CONCEPTUAL ENERGY PLAN FOR THE KNOXVILLE CAMPUS OF THE UNIVERSITY OF TENNESSEE

Prepared by

The Committee on the Campus Environment

Mary English and John Nolt, Co-Chairs
2006-07 Committee Membership:
Greg Britten
Leslie Chinery
Wayne Davis
David Doane
Terry Ledford
John McRae
Mike McKinney
John Overly
Jonathan Overly
William Park
Reagan Richmond
Samuel Rogers
Gerald Schroed1
Mike Sherrell
Mark Smith
Ken Stephenson
Sarah Surak
Amanda Womac

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Executive Summary

Why Adopt an Energy Plan?

There are both practical and ethical reasons for adopting an energy plan. Energy costs are rising and are likely to rise further, especially if carbon dioxide emissions are regulated. Conventional forms of energy—particularly those associated with global climate change—also impose environmental and social costs.

Recent institutional commitments require energy planning. On behalf of UTK, Chancellor Crabtree has signed the Talloires Declaration and the American Colleges and Universities Presidents' Climate Commitment. In addition, an energy plan will help to inform the UT Knoxville Campus Master Plan and the Cherokee Campus Plan.

The plan presented here is a conceptual 25-year plan. It sets the stage for more detailed, facility- and technology-specific energy planning at UTK. It has been prepared by the Committee on the Campus Environment at the request of Chancellor Crabtree.

The Current Picture

In general, UTK's current energy performance is neither terrific nor terrible. The Sustainable Endowments Institute's 2007 College Sustainability Report Card gives UTK a grade of C in the two relevant categories of "Climate Change & Energy" and "Green Building." UTK's recent energy consumption (measured in BTUs per square foot of gross floor area) has been slightly above the median for American educational institutions but below the median for Carnegie research institutions.

Apart from transportation, which is not addressed in this plan, the main sources of energy used by UTK are coal and natural gas in the campus steam plant and electricity from the Tennessee Valley Authority. The use of coal for the steam plant and electricity from TVA has increased significantly in recent years; natural gas use has declined, due to increasing cost.

Over the past two decades, UTK's total energy consumption has increased at an average rate of 1.7 percent per year. Energy use per square foot rose an average of 0.65 percent annually over this same period, though since about 2000 it has generally been decreasing. Much of the growth has been due to the increased use of air conditioning and electronic equipment such as computers.

UTK is already engaged in a number of efforts to save energy, switch to renewable energy sources, and reduce greenhouse gas emissions. Many of these are funded by the Student Environmental Initiatives Fee. The fee funds UTK's green power purchases (currently, 2.6 percent of UTK's total electricity consumption) through the

TVA/Knoxville Utilities Board Green Power Switch Program. The fee also funds lighting upgrades in the Stokely Management Center, upgrades of steam valve controls, motion sensors to control lighting, the purchase of hybrid vehicles, a compact fluorescent light bulb exchange, and a variety of other projects. The Make Orange Green program publicizes UTK's environmental efforts and educates the campus community on sustainable practices. In addition, Chancellor Crabtree has announced that all new campus buildings will be built to Leadership in Energy and Environmental Design (LEED) standards.

The Next 25 Years at UTK

A larger campus community and more facilities are likely to increase campus energy demands. Current student population is about 26,500. It can be expected that over the next 25 years, the student population—and with it, the number of faculty and staff—could increase by as much as 58 percent. Projected construction from now through 2020 will add about 3 million square feet of building space to the current 13.7 million square feet. Despite energy efficiencies that have now become standard with new construction, a continued annual growth rate in total energy use of between one and two percent is a reasonable estimate for a "business-as-usual" scenario—at least in the short term, and possibly for the long term.

A strong conservation and energy efficiency program might reasonably be expected to keep total energy use roughly constant and further reduce consumption per square foot.

The Larger Picture: Future Energy Supplies, Prices, and Policy

Global energy demand is expected to increase at an average rate of two percent per year over the next 25 years. The high global demand for petroleum, coupled with constrained sources of supply, is likely to cause price escalation of crude oil and related petroleum products. Similar supply and demand behavior can be expected with natural gas prices. According to projections by the U.S. Department of Energy's Energy Information Administration (EIA), new natural gas supplies and slower growth in consumption are likely to cause natural gas prices to decline through 2016; after that, as the cost of developing remaining natural gas resources increases, natural gas prices are likely to increase. The EIA projects the average delivered price of coal in the United States to be stable over the next 25 years, due to the nation's large supply of recoverable coal reserves. Given the high fraction of coal used in the generation of electricity, corresponding prices of electricity are expected to be stable (in real dollars) as well.

These projections, however, do not reflect the possibility of new regulations – in particular, regarding carbon dioxide emissions. New emission reduction requirements may have a significant impact on the price of electricity as well as on the resource mix used to generate electricity.

Environmental Considerations

UTK's energy use has significant environmental impacts. Of greatest long-term concern are greenhouse gas emissions, the most important of which is carbon dioxide. The largest on-campus source of atmospheric carbon is the coal burned by the steam plant. Other pollutants emitted by the steam plant include nitrogen oxides (precursors to ozone formation), sulfur dioxide, particulate matter, and mercury. Use of coal also is associated with considerable land disturbance and water pollution, especially if the coal is surface-mined. While UTK has a policy of avoiding surface-mined coal, TVA does not. UTK indirectly causes carbon dioxide emissions and other environmental problems through the electricity it buys from TVA, about 60 percent of which is produced by burning coal.

Budgetary Considerations

Energy costs have risen both in dollar amounts and as a percentage of the UTK budget over the last fifteen years. In FY 1990-91, UTK's "energy budget" (for electricity, coal, natural gas, and the production and distribution of steam) was 3.25 percent; in FY 2006-07, it was 4.14 percent.

Informational and Organizational Constraints to Optimal Energy Savings

UTK lacks detailed building-by-building information on energy use. This information is needed for careful planning, including weighing the costs and benefits of various actions. In addition, there are a number of organizational barriers that deter the optimal implementation of energy-saving practices. These include constraints on:

- Applying utility budget savings to energy-savings projects.
- Connecting capital improvement decisions with subsequent operations and maintenance costs.
- Making improvements to the steam plant.
- Thinking with foresight about campus buildings and the campus as a whole.
- Collaboration in design and engineering processes.

Possible Strategies, Methods, and Technologies for Reducing Energy Usage and Greenhouse Gas Emissions at UTK

To lay the groundwork for more detailed energy planning, this section assesses various current and prospective practices and technologies for reducing energy consumption and greenhouse gas emissions. For each practice or technology, rough estimates are provided for the following parameters:

- Feasible time frame.
- Implementation considerations.
- Constraints and caveats.
- Effectiveness in reducing UTK’s carbon footprint.

For current practices and technologies, examples also are noted in several instances.

Recommendations

No single suite of energy-saving technologies or practices will achieve significant reductions in energy use and carbon emissions. An on-going, multi-pronged effort is needed. Recommendations for this effort are listed in Section VI, beginning with a set of goals and short-term and long-term strategies for achieving them. The recommended goals are:

- Reduce energy consumption (measured in BTUs per square foot per year) by five percent by 2012 and 25 percent by 2030, using 2006-07 figures as a base.
- Achieve carbon neutrality by 2030, in accordance with the Presidents’ Climate Commitment guidelines.
- Make UTK a leader in energy-efficient, high-performance, sustainable design.
- Support clean energy research on campus (especially research that benefits the campus itself).
- Educate students about energy use, environmental impacts, and sustainability.
- Create a culture of energy conservation on campus.

General recommendations for the UTK campus are followed by recommendations specific to the Cherokee Campus, the Campus Master Plan, and the Presidents’ Climate Commitment.

Funding Possibilities

In developing this conceptual energy plan, funding mechanisms were not a central charge to the Committee on the Campus Environment. Nevertheless, several means are noted for funding energy conservation and greenhouse gas reduction efforts. These include, for example, the existing Student Environmental Initiatives Fee and Campus Environmental Stewardship Fund, class donations, revolving loan funds, Clean Renewable Energy Bonds, corporate grants and partnerships, partnerships with state and local governments, federal grants, and foundation grants.

I. Introduction

This energy plan is called a “conceptual plan” because it sets the stage for more detailed, facility- and technology-specific energy planning at UTK. The plan reviews demand and supply considerations, both currently and over the next 25 years; it discusses environmental and economic considerations that should be factored into decisions on energy at UTK; it identifies strategies, methods, and technologies that may be workable for UTK; and it recommends goals and strategies—immediate and long-term—for UTK.

A. <u>The Need for a Campus Energy Plan</u>

The need for campus energy planning is beyond question. Energy prices are rising, absorbing a larger proportion of the university’s budget; evidence of global climate change and other damages and risks from current energy practices is mounting; the regulation of carbon dioxide emissions looms. The imperative for proactive change is obvious.

In addition, UTK has made several institutional commitments that call for an energy plan. In April 2004, Chancellor Crabtree promulgated an Environmental Policy which includes the principle that “in its daily operations, UTK will attempt to conserve energy and to promote the use of renewable energy sources.” Chancellor Crabtree also has signed two agreements that deepen UTK’s commitments to energy planning: the Talloires Declaration and the American Colleges and Universities Presidents’ Climate Commitment. The Talloires Declaration requires, among other goals, that the campus “[s]et an example of environmental responsibility by establishing institutional ecology policies and practices of resource conservation …”[1] The Presidents’ Climate Commitment (see Appendix 4) is more specific. It commits the campus to a rigorous series of steps toward climate neutrality.

In April 2005, at the direction of the Chancellor, the Committee on the Campus Environment (CCE) issued an Environmental Progress Report for the campus (see http://www.cce.utk.edu/05progressreport.pdf). The energy section of this report documented UTK’s energy consumption over the prior two decades and made recommendations for reducing energy consumption in buildings and other campus settings.

In May 2005, Chancellor Crabtree requested CCE to develop a 25-year energy plan for the UTK campus. In the following months, CCE sought and obtained the assistance of two ORNL researchers, funded through a $25,000 technical assistance grant from the U.S. Department of Energy’s Rebuild America Program. In September 2006, CCE and ORNL organized an energy-planning charrette to strategize about the recommended goals and actions for the plan. Research continued through the following year. The current document is the result.

