ESL-TR-99/12-02

Report of Energy Efficiency Study and Metering/Utilities Profile for Electricity Deregulation at Tarleton State University (TSU) Stephenville, Texas

Submitted to

Tarleton State University
The Texas A&M University System

Submitted by

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December, 1999

Acknowledgement

The Electric Utility Regulation and Energy Efficiency Study for all universities in the TAMU System was initiated in May 1999 and is funded through an interagency agreement between the Chancellor's office and TEES's Energy Systems Laboratory. Detailed site visits were made to all system universities throughout the summer and fall. The Energy System Laboratory wants to thank all physical plant directors and their staff for their cooperation and support during the site visits.

Executive Summary

The director of Energy Management & Controls and staff at Tarleton State University (TSU) do a very good job of maintaining TSU and keeping expenses down. They have metering installed in many buildings and track the campus energy use closely. During our visit, however, we were able to identify several opportunities for energy efficiency.

Energy Savings Potential for the Campus

1. For the whole campus: about $80,000/yr, which is 7% to 8% of the utility bill.
2. For top commissioning targets: about $50,000/yr, or 20% of the energy costs savings if the special recommendations plus selected energy measures can be implemented.

Special Recommendations

1. Change the cleaning staff working schedule from the current schedule to the proposed schedule: 4:00am to noon. If this schedule can be implemented, several of the HVAC systems on this campus can be shut down from 11:00 pm to 3:30 am.
2. Change the air filters for the AHUs on a regular schedule. Dirty filters restrict air flow causing unnecessary pressure losses (increased fan horsepower) and can also contribute to poor indoor air quality.

Commissioning Targets Ranked by Potential Energy Savings

1. Student Development Center and SDC central plant
2. Gym and Human Science
3. Library
4. Fine Arts
5. Humanities
6. Business Building
7. Education Building
8. Administration Building

Metering Recommendations for Electric Deregulation

TSU is currently monitoring campus electrical consumption thorough their Johnson Controls EMCS. Several options exist – use EMCS, share signal with EMCS, or split the signal from the main meter. If the energy efficiency study is pursued, then hourly gas data will be necessary. Our recommendation is to install the ESL metering system and meter both the total gas and total electrical consumption for the campus. Fifteen minute electrical data are needed for any electrical deregulation program.

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Energy Efficiency Study

General Introduction

The Tarleton State University campus is located in Stephenville, Texas. The weather is typical for north Texas, hot in the summer and mild in the winter.

There are a total of approximately 1,284,295 square feet of building area on the campus.

The electricity and gas costs for FY99 were about $953,450 and $163,150 respectively. This translates to about $0.87/yr/ft^2 for all of the buildings on the campus.

Currently, the campus does not have a central chiller plant. Most of buildings have their own individual chiller or chillers located in the building and provide chilled water (ChW) to that building and, in a few instances, supply ChW to a few neighboring buildings as well. Three ten MMBtu/hr boilers are located in the central heating plant.

The HVAC systems in three buildings are fully controlled by a Johnson Controls Metasys direct digital control (DDC) system. Those buildings are the Student Development Center, Tarleton Center, and the Administration Building. Pneumatic controllers control the HVAC systems in other buildings. However, the on/off control for most of the buildings is connected to the Johnson Controls Metasys DDC system. As building HVAC systems are replaced or when their budget allows, the controls are also being upgraded to full DDC.

From July 26 to July 28, 1999, engineers with the Energy Systems Laboratory conducted a commissioning survey for the campus. A total of 22 major buildings, 1 central heating plant and about 20 individual building chiller and/or boiler stations were visited during the trip. The major buildings were surveyed in detail and measurements were also performed on most of air-handlers and pumps.

According to the information from the DDC control system and from the plant operator, the boilers are shut down from mid-May to mid-October. No heating consumption was found except at the Dining Hall. Equipment typically runs 24 hours during the weekday, is shut down on Saturday, and partial shut down on Sunday because of the cleaning staff schedules. This survey found that most campus air conditioning equipment supplies very little outside air to the buildings.

