TEXAS A&M UNIVERSITY
UTILITIES & ENERGY SERVICES

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Utilities & Energy Services

(A Full-Service Campus Utility in College Station, Texas, United States)

Submission for the

3rd International District Energy Climate Award

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Purpose

The Utilities & Energy Services (UES) Department at Texas A&M University (TAMU) remains committed to providing world class service to support the university mission of teaching, research, and service, with a focus on ***Vision 2020: Creating a Culture of Excellence*** through implementation of the ***Action 2015: Education First*** Strategic Plan. As a result, UES developed ***Energy Action Plan (EAP) 2015*** to support these initiatives which is being systematically implemented to ensure continued alignment with the broader University vision and mission.

Overview

UES provides comprehensive utilities and energy management services for the entire University, serving 23 million gross square feet (GSF) of facilities and over 19 million GSF of conditioned (cooled and heated) space. Approximately 90 percent of conditioned building space on campus is served by centrally-supplied thermal district cooling and heating systems, supplied from four major utility plants – a Central Utility Plant (CUP) and three satellite utility plants (SUP1, SUP2 and SUP3). The original CUP boiler facility was placed into service in 1912 at and the SUPs were placed into service in 1975, 1981 and 1987 respectively, yielding an average facility life of 50 years. An extensive network of electrical distribution and water distribution/collection systems serve over 750 buildings on campus, and provide utility service to over 60,000 faculty, staff, and students engaged in research and teaching activities.

The utility infrastructure alone at TAMU has an estimated replacement value of $1.25 billion which includes the production, distribution and processing of electricity, chilled water, heating hot water, steam, domestic cold water production and distribution, domestic hot water, sanitary sewer collection and treatment, storm drainage, solid waste and recycling services. When combined with metering, monitoring, billing, operation and maintenance of building automation systems (BAS) and extensive energy management services, UES provides a comprehensive and cost-effective range of mission-critical services for the students, faculty, staff, visitors, and contractors on campus.

The utility systems at the university have operated continuously longer than any other in the region, with on-site power generation since 1893, together with thermal energy production (cooling and heating) to meet university requirements. A combined heat and power (CHP) plant is operated at the CUP which was upgraded in 2011 to provide the capacity to self-generate up to 50 megawatts (MW) of electrical power, with a campus peak load of 70 MW. On-site power generation serves almost 70 percent of the campus electrical load with the balance of electrical requirements supplied from the 138 kV Volt incoming redundant power transmission feeds to campus. This ability to both self-generate and purchase electrical power from the grid provides redundancy with greater flexibility and reliability to ensure the most cost-effective procurement of electricity supply. Another benefit of CHP is the important capability it provides to meet essential University power requirements in the event of a regional power outage or other emergency that requires isolation from the external system.

With the installation of 26,000 tons of high efficiency electric motor-driven chillers since 2002, chilled water production capacity in the four campus utility plants is now at 52,000 tons. The four utility plants on campus produce and deliver over 175 million ton-hours of cooling annually to campus facilities,

which is enough capacity to cool over 10,000 average homes in Texas. Central heating and domestic hot water for campus facilities is generated by 23 boilers and multiple heat exchangers at the four utility plants, which is then distributed throughout campus.

UES operates and maintains an extensive water production, transmission, storage, and distribution system that supplies all domestic water to campus. The production wells are located several miles north of campus and water is transmitted to campus via redundant supply lines. Storage is provided in several above-ground storage tanks and two elevated tanks – one on the main campus and the other on Riverside campus. Domestic water storage capacity is sufficient to supply campus for 24 hours in the unlikely event of an emergency interruption of water supply. Emergency interconnections between the university and City of College Station water systems provide additional redundancy for both the City and TAMU. The domestic water system serving TAMU is held to the same rigorous testing standards required of all municipal water systems in Texas and is consistently rated as a Superior system by the Texas Commission for Environmental Quality (TCEQ).