The plan covers 25 years, beginning in 2005 and ending in 2030. The "short-term" sections cover the period roughly to 2012. The "long-term" sections cover the period to 2030. In accordance with the aims of the Presidents' Climate Commitment, climate neutrality considerations have been integrated into the energy plan. At Chancellor Crabtree's suggestion, transportation-related uses of energy largely have been excluded. To tackle the energy aspects of transportation planning would have been a huge task in itself. It should be emphasized, however, that any complete plan for climate neutrality must consider transportation as a major source of greenhouse gases. In addition, the energy plan does not consider energy used in landscape maintenance, nor does it include embodied energy—i.e., energy used in producing and delivering various goods and services. These too should not be ignored in a complete plan for climate neutrality.

B. Relation of the Energy Plan to the Campus Master Plan and the Cherokee Campus Plan

In Fall 2005, Chancellor Crabtree created a committee to update the Campus Master Plan. Initially, CCE sought to coordinate the energy plan with the Campus Master Plan, but completion of the latter has been delayed. It appears that a separate planning committee will be appointed to address the Cherokee Campus. This energy plan is constructed to be useful to both committees. Recommendations for the UTK Campus Master Plan and the Cherokee Campus appear in Section VI.

Though campus planning is in flux, nearly everyone agrees that the UTK student population will grow, and with it, the number of faculty and staff (see Section III-A for a discussion of projected growth). A larger campus population means larger energy demands and further need for far-sighted energy planning. There is also general agreement that the new construction needed to accommodate an expanded UTK population will require increased campus density. This is a further argument for far-sighted planning, in order to integrate design features that achieve energy efficiency under complex conditions.

The Campus Master Plan, while not yet complete, appears to share some of its goals with this Energy Plan. The May 2007 draft of the Campus Master Plan goals includes the following:

> **Promote sound environmental policies** that enhance the quality of both the natural and built environment of the campus.
>
> **Conserve energy** and make the campus a model of sound energy management.

And one of the draft Master Plan's governing principles is to:

> Develop construction and maintenance policies and practices that promote energy conservation and sustainability, incorporating Leadership in Energy and Environmental Design (LEED) principles in all projects to the extent feasible.

C. Energy and Climate Programs at Other Universities

Across the nation and around the world, universities are adopting energy-conservation and energy-production measures that provide long-term savings, reduce greenhouse gas emissions, provide research and educational opportunities, and fulfill ethical obligations. The Association for the Advancement of Sustainability in Higher Education (AASHE) issues weekly updates on sustainability practices, including energy planning and climate neutrality planning, on campuses across North America. These paint an impressive picture of rapid and widespread progress. A few examples of general commitments and programs follow:

The **University of Buffalo**'s energy conservation program has a history exceeding 20 years. The program has documented annual energy dollar savings in excess of $9 million a year. In 1998, a $17 million demand side management project which the UB conducted from 1994-1997 was awarded "Energy Project of the Year" from the Association of Energy Engineers. UB aims to reduce campus energy consumption by an additional 20 percent by the year 2010.[2]

The **University of Iowa** saved more than $5 million in energy expenditures for a 24-month period ending in June 2007. The University was able to achieve this goal through a variety of measures, including the use of oat hulls to replace coal in the campus power plant, the development of higher efficiency standards for building construction and maintenance, and implementation of a campus-wide energy conservation outreach campaign. UI's new Energy Conservation Strategic Plan calls for a ten percent reduction in energy use per square foot by 2013 and reliance on renewable resources for 15 percent of its energy by 2013.[3]

The **University of British Columbia's** ECOTrek program, the largest water and energy retrofit in any Canadian university, completed in 2006, saves the university $2.6 million (Canadian dollars) annually as a result of a greater than 20 percent reduction in energy use. UBC claims reductions in greenhouse gas emissions of 80 percent.[4]

In 2004, the **University of California** system adopted a policy requiring new building projects to outperform the California Energy Code (Title 24) by 20 percent; system-wide growth-adjusted energy consumption to be reduced by ten percent by 2014; ten megawatts of locally renewable power to be produced by 2014; and 20 percent of electricity needs to be obtained from renewable sources by 2017.[5]

II. Current and Near-Term Conditions

A. Consumption

UTK Compared with Other Universities
In general UTK's energy performance is neither spectacularly good nor spectacularly bad. In its 2007 report, the Sustainable Endowments Institute, which issues an annual College Sustainability Report Card, gives UTK a grade of C in "Climate Change & Energy" and "Green Building" (see http://www.endowmentinstitute.org/sustainability/).

According to an analysis prepared for this Energy Plan by Dr. Randy Hudson at Oak Ridge National Laboratory (see http://www.cce.utk.edu), UTK's energy consumption (measured in BTUs per square foot of gross floor area) was slightly above the median for American educational institutions for the year 1997-98, the most recent period for which national data are available. However, energy use varies by type of institution; for example, K-12 schools typically have the lowest energy use, while research universities typically have the highest. Compared with other Carnegie research institutions, UTK's energy consumption was below the median, with only 30 percent of Carnegie institutions having lower energy consumption.[6]

Growth in Energy Consumption at UTK
Though UTK's total energy use continues to increase (at an average rate of about 1.7 percent per year over the last two decades), campus-specific information on end uses of energy is not available. Newer buildings are, for the most part, separately metered for electricity and gas, but the resulting data are not very informative regarding end-use. Facilities Services has not been able to obtain accurate steam meters, so building-by-building data on steam usage are not available. Thus, the percentages of energy consumed by, for example, heating, ventilation, air conditioning, water heating, and lighting cannot be accurately estimated. These are, however, the five largest uses of energy on campus. Improvements in them will provide the most savings.

A general guideline is that electrical uses have higher costs per BTU, and they also require significantly more amounts of primary energy to provide the end-use energy (since generation on average is around 33 percent efficient) than other ways of using energy. Energy savings in electrical end-uses such as lighting or office equipment will have an appreciably larger impact on total energy savings.[7]

Causes of Growth in Energy Consumption
Energy use at UTK is partly a function of student population. Student enrollment peaked in 1979-80 at 30,391 but then declined. It hovered around 25,000 for two decades, from 1984-85 to 2004-05, but has since grown to about 26,500. Changes in housing patterns also are occurring. On the one hand, more students live off-campus. This shifts some of the demand for housing to private off-campus sources, but it increases the vehicle-miles traveled by students to and from campus, as well as increasing the demand for parking near campus. On the other hand, all freshmen who do not live at home are required to live

on campus, and the freshman classes are expected to continue to grow for the foreseeable future. (For details on expected growth in student population, see Section III-A.)

Energy use at UTK is also a function of the amount and type of built space. The Knoxville campus includes over 550 acres with over 200 buildings. The square footage of UTK building space has grown significantly over the past 20 years:

1986-87: 10,853,010 square feet
1996-97: 12,257,514 square feet (13% increase from 1986-87)
2006-07: 13,657,878 square feet (11% increase from 1996-97, 26% from 1986-87)

With planned improvements in UTK's teaching, research, and other facilities, its square footage of building space will to continue to grow, and some of the added space – especially for research – will necessarily be energy-intensive. (For details on new construction, see Section III-A and Appendix 1.)

Trends in Consumption: Electricity
UTK's electricity is supplied by the Tennessee Valley Authority through the Knoxville Utilities Board (KUB). The UTK steam plant also operates a 5-megawatt electrical power generator when it is economical to do so, but UTK mainly relies on KUB for its electricity.

At UTK, electricity is used mainly in buildings for lighting, computers, air conditioning, etc., but also outside for street lighting, etc. Energy consumption grew significantly over the past two decades:

Electricity Consumption (kilowatt-hours)*					
	1986-87	**1996-97**	**10-yr change**	**2006-07**	**10-yr change**
Total	151,983,085	197, 080,382	+30%	244,975,745	+25%
Per sq. ft.	14.0	16.1	+15%	17.9	+11%

*Here and elsewhere, numbers have been rounded.

Two factors have contributed substantially to these increases: computers and air conditioning. Air conditioning is provided to campus buildings through various means: window air conditioners, split direct expansion (DX) units, chilled water from chiller systems located at individual buildings, and chilled water from regional chiller plants that serve several UTK buildings within a given vicinity. Of these, the regional chiller plants are the most energy-efficient and least-polluting, and much of the campus is being switched over to them.

The figures above include both electricity purchased from KUB and electricity generated on-site at the steam plant. On-site generation accounts for only a small fraction of the total and varies considerably from year to year, depending on the price of natural gas used to fire the turbine that generates electricity:

Electricity Generated Onsite at UTK Steam Plant	
Year	**kWh**
1996	1,584,090
1997	22,811,119
1998	30,805,014
1999	32,962,025
2000	13,276,131
2001	3,626,593
2002	8,958,719
2003	159,351
2004	50,857
2005	0
2006	66,884

Trends in Consumption: Coal

UTK's steam plant provides steam for building heating, domestic hot water, and laboratory sterilization needs. The plant is powered mainly by coal, but natural gas is used as well. The plant has two coal-fired boilers, one natural gas-fired boiler, and one boiler that can be fired with either coal or natural gas. Steam is supplied to campus buildings through a UTK-owned and –operated distribution system.

At the steam plant, the use of coal declined somewhat relative to natural gas, especially in the past ten years with the installation of natural gas-fired equipment in the mid-1990s, but the cost of natural gas has since escalated.

Coal Consumption (tons)					
	1986-87	**1996-97**	**10-yr change**	**2006-07**	**10-yr change**
Total	28,740	22,035	-23%	29,897	+36%
Per sq. ft.	.0026	.0018	-36%	.0022	+22%

Trends in Consumption: Natural Gas

Natural gas is cleaner to burn than coal, producing fewer pollutants, such as sulfur dioxide, nitrogen oxide, particulate matter, and mercury. Until recently the cost of natural gas had stayed low; now its cost has gone up significantly.

