Model CVHD, rated at 1,800-tons each, and a Trane Horizon™ absorption chiller rated at 1,000-tons. This combination of machines met the university's requirement to be able to use the existing pipeline and to operate efficiently at condenser water inlet temperatures of 80°F, or even occasionally above that.

The purpose of the absorption chiller was to take full advantage of surplus steam, particularly during times of year that the combustion turbines were operating and there was low demand for heating steam. Additionally, the university wanted increased flexibility in energy choices, and the ability to help minimize electric load during peak demand hours.

The electric supplier is Duke Power, and peak demand is established monthly year-round, based on usage coincidental to Duke's system peak. In order to reduce demand charges, the university commonly operates its own generation during the afternoon hours, the typical time of the peak. Hinson smiles, "We try to anticipate when that peak will occur, and have our generation on line at that time. Usually we guess right."

Plant Installed on Tight Schedule

The mechanical contractor chosen was Stanley Jones Corporation from South Fulton, Tennessee, and the electrical contractor selected was Walker Electric of Nashville. Installation of the new chiller plant started in January 2000, and the plant was up and running by mid-May. While work was in progress, the university relied on a 2,000-ton remote plant to carry the entire campus load.

Hinson indicates that the installation went without major problems. The old boilers and chillers needed to be

A Trane Horizon absorption chiller allows the university to take advantage of seasonally - available surplus steam capacity from heating boilers.

completely removed from the central plant building before the new boiler and chillers could be moved in. An air jack was used to move the heavy equipment into place.

Hinson indicates that the chilled water system startup was uneventful. "That went really well, too. We did a few tweaks on the communication system, but nothing serious. The entire new chiller plant was able to carry the full campus load almost immediately. The units have performed as we expected, and we are providing much colder water to the entire campus," he remarks. As designed, the plant delivers chilled water at 40°F (4°C).

Most of the chilled water is used for cooling academic buildings, laboratories and administrative facilities. It is used in a wide variety of air handler and fan coils. Chilled water is also sold to the independent authority that operates residence halls. According to Hinson, this customer immediately noticed the difference in chilled water temperature, and found that much more effective cooling and dehumidification was now possible.

Today, with the new central plant in operation, plans are being finalized to integrate operations with the Energy Systems Laboratory. Research on the advanced cycle combustion turbine is an important project being done for the U.S. Department of Energy. Students and faculty are learning to use the central plant as a learning center.

Condensing water is supplied by a pipeline that runs directly beneath the Clemson football stadium.

According to ESL program manager Dave Stubblefield, in coming months, students and researchers will be able to visit the World Wide Web to observe a wide range of operations at the center, observing energy use, operating temperatures and pressures, and comfort levels throughout the campus. Stubblefield says, "With our close affiliation with the central energy plant, we feel we have a unique learning and research opportunity. This will only expand in coming years."

The tight integration of energy generation, steam production, and chilled water production using multiple energy sources makes the plant a unique opportunity for research and teaching. It also represents an opportunity for a pioneering university to maintain a quality campus environment at the lowest possible cost. At Clemson, the tradition of innovation continues.

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