Based on our survey results, the general mechanical systems seem to be well maintained. However, extremely dirty filters were a common problem on many air handling units (AHUs). Several energy saving measures were identified and the following is a summary of the results of the commissioning survey.

The layout of Tarleton University Campus is shown in Figure 1.

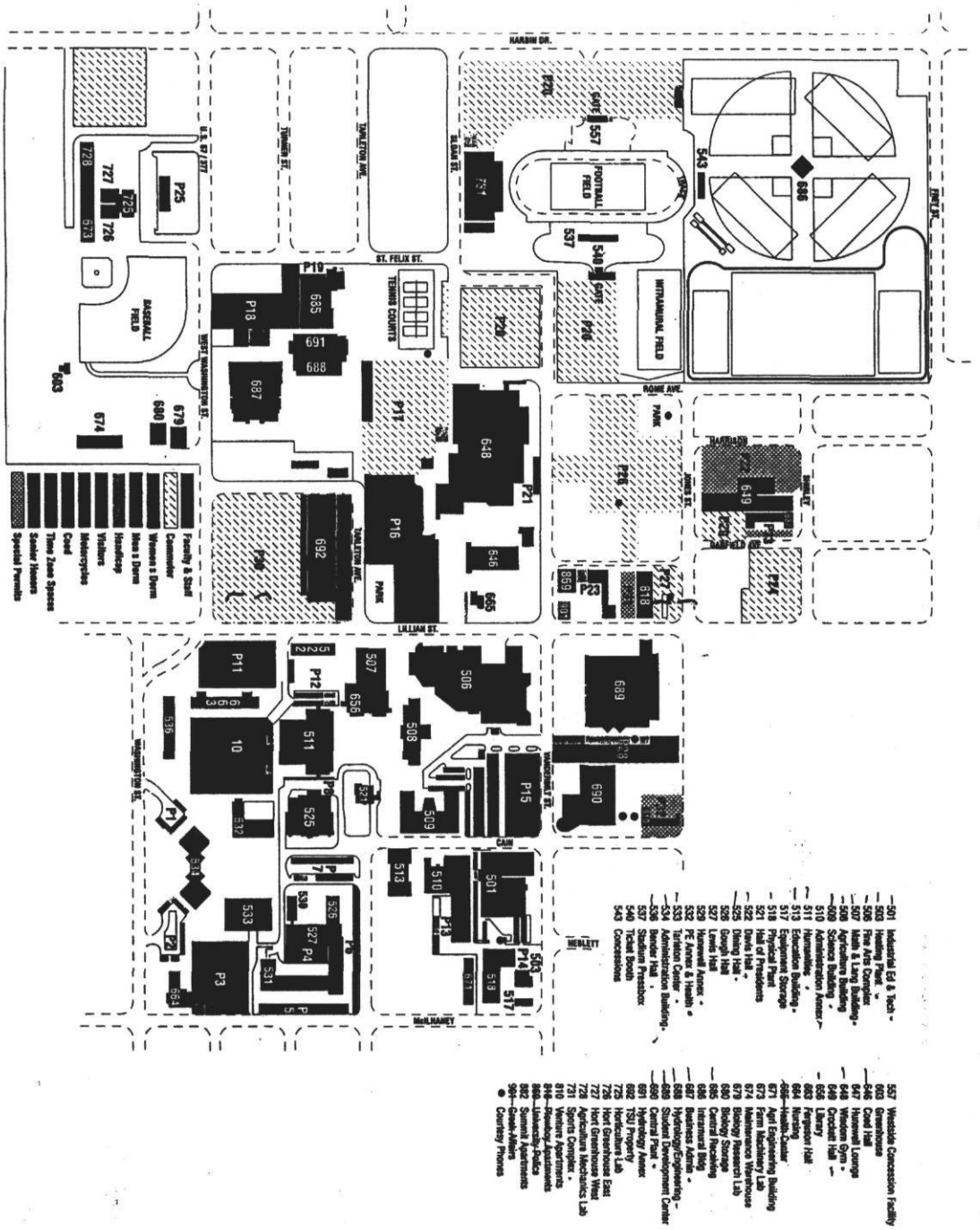

Figure 1. Tarleton State University Campus.