Sanitary sewer collection systems and two wastewater treatment plants (WWTP's) are operated and maintained to serve campus. The main WWTP has a capacity of 4 million gallons per day and serves all of main campus, with a smaller collection system and WWTP serving Riverside Campus. Solid waste disposal and recycling services for the University are also managed by UES, with solid waste generated by the University averaging 1,000 tons per month. Since 2010, the diversion rate for recycled materials (recycled tonnage divided by total solid waste tonnage) has increased to over 60 percent, increasing significantly from diversion rates that prior to 2010 were below 10 percent. Continued improvements in the recycling program continue to be made such as the placement of additional three-stream recycling containers and upgraded Recycling Center drop-off facilities located on campus in 2011. Ongoing efforts continue to find and implement cost-effective ways to raise awareness about the importance of recycling, while keeping the recycled material diversion rate as high as practical and encouraging active participation in the program by the campus and local community.

UES also has responsibility for energy management services for the university, which includes operation, maintenance, and optimization of all energy and water systems. A Siemens BAS is utilized to monitor and regulate heating, ventilation, air conditioning (HVAC) and lighting in 11 million gross square feet of campus facilities. Pneumatic control systems are used to regulate and control HVAC systems in an additional 8 million GSF. UES also manages building retro-commissioning, utility metering, and energy stewardship to ensure needs are met in the most efficient and cost-effective manner. Siemens reports that the BAS at TAMU is one of the largest and most sophisticated BAS in the world, with over 400,000 monitoring and control points to regulate temperatures, humidity, air and water flow, and lighting in campus facilities. HVAC and lighting systems are routinely scheduled in many of the buildings to conserve energy and improve operating efficiency. System monitoring and alarming capabilities allow for prompt identification of operational issues so effective troubleshooting and system analysis can be performed to ensure that mission-critical teaching, research, labs, and offices can remain fully operational. UES also employs the use of the Schneider Square D metering system to meter the consumption of every building over 5,000 GSF for electricity, chilled / heating hot

water, and domestic cold / hot water. This data from over 2,000 meters is invaluable in tracking building performance and educating building occupants.

From September 2002 through August 2012, operational efficiencies have been dramatically improved:

- 27 percent reduction in total university energy consumption (6.7 to 4.9 million mmBtu)
- 24 percent reduction in scope 1 & 2 GHG output (.374 to .285 million MTeCO2)(FY04 – FY12)
- 40 percent reduction in energy consumption per square foot (364 to 214 mBtu / GSF)
- Addition of over 4.4 million GSF of facilities served on campus (18.5 to 22.9 million GSF)
- $140 million cost avoidance achieved through improved operating efficiency and conservation

In FY12 alone, operational efficiencies were again improved significantly from the installation of CHP resulting in the following improvements:

- 7 percent reduction in total university energy consumption (5.3 to 4.9 million mmBtu)
- 12 percent reduction in scope 1 &2 GHG output (.326 to .285 million MTeCO2)
- 9 percent reduction in energy consumption per square foot (235 to 214 mBtu / GSF)
- Addition of over 1 million GSF of facilities served on campus (22.3 to 22.9 million GSF)
- $6 million cost avoidance achieved through improved operating efficiency and conservation

System Description

To meet the planned electrical, heating and cooling load growth of the Campus, UES implemented a $73.25 million phase of the UES Master Plan to install a 45 MW Combined Heat and Power (CHP) system. TAMU was only one of nine recipients nationwide to receive a DOE grant to help finance this $73.25 million major CHP system upgrade. This $10 million DOE grant awarded to TAMU helped fund the project. The system will produce electricity to serve a significant portion of campus power needs and steam for heating and cooling of campus facilities. The CHP system efficiency is 70% or greater and significantly improves the overall operating efficiency, reliability and emissions profile of the University. This CHP system consists of a GE LM2500 +G4 natural gas-fired combustion turbine with a 210,000 lb per hour EIT heat recovery steam generator, together with a Dresser-Rand backpressure steam turbine, with 600 psi input and 20 psi exhaust steam serving campus heating loads. This new 45 megawatt CHP power and steam generation capacity replaces the previous generation of CHP equipment and collectively with an existing 5 megawatt steam turbine generator; TAMU has 50 megawatts of power generation, together with purchased power capacity to serve 23 million gross square feet of facilities and over 5,000 acres on the TAMU campus. The system operates at a heat rate of 8,100 mBtu/ MWh and at approaches 70% efficiency.

