EVALUATION OF SELECTED ENERGY OPTIONS FOR A SUSTAINABLE CAMPUS IN TEXAS

A Thesis

by

KATHRYN ELAINE CLINGENPEEL

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2007

Major Subject: Mechanical Engineering

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Chair of Committee,	David E. Claridge
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ABSTRACT

Evaluation of Selected Energy Options for a Sustainable Campus in Texas.

(December 2007)

Kathryn E. Clingenpeel, B.S., Texas A&M University

Chair of Advisory Committee: Dr. David E. Claridge

This thesis examines ways to reduce energy consumption in university buildings. Occupancy based controls and other advanced building technologies being studied at the Intelligent Workplace (IW) at Carnegie Melon University were examined to see if they could be applied in at Texas A&M International University (TAMIU). Additionally, a sustainability assessment for the current TAMIU campus was performed with an analysis of the potential for TAMIU to obtain LEED certification from the US Green Building Council.

First, occupancy-based controls that would shut off lighting, utilize power management features on computer equipment, and reduce airflow when a space is unoccupied were examined. An estimated annual savings of $525 could be obtained in the test office at Texas A&M by implementing these controls. If same controls were applied to the proposed green building at TAMIU, approximately $203,422 could be saved annually.

Secondly, advanced building technologies used at the IW were examined to see if they are feasible in the new green building at TAMIU. Biodiesel cogeneration was found to be economically infeasible as a main power supply using the loads calculated for the building. A feasibility calculation for a radiant heating and cooling system with

ventilation was performed and it was estimated that using one of these systems could have potential at TAMIU if the building envelope is designed correctly. Displacement ventilation could be implemented for research purposes in the test bed, but should not be implemented on a broader basis until more is known about the performance of these systems in hot and humid climates. Daylighting should be used in the new building whenever its implementation will not significantly increase solar loads.

Thirdly, a sustainability assessment of the current TAMIU campus was performed. Several good practices and areas for improvement were identified in nine sustainability-related areas. The current TAMIU campus was examined to see what scope of work would be required to achieve LEED certification from the US Green Building Council. It was found that 39 credits, which is enough to achieve LEED certification, are either achievable as-is, achievable with a policy change, or achievable with a minor retrofit scope.

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INTRODUCTION

Buildings use a tremendous amount of energy. In 1995, the Energy Information Administration found that almost 40% of the energy in the USA is used to heat, cool, light, and ventilate buildings.[1] In recent years increased attention has been given to reducing this energy use, which is seen through the increase in green buildings and building commissioning. By implementing the best technologies, energy efficiency in buildings can be further increased. This project is part of a joint Texas A&M University (TAMU) and Carnegie Melon University (CMU) Department of Energy (DOE)-funded project that seeks to use advanced building technologies to decrease energy use in commercial buildings.

Several advanced technologies have been implemented or are scheduled for implementation at the Intelligent Workplace (IW) at CMU. A micro cogeneration unit is scheduled for use as an energy supply source, and the waste heat, as well as heat from solar receivers, will be used to produce hot and chilled water with an absorption chiller that is currently operational. Daylighting, radiant heating and cooling, and an innovative desiccant ventilation system are also used.

One goal of the project is to implement some of the advanced building technologies in a Texas A&M facility or building. All Texas A&M System campuses were considered. Texas A&M International University (TAMIU), located in Laredo, Texas, was an ideal candidate based on its size, age, and expansion plans. TAMIU

This thesis follows the style of *ASHRAE Journal* leaders were extremely excited about the project and are willing to consider an advanced technology test bed as part of the upcoming Student Success Center (SSC). TAMIU leaders also expressed interest in implementing a sustainable campus initiative that will make them a green campus leader for the city of Laredo, the state of Texas, and university campuses throughout the nation. Personnel with the Energy Systems Laboratory (ESL) at Texas A&M University performed a Sustainability Assessment for the TAMIU campus and continue to assist TAMIU with its goal to become a green campus leader.

One objective of this project was to perform a coarse examination of the advanced building technologies being studied at CMU and determine which technologies may be desirable for TAMIU. Laredo should be a great location to consider and/or test these technologies since the hot climate is quite different from that of the CMU Intelligent Workplace in Pittsburgh, Pennsylvania. Technologies that were examined include biodiesel cogeneration, use of an absorption chiller, displacement ventilation, minimizing computer and office equipment power, daylighting, and HVAC (heating, ventilation, and air conditioning), lighting, and equipment occupancy-based control.

Occupancy-based control was examined in an office setting at TAMU in the areas of HVAC, lighting, and computer equipment control. Whenever the office occupant left the room, the lights were shut off, the computer went into standby mode, and a damper closed in the supply air duct, effectively shutting down HVAC energy usage while the occupant was away. Analysis was conducted to see how much energy could be saved if this strategy were applied to a whole building, such as the Student Success Center at TAMIU.

1.1 Objectives

The objectives of this thesis were to 1) analyze the savings from occupancy-based control in an office 2) conduct a preliminary feasibility study of advanced building technologies to be considered for implementation in the Student Success Center at TAMIU, and 3) conduct a sustainability assessment of TAMIU and identify the work scope required to achieve LEED-EB certification for the existing TAMIU campus.

1.2 Literature Review

1.2.1 Occupancy-Based Controls to Reduce Office Energy Usage

Much energy is wasted by means of computers, lighting and HVAC use in unoccupied offices. This project examined how much energy could be saved by using occupancy-based controls. Occupancy patterns are very difficult to predict because they are typically random.[2] Much depends on the type of space and the usage of the space. Wang did a study of 35 single person offices over 171 days and found the average occupied hours to be 6.17 hours per day.[3] During the first two weeks of December 2006, the office occupant in the office studied at TAMU was in the office an average of 7 hours a day during the week.

Lighting consumes 25-30% of all energy in commercial buildings, accounts for 17% of all electricity sold in the United States, and is a major source of heat gain that must be removed by air conditioning systems.[4] Several office users do not turn off their lights when they leave for meetings during the day. The Texas A&M Energy Systems lab was asked to look into high lighting and plug loads in an office building at a national laboratory. At 10:00 AM and at 3:00 PM a walk-around was conducted on one floor of the building to see how many people were present in each office to determine how many offices are unoccupied at an average time during a business day. At both times, over half of the offices were unoccupied (31/60 at 10:00 and 33/60 at 3:00). At 10:00, the overhead lights were on in 11 unoccupied offices and desk lights were on in 3 unoccupied offices.

Occupancy sensors are becoming more common in offices to decrease lighting energy consumption. There have been several different studies on lighting energy usage that can be saved by using an occupancy sensor, and the results vary tremendously.[2] Lighting savings "depend greatly on occupant habits, custodial practices and the baseline of the building".[5] Chung evaluated the savings that would result from using an occupancy sensor in a Hong Kong office building.[2] The study showed that using occupancy sensors with a 10 minute delay time would result in a 29.6% savings over a base case where all lights are on between 7:00 am and 7:00 pm and 10.4% savings over the actual lighting use of the building before installation of occupancy sensors.[2] Jennings found that use of occupancy sensors in an open office area saved an average of 10% lighting energy savings.[5]

Computers consume a tremendous amount of electricity. Kawamoto found that 74 TWh per year were consumed in the US by computer and network equipment at the end of 1999, with more than 70% of that use in commercial buildings.[6] The same study found that power management saved over 23 TWh per year in the US, but could save an additional 17 TWh per year. Nighttime shutdown of equipment not required to run at night could save an additional 7 TWh per year.[6] In a subsequent study, Kawamoto found that, due to annoyance with delays in power management, several users increase the delay time in their power management settings, which decreases the energy savings. Kawamoto concluded that, “Technological innovation to shorten the inconvenience of power management is necessary to achieve more energy savings by power management”.[7] Many computer users are still not utilizing the power management features on their systems. In the same national laboratory office building, ESL personnel conducted a nighttime walkthrough and found that on two floors 65% of the computers and 25% of the monitors were running at night. While several people did have a power management feature running on their monitors, it is estimated that 22.3 kW of computer energy are being wasted in this building during nighttime hours. Perhaps research studies such as this will encourage more people to utilize the power management features on their systems.

1.2.2 Additional Advanced Building Technologies

Intelligent Workplace at Carnegie Mellon

The Intelligent Workplace (IW) is the primary test site for the DOE Advanced Technology test bed. The Intelligent Workplace Energy Supply System (IWESS) is the energy system that provides power, cooling, heating, ventilation, and hot water for the occupants of the south section of the IW. At the time of writing, it is not yet complete. The goals for this system are to get the highest level of comfort, health, security, and productivity of the IW occupants and to have a reliable, efficient, and economic provision of energy. This energy system will receive natural gas and solar heat as the energy sources and generate power at 60 Hz and 110V. The system will recover and utilize reject heat. Chilled and hot water are produced for space heating and cooling, and outside air is conditioned for ventilation.[8]

The main parts of the IWESS will include a 10 kW power generator with a heat recovery steam generator, a 16 kW steam-driven absorption chiller for chilled water production, a 16 kW battery of high temperature solar thermal receivers, radiant heating and cooling systems, and a 2 kW liquid desiccant air dehumidifier. The IWESS will reduce the consumption of energy, reduce the emissions of pollutants and CO_2, and reduce the life cycle costs of building energy supply over a traditional system.[8] Detailed studies of several of these systems are being performed as PhD dissertation studies. Xiangyang Gong of Texas A&M University studied the radiant heating and cooling systems[9], the absorption chiller is being studied by Hongxi Yin of Carnegie Melon[10], and Chaoquin Zhai of CMU is beginning an analysis of the desiccant system.

The IW has an innovative, occupant-based ventilation system. Six workstations each have a variable air volume (VAV) box with two desktop diffusers with adjustable airflow direction. The unit also has an occupancy sensor that reduces air flow to a minimum when the workstation is unoccupied for 15 minutes.[11] The Mahdavi study[11] focused on the effectiveness of this ventilation system but did not find the savings or cost compared to a traditional system.

Building as a Power Plant

The IW is a precursor to an additional project, called Building as a Power Plant (BAPP). "BAPP seeks to integrate advanced energy-efficient building enclosure, HVAC, and lighting technologies with distributed energy generation systems, which can meet energy requirements of the building substantially on site".[12] The building will contain offices, classrooms, labs, and shops.

The building will be powered by a 250 kW solid oxide fuel cell (SOFC), and, like the IW, chilled water will be produced by a steam driven absorption chiller. A heat recovery steam generator (HRSG) will heat hot water for the building heating and the domestic hot water supply. Chilled and hot water will be piped to fan coil units, radiant panels, and finned heat exchangers located in distributed fresh air supply units on each floor.[12] The BAPP will utilize an "ascending strategy" to decrease the cooling energy consumption as much as possible.[13]

Cogeneration

"Cogeneration is broadly defined as the coincident or simultaneous generation of combined heat and power".[14] In cogeneration a significant amount of waste heat from power production is recovered and used in a thermal process. One of the main parts of a cogeneration system is the "prime mover", which is the device that "convert(s) fuel energy into rotating shaft power to drive electrical generators".[15] The main types of prime movers are steam turbines, gas turbines, and reciprocating engines. Internal combustion engines are well suited for use in commercial and light industrial applications of less than 10 MW.[14] For use at TAMIU, cogeneration with a diesel engine is considered. The advantages of using a reciprocating engine for cogeneration are that engines are more efficient than simple cycle gas turbines at part load, they have a wide range of power levels, and rejected heat can be harnessed from both exhaust gas and cooling liquid.[15]

Biodiesel is a clean-burning, alternative fuel manufactured from vegetable oils, animal fats, or recycled restaurant greases. Biodiesel is gaining popularity because it is safe and reduces serious air pollutants. Blends of 20% biodiesel and 80% petroleum diesel, called B20, are able to be used in unmodified diesel engines. Pure biodiesel (B100) may also be used in some diesel engines without modification, but requires special handling and storage.[16] Biodiesel has been successful in electrical generation. In August, 2001 a 6 MW B100-fueled backup power system was installed at the University of California Riverside campus to reduce emissions from standby emergency generators.[17] If TAMIU were to implement a biodiesel cogeneration system for one of their new buildings, it would be a tremendous showcase in their campus sustainability efforts. Additionally, up to three points can be earned for on-site renewable energy if pursuing the U.S. Green Building Council's LEED certification.[18]

Absorption Chiller

When waste heat is available, an absorption chiller may be used. Waste heat from electricity production is transferred to the absorption chiller in the form of steam or hot water to produce chilled water. The advantage of an absorption chiller over typical chillers is that little or no mechanical energy is consumed in an absorption chiller, and little or no electric power is required. This creates more constant electricity loads throughout the year.[15] Absorption chillers are considered particularly advantageous for locations where heating loads are minimal during a good part of the year. In fact Caton says that “In warm climates, absorption chillers are often an important, if not an essential, aspect of technically and economically successful cogeneration systems”.[15] If cogeneration were found to be economically feasible in Laredo, use of an absorption chiller makes sense. There are three main types of absorption chillers: water and ammonia, lithium bromide and water, and lithium chloride and water.[15]

The Yin study focused on the microscale (4.5 refrigeration tons (RT) water-LiBr absorption chiller installed in the IW.[10] Yin created a model to analyze the chiller performance that was refined based on his experimental measurements. The model involves 416 variables and 409 non-linear algebraic equations. It requires specifying values for seven operating parameters: chilled water inlet and outlet temperatures, chilled water flow, cooling water supply temperature and flow, and steam supply pressure and flow.[10]

Radiant Heating and Cooling

The advantages of radiant heating and cooling are low operational noise and no fan power, which typically accounts for more than 30% of the energy consumption cost of a traditional system.[9] The main problems with radiant cooling systems are moisture condensation and proper dehumidification of the air. Radiant cooling must be used in conjunction with an outdoor air handling unit or a solid desiccant ventilation system with a chilled water coil.[9] There are two types of solid desiccants, active and passive. A passive solid desiccant system requires no regeneration energy but has limited drying capacity, while an active solid desiccant has much greater drying power but does require heat input. [9]

While implementing a radiant cooling system in a hot and humid climate is a challenge, Stetiu concluded that "an adequately designed and operated radiant cooling system can function in a state-of-the art office building at any US location with low risk of condensation." [19] However, she does caution that to achieve this in humid climates, humidity should be controlled with continuous ventilation of dehumidified air. The study found that over all locations examined, the average savings potential is 30% of energy consumption and 27% of peak power demand over a traditional system. Dehumidification energy consumption was a large part of the total energy consumption in the hot and humid climates, resulting in less energy savings. [19]

Gong has developed models to study the effectiveness of radiant heating and cooling systems used with a desiccant. His models take into account radiant temperature distributions, heat transfer of surfaces in a radiantly heated enclosure, heat transfer between a heated or chilled mullion and nearby surfaces, mullion surface temperature, dehumidification, infiltration and condensation.[9]

Displacement Ventilation

Displacement ventilation systems have been tremendously successful in Europe, particularly Scandanavia, but have not yet become common in the United States. These systems have been shown to improve indoor air quality, occupant comfort, productivity and health in buildings.[20] With displacement ventilation, moderately cooled air is introduced through diffusers located in the walls or floor. The cool air displaces warmer, stale air toward the ceiling, where it leaves the space.[21] Since these systems have a higher supply air temperature they result in chiller savings and allow for extra free cooling[20]; however, supplemental cooling and heating may be required.[21] In all studies examined by Hamilton, displacement ventilation decreased cooling energy consumption while increasing supply and return fan energy consumption.[21] The first cost of displacement ventilation systems is typically 5%-17% more than for mixing ventilation systems (or \$1-\$5 per m^2), with an additional cost premium (\$20-\$50 per m^2) if supplemental cooling is required .[21] Therefore, the payback time is strongly dependent on climate.

Lau used a detailed computer simulation to compare a floor-supply displacement ventilation system to a mixing ventilation system in an industrial workshop in 5 different U.S. climates.[20] In New Orleans, her hot and humid example, humidity levels reached an incredible 80% at times. Therefore, she does not recommend using displacement ventilation in humid regions.[20] A study by Gupta and Woods has shown that there are significant problems with air leakage in underfloor air distribution systems.[22] It is difficult to control the leakage of these systems and predictions of air leakage are unreliable.[22] This can cause the overall energy consumption to be higher than in conventional installations.

Daylighting

Daylighting, or designing a building to take advantage of natural light, can offer significant energy savings by reducing the lighting load in a building. Not only are lighting energy savings achieved, but cooling energy is saved as well by decreasing internal heat gains. Daylighting has also been found to improve occupant comfort and productivity.[23] It is important to prioritize the spaces that will benefit most from daylight and to use daylighting in conjunction with occupancy sensors and light sensors. Lighting sensors can shut off or dim lights when there is significant daylight to satisfy occupants.[22] The U.S. Green Building Council has included credits for daylight and views in their LEED green building rating system, so including significant daylighting could help TAMIU achieve LEED certification.[18]

1.2.3 Sustainability on University Campuses

A growing trend throughout the nation is that of "green" or sustainable operation. There are many different definitions of sustainability, but one of the most widely accepted definitions is "meeting the needs of the present without compromising the ability of future generations to meet their own needs".[24] Most see minimizing the impact on the environment and conserving natural resources as key aspects of sustainability. Some view it as an ideal, while others see it as an attainable goal.

The U.S. Green Building Council has established the Leadership in Energy and Environmental Design (LEED) green building rating system as a benchmarking tool for sustainable buildings. They have several rating systems including LEED-NC for new construction and LEED-EB for existing buildings.[25] Achieving LEED certification is one of the most noticeable ways to engage in sustainable development.

Sometimes there is hesitancy toward building green because it requires an extra initial investment. Kats conducted what he considers to be "the most comprehensive analysis of the financial costs and benefits of green building conducted to date" and found that an initial investment of about 2% of construction cost typically yields a life cycle savings of over ten times the initial investment.[26] The financial benefits of green buildings considered in this study were "lower energy, waste disposal, and water costs, lower environmental and emissions costs, lower operations and maintenance costs, and savings from increased productivity and health".[26]

Green movements have been started on several campuses including University of California (Cal), University of British Columbia (UBC), University of Colorado (CU), University of California Santa Barbara (UCSB), Harvard University, and Penn State University (PSU). Texas A&M International University (TAMIU) would like to join these universities in becoming a sustainable campus leader. Websites from several universities and organizations, such as the University Leaders for a Sustainable Future and the Association for the Advancement of Sustainability in Higher Education, were examined to note common practices. Information from these sources and the LEED reference guides were used to create the TAMIU sustainability assessment. Some of the practices that stood out from various universities are stated.

Energy

- UBC has reduced energy use in core buildings by 14% through infrastructure upgrades, green building technologies, a sustainability coordinator program, and increased energy-efficient practices by students and staff .[27]
- CU students living on campus have the option to buy wind energy for their dorms.[28]

- CU has a kiosk display and web display of solar energy generated by campus solar panels so that the impact of renewable energy can easily be seen.[28]
- The UC system has adopted policy that requires 20% of energy to be clean and renewable by 2017.[29]

Water

- UCSB has been using reclaimed water for irrigation since 1994, which costs 1/5 that of potable water. Reclaimed water reaches 90% of the campus and has been successful in some toilets as well as in irrigation. They have also installed waterless urinals, and dual flush toilets, as well as low flow faucets, flush valves, and showerheads. Waterless urinals are going to be installed in all new buildings, which could save 45,000 gallons of water per year.[30]
- Cal performed an audit of one building that found that 68% of the toilets and 63% of the urinals have leaks. By scheduling maintenance on toilets to fix current leaks and prevent future leaks, they will save money and water.[29]

Built Environment

- UBC has purchased enough green power to power two of their green buildings. [27]
- At Cal, the 2003 Regents' Green Building Policy and Clean Energy Standard requires all new building and major renovation projects in the UC system to be LEED certified or equivalent. [29]

Transportation

- UBC plans to decrease commuting impact to and from campus by increasing the population living on campus to 18,000 students, faculty and staff by 2021.[28]

- At UBC the Universal Transit Pass or U-Pass increased transit use to such a degree that it is now the most popular mode of travel to and from campus.[27]
- CU has free bicycle rentals for students and no interest loans for purchasing a bicycle to encourage bicycle use.[28]
- CU has website for students interested in carpooling to nearby ski resorts and other attractions as well as busses to the more popular ski resorts.[28]
- The CU bus pass allows students to ride for free on Boulder and Denver busses.[28]
- CU has committed to shifting a majority of its diesel fuel use to biodiesel.[28]
- CU is starting a rental car program for students to make it easier to live on campus without a car.[28]
- Cal University has stations for electric Rav-4s used by Cal staff and for commuting.[29]

Purchasing and Waste

- UBC has Canada's first and only university "in-vessel" composting system, which independently recycled 130 tones of organic waste.[27]
- Cal is developing an Environmentally Preferred Purchasing (EPP) program.[29]
- The Cal Residential and Student Services Program specifically sought out and purchased wood furniture made from non-rainforest, sustainably harvested wood.[29]
- CU has a green products guide for commonly purchased items and has an Environmentally Responsible Purchasing (ERP) program.[31]

Land Use

- UCSB's landscape management promotes native species, emphasizes xeriphytic, or low water use, plants and utilizes herbicides that have limited or no adverse effects on the environment.[30]

Food

- Cal has switched to cooking with oils free of trans-fats.[29]
- Cal has a produce stand where students can use meal credits to purchase produce as an alternative to package vending-machine foods.[29]
- Cal Dining offers beverage discounts for the use of plastic reusable mugs as an alternative to disposable cups. They also offer biodegradable to-go containers that are designed to begin decomposing in one week.[29]
- In January 2006 the first organic dining unit was opened on the CU campus.[31]

Health and Wellbeing

- Cal Custodial Services is experimenting with new “Fill Station” technology, which makes use of concentrated cleaners in sealed containers, greatly reducing handling and therefore leak and exposure potential.[29]
- Ergonomics programs have been implemented at Cal.[29]

Academics and Culture

- UBC developed a sustainability training program for 500 first-year student orientation leaders. These leaders then promoted sustainable behaviors to 4,200 first-year students on Imagine UBC Day.[29]

- CU has a volunteer organization “Earth Education” that provides free environmental education programs to local public and private schools in the greater Boulder community.[29]

CHAPTER II

OCCUPANCY-BASED CONTROL

2.1 Savings with an Occupancy Based Control System in a Single Office

An experiment was performed in an office on the Texas A&M campus using occupancy-based controls for lighting, computers and monitors, and HVAC. Several studies have shown that, independently, each of these strategies can save significant energy, but no studies have looked at how these strategies can be combined to achieve aggressive savings on a building or campus-wide level.

