THE UNIVERSITY OF ARIZONA.
Facilities Management

Climate Action Response

November 2010

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The President's Climate Commitment

The University of Arizona is a leader in the study of climate change. An undergraduate and graduate academic initiative that broadly spans the colleges and departments includes internationally renowned scientists and significant contributions in numerous fields, including Geosciences, Environmental Studies, Geography, Arid Lands, and Agriculture. ***Education and research on issues associated with global climate change are an integral and vibrant part of the University's academic mission*.**

A correlation between increasing levels of greenhouse gas emissions and global climate change has been established. Physical operation of facilities on the scale of the University of Arizona main campus in Tucson involves many of the same processes implicated worldwide in rising atmospheric levels of Carbon Dioxide and other greenhouse gases - primarily, the combustion of fossil fuels for transportation, electric power, heating, and cooling. ***As signatory to the American College and University Presidents' Climate Commitment (ACUPCC), President Shelton has acknowledged the University's responsibility to address its own greenhouse gas emission levels.***

University administration and staff across the board have been actively engaged in reduction of the campus carbon footprint for some time. The largest components of the University's annual utility bill, natural gas and electric power, are primarily fossil fuel based. In an era of increasing pressure on annual operating budgets, institutional standards for the design, construction, and operation of new and renovated buildings have tightened the requirements for energy efficiency, intelligent operation and control, and sustainable design. ***The drive to lower operating costs through improved energy efficiency has been an important strategy in the reduction of campus carbon emissions.***

"The American College & University Presidents' Climate Commitment (ACUPCC) is a high-visibility effort to address global climate disruption undertaken by a network of colleges and universities that have made institutional commitments to eliminate net greenhouse gas emissions from specified campus operations, and to promote the research and educational efforts of higher education to equip society to re-stabilize the earth's climate. Its mission is to accelerate progress towards climate neutrality and sustainability by empowering the higher education sector to educate students, create solutions, and provide leadership-by-example for the rest of society."

excerpt from
http://www.presidentsclimatecommitment.org/

Background Data

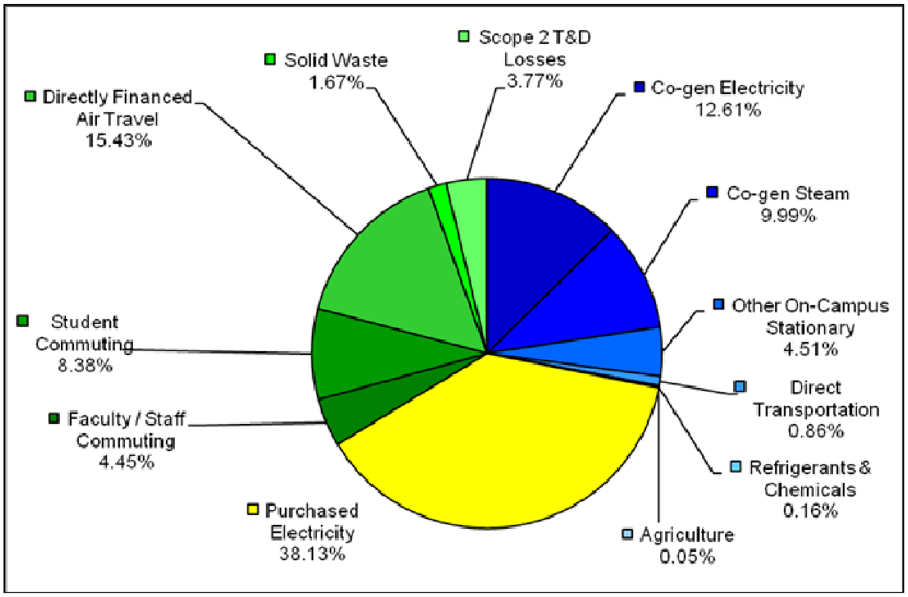
Facilities Management at the University of Arizona was committed to sustainability before sustainability became a household word. Sustainability can be defined as:

Using today…what you produced yesterday…to meet needs tomorrow.