The new CHP plant is an integral component of comprehensive mission-critical utilities and energy services provided at TAMU, which includes utility production and distribution combined with comprehensive demand-side energy management. CHP has been an important component that has made it possible for TAMU to reduce energy consumption by over 40 percent per gross per square foot over the last 10 years, resulting in close to $140 million cost avoidance. As a result of the CHP Project completed in 2012, purchased energy cost avoidance of over $6 million annually has been achieved through more efficient power and thermal energy generation, together with a significant reduction in

GHG emissions. The new gas turbine generator and heat recovery steam generator were placed in operation in August 2011, with the new steam turbine generator available for operation in March 2012.

High pressure, superheated (600 psi, 750F) steam is produced by the heat recovery steam generator (HRSG) using gas turbine exhaust, together with supplemental firing capability, to provide 210,000 lb/hr in steam generation capacity. The 600 psi steam is used to drive a back pressure turbine to generate additional electricity while providing low pressure (20 psi) exhaust steam for heating hot water and domestic hot water service to campus. 600 psi steam generated in the HRSG is also used to drive steam turbine-driven chillers along with electric motor-driven chillers, and provide district cooling to 19 million gross square feet of conditioned facilities on campus.

The CHP system provides up to 70 percent of the campus heating for heating hot water, campus steam distribution, and domestic hot water uses and up to 35% of the university's cooling requirement through the use of steam turbine-driven chillers.

In addition to providing heat to serve 70 percent of the total campus heating demand and the campus steam distribution system, the CHP system also provides heat to serve domestic hot water for all student housing, dining facilities, and a number of other general use buildings. TAMU has the capability to sell electricity back to the grid and has done so at times when high thermal loads on campus are combined with relatively low electrical demand, but this is only a very small percentage of the time during cold winter weather. TAMU is in the process of designing a 3 million gallon thermal storage tank that will be operational in 2015 and will provide the capability to keep CHP power generation base loaded at all times.

Before this CHP system upgrade, the university operated a previous generation natural gas-fired combustion turbine, heat recovery steam generator, and steam turbine-driven generator. The new CHP system upgrade increased production capacity, reliability, and efficiency, while significantly reducing GHG emissions. The CHP system in the Central Utility Plant at Texas A&M University is a model plant for high reliability, efficiency, safety, and cleanliness.

Photos of the Central Utility Plant (CUP)

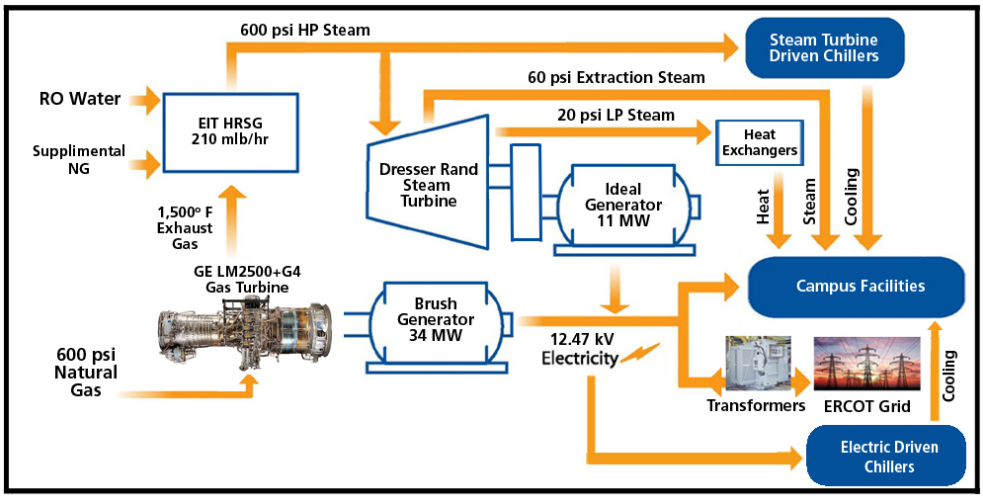
Heat Recovery Steam Generator (HRSG) 600 psi, 210 mlb/hr

