INTERNATIONAL DISTRICT ENERGY ASSOCIATION

THE UNIVERSITY OF TEXAS AT AUSTIN

UTILITIES AND ENERGY MANAGEMENT

University of Texas at Austin increases investment in co-generation to achieve greater utility reliability and economy.

ENVIRONMENTAL BENEFITS AND ENERGY SAVINGS

- Power plant efficiency improved from 43% to 50% since 1996, resulting in annual fuel savings of $2.4 million
- While campus space increased over 2 million square feet since 1998 and energy consumption increased 8%, fuel consumption for cogeneration increased only 3% due to plant upgrades
- Historical maximum NOx emissions have decreased 60 tons per year due to plant upgrades
- Addition of new 25 MW steam turbine will further reduce NOx, will provide 100% ROI in under 20 years, and will improve firm capacity from 52 MW to 78 MW to meet projected campus load
- 50 million gallons of recovered water used as make-up water, saving $130,000 annually

CHP SYSTEM SPECIFICATIONS

- 160 campus buildings served
- 1,146,000 lbs per hour heating capacity
- 4 watertube boilers, 2 HRSGs, 1 steam loop
- 88 MW electric generating capacity
- 40,800 tons cooling capacity
- 4 chilling stations, 1 chilled water loop

SEARCH WORDS: DISTRICT ENERGY, CHP, COGENERATION, CHILLED WATER, REDUNDANCY, CONDENSATE TREATMENT, ECONOMICS

BACKGROUND

The University of Texas at Austin has grown over the years into one of the nation's largest research-oriented universities. In the process, it has built a very reliable utility system to ensure that the mission of the university is not disrupted by energy system failures. A testament to the robust design of the system is the fact that the campus has had only one complete blackout in the past 30 years.

This enviable record is accomplished through a variety of means, primarily through self-reliance for all of its energy needs and redundancy designed into the energy delivery system.

UT-Austin continues to grow. As the university's energy needs increase, the utilities department is adding to its available capacity to ensure that it can continue to provide the same high levels of reliability it does today.

Figure 1. UT Austin's CHP Facility. Source: UT Austin.

REDUNDANT DESIGN INCREASES ECONOMY AND RELIABILITY

The CHP plant at UT-Austin has provided very reliable utilities since its inception. This reliability is a product of the system's design and interconnectedness.

The HRSG and boiler plant are part of one contiguous steam system, allowing the university to use both sources to generate steam if needed. If a gas turbine and/or HRSG were to fail, standby electrical power (25 MW) from the local utility, Austin Energy, is used to support the electrical system. Concurrently, one or more of the fired boilers is used to run the steam system, which keeps the steam distribution supported and most of the electrical system on-line via steam turbines. This interconnection of plant equipment provides both benefits and challenges, due to the added complexity of plant operations.

CHP SYSTEM METRICS

System currently serves 160 buildings; adding 1,000,000 sq. ft. served in the next 8-10 years.

HEATING CAPACITY: 1,146,000 lbs/hr

- 4 watertube boilers with total capacity 800,000 lbs/hr
- 2 HRSGs with total capacity 346,000 lbs/hr
- 1 steam loop
- Steam distribution pipe: 81,316 linear feet, supply and return
- Chilled water distribution pipe: 89,228 linear feet, supply and return

COOLING CAPACITY: 40,800 tons

- 4 chilling stations and 1 chilled water loop
- 30,000 tons electric-driven
- 10,800 tons steam-driven
- Peak consumption: 28,000 tons

GENERATION CAPACITY: 88 MW

- 51 MW from gas turbines
- 37 MW from steam turbines
- Capacity increasing to 110 MW in 8-10 years
- Adding 25 MW steam turbine
- Peak consumption 56 MW, growing to 75 MW in 8-10 years
- Standby power: 25MW from local utility
- Electric distribution: switched multiple bus system