Natural Gas Consumption (therms)					
	1986-87	**1996-97**	**10-yr change**	**2006-07**	**10-yr change**
Total	268,472	5,651,182	+2,105%	1,934,117	-66%
Per sq. ft.	.025	.461	+1,844%	.142	-70%

Translating Coal and Natural Gas into Their Steam Outputs

Together, coal and natural gas used at the UTK steam plant produced the following amounts of steam over the past two decades:

Steam (pounds)					
	1986-87	**1996-97**	**10-yr change**	**2006-07**	**10-yr change**
Total	535,228,000	644,310,652	+20%	671,906,602	+04%
Per sq. ft.	49.3	52.6	+07%	49.2	-06%

Total Energy Use

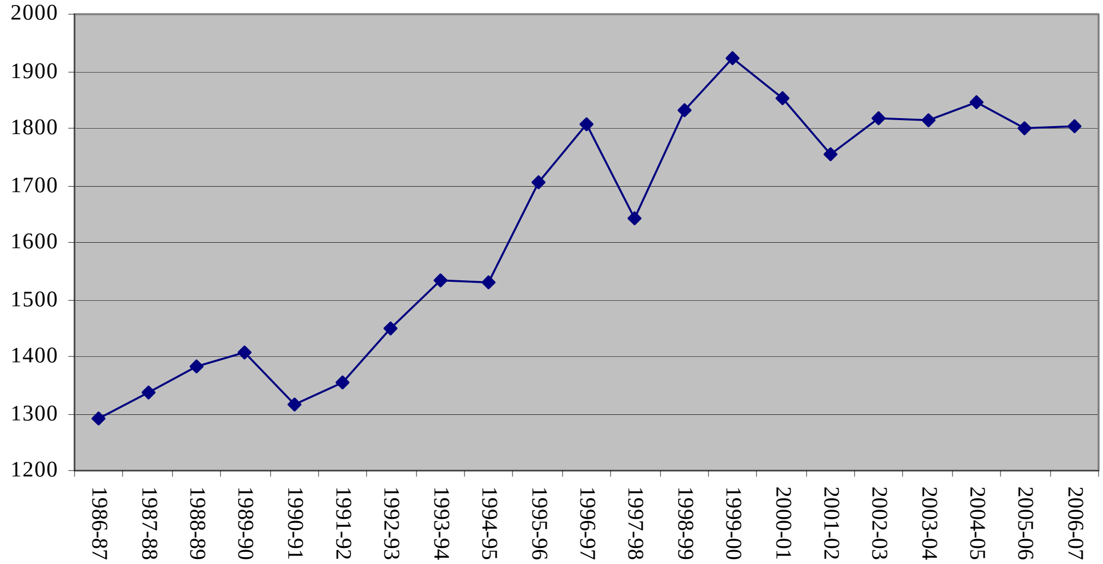
The following table provides a summary of UTK's total energy use over the last two decades, with all figures converted to a common BTU measure:

Year	Coal		Electricity		Natural gas		Total Energy	Energy / sq. ft.
	tons	Billion BTUs	kWh	Billion BTUs	therms	Billion BTUs	Billion BTUs	BTUs per sq. ft.
86-87	28,740	747	151,983,085	517	268,472	27	1291	118937
87-88	29,473	766	158,846,175	540	310,889	31	1337	122312
88-89	30,549	794	163,644,258	556	328,620	33	1384	125234
89-90	30,717	799	169,424,595	576	332,892	33	1408	125675
90-91	28,894	751	155,371,175	528	361,714	36	1316	115885
91-92	30,559	795	154,631,635	526	357,044	36	1356	121255
92-93	31,878	829	170,630,171	580	418,424	42	1451	127665
93-94	32,536	846	188,847,792	642	443,617	44	1532	134817
94-95	32,198	837	193,048,731	656	359,303	36	1529	134502
95-96	33,765	878	203,479,827	692	1,347,927	135	1705	139059
96-97	22,035	573	197,080,382	670	5,651,182	565	1808	147510
97-98	26,544	690	210,714,106	716	2,341,741	234	1641	127243
98-99	20,235	526	218,153,153	742	5,624,887	562	1830	141945
99-00	23,278	605	220,464,333	750	5,675,407	568	1922	147794
00-01	34,353	893	227,298,332	773	1,871,057	187	1853	146692
01-02	28,531	742	222,941,427	758	2,538,186	254	1754	138108
02-03	30,515	793	234,563,915	798	2,256,471	226	1817	143064
03-04	28,530	742	223,331,935	759	3,137,317	314	1815	142929
04-05	32,348	841	246,208,960	837	1,680,516	168	1846	135087
05-06	29,973	779	249,049,225	847	1,722,275	172	1798	131395
06-07	29,897	777	244,975,745	833	1,934,117	193	1804	135073

*Note: Electricity figures refer to **site energy**, the energy contained in the electricity actually purchased and used by UTK, Site energy for electricity is about 33 percent of **primary energy**, which is site energy plus the energy used to generate, transmit, and distribute the electricity.*

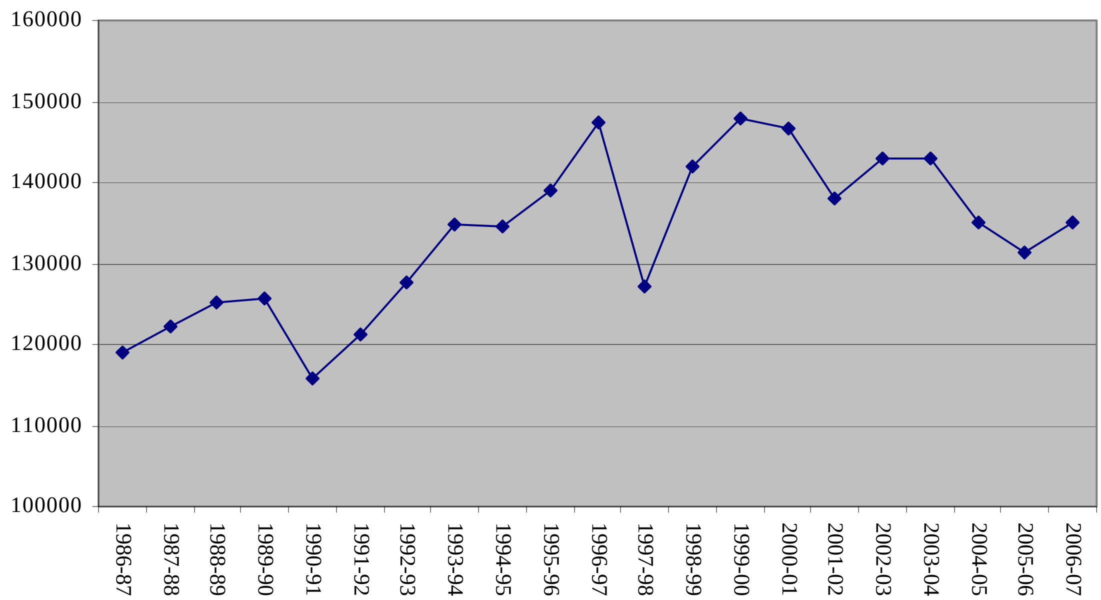
Over the two decades covered by this chart, UTK's total energy use has increased about 40 percent—an average annual growth rate of about 1.7 percent, though in the past few years total energy use has leveled off, as the following graph illustrates:

Total Energy Use (Billions of BTUs)



From 1986-87 to 1999-2000 UTK's energy use per square foot of floor area grew about 24 percent. However, since 1999-2000 energy use per square foot has decreased by about nine percent, probably as a result of increasing energy efficiencies in new buildings and upgrades to existing buildings. The following graph shows the somewhat erratic nature of this trend:

Total Energy Use (BTUs per Square Foot of Floor Area)



B. Recent and Prospective Energy Improvements

This section presents a sample of recent energy improvements at UTK, emphasizing those undertaken during the last two academic years. Many of these improvements have been funded by the Student Environmental Initiatives Fee.

2006-2007

Green Power Purchase
For the second year, the Student Environmental Initiatives Fee funded the purchase of 3,375 blocks of green power from the TVA/KUB Green Power Switch Program. The 3,375 blocks, or 506,250 KWh/month, offsets approximately 382 tons of CO_2, SO_2, and NO_X each month. This is the equivalent of removing 732 cars from the road.[8] UTK's green power consists of 2.6 percent of campus annual electricity use, making it a member of the EPA Green Power Partner program.

Stokely Management Center Lighting and Lighting Controls Upgrade
The Student Environmental Initiatives Fee has funded five years at $125,000 per year to perform a lighting upgrade in Stokely Management Center. The original lighting resulted in lighting control on half floors only. Therefore, for the lights to be on in a single office, all lights for half of the floor had to be on. In addition, the lighting in SMC is 1970s lighting, which is considerably less efficient than current lighting. This project will replace all lighting in the building with current lighting that also can be controlled on a per fixture basis. In addition, it will incorporate occupancy sensors and daylight harvesting. The Facilities Services Department is donating labor for Environmental Initiatives projects. This should result in this project costing less than the proposed $625,000.

In a related project, Facilities Services has converted old pneumatic controls for the air handlers in SMC to direct digital controls (DDC). The DDC system gives more accurate control and improves energy savings by providing better control of systems during unoccupied periods.

Steam Valve Controls
The Student Environmental Initiatives Fee funds $13,000 per year for five years to perform upgrades of controls and valves that turn steam on and off in Perkins Hall, Hess Hall, and the Facilities Services building. These controls will improve comfort levels and help eliminate situations where windows are opened and air conditioners are run to offset overheating. Because Facilities Services is donating labor, the project may cost less than the estimated $65,000.

Lighting Motion Sensors
The Student Environmental Initiatives Fee funds $5,000 for the purchase of lighting motion sensors. These will sense occupancy in a room, in order to automatically turn lighting off when the room is vacant. These are being installed in several buildings on campus; they may spur greater energy awareness to the campus community. Because

Facilities Services is donating labor, all of the funding will be used for the purchase of sensors.

Hybrid Vehicle Purchase (Electric)
The Student Environmental Initiatives Fee funded the purchase of three Global Electric Motorcars (GEM) vehicles. For more vehicle information, see http://www.gemcar.com .

Compact Fluorescent Light Bulb Exchange
In Fall 2006, a project funded jointly by the Facilities Fee ($4,000), University Housing ($6,000), and Facilities Services ($5,500) enabled students in UTK housing facilities to swap incandescent bulbs for compact fluorescent bulbs for their desk lamps. Over 2,000 bulbs were swapped in campus residence halls, resulting in an estimated savings of $4,000/semester in electrical costs and eliminating over 100,000 pounds of emissions per semester.[9]

"Make Orange Green"
In Fall 2006, UTK rolled out "Make Orange Green," an ongoing campus-wide campaign to promote, coordinate, and provide information about environmental stewardship activities at UTK. "Make Orange Green" is a collaborative effort of the UTK Office of Public Relations, which originated the idea; the Committee on the Campus Environment; the Facilities Services Department; and the Student Environmental Initiatives Committee.

2005-2006

The Student Environmental Initiatives Fee funded $8,000 for controls to inhibit unnecessary firing cycles of natural gas-powered water boilers. The controls are expected to result in natural gas savings of up to ten percent and will be installed in the International House, Black Cultural Center, Conference Center, and Middlebrook Building.