The office at Texas A&M had a damper in the HVAC supply duct that shut off supply air to the office whenever the lights were turned off. The office occupant turned the lights off every time he left the room. The computer in this office did not originally utilize the power management features available, but was set to go into standby mode whenever it was idle at onset of the experiment. While an occupancy sensor was not installed in this particular office, these controls would typically be implemented through use of an occupancy sensor. This would ensure that the lights will actually turn off when the occupant leaves.

Several sensors were set up in this office including temperature and relative humidity sensors, a light intensity sensor, a data logger that logs the computer energy usage, a supply air temperature sensor, and a flow sensor in the supply air duct. Data gathered showed that the temperature control is compromised when the HVAC was turned off in the office. This is not a problem in the one-office application because the adjacent spaces are conditioned and therefore maintain acceptable conditions in the office. However, when this setup is installed in a building-wide application, a thermostat should be used on the on/off damper to maintain temperature when the equipment is off. This will effectively act as a very low minimum flow setting while the area is unoccupied.

A Windows AirModel [32] simulation has been performed for this office to analyze the savings that can be achieved with these strategies. Only annual savings are analyzed. Three different cases were examined: the original case (referred to as "original"), the case in the office where a damper shuts off the airflow at all unoccupied times (referred to as "damper only"), and a case where the damper is attached to a thermostat that will open the damper as needed during unoccupied periods to maintain the temperature set point (referred to as "damper with thermostat"). Most of the simulation inputs were identical for all three cases. These include:

- Vacation periods: 15 total days
- System: single duct AHU with reheat at the terminal box
- Office area: 142 ft^2
- Thermostat set point: 73°F
- Maximum airflow into the office: 0.704 cfm/ft^2 (100 cfm), this was the maximum airflow value measured
- Outside air fraction: 10%
- Minimum airflow during occupied hours: 0.5 cfm/ft^2
- Heat transfer coefficients for the walls and windows: 0.1 and 1.1 Btu/(hr ft^2 °F), respectively

- Supply fan horsepower: 0.042 hp; 0.12 hp. The AHU that serves this office has a 25 horsepower fan and a design flow rate of 22,000 cfm. However, when Continuous Commissioning® of the building was performed a maximum flow rate of 13,100 cfm was measured.[33] According to the fan laws, this would reduce the fan power to 5.3 hp, but if the reduced flow at full speed is due to flow resistance, the fan is likely operating around 15 hp. This office received 100 cfm, or approximately 0.8% of the total airflow of the AHU. Therefore, it was assumed that 0.8% of the fan horsepower, or 0.042-0.12 hp is used to condition this office.
- Cooling Coil Schedule: 62°F when the ambient temperature is at or below 50°F and 50°F when the ambient temperature is at or greater than 90°F. The set point varies linearly when the ambient temperature is between 50°F and 90°F.

Differences in the cases include the maximum electrical heat gain, the electrical heat gain schedule, and the HVAC operation schedule. There are two panels of fluorescent lights in the office, each with three fluorescent tubes. One light switch controls the two middle tubes in each panel and another light switch controls the remaining four tubes. Before this experiment was started, the office occupant typically kept his window blinds closed during the day and did not take advantage of the natural light available. Therefore, to get the lighting level he desired, he would use all 6 fluorescent tubes. With the computer equipment, this created a maximum electrical heat gain of 2.4 W/ft^2. For this experiment he agreed to make use of the natural light through the window and reduce his artificial lighting usage to two fluorescent tubes. This is similar to implementing daylighting in a building. This was easy to do because of the two switches. This reduced the maximum electrical heat gain to 1.5 W/ft^2.

For the original case, the computer was typically left on during the weeknights but manually put in standby during weekends and holidays. The lights were always turned off at night, but were on during the entire day. This resulted in a 2.4 W/ft^2 electrical gain during the daytime, a 1.06 W/ft^2 electrical gain on weeknights, and a 0.106 W/ft^2 electrical gain on the weekends and holidays.

The computer operation varied for the “damper only” and “damper with thermostat” cases. For both cases where a damper was present, the computer went into standby and the lights were shut off every time the occupant left the office including, weeknights, weekends, holidays, and unoccupied times during the workdays. The occupancy pattern in the office was determined from the measurements of the airflow into the office and is shown in Figure 1. For the weekdays, the gains at each time were based on this occupancy schedule.

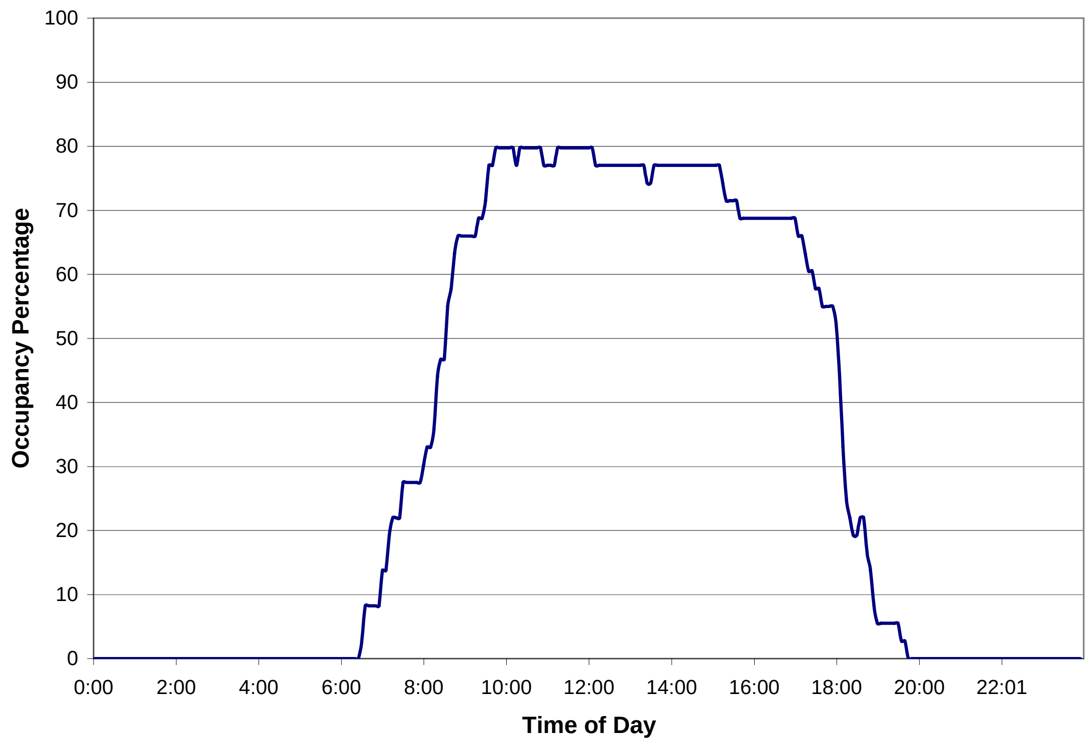

Figure 1: Weekday Occupancy Pattern in Study Office

The only other difference between the three cases in the simulation inputs is the HVAC operation schedule. For the "original" case, the HVAC system operated around-the-clock. The 0.5 cfm/ft^2 minimum flow setting was used for both occupied and unoccupied hours. In the "damper only" case, HVAC operation was shut down during all hours that the office was unoccupied. In the "damper with thermostat" case the minimum flow was set to 0.0 cfm/ft^2 during unoccupied hours, which allows the damper to close if the thermostat set point is met, but would cause the damper to open if the office needs conditioning during the unoccupied hours.

The simulation was run for each case, and the results are shown in Table 2. The simulation was run for the high and low ends of the horsepower range.

	Annual Chilled Water (CHW) Usage (MMBtu)	Annual Hot Water (HW) Usage (MMBtu)	Annual HVAC Electricity Usage (kwh)
Original	14.6	7.1	1554
Damper Only	2.2 (85% savings)	0.25 (97% savings)	218 (86% savings)
Damper w/ Thermostat	3.7 (75% savings)	2.4 (67% savings)	220 (86% savings)

Table 1: Air Model Simulation Results Using Fan Power=0.042 hp

	Annual CHW Usage (MMBtu)	Annual HW Usage (MMBtu)	Annual HVAC Electricity Usage (kwh)
Original	14.6	7.1	1802
Damper Only	2.2 (85% savings)	0.25 (97% savings)	228 (87% savings)
Damper w/ Thermostat	3.7 (75% savings)	2.4 (67% savings)	233 (87% savings)

Table 2: Air Model Simulation Results Using Fan Power=0.12 hp

The change in fan horsepower was not enough to change the cooling or heating consumption, but it did slightly change the HVAC electricity usage. The savings percentages were similar. In addition to these impressive HVAC savings, 843 kwh (60.2%) of lighting and plug load savings were seen with this occupancy-based control scheme. The total savings for the "damper with thermostat" case are shown in Table 3. These results use assumed energy prices of $0.125 per kwh, $14.804/MMBtu for chilled water, and $19.431/MMBtu for hot water. These were the values used in June 2007 by the Continuous Commissioning group on the Texas A&M main campus to evaluate savings. These savings are especially impressive considering that they are for only one 142 ft^2 office on a large campus. These savings will vary from office-to-office depending on the current practices of the office occupant. Since the savings are slightly less when the fan power is 0.042 hp, this case was used in Table 3.

	Original Cost	**Controls Cost**	**Cost Savings**
Chilled Water	$216	$55	$161 (75% savings)
Hot Water	$139	$46	$93 (67% savings)
HVAC Electricity	$194	$28	$166 (86% savings)
Lighting and Computer Electricity	$175	$70	$105 (60% savings)
Total	**$724**	**$199**	**$525** **(73 % savings)**

Table 3: Total Annual Savings from Implementing Occupancy-Based Control in an Office

2.2 Savings with an Occupancy Based Control System in the TAMIU SSC

These strategies were applied to the SSC at TAMIU to see the savings that may be achieved in that building. Several assumptions about the SSC had to be made since the plan for the building has not been completed. It is known that the building will be 120,000 ft^2, it will be rectangular in shape with the longer walls facing the east and west directions, it will primarily be an office building with some classroom space, and TAMIU is hoping to achieve LEED certification for the building. Therefore, green or energy-efficient practices were considered when entering the inputs. Some of the inputs are:

- Vacation periods: 15 total days
- System: single duct AHU with reheat at the terminal box
- Building area: 120,000 ft^2
- Thermostat set point: 73°F
- Maximum airflow: 1.0 cfm/ft^2

- Outside air fraction: 10%
- Minimum airflow during occupied hours: 0.5 cfm/ft^2
- Maximum room relative humidity: 60%
- Heat transfer coefficient for the walls: 0.1 Btu/(hr ft^2 °F)
- Heat transfer coefficient for the windows: 0.33 Btu/(hr ft^2 °F)
- Supply fan horsepower: 150 hp.
- Cooling Coil Schedule: 62°F when the ambient temperature is at or below 50°F and 50°F when the ambient temperature is at or greater than 90°F. The set point varies linearly when the ambient temperature is between 50°F and 90°F.
- Economizer implemented when the ambient temperature is between 30°F and 65°F
- Maximum internal heat gain= 0.937 W/ft^2

The primary differences in this case, due to the green building assumption, are the heat transfer coefficient for the windows, the economizer, and the maximum internal heat gain. The windows were assumed to be low-emissivity, double-pane windows, which are much more energy efficient than the windows used in the office in College Station. For the electrical gain, it was assumed that daylighting and the most efficient bulbs and ballasts will be used to reduce the lighting gain to 0.6 W/ft^2. It was also assumed that half of the building occupants will use energy-efficient CPUs with flat screen monitors while the other half can be convinced to use laptops with docking stations and flat screen monitors. These assumptions yield the maximum internal heat gain of 0.937 W/ft^2. This is much less than the 2.4 W/ft^2 used in the original case for the single office in College Station.

For the base case, it was assumed that 2/3 of the building lights were turned off at night and on the weekends and half of the computers were put into standby at night and on the weekends. This reduced the nighttime and weekend gains to 0.368 W/ft^2 or 39.3% of the maximum internal gains.

For the case with occupancy-based controls, the minimum flow during unoccupied hours was reduced to 0 cfm/ft^2. The file was set up so that the building is occupied nine hours a day, but the Wang study [3] found that the average office is only occupied 6.17 hours a day, (or 68.56% of the number of hours this building is occupied). Therefore, during the 9 occupied hours, the electrical gains were set to be 68.56% of the maximum electrical gain. At night and on the weekends it was assumed that some of the lights are left on for emergency lighting but all of the computers were put into standby.

Only the annual savings are analyzed; the initial costs of installing this equipment are not considered. The simulation was run for these two cases (base case and occupancy-based control case). The results are seen in Table 4. Significant savings can be achieved by implementing occupancy-based controls, even on top of other energy-efficient measures. The load profiles created with this simulation were used in evaluating the potential of using the other advanced building technologies in the SSC.

	Annual CHW Usage (MMBtu)	Annual HW Usage (MMBtu)	Annual HVAC Electricity Usage (kwh)	Annual Lighting and Computer Electricity (kWh)
Base Case	11,162	7130	698,707	540,571
With Controls	2037 (82% savings)	270 (96% savings)	301,248 (57% savings)	291,687 (46.0% savings)

Table 4: Simulation Results for Student Success Center at TAMIU

2.3 Current Energy Costs for SSC

Although there are no "current" costs of the SSC since the building is still in the planning stages, we can calculate what the energy cost would be using the current rates the loads found in the Windows AirModel simulation. The electricity rate schedule at TAMIU, as negotiated by the Energy Systems Lab, uses different rates for the summer (June-September) and for the winter (October-May). In the summer there is also a difference in the on-peak (6am to 6pm) and off-peak (6pm to 6am) rate schedule. The average transportation and distribution charge is $0.00687 per kWh. The rate structure is shown in Table 5. The price for natural gas was assumed to be $11.00 per MCF. The average price paid for natural gas by the university between September 2003 and June 2006 was $10.09 per MCF, so $11.00 is a reasonable estimate for the current price the university is paying.

Time	Charge per kWh	Total Charge
On-Peak Summer	$0.10903 per kWh	$0.11590 per kWh
Off-Peak Summer	$0.07456 per kWh	$0.08143 per kWh
Winter	$0.06856 per kWh	$0.07543 per kWh

Table 5: Electricity Rate Structure for TAMIU

Using these values for the pricing and the loads simulated in Chapter II, the "current" operating costs for the building are $270,168 ($\$2.25/ft^2$) for the "base" case and \$66,746 (\$0.556/ft^2) for the "with controls" case. At TAMIU, a heat pump provides heating during the non-winter months. However, these calculations were performed assuming that boilers must take care of the SSC heating load all year, since TAMIU has indicated that the heat pump is reaching its maximum capacity. Because of this assumption, the costs calculated for the green or base case were higher than the current campus costs (\$2.0/ft^2). If the heating loads from March through November were carried by the heat pump, the base case costs for the SSC would be reduced to \$1.74/ft^2.

CHAPTER III

ADVANCED BUILDING TECHNOLOGIES

The other advanced building technologies that are being used at CMU have been analyzed to find if they would be a good option for an advanced technology test bed in the SSC at TAMIU. These include cogeneration with an absorption chiller, radiant heating and cooling, displacement ventilation, and daylighting.

3.1 Cogeneration

A cogeneration feasibility analysis was performed using the loads calculated for the SSC in Chapter II. Both the "base" case and the "with controls" case were used. Caton lists four methods for implementing cogeneration: 1) Baseline cogeneration system which meets a portion of the facility's electrical and thermal requirements, 2) Cogeneration system sized to match the electrical loads, 3) Cogeneration system sized to meet a high thermal load, but does not meet all the electrical requirements, and 4) Cogeneration system sized to meet high thermal loads, but with lower equivalent electrical requirements.[15] He suggests that the first method works well for universities that have variable loads and do not wish to pursue electrical sales, but the fourth method is good for university facilities that require electrical sales to make the project economically feasible. The first mode of operation will be analyzed first.

3.1.1 Baseline Cogeneration System

For the "base" case the minimum electricity usage without the chiller is 106 kW. This will be the constant electrical output of the diesel engine. When the electrical loads are greater than 106 kW, the electricity will need to be purchased at the market rate. For the "with controls" case the electrical baseline is 35 kW.

For a diesel engine running at full power, 30% of the fuel energy can be used to produce electricity, 30% of the fuel energy is transferred to the jacket water, 23% of the fuel energy is released as exhaust heat, 2% is lost as lube oil heat, and 15% is lost through radiation and other losses.[14] Therefore, to produce 106 kW of electricity, 352 kW of fuel energy must be used to produce 35 kW of electricity, 118 kW of fuel energy must be used. The exhaust heat will be used to power the absorption chiller and the jacket water will be run through a heat exchanger and used for heating water. Using the heating value of B100 and assuming a price of $2.50 per gallon, the cost of producing this energy is calculated. The fuel energy breakdown and fuel cost is found in Table 6.

	Percentage	**Base Case**	**Controls Case**
Total Fuel Energy	100	352 kW	118 kW
Power Output	30	106 kW	35 kW
Jacket Water	30	106 kW	35 kW
Lube Oil Heat	2	7 kW	2 kW
Exhaust Heat	23	81 kW	27 kW
Radiation, etc Loss	15	53 kW	18 kW
Gallons B100 Required	---	88,938 gallons	29,688 gallons
Fuel Cost	---	**$222,344**	**$74,220**

Table 6: Fuel Energy Breakdown and Fuel Cost

Since this will only meet the baseline electrical loads, additional electricity will need to be purchased. Using the rule of thumb that one ton-hr of cooling is available with a double-effect absorption chiller for every 3 kWh of electricity produced, 35 tons of cooling are produced for the "base" case and 11.8 tons of cooling are produced for the "with controls" case. Assuming 85% effective heat transfer, 0.31 MMBtu/hr of heating from the jacket water is available for the base case and 0.102 MMBtu/hr of heating is available for the "with controls" case. Additional heating and cooling will have to be purchased. A breakdown of the additional costs is shown in Table 7. At times, there is more chilled water or hot water produced than is used in the building. This amount is more significant for the "with controls" case. It is assumed that this CHW or HW could be put into the campus loop and used in other buildings. Therefore, the typical cost to produce this CHW or HW is subtracted from the operating cost of the cogeneration system to give an "adjusted cost". However, the adjusted cost is still greater than the original cost to operate the building. Using a cogeneration system in this manner is not economically feasible.

	"Base" Case	**"With Controls" Case**
Cost of B100	$222,344	$74,220
Additional General Electricity Purchase	$28,068	$25,367
Additional Chiller Electricity Purchase	$45,592	$7,281
Additional Natural Gas Purchase	$65,227	$1,237
Total Cost	**$361,231**	**$108,105**
Adjusted Cost	**$356,277**	**$96,620**
Original Cost	$270,168	$66,746
Extra Cost for Cogen	***$86,109 (32% more)***	***$29,874 (45% more)***

Table 7: Costs for Baseline Cogeneration System

3.1.2 Cogeneration System Sized to Meet Higher Thermal Loads

While a baseline cogeneration system was not economically feasible, one that is sized to meet higher thermal loads may be. This system will produce more electricity than the building needs at times, but this additional electricity may be used for other buildings on the TAMIU campus. A similar cogeneration analysis is performed where the engine produces 180 kW of electricity. The purchase price of this electricity is used to find the adjusted cost of the cogeneration system. The results are seen in Table 8.