It is no coincidence that this sounds like good fiscal planning, because the purpose of good fiscal planning is sustainability. Much of UAFM's "green" efforts were undertaken to reduce costs. The best way to reduce costs is to reduce the energy, water, and other natural resources needed to do a particular job, because all of those add to the costs of doing business. Truly green efforts will save money over the long run, even without artificial incentives.

An initial step in the ACUPCC program, completed in Spring 2010, derived a baseline inventory of the University's greenhouse gas (GHG) emissions. A graphic of the 2008-2009 data, shows contribitions from the range of sources associated with campus operations. Production of electricity and steam comprises almost 70% of total emissions and is recognized as a prime target in planning reductions.

On net, in 2008-2009, day-to-day operation of the University generated an estimated total carbon footprint of 250,752 Metric Tons of Carbon Dioxide Equivalent (MTCO2eq). Corresponding to 7.0 MTCO2eq per full-time student, or 25.7 MTCO2eq per 1,000 SF, this reflects the high percentage of energy intensive research done in facilities on the UA Main and AHSC campuses.



The campus carbon footprint is sensitive to the types of fuel used to generate electricity. Combustion of coal in a steam cycle power plant, for example, generates roughly twice the carbon emission per kilowatt-hour of electric power that natural gas does. Electric power utility production in Arizona involves a range of sources, including hydroelectric, nuclear, natural gas, and an increasing percentage of solar and wind. The region's abundant coal reserves make coal the preponderant fuel source for generation of electric power. The high percentage of campus MTCO2eq resulting from electricity purchased from the local utility, Tucson Electric Power, reflects this fact. The university's on-campus cogeneration systems, which produce roughly half the annual consumption of campus kilowatt hours, is fired on natural gas and generates substantially less carbon emissions.

Other sources of carbon, or carbon equivalent, emissions that fall under the jurisdiction of Facilities Management are direct transportation (fleet), solid waste, landscape, and refrigerants and chemical, particularly those used in cleaning and maintenance. Water use is of particular importance to sustainability in this region of the country. Management of water resources and use also fall under the scope of Facilities Management. Other significant sources of carbon dioxide equivalent emissions are driven by the combustion processes involved in student, faculty and staff commuting, and air travel for university purposes. Development of specific actions to address reduction in these sources will need to become a part of the planning effort.

Facilities Management Response

Operations, maintenance, and engineering staff have long been committed to efficiency, safety, and reliability of the energy and water systems at the University of Arizona. ***Crossing departmental lines and involving planning, design and construction, building plumbing, HVAC, electrical and mechanic shops, central plant operations, energy management, fire and life safety, grounds, and many others, this ongoing collaborative effort has produced remarkable success.***