Gas Turbine Generator 1 (GTG1)
34 MW 45,600 HP

Steam Turbine
Generator 4 (STG4)

Configuration of Production Units

A higher level schematic of the system below shows that the campus is connected in parallel with the local electrical utility grid but the system can be operated as an island. The diagram shows that the chilled water distribution system also provides inlet air cooling needed to provide the campus optimum, high efficiency combustion turbine power year-round.



Central Utility Plant (CUP)
CHP System Schematic

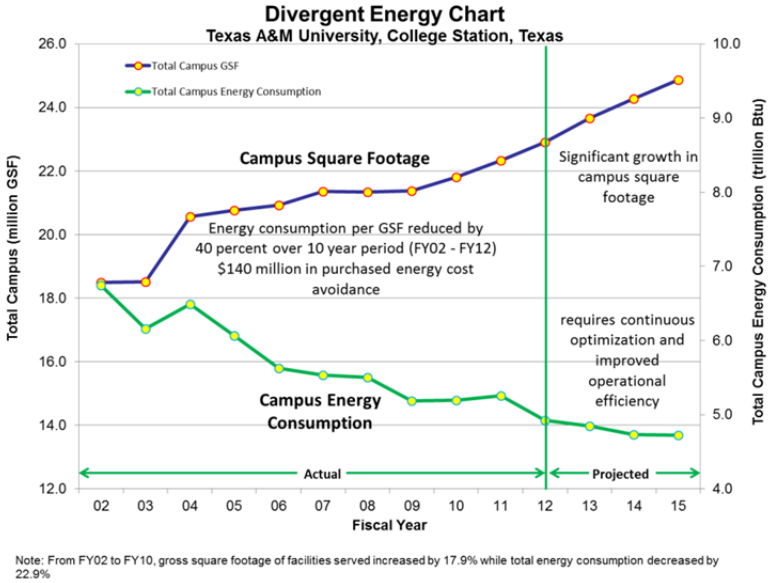
The installed equipment listed in **Appendix i** totals 50 MW of on-site combined heat and power, 450,000 lbs/hr of steam generation and 52,000 tons of chilled water capacity. A high level view of the system configuration can be found in the **Appendix ii**. This screen-capture from the real-time plant optimization system shows the steam system configuration. Additionally, a one-line diagram of the campus electrical system can be found as **Appendix iii**. Future plans include a 2.8 million gallon chilled water thermal energy storage system is planned to come on line by September 2015.

System Energy Efficiency

TAMU is a constantly growing campus in physical size but not in energy consumption. As new buildings are built and existing buildings expanded, the heating and cooling demands overall have decreased. New classroom technology and advanced research labs usually require greater levels of electricity and increased demands on chilled and heating hot water for cooling and heating, but not at TAMU. UES has met this increased demand with innovations and initiatives that have increased efficiency and decreased the overall campus energy consumption through a focus on production efficiencies and demand side reductions. When efficiency is measured only by the conversion of fossil fuels (or other sources) to electricity and chilled / heating hot water, it disregards overall campus efficiency which includes demand side consumption. At TAMU, both sides of the equation are managed.

Reduced energy consumption

From 2002 through 2012, the campus grew by over 4.5 million GSF, or 24%, but due to the high efficiency and versatility provided by the campus's district energy system, and advances in the efficiency and operations in utilities generation, overall energy consumption has decreased from 6.7 million to 4.9 million mmBtus in spite of increasing campus demands. The figure below illustrates the past 10 years of campus energy consumption, demonstrating the years increasing campus size and decreasing energy consumption. In FY12 the new CHP system was put into operation and this alone resulted in a 7 percent reduction in total university energy consumption (5.3 to 4.9 million mmBtu), a 9 percent reduction in energy consumption per square foot (235 to 214 mBtu / GSF) and over $6 million cost avoidance even though the campus grew by .5 million GSF. This is a chart that few can replicate!