	"Base" Case	**"With Controls" Case**
Cost of B100	$378,996	$378,996
Additional General Electricity Purchase	$12,116	$0
Additional Chiller Electricity Purchase	$35,537	$561
Additional Natural Gas Purchase	$38,194	$0
Total Cost	**$464,843**	**$379,557**
Adjusted Cost	**$429,015**	**$229,698**
Original Cost	$270,168	$66,746
Extra Cost for Cogeneration	***$158,847 (59% more)***	***$162,952 (244% more)***

Table 8: Costs for Higher Thermal Load Cogeneration System

This cogeneration system is also not economically feasible for the SSC. It appears that the cost of B100 biodiesel is too high to justify a biodiesel cogeneration system. A system of this type could be considered for backup electricity generation.

3.2 Radiant Heating and Cooling

While radiant heating and cooling have shown several benefits, there has been hesitancy about implementing these systems in hot and humid climates due to complications with condensation and humidity control. For the IW at Carnegie Melon, Gong found that the radiant heating and cooling system consumes 21% less thermal energy, 2% less electricity and 11% less primary energy than a single duct VAV system when using a passive desiccant ventilation unit.[9] However, when using an active desiccant ventilation unit, the radiant heating and cooling system consumes 29% more thermal energy, 3% less electricity, and 10% more primary energy than a single duct VAV system. This building has very significant air leakage, and the performance of the desiccant units is seriously compromised due to this leakage. It is unlikely that a passive desiccant ventilation unit would be able to handle the humidity loads in Laredo, Texas. Therefore, these results tend to indicate that radiant heating and cooling might not be economically feasible in Laredo since the consumption is actually higher when employing an active desiccant; however, the results will depend on the properties of the building envelope.

Stetiu, on the other hand, produced a simulation of a radiant cooling system with very favorable results for New Orleans, which has a hot and humid climate.[19] The simulation used 68°F chilled water to avoid condensation and a design setpoint for the building was 75.2°F.[19] Continuous ventilation with dehumidified air was provided to control humidity levels. The system required less energy consumption, provided similar temperature and relative humidity levels as the mixing ventilation system, and provided more stable indoor air conditions over a 24-hour period.[19] This study suggests that it may be possible to implement a successful radiant heating and cooling system in the Student Success Center that can achieve energy savings over the traditional VAV system. However, since continuous ventilation is required to control humidity levels, the occupancy based controls would not be able to shut down the airflow into the test bed area during unoccupied times.

Vangtook also successfully simulated a radiant cooling system for a hot and humid climate; however, the conditions were quite different from those of the SSC. This study focused on houses in hot and humid southeast Asia.[34] These homes have a very low heat gain and occupants were assumed to have low activity levels. In this environment, occupants were comfortable with a 28°C (82.4°F) room temperature setpoint, so the simulation used 25°C (77°F) water as a supply for the panels.[34] This would not be practical in an office/classroom setting such as the SSC, where occupants prefer lower setpoint temperatures, internal heat gains are much higher, and occupants are more active.

It appears that there is a need to have an experimental study of radiant heating and cooling in a hot and humid climate. While simulations such as Stetiu's indicate that these systems can be beneficial in a hot and humid climate, it is unlikely that they will begin to have widespread implementation until measured results show that they exhibit energy saving potential while maintaining occupant comfort. TAMIU could be a pioneer in the use of radiant heating and cooling in a hot and humid environment by implementing these systems in their advanced technology test bed as part of the Student Success Center. However, preliminary calculations should be performed to see if there is potential for energy savings with radiant heating and cooling in this building.

To see if there is a possibility of energy savings with this system, radiant heating and cooling feasibility calculations were performed. The building load was calculated assuming that the occupancy-based controls are used. A ventilation system was implemented in the calculations to take care of latent loads, provide fresh air to building occupants, and dehumidify outside air. This ventilation system runs anytime the building is occupied or if the outside air humidity ratio is higher than the desired indoor air humidity ratio. Since the building has not yet been built, the amount of air that is needed to properly pressurize the building is unknown. If the building envelope is leaky, like that of the IW, more pressurization air will be needed than if the building is properly built. Three sets of calculations were done using 16,000 CFM, 8000 CFM, and 4000 CFM to pressurize the building when unoccupied.

Most of the time, the ventilation system also carries part of the sensible load in the space. If needed, the ventilation air was reheated. The chiller, boiler, pump, and fan power were calculated for both the ventilation system and the radiant heating and cooling system, and the costs were found based on the TAMIU electricity pricing schedule found in Table 5. The total cost of operating the building with this system was found to be $96,406. The breakdown is seen in Table 9.

	Pressurization CFM		
	16,000 CFM	**8000 CFM**	**4000 CFM**
Ventilation System	$60,686	$32,694	$25,120
Radiant Heating and Cooling	$10,585	$14,423	$21,180
Lighting and Equipment Electricity	$25,136	$25,136	$25,136
Total	**$96,407**	**$72,252**	**$71,436**
Cost above traditional system	**$29,660 (44% higher)**	**$5,406 (8% higher)**	**$4,690 (7% higher)**

Table 9: Cost of Radiant Heating and Cooling System with Ventilation for the SSC

When 16,000 CFM of pressurization air is used, the ventilation system is not economically feasible. In this case, the ventilation air needs to use a lot of reheat to provide comfort in the space. As the pressurization air is decreased, the cost of the ventilation system decreases and the cost of the radiant heating and cooling system increases. This is because the ventilation system carries less of the cooling load and leaves more load for the radiant system to carry. As the pressurization CFM is decreased to 8000, very little reheat is needed. Therefore, significant savings are seen between 16,000 and 8000 CFM. While savings continue to be seen when the flow is decreased from 8000 to 4000 CFM, the savings are not as dramatic.

These results show that knowing the properties of the building envelope are critical for determining the cost of a radiant heating and cooling system. When it is assumed that 4000-8000 CFM are needed to pressurize the building, the cost of the radiant heating and cooling system is found to be less than 10% more than the traditional system. This shows that radiant heating and cooling could be a viable option for this building, especially considering that when these calculations and the air-side simulation were performed, several assumptions were made about the building since it is still in the planning stages. Once the plans for this building are finalized, radiant heating and cooling should be further explored.

3.3 Displacement Ventilation

While the benefits of displacement ventilation systems in certain climates are understood, very little research has been conducted to see if energy savings can be achieved using a displacement ventilation system in a hot and humid climate. Simulation studies by Lau[20] and Hu[35] both examined the effect of using displacement ventilation in five areas, including New Orleans, which has a hot and humid climate. Both found that displacement ventilation systems save chiller and boiler energy consumption while increasing fan energy consumption. Hu does not discuss the New Orleans results aside from saying that the displacement ventilation system had a very small total energy savings over a traditional mixing ventilation system. Lau points out that the humidity levels observed were extremely high at times and that the displacement system could not actually function alone in this environment; dehumidification would have to be implemented. Lau's study does not examine the extra energy consumption that would be required by a dehumidification system. Hamilton also mentions that in hot climates supplemental cooling is typically required.[21] These supplemental cooling and/or dehumidification systems may cause a displacement ventilation system to actually consume more overall energy than a mixing ventilation system.

Because displacement ventilation systems are untested in a hot and humid climate, TAMIU should not implement displacement ventilation as the primary ventilation system in the SSC. However, there is potential for conducting a study of the energy consumption of displacement ventilation systems in a hot and humid climate. Most studies on displacement ventilation in the United States, including the Lau and Hu studies, are simulation studies. Very little measured results exist for displacement ventilation systems in the United States, particularly in hot and humid climates. Implementing a displacement ventilation system would allow accurate comparisons between displacement ventilation and mixing ventilation systems, including energy costs of supplemental cooling and dehumidification systems. If TAMIU is interested in this research project and funding can be secured, a displacement ventilation experiment could be implemented in the test bed portion of the new building.

One hurdle to implementation of a displacement ventilation test bed might be finding a designer with experience designing displacement ventilation systems. Very few designers in the United States have experience with displacement ventilation.

Special care should be taken during design to attempt to avoid the leakage problems discussed by Gupta and Woods.[22]

The literature indicates that little to no energy savings could be seen in Laredo with a displacement ventilation system, so from a pure energy and money-saving standpoint, TAMIU should not implement a displacement ventilation system. However, from a research standpoint there is still much to be learned about these systems, particularly in hot and humid climates. Therefore, if interested, TAMIU may consider implementing a displacement ventilation test bed for research purposes.

3.4 Daylighting

While using daylighting strategies can save tremendous amounts of lighting and HVAC energy, "the blind application of daylighting can result in increased life cycle costs".[36] This can occur when too much glass is used which causes increased solar gains to enter the space. Busch and Scheuch found that in Fresno, California, daylighting was most effective when 15% of the wall was covered by clear glass.[36] This percentage will vary slightly with climate.[36] These results show that effective daylighting does not require large amounts of glass. The more important factor is the placement of the glass. By placing the glass high in the room so that it doesn't cause discomfort and impede vision, daylighting can decrease energy consumption while improving occupant productivity.[37] The daylight zone includes the top floor (through the use of skylights) and 5 m (16.5 ft) from the exterior wall on lower floors. Leslie mentions several methods that have been used to increase this zone, but none of them have yet proven to be cost effective.[37] The most effective daylighting can be achieved by locating the building on the east-west axis to maximize northern exposure .[37]

The SSC at TAMIU is planned to be located on a north-south axis. The location of the Student Success Center within the TAMIU master plan is shown in Figure 2. While daylighting can and should be implemented in this building, it is not ideally situated for a daylit design. Skylights could be used to daylight the top floor of the building, but since the northern exposure is somewhat small, it will be difficult to use large amounts of daylighting on the other floors. TAMIU should utilize daylighting in the Student Success Center; however, proven techniques should be used to make sure that the project is cost effective, especially since the daylighting potential of the building appears to be somewhat low. If research into cutting edge daylighting technologies is desired, it should be performed in a building with a larger northern exposure. The building adjacent to the Student Success Center appears to have great potential for daylighting and may show tremendous reductions in lighting usage through the use of daylighting.

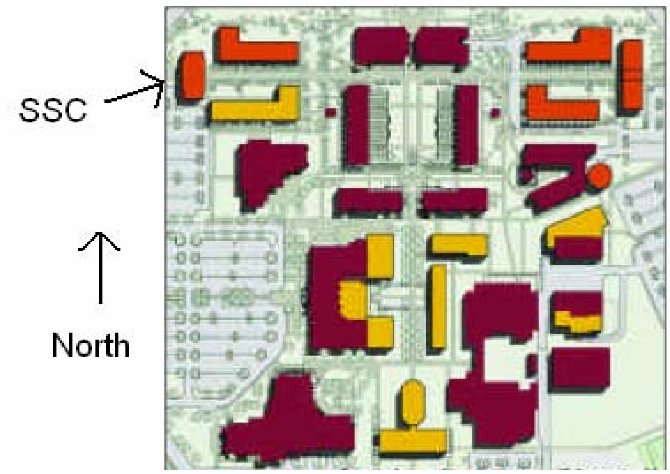

Figure 2: Location of the Student Success Center on the TAMIU Campus

CHAPTER IV

SUSTAINABILITY ON THE TAMIU CAMPUS

4.1 Campus Sustainability Assessment

After reviewing the literature on sustainability and looking at what other campuses have done when performing a sustainability assessment, a plan was developed for a sustainability assessment of Texas A&M International University in Laredo. Many of the areas covered in the UC assessment were included, with some sections combined to cover the specific concerns of TAMIU. Questions were included to gauge the scope of work required for TAMIU to obtain a LEED-EB rating. TAMIU personnel were interviewed concerning their activities and progress in each area. Good practices and opportunities were identified in each category. The areas examined were energy, water, waste and recycling, built environment, transportation, land use, consumable supplies and equipment, food, health and well-being, sustainability-related courses and research, sustainability-related campus organizations, and sustainability and campus leadership. A list of the good practices and opportunities for improvement in each area is given. More detail can be found in the sustainability assessment report, which is presented in its entirety in the appendix.

4.1.1 Energy

Good Practices

- Many campus buildings have been commissioned
- Campus buildings use direct digital control (DDC), allowing for accurate monitoring and easy changes

- Low vehicle fleet energy consumption
- Solar panel used to light campus signage with plans for more solar panels
- Have energy goals pursuant to Governor's executive order
- Internal energy awareness program
- Building sub-metering

Opportunities

- Assess potential for additional building commissioning and energy retrofits
- Commission buildings, such as the science center, that have not yet been commissioned
- Commission new buildings as they come online
- Encourage students living on campus to conserve energy in their dorms or apartments. Consider using an incentive program or competition.
- Put a clause into contract with dorm management companies saying that green buildings are required on campus
- Investigate the use of local natural gas
- Investigate the use of clean diesel for standby power generators
- Investigate purchase of green electric power, such as wind power or other renewable energy sources, through the TAMU system electricity contract
- Make energy consumption numbers easily available for faculty, staff, and students
- Investigate the use of additional solar-powered illumination
- Track Energy Utilization Index (EUI)

4.1.2 Water

Good Practices

- Automated irrigation control system
- Ongoing water conservation research
- Drought-tolerant vegetation
- Low-flow shower heads and toilets used in dormitories
- Excellent sub-metering
- Wastewater is kept free of hazardous chemical waste

Opportunities

- Implement a water conservation awareness program that will educate students and staff on the importance of water conservation and encourage conservation of water
- Continue pursuit of use of gray water from the City of Laredo for irrigation
- Continue investigation of irrigation control based on measured evapo-transpiration
- Continue to press for evaporation sewer allowance for cooling tower water
- Continue to investigate viable use(s) for AHU condensate
- Investigate viability of mulching for water conservation
- Investigate use of retention pond for irrigation water
- Consider using waterless urinals in new construction and/or as a demonstration

4.1.3 Waste and Recycling

Good Practices

- Strong participation in active recycling program with broad range of materials recycled
- Several paper waste mitigation strategies
- Excellent accounting of chemical and hazardous waste control

Opportunities

- Quantify recycling
- Find alternative ways to increase recycling capacity if city will not provide a second pickup
- Continue to educate about the recycling program by trying other avenues such as flyers and the website
- Further investigate opportunity for composting
- Continue to look for strategies to reduce paper waste
- Encourage neutralizing acid/base combinations as part of the teaching process to eliminate these wastes and teach about waste disposal issues

4.1.4 Built Environment

Good Practices

- Automatic lighting controls is all classrooms and most offices
- Compact florescent lights and T-8 fluorescents in all buildings
- Interest in LEED certification for new Student Success Center

- Interest in high-performance test facility capabilities to explore advanced technology

Opportunities

- Assess opportunity for LEED-NC (New Construction) rating of new Student Success Center
- Assess potential for a LEED-EB (Existing Building) rating for the existing campus
- Hire architects for future construction that have experience in green building design.
- Create a statement of how energy efficiency will be considered in future construction

4.1.5 Transportation

Good Practices

- City bus service to campus
- City buses run on natural gas
- Bicycle path along Bob Bullock Loop
- Bicycle racks on campus
- Campus vehicle fleet is 75% electric
- Increasing number of students are living on campus

Opportunities

- See if the city can add a bicycle rack to all bus lines that come to campus
- Complete campus loop to ease transportation in and around campus

- Facilitate the use of more bicycles by adding dedicated bicycle paths and ensuring adequate racks and shower and changing facilities
- Set up preferred parking for alternative fuel and hybrid vehicles
- Investigate incentives to encourage carpooling

4.1.6 Land Use

Good Practices

- Stormwater management policies in place
- Use plants that fit in the local ecosystem
- Much open space is preserved on campus, with plans to keep a green space reserve as the campus grows
- Campus lighting is compatible with night-sky regulations
- Shade trees have been planted and plans are in place for a trellis that will add shade along sidewalks
- Integrated Pest Management System with complete tracking and use of some organic pest control options

Opportunities

- Investigate use of a retention pond for stormwater
- Investigate heat island mitigation strategies (especially for parking and roofs)

4.1.7 Consumable Supplies and Equipment

Good Practices

- Recycled content paper is purchased for the entire campus

Opportunities

- Implement a green purchasing policy for consumables and office equipment
- Encourage departments to choose Energy STAR equipment and appliances

4.1.8 Food

Good Practices

- Dining Services has healthy options such as a salad bar in the main dining facility and a Subway sandwich vendor
- Organic foods are available for catered events
- Have wellness committee

Opportunities

- Investigate student interest in sustainable food products such as organic and hormone free foods
- If an interest in shown, increase availability of sustainable food products
- Investigate use of food scrap as animal food source.
- Encourage students to bring their own coffee mug or drink bottle to help mitigate food waste.
- Use napkins made from recycled paper content
- See if dining center patrons would be willing to take on the extra cost of using biodegradable dining ware instead of Styrofoam plates and bowls and plastic utensils.
- Plan for dish washing facilities in the new campus dining center and focus on sustainable practices throughout the dining center planning process.

4.1.9 Health and Well-Being

Good Practices

- Have excellent custodial chemical use and practices underway
- Custodian's presence does not significantly increase lighting energy consumption
- Asbestos-Free campus
- No smoking policy around buildings
- Campus print room has separate ventilation
- Air changes can be increased by physical plant if needed
- Carbon Dioxide monitoring in gym
- Aggressive workplace safety training and education program
- Ergonomic assessments and workshops available to employees

Opportunities

- Carry out green custodial plan
- Use low VOC materials for carpeting and paint

4.1.10 Sustainability-Related Courses and Research

Good Practices

- Sustainability related courses include Environmental Science and Environmental Geology
- Various sustainability-related research is already in progress
- Engineering curriculum is getting started
- Professors are willing to integrate sustainability into core courses

Opportunities

- Get students involved through course project participation
- Insert sustainability related modules in existing courses, particularly core courses

4.1.11 Sustainability-Related Organizations

Good Practices

- Director of Student Activities has interest in Sustainability-related organizations

Opportunities

- Involve student organizations in sustainability activities such as cardboard and aluminum recycling
- Create activities that foster participation in and awareness of sustainability (such as adopt-a-road, earth day, etc.)
- Educate students about the Green Campus Initiative at orientation

4.1.12 Sustainability and Campus Leadership

Good Practices

- Dr. Keck, TAMIU President, has stated publicly several times to staff and faculty that he is committed to creating a green campus Sustainability Initiative
- Faculty and staff have existing plans in place for recycling, water management energy practices, and other sustainable practices as part of their job duties
- TAMIU has formed a campus Green Team comprised of administrative staff, faculty, and students to evaluate options and to move towards a more Green Campus

- Dr. Keck signed a letter in September 2006 to seek additional funding to pursue a green campus initiative

Opportunities

- Implement a green campus initiative based on assessment report
- Formalize management policy through a modified mission statement and written strategy
- Include sustainable practices in job descriptions or relevant personnel and faculty
- Identify personnel to take lead role for plan implementation
- Utilize student organizations and manpower (interns) wherever possible to increase buy-in and reduce implementations costs
- Communicate strategies to community, peers, staff, and students periodically

4.2 LEED-EB Assessment for TAMIU Campus

As discussed, one opportunity for TAMIU to achieve recognition as a sustainable campus is to earn LEED-EB certification for some or all of its campus buildings. Levels of certification under LEED-EB are achieved by meeting a set number of credits: Certified- 32-39 points, Silver- 40-47 points, Gold- 48-63 points, and Platinum- 64-85 points. This section goes through each prerequisite and credit to identify which credits TAMIU might consider pursuing. For each credit, the Green Compass software by Johnson Controls was used to help identify the scope of work that it would take to meet the credit. The various scopes include “achievable as-is”, “policy or operational procedure change”, “minor retrofit”, “moderate to aggressive retrofit”, and "unachievable". The report also summarizes which credits may be achieved on a campus-wide basis and which must be achieved on a building-by-building basis.

4.2.1 Prerequisites

To obtain LEED-EB certification (at any level), fourteen prerequisites must be met before any credits may be achieved. This section discusses each prerequisite and what TAMIU will need to do to meet each credit.

SS Prereq 1- Erosion and Sedimentation Control

TAMIU must implement an erosion and sedimentation control policy that addresses the points outlined in the LEED-EB reference guide. Activity must be logged to ensure that the plan is being followed. This prerequisite could be met on a campus-wide basis and applied to all buildings attempting to achieve LEED-EB certification. Meeting this prerequisite typically falls into the "policy or operational procedure change" work scope.

SS Prereq 2- Age of Building

This prerequisite will need to be met on a building-by-building basis. LEED-EB applies to buildings at least two years old. Therefore, the majority of TAMIU campus buildings are eligible for LEED-EB certification. Buildings less than two years old or upcoming buildings, such as the Student Success Center, may apply for LEED-NC.

WE Prereq 1- Minimum Water Efficiency

To achieve this prerequisite, fixture potable water usage must be reduced "to a level equal to or below water use baseline, calculated as 120% of the water usage that would result if 100% of the total building fixture count were outfitted with plumbing fixtures that meet the Energy Policy Act of 1992 fixture performance requirements”.[38] Since the campus was built in 1995, this prerequisite should already be achieved.