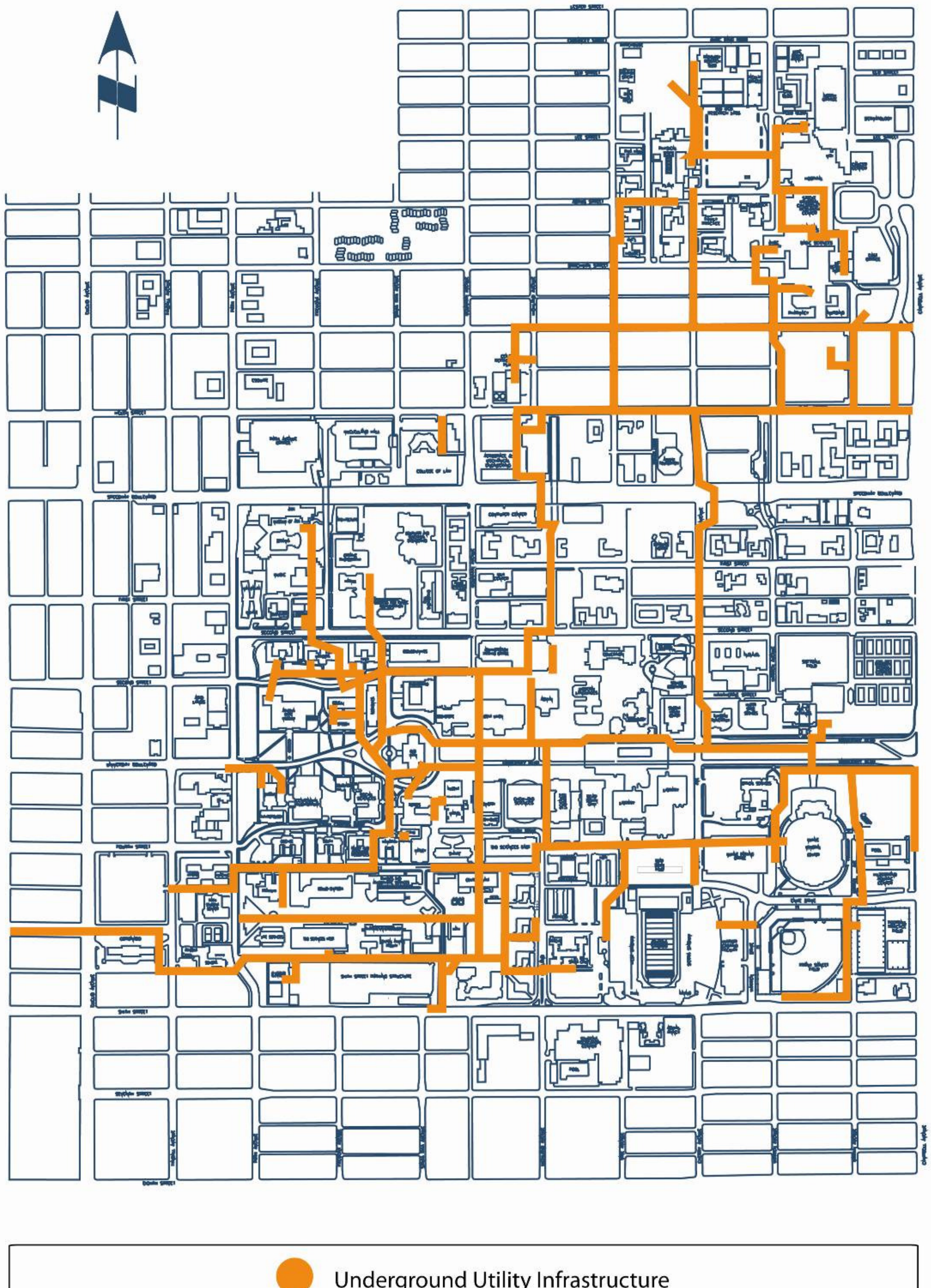
Early motivation for campus wide energy system improvement was driven by academic and research demands for high reliability, near continuous growth in campus loads, and intense downward pressure on the annual operating budget. For well over ten years, the planning, design, and implementation of energy and efficiency-related projects has been an ongoing and near continuous collaboration among the staff of facilities management, utility operations and planning, and design and construction. Examples of major successes include conversion of three discrete and independently operated campus cooling systems into one interconnected central utility utilizing highly efficient refrigeration machinery. The planning and construction of a subterranean network of large bore chilled water distribution piping and steam piping tunnels enabled cost effective addition of major new medical and scientific research buildings while lowering pumping costs.

A program that controls building systems to intelligently respond directly to occupancy demands in classrooms is well underway. Technical design and construction standards, developed by in-house university staff, define minimum requirements for energy-efficient systems. These are now applied in conjunction with the increasingly-stringent US Green Building Council's LEED criteria to assure that energy and water are now mandated as essential considerations in the design of all new buildings and facilities. It is interesting to observe that the University's institutional standards for building design, primary utility production and distribution, building lighting and air handling systems, campus energy management, and metering, often exceed the minimum LEED metrics. *A facilities team with the motivation, experience, and skills to establish and implement the University's climate action plan is in place.*

The 54,000 sf University of Arizona Student Recreation Center Expansion, completed in 2009, is the nation's first athletic facility to be awarded LEED Platinum certification by the USGBC. Passive solar measures significantly contribute to the facility's energy efficiency, including optimal building orientation, deep overhangs that shade glass and ground surfaces, high efficiency building envelopes, and cool roofs. The building incorporates high efficiency plumbing fixtures, which reduce by 47.5% its water use (compared to the LEED baseline). Passive stormwater harvesting strategies were utilized in the landscaped areas, increasing permeability and reducing runoff through the use of infiltration basins. Most of the plantings were selected for their ability to thrive in an arid environment. Materials using recycled content make up over 20% of the total value of the materials. More than 10% of all the materials used for construction were either manufactured or produced within 500 miles of Tucson.