The Student Environmental Initiatives Fee funded $20,000 to replace old, inefficient electric motors. Old motors have efficiencies of about 80-85 percent; new motors can achieve efficiencies of 90 percent or better. This project also will installing a variable speed controller on the air handler supply fan at Austin Peay, producing energy savings by eliminating inlet guide vanes on the fan.

The Student Environmental Initiatives Fee set aside $20,000 for the purchase of more efficient lighting fixtures for Perkins and Ferris Halls and also for student desk lamps. A previous project funded by the Chancellor had replaced some of the fixtures in Perkins and Ferris. The additional funding enabled the replacement of all remaining four-bulb fluorescent fixtures with three-bulb fixtures.

In Spring 2006, Facilities Services began to replace incandescent lighting with compact fluorescent lighting wherever possible. This will result in a savings of 75 percent in electricity for each lamp replaced.

Other Recent Improvements
Additional improvement measures that UTK has undertaken in recent years include:

- Improved energy savings at the UTK steam plant by reducing steam pressure from125 psig to 110 psig.
- Continual, aggressive work to find and repair condensate leaks within campus steam piping systems.
- Replacing older air conditioning units with more effective models, oversizing ductwork and filter banks to reduce horsepower needed for operation, and oversizing cooling towers to reduce the temperature of water returned to the chiller reducing horsepower needs.
- Installing automated systems to turn off heating, ventilating, and air conditioning (HVAC) systems during unoccupied periods.
- Lowering temperatures in hot water systems for domestic uses such as washing and for building heating.
- Replacing single pane, leaky windows with double pane, better insulated windows in buildings such as Hesler Biology, Austin Peay, and Alumni Memorial.
- Low-E retrofits to the windows of older buildings including parts of McClung Tower.
- Installing low-flow shower heads and water faucets in new and retrofitted buildings during all renovations to reduce hot water use.
- Installing low-flow plumbing fixtures in renovations.
- Upgrading to more efficient lighting systems during renovations.
- Solar panel and wind turbine demonstration.

The Student Environmental Initiatives Fee also has paid UT's membership dues for the Association for the Advancement of Sustainability in Higher Education (AASHE). The AASHE website (www.aashe.org) provides a wide range of information on sustainability activities at college and university campuses. Any person with an *@utk.edu* or *@tennessee.edu* e-mail address can access this information.

Prospective Energy Improvements
Facilities Services plans to continue to incorporate maximum energy efficiency into campus projects. Major campus renovations and new construction incorporate ASHRAE 90.1 guidelines as a minimum. Future projects are aspiring to meet LEED certification. The Student Environmental Initiatives Fee will continue to fund projects such as replacing inefficient lighting fixtures, updating lighting controls, and providing better controls on steam systems to minimize overheating of some older buildings. Where possible, HVAC systems are being turned off during off-hours. Variable speed drives are being installed on cooling towers, chillers, and other large load systems. The "Make Orange Green" program strives to get the word out about how individuals can contribute to energy conservation efforts. Green power purchases paid for by the Student Environmental Initiatives Fee will continue.

III. The Long Term (to 2030)

In this section, future UTK energy consumption is estimated, and possible changes in energy supply, prices, and policies over this period are discussed. Because of the long time frame, these forecasts are fraught with uncertainty.

A. <u>Projected Consumption</u>

Student Enrollment
Based on current discussions, it is reasonable to expect that student enrollment will grow over the next ten years from the current 26,500 to roughly 32,000 – about 21 percent.[10] Longer-range predictions are difficult: They depend on both student demand and UTK policies. It is possible, however, that UTK will grow considerably in subsequent years.

If a growth rate of one percent annually (roughly the rate of recent population growth in East Tennessee) were assumed, then (using 2006-7 as a base) student population would reach about 28,700 in 2015, 29,200 in 2017 and 33,300 in 2030. However, if UT grows to 32,000 by 2017, that represents an annual growth rate of nearly two percent. If *that* rate were to continue until 2030, the student population would reach 41,700 – a total growth of 15,300 students, or 58 percent. This figure may be taken as the upper limit of likely growth. Faculty and staff positions may be assumed to increase roughly in proportion to the student population in either of these scenarios.

New Construction
Over the past two decades, UTK's total energy consumption has increased at an average rate of about 1.7 percent per year. Most of this increase is due to an increase in facilities (gross square footage has increased about one percent per year), but some is due to increased energy intensity (energy use per square foot). Energy intensity has, however, been generally decreasing since 2000, and this accounts for a leveling off of total energy use since then.

The pace of growth in square footage of building space is expected to accelerate. A list of anticipated building projects to 2020 is given in Appendix 1. Together, these buildings will add roughly 3 million square feet of building space to the campus. With a current total of about 13.7 million square feet, this constitutes a growth rate of about 1.6 percent per year between 2007 and 2020. If energy use per square foot remained constant, this would imply a 1.6 percent annual growth in energy use over the period to 2020. Over the last two decades energy use per square foot rose an average of about 0.65 percent annually, though since about 2000 it has been decreasing. However, enrollment grew only slowly during the last seven years, and the pace of enrollment growth is likely to increase. There are, therefore, various conflicting tendencies. For a "business as usual scenario" it is reasonable to project a continued annual increase in total energy use of between one and two percent in the short term, and possibly in the long term as well. A strong conservation and energy efficiency program might reasonably be expected to keep total energy use roughly constant and further reduce consumption per square foot.

B. <u>Energy Supply and Policy Prospects</u>

The following discussion of global energy demand, domestic energy demand, energy prices, and energy policy is based on a paper prepared for CCE by Dr. Randy Hudson at ORNL. (See http://www.cce.utk.edu .)

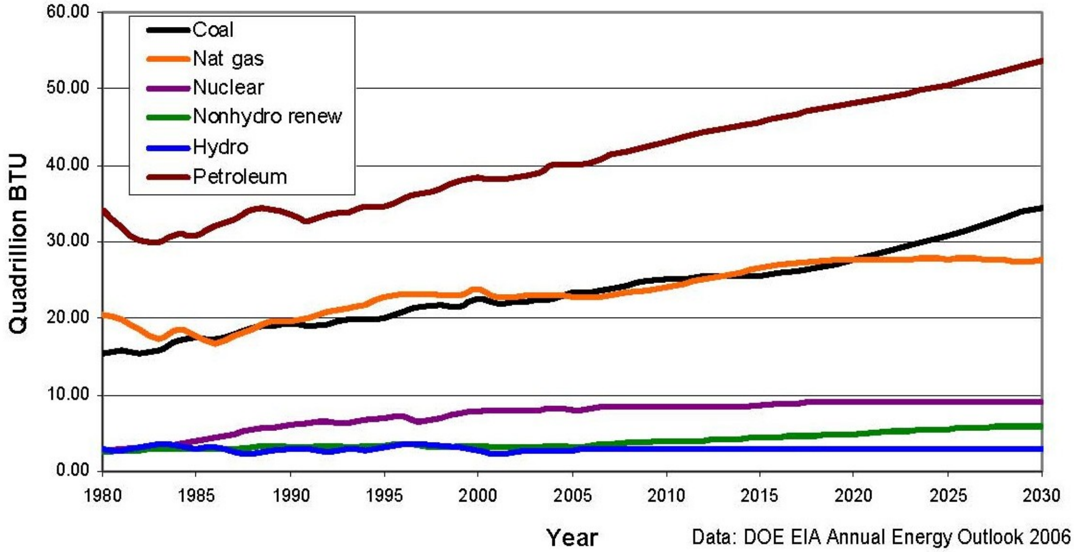
Global Energy Demand

According to the U.S. Department of Energy's Energy Information Administration (EIA) in its *International Energy Outlook* (June 2006), global energy demand is expected to grow at an average rate of two percent per year over the next 25 years. Major growth in the economies of Asia, particularly those of China and India, are expected to drive their energy use to the highest of any region. Projections by the EIA indicate that 86 percent of this global demand is likely to be met by fossil fuels (i.e., petroleum, natural gas, and coal). Petroleum, while in greatest absolute demand, is projected to have an average rate of 1.4 percent per year. Coal and natural gas are likely to experience a higher rate of increase, at 2.4 percent per year. Hydro and renewable resources also are projected to have a 2.4 percent per year growth rate, but with much smaller absolute contributions. Nuclear power is expected to grow at one percent per year over the next 25 years.

Domestic Energy Demand

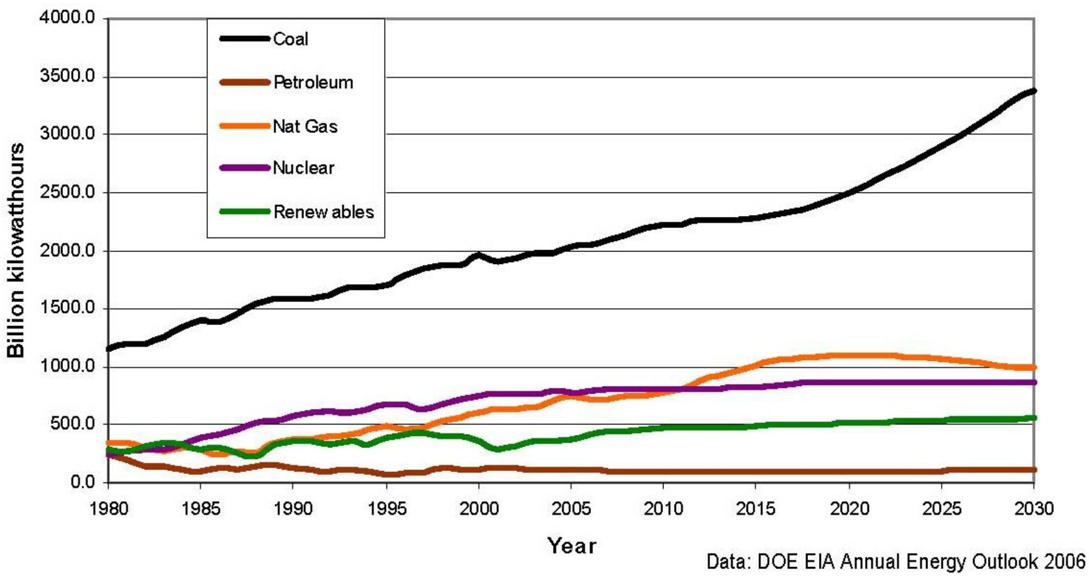
Domestically, as shown in the graph below, EIA projections of energy resource consumption follow a similar pattern (EIA, *Annual Energy Outlook*, February 2006). *It should be noted, however, that these projections assume no major new policies or regulations.* As such, they represent a "business as usual" scenario.