WE Prereq 2- Discharge Water Compliance

If the facility is regulated by the EPA National Pollution Discharge Elimination System (NPDES) Clean Water Act requirements NPDES permit compliance must be demonstrated. If the facility is not regulated by this Act, the prerequisite is achieved.[38]

EA Prereq 1- Existing Building Commissioning

The purpose of this prerequisite is to verify and ensure that fundamental building elements and systems are installed, calibrated and operating as intended so they can deliver functional and efficient performance.[38] The Energy Systems Laboratory (ESL) of the Texas Engineering Experimentation Station performed Continuous Commissioning® (CC) on 408,000 ft^2 of campus space beginning in June 2000. Additional CC® projects were performed in 2004.[39] CC® accomplishes the same objectives as this prerequisite but uses different activities and sequences. CC® actually goes beyond the requirements of this prerequisite by not only verifying that the building systems work, but optimizing HVAC performance too. CC® does not address lighting or safety systems, so those systems will have to be verified on all buildings wishing to pursue LEED-EB certification. This prerequisite will need to be met on a building-by-building basis and falls into the minor retrofit scope for buildings that have been commissioned and the moderate to aggressive retrofit scope for buildings needing to be commissioned.

EA Prereq 2- Minimum Energy Performance

To achieve this prerequisite, each building must be shown to have an EPA Energy Star rating of at least 60, or be shown to have energy performance equivalent to an Energy Star rating of at least 60.[38] Energy Star ratings are available for offices, K-12 schools, and residence halls/dormitories, but not general university buildings. Therefore the alternative analysis must me done on these types of buildings. The historical average energy usage must be determined from three consecutive years of data and must fall within six years of the performance period. Then, the percentage reduction in energy use must be found relative to the historical energy usage. To meet this prerequisite, the percentage reduction from the baseline must be at least 10%.[38] Continuous Commissioning® of the remaining buildings should allow them to meet this requirement; therefore, meeting this prerequisite falls into the minor retrofit scope. This calculation procedure will also be used in achieving EA Credit 1.

EA Prereq 3-Ozone Depletion

This prerequisite can be met by either using no CFCs in HVAC&R systems, or if replacement or conversion is not economically feasible, it can be met by reducing "annual leakage to 5% or less using EPA Clean Air Act, Title VI, Rule 608 procedures governing refrigerant management and reporting and reduce the total leakage over the remaining life of the unit to less than 30% of its refrigerant charge".[38] Since most systems are fed through the central plant, this prerequisite can be met on a campus-wide basis.

MR Prereq 1.1- Source Reduction and Waste Management: Waste Management Policy and Waste Stream Audit

A waste stream audit of the facility must be conducted that establishes a waste baseline and identifies the types and quantities of various types of waste. A waste management policy must also be implemented that will help reduce waste. The policy could be implemented on a campus-wide basis, but the audit will likely need to be performed on a building-by-building basis. The audit and policy implementation typically falls into the moderate to aggressive work scope.

MR Prereq 1.2- Source Reduction and Waste Management: Storage and Collection of Recyclables

This prerequisite involves setting up collection sites for recyclable paper, glass, plastics, cardboard, and metal. TAMIU currently does recycle all of these items other than glass through the city of Laredo. If it is found that no recycling services for glass are available within 50 miles of the TAMIU campus, then an exception can be obtained. However, if these services do exist, TAMIU will need to add glass recycling to their program. Additionally, the recycling area capacity needs "to accommodate at a minimum the potential recycling volumes identified in the waste stream audit".[38] This prerequisite could be met on a campus-wide basis and would require a minor retrofit.

MR Prereq 2- Toxic Material Source Reduction: Reduced Mercury in Light Bulbs

The purpose of this prerequisite is to "establish and maintain a toxic material source reduction program to reduce the amount of mercury brought into buildings through purchases of light bulbs".[38] The weighted average of mercury content in the light bulbs must be maintained below 100 picograms per lumen hour during the performance period. This prerequisite could be met on a campus-wide basis and will require a moderate to aggressive retrofit to complete if the mercury content in the lights on campus is high. The work scope could be lessened if high-mercury bulbs are replaced with low-mercury bulbs as they go out prior to the performance period.

IEQ Prereq 1- Outside Air Introduction and Exhaust Systems

To meet this prerequisite the building outside air distribution system must supply at least the amount of ventilation air required by ASHRAE 62.1-2004. Additionally, all building exhaust systems must be tested and maintained. The testing and verification will need to be done on a building-by-building basis and typically will require a moderate retrofit work scope.

IEQ Prereq 2- Environmental Tobacco Smoke (ETS) Control

TAMIU has already met this requirement since the campus policy does not allow smoking in or around campus buildings.

IEQ Prereq 3- Asbestos Removal and Encapsulation

As an asbestos-free campus, TAMIU has already met this prerequisite.

IEQ Prereq 4- Polychlorinated Biphenyl (PCB) Removal

Since the first phase of the TAMIU campus was built in 1995, it is assumed that no PCBs are present on campus. Therefore, this prerequisite is met.

Meeting all of these prerequisites will present one of the largest challenges to obtaining LEED Certification for the TAMIU campus. The most burdensome prerequisites will most likely be EA Prereq. 1, MR Prereq. 1.1, MR Prereq. 2, and IEQ Prereq. 1.

4.2.2 Sustainable Sites Credits

SS Credit 1.1 and 1.2- Plan for Green Site and Exterior Management

To meet this credit, a low-impact site and green building exterior management plan that addresses the topics listed below must be implemented. One point is earned for each four items addressed.[38]

1. Maintenance equipment
2. Plantings
3. Animal and vegetation pest control
4. Landscape waste
5. Irrigation management
6. Fertilizer use
7. Snow removal (where applicable)
8. Cleaning of building exterior
9. Paints and sealants used on building exterior
10. Other maintenance of the building exterior

This credit could be achieved on a campus-wide basis and is typically achievable with a “policy or operational procedure change” work scope.

SS Credit 2- High Development Density Building Area

To achieve this credit, the building must be located in a high-density area. While some parts of the campus may have achieved this development density, the calculation procedure for the credit requires using the “total property area”.[38] Most of the TAMIU property is undeveloped, so since the entire property area is required rather than the developed area, this credit is unachievable.

SS Credit 3.1- Alternative Transportation: Public Transportation Access

TAMIU meets this credit since a bus comes to campus and transports students to public transportation at the city bus station (option C).

SS Credit 3.2- Alternative Transportation: Bicycle Storage and Changing Rooms

To obtain this credit, bicycle storage and shower/changing facilities must be located within 200 yards of the building for 1% of building occupants or 125% of peak demand. This credit should be achievable for the gymnasium and library since they have shower and changing facilities. Any buildings within 200 yards of these may be able to achieve the credit too. For other buildings, a retrofit would be needed to install showers.

SS Credit 3.3- Alternative Transportation: Alternative Fuel Vehicles

To achieve this credit either preferred parking programs for hybrid or alternative fuel vehicles must be provided for at least 3% of the total vehicle parking capacity and increased as necessary to meet the demand for preferred parking up to 10% or more of the total vehicle parking capacity (option C). This could be achieved on a campus-wide basis. Option C is achievable as a “minor retrofit” scope simply by designating preferred parking.

SS Credit 3.4- Alternative Transportation: Car Pooling and Telecommuting

This credit can be achieved through a "minor retrofit" scope by implementing preferred parking and programs for carpools and vanpools. This could be achieved on a campus-wide basis.

SS Credit 4.1 and 4.2- Reduced Site Disturbance–Protect or Restore Open Space

For these credits, points are achieved by using native or adapted vegetation or other ecologically appropriate features on the site area. One credit is earned by covering 50% of the site area and the second credit is earned by covering 75% of the site area. Since TAMIU has large amounts open space covered with native vegetation, this credit should be achievable as is.

SS Credit 5.1 and 5.2- Stormwater Management: Rate and Quantity Reduction

This credit can be achieved by having measures in place that mitigate at least 25% (1 point) to 50% (2 points) of the annual stormwater falling on the site. This point could be obtained on a campus-wide or a building-by-building basis. The Green Compass software suggests that to achieve one point would be within a minor retrofit scope but to achieve two points would be within a moderate to aggressive retrofit scope.

SS Credit 6.1- Heat Island Reduction, Non-Roof

The options to obtain this credit include A) Providing shade on at least 30% of non-roof impervious surfaces on the site, including parking lots, walkways, plazas, etc. B) Using/maintaining light-colored/high-albedo materials (reflectance of at least 0.3) for 30% of the site's non-roof impervious surfaces on the site, including parking lots, walkways, plazas, etc. C) Placing/maintaining a minimum of 50% of parking space underground. D) Using/maintaining an open-grid pavement system (net impervious area of LESS than 50%) for a minimum of 50% of the parking lot area.[38] All of these options would require a moderate to aggressive retrofit, but could be achieved on a campus-wide basis.

SS Credit 6.2- Heat Island Reduction, Roof

To achieve this credit 75% of the roof surface must be Energy Star compliant, high reflectivity, high emissivity roofing material or a vegetated roof must cover 50% of the roof surface. This credit will need to be achieved on a building-by–building basis. To implement these types of roofs would require a moderate to aggressive retrofit.

SS Credit 7- Light Pollution Reduction

The intention of this credit is to "eliminate light trespass from the building and site, improve night sky access and reduce development impact on nocturnal environments".[38] While most luminaries on the TAMIU campus do comply with night sky regulations, a minor retrofit will be required to shield the Phase 1 globe lights. Additionally, light trespass measurements will need to be performed. This credit could likely be achieved on a campus-wide basis.

4.2.3 Water Efficiency Credits

WE Credit 1.1 and 1.2- Water-Efficient Landscaping- Reduce Water Use

These credits can be achieved by reducing potable water use for irrigation over conventional irrigation techniques. A 50% reduction earns 1 point and a 95% reduction earns the second credit. To demonstrate this reduction requires a moderate to aggressive retrofit. This credit could be achieved on a campus-wide basis.

WE Credit 2- Innovative Wastewater Technologies

Meeting this credit requires reducing potable water use for building sewage conveyance by 50% based on the water use baseline calculated in WE Prereq. 1.[38] This credit would need to be achieved on a building-by-building basis and would likely require a moderate retrofit.

WE Credit 3.1 and 3.2- Water Use Reduction

Through this credit, one point can be achieved by reducing fixture water use by 10% from the baseline and two points can be achieved with a 20% reduction. This credit must be earned on a building-by-building basis. Achievement is typically within a moderate retrofit scope.

4.2.4 Energy and Atmosphere Credits

EA Credit 1- Optimize Energy Performance

As many as ten credits may be achieved by showing performance equivalent to an Energy Star rating. Table 10 shows the point schedule. As discussed with EA Prerequisite 2, the current energy use must be compared to the energy use baseline. When Continuous Commissioning® was performed between 8/2000 and 11/2001 energy savings of 26.3% of the baseline campus energy usage were achieved.[39] Likewise, when additional buildings were commissioned between 9/2000 and 8/2003, 27.3% of baseline use was saved.[39] It is likely that some degradation in savings has occurred since commissioning was completed. If commissioning were performed again, it is likely that similar savings would be seen due to this degradation and since several new buildings have not yet been commissioned. This would result in four points. Since the buildings will need to be commissioned to fulfill EA Prerequisite 1, achieving these four points falls within the minor retrofit work scope. Achieving additional points would require a moderate to aggressive retrofit work scope.

Percentage Reduction from Baseline	**Points**
10	Meet EA PR 2
13	1
17	2
21	3
25	4
29	5
33	6
37	7
41	8
45	9
49	10

Table 10: Point Schedule for EA Credit 1

EA Credit 2- On-site and Off-site Renewable Energy

As many as four credits can be achieved through either on-site or off-site renewable energy. Achieving these credits would be in the moderate retrofit scope. The easiest way to achieve points would be to investigate acquiring green power when the TAMU system does its annual power negotiations. The Energy Systems Lab can assist TAMIU with this. Table 11 details the credit schedule.

LEED-EB Points	**On-site Renewable Energy**		**Off-site Renewable Energy / Certificates**
1	3 %	OR	15 %
2	6 %	OR	30 %
3	9 %	OR	45 %
4	12 %	OR	60 %

Table 11: EA Credit 2 Point Schedule

EA Credit 3.1- Building Operations and Maintenance: Staff Education

This credit is achieved by having a building operations and maintenance staff education program that provides each staff person primarily working on building maintenance with at least 24 hours of education each year. This credit could be achieved on a campus-wide basis and would require a policy change/minor retrofit.

EA Credit 3.2- Building Operations and Maintenance: Building Systems Maintenance

By having "a comprehensive Best Practices Equipment Preventative Maintenance Program that provides in-house resources or contractual services to deliver post-warranty maintenance" [38] this credit can be achieved. The maintenance program could be implemented on a campus-wide basis. The scope of work required for this credit typically falls into the minor retrofit category.

EA Credit 3.3- Building Operations and Maintenance: Building Systems Monitoring

This credit requires "a system for continuous tracking and optimization of systems that regulate indoor comfort and the conditions (temperature, humidity and CO2) delivered in occupied spaces".[38] This credit would need to be achieved on a building-by-building basis. While gathering information for the TAMIU Campus Sustainability Assessment, ESL personnel were told that the only CO_2 monitoring on campus is in the gymnasium. Therefore, this credit would require a moderate to aggressive retrofit in all other areas.

EA Credit 4- Additional Ozone Protection

This credit is achievable by using HVAC, refrigeration, and fire suppression systems that do not contain CFCs, HCFCs or Halons. If HVAC systems or refrigeration systems do use these chemicals, the credit may be achieved by reducing emissions and restricting the leakage. Since most systems are fed through the central plant, this credit can be met on a campus-wide basis.

EA Credit 5.1 – 5.3-Performance Measurement- Enhanced Metering

Points can be earned by continuously monitoring each of the following. (Up to 3 points can be earned — one point is earned for each four actions implemented/maintained).[38]

- Lighting systems and controls.
- Separate building electric meters that allow aggregation of all process electric loads (Process electric loads are defined in the LEED-EB Reference Guide).
- Separate building natural gas meters that allow aggregation of all process natural gas loads (Process natural gas loads are defined in the LEED-EB Reference Guide).
- Separate meters that allow aggregation of all indoor occupants' related water use for required fixtures.
- Separate meters that allow aggregation of all indoor process water use (Process water uses are defined in the LEED-EB Reference Guide).
- Separate meters that allow aggregation of all outdoor irrigation water use.
- Chilled water system efficiency at variable loads (kW/ton) or cooling loads (for non-chilled water systems).

- Cooling load.
- Air and water economizer and heat recovery cycle operation.
- Boiler efficiencies.
- Building specific process energy systems and equipment efficiency.
- Constant and variable motor loads.
- Variable frequency drive (VFD) operation.
- Air distribution, static pressure and ventilation air volumes.

Some of these items refer to the entire campus and some refer to the each building. It is likely that these credits could immediately be obtained since TAMIU has a modern building automation system.

EA Credit 5.4- Performance Measurement: Emission Reduction Reporting

The intent of this credit is to, "Document emission reduction benefits of building efficiency actions, retire a portion of the reductions and reduce emissions in the supply chain".[38] The requirements are outlined in the LEED-EB reference manual. This credit would need to be achieved on a building-by-building basis and is within the moderate retrofit work scope.

EA Credit 6- Documenting Sustainable Building Cost Impacts

By documenting the operation costs of the building from the previous five years and then documenting the changes in operating costs over the performance period, this credit can be obtained. This would need to be done on a building-by-building basis and is typically within the minor retrofit scope.

4.2.5 Materials and Resources Credits

MR Credit 1.1 and 1.2- Construction, Demolition and Renovation Waste Management

These credits are achieved by implementing a waste management policy for future building renovations, retrofits and modifications. The plan should "quantify diversions of construction, demolition and land-clearing debris from landfill and incineration disposal by weight or volume." By diverting 50% of this waste, one credit is achieved and by diverting 75% of this waste, the second credit is awarded. This policy could be implemented on a campus-wide basis and will require policy or operational procedure change.

MR Credit 2.1-2.5- Optimize Use of Alternative Materials

These credits involve implementing a sustainable purchasing plan. According to the LEED-EB reference guide, "one point (up to a maximum of five) will be awarded for each 10% of total purchases over the performance period (on a dollar basis) that achieve at least one of the following sustainability criteria:

- Contains at least 70% salvaged material from off site or outside the organization.
- Contains at least 70% salvaged from on site through an internal organization materials & equipment reuse program.
- Contains at least 10% post-consumer or 20% post-industrial material.
- Contains at least 50% rapidly renewable materials.
- Is Forest Stewardship Council (FSC) certified wood.

- Contains at least 50% materials harvested and processed or extracted and processed within 500 miles of the project”.[38]

The sustainable purchasing plan could be implemented on a campus-wide basis. One to two points could potentially be earned with a minor retrofit, with more points being earned with a more aggressive retrofit.

MR Credit 3.1-3.2- Optimize Use of IAQ Compliant Products

The purpose of these points is to “reduce the indoor air quality (IAQ) impacts of the materials acquired for use in the operation, maintenance and upgrades of buildings”.[38] One point is awarded, up to a maximum of 2 points, for each 45% of annual purchases calculated on a cost basis that conform with one of the sustainability criteria outlined in the LEED-EB reference guide. According to the Green Compass software, these credits could be earned with a minor retrofit. A campus-wide IAQ Compliant Products policy could be put in place.

MR Credit 4.1-4.3- Sustainable Cleaning Products and Materials

For these credits, “one point will be awarded for each 30% of the total annual purchases of cleaning and janitorial products (on a cost basis) that meet one of the following sustainability criteria:

- Cleaning products that meet the Green Seal GS-37 standard if applicable, OR if GS-37 is not applicable (e.g., for products such as carpet cleaners, floor finishes or strippers), use products that comply with the California Code of Regulations maximum allowable VOC levels.

- Disposable janitorial paper products and trash bags that meet the minimum requirements of U.S. EPA's Comprehensive Procurement Guidelines.[38]

Since TAMIU already has a campus-wide sustainable cleaning products policy, these points should be immediately achievable. An analysis will need to be done to determine the exact percentage of annual purchases of these types of products.

MR 5.1-5.3- Occupant Recycling

To earn these credits, TAMIU must "collect and recycle at least 95% of the batteries used, and collect and recycle at least 95% of the fluorescent light bulbs used.

AND

- Divert/Recycle 30% of total waste stream (by weight or volume) (1 point)
- Divert/Recycle 40% of total waste stream (by weight or volume) (2 points)
- Divert/Recycle 50% of total waste stream (by weight or volume) (3 points)"

This credit could be earned on a campus-wide or building-by-building basis. Since a waste stream audit has not, yet been performed, it is difficult to know what work scope is required to meet this credit; therefore, a moderate retrofit will be assumed.

MR 6- Additional Toxic Material Reduction: Reduced Mercury in Light Bulbs

This credit is achieved by "Maintaining mercury content of all mercury-containing light bulbs below 80 picograms per lumen hour of light output (picogram/lumen hour), on weighted average, for all mercury-containing light bulbs acquired for the existing building and associated grounds. This is likely done best on a building-by-building basis and will typically require a moderate to aggressive retrofit to implement.

4.2.6 Indoor Environmental Quality Credits

IEQ Credit 1- Outdoor Air Delivery Monitoring

To meet this credit, TAMIU must “install permanent monitoring systems that provide feedback on ventilation system performance to ensure that ventilation systems maintain minimum ventilation rates”.[38] There are three different options for this credit, all of which are outlined in the reference guide. This credit would need to be earned on a building-by-building basis and would require a moderate retrofit.

IEQ Credit 2- Increased Ventilation

By increasing outdoor air ventilation levels to all occupied spaces by at least 30% over the minimum required by ASHRAE 62.1-2004, this point will be earned. This would need to be done on a building-by-building basis and will typically require a moderate to aggressive retrofit.

IEQ Credit 3- Construction IAQ Management Plan

An Indoor Air Quality Management Plan as detailed in the LEED-EB reference guide must be implemented to earn this point. A campus-wide plan could be published that would be implemented any time a building is remodeled or renovated. Achieving this credit typically falls under the minor retrofit scope.

IEQ Credit 4.1- Documenting Productivity Impacts: Absenteeism and Health Care Cost Impacts

Earning this credit involves documenting absenteeism and health care costs for building occupants over the past five years and then documenting improvements due to sustainable building improvements. This would need to be done on a building-by-building basis and would require a policy or operational procedure change.

IEQ Credit 4.2- Documenting Productivity Impacts: Other Productivity Impacts

This credit involves documenting other improvements due to sustainable practices, beyond those of Credit 4.1, such productivity impacts. This credit could be earned on a building-by-building basis with a policy or operational procedure change.

IEQ Credit 5.1- Indoor Chemical and Pollutant Source Control: Non-Cleaning System – Reduce Particulates in Air Distribution

Through a minor retrofit, this credit can be earned by using filters with MERV 13 effectiveness or greater on all outside air intakes and return air grills. This credit would need to be achieved on a building-by-building basis.

IEQ Credit 5.2- Indoor Chemical and Pollutant Source Control: Non-Cleaning – Isolation of High-Volume Copying/Print Rooms/Fax Stations

This credit involves isolating high-volume copy, print, and fax machines through deck-to-deck partitions and separate exhaust systems. This would need to be done on a building-by-building basis and would require a moderate retrofit.