Energy Savings Potential for the Campus, Special Recommendations, and Potential Commissioning List

Energy Savings Potential for the Campus

1. For the whole campus: about $80,000/yr, which is 7% to 8% of the utility bill.
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Special Recommendations

1. Change the cleaning staff working schedule from the current schedule to the proposed schedule: 4:00am to noon. If this schedule can be implemented, several of the HVAC systems on this campus can be shut down from 11:00 pm to 3:30 am.
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Commissioning Targets Ranked by Potential Energy Savings

1. Student Development Center and SDC central plant
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Summary of Building Information and Major Recommended Energy Measures

Student Development Center (offices, ballrooms, book store, game room, meeting rooms, kitchen and food service, post office, lobby, work rooms and newspaper room)

Building Information
It is a 3-story building with an area of 103,750 ft^2. All building HVAC systems are controlled by the Johnson Controls DDC system.

The building receives chilled water from its own chiller located in the central plant building and receives steam to generate hot water from the central heating plant. The hot water pump was off. The manual blending valve was 60% open for the HW pump. There was a bypass valve for the HW pump.

Two 200 ton chillers provide the ChW to the SDC building and the central plant building. Two primary loop pumps circulated ChW across the chiller and to the two buildings. The manual valves in the plant were 50% open. Only one chiller and one primary pump were online at the time of the ESL visit. The supply ChW temperature setpoint was 44°F. The return and supply

temperatures were 50°F and 44°F, respectively. This resulted in an actual temperature difference of only 6°F. One ChW pump located in the SDC building was operating with a variable frequency drive (VFD) setting of 25 Hz and the blending valve was 100% open.

A total of eight double duct VAV (DDVAV) AHUs and three single duct constant volume (SDCV) AHUs serve the building. For the DDVAV AHUs, the static pressure setpoint is maintained by modulating the VFD speed. The static pressure setpoints were from 1.0" to 1.5" for different AHUs. The cold deck setpoint was 55°F for AHUs. The measured cold deck temperature was from 50.3°F to 53.8°F for 4 DDVAVs and about 54°F for the other 4 DDVAVs. The hot deck setpoints were a fixed value (no reset schedule) at 75°F for the DDVAVs. The VFD speed range for different AHUs varied from 51% to 65%. AHU 2-2 which serves the ballroom was turned on or off based on the room schedule. For the SDCV AHUs, the discharge air temperature was controlled by the zone temperature setpoint. Some of manual valves for ChW line were partially open.

Recommended Energy Measures

1. Optimize the chilled water loop and pumping system operation
2. Optimize the hot water pumping system operation and reset the differential pressure schedule.
3. Reset the cold deck, hot deck temperature and static pressure schedules.
4 . If the cleaning schedule is changed, reduce the system operating hours.

Wisdom Gym and Human Science (gym, classrooms, offices and swimming pool)

Building Information

It is a 3-story building with an area of 111,826 ft^2. HVAC systems for this building are pneumatically controlled with on/off control by the JCI DDC system. A total of 15 AHUs serve the building.

Two multi-zone units (No.6 & 7) serve the hallway, offices, classrooms, and locker rooms. The AHUs receive ChW from two air cooled chillers that serve this building. The cold deck temperature was 50°F and 60°F for AHUs 6 and 7. There was no automatic control valve for the ChW line. The air filters for the AHUs were very dirty. The room temperatures were 69°F to 70°F.