U.S. Energy Resource Consumption



Electricity consumes 40 percent of primary energy in the United States. As shown in the graph below, coal is projected to be its dominant resource, producing more electricity than all other resources combined. A*gain, however, this assumes a "business as usual" scenario.*

U.S. Electricity Generation by Fuel Source



Energy Prices
Supply and demand pressures are expected to heavily influence prices. The high global demand for petroleum, coupled with constrained sources of supply, is likely to cause price escalation of crude oil and related petroleum products. Similar supply and demand behavior can be expected with natural gas prices. According to EIA projections, new natural gas supplies and slower growth in consumption are likely to cause natural gas prices to decline through 2016; after that, as the cost of developing remaining natural gas resources increases, natural gas prices are likely to increase.

The EIA projects the average delivered price of coal in the United States to be stable over the next 25 years, due to the nation's large supply of recoverable coal reserves. Given the high fraction of coal used in the generation of electricity, corresponding prices of electricity are expected to be stable as well. *Again, these projections do not reflect the possibility of new regulations – for example, regarding carbon dioxide emissions.* New emission reduction requirements may have a notable impact on the price of electricity as well as on the resource mix used to generate electricity. In addition, in the decades following 2030, the price of coal may be affected by supply considerations.

Energy Policy Considerations
The Energy Policy Act of 2005 (EPAct) is, as of mid-2007, the most significant federal energy legislation in many years. The primary concern driving EPAct was the desire to have assured future energy supplies. EPAct authorized numerous programs, tax credits, and studies related both to supply (e.g., oil, gas, coal, nuclear, renewables, hydrogen) and to demand (e.g., energy efficiency). EPAct also included a section on climate change. This section mainly addressed greenhouse-gas (GHG) reduction technologies; it did not address GHG regulation. EPAct also did not increase Corporate Average Fuel Efficiency (CAFE) standards, nor did it establish a renewable portfolio standard (RPS) for electricity. Moreover, while EPAct authorized a number of new programs and activities, it did not appropriate the funds. Funds to implement EPAct activities must come from budget appropriations.

Despite EPAct's limited attention to global climate change, it is likely to be the biggest issue affecting long-term energy policy. Under the current course, 86 percent of global energy will be supplied by fossil fuels. Anthropogenic (i.e., human-triggered) carbon dioxide emissions are now widely regarded as the major driver of anthropogenic climate change. (See, for example, the 2005 Joint Statement from 11 national science academies, including the National Academy of Science for the United States, on the subject of climate change http://nationalacademies.org/onpi/06072005.pdf .)
Anthropogenic carbon dioxide emissions follow in lock-step with world energy consumption, increasing at a compound rate of two percent per year. With no change in current regulations, global CO_2 emissions in 2030 will be 75 percent higher than 2003 levels.

A study of GHG emissions by the International Energy Agency (*Energy Technology Perspectives 2006 – Scenarios & Strategies to 2050*, 2006) stated that:

> It will take a huge and coordinated international effort to achieve the [emission reduction] results…Public and private support will be essential. Unprecedented cooperation will be needed between the developed and developing nations, and between industry and government. The task is urgent… The effort will take decades to complete, and it will require significant investments.

Similarly, a report from the National Petroleum Council (*Facing Hard Truths about Energy: A Comprehensive View to 2030 of Global Oil and Natural Gas*, July 2007) calls for five core strategies to meet significant energy challenges, including growing demand and growing concern about climate change. These five strategies include (1) moderating growing demand by increasing efficiency; (2) expanding and diversifying production from a variety of sources; (3) integrating energy policies into economic, environmental, security, and foreign policies; (4) enhancing science and engineering capabilities; and (5) developing the legal and regulatory framework to enable carbon capture and sequestration.

Major stabilization and reduction of GHG emissions cannot be accomplished by one sector or with one technology. It will require a portfolio of solutions. There are substantial challenges to GHG reduction, however. Some technical solutions may be difficult and/or expensive to implement (e.g., carbon dioxide capture and sequestration). A mechanism to equitably share the costs of emission reductions has yet to be decided. For developing countries, questions of sovereign rights and international inequities may complicate progress. Some potential solutions will require improved technologies and greater public acceptability (e.g., nuclear power). Overall, success will require strong political will. While no individual or entity can single-handedly solve the climate change crisis, all must be part of the solution.

IV. Environmental and Economic Considerations

Two central reasons for concern about energy consumption at UTK are (1) impacts on the local to global environment, and (2) impacts on UTK's budget. Environmental impacts are discussed in Section A. Economic considerations are taken up in Section B.

A. Environmental Considerations

This section considers key environmental impacts associated with UTK's energy use.[11]

Carbon Dioxide Emissions

Because carbon dioxide is the most important anthropogenic greenhouse gas, it is now widely regarded as a pollutant. Anthropogenic carbon dioxide emissions are due primarily to burning fossil fuels. Of the fossil fuels, coal produces the highest carbon dioxide emissions per unit of energy.

The largest on-campus source of atmospheric carbon is the steam plant, which emitted 73,568 tons of carbon dioxide in FY 2006-07 from coal combustion. In addition, the steam plant emitted 82 tons of carbon monoxide. UTK also indirectly emits carbon dioxide through the electricity it buys from TVA, about 60 percent of which is produced by burning coal. During FY 2006-07, UTK's electricity purchases resulted in an additional 103,000 tons of carbon dioxide emissions. Total natural gas use by UTK during FY 2006-07 produced an additional 11,107 tons of carbon dioxide. Thus the total carbon dioxide emissions from utility use on campus are roughly 188,000 tons annually. This figure does not include the carbon dioxide emitted by UTK vehicles, small engines, commuter vehicles, and other carbon dioxide sources. Appendix 5 contains a more thorough analysis of UT's greenhouse gas emissions.

Ozone

Ozone is a highly reactive form of oxygen whose molecules consist of three oxygen atoms instead of the usual two. Because of its reactivity, it can oxidize (that is, sear or burn) sensitive respiratory tissues in plants, humans, and other animals. Ozone can irritate eyes and sear lung tissue even at low levels in sensitive populations. It promotes asthma, chronic bronchitis, and other respiratory problems. Some recent studies even link ozone exposure to cardiovascular disease, strokes, and lung cancer.[12] Ozone also damages plants (especially in the mountains) and crops. Due in part to our geographical location, Knoxville has in recent years often ranked among the 25 most polluted cities in the nation with respect to ozone. Knox County was given a grade of F for ozone pollution in the American Lung Association's *State of the Air: 2007* report.[13]

Small amounts of ozone occur naturally, but human activities, especially in the summer months, can increase ozone concentrations to harmful levels. Nearly all anthropogenic ozone pollution is formed in the air by reactions between two other pollutants, volatile organic compounds (VOCs) and nitrogen oxides (collectively designated as NO_x), in the presence of sunlight. Ozone is therefore a secondary pollutant derived from these two primary pollutants. Enough VOCs occur naturally in the atmosphere to create ozone when NO_x and sunlight are present; consequently, reducing ozone pollution requires reducing NO_x emissions. NO_x is a byproduct of burning, created when the heat of combustion causes oxygen and nitrogen molecules that occur naturally in the air to combine. Its main sources are power plants, industrial processes and internal combustion engines.

UTK's steam plant emitted 180 tons of NO_x during the year 2006-07. During that same period, its electricity purchases accounted for the emission of 191 tons by TVA, for a total of 371 tons.

Sulfur Emissions

Sulfur dioxide (SO_2) is a contributor to three important problems: regional haze, acid deposition, and fine particulate matter. Haze reduces visibility. Acid deposition harms plants and aquatic animals and is especially pronounced in the Great Smoky Mountains National Park. Fine particulate matter impairs human and animal health.

Like NO_x, sulfur dioxide is primarily a product of combustion; unlike NO_x, it is created only if the fuel itself contains sulfur. Gasoline, propane, natural gas, and other hydrocarbon fuels typically contain little or no sulfur and so do not contribute much to SO_2 pollution. There is often a good bit of sulfur in coal, however. Thus, coal-fired power plants are by far the largest source of sulfur dioxide pollution, accounting for about 75 percent of it in our region.

Fine particulate matter (often called $PM_{2.5}$ or PM fine) is formed when sulfur dioxide mixes with sulfate and nitrate particles, ammonia, organics, and soil dust. Fine particulate matter has been linked with asthma attacks, chronic bronchitis, emphysema, lung cancer, heart disease (ischema), strokes, birth defects, impaired fertility and premature death.[14] Long-term exposure to particulate matter is believed to account for up to four percent of all deaths in the United States – the equivalent of a one to three year drop in life expectancy.[15] Knox County received a grade of F for particulate pollution in the American Lung Association's *State of the Air: 2007* report.[16]

UTK's energy use in the year 2006-07 resulted in the emission of 1,280 tons of $SO_{2:}$ 470 tons produced by generation of the electricity that UTK buys from TVA, and 810 tons produced by the steam plant.

Other Forms of Pollution Associated with the Steam Plant

Coal typically contains traces of radioactive metals, particularly uranium and thorium. When large amounts of coal are burned, significant quantities of radionuclides are released. Combustion at the UTK steam plant during FY 2006-07 resulted in the release of 78 pounds of uranium and 191 pounds of thorium, most of which was captured in the fly ash. Traces of other toxic elements, including beryllium, cadmium, chromium, fluorine, mercury, nickel, and lead are also released by coal combustion, but these too are mostly deposited in fly ash.

Two toxic gases are released into the air by the steam plant in notable quantities: hydrogen chloride (19 tons in 2006-07) and hydrogen fluoride (two tons in 2006-07), the precursors respectively of hydrochloric and hydrofluoric acids. Each year the steam plant also releases about a ton of VOCs into the atmosphere.

In addition to the sulfur dioxide mentioned above, the steam plant is a significant source of other forms of particulate pollution, which, like sulfate particles, have been implicated in a wide range of respiratory and cardiovascular diseases. From January to December 2006, the steam plant emitted 7.23 tons of particulate matter (fly ash) of diameter 10 microns or less into the ambient air.

Other Environmental Considerations

Because of UTK's steam plant and TVA's reliance on coal, most of the energy used in campus operations is produced by coal combustion. In addition to the air emissions noted above, coal has other adverse environmental impacts.