From Press Release by the architect.

University of Arizona

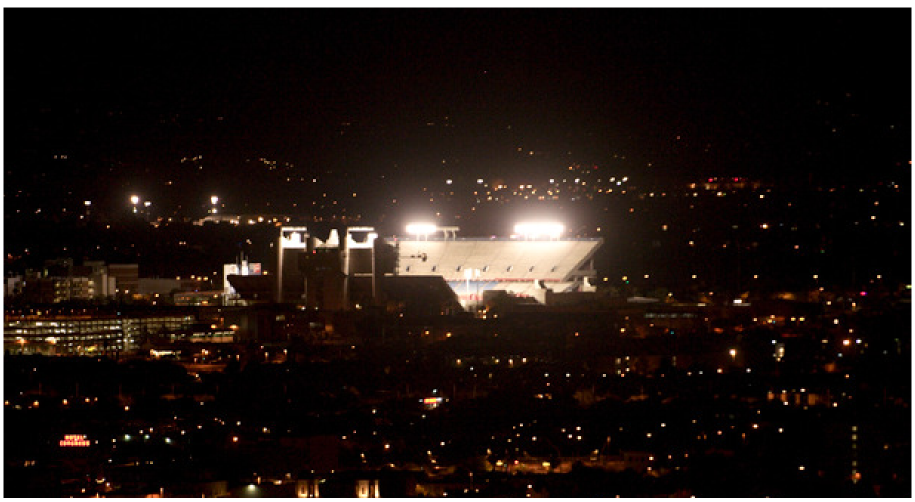


Underground Utility Infrastructure

Campus Energy Systems Overview

Energy flows through the University of Arizona Campus in a number of ways. Natural gas also flows into campus in two locations. With very few exceptions, natural gas is used at the central utility plants to fire steam boilers for campus heat or as fuel to drive natural gas fired combustion turbine generators. Approximately 50% of the University's annual power is produced with these on-site generators. The hot exhaust from the two combustion turbines is routed through heat recovery boilers, making this a combined heat and power, or co-generation operation. The ability to recover this (otherwise wasted) heat for practical use on campus makes this a very efficient process. The ultimate uses of steam produced in the boilers and cogeneration equipment are building heat and temperature control, research needs, including sterilization, and domestic water heating for use in residence halls, athletic facilities, and food service. Although Tucson has a relatively low seasonal heating demand when compared to other areas of the country, ventilation required by the campus' high percentage of laboratory space makes peak steam capacity critical.

The remaining portion of the electric power, purchased from Tucson Electric Power, enters campus through one of two main substations where it is transformed into lower voltage and distributed via an underground duct bank system to over 100 campus buildings and the three central cooling and heating plants. Ultimate campus and building uses of electric power include lighting, air moving fans, elevators, computers, personal electronics, and research equipment. Reliable electric power to maintain ventilation fans and research electric loads is often a critical requirement. The largest single consumer of electricity on campus is the refrigeration equipment that drives the central campus cooling system.



Left: the lighting at Arizona Stadium before and after the new fixtures were installed in 2010. The new fixtures are controlled to direct light in a way that reduces the amount of luminaires required. The new lighting allows greater observation of Dark Skies guidelines. Energy saved in this lighting project reduces the University's electric purchase, reducing its carbon footprint.

Key Points

Over 100,000 watts in energy savings from prior lights

500,000 kWh estimated reduction over next 25 years

Increased on-field light levels by 25% to meet NCAA Best

Reduced off-site spill light by 75%

Improved uniformities on-field

Eliminated maintenance costs for 25 years

Photographs taken from Sentinel Peak (A Mountain). Before and after photographs were taken with same camera at same settings.

Right: the Central Heating and Refrigeration Plant (CHRP) on the University's main campus. One of the University's two cogeneration units is in the foreground, a new central cooling system cooling tower is in the back.