Four single duct constant volume (SDCV) AHUs serve the large Gym area. They receive ChW from the same chillers as above. The Gym was unoccupied with a space temperature of 68°F. The room thermostat controls the coils.

AHUs 1, 2 & 3 serve a small Gym and locker room. There are two ducts for the air passing through, one for the cooling coil, the other is a bypass. The mixing box is a fan-powered electric reheat type. The space thermostat controls the coil, bypass and reheat. The AHUs are DX cooling types. The room temperature was found to be about 67°F.

Six rooftop units with VAV electric reheat terminal boxes serve the Human Science classroom and office area. Simultaneous heating and cooling was observed with these systems.

For the swimming pool area, there is an exhaust system and a gas heater for the 100% outside air operation. At the time of the visit, the systems were off-line.

Recommended Energy Measures

1. Increase the room temperature setpoint for the Gym area.
2. Install a VFD for AHU1.
3. Balance the zone for AHUs 6 & 7.
4. If the cleaning schedule is changed, reduce the system operating hours.
5. Optimize discharge air temperature for the 6 roof top units.

Smith Library (library, book stacks, offices)

Building Information

It is a 3-story building with an area of 65,870 ft^2. The HVAC systems are controlled by Honeywell pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from a chiller located in the building and receives steam, which is used to generate heating hot water, from the central heating plant. The hot water pump was off.

Chiller No.1 provides ChW to the building in a simple pipe loop. Chillers No.2 and 3 are connected to a separate loop. On the two chiller loops, two primary loop pumps circulate ChW across the chiller and to the secondary building pumps. The manual valves in the plant were found to be partially open. Two building pumps supply ChW to different AHUs in the building. There was a blending station with no manual shutoff valve. The manual valves for the two building pumps were only partially open.

Two multi-zone and five SDCV AHUs with terminal box reheat serve the building. The cold deck temperatures were measured at 46°F for the multi-zone units.

For the SDCV units, the discharge air temperature was controlled by the pneumatic controller temperature setpoint. The measured temperatures ranged from 44.8°F to 52.6°F for the four SDCV units. The room thermostat controls the terminal reheat. The room temperatures were measured at 66°F to 68.2°F for A-1, A-2 and A-3 units.

Recommended Energy Measures

1. Optimize the discharge air temperature setpoint for all SDCV units.
2. Calibrate the controller for A-2 and the two multi-zone units.
3. If the cleaning schedule is changed, reduce the system operating hours.
4. Optimize the chilled water loop operation.

Fine-Arts Building (offices, classrooms, practicing rooms, printing rooms and one auditorium)

Building Information

It is a 2-story building with an area of 85,604 ft^2. The HVAC systems are controlled by

Robertshaw pneumatic controllers with on/off control by the JCI DDC system.

The building receives chilled water from a chiller located in the building and receives steam to generate hot water from the central heating plant. The hot water pump was off.

Two air-cooled chillers provide ChW to the building. Two primary loop pumps circulate ChW across the chiller and to the building pumps. The manual valves in the plant were partially open. Five building pumps supply ChW to the different AHUs in the building. There was one blending valve.

Six multi-zone and ten SDCV AHUs serve the building. The cold deck temperatures ranged from 51.6°F to 59.8°F. One control linkage was disconnected for AHU 12. The control system does not work properly according to the operator. There was no insulation for the condenser piping. This building is a very large energy consumer based on the electric bill.

Recommended Energy Measures

1. If the cleaning schedule is changed, reduce the operating hours for the system.
2. Balance the multi-zone units.
3. Optimize the cold deck temperature for AHU 13.
4. Install insulation for the air-cooled condenser piping.
5. Reattach the actuator for the zone damper, (had been disconnected).
6. Upgrade pneumatic controllers to the Johnson Metasys control system.

Humanities Building (offices and classrooms)

Building Information

It is a 3-story building with an area of 61,503 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from two air-cooled chillers located in the building and receives steam to generate hot water from the central heating plant. Two 7.5 hp ChW pumps were on. One HW pump was off.