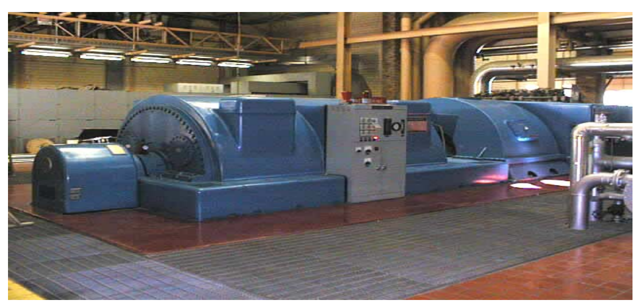


Figure 2. 25 MW steam turbine. Source: UT Austin.

An important factor that enables the plant to operate so economically is that approximately 10,800 tons of refrigeration (out of 40,800 tons total) can be generated using steam turbine-driven chillers. In the summer, when chilling load is the highest (28,000 tons peak) and electrical peak load is the highest (56 MW peak out of 88 MW total installed capacity), HRSG-generated steam supports the chilling system. In addition to electrical generation and chilled water support, heating and hot water systems in the 160 campus buildings are supported by the steam system (Figure 5).

The 40,800-ton chiller plant consists of four chilling stations that feed one common chilled water loop through a walkable tunnel system. System reliability is ensured since any one or more of the four stations can support the campus hydraulically as well as satisfy refrigeration needs. Hydraulically, each chilling station is sized to handle the total GPM needs of its station; booster pumps are located at the buildings to support the building needs (Fig. 6).

Figure 3. One of UT-Austin's 5,000 ton electric chillers.
Source: UT-Austin

Almost all of the campus facilities are designed with double-ended substations, so that if one transformer were to fail, the remaining transformer can handle 100% of the building load. In addition, almost all facilities have two feeds for chilled water, steam, and potable water so that supplies can quickly be rerouted in case problems develop. The electrical distribution system is designed as a switched multiple bus system that allows for an alternate feed to the bus from another bus should one fail.

Emergency power to campus buildings is provided in one of three ways. One way is via traditional stand-by generators. Another way is via an alternate feed from a separate bus in the electrical distribution system. This is possible due to the generator redundancy in the plant and the electrical distribution system design. The third way is through an outside feed from the local utility that is procured via a separate stand-by electrical agreement, since the university generates power for all of its needs. The latter two options significantly reduce the maintenance operations costs of the standby generators.

The university also makes use of recovered water to reduce consumption. The campus consumes about 900 million gallons of domestic water per year. Of that total about 500 million gallons is for plant operations. Approximately 50 million gallons are recovered from once-through cooling water, ground water, rainwater cisterns, water from drained swimming pools, and condensate from building cooling coils. This recovered water is separately routed via PVC piping back to cooling towers in the plants and is used as make-up water.

INVESTING IN THE FUTURE

UT-Austin continues to invest in its physical plant, making it even more efficient and reliable. It is taking a multi-pronged approach which includes projects related to controls, condensate treatment, and co-generation capacity expansion.

The university has invested approximately $6,000,000 over the last four years in digital controls for the power plant and chilling stations. This effort is expected to be completed within the next three years, with an additional investment of $3 to $4 million.

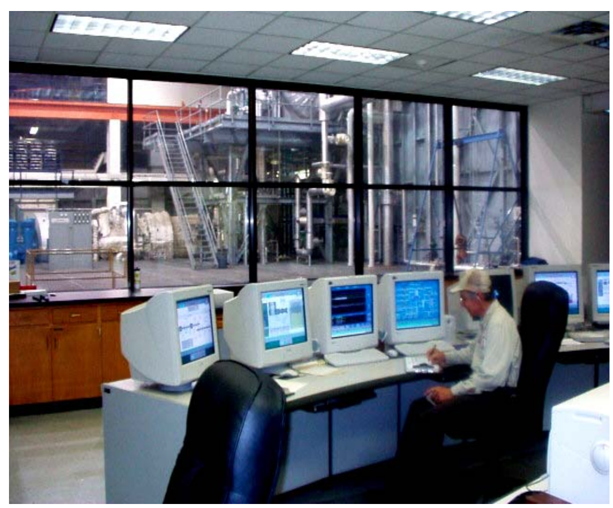


Figure 4. Digital control station. Source: UT Austin.