<u>Cooling Tower Facts</u>

6,400 sf of tower basin

36" headers with 30" branches to plant

Four pump sumps, 16,800 gallons each

Total cost $8.8 million

12,000 Tons of heat rejection capacity

Lowest possible drift at .0005%

Four condenser water pumps, variable speed, 300 hp, saving $133,000/year

Four cooling tower fans, variable speed, 24' fan diameter, 125 hp, saving $18,000/year

Cooling is an essential utility at the University of Arizona. A fleet of electric driven refrigeration machines, housed in utility plants at the north, center, and south of campus cool water that circulates through a vast network of underground pipes to all of the campus buildings. Heat drawn from buildings through internal air handling systems is transferred into the circulating water, on return to the plant the heat is transferred from the closed cooling system into evaporating refrigerant in the water chillers, then transferred a third time into an open condensing circuit and, finally, dissipated into the atmosphere by evaporation through cooling towers. Each stage of the heat transfer requires the addition of electric energy to drive pumps, fans, and compressors. There have been many opportunities to improve efficiency and reduce operating costs for this essential system. Improvements in pumping efficiency and replacement of aging chillers, cooling towers, and auxiliary equipment with equipment designed to take maximum advantage of Tucson's typically low early summer humidity has made this university's system one of the most efficient in the United States. Operation of a Thermal Energy Storage system that freezes a large mass of water into ice each night, and later provides campus cooling by melting back into water, provides a substantial reduction in the purchase of electricity during daytime peak periods.

Originating in the utility plants, the heating, cooling, and power flows through underground piping, conduit banks, and subterranean tunnels to ultimate use in the buildings. Building ages, sizes, and types reflect over one hundred years of campus history and growth. Although current energy use density and efficiency often reflect age of the structures, many older campus buildings have been renovated, and now include higher performing envelopes, more appropriately-sized air handling equipment, and better control of air conditioning and lighting. Campus-wide projects have systematically replaced building lighting systems, improved motor efficiencies, and installed variable frequency drives and digital building controls when cost effective. Retrofit and renovation projects targeting reduction of energy consumption in research and teaching laboratories have been a particular focus. Low water use plumbing fixtures, construction of reclaimed water systems for turf irrigation, and changes in landscape management have lowered water consumption.

Project Success to Date

The correlation between campus greenhouse gas emissions and fossil fuel derived energy use is direct. Reduction in campus energy use, through improvements in energy efficiency, is an essential first step in the University's climate action plan. ***Improving energy efficiency has the dual benefit of simultaneously reducing metric tons of greenhouse gas per square foot and holding the University's annual utility purchase budget in check.*** A few of the many examples of successful campus projects and initiatives offers insight into the capabilities of university staff and opportunities for further action:

Building Scheduling and Campus Closure

- Shutting down building systems that are not in use is a simple and effective way to reduce energy. Coordinating the varying time schedules of over 300 building air handling systems with academic schedules and developing infrastructure that allows monitoring and the ability to and maintain maximum space temperatures has achieved considerable success.

- A campus-wide holiday shutdown that deactivates 180 buildings for an 11-day period in the winter has a substantial effect on annual utility consumption. Several thousand horsepower of fan motors remain off, along with megawatts of lighting. Plant production of steam and chilled water back down in response to the diminished loads. Critical loads within the buildings remain on and are monitored. Research facilities housing experiments that require ongoing activity and life safety systems throughout remain active.

"Smart" Classrooms

- Installation of infrared sensors that activate lights and bring air conditioning to occupied levels has been completed in a large number of classrooms as an in-house improvement project.

Lighting Retrofits

- Several campus-wide initiatives have systematically swept campus, replacing lighting, lighting ballasts, and in some instances, lighting controls. These projects often result in substantial economic return through energy savings. Improvements in lighting efficiency lower the watts needed per square foot to adequately illuminate spaces.

Building HVAC Renewal

- Ongoing equipment renewal projects have provided the platform on which to replace antiquated air conditioning systems with new technology and higher efficiency. Use of ducted air handling systems became a standard for the University in the 1950s. Many of these systems are still in operation but nearing the end of their service life. Although duct systems often remain salvageable, the fans, filter banks, coils, and room controls must be replaced. Installation of new systems is done to meet current codes and standards but uses equipment that is substantially more energy-efficient and has far more responsive digital control technologies.