IEQ Credit 6.1- Controllability of Systems: Lighting

To meet the requirements for this point, lighting controls must be provided "for at least 50% of building occupants, enabling adjustments to suit individual task needs and preferences, or those of a group sharing a multi-occupant space or workgroup area".[38] The work scope to meet this credit will need to be evaluated for each building, but will typically fall under a moderate to aggressive retrofit scope.

IEQ Credit 6.2- Controllability of Systems: Temperature and Ventilation

Temperature and ventilation controls must be provided to at least 50% of building occupants, allowing them to adjust as desired. This credit would likely require a moderate to aggressive retrofit and would need to be earned on a building-by-building basis.

IEQ Credit 7.1-Thermal Comfort- Compliance

This credit is achieved by complying with ASHRAE Standard 55-2004, Thermal Comfort Conditions for Human Occupancy. According to the Green Compass software this would require a minor retrofit. This should be examined on a building-by-building basis.

IEQ Credit 7.2-Thermal Comfort- Permanent Monitoring System

To earn this point, TAMIU must "provide a permanent monitoring system to ensure building performance to the desired comfort criteria as determined by IEQ Credit 7.1, Thermal Comfort: Compliance".[38] This would require a moderate to aggressive retrofit and would need to be achieved on a building-by-building basis.

IEQ Credit 8.1 & 8.2-Daylight and Views: Daylight

This credit involves using daylighting in occupied spaces in the buildings. It would need to be earned on a building-by-building basis and the work scope will vary from building to building. For instance, some buildings may have already achieved this credit, while in others it may be unachievable. The point schedule is as follows[38]:

- IEQ Credit 8.1: Achievement of a 2% daylight factor in 50% of all spaces occupied for critical visual tasks. (1 point)

• IEQ Credit 8.2: Achievement of a 2% daylight factor in 75% of all spaces occupied for critical visual tasks. (1 point)

IEQ Credit 8.3 & 8.4-Daylight and Views: Views

These credits involve giving building occupants views to the outdoors. Once again, these credits may already be achieved in some spaces, while unachievable in others. The point schedule is as follows:

• IEQ Credit 8.3: Achieve direct line of sight to vision glazing for building occupants from 45% of regularly occupied spaces. (1 point)

• IEQ Credit 8.4: Achieve direct line of sight to vision glazing for building occupants from 90% of regularly occupied spaces. (1 point)

IEQ Credit 9- Contemporary IAQ Practice

To earn this credit, TAMIU must "develop and implement on an ongoing basis an IAQ management program for buildings based on the EPA document "Building Air Quality: A Guide for Building Owners and Facility Managers," EPA Reference Number 402-F-91-102, December 1991, which is available on the EPA Web site, www.epa.gov/iaq/largebldgs/graphics/iaq.pdf.[38] This plan could be implemented campus-wide and typically falls within the minor retrofit scope of work.

IEQ Credit 10.1- Green Cleaning- Entryway Systems

For this credit, entryway systems (grills, grates, mats etc.) must be used "to reduce the amount of dirt, dust, pollen and other particles entering the building at all entryways, and develop the associated cleaning strategies to maintain those entryway systems, as well as the exterior walkways".[38] If these systems are not already in place, it would require a moderate to aggressive retrofit. This credit will need to be earned on a building-by-building basis.

IEQ Credit 10.2- Green Cleaning-Isolation of Janitorial Closets

To meet the requirements for this credit, TAMIU must use "structural deck-to-deck partitions with separate outside exhausting, no air re-circulation and negative pressure in all janitorial closets".[38] Additionally, special care must be taken for disposal of janitorial chemicals. This credit would need to be earned on a building-by-building basis and would require a moderate to aggressive retrofit if the facilities are not already in place.

IEQ Credit 10.3- Green Cleaning- Low Environmental Impact Cleaning Policy

Earning this credit would involve implementing a green cleaning policy that addresses the following points:

- "Sustainable cleaning systems.
- Use of sustainable cleaning products.
- Use of chemical concentrates and appropriate dilution systems.
- Proper training of maintenance personnel in the hazards, use, maintenance and disposal of cleaning chemicals, dispensing equipment and packaging.
- Use of hand soaps that do not contain antimicrobial agents (other than as a preservative system), except where required by health codes and other regulations (i.e., food service and health care requirements).
- Use of cleaning equipment that reduces impacts on IAQ." [38]

The plan could be implemented on a campus-wide basis, but will typically require a moderate to aggressive retrofit scope of work.

IEQ Credit 10.4 & 10.5- Green Cleaning- Low Environmental Impact Pest Management Policy

For these credits, a Low Impact Indoor Pest Management Policy must be implemented that requires that any cleaning products integrated into the pest management policy follow the requirements found in MR Credit 4.1-4.3. TAMIU has a low environmental impact pest management policy for outdoors, but not for the indoors. An indoor policy could be implemented on a campus-wide basis and the work scope would be that of a minor retrofit.

IEQ Credit 10.6- Green Cleaning- Low Environmental Impact Cleaning Equipment Policy

Achieving this credit would require implementing "a policy for the use of janitorial equipment that maximizes effective reduction of building contaminants with minimum environmental impact"[38] as outlined in the LEED-EB reference guide. This policy would need to be implemented on a building-by-building basis and will typically require a moderate to aggressive retrofit.

4.2.7 Innovation in Upgrades, Operations and Maintenance Credits

IUOM Credit 1- Innovations in Upgrades, Operations, and Maintenance

This credit is for additional environmental benefits achieved beyond those already addressed by LEED-EB Rating System. One point could be achieved by implementing a sustainability education program through placing signage around the buildings identifying green elements and providing staff and students with education and updates about the sustainable aspects and operation of the campus. This could be done campus-wide and is achievable as-is. Up to three additional points could be earned for other innovations.

IUOM Credit 2-LEED AP

To earn this credit, at least one principal member of the project team must be a LEED Accredited Professional. This credit is achievable as is, since the ESL has several LEED Accredited Professionals.

4.2.8 Summary and Recommendations

This section will examine the credits to see which ones are most readily achievable for TAMIU. As mentioned when discussing specific credits, some credits may be achievable as is for some buildings while unachievable for others (such as the daylight and views credits). This summary is for the campus as a whole. A detailed analysis of each building should be performed before applying for certification. As discussed in the Prerequisites section, all prerequisites must be met before any credits may be earned. Once the prerequisites are met, TAMIU has a choice as to which level of certification they wish to achieve for each building.

Credits which are achievable as-is include:

- SS Credit 3.1- Alternative Transportation: Public Transportation Access
- SS Credit 4.1 and 4.2- Reduced Site Disturbance–Protect or Restore Open Space
- EA Credit 4- Additional Ozone Protection
- EA Credit 5.1 – 5.3-Performance Measurement- Enhanced Metering

- MR Credit 4.1-4.3- Sustainable Cleaning Products and Materials
- IUOM Credit 1- Innovations in Upgrades, Operations, and Maintenance
- IUOM Credit 2-LEED AP

These twelve credits give TAMIU a great start toward getting buildings LEED certified. Other than the documentation, these credits will not involve a lot of work to complete. Once these credits have been earned, those credits that involve a policy or operational procedure change or a minor retrofit should be examined.

Credits achievable with a policy or operational procedure change include:

- SS Credit 1.1 and 1.2- Plan for Green Site and Exterior Management
- EA Credit 3.1- Building Operations and Maintenance: Staff Education
- MR Credit 1.1 and 1.2- Construction, Demolition and Renovation Waste Management
- IEQ Credit 4.1- Documenting Productivity Impacts: Absenteeism and Health Care Cost Impacts
- IEQ Credit 4.2- Documenting Productivity Impacts: Other Productivity Impacts

Credits achievable through a minor retrofit include:

- SS Credit 3.3- Alternative Transportation: Alternative Fuel Vehicles
- SS Credit 3.4- Alternative Transportation: Car Pooling and Telecommuting
- SS Credit 5.1 - Stormwater Management: Rate and Quantity Reduction
- SS Credit 7- Light Pollution Reduction
- EA Credit 1.1-1.4- Optimize Energy Performance

- EA Credit 3.2- Building Operations and Maintenance: Building Systems Maintenance
- EA Credit 6- Documenting Sustainable Building Cost Impacts
- MR Credit 2.1-2.2- Optimize Use of Alternative Materials
- MR Credit 3.1-3.2- Optimize Use of IAQ Compliant Products
- IEQ Credit 3- Construction IAQ Management Plan
- IEQ Credit 5.1- Indoor Chemical and Pollutant Source Control: Non-Cleaning System – Reduce Particulates in Air Distribution
- IEQ Credit 7.1-Thermal Comfort- Compliance
- IEQ Credit 9- Contemporary IAQ Practice
- IEQ Credit 10.4 & 10.5- Green Cleaning- Low Environmental Impact Pest Management Policy

If TAMIU decided to complete all 27 of these credits, along with the 12 credits designated as “Achievable As-Is”, each building will have met 39 credits, and will receive a LEED Certified designation from having met between 32 and 39 credits. If a higher designation is desired, other credits would have to be explored.

There are several credits in the “Moderate to Aggressive Retrofit” work scope that might actually require only a minor retrofit in certain buildings or possibly be achievable as-is in certain buildings. A list of the credits in that would likely require a moderate to aggressive retrofit are listed below:

- SS Credit 3.2- Alternative Transportation: Bicycle Storage and Changing Rooms *may be achievable as-is for certain buildings*

- SS Credit 5.2- Stormwater Management: Rate and Quantity Reduction
- SS Credit 6.1- Heat Island Reduction, Non-Roof
- SS Credit 6.2- Heat Island Reduction, Roof
- WE Credit 1.1 and 1.2- Water-Efficient Landscaping- Reduce Water Use
- WE Credit 2- Innovative Wastewater Technologies
- WE Credit 3.1 and 3.2- Water Use Reduction
- EA Credit 1.5-1.10- Optimize Energy Performance
- EA Credit 2- On-site and Off-site Renewable Energy
- EA Credit 3.3- Building Operations and Maintenance: Building Systems Monitoring
- EA Credit 5.4- Performance Measurement: Emission Reduction Reporting
- MR Credit 2.3-2.5- Optimize Use of Alternative Materials
- MR 5.1-5.3- Occupant Recycling
- MR 6- Additional Toxic Material Reduction: Reduced Mercury in Light Bulbs
- IEQ Credit 1- Outdoor Air Delivery Monitoring
- IEQ Credit 2- Increased Ventilation
- IEQ Credit 5.2- Indoor Chemical and Pollutant Source Control: Non-Cleaning – Isolation of High-Volume Copying/Print Rooms/Fax Stations
- IEQ Credit 6.1- Controllability of Systems: Lighting
- IEQ Credit 6.2- Controllability of Systems: Temperature and Ventilation
- EQ Credit 7.2-Thermal Comfort- Permanent Monitoring System

- IEQ Credit 8.1 & 8.2-Daylight and Views: Daylight *may be achievable as-is for certain buildings*
- IEQ Credit 8.3 & 8.4-Daylight and Views: Views *may be achievable as-is for certain buildings*
- IEQ Credit 10.1- Green Cleaning- Entryway Systems
- IEQ Credit 10.2- Green Cleaning-Isolation of Janitorial Closets
- IEQ Credit 10.3- Green Cleaning- Low Environmental Impact Cleaning Policy
- IEQ Credit 10.6- Green Cleaning- Low Environmental Impact Cleaning Equipment Policy

When deciding which of these credits to pursue, it may be a good idea to see if the credit could be achieved on a campus-wide basis or would need to be met on a building-by-building basis. Those credits which can be applied on a campus-wide may be more desirable since the documentation process will require less work for these credits. Table 12 summarizes which credits must be achieved on which basis.

Campus-Wide Basis	Building-by-Building Basis	Either/Both
Prerequisites		
SS 1- Erosion and Sedimentation Control	SS 2- Age of Building	MR 1.1- Source Reduction and Waste Management: Waste Management Policy and Waste Stream Audit
EA 3-Ozone Depletion	WE 1- Minimum Water Efficiency	
MR 1.2- Source Reduction and Waste Management: Storage and Collection of Recyclables	EA 1- Existing Building Commissioning	
MR 2- Toxic Material Source Reduction: Reduced Mercury in Light Bulbs	EA 2- Minimum Energy Performance	
IEQ 2- Environmental Tobacco Smoke (ETS) Control	IEQ 1- Outside Air Introduction and Exhaust Systems	
Campus-Wide Basis	**Building-by-Building Basis**	**Either/Both**
IEQ Prereq 3- Asbestos Removal and Encapsulation		
IEQ Prereq 4- Polychlorinated Biphenyl (PCB) Removal		
Credits		
SS 1.1 and 1.2- Plan for Green Site and Exterior Management	SS 3.2- Alternative Transportation: Bicycle Storage and Changing Rooms	SS 5.1 and 5.2- Stormwater Management: Rate and Quantity Reduction
SS 2- High Development Density Building Area	SS 6.2- Heat Island Reduction, Roof	EA 2- On-site and Off-site Renewable Energy
SS 3.1- Alternative Transportation: Public Transportation Access	WE 2- Innovative Wastewater Technologies	EA 5.1 – 5.3-Performance Measurement- Enhanced Metering
SS 3.3- Alternative Transportation: Alternative Fuel Vehicles	WE 3.1 and 3.2- Water Use Reduction	MR 5.1-5.3- Occupant Recycling
SS 3.4- Alternative Transportation: Car Pooling and Telecommuting	EA 1- Optimize Energy Performance	
SS 4.1 and 4.2- Reduced Site Disturbance–Protect or Restore Open Space	EA 3.3- Building Operations and Maintenance: Building Systems Monitoring	
SS 6.1- Heat Island Reduction, Non-Roof	EA 5.4- Performance Measurement: Emission Reduction Reporting	
SS 7- Light Pollution Reduction	EA 6- Documenting Sustainable Building Cost Impacts	

Table 12: Basis on Which Each Credit May Be Achieved

WE 1.1 and 1.2- Water-Efficient Landscaping- Reduce Water Use	MR 6- Additional Toxic Material Reduction: Reduced Mercury in Light Bulbs	
EA 3.1- Building O&M: Staff Education	IEQ 1- Outdoor Air Delivery Monitoring	
EA 3.2- Building Operations and Maintenance: Building Systems Maintenance	IEQ 2- Increased Ventilation	
EA 4- Additional Ozone Protection	IEQ 4.1- Documenting Productivity Impacts: Absenteeism and Health Care Cost Impacts	
MR 1.1 and 1.2- Construction, Demolition and Renovation Waste Management	IEQ 4.2- Documenting Productivity Impacts: Other Productivity Impacts	
MR 2.1-2.5- Optimize Use of Alternative Materials	IEQ 5.1- Indoor Chemical and Pollutant Source Control: Non-Cleaning System – Reduce Particulates in Air Distribution	
MR 3.1-3.2- Optimize Use of IAQ Compliant Products	IEQ 5.2- Indoor Chemical and Pollutant Source Control: Non-Cleaning – Isolation of High-Volume Copying/Print Rooms/Fax Stations	
Campus-Wide Basis	**Building-by-Building Basis**	**Either/Both**
MR 4.1-4.3- Sustainable Cleaning Products and Materials	IEQ 6.1- Controllability of Systems: Lighting	
IEQ 3- Construction IAQ Management Plan	IEQ 7.1-Thermal Comfort- Compliance	
IEQ 9- Contemporary IAQ Practice	IEQ 7.2-Thermal Comfort- Permanent Monitoring System	
IEQ 10.3- Green Cleaning- Low Environmental Impact Cleaning Policy	IEQ 8.1 & 8.2-Daylight and Views: Daylight	
IEQ 10.4 & 10.5- Green Cleaning- Low Environmental Impact Pest Management Policy	IEQ 8.3 & 8.4-Daylight and Views: Views	
IUOM 1- Innovations in Upgrades, Operations, and Maintenance- Educational System	IEQ 10.1- Green Cleaning- Entryway Systems	
IUOM 2-LEED AP	IEQ 10.2- Green Cleaning-Isolation of Janitorial Closets	
	IEQ 10.6- Green Cleaning- Low Environmental Impact Cleaning Equipment Policy	

Table 12 (Continued)

While some of the prerequisites will present a challenge, Certified and Silver certification levels should require a relatively low amount of work to achieve since TAMIU already has many sustainable practices in place.

CHAPTER V

SUMMARY

This thesis examined ways to reduce energy consumption in a university building. First, occupancy-based controls that would shut off lighting, utilize power management features on computer equipment, and reduce airflow when a space is unoccupied were examined. It was found that 75% of chilled water, 67% of hot water, 86% of HVAC electricity, and 60% of lighting and computer electricity could be saved annually in an office at Texas A&M University. This amounts to an estimated annual savings of $525. The same controls were applied to the proposed green building at TAMIU and it was found that 82% of chilled water, 96% of hot water, 57% of HVAC electricity, and 46% of lighting and computer electricity could be saved annually. This amounts to an estimated $203,422 annual savings from using these controls.

Secondly, advanced building technologies used at the Intelligent Workplace were examined to see if TAMIU should consider implementing them in an advanced technology test bed in the new green building. Biodiesel cogeneration was found to be economically infeasible using the loads calculated for the building. This type of cogeneration system could be examined for backup generation but should not be used for the main power supply. A feasibility calculation for a radiant heating and cooling system with ventilation was performed and it was estimated that using one of these systems could have potential in the Student Success Center (SSC) at TAMIU if the building envelope is designed correctly. Displacement ventilation could be implemented for research purposes in the test bed, but should not be implemented on a broader basis until more is known about the performance of these systems in hot and humid climates. Daylighting should be used in the new building, but designers should be careful to ensure that solar gains into the building are not significantly increased with the addition of daylighting.

Thirdly, a sustainability assessment of the current TAMIU campus was performed. Several good practices and areas for improvement were identified in the areas of energy, water, waste and recycling, built environment, transportation, land use, consumable supplies and equipment, food, health and well-being, sustainability-related courses and research, sustainability-related campus organizations, and sustainability and campus leadership. Additionally, the current TAMIU campus was examined to see what scope of work would be required to achieve LEED certification from the US Green Building Council. It was found that 39 credits are either achievable as-is, achievable with a policy change, or achievable with a minor retrofit scope. Achievement of 32-39 credits would allow TAMIU to receive a LEED-certified rating for existing buildings.

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APPENDIX: SUSTAINABILITY ASSESSMENT AND ROADMAP FOR A GREEN CAMPUS INITIATIVE FOR TEXAS A&M INTERNATIONAL UNIVERSITY

ESL-TR-06-10-01

DRAFT:

Sustainability Assessment and Roadmap for a Green Campus Initiative

Texas A&M International University
Laredo, Texas

Prepared By
Energy Systems Laboratory
Texas Engineering Experiment Station
College Station, Texas
October, 2006

Disclaimer

Acknowledgments

This report was prepared by staff of the Energy Systems Laboratory, Texas Engineering Experiment Station, Texas A&M University System as part of a technical transfer initiative for high performance buildings funded in part by a US Department of Energy award to Carnegie Mellon University's Advanced Building Energy Technology Initiative.

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The ESL also acknowledges the outstanding vision and leadership of President Ray M Keck, III who immediately recognized the potential of this initiative for the future of TAMIU, its students, faculty, staff, and the community it serves in the vibrant Laredo economy and sensitive environment. His initial reaction to this concept was, "What's not to like!" His commitment to a realistic, sustainable, Green Campus Initiative is without parallel in the Texas A&M System and serves as an outstanding example for his counterparts to follow.

Sustainability Assessment "Green Team"

Special thanks goes to the TAMIU "Green Team" whose commitment and enthusiasm for this project make it possible for this assessment by the ESL. We would like to acknowledge all who have taken time out of their busy work schedules to meet concerning this initiative.

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Foreword

This document was produced by the Energy Systems Laboratory of the Texas Engineering Experiment Station, to provide a practical first-step to Texas A&M International University's quest for a more sustainable future. This is a living document that should be referenced often, critically questioned, and improved through constant input from University leaders, staff, students, and others to preclude it becoming obsolete. The authors believe that this is only the beginning of a long, rewarding, more sustainable path for the University, now and in the future. It will also serve as a model for the Texas A&M System and the surrounding Community to subscribe.

Executive Summary

Texas A&M International University and the Energy Systems Laboratory of the Texas Engineering Experiment Station have partnered to conduct a campus sustainability assessment and create a subsequent campus sustainability plan for TAMIU. This sustainable campus initiative will make TAMIU a leader in efficient and environmentally friendly campuses throughout the A&M system and the State.

Energy System Laboratory conducted a site visit and interview TAMIU management, staff, contractors, and student representatives to obtain data for this assessment. The current progress, good practices, and opportunities for TAMIU are discussed for four areas:

- Resource Conservation
- Campus Infrastructure
- Health and Well-Being
- Academics and Culture

The investigation revealed several points where TAMIU is already performing well and also revealed many opportunities. The authors of this assessment see the following areas as major opportunities. They are divided into immediate opportunities and areas that warrant additional study.