This PLC-based system has dramatically improved reliability, since, prior to the effort, boilers were without burner management systems, and the plants were manually operated. Tripped boilers and significant upsets were commonplace, and while the campus services were not affected significantly, this was creating major operational challenges. The utilities department is now able to consolidate power plant and chilling station operations with common controls. A reduction in operating costs and improved cross training between power plant and chilling station staffs are anticipated.

The campus consumes about nine million gallons of distilled water for laboratory use that is derived from the condensate return system. This laboratory application has prevented the use of amines to treat condensate in the past. When a campus facility hot water generator (steam to hot water converter/exchanger) develops a tube leak, raw, untreated water is introduced to the condensate return. The water in Austin is very hard, which further contaminates the condensate.

Studies have indicated the need to start condensate treatment via amines. There have been complications at the boiler plant, resulting in a failure of the 286,000 lb/hr HRSG at a repair cost of $2,000,000. The utilities department will shortly reroute the supply of distilled water from condensate return to the de-mineralized water system. This will allow them to start treating the condensate system. The return condensate will also include the use of polishers for further treatment. This will be accomplished by 2003 and should resolve these complications.

Finally, the campus is expected to grow by 1,000,000 additional square feet over the next eight years, causing a strain on the power plant. At a current peak of 56 MW, the firm capacity is 52 MW, and load is projected to grow to 73 MW by 2008. To respond to this growth, the largest cooling tower, constructed in 1958, is being replaced with sufficient capacity to handle the addition of a 25 MW steam turbine. This new turbine will increase total capacity to 113 MW and firm capacity to 77MW by 2003/2004. In addition, the department is increasing capacity at the substation from 56 MVA to 100 MVA. The substation is the campus' parallel interconnection with Austin Energy that provides 25 MW of stand-by power.

The design of UT-Austin's energy system makes campus-generated power a more cost-effective option compared to power purchased from a utility. A recent study on the option to purchase rather than to generate electricity indicates that a 90% "buy" vs. 100% "generate" would cost the campus about $10 million more per year because of the university's need for steam and dependence on steam for chilled water production. This trend of additional cost is consistent even when considering smaller increments of purchased power.

While fuel costs for gas turbine generation would drop proportionally to the amount of electricity purchased, it would also result in increased direct-fired boiler use. This boiler use is needed to support steam use for campus heating/hot water, generation, and chilled water production, and is relatively constant. The reduction in gas turbine generation results in an energy penalty because turbines would now be operating at a less efficient point on the load curve, and the HRSG would proportionately be providing less free steam from the turbine exhaust. The combined electrical purchase and increased natural gas purchase for fired boilers results in an increase in total costs rather than in savings.

CONTINUALLY MOVING FORWARD

The campus will continue to strive for self-dependence in electricity because the utilities department continue to provide the level of reliability and economy in the current market that the campus has enjoyed over the last 70 years. The department will, however, continue to look for future opportunities from the deregulated market, compare this to the need to add further capacity, and respond to the reliability needs.

PROJECT IMPACT

- The investment to the campus substation, switchgear, cooling tower, and new turbine will prepare the campus to manage projected load growth.
- The new 25 MW turbine will provide $1,000,000 per year in fuel savings.
- Firm capacity will exceed the peak electrical demand for the first time in many years.
- Digital controls in the substation and switchgear project will allow for improved reliability, monitoring, and response to problems.
- The new tower will save over $500,000 in energy over its life due to improved efficiency.

Figure 5. Source: UT Austin.