Laboratory Energy Retrofits

- Energy use in the teaching and research laboratories has a large impact in the University's overall carbon footprint. Substantial strides have been made in reducing energy through installation of more efficient equipment and improved control of ventilation systems. Among state institutions, the University of Arizona leads the way in adapting its laboratories to lower flow, but inherently safer, chemical fume hoods. Energy savings from projects that replace aging hoods with low flow units, allowing rebalance of the building air have been significant. Laboratory energy renovations have been completed as stand alone energy savings projects, and as a part of research driven space renovation.

Planning, design, and construction standards for energy-efficient design of new laboratory ventilation systems are quite stringent, requiring energy modeling, life cycle cost analysis, and thorough systems commissioning. Periodic recommissioning of energy intensive laboratory ventilation systems is an ongoing function of Facilities Management

<u>New Building Construction</u>

- All new construction at the University must comply with USGBC LEED Silver or greater rating for sustainable design. Among the criteria is demonstration that the new building design exceed the industry energy efficiency standards by 10% or more. Architects now take more express responsibility for the energy performance of the building envelope, lighting, and mechanical systems.

<u>Campus Energy Management and Control</u>

- The University has adopted a standard building Energy Management and Control System (EMCS) protocol that allows central monitoring and control of individual buildings and central plants via Ethernet. In addition to remote control, the system allows monitoring of energy use and data trending for diagnostic evaluation.

<u>Energy Metering</u>

- A program to install, monitor, and maintain energy meters for steam, chilled water, and electric power is in place. Buildings housing federally-funded research grant activities, residence halls, and athletic facilities are metered for purposes of internal billing. All new building construction projects are required to install meters. Metering and periodic verification of energy performance is likely to be required by sustainable building metrics in the near future.

<u>Electrical Power</u>

- Projects to improve campus electric power distribution have been ongoing for a number of years. Although primarily directed at renewal, code compliance, and capacity, energy improvements are realized through better efficiencies in the voltage transformation.

- A new main substation that interfaces the UA system with that of Tucson Electric Power is currently in the planning and design phase. When complete, this unit will solve a number of power constraints and provide service for substantial growth on main campus. Improvements in transformer efficiencies reduce power input to campus at its source.

The College of Architecture and Landscape Architecture Expansion is a reflection of the school's curriculum and a working laboratory for sustainable practices. The south side of the site is occupied by a water conservation demonstration garden showcasing five different Arizona ecosystems, where students and the public can learn about water efficient irrigation and native plants. Water captured from the roof deck and condensate from the HVAC system filters into a 12,000 gallon holding tank used for the garden's irrigation system, resulting in an 87% reduction in the use of potable water for the garden. The building is connected into the University's Central Plant systems which efficiently generate the energy to serve the building's heating, cooling and electrical needs. High performance HVAC and lighting systems integrated with state of the art digital controls work in unison with the building's architectural elements to ensure maximum efficiency, flexibility and environmental comfort. HVAC system performance is further enhanced by continuously monitoring and dynamically utilizing seasonally available outdoor air heating and cooling energy. The building's south exposure is protected with shade canopies and a green wall that allows vines to grow up for additional shading.

Facilities Management is adapting to changes in building systems technologies, and operating requirements found in today's green buildings.

From the UA Planning, Design, and Construction website.

Central Utility Plant Upgrades

- A broad range of improvements have been made to the University's central utility plants in recent years. Driven by a combination of aging equipment, increasing demand for high reliability, and substantial growth in campus loads and energy efficiency, the University has invested in heating, cooling, and electric power production and distribution systems.

  - Recent heating system improvements included replacement of a natural gas-fired boiler and steam system auxiliaries at the Arizona Health Sciences Center and installation of new lines and utility tunnels that connect the steam piping systems on both sides of Speedway Boulevard.

  - Cooling System improvements included installation of high efficiency water chillers, cooling towers, pumps and auxiliary systems. The highly-interconnected, large bore piping network provides low pumping resistance. Overall operating efficiency metrics for the University of Arizona central chilled water plant are among the best in the country for campus systems of this scale.

  - Thermal Storage improvements, including installation of an ice-making storage and melting system to shift electric demand to off-peak time have been extremely reliable and economical.