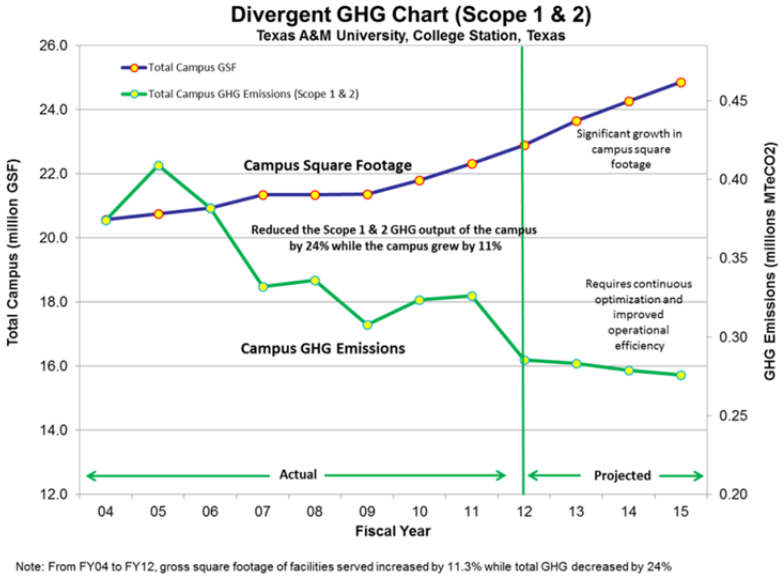


Note: From FY02 to FY10, gross square footage of facilities served increased by 17.9% while total energy consumption decreased by 22.9%

Campus Growth and Energy Consumption

Reduced GHG emissions

All utilities on campus are either self-generated from natural gas or purchased from the ERCOT grid which is comprised of a combination of natural gas, coal, nuclear, wind and solar generated power. With over 70% of the campus requirements being met by relatively clean burning natural gas, carbon emissions are still a large concern. However, due to the high efficiency and versatility provided by the campus's district energy system and advances in the efficiency and operations in utilities generation and consumption, GHG (scope 1 & 2) emissions have been reduced while the campus grew. Overall GHG (scope 1 & 2) emissions have decreased in spite of the constantly increasing campus demands. In the figure below, it can be seen that from the period from FY04 through FY12, the GHG (scope 1 & 2) emissions were reduced by 24% while the campus grew by 11%. The largest single year decrease was from FY11 to FY12 when the new CHP system began operation and GHG (scope 1 & 2) emissions were reduced by 12%. It is estimated that over the 30 year life of the system, CHP will help avoid emitting over 1.2 million MTeCO2.



Campus Growth and GHG Emissions

Note: From FY04 to FY12, gross square footage of facilities served increased by 11.3% while total GHG decreased by 24%

Other Environmental Benefits

In 2011 the Electric Reliability Council of Texas (ERCOT) estimated that almost 25% of the power production resources for ERCOT (State of Texas) were coal fired. The EPA points out that:

"The average emissions rates in the United States from natural gas-fired generation are: 1,135 lbs/MWh of carbon dioxide, 0.1 lbs/MWh of sulfur dioxide, and 1.7 lbs/MWh of nitrogen oxides.[1] Compared to the average air emissions from coal-fired generation, natural gas produces half as much carbon dioxide, less than a third as much nitrogen oxides, and one percent as much sulfur oxides at the power plant.[2] In addition, the process of extraction, treatment, and transport of the natural gas to the power plant generates additional emissions"

Source: http://www.epa.gov/cleanenergy/energy-and-you/affect/natural-gas.html

By installing the clean burning and highly efficient CHP system, TAMU is helping to ensure that the energy required to support the teaching and research mission of the University minimizes its impact on the environment.