Six multi-zone AHUs serve the building. The cold deck temperatures ranged from 50°F to 60°F for different AHUs. The room temperatures were 69°F to 70°F for most areas. There are no automatic control valves for the ChW line of the AHUs. Four FCUS serve the lecture room with motion sensors for lighting control in the lecture rooms. All of the hot decks were off.
The mainframe computers are located in this building. Four Liebert units serve the main-frame computer room.

Recommended Energy Measures

1. Install 2-way automatic control valves on the ChW supply piping for all of the AHUs.
2. Optimize the cold deck temperatures all year round.
3. Balance the supply air for all zones.
4. Conduct a detailed review of requirements of the air supply for the computers in the "mainframe" room. Reduce air flow/capacity as allowed.

5. If the cleaning schedule is changed, reduce the system operating hours.

Business Administration Building (offices and classrooms)

Building Information
It is a 2-story building with an area of 47,442 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from chillers located in the Hydrology Engineering Building and receives also hot water from that building.

Four SDVAV AHUs with terminal box reheat serve the building. The VFD speeds ranged varying from 34Hz to 60Hz. The static pressure setpoint was 1.0" for AHU-1, 2 and 4. The cold deck temperatures ranged from 49°F to 52.6°F for the 3 SDVAVs. The room temperatures were 68°F for AHU-2 and 4. The automatic control valve for the cooling coil of AHU-1 was hunting.

Recommended Energy Measures
1. Tune the PI valve controller to eliminate hunting for the ChW valve on AHU-1.
2. If the cleaning schedule is changed, reduce the system operating hours.
3. Optimize the discharge air temperature setpoint.
4. Optimize the static pressure setpoint.

Education Building (offices and classrooms)

Building Information
It is a 4-story building with an area of 29,299 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from an air-cooled chiller located at the building. One of two ChW pumps was on. The building receives steam to generate hot water from the central heating plant. The hot water pump was off.

Four SDVAV AHUs with terminal box reheat serve the building. The static pressure setpoints were 1.0" to 1.2" for the AHUs. The cold deck temperatures ranged from 49°F to 57°F for the AHUs. Inlet vanes are used to modulate and maintain the static pressure setpoint. The ChW supply temperature setpoint from the chiller was 37°F.

Recommended Energy Measures
1. Optimize the ChW supply temperature setpoint for the chiller.
2. If the cleaning schedule is changed, reduce the system operating hours.
3. Optimize the cold air temperature for the units.
4. Optimize the static pressure setpoint.

Administration Building (offices)

Building Information
It is a 2-story building with an area of 30,689 ft^2. The HVAC systems are controlled by the JCI DDC system.

The building receives chilled water from a co-located air-cooled chiller. One of two ChW pumps was operating. The building receives steam to generate hot water from the central heating plant. The hot water pump was off.

Four SDVAV AHUs with terminal box reheat serve the building. The static pressure setpoint was 1.0" for the AHUs. The cold deck temperatures ranged from 47°F to 51°F for the AHUs. The VFD speeds ranged from 49 Hz to 60 Hz. The filters were very dirty for all AHUs. Thirteen small AHUs circulate return air around the exterior fenestration area.

Recommended Energy Measures

1. Reset discharge air temperature setpoint with a schedule.
2. If the cleaning schedule is changed, reduce the system operating hours.
3. Reset the static pressure setpoint.
4. Replace the air filters on a regular schedule.

Agriculture Building (offices, lecture rooms)

Building Information
It is a 3-story building with an area of 32,524 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control by the JCI DDC system.

The building receives chilled water from a chiller located in the building and receives steam which is used to generate heating hot water from the central plant. The hot water pump was off.

Two 30 ton air cooled package chillers provide the ChW to the building.

One AHU serves the lecture room. The on/off control is based on a time schedule. It was in the off mode during the visit. All other rooms are served by fan coil units (FCUs) with no outside air intake.