Coal combustion produces ash and slag, which create a waste-disposal problem. There are two kinds of ash: fly ash and bottom ash. Fly ash is material precipitated out of the coal smoke before it is released into the atmosphere. Bottom ash is the ash left in the boilers, along with the slag. The primary components of ash and slag are relatively harmless minerals, but smaller quantities of toxic metals and radioactive materials are also present, which means that the ash and slag require careful handling and disposal in special landfills.

Coal mining—especially surface mining—can cause severe environmental damage. For this reason, UTK recently adopted a policy of preferring deep-mined to surface-mined coal for its steam plant. Nevertheless, the electricity UTK buys from TVA is largely produced by surface-mined coal, so a brief discussion of the environmental effects of surface mining is relevant here.

Surface mining begins with a clear cut—in fact, *all* the vegetation is bulldozed down to the bare earth. Then the topsoil is scraped away and (if the mine is well-operated) stored or used separately. This exposes the overburden (subsoil and rocks overlying the coal seam), which is drilled and blasted. The pulverized overburden is removed to expose the coal, which then is fractured by blasting and hauled away. After the coal is gone, dump trucks and bulldozers replace the overburden, then the topsoil. (The original overburden and topsoil are usually used elsewhere, so the replacing overburden and topsoil come from a newly mined area.) Since the blasting decompresses the overburden, its volume increases, so the excess must usually be deposited in a fill somewhere else. Finally the topsoil is sowed and replanted.[17]

This process greatly increases erosion and siltation, even under the best of conditions. Watercourses and aquifers are disturbed or destroyed, and water both on the surface and beneath the ground may be contaminated with acid drainage from sulfur-bearing rocks, or with toxic metals or minerals. Aquatic life may disappear as springs and streams turn red with iron oxide or yellow with iron hydroxide ("yellow boy"). Nearby wells may become cloudy, dry up, or be poisoned. Acid mine drainage often continues polluting streams even after restoration efforts have been completed.[18] The blasting and moving of earth may buckle or crack the foundations of buildings. Coal-hauling trucks can create potholes and other road hazards.

Mountaintop removal (or cross ridge mining, which is the currently popular variant of it) has become increasingly common throughout Appalachia. This practice involves blasting entire hilltops in order to expose the low-sulfur coal that lies underneath. The spoil that is blasted away is often bulldozed into nearby valleys and streams. According to a recent federal study, this practice resulted in 724 miles of streams in Kentucky, West Virginia, Virginia, and Tennessee being covered by valley fill between 1985 and 2001.[19]

Underground mining is often less environmentally damaging than surface mining, since it disturbs less on the surface. The harm from mining roads and initial cuts may still be considerable, however, and like surface mining, underground mining can disrupt aquifers. Old underground mines may fill with water, which builds up pressure and may eventually create a "blow-out," sending toxic or acidified water into aquifers or streams. Underground mines may collapse unpredictably decades after their abandonment, disturbing water flow, opening sinkholes, and damaging buildings on the surface.

The Importance of Energy Efficiency and Conservation

It should be kept in mind that from an environmental standpoint, consuming energy – no matter *how* that energy is generated – is inferior to saving energy. While judicious choice of energy sources can significantly reduce certain environmental risks and impacts, the greatest environmental gains almost always result from reducing energy consumption through energy efficiency and conservation measures.

B. Economic Considerations

This section provides information on energy costs at UTK and then lists budgetary and institutional constraints on reducing energy costs.

Energy Costs as a Percentage of UTK Budget

Energy costs generally have increased over the past fifteen years, both in dollar amounts and as a percentage of UTK's budget. This increase is evident in the following table:

Fiscal Year	Operating Budget*	Energy Budget*,‡	Energy as % of Operating Budget	Operation and Maintenance of Physical Plant†	O&M of Physical Plant as % of Operating Budget
1990-91	$404,839,527	$13,163,336	3.25	$23,157,964	5.72
1991-92	$420,556,146	$12,653,981	3.01	$21,601,321	5.14
1992-93	$414,263,973	$12,047,324	2.91	$20,145,714	4.86
1993-94	$435,071,397	$13,030,369	2.99	$20,314,656	4.67
1994-95	$456,275,716	$13,621,063	2.99	$23,891,919	5.24
1995-96	$461,916,469	$14,723,452	3.19	$27,033,148	5.85
1996-97	$463,968,337	$14,351,327	3.09	$27,981,731	6.03
1997-98	$474,916,596	$15,164,242	3.19	$26,108,857	5.50
1998-99	$473,006,252	$15,482,834	3.27	$26,342,193	5.57
1999-00	$498,935,025	$15,605,019	3.13	$27,426,455	5.50
2000-01	$521,139,971	$16,213,876	3.11	$30,001,540	5.76
2001-02	$543,392,977	$16,719,666	3.08	$33,762,735	6.21
2002-03	$568,756,483	$16,838,155	2.96	$37,154,093	6.53
2003-04	$578,260,179	$17,348,751	3.00	$39,106,401	6.76
2004-05	$582,498,240	$18,945,322	3.25	$39,565,602	6.79
2005-06	$622,619,771	$20,234,756	3.25	$40,425,418	6.49
2006-07	$641,703,461	$26,593,618	4.14	$42,275,580	6.59

** Adjusted for inflation, based on 2003 dollars.*
‡Energy budget includes cost of electricity, coal, natural gas, and the production and distribution of steam.
† "Physical plant" covers the Facilities Services budget, not including utilities. This figure is from the UT's Office of the President Budget Document Current Restricted and Unrestricted Funds Schedule.

From this table, it is evident that the energy budget has surged over the past year. These increases are likely to be permanent: Rates for TVA-generated electricity have increased by nearly ten percent, and the cost of coal for the UTK steam plant has increased by more than 50 percent, to approximately $85 per ton.

Budgetary and Organizational Constraints
Energy savings at UTK currently encounter several budgetary and organizational constraints.

Constraint on Applying Utility Budget Savings to Energy-Savings Projects
The current net electricity and gas (E&G) utilities budget for UTK is approximately $15 million. The Tennessee Higher Education Commission (THEC) has classified UTK with an expected net E&G budget of $1.78 per square foot. At UTK, approximately 10 million square feet qualifies as E&G, yielding a THEC expected budget of $17.8 million. The state allows savings from the $1.78 per square foot to be returned to the campus for energy savings projects. Thus, if the state fully funded UTK's E&G utilities budget, UTK would realize a savings of about $2.8 million. But the state only funds 60 percent ($10.6 million) of UTK's E&G budget. The remainder must be made up by the campus. At present, energy savings are simply reducing the amount that the campus must make up; they are not being applied to energy-savings projects.

A possible solution would be to reserve all or a portion of monetary energy savings for investment in energy-savings projects.

Constraint on Connecting Capital Improvement Decisions with Subsequent Operations and Maintenance (O&M) Costs
Decisions on capital improvements are made by the UT System within the context of requirements of state funding decisions and the State Building Commission. The campus inherits the long-term consequences of these decisions, including inheriting responsibilities for O&M.

A possible solution would be to require that all new building projects include a presentation of estimated energy use in millions of BTUs per square foot per year. This presentation should be made to the State Building Commission before initial project construction approval.

Constraint on Improvements to the Steam Plant
Central power plants such as the UTK Steam Plant provide the most cost-efficient production of utilities due to economies of scale. New or renovated facilities typically place increased demand on the steam plant, but the costs of the necessary infrastructure are not factored in to the costs of the facilities.

The University of Iowa has adopted one solution: Capital project budgets must include contributions to a "utilities infrastructure growth fund" for central plants. A project's contribution is no more than the estimated cost to install gas-fired boilers and electric-powered chillers in the building, sized to meet building capacity, including 50 percent redundancies, the minimum redundancy for a stand-alone system.

Constraint on Long-Term Thinking about Campus Buildings and the Campus as a Whole
Campus buildings last an average of 50 years or more, but many people involved in planning, constructing, managing, and using these buildings think in much shorter

terms—at most, a couple of decades. As a result, when changes must be made, conditions are difficult and major investments are required. Similarly, the campus tends to be seen as a self-contained microcosm within Knoxville, rather than an integral part of a changing city.

A possible solution to short-sighted plans for individual buildings would be to require plans for long-term future reuse and expansion (and for long-term sustainability) in the original building designs. A possible solution to myopic thinking about the relationship of the campus to the city would be to require integration of the campus master plan with the city master plan, including taking account of shared sustainability goals. One way to improve sustainability is to share facilities and reduce resource requirements.

Constraint on Collaborative Thinking in the Design and Engineering Process
Due to "turf thinking," many architects avoid brainstorming processes with engineers, and many engineers prefer not to be involved until the architect has fleshed out a building design that can be used as the basis for calculations. This constraint echoes the shortcomings that arise when decisions on capital projects are separated from decisions on O&M.

A possible solution would be to require team designing processes on all key aspects of proposed new construction. All participants would work as one team using "system thinking": for example, to link initial construction costs with long-term O&M costs and energy-use data with energy-savings projects.

V. Potential Opportunities for Energy and Greenhouse Gas Savings

This section identifies and briefly assesses methods, strategies, and technologies that might be useful at UTK for improving energy use and reducing greenhouse gas emissions. It draws in part on information provided by S.W. Hadley at Oak Ridge National Laboratory to the CCE (see http://www.cce.utk.edu) as well as information collected by CCE members. Some practices and technologies are already in use here or at other campuses. Others are prospective and likely to become available within the next 25 years. The aim of this section is to summarize possible options, not to make recommendations. Recommendations follow in Section VI.

A. Potential Strategies and Methods

Table 1 summarizes the strategies and methods that CCE thinks may be practical and effective for reducing energy consumption and greenhouse gas emissions at UTK. Items are listed alphabetically, not by priority. Details on these and other strategies and methods are given in Appendix 2.