Resource Conservation

Immediate Opportunities	Areas that Need Further Investigation or Time
• Make energy conservation numbers easily available to faculty, staff, and students	• Investigate purchase of green power through the TAMU system electricity contract
• Commission buildings that have not yet been commissioned and any buildings that are showing poor performance	• Investigate the use of local natural gas
• Investigate use of more solar-powered illumination like the illumination for the signage at the entrance to campus	• Investigate the use of clean diesel for standby generators
• Implement a water conservation awareness program that will educate students and staff on the importance of water conservation and encourage conservation of water	• Continue investigation of irrigation control based on measured evapo-transpiration
• Continue pursuit of use of gray water from the City of Laredo for sustainable irrigation	• Continue to investigate viable uses(s) for AHU condensate
• Continue to press for evaporation sewer allowance for cooling tower water	• Investigate viability of mulching for water conservation
• Consider using waterless urinals in new construction	• Further investigate opportunity for composting
• Quantify recycling (document and further publicize)	

Campus Infrastructure

Immediate Opportunities

- Create a statement of how energy efficiency and other sustainability issues will be considered in future construction
- Set up preferred parking for alternative fuel and hybrid vehicles in visible, choice locations
- See if the city can add a bike rack to the bus line that comes to campus
- Encourage departments to choose Energy STAR equipment and appliances

Areas that Need Further Investigation or Time

- Assess opportunity for LEED-NC certification of the Student Success Center
- Assess potential for LEED-EB certification of the existing campus
- Investigate incentives to encourage carpooling
- Complete Campus Loop
- Facilitate the use of more bicycles
- Investigate heat island mitigation strategies
- Investigate use of retention pond for storm water
- Implement an green purchasing policy

Health and Well-Being

Immediate Opportunities

- Increase availability of sustainable food products such as organic and hormone free foods (if there's interest)
- Mitigate waste materials from food service
- Implement green custodial plan and practices
- Use low VOC materials for carpeting and paint
- Encourage neutralizing acid/base combinations as part of teaching process to eliminate these wastes and teach about waste disposal issues.

Areas that Need Further Investigation or Time

- Investigate use of food scrap as animal food source
- Plan for dish washing facilities in new campus dining center

Academics and Culture

Immediate Opportunities

- Get students involved through course project participation
- Insert sustainability related modules in existing courses
- Create activities that foster participation in and awareness of sustainability (such as adopt-a-road, earth day, etc.)

Areas that Need Further Investigation or Time

- Implement green campus initiative based on this assessment report

Next Steps

The next steps for TAMIU are to put together an action plan that will make sustainable practices part of the University policy. The implementation plan should address the steps that they plan to make and show a timeline for completion of these steps.

Recommended steps:

- Finalize assessment plan
- Adopt University policy on Sustainable Campus
- Adopt action plan
- Create permanent Green Team and assign responsibilities for implementation

- Identify and secure implementation funding and personnel
- Actively involve students in planning and implementation
- Annually review progress and update implementation plan

Benefits

A Sustainable Campus initiative will have many short and long term benefits as follows:

- Reduced utility expenses (as much as 50% in new construction)
- Improved indoor air quality
- Improved learning environment
- Reduced air, land, and water impacts on environment
- Create new generation of resource and energy conscious graduates
- Creates benchmark for others in the Valley to follow
- Identifies TAMIU as a regional and national leader in sustainable educational advancements

This project will have significant impact on the University, local community, and Texas A&M University System as well as its international neighbors in Mexico.

Table of Contents

Introduction

Background

Texas A&M University and Carnegie Melon University (CMU) have a three-year Department of Energy grant to study Advanced Building Systems for high-performance buildings to significantly reduce energy use. One goal of the grant is to transfer and replicate approaches that are being researched at CMU in a TAMU facility or building. All Texas A&M System campuses were considered, but TAMIU seemed to be an ideal candidate based on its size, age, and expansion plans. TAMIU leaders also expressed interest in creating a Sustainable Campus Initiative that could include Advanced Building Systems technologies to reduce energy consumption. ESL employees agreed to facilitate a Sustainability Assessment and subsequent Sustainability Roadmap. Representatives from ESL met with TAMIU administration in June 2006 to kick off the project and decided to begin the Sustainability Assessment part of the Sustainable Campus Initiative immediately. In August 2006, ESL and TAMIU staff met to explore areas where TAMIU has existing excellent sustainable practices and explore areas of opportunity.

Sustainability Defined

There are many different definitions of sustainability, but one of the most widely accepted is "meeting the needs of the present without compromising the ability of future generations to meet their own needs." Most see minimizing the impact on the environment and conserving natural resources as key aspects of sustainability. Some view it as an ideal, "Sustainability is an ideal end-state. ….it is a lofty goal whose perfect realization eludes us" (Alan Atkinson, *The Compass of Sustainability*, 1998), while others see it as an attainable goal. Some of the many indicators of campus sustainability include energy and water consumption, building technology, decision making processes, and curriculum.

Relevance

Texas A&M International University in Laredo, Texas has the unique opportunity to become a sustainability leader for the Texas A&M University System, the State, and the local community. TAMIU is in a great position to become a sustainability leader because their campus is relatively new (opened in 1995), the university leaders are excited about sustainability, and the university generally has a "let's try it" attitude. Thanks to this positive attitude, TAMIU already has many excellent sustainable practices. TAMIU is also unique in that 75-80% of its enrollment is first generation college students. Additionally, most of the students on campus (70-75%) are from the Laredo area. Many of the students do not have preconceived notions about campus life and since the university is young, there is not a stigma of doing things the way that they have always been done. These factors create the perfect environment for a successful sustainable campus initiative.

Approach

TAMIU is growing rapidly in enrollment, which means the campus will continue to add buildings to keep up with the rapid growth. Currently, the campus consists of ten primary classroom, laboratory and office buildings, the Residential Learning Center dormitories, the University Village Apartments, and the physical plant. There is ongoing construction to finish a theater in the Center for the Fine and Performing Arts and an addition to the Kinesiology

Building is underway. In the next few years the university plans to complete the Campus Loop drive to ease transportation in and around campus and to construct a Student Success Center. There may be opportunity for the Laredo Children's Museum to relocate the TAMIU campus in about 5 years in a LEED™ Gold Building. The Leadership in Energy and Environmental Design (LEED) Green Building Rating System™ is the nationally accepted benchmark for the design, construction, and operation of high performance green buildings.

All of this activity creates tremendous opportunity to implement green initiatives at TAMIU. To control utility expense, efficient operation is not only an option but a "must" as energy and water costs will continue to rise. Energy prices have increased over 50 % in the last two years due to rising natural gas prices.

Assessment Areas

This assessment examines several areas under the broad categories of:

1) Resource Conservation,
2) Campus Infrastructure,
3) Health and Well-Being, and
4) Academics and Culture.

In each area, the importance to sustainability is discussed and TAMIU's existing practices and key opportunities are listed.

Purpose

The purpose of this assessment report is to identify existing green practices and identify opportunities for a TAMIU Green Campus Initiative for a Roadmap to a more sustainable campus.

Texas A&M International University
Campus Sustainability Assessment

Resource Conservation

Energy

Water

Waste and Recycling

Energy

Both energy consumption and energy sources are important components of sustainability. By operating efficiently, a campus can conserve vital resources, save money, and decrease pollution from reduced generation that often leads to air emissions, acid precipitation, and climate change. Important areas to consider are building lighting and plug loads, HVAC consumption, and transportation energy. By purchasing green power, universities can contribute to a more secure and healthy energy future.

Building Energy Consumption

The Energy Systems Laboratory (ESL) of the Texas Engineering Experimentation Station performed Continuous Commissioning®[1] on 408,000 ft^2 of campus space beginning in June 2000. Additional CC® projects were performed for the Center for Western Hemispheric Trade and the Student Center. The CC® report was published in June 2004. Since commissioning, the Lamar Bruni - Vergara Science Center and the Residential Learning Center have been added. These buildings should be commissioned and the previously commissioned buildings should be analyzed to see if they would benefit from re-commissioning. The Residential Learning Center and University Village Apartments are run by an external dorm management company.

Many more additions are planned for the TAMIU campus. Currently, the Kinesiology Building is being expanded and the theater in the Fine Arts Building is being completed. A Student Success Center is planned to come online in 2008-2009. As these new buildings are opened, it will be necessary to commission them to achieve optimum energy consumption and occupant comfort.

The plant on campus has four 1000 ton chillers, a heat pump and two boilers. During the hottest days of the year they use 1 ½ chillers. The boilers are turned off during the summer and the heat pump provides any hot water needed. There are 5 diesel standby energy generators. All building HVAC systems are controlled through a modern Siemens Direct Digital Control system. The gas usage and cost for the campus from September 2003 to June 2006 can be seen in Figure 1, and the monthly metered electricity usage for the past few years is shown in Figure 2.

[1] Continuous Commissioning and CC are registered trademarks of the Texas Engineering Experiment Station.

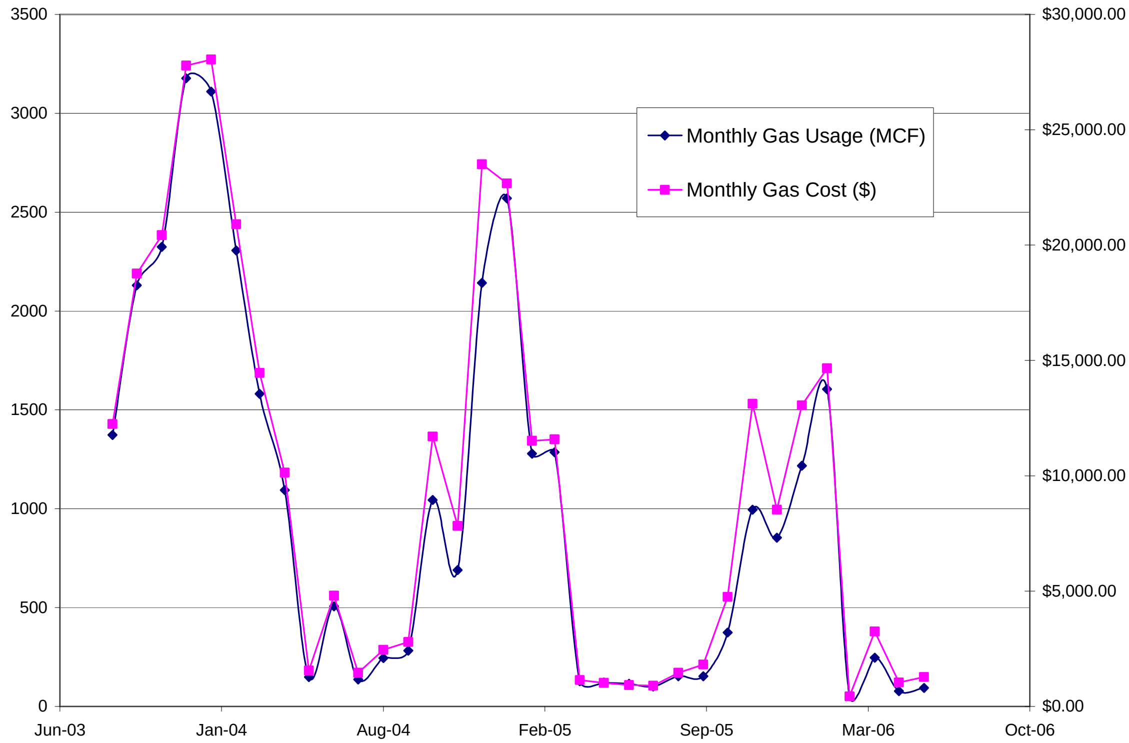


Figure 1: TAMIU Gas Usage September 2003-June 2006

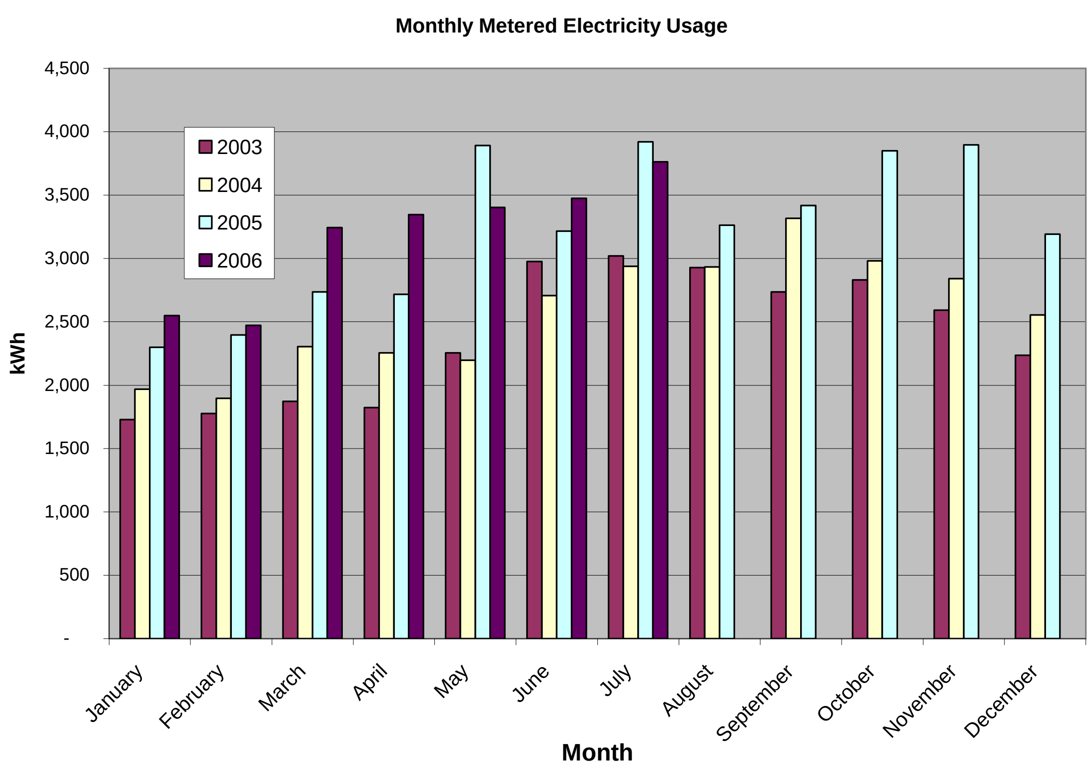


Figure 2: Monthly Metered Electricity Usage

Vehicle Energy Consumption

TAMIU has five gasoline vehicles in their fleet: 2 police cars, 1 Physical Plant pickup truck, 1 van that departments can rent, and 1 mail van. The remainder of the fleet consists of 20 golf carts, 19 of which are electric. Grounds maintenance has four riding lawn mowers and 1 tractor. TAMIU is unique in that 76% of its vehicle fleet is alternative fuel (electric) vehicles. By using golf carts rather than gas-powered vehicles to move in and around campus, TAMIU saves considerable transportation energy and reduces the environmental impact. This is one area where current practices really stand out.

Energy Sources

Campus electricity is competitively bid annually for the TAMU system and is negotiated by the Energy Systems Laboratory. TAMIU staff does not know if any renewable sources are used in off-site energy generation purchases. On campus, they have one solar panel to illuminate campus signage at the campus entrance. They would like to add more solar panels to light the other campus signage. Another solar panel is being installed to power the controller for the sprinkler system on the band field.

Figure 3: Solar Panel that Provides Lighting to Campus Signage

Energy Tracking and Education

TAMIU participates in the Governor’s initiative to save energy. They also have an internal program to educate staff and students about saving energy, which includes stickers on manual light switches reminding building users to save energy. The website and campus newsletter advertise the campus energy plan but have never reported energy use numbers. Electricity sub-meters exist in all auxiliary enterprise buildings and there is an electronic meter in the science building to facilitate energy tracking.

Good Practices

- Many campus buildings have been commissioned

- Campus buildings use Direct Digital Control, allowing for accurate monitoring and easy changes
- Low vehicle fleet energy consumption
- Solar panel used to light campus signage with plans for more solar panels
- Have energy goals pursuant to Governor's executive order
- Internal energy awareness program
- Building sub-metering

Opportunities

- Assess potential for additional building commissioning and energy retrofits
- Commission buildings, such as the science center, that have not yet been commissioned
- Commission new buildings as they come online
- Encourage students living on campus to conserve energy in their dorms or apartments. Consider using an incentive program or competition.
- Put a clause into contract with dorm management companies saying that green buildings are required on campus
- Investigate the use of local natural gas
- Investigate the use of clean diesel for standby power generators
- Investigate purchase of green electric power, such as wind power or other renewable energy sources, through the TAMU system electricity contract
- Make energy consumption numbers easily available for faculty, staff, and students
- Investigate the use of additional solar-powered illumination
- Track Energy Utilization Index (EUI)

Water

Water is an essential but limited natural resource, and its efficient use and protection from pollution are required to meet the needs of an increasing population (2). In Laredo, where all water comes from the Rio Grande River, water conservation is especially important. TAMIU has the opportunity to be a leader to the community through exceptional practices by demonstrating how to incorporate sustainable water use and planning into all areas of operations. Reducing wastewater production is also important as it reduces sewage costs, reduces energy used to transport and treat the wastewater, and decreases the amount of chemicals needed in the treatment process. By tracking water usage and educating students and staff, water savings methods can continue to be successful in the long-term.

Current Water Practices

For the first 11 months of FY 2006, the total water consumption at TAMIU totaled 96.5 million gallons. An overwhelming 80% of the total water consumption is used for irrigation, with only 6% used within the campus buildings. The central plant water is overwhelmingly used as cooling tower make-up. Figure 4 shows the breakdown of campus water usage. Of the 300 acres of space on campus, only 125 are developed. These 125 acres include the buildings and are the only areas that are irrigated. All of the water is acquired from the city, which comes from the Rio Grande River.

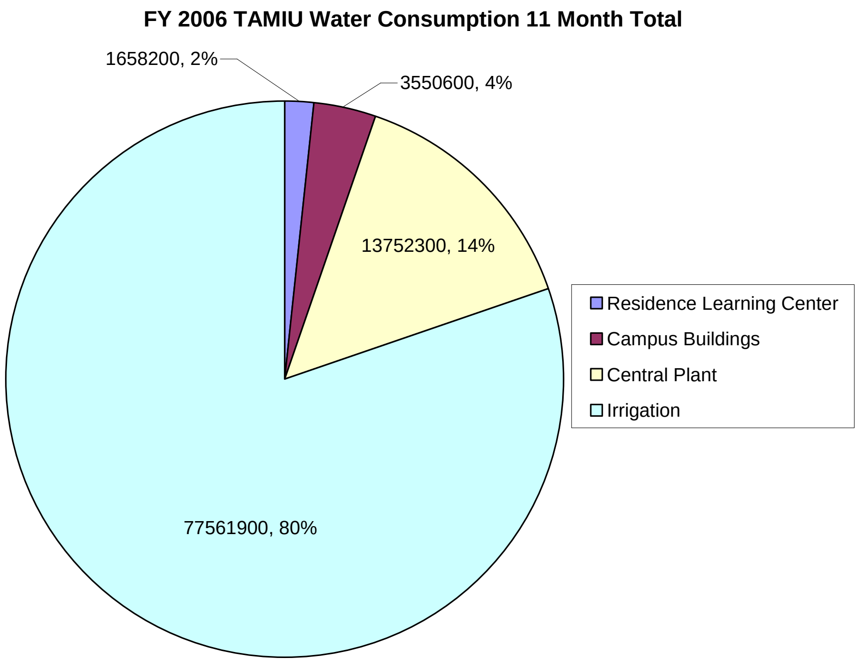


Figure 4: Breakdown of Campus Water Consumption

TAMIU has looked at alternative water sources and have concluded that a well is not viable since well water in the area is generally salty. The most viable option for irrigation water appears to be a treated effluent line (or “gray water” line) from the city that runs along the Bob Bullock Loop, which passes by the university (See Figure 5). This effluent line is presently used as an irrigation source for two golf courses. The university may be able to purchase this water at less cost than potable city water. The irrigation system could easily be converted to using this gray water. Campus gray water production is not feasible since the overwhelming majority of water consumption is irrigation and cooling tower makeup.

Figure 5: Location of TAMIU in Laredo

Some important water reduction steps have been implemented. A new centralized irrigation system should control irrigation better and result in savings. Dr. Tobin of TAMIU has been working with the physical plant to see if they can couple a local weather station with the sprinkler system to better control irrigation based on evapo-transpiration rates. The university does use drought-tolerant plants but they also must be deer-proof. The campus has policies requiring native vegetation to remain in undeveloped areas of the campus.

The typical rainfall in Laredo is 16-20 inches per year, so there may be potential for a rainwater runoff retention pond. However, in the last year there was only 6 inches of total rainfall. AHU condensate is a more constant source of water that is not currently utilized.

Low-flow shower heads and toilets are used in the dormitories and other locations on campus, and there is excellent submetering on campus. There are no apparent programs on campus to encourage students and staff to conserve water.