Recommended Energy Measures

1. If the cleaning schedule is changed, reduce the system operating hours.

Hydrology Engineering Building (offices and classrooms)

Building Information
It is a 2-story building with an area of 27,803 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from chillers located in the building and receives hot water

from boilers in the building as well. The two hot water pumps were off. Two chillers provide ChW to the Hydrology and Business buildings. Two loop pumps circulate ChW across the chiller and to the buildings. The manual valves in the plant were partially open. There was one blending valve. The two chillers share a common header. The two 0.84 MMBtu/hr boilers were off-line during the visit.

One SDVAV AHU with terminal box reheat serves the building. The VFD was "hunting" with a 10 second period and amplitude of 45Hz to 52Hz. The cold deck temperature ranged from 48°F to 52°F. The room temperature was 67°F. There was no insulation on the condenser piping.

Recommended Energy Measures

1. If the cleaning schedule is changed, reduce the system operating hours.
2. Tune the PI controller for the VFD.
3. Optimize the discharge air temperature all year round.
4. Insulate the condenser piping.

Central Receiving Building (offices and warehouse)

Building Information

It is a 2-story building with an area of 16,021 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

Two multi-zone AHUs serve the office area. The warehouse is served by a ventilation exhaust fan only.

Recommended Energy Measures

1. If the cleaning schedule is changed, reduce the system operating hours.

Science Building (laboratories, offices)

Building Information

It is a 3-story building with an area of 48,429 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from chillers located in the building and receives steam from the central heating plant. There was no steam during the visit.

Six multi-zone AHUs serve the building. The cold deck temperatures were found to vary from 44.6°F to 53°F. This was because there are no control valves on the ChW line.

Recommended Energy Measures

1. Install automatic 2-way control valves for the cooling coils of all AHUs.
2. Optimize the cold deck temperature all year round by manual valves before installation of control valve.
3. Balance the zones served by each AHU.
4. If the cleaning schedule is changed, reduce the system operating hours.

Dining Hall (kitchen, food service and dining table area)

Building Information
It is a 1-story building with an area of 23,730 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

There is an evaporative cooling system for this building. One steam boiler is used for the building also.

Two SDCV cooling only units serve the dining area. The steam radiators receive steam from the central heating plant to heat the room during winter. The inspection found that the dining area has a very high volumetric air flow rate.

Recommended Energy Measures

1. Change the pulley sheave on the AHU to reduce air flow to the dining area.
2. If the cleaning schedule is changed, reduce the system operating hours.
3. Balance the air distribution to the dining area.

Davis Hall (offices)

Building Information
It is a 4-story building with an area of 18,058 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from a 50 ton air-cooled chiller. Two ChW pumps were on. The building receives steam to generate hot water from the central heating plant. Two hot water pumps were off.

Twenty two FCUs serve the building.

Covet Dorm-Modular Dorm (residence rooms)

Building Information
It is a 4-story building with an area of 53,794 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives chilled water from a co-located air-cooled chiller. Two ChW pumps were operating. The building receives steam to generate hot water from the central heating plant. Two hot water pumps were off.

Two SDCV units serve the hallways and public areas. FCUs are used to serve the dorm rooms and these units have no provision for outdoor air intake.

Industrial Technology (offices and machine rooms)

Building Information
It is a 1-story building with the area of 31,021 ft^2. The HVAC systems are controlled by pneumatic controllers with on/off control through the JCI DDC system.

The building receives steam to generate hot water from the central heating plant. The hot water pump was off.

One multi-zone AHU serves the building. The cold deck temperature was 57°F.

Recommended Energy Measures

1. If the cleaning schedule is changed, reduce the system operating hours.
2. Balance the air supply for all zones.

Tarleton Center (offices and classrooms)

Building Information
It is a 3-story building with an area of 51,029 ft^2. The HVAC systems are controlled by the JCI DDC system.