Table 1. Selected Potential Strategies and Methods

Strategy or Method	Time frame	Implementation	Considerations	Current examples	Cost-effective-ness in energy savings	Effective-ness in reducing carbon footprint
Carbon sequestration	Mid to Long term	Managed use of UTK forest land for carbon sinking	Per ACUPCC†, UTK must follow the Land Use, Land Use Change, and Forestry Guidance for GHG Project Accounting		None	High
Climate neutrality policy	Near term process, long-term goal	Required at UTK by Presidents' Climate Commitment	Will be developed per ACUPCC† implementation document (due fall 2007) by September 15, 2009	Florida, over 320 ACUPCC† schools	Low	High
Curricular initiatives	Near term	Administrative			Medium	Medium
De-lamping	Near term	Campus-wide		Will be focus of a GA located within Facilities Services this fall	High	Low
Discounts for buying energy-efficient appliances	Near term	Administrative	UTK could potentially find a sponsor that would offer UTK students, faculty, staff a discount	University of New Hampshire	High	Low

Strategy or Method	**Time frame**	**Implementation**	**Considerations**	**Current examples**	**Cost-effective-ness in energy savings**	**Effective-ness in reducing carbon footprint**
Distance learning and telecommuting	Medium term	Administrative			High	High
Dormitory energy competitions	Already in place	Administrative		UTK, Yale	High	High
**Energy Star policies	Near term	Administrative		Duke, UC system	Medium	Medium
Fume hood management	Near term	Administrative		MIT	High	Medium
**Green power purchase and production	2.6% of UTK's electricity is green power	Administrative	ACUPCC† recommends 15% of electricity be green power	NYU, Pennsylvania, Penn State, and many others are leaders	Low	High
*Greenhouse gas inventory	Near term	Student project will complete by August 2007 and maintained by a GA located within Facilities Services		Over 320 of the ACUPCC schools	—	—
**Greenhouse gas offset policies	Near to long-term	Administrative; probably necessary for UTK to fulfill Presidents' Climate Commitment	Of controversial effectiveness		None	High
Heating and cooling policies	Imme-diate feasibi-lity	Administrative but requires new equipment	Low risk, high benefit	University of Washington, Yale, Cal State Chico	High	Medium
High-performance contracting policies	Near to mid-term	Administrative		Harvard	Medium	Medium
**LEED certification	LEED certifica-tion now required at UTK	New buildings or renovations	ACUPCC† recommends LEED silver rating	North-western, Yale, Sierra Nevada College, UNC Chapel Hill	Medium	High
Performance contracting	Near term	Administrative		University of South Carolina, UNC Greensboro	Medium	High
Renewable energy hedges	Near term	Administrative		Southern New Hampshire		High

Strategy or Method	Time frame	Implementation	Considerations	Current examples	Cost-effective-ness in energy savings	Effective-ness in reducing carbon footprint
Revolving loan funds	Near term	Administrative	Requires initial investment, but rate of return may be high	Harvard, University of Colorado	High	Medium
Stadium lighting reduction	Near term	Administrative measure; reduction in time of use or intensity of light used		University of Washington, Assumption College	High	Low to medium
Sustainability office	Near term	Administrative measure	Significant recurring cost, but probably recoverable in energy savings	NYU, Stanford	High	High
Use-based billing	Short term	Administrative; Requires metering		University of Illinois, Springfield	Medium	Medium

*Required by Presidents' Climate Commitment (*see* Appendix 4).
**Use of some version of this strategy is one of seven actions, at least two of which are required by the Presidents' Climate Commitment (*see* Appendix 4).
†American College and University Presidents' Climate Commitment

B. <u>Potential Technologies</u>

In addition to strategies and methods, a variety of existing and prospective technologies can help reduce energy use and greenhouse gas emissions. The ones likely to be of use at UTK are summarized in Table 2. Items are listed alphabetically, not by priority. More detailed descriptions of these and other technologies are given in Appendix 3.

Table 2. Selected Potential Technologies

Technology	Time frame	Implementation	Considerations	Current examples	Estimated cost-effective-ness in energy savings	Estimated effective-ness in reducing carbon footprint
Biofuels in campus vehicles	Now in use	All UTK Facilities Services vehicles use B20, as do mass transit vehicles	E-85 will implanted in the near future at UTK	UTK, Georgia, Emory	Low	Low
Biomass cofiring	Near to long-term	Boiler modifications, handling and mixing equipment	Fuel supply availability, cost, sustainability, technical issues	Colgate, Central Michigan, UT Martin	Low	High

Technology	Time frame	Implementation	Considerations	Current examples	Estimated cost-effective-ness in energy savings	Estimated effective-ness in reducing carbon footprint
Biomass gasification	Long term	New facility	High initial cost, fuel supply availability	University of South Carolina	Low to medium	High
Cool roofs	Near to mid-term	New or retrofit	Appropriate roofs, mildew issues		Low to Medium	Medium
Daylight harvesting	Near term	New or retrofit in major renovations			High	High
Desiccant cooling systems	Near to long-term	New or retrofit	Retrofit difficulties, energy source		Medium	Medium
Energy management systems	Near to long-term	New or retrofit; UTK's current system does not have extensive room-by-room sensors	Sensors, communications, software, training	University of British Columbia	Medium to High	Medium
Fuel cells	Long term	New power plant	High initial cost	Cal State, Northridge	Low to Medium?	High
Geothermal systems	Near to long-term	New facilities	Soil conditions, new technologies, TN grouting requirement, high first cost	Eastern Connecticut, Lipscomb, UNC Chapel Hill	Low to medium	High
Green roofs	Mid- to long-term	New buildings	High initial cost, architectural limitations		Low	Medium
Hybrid lighting	Near to mid-term	Roof mounts, cabling, fixtures	Only applicable on top floors of building; initial expense; needs more R&D	ORNL	Low	Medium
Integrated energy systems	Near to mid-term	New facilities, retrofit where economic	Existing steam system already in place		Medium to High	Medium to high
Methane generation	Near to long-term	Evaluate possible use in steam plant or elsewhere on campus of waste methane from KUB's Kuwahee Wastewater Plant	Possible inadequate energy content or flow	Working with KUB to obtain better data on methane stream	?	?
Motion (occupancy) and other sensors	Near to long-term	New or retrofit, connect to energy management software for max savings	Low-cost, low-power, communications		Medium	Medium
Natural gas	Now used	Gas turbines, many smaller uses	Increased use will have issues with cost and availability, also carbon emissions		Low	Low
Passive solar water heating	Near to mid-term	New buildings, retrofits	Initial expense, small scale	Guilford College,	Medium	Medium

Technology	**Time frame**	**Implementation**	**Considerations**	**Current examples**	**Estimated cost-effective-ness in energy savings**	**Estimated effective-ness in reducing carbon footprint**
				Governor's State		
Photovoltaic generation	Mid to long-term	New or retrofit, buildings or open areas; carbon-neutrality measure	High cost for panels, power density low	Cal State East Bay, three Massa-chusetts campuses	Low	High
Smart roofs	Long-term	New or retrofit	Research needed		Low to Medium	Medium
Solar heating and cooling	Mid to long-term	New or retrofit		Cochise College	Low	Medium
Solid state lighting	Long-term	New fixtures	Improvements needed before wide-scale adoption		High	High
Vending misers	Short term	Vending machines		University of Washington, Yale	High	Low
Wind turbines	Long term	Off-campus turbines	Not practical on campus, but possible off campus. Expensive, but effective in reducing carbon emissions.	Colorado State, NYU	Low	High

VI. Recommendations

No single suite of technologies or practices will achieve either significant reductions in energy use or carbon neutrality. An on-going, multi-pronged effort is needed. The CCE's recommendations for this effort are provided below, beginning with a set of goals and immediate and long-term strategies for achieving them. These general recommendations are followed by recommendations specific to the Cherokee Campus, the Campus Master Plan, and the Presidents' Climate Commitment.

The lists of strategies do not include specifics on research, because energy research is comprehensively addressed elsewhere at UTK. Nevertheless, as noted in the Goals section, CCE recommends that UTK's energy research benefit the campus whenever possible, with the campus as a "laboratory" for that research where appropriate.

A. UTK Energy Plan: Goal

- Reduce energy consumption (measured in BTUs per square foot per year) by five percent by 2012 and 25 percent by 2030, using 2006-7 figures as a base.
- Achieve carbon neutrality by 2030, in accordance with the Presidents' Climate Commitment guidelines.
- Make UTK a leader in energy-efficient, high-performance, sustainable design.
- Support clean energy research on campus (especially research that benefits the campus itself).
- Educate students about energy use, environmental impacts, and sustainability.
- Create a culture of energy conservation on campus.

B. UTK Energy Plan: Immediate Strategies

Policy

- Require LEED silver certification for all buildings, including existing buildings.[20]
- In procurement contracts, require (1) state-of-the-art energy efficiency equipment (e.g., Energy Star, Vending Miser) and (2) feasible measures to reduce UTK's carbon footprint.*
- Remove budgetary and organizational impediments to energy efficiency and greenhouse gas reduction. Specifically:
    a. Establish policies to incorporate prospective energy savings from operations and management efficiency into initial capital cost decisions.
    b. Reserve all or a portion of monetary energy savings for investment in energy-savings projects.
    c. Require that all new building projects estimate energy use in millions of BTUs per square foot per year. This estimate should be given to the State Building Commission before initial project construction approval.

d. Require capital project budgets to include contributions to a utilities infrastructure growth fund for central plants.
e. Require plans for long-term future reuse, expansion, and sustainability in the original building designs.
f. Require team designing processes on all key aspects of proposed new construction.

- Incorporate carbon costs and other environmental impacts (e.g., the impacts of mountaintop coal removal) into UTK's budgeting and energy decision-making.
- Establish a campus policy regarding both temperature settings (e.g., winter heating to 68 degrees; summer cooling to 78 degrees) and the use of space heaters.
- Consider offsetting all greenhouse gas emissions generated by air travel paid for by UTK.*
- Establish a policy or a committee that supports climate and sustainability shareholder proposals at companies where UTK's endowment is invested.*
- Establish a policy for energy reduction in stadium lighting.
- Integrate energy efficiency and climate neutrality concerns with concerns for campus beautification and historic preservation.

Management

- Develop institutional structures to plan and implement energy and climate-neutrality measures.[21] These structures should include:
    - An **Office of Sustainability** to oversee energy and climate-neutrality operations and other aspects of campus sustainability. The office should be headed by a high-level administrator, hired by national search, who is provided with an adequate budget and staff.
    - A **Technical Advisory Committee**, reporting to the sustainability administrator, whose functions would be: to collect and monitor data on all aspects of energy use and greenhouse gas emissions, monitor trade journals for best practices and technologies, oversee technological improvements, perform cost-benefit analyses, and make recommendations on applications of specific policies and technologies for energy savings and greenhouse gas emission reduction. This committee should also regularly assess progress toward and suggest modifications to the campus energy plan and greenhouse gas reduction plan.
    - A committee to create a culture of sustainability across the university, with special emphasis on energy savings and greenhouse gas emission reduction. Such a committee could include but also expand on the current functions of the Committee on the Campus Environment and the Make Orange Green Committee. It would increase sustainability awareness among administrators, faculty, staff, and students and engage them in sustainability practices. It would conduct workshops and talks, interact with curriculum committees at all levels, work with the Office of Research to promote and sustainability research and pilot projects on campus. This function should be located in the Office of Sustainability.