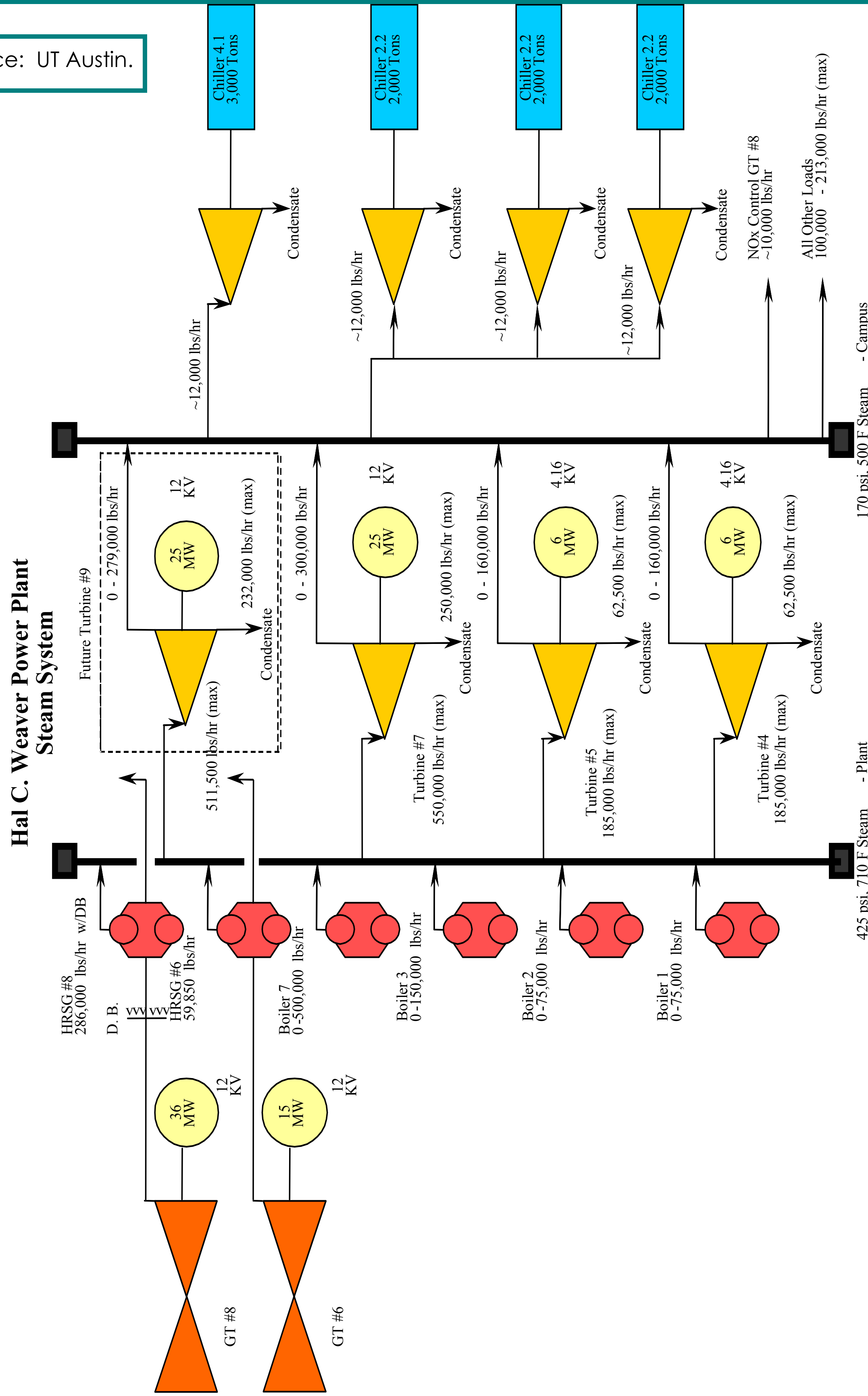
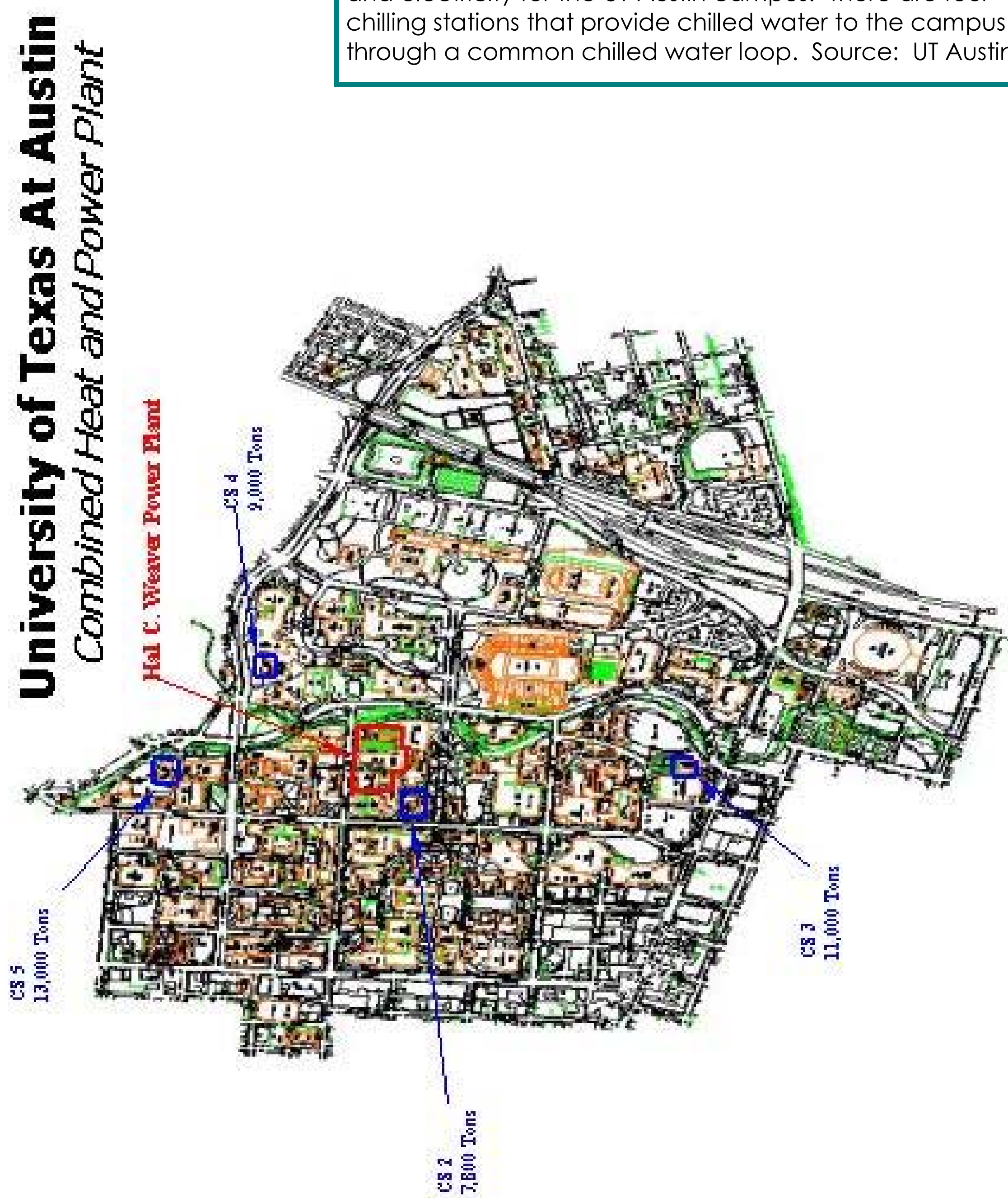


Figure 6. The Hal C. Weaver power plant provides steam and electricity for the UT-Austin campus. There are four chilling stations that provide chilled water to the campus through a common chilled water loop. Source: UT Austin.



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