Wastewater

The university recently began incorporating data on sewer fees. The physical plant does have a submeter on the cooling tower makeup line, but they do not receive a financial credit from the city for cooling tower evaporation. They have been lobbying with the city for three years over an evaporation credit. The university ensures that wastewater is not contaminated by Hazardous Waste. All chemicals are disposed of through the Hazardous Waste Disposal EOG and are not put down the drain.

Good Practices

- Automated irrigation control system
- Ongoing water conservation research
- Drought-tolerant vegetation
- Low-flow shower heads and toilets used in dormitories
- Excellent sub-metering
- Wastewater is kept free of hazardous chemical waste

<u>Opportunities</u>

- Implement a water conservation awareness program that will educate students and staff on the importance of water conservation and encourage conservation of water
- Continue pursuit of use of gray water from the City of Laredo for irrigation
- Continue investigation of irrigation control based on measured evapo-transpiration
- Continue to press for evaporation sewer allowance for cooling tower water
- Continue to investigate viable use(s) for AHU condensate
- Investigate viability of mulching for water conservation
- Investigate use of retention pond for irrigation water
- Consider using waterless urinals in new construction and/or as a demonstration

Waste and Recycling

Universities can generate a tremendous amount of solid waste. Between minimization and recycling of waste, we can greatly reduce the amount of waste that ends up in landfills. Recycling programs must be convenient and accessible to faculty, staff and students to be effective. Hazardous waste, though a small percentage of total campus waste, poses a large risk to handlers and to the environment and must be handled accordingly.

General Waste

TAMIU uses a program run by the City of Laredo for recycling all paper, metal, cardboard, and plastic. They will not take Styrofoam™ or glass. The recyclables are picked up and separated by the city, making it convenient for the university to participate. The city provides blue bags for these recyclables that are distributed to all university departments who are interested in participating. Additional recycling boxes are placed by main copiers and printers. The custodian takes the bags to a central location daily and the city retrieves them weekly. Currently, the university is in need of a second weekly pickup to accommodate for the large response to the program, but the city has been unable to provide one. The university advertises the program with blue recycling bins and provides detailed information once a year in the safety newsletter. There is currently no quantification of the recycling efforts so it is difficult to know what effect the program has had on waste mitigation.

Figure 6: Picture of TAMIU Recycling Container

In addition to these common recyclables the university recycles batteries, lights, and phones. They used to have a toner refilling program but do not anymore because of purchasing issues. Computers are recycled through a state program that sends them to a correctional facility.

There is no composting program, but the physical plant has considered it and wants to investigate it further. Equipment such as a tractor with a front end loader may need to be purchased.

The university pays an external company to pick up boxes from food shipments to Dining Services. The company then sells the cardboard. If a student organization were to take this duty, they would be able to raise funds for their activities and save the university the cost of having these boxes removed.

TAMIU has implemented some measures to reduce paper waste on campus, in addition to placing recycling bins by copiers and printers. All bathrooms have roll towels and new buildings will most likely have motion sensing towel dispensers. This year TAMIU has implemented a debit system that has eliminated student refund checks, and 99% of all employees (including student workers) receive paychecks through direct deposit. The university is in the process of changing the employee reimbursement system to the same debit system used for student refunds and they are moving toward a paperless work order system.

Hazardous Waste

The university is very careful about hazardous waste generation and disposal. TAMIU is a small quantity generator with very few sources of hazardous waste. All oils are recycled and professors are encouraged to teach students to neutralize acids and bases as part of their lab experiments. Other hazardous waste generation points are the print shop and the photo lab in the Fine Arts Building. The university recycles all fluorescent tubes and ballasts with a company out of Dallas.

Good Practices

- Strong participation in active recycling program with broad range of materials recycled
- Several paper waste mitigation strategies
- Excellent accounting of chemical and hazardous waste control

Opportunities

- Quantify recycling
- Find alternative ways to increase recycling capacity if city will not provide a second pickup
- Continue to educate about the recycling program by trying other avenues such as flyers and the website
- Further investigate opportunity for composting
- Continue to look for strategies to reduce paper waste
- Encourage neutralizing acid/base combinations as part of the teaching process to eliminate these wastes and teach about waste disposal issues

Texas A&M International University
Campus Sustainability Assessment

Campus Infrastructure

Built Environment

Transportation

Land Use

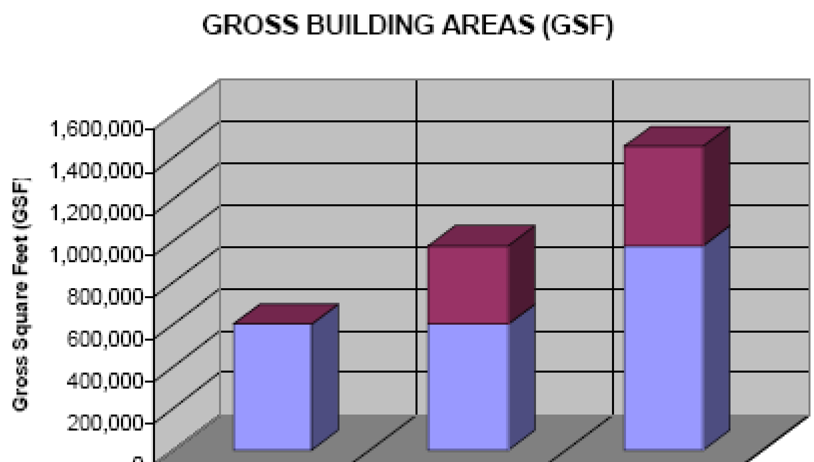
Consumable Supplies and Equipment

Built Environment

Buildings play a critical role in the public perception and efficient operation of the campus. The TAMIU campus is made up of modern, beautiful Spanish-style buildings that make Laredo proud. As an architectural benchmark of the community, TAMIU buildings can also set the precedent for sustainability. Some sustainable buildings actually produce their own energy, recycle and reuse their own water, provide healthy indoor air quality, increase worker productivity, and use sustainable and non-toxic renewable materials in their construction (UC). It is important, that as campus expansion goes forward, sustainable thinking is included in the building decision-making process and long-term campus planning.

Green Building Practices and Policies

It is expected that the TAMIU campus will double in size in the next ten years, which will allow significant opportunity for green, efficient building initiatives. The master plan indicates plans for several new buildings with a space distribution as shown in Figure 7.



	2004	5 Yr	10 Yr
Added GSF	0	374,914	473,463
Existing	601,026	601,026	975,940

Figure 7: Planned Building Growth Detailed in TAMIU Master Plan (Does not include Residence Halls or Dormitories)

TAMIU has been considering and implementing many green practices in their existing buildings. All classrooms have lighting controls and all offices built during Phase II or later have lighting controls. Compact fluorescent lights and high-efficiency T-8 fluorescents have been installed in all buildings. All classrooms are wired with a double switch so users can shut down the lighting in thirds in classrooms. A modern, efficient central plant provides air conditioning to the campus.

For the new Student Success Center, the university leaders would like to look at constructing it to receive a LEED-NC Silver rating, if costs are acceptable. LEED (Leadership in Energy and Environmental Design) is a green building certification program established by the US Green Builidng Council. Having a LEED certified campus building would point out TAMIU's commitment to sustainability. The architect has not yet been selected for the project. In the past TAMIU has never requested a LEED AP architect or asked questions about experience with green building projects during interviews, but they plan to do so for this building. The campus planning committee and the Green Committee will need to work together when new buildings are planned.

A high performance test facility that will be part of the TAMU/CMU project will be a great opportunity for sustainable building research at TAMIU to be led by the Energy Systems Laboratory with federal funding. With minimal funding, the mechanical infrastructure can be designed to facilitate "plug and play" applications of advanced HVAC, solar, and automated controls. The building will be an instructional tool for students who can take its principles and apply them to their own lives and careers. The publications that result from this research will make the university's commitment to sustainability known nationally, and provide a low-cost, on-site testing facility for equipment that can be used in future construction at TAMIU and the TAMU System.

All architecture on the TAMIU campus is Spanish-style (see Figure 8) and the campus master plan has guidelines for future buildings to make sure they fit in with the campus setting. Some unique architectural structures such as the pyramid at the Lamar Bruni -Vergara Science Center are in place (See Campus Infrastructure Title Page).

Figure 8: Example of the Architectural Style on Campus

<u>Good Practices</u>

- Automatic lighting controls is all classrooms and most offices
- Compact florescent lights and T-8 fluorescents in all buildings
- Interest in LEED certification for new Student Success Center
- Interest in high-performance test facility capabilities to explore advanced technology

<u>Opportunities</u>

- Assess opportunity for LEED-NC (New Construction) rating of new Student Success Center
- Assess potential for a LEED-EB (Existing Building) rating for the existing campus
- Hire architects for future construction that have experience in green building design.
- Create a statement of how energy efficiency will be considered in future construction

Transportation

To promote sustainability, TAMIU should minimize single-occupant vehicle (SOV) transportation to, from, and around campus. SOV trips can be thought of as particularly costly due to their proportionately higher per capita emissions, as well as the related infrastructure costs and traffic and parking demand they generate (2) By encouraging bus use, bicycling, and carpooling, TAMIU can greatly reduce these problems. The university should support these types of alternative transportation as well as alternative fuel vehicle use and living on campus to reduce negative transportation impacts.

<u>Transportation Practices</u>

The primary mode of transportation to and from the TAMIU campus by faculty, staff, and students is the use of a private car. This is primarily due to being in an area where few people use alternative transportation and being on the outskirts of town. However, there are good alternative options for commuters. A city bus line, which operates on clean natural gas, runs between the TAMIU campus and the downtown transit center where campus riders can pick up a bus to other parts of Laredo. The bus service runs from 7:00 AM to 9:00 PM. For bicycle riders there is a bike path along the Bob Bullock loop, which is the main feeder to the campus. On the campus, there are no dedicated bike paths or bike lanes, but there are many students, particularly those who live in the dorms, who ride bikes on campus. Bike racks for these students are located at the dorms, the gym, the Student Center, and the library. There are showers available at the gym for those with gym memberships, and there are two men's showers and two women's showers in the library restrooms. The university hopes to add bicycle paths along the campus loop when it is completed (see Figure 10). This path will continue to the future baseball and softball complex and pass by student housing.

Figure 9: City bus with service to and from TAMIU and Bike Racks on Campus

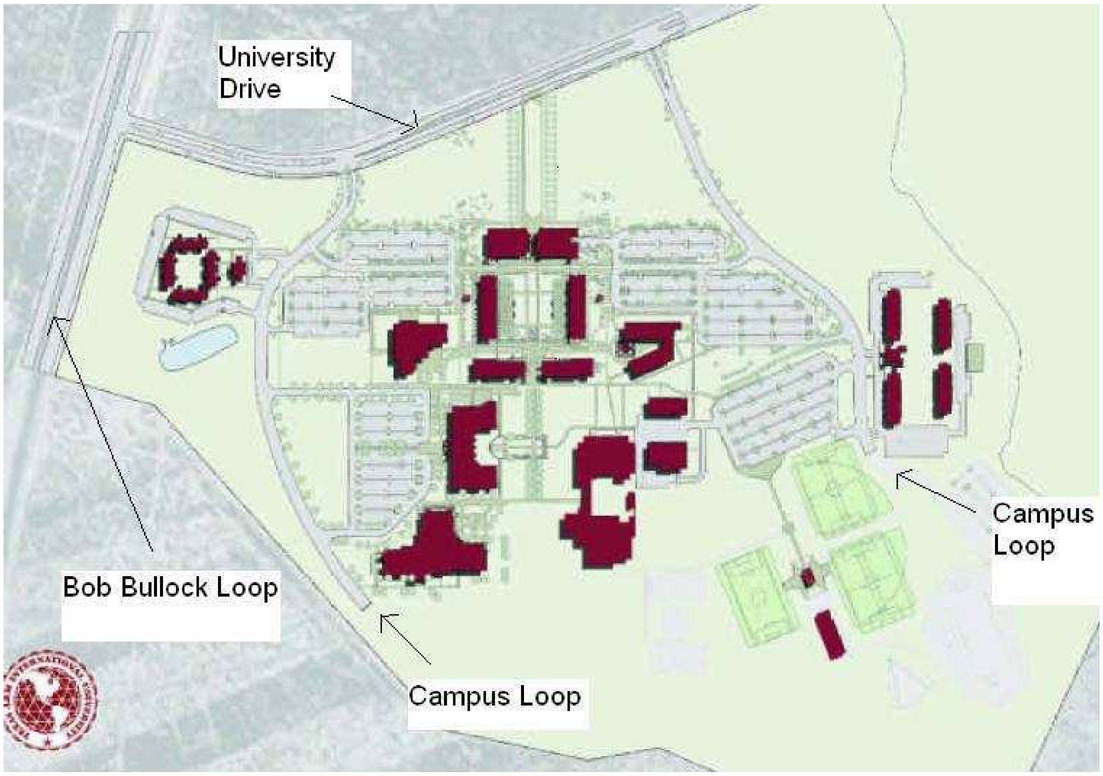


Figure 10: Campus Map Showing Bob Bullock Loop and the incomplete Campus Loop

There seems to be minimal carpooling to and from the TAMIU campus and no carpool or vanpool incentives are in place. The university staff likes the idea of having preferred parking for hybrid or other alternative fuel vehicles and could possibly implement a discount parking pass for those choosing to use these vehicles or carpool. As mentioned in the energy section, TAMIU is unique in that 75% of its campus vehicle fleet consists of electric vehicles.

There has been a large demand for on-campus housing for the 2006-2007 academic year. For the first time, on-campus housing will be near capacity. By increasing the number of students living on campus, the transportation burden is lessened. The housing demand will soon exceed the capacity of the 256-bed University Village and the 424-bed Residential Learning Center. The campus master plan includes adding another housing unit to accommodate the increased demand. By living in these facilities, the students will contribute to a sustainable campus.

<u>Good Practices</u>

- City bus service to campus
- City buses run on natural gas
- Bicycle path along Bob Bullock Loop
- Bicycle racks on campus
- Campus vehicle fleet is 75% electric
- Increasing number of students are living on campus

<u>Opportunities</u>

- See if the city can add a bicycle rack to all bus lines that come to campus

- Complete campus loop to ease transportation in and around campus
- Facilitate the use of more bicycles by adding dedicated bicycle paths and ensuring adequate racks and shower and changing facilities
- Set up preferred parking for alternative fuel and hybrid vehicles
- Investigate incentives to encourage carpooling

Land Use

TAMIU strives to have a healthy, aesthetically pleasing, and ecologically sustainable campus landscape. Stormwater must be well-managed so that it does not create problems for local bodies of water, and pest management practices that do not harm the health of people or wildlife on campus must be in place. This area is one where visitors to campus and the community will be able to notice excellent practices.

Stormwater

TAMIU does not have a stormwater permit because drainage does not cross a city street. The stormwater from the parking lot is collected and goes to the city storm sewer. The stormwater does not flow into a local body of water. The physical plant would like to figure out a way to use stormwater, but because of the low amounts of rainfall in Laredo, AHU condensate is a steadier alternative. A stormwater retaining pond on the south end of campus has been considered.

Landscape and Habitat

Landscaping on the TAMIU campus is regulated by stipulations in the master plan. The campus uses low-maintenance native species that are deer-proof so as to not harm the many deer on and around campus. Only 125 of the 300 acres of campus are developed, so there is plenty of open space. All new construction detailed in the Campus Master Plan through 2014 is planned for the core of campus and will not infringe on the natural, open space. The campus plan has reserved a “Green Space” border around campus (see Figure 11). For the duration of the campus master plan, they will keep this area in its natural, xeriscape state. Many species of wildlife can be found on the TAMIU campus including white-tailed deer, wild pigs, and javelina (see Figure 12). Erosion and sedimentation control on campus are governed by a State (TCEQ) regulations.

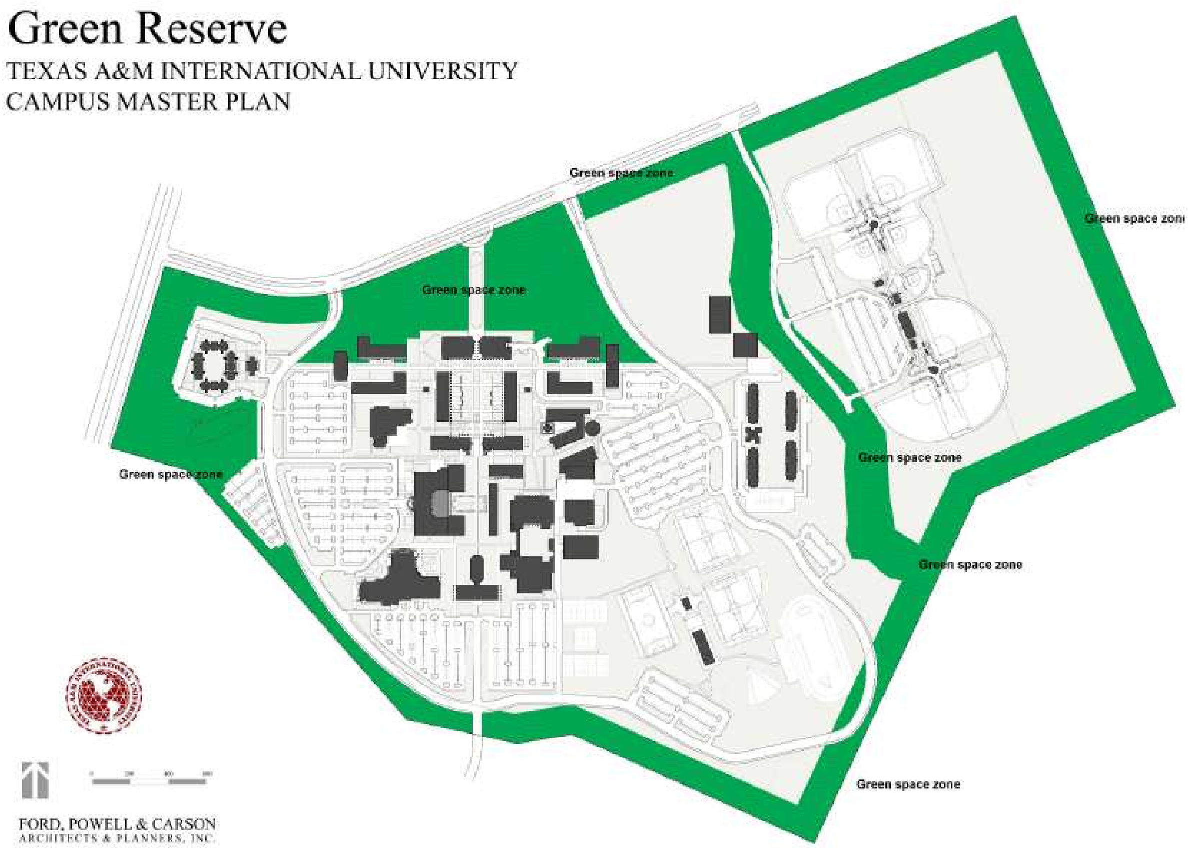


Figure 11: Ten Year Campus Green Reserve Plan for TAMIU

Figure 12: Javelinas, Natural Vegetation, and a Palm Tree on the TAMIU Campus

State legislation was passed on September 1, 1999 requiring all State-funded projects to use lighting that reduces outdoor light pollution. All lights on campus, other than the Phase 1 globe lights (installed prior to 1999) on the interior of campus, are in compliance with this act. In fact, when driving along the Bob Bullock Loop at night, one cannot see the campus. There is no good shading on parking, all of which is concrete.

Figure 13: A New Campus Light Fixture, A Parking Light, and a Discontinued Campus Light Fixture

The master plan includes additions of surface parking. Space has been reserved for potential parking garages, but there is currently no need for garages. Some shade trees have been planted near walkways that will provide more shade in time. The university also has planned to add a trellis by the Kinesiology Building that will add shade and provide a spot for food vendors. The roofs on campus are Spanish-style tile. While it is unlikely that any campus buildings (other than possibly the future children's museum) will have green roofs, there may be a Spanish-style tile that has a higher reflectance available that will mitigate heat island effects.

Pest Management

An Integrated Pest Management system (IPM) is used at TAMIU for outdoor pest control. This means that if there is a problem, the insect is identified and then controlled. Preventative spraying is done indoors on a rotation. By law the university keeps track of everything they spray, and generally there are very few chemicals sprayed. There is a small amount of weed control implemented on the athletic fields.

Good Practices

- Stormwater management policies in place
- Use plants that fit in the local ecosystem
- Much open space is preserved on campus, with plans to keep a green space reserve as the campus grows
- Campus lighting is compatible with night-sky regulations
- Shade trees have been planted and plans are in place for a trellis that will add shade along sidewalks
- Integrated Pest Management System with complete tracking and use of some organic pest control options

Opportunities

- Investigate Use of a Retention Pond for Stormwater
- Investigate heat island mitigation strategies (especially for parking and roofs)

Consumable Supplies and Equipment

Universities purchase large amounts of products such as paper, computers, printers, copiers, office supplies, research supplies, cleaning supplies, building materials, furniture, paint, carpet, food and more. The purchasing practices of the university should educate students, improve human health conditions on campus, and lead the way as stewards of the Earth's resources by making environmentally preferable purchasing (EPP) choices (2). TAMIU can make a difference by purchasing recycled content paper and by requiring recycled content, reused, or regional building materials. Using Energy STAR equipment in offices and Energy STAR appliances in campus dormitories is an effective and noticeable method to promote sustainability.