Innovation

TAMU is a leader in managing not only procurement and production efficiencies but takes the concept one step further by ensuring that demand side efficiencies are managed as well. As the manager of the BAS, UES responds to all HVAC and environmental work requests and ensures that systems are optimized for occupant comfort and scheduled to shut down or set back during unoccupied periods. In addition, UES has a team of seven full-time Energy Stewards that meet with customers and understand their requirements to effectively schedule buildings. This focus on meeting customer requirements has allowed UES to develop the relationships and earn the trust of the campus customers allowing further reductions to be made.

Starting in 2007, all new proposed building projects and major renovations on campus must qualify for a minimum LEED Silver Certification. LEED (Leadership in Energy and Environmental Design) building certification requires adhering to stringent specifications that ensure a sustainable approach to construction and ongoing building operations, with heavy emphasis on energy efficiency. Additional guidance applies to the district energy system supporting the buildings, and the UES Department has four LEED Accredited Professionals on staff to assist in this process.

Impact on Community

From the start of the CHP initiative, UES did not simply assume that a natural gas fired turbine would be the best solution. A review was performed called the Energy Procurement / Generation Evaluation or EPGE which considered all options from solar, thermal, coal, natural gas, etc. From a financial perspective, the final report concluded that natural gas made the most sense, but we weren't sure how the campus community would respond so we shared the report with the major campus stakeholders though a series of town hall style meetings to solicit their opinions and get their buy-in. In the end, all agreed that a natural gas fired CHP system was best for our campus from an environmental perspective as well as a financial one. UES continues to reach out the campus constituency and its customers by making as much data as possible available on its web site but more importantly by meeting with its customers on a regular basis and helping them understand their utility invoices and consumption patterns. Unlike a for-profit utility, our objective of reducing our customer's consumption and cost is mutually aligned with theirs.

UES welcomes and engages in constant communications with the campus community. Educational tours for campus environmental groups are frequently arranged; data and support is provided to interested students and professors performing efficiency and environmental analysis; and student journalists from The Battalion, the campus newspaper, often run stories detailing the operations and innovations occurring within the utilities department. Regular meetings are also scheduled with key clients to describe the fuel procurement process, procurement strategies, and fuel budget status.

Customer satisfaction

Our UES Department offers facility tours and interactive learning opportunities to students, faculty, and visitors on a regular basis. The university CHP and district energy system is a not-for-profit operation that serves the entire campus. The end clients are the students, faculty, and staff who study, research, and work on campus. The uninterrupted availability of utilities leaves many customers

unaware of the district energy system around them. Customer satisfaction is most greatly expressed as a lack of dissatisfaction, as utilities can always be relied on for the critical research and education occurring on campus. As the first responder to building HVAC issues, UES ensures that occupant comfort and research requirements are being while doing so in the most efficient manner possible. As a service center, all cost to operate and upgrade the utility operation are passed on to the customer but because of the CHP project, plant upgrades and demand side efficiency improvements, the University continues to benefit from lower than peer utility costs.

Additional recognition

The Executive Director James (Jim) G. Riley and employees of the UES participate in many professional organizations such as the International District Energy Association (IDEA), The Association of Physical Plant Administrators (APPA), and the Texas Association of Physical Plant Administrators.

Below is a summary listing all awards and recognition the department has received since 2006.

2006	Energy Management Award	TAMU - UES	State Energy Conservation Office
2007	Corporate Energy Mgmt	TAMU - UES	Association of Energy Engineers
2007	Energy Management Award	TAMU - UES	World Energy Engineering Congress
2007	Mega Energy Saver	TAMU - UES	Energy Systems Laboratory
2010	CHP $10M Funding Grant	TAMU	U. S. Department of Energy - National Energy Tech Lab
2011	CHP Project of the Year	TAMU - UES	Texas Combined Heat & Power Initiative
2013	Energy Star CHP Award	TAMU - UES	U.S. Environmental Protection Agency