The building receives chilled water from three natural gas driven absorption chillers. It receives steam to generate hot water from the central heating plant. The hot water pump was off. Two chillers were on-line during the visit.

A total of eight AHUs serve the building. They are a combination of multi-zone and SDCV units. There are no automatic control valves for the ChW line of the AHUs.

Recommended Energy Measures

1. Install ChW automatic 2-way control valve for each of the AHUs.
2. If the cleaning schedule is changed, reduce the system operating hours.
3. Reset discharge air temperature setpoints after the ChW control valves have been installed.

Hunewell Annex (dorm rooms)

Building Information
It is a 3-story building with an area of 35,722 ft^2. The HVAC systems are controlled by pneumatic controllers.

The building receives chilled water from a co-located air-cooled chiller. The building receives steam to generate hot water from the central heating plant. The hot water pump was off.

Bender Hall, Ferguson Hall and Math Building

Only a short inspection was performed at these buildings. No detailed information is available for these three buildings.

Electricity Deregulation Metering Options

Whole Campus Metering

The Tarleton campus main utility feed is located on the west side of campus near the Fine Arts building. The main gas feed is also located at the south side of the Fine Arts building. Domestic water is fed through several locations around the campus. The Tarleton energy manager has implemented an aggressive metering program so almost all buildings have individual electric, gas, and water meters. Each of the existing meters is read on a monthly basis and totalized for comparison with the utility bills.

The primary electric meter for the Tarleton campus is connected to the Johnson Controls Metasys DDC system. A digital conversion would be required for the primary gas meter located next to the Fine-Arts building ($1,000 - $3,000). Data could be collected by the Johnson system or the ESL could install dataloggers($10,000).

Metering Options

Since the main campus electric meter is already connected to the DDC system, the ESL could set up logging through the Johnson system. Costs associated with this data-logging effort would be minimal. However, ESL's history with DDC systems as energy metering equipment does not suggest success with this method.

If this is not a workable scheme, it is recommended we install one digital data-logger at the Fine Arts building and split the pulse signal from the electric utility meter to the data logger and to the JCI system. The main gas meter would need to be retrofitted with a pulse initiator and the pulse signal wired via best route back to data logger. Communication with the data logger would be via modem, very similar to other ESL installations. The installed cost for this metering scheme would be approximately $6,500.

Attachment of the Utility Summary

Tarleton State University							
	Electricity				Gnatural Gas		
Month	Energy -kwh	Energy Costs $	Demand-kW	Demand Costs $	Gas-MCF	Gas Costs $	Total costs
Sep-98	2,219,400	98,982.61	4,531		3,407	8,301	107,283
Oct-98	1,880,480	77,526.38	3,872		4,046	11,554	89,080
Nov-98	1,730,160	78,081.74	3,616		6,122	17,078	95,160
Dec-98	1,301,940	68,587.62	3,616		9,449	26,156	94,744
Jan-99	1,576,800	74,996.93	3,616		8,634	21,083	96,079
Feb-99	1,554,120	74,590.34	3,616		7,606	18,980	93,570
Mar-99	1,655,640	76,978.63	3,616		7,754	17,986	94,964
Apr-99	1,688,600	80,081.68	3,883		4,499	10,828	90,909
May-99	1,587,060	54,009.34	3,812		3,091	8,927	62,936
Jun-99	2,088,720	93,029.01	4,325		2,489	6,366	99,395
Jul-99	2,093,040	91,428.32	4,158		2,577	7,225	98,654
Aug-99	2,128,680	85,158.34	4,725		2,893	8,668	93,826
Totl/max	**21,504,640**	**953,450.94**	**4,725**		**62,567**	**163,150**	**1,116,60**
Demand charge is included in the energy costs.							
If demand is smaller than 3616kW, then the power company charge 3616kW.							
Electricity Provider: TXU: Texas Utility Electric							
Gas Provider: GLO & LST: General Land Office & Lone Star Transmition							