Campus Purchasing

Many TAMIU purchases are procured through cooperative purchasing contracts or State Contracts with the Texas Building and Procurement Commission. Computer equipment is purchased from the Department of Information Resources (DIR) or from TAMU Master Contracts. Building material and furniture purchases are primarily handled by the Texas A&M Facilities and Planning Office in College Station. If TAMIU orders furniture, they use cooperative purchasing contracts or TAMU master contracts. TAMIU purchasing does not know if energy-efficient computer equipment is given preference or if sustainable building materials are used. For appliance purchases, the department needing the appliance decides what they want to purchase and campus purchasing handles the purchase for them. Custodial supplies and physical plant purchases are not handled by the campus purchasing department. Campus purchasing does control the central stores, so they purchase paper for the entire campus. Recycled content paper is purchased as part of a state contract.

Good Practices

- Recycled content paper is purchased for the entire campus

Opportunities

- Implement a green purchasing policy for consumables and office equipment
- Encourage departments to choose Energy STAR equipment and appliances

Health and Well-Being

Food

General Health and Well-Being

Food

Eating healthy is a key component to a healthy lifestyle. Food provided on campus should promote the use of fresh fruits, vegetables and whole grains as an alternative to refined starches and sugars, artificial preservatives and processed foods. By purchasing locally grown and raised foods, a university can promote the local economy, and by purchasing organic foods, universities can help eliminate many of the harmful impacts of typical farming practices on soil and water quality, habitat and human health (2). Dining also produces a considerable amount of organic and inorganic waste that should be minimized.

<u>Dining Services</u>

Dining Services at TAMIU is provided by Aramark under the direction of Mr. Humberto Rivera. The on-campus dining facilities include a cafeteria-style all-you-can-eat Residential Dining Center, a Subway vendor, a grill, and a pizzeria. The only kitchen on campus is located in the student center. TAMIU Dining Services can be visited at www.tamiu.edu/foodservice. There is no convenience store located on campus, but there are vending machines in the main buildings.

Dining services does not regularly provide organic, hormone-free or other sustainable food options. These options are available through Aramark's food vendor and may be requested for catered events. Food for campus dining is not acquired through local vendors, mostly because there is very little locally-grown produce available. Low fat cooking oils are used in the campus kitchen.

Dining services tries to limit the amount of food waste generated by using leftovers for the next meal and keeping track of food closely to control products and portions. They do not donate left over food to food kitchens because of associated liability risks.

Currently, all dining ware (plates, bowls, forks, knives, cups, etc) is disposable because dining services does not have the facilities to wash reusable dining ware. There is no space in the existing student center to provide extra dish washing facilities, but the university does plan to build a new dining facility in a few years that will have dish washing capacity. Reusable dining ware would be a considerable cost and waste saver for the university. The campus does not acquire biodegradable dining ware due to high costs but can if it is specially requested for a catered event. There are no incentives offered to decrease waste consumption such as a discount on drinks if a student brings a reusable cup.

TAMIU has a wellness committee that encourages healthy options in campus dining, and Dining Services conducts surveys to see what food options students are interested in. The Residential Dining Center does provide a variety of options, many of which are healthy, including a salad bar. In addition to the new dining hall that is planned for 3-4 years from now, a coffee shop will be added at the library.

<u>Good Practices</u>

- Dining Services has healthy options such as a salad bar in the main dining facility and a Subway sandwich vendor
- Organic foods are available for catered events
- Have wellness committee

Opportunities

- Investigate student interest in sustainable food products such as organic and hormone free foods
- If an interest in shown, increase availability of sustainable food products
- Investigate use of food scrap as animal food source.
- Encourage students to bring their own coffee mug or drink bottle to help mitigate food waste.
- Use napkins made from recycled paper content
- See if dining center patrons would be willing to take on the extra cost of using biodegradable dining ware instead of Styrofoam plates and bowls and plastic utensils.
- Plan for dish washing facilities in the new campus dining center and focus on sustainable practices throughout the dining center planning process.

General Health and Well-Being

There are many places in and around campus buildings where occupant health must be considered. Some of the key areas are custodial practices, indoor environmental quality, and workplace safety.

Many traditional chemical cleaning products contain toxins that pose public health risks and cause environmental damage if used improperly. Fortunately, recent years have seen a surge in the availability of more environmentally friendly “green” institutional cleaning products that rival the effectiveness and cost of their traditional competitors (2). Using these products can greatly benefit the campus community.

Indoor air quality (IAQ) has a tremendous impact on productivity and health of building occupants. TAMIU must strive for excellent IAQ to promote the best learning environment possible. Quality of life on campus an also be increased by promoting a safe working environment for its employees, including consideration of training accessibility on ergonomic safety and monitoring of progress.

<u>Custodial Practices</u>

The RFP for custodial contracts is currently being negotiated. The contract will specify that the Physical Plant Director must approve all chemical purchases. This will ensure that only green chemicals will be purchased. The new custodial company will begin providing supplies and working in October.

All custodians go through training and must be OSHA certified. The university keeps a good inventory of cleaning chemicals and enforces fill station technology.

The custodians work from 6 PM-2 AM. Since most lights in the university are on occupancy sensors, the custodians’ presence after hours does not cause large lighting consumption. The Student Center lights are on timers and turn off at 2AM, once the custodians are out of the building.

<u>Indoor Environmental Quality</u>

The campus does not specifically monitor indoor air quality, but they do have good ventilation systems and humidity control in buildings. The campus print room has its own ventilation system, and the Physical Plant has the ability to increase the air changes in a building if needed due to painting or other reasons. There is carbon dioxide monitoring in the gym. A no smoking policy is strictly enforced in and around all buildings. Comfort of occupants is always given priority and workers are welcome to call the plant and request a temperature change in their office if they are uncomfortable. Additionally, TAMIU is a 100% asbestos-free campus.

For new buildings and renovations, there is not a program in place to purchase low VOC and IAQ compliant products such as paints and carpets.

<u>Workplace Safety</u>

All employees on campus are required to go through a safety program that teaches about safe lifting procedures. The Physical Plant has belts available for heavy lifting projects. Excellent documentation is in place for tracking injuries and any associated costs. The department puts out a monthly safety newsletter and has a staff enrichment day that focuses on safety.

TAMIU wants to encourage ergonomics among their employees. They have had a specialist come to campus to offer one-on-one ergonomic consultations. There has been an ergonomics workshop each of the last few years at the staff enrichment day that has been well attended.

Good Practices

- Have excellent custodial chemical use and practices underway
- Custodian's presence does not significantly increase lighting energy consumption
- Asbestos-Free campus
- No smoking policy around buildings
- Campus print room has separate ventilation
- Air changes can be increased by physical plant if needed
- Carbon Dioxide monitoring in gym
- Aggressive workplace safety training and education program
- Ergonomic assessments and workshops available to employees

Opportunities

- Carry out green custodial plan
- Use low VOC materials for carpeting and paint

Academics and Culture

Sustainability-Related Courses and Research

Sustainability-Related Organizations

Sustainability and Campus Leadership

Sustainability-Related Courses and Research

By teaching sustainability through courses in a wide range of disciplines, TAMIU can provide students information about sustainability that will encourage them to promote and participate in sustainable practices on campus and help students in future endeavors. By providing opportunities for research, TAMIU can make an impact far beyond Laredo and the TAMIU campus by finding new ways to preserve resources and benefit the environment.

Courses and Research

Dr. Cass, the Associate Provost, believes that many professors already fold some sustainable practices into their courses. Some of the courses available that include sustainability-related topics are Environmental Geology, Environmental Science, Ecology, Biology, and Chemistry. Dr. Tobin, who teaches the freshman level Environmental Geology course, also teaches a lab on fossil fuels that could tie into the sustainable campus initiative by teaching students about their personal greenhouse gas impact. There is no Environmental Studies major or program at the university, but there is some ongoing sustainability-related research. Dr. Vaughn does water quality research and Dr. Tobin's idea to tie a weather station to the irrigation system could benefit the university tremendously.

The university is in the process of beginning their first engineering program in Civil Engineering. Having engineering curriculum will increase the amount of sustainability-related research at the university. Michael Yoder is one individual whose interest and expertise in environmental concerns in urban geography will help introduce sustainability to this new department.

The sustainability Green Team, Dr. Cass, and others find it very important to integrate sustainable ideas into the core courses so that all students will learn what is going on around campus and get excited about continuing in a sustainable direction.

Good Practices

- Sustainability related courses include Environmental Science and Environmental Geology
- Various sustainability-related research is already in progress
- Engineering curriculum is getting started
- Professors are willing to integrate sustainability into core courses

Opportunities

- Get students involved through course project participation
- Insert sustainability related modules in existing courses, particularly core courses

Sustainability-Related Organizations

Sustainability-related organizations provide an important avenue for students, staff and faculty to learn and share information about issues and to generate and advocate new ideas for further movement toward campus sustainability (UC). These organizations can promote sustainability to the campus and community.

Student Organizations

Of the 52 student organizations on the TAMIU campus, none are directly related to sustainability. In fact, there are no groups currently purely dedicated to community service. Dennis Koch, Director of Student Activities, would like to start activities to get students involved in the community such as the Big Event and highway cleanups. These groups would spread sustainability to the community as well as foster excitement on the campus. As a young school still defining traditions, there is tremendous opportunity to make sustainability a campus tradition.

While there is a student orientation on campus, it is not mandatory for all new students to attend. Next year they plan to require attendance. This is an excellent opportunity to educate new students about the sustainable campus initiative on TAMIU and tell them how they can get involved. The university also has a First-Year Student Experience Office that could have material available educating about sustainability.

Good Practices

- Director of Student Activities has interest in Sustainability-related organizations

Opportunities

- Involve student organizations in sustainability activities such as cardboard and aluminum recycling
- Create activities that foster participation in and awareness of sustainability (such as adopt-a-road, earth day, etc.)
- Educate students about the Green Campus Initiative at orientation

Sustainability and Campus Leadership

The strength of an organization comes from the vision and management skills of its leadership as well as its ability to find resources and dedicated personnel to accomplish its mission. Strong leadership skills and a clear vision of the future are essential to change existing campus practices and perceptions to more sustainable practices. A green campus or sustainable initiative can be a daunting challenge to get every on the same page and working to a common goal. It is not an easy concept to grasp initially and the end game is often a moving target.

TAMIU Leadership

Leadership for a more sustainable campus most often comes from the students and/or faculty who are concerned with the short and long term impacts of existing practices on the environment and its use of natural resources and energy. If often takes years for a “grass roots” effort from students and/or faculty to take hold and convince senior management to adopt sustainable practices in is buildings, purchasing, food, housing, and supportive academic classes.

Good Practices

- Dr. Keck, TAMIU President, has stated publicly several times to staff and faculty that he is committed to creating a green campus Sustainability Initiative.
- Faculty and staff have existing plans in place for recycling, water management, energy practices, and other sustainable practices as part of their job duties,
- TAMIU has formed a campus Green Team comprised of administrative staff, faculty, and students to evaluate options and to move towards a more Green Campus, and
- Dr. Keck signed a letter in September 2006 to seek additional funding to pursue a green campus initiative.

Opportunities

- Implement a green campus initiative based on assessment report
- Formalize management policy through a modified mission statement and written strategy
- Include sustainable practices in job descriptions or relevant personnel and faculty
- Identify personnel to take lead role for plan implementation
- Utilize student organizations and manpower [interns] wherever possible to increase buy-in and reduce implementations costs
- Communicate strategies to community, peers, staff, and students periodically

Summary and Roadmap for Green Campus Initiative

TAMIU already has many excellent practices in place. The campus is well on its way to becoming a benchmark for sustainability. Some of the current standout practices that the assessment identified are

- Many campus buildings have been commissioned
- Have measurable energy goals pursuant to governor's executive order
- Automated irrigation control system and excellent water sub-metering
- City bus service provides mass transportation options to campus
- Campus vehicle fleet is 75% electric
- Strong participation in active recycling program with broad range of materials recycled
- Excellent accounting of chemical and hazardous waste control
- Trees and plants are used that fit in the local ecosystem and require little irrigation
- Integrated Pest Management System with complete tracking and use of some organic pest control options
- Have an existing wellness committee
- Have good custodial chemical use and practices, including procurement, underway
- Asbestos-Free campus
- No smoking policy in and around buildings
- Carbon Dioxide monitoring in gym
- Aggressive workplace safety training and education program and ergonomic assessments
- Sustainability-related courses include Environmental Science & Environmental Geology

While TAMIU is well on its way to becoming a sustainable campus leader, there is much opportunity for improvement. The key opportunities for the campus are listed below. Some of these may be implemented immediately, while others may require more time or further investigation. The university can decide which areas it would like to pursue based on budget, impact and interest.

Resource Conservation

Immediate Opportunities	Areas that Need Further Investigation or Time
• Make energy conservation numbers easily available to faculty, staff, and students	• Investigate purchase of green power through the TAMU system electricity contract
• Commission buildings that have not yet been commissioned and any buildings that are showing poor performance	• Investigate the use of local natural gas
• Investigate use of more solar-powered illumination like the illumination for the signage at the entrance to campus	• Investigate the use of clean or biodiesel for standby generators
• Implement a water conservation awareness program that will educate students and staff on the importance of water conservation and encourage conservation of water	• Continue investigation of irrigation control based on measured evapo-transpiration
• Continue pursuit of use of gray water from the City of Laredo for sustainable irrigation	• Continue to investigate viable uses(s) for AHU condensate
• Continue to press for evaporation sewer allowance for cooling tower water	• Investigate viability of mulching for water conservation
• Consider using waterless urinals in new	• Further investigate opportunity for composting

construction
- Quantify recycling (document and further publicize)

Campus Infrastructure

Immediate Opportunities	Areas that Need Further Investigation or Time
• Create a statement of how energy efficiency and other sustainability issues will be considered in future construction	• Assess opportunity for LEED certification of the new Student Success Center & future buildings
• Set up preferred parking for alternative fuel and hybrid vehicles in visible, choice locations	• Assess potential for LEED certification of the existing campus
• See if the city can add a bike rack to the bus line that comes to campus	• Investigate incentives to encourage carpooling
• Encourage departments to choose Energy STAR equipment and appliances	• Complete Campus Loop
	• Facilitate the use of more bicycles • Investigate heat island mitigation strategies • Investigate use of retention pond for storm water • Implement green purchasing policy

Health and Well-Being

Immediate Opportunities	Areas that Need Further Investigation or Time
• Increase availability of sustainable food products such as organic and hormone free foods (if there's interest)	• Investigate use of food scrap as animal food source
• Mitigate waste materials from food service	• Plan for dish washing facilities in new campus dining center
• Implement green custodial plan and practices • Use low VOC materials for carpeting and paint • Encourage neutralizing acid/base combinations as part of teaching process to eliminate these wastes and teach about waste disposal issues.	

Academics and Culture

Immediate Opportunities	Areas that Need Further Investigation or Time
• Get students involved through course project participation	• Identify resources and personnel for implementation
• Insert sustainability related modules in existing courses	• Implement green campus initiative based on this assessment report
• Create activities that foster participation in and awareness of sustainability (such as adopt-a-road, earth day, etc.)	

Next Steps

The next steps for TAMIU are to put together an action plan that will make sustainable practices part of the University policy. The implementation plan should address the steps that they plan to make and show a timeline for completion of these steps.

Recommended steps:

- Finalize assessment plan
- Adopt University policy on Sustainable Campus
- Adopt action plan
- Create permanent Green Team and assign responsibilities for implementation

- Identify and secure implementation funding and personnel
- Actively involve students in planning and implementation
- Annually review progress and update implementation plan

Benefits to TAMIU for Sustainable Initiative – A Sustainable Campus initiative will have many short and long term benefits as follows:

- Reduced utility expenses (as much as 50% in new construction)
- Improved indoor air quality
- Improved learning environment
- Reduced air, land, and water impacts on environment
- Create new generation of resource and energy conscious graduates
- Creates benchmark for others in the Valley to follow
- Identifies TAMIU as a regional and national leader in sustainable educational advancements

This project will have significant impact on the University, local community, and Texas A&M University System as well as its international neighbors in Mexico.

Appendices

Appendix A: Campus Sustainability Mission Statement and Sample Policy Statement

Model Addendum to Existing Mission Statement:

Texas A&M International University also recognizes the critical importance of sustainability to better prepare for the future of the University, the students, and the community. Our present needs must be met while protecting the interests of future generations.

Sample Policy Statement from Duke University

Duke Environmental Policy Statement

Duke University seeks to attain and maintain a place of leadership in all that we do. This includes leadership in environmental stewardship and sustainability on our campus, in our medical institutions, and in the larger community of which we are a part. We will bring vision, intellect, and high ethical standards to our pursuit of environmental leadership in research and teaching, institutional operations, and our relationship with the community.

Academics

Duke University will continue to be in the forefront of environmental research and education and will continue to use our institutional capability to constructively affect environmental policy throughout the world. We are committed to supporting interdisciplinary environmental scholarship and research, disseminating information about environmental research and policy, increasing faculty and student awareness of environmental issues, and enhancing environmental educational offerings.

Operations

Duke University will comply with all relevant environmental laws and regulations and go beyond compliance by integrating the values of sustainability, stewardship, and resource conservation into our activities and services. We will make decisions to improve the long-term quality and regenerative capacity of the environmental, social, and economic systems that support the University's activities and needs. We will engage in pollution prevention activities and develop and promote practices that maximize beneficial effects and minimize harmful effects of operations, research, and activities on the surrounding environment. We are committed to assessment of the environmental impacts associated with our activities and services, and we will develop and track measures of our progress.

Community

Duke University is committed to playing a constructive and collaborative role as a responsible environmental citizen in the life of the surrounding community. We will maintain a positive and proactive role in communicating with the surrounding community, especially the Durham community, regarding our environmental activities and performance.

Richard H. Brodhead
President

Victor J. Dzau
Chancellor for Health Affairs

Tallman Trask III
Executive Vice President

Peter Lange
Provost

March 1st, 2005

Other Resources for Campus Model Policy and Mission Statements from the Association of University Leaders for a Sustainable Future

http://www.ulsf.org/cgi-bin/searchresults.cfm?catID=4&subcatID=13

Appendix B: Reference Sources for Sustainable Campuses

Documents:
1. Good Company's *Sustainable Pathways Toolkit for Universities and Colleges Indicators for Campuses*, Version 4.0, 2004.
http://www.goodcompany.com/lib/documents/SPToolkit-v4-101904.pdf

2. UC Berkeley Campus Sustainability Assessment, 2005.
http://sustainability.berkeley.edu/assessment.html

3. University Leaders for a Sustainable Future's *Sustainability Assessment Questionnaire (SAQ) for Colleges and Universities.*

Sustainability Websites:
Association for the Advancement of Sustainability in Higher Ed: http://www.aashe.org/
Furman University http://www.furman.edu/sustain/
Rice University http://sustainability.rice.edu/

University Leaders for a Sustainable Future: http://www.ulsf.org/

University of British Columbia: http://www.sustain.ubc.ca/

University of California Berkeley: http://sustainability.berkeley.edu/index.html

University of California Office of the President: http://www.ucop.edu/facil/sustain/

University of California Santa Barbara http://sustainability.ucsb.edu/

University of Colorado: http://ecenter.colorado.edu/index.html

Appendix C: Commitment Letter for Interim Funding

TEXAS A&M INTERNATIONAL UNIVERSITY
A Member of The Texas A&M University System

Office of the President

September 18, 2006

Dr. Dan Turner, Director
Energy Systems Laboratory
3581 TAMU
College Station, Texas 78743-3581

RE: Carnegie Mellon Advanced Building Energy Technology Initiative

Dear Dr. Turner:

It is my understanding that the Energy Systems Laboratory is participating in a proposed U.S. Department of Energy funded project for the transfer of technologies from the Advanced Building Energy Technology Initiative (ABETI) at Carnegie Mellon University in Pittsburgh, Pennsylvania. The purpose of this letter is to indicate our strong interest in collaborating with your Laboratory by evaluating the techniques and technologies of the ABETI program for potential application in our new $25 Million Student Success Center planned for our campus in 2007.

The planning and design for the new Center is imminent so timing is of the essence if we are to consider any of the lessons learned from the ABETI project. Our goal is to make this new facility as energy efficient as possible, while utilizing the latest technologies and renewable resources in a building that will be a flagship for our new Sustainable Campus Initiative as well as serve as a pilot project for the entire Texas A&M University System capital expansion plan.

We look forward to working closely with your team.

Sincerely,

Ray M Keck, III
President

CC: David Claridge Malcolm Verdict

5201 University Boulevard, Laredo, Texas 78041-1900, (956)-326-2320, Fax (956)-326-2319

VITA

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