Cogeneration

- An on-campus cogeneration system installed a decade ago has proved to be a reliable and efficient component in the University's energy production system. The system provides several important benefits.

  Use of the exhaust gas from the power generating turbine to generate steam makes this system roughly 40% more efficient than separately purchasing electric power from one utility and natural gas to fire boilers from another. Burning less fuel to provide the same value to campus means less metric tons of CO_2 per year.

  The second benefit is that the fuel is entirely natural gas, which has a carbon-to-energy content that is roughly half that of coal. Because the southwest regional utility power production portfolio is heavily weighted to coal, operation of the University's cogeneration system provides a fundamentally lower carbon footprint per megawatt hour of electricity.

  A third benefit is that the units are on-campus, meaning that there is no need to account for the power transmission and distribution losses associated with high-line power from remote utility plants.

- The two cogeneration units were installed before concerns over climate change stimulated the American College and University Presidents Climate Commitment, or need to prepare a Climate Action Plan. Following commissioning of the two systems (which total approximately 12 MW) the University's annual electric purchase dropped, while its natural gas purchase increased. Regional energy markets have held such that the net offset in cost between reduced electric power and increased natural gas has been sufficient to not only amortize the cost of installing the units, but provide a return, in the form of lower annual utility cost.

- Opportunities to further expand campus cogeneration may exist, with a promise of simultaneously providing economic benefit and substantive reduction in campus carbon footprint.

Left: the cogeneration plant serving north campus and the Arizona Health Sciences Center. This unit generates 5 MW of electric power and 28,000 lb/hr of steam for use in the Health Sciences Center and adjacent Hospital.

In 2006, the University installed its first Thermal Energy Storage (TES) system. It includes three 1,200 Ton Glycol chillers, plate and frame heat exchangers, and over 100 Calmac Ice Tanks. The intent of the system is to shift operation of electric driven chillers from periods of peak campus cooling and high utility electric demand to less expensive off-peak, night-time hours. The system has operated with no control-related lost time. Following the success of the first plant, the University installed a second TES plant in 2008 at the Central Heating and Refrigeration Plant (CHRP) on main campus. The second system includes a 1,200 Ton Glycol chiller and approximately 50 individual tube-in-tank storage units.

Renewable Energy Initiatives

- Work managed by Planning, Design and Construction to install solar photovoltaic panels on parking garages and building rooftops through an energy services performance contract is actively underway. A great deal of regional interest and investment in this technology is causing its life cycle economic outlook to improve. At current panel conversion efficiencies it is estimated that somewhere on the order of 2 MW of peak solar power could reasonably be installed on existing building rooftops on the UA Tucson campus. Electric power produced by solar photovoltaic systems is a direct offset to the purchased electricity component of the University's carbon emission inventory.

- Solar thermal collection systems can provide nearer term economic payback in campus use. Systems currently in place, in planning or in construction, include solar pool heating at the Student Recreation Center and solar domestic hot water for the new Sixth Street Residence Halls. Improving technologies to convert solar heat to building cooling through adsorption chilling are of particular interest in Tucson. Thermal energy produced by solar collectors is an offset to the on-site steam component of the University's carbon emission inventory.

Right: the photovoltaic panels installed on the 2nd Street Parking Garage behind the University's Administration Building. The 26,000 SF photovoltaic array is mounted on a recycled content steel structure that utilizes 1,152 south-facing PV modules, inclined at 10° to generate 200 kW of AC power, which will serve the garage and feed surplus power into the University's electrical grid. Future solar installations are planned for McClelland Hall, McClelland Park, Hillenbrand Aquatic Center, and the Student Recreation Center that will include both solar photovoltaic and solar water heating.

From the UA Planning, Design, and Construction website.

Photovoltaic Facts

Typical PV Module: 59x39x1.5" weight 40lbs - rated at 210W DC

PV Array Production: 415,000 Kilowatt Hours (kWh) per year.

Greenhouse Gas: Reduction of 300 metric tons - equivalent to removing 55 passenger vehicles from Tucson's roads per year.

Climate Action Planning

Going forward, a next step in the ACUPCC process is development and formal submittal of a Climate Action Plan that includes milestone dates for quantitative reduction in the campus Greenhouse Gas inventory. The prescriptive requirements for preparation of the Climate Action Plan include institutional responses to a specific set of questions involving not only GHG emissions, but University plans to address climate change through teaching, research and outreach programs.

Preparation of the Climate Action Plan requires integration of broad campus planning objectives with economic realities and budget constraints. Ultimately, financial engineering may be a component of the University's Climate Action Plan with energy services contracts, public-private partnerships, and private enterprise solutions playing a role in implementation.

The University's Climate Action Plan will involve operational actions leading to the objective of reduction of green house gases. A few of these are described below.

<u>Demand side energy reduction</u>

- Substantial further reductions in building specific energy use through:
  - increased focus on energy use in design of new buildings,
  - increased focus on energy use in building renovation projects, and
  - re-commissioning of existing building systems to optimize performance.
- Substantial reductions in campus-wide energy use through:
  - continued implementation of building automation, energy management, and controls,
  - further development, sophistication, and real time use of campus energy metering, monitoring, and control, and
  - increases in the levels of energy and greenhouse gas awareness, collaboration, and personal responsibility across the entire campus population.
- Further reductions in waste heat through:
  - greater use of low temperature heat recovery,
  - improvements to the steam distribution systems, and
  - greater utilization of combined heat and power equipment.

<u>Supply side shifts away from carbon based energy</u>

- Carbon content of electric power purchased from Tucson Electric Power is anticipated to diminish somewhat as regulatory mandates to increase its renewable energy generation portfolio take effect.
- Increases in the ratio of campus combined heat and power to purchased electric power and natural gas for heat will reduce carbon emissions.
- Increase utilization of solar thermal energy for building heat, domestic water heat, and cooling.
- Increase utilization of on-campus photovoltaics utilizing available roof space and as integrated envelope components to future buildings.
- Develop, perhaps in conjunction with others, utility-scale off-campus solar energy power plants utilizing the University's substantial land holdings, existing power transmission infrastructure and the regions abundant solar resource.
- Alternative low carbon fuel sources for on-campus combined heat and power such as source separated urban biomass or cultivated biofuels may become regionally viable in later years of the plan.

Next Steps

Although a goal of achieving carbon neutrality by the year 2050 is daunting, it is no means unobtainable. A continuous process of incremental improvements to demand side energy efficiency and systematic supply side shifts away from high carbon content fuels can have a profound impact on the campus greenhouse gas inventory in early years of the plan. An incentive for university investment in these sorts of facilities improvements is the potential that they can be inherently fiscally responsible. A project that substantially reduces building energy use, for example, not only lowers annual campus purchase of electric power utility and natural gas, but also frees plant energy production and distribution capacity, deferring needs to install new equipment as the campus grows. Overall life cycle analysis should be applied to efficiency and greenhouse gas reduction decision making.

In later years, the University's climate action plan will need to rely on improvements in technology. Improvements that make renewable energy more economically viable will perhaps involve large scale concentrating solar plants, substantially higher-efficiency photovoltaic arrays, solar thermal cooling, algae derived biofuels, or any number of technologies that are still being developed through basic research laboratories. Pressure to stem climate change could ultimately have significant effect on global and national energy markets, perhaps providing incentive for expanded regional adaptation of carbon sequestration, lower carbon, nuclear, or other carbon-free energy power sources.

The ACUPCC involves preparation of graphics depicting the planned rate at which greenhouse gas is to diminish. This exercise will need to involve broader campus input, as it must address the significant GHG contributions of the vehicle fleet, student and staff commuting, and air transportation.

Water use is indirectly tied to University of Arizona greenhouse gas emissions, but is of great concern in an overall University Climate Action Plan. Although much of its water is drawn from campus wells, the UA taps into an aquifer in a diminishing regional watershed, and focus is increasing to minimize building water use on campus, adapt to lower water use landscape materials and irrigation techniques, and make better use of reclaimed water, water harvesting, and storm water retention. Like greenhouse gas emission reductions, incremental and intelligent actions are an essential part of the plan.

Right: the open space in north campus. As the natural desert landscaping matures, it helps cool the buildings and surrounding walkways during hot summer months.