    - A committee, located primarily within the Development Office but with ties to the Office of Sustainability, to (1) explore avenues of raising funds and obtaining rebates and incentives specifically earmarked for sustainability initiatives; and (2) seek partnerships with governmental agencies such as TDEC, DOE and TVA and private corporations toward the goal of improving campus sustainability.
- By September 15, 2008, complete a comprehensive inventory of all greenhouse gas emissions (including emissions from electricity, heating, commuting, and air travel) and update the inventory every other year thereafter.[22] (An initial inventory undertaken by Leslie Chinery is included in this report as Appendix 5.)
- By September 15, 2009, develop an institutional action plan for becoming climate neutral. Actions should include: [23]
    - A target date for achieving climate neutrality as soon as possible.
    - Interim targets for goals and actions that will lead to climate neutrality.
    - Actions to make climate neutrality and sustainability a part of the curriculum and other educational experiences for all students.
    - Actions to expand research or other efforts necessary to achieve climate neutrality.
    - Mechanisms for tracking progress on goals and actions.
- Establish benchmarks and set quantifiable goals for energy-use reduction that are separate from and in addition to the climate neutrality goals and benchmarks. Issue annual reports on performance. Have a multi-functional team of internal and external experts perform a full assessment every five years.
- Consider either a performance contractor, who may be able to front costs that cannot be covered in the budget of Facilities Services, or creative financing for efficiency projects within Facilities Services.
- Obtain meters and sensors to generate specific data on energy consumption and end-uses. All sensors newly installed should be standard and capable of easy integration with a campus-wide computerized energy management system. Use infrared photography and metering of buildings to locate energy inefficiencies. Once metering is in place, make all campus units accountable for energy uses.
- Choose, purchase, and install a campus-wide computerized energy management system.
- Make efforts to move toward integrated energy systems whenever campus energy system changes are contemplated.
- Consider renewable energy hedges. Initiate discussions with TVA concerning the possibility of a hedge with them.
- Engage with peer institutions and with national organizations (such as AASHE) by such means as newsletters, list serves, and conferences.
- Establish a revolving loan fund that offers energy-improvement loans to departments which can be paid back over a given period (e.g. five years) in energy savings.
- Increase green power purchases.[24]
- Explore carbon sequestration options (e.g., reforesting UTK land; buying carbon credits), and integrate energy and greenhouse gas considerations into a centralized long-term planning process for UTK land management.

- Consider providing discounts to students who purchase energy-efficient appliances for dorms.

Education

- Incorporate energy efficiency principles into orientation and the freshman experience.
- Increase prominence of energy efficiency and sustainability in the curriculum.
- Provide energy training for faculty and staff.
- Continue and expand dormitory energy competitions.
- Create a degree program in sustainability.

Technology

- Establish a campus-wide system of window upgrades for energy efficiency.
- Install "vending miser" technology on all campus vending machines.
- Ensure that Information Technology is energy-efficient.
- Consider various forms of co-firing for the steam plant using a biofuel such as switchgrass or agricultural waste.
- Incorporate hybrid lighting systems into new buildings or as retrofits.
- Explore technical and behavioral means to make stadium lighting as energy-efficient as possible.
- Study various potential campus uses of waste methane from KUB's Kuwahee Wastewater Treatment Plant.
- Explore green roof technologies to minimize stormwater runoff and absorb and reflect sunlight.
- Investigate solar water heating projects.

C. UTK Energy Plan: Long-Term Strategies

Policy

- Revisit the Campus Energy Plan every five years (on the same cycle as the Campus Master Plan) to adjust goals and strategies to changing regulatory requirements and technological developments.
- Seek a major endowment to help fund energy efficiency and carbon neutrality, using the current Campus Environmental Stewardship Fund as the vehicle.

Technology

- Install smart roofs as retrofits or on new buildings.
- Install solid state lighting for all feasible applications.
- Explore options to reduce or eliminate coal use at the steam plant – for example, by using integrated fuel systems (e.g., biomass) or by replacing steam with integrated heating and cooling systems, fuel cells, or a biomass gasification plant.
- Explore green power production on campus—for example, using solar panels.
- Explore photovoltaic-powered plug-ins for hybrid and electric vehicles.

- Explore nanotechnology – e.g., carbon sequestration in building materials, superconductive electrical transmission, high-efficiency solar panels.
- Explore building off-campus wind turbines for electricity generation.

D. Recommendations for the Cherokee Campus

Because the Cherokee Campus is a “greenfields” development, it offers significant opportunities for energy-saving site design, infrastructure, and buildings. In addition, because the UTK steam system cannot be extended across the river, alternative sources of heating and hot water will be needed. In addition to recommendations generally applicable to UTK (see above) and the Campus Master Plan (see below), recommendations specific to the Cherokee Campus include:

- Hire a nationally known sustainable design master planning firm for design of the Cherokee Campus.
- Develop a comprehensive plan for the Cherokee Campus that integrates energy savings into other aspects of the campus design.
- Explore innovative heating and cooling approaches for the Cherokee Campus.

E. Recommendations for the Campus Master Plan

The following energy efficiency ideas for new construction should be incorporated into the Master Plan. (See Appendices 2 and 3 for fuller descriptions of some of these ideas.)

- Design to LEED silver standards.
- Provide for the eventuality of a centralized campus-wide energy management system.
- With infrastructure, design for integrated energy systems.
- Place utilities, steam pipes, and other infrastructure in easily accessed spaces beneath removable sidewalks.
- Use cool roofs, green roofs, or smart roofs.
- Design grounds to minimize the need for outdoor lighting.
- In site design and building orientation, reduce heat islands for summer cooling while taking advantage of solar gain for winter heating.
- Use trees for natural cooling and carbon sequestration.
- Incorporate hybrid lighting on upper floors.
- Design circulation systems to encourage walking, biking and public transportation and discourage the on-campus use of private automobiles.
- Increase vegetated green space by reducing surface parking and setting green space goals for each new building.
- Establish Sustainable Campus Design Guidelines – e.g., regarding solar orientation, daylighting, air circulation, parking, and energy efficiency.

- Revise UTK Site Design Guidelines (see UTK Facilities Services website) to add sustainability principles regarding, e.g., site lighting, outdoor furniture, and recycling containers.

F. <u>Recommendations regarding the Presidents' Climate Commitment</u>

As noted in Section I, Chancellor Crabtree has signed the American Colleges & Universities Presidents' Climate Commitment. The goals of the Commitment are given in Appendix 4. To meet this Commitment, the UTK Campus must (1) create institutional structures to guide the development and implementation of a climate neutrality plan; (2) complete and annually update a comprehensive inventory of its greenhouse gas emissions; and (3) develop an institutional action plan for becoming climate neutral. These three commitments must be fulfilled over the next two years.

Over the next two years, the UTK campus also must initiate at least two actions from among a list of seven. Six of those have been noted in the foregoing recommendations:

- Establish a policy that all new campus construction will be built to at least the U.S. Green Building Council's LEED Silver standard or equivalent.
- Adopt an energy-efficient appliance purchasing policy requiring purchase of Energy Star certified products in all areas for which such ratings exist.
- Establish a policy of offsetting all greenhouse gas emissions generated by air travel paid for by our institution.
- Begin purchasing or producing at least 15 percent of our institution's electricity consumption from renewable sources.
- Establish a policy or a committee that supports climate and sustainability shareholder proposals at companies where our institution's endowment is invested.
- Participate in the waste minimization component of the national RecycleMania competition

A seventh action in the Presidents' Climate Commitment—

- Encourage use of and provide access to public transportation for all faculty, staff, students and visitors at our institution

—has not been previously mentioned, because, as noted in the introduction, this energy plan does not address UTK transportation issues. The CCE, however, strongly advocates such measures as designing for a bicycle- and pedestrian-friendly campus, exploring the use of biofuels for motor vehicles, and encouraging the use of public transportation. It also advocates the long-term integration of transportation planning with energy planning, although that vision has not been accomplished here.

The Knoxville campus currently meets the requirements of the Presidents' Climate Commitment in two areas: transportation and waste minimization. The CCE recommends that UTK strive to meet additional tangible action goals in the next two years, in particular, by developing (1) a written LEED building policy and (2) an Energy Star purchasing policy.

VII. Potential Opportunities for Funding Energy-Savings Projects

Though many energy efficiency and conservation measures save money in the long run, nearly all require initial investment. This conceptual energy plan has focused on what needs to be accomplished, not on how measures will be funded. Nevertheless, it is worth mentioning some possible funding sources.

Student Environmental Initiatives Fee
The UTK Student Environmental Initiatives Fee, initiated by a Student Government Association referendum in 2004 and enacted in 2005, adds a $5.00 charge to student fees to support environmental projects across the campus. The fee brings in approximately $425,000 annually to fund purchases of green power and campus environmental improvements.[25]

Class Donations
It is traditional for the Senior Class to make a gift to the university. Seniors might be encouraged to use class gifts to fund energy conservation and efficiency projects. This year, the Class of 2007 at Middlebury College, a small liberal arts college in Vermont, raised over $92,000 to create a Green Fund for their campus.[26]

Campus Environmental Stewardship Fund
UTK's Campus Environmental Stewardship Fund was set up in 2005 to "provide a means for faculty, staff, alumni, and other donors to help fund UTK's efforts to achieve leadership in energy conservation and efficiency, pollution reduction, waste management, and other forms of environmental stewardship." So far, the fund has received only modest publicity. Increased efforts by the Development Office to attract donors to this fund could provide a means of financing additional energy-saving projects on the Knoxville campus.

Revolving Loan Funds
A revolving loan funds is a pool of money that provide low-interest or interest free loans to university departments to initiate energy projects that pay for themselves in energy cost savings. Once an initial pot of money is established, the loan fund can operate essentially cost-free, producing continual energy savings.

Clean Renewable Energy Bonds
Campus clean-energy projects can be funded by Clean Renewable Energy Bonds. These are essentially zero-interest loans and are available through EPAct as an alternative for public institutions unable to take advantage of tax credits for clean energy.[27]

Corporate Grants and Partnerships
As the problem of global climate change grows more acute and public opinion shifts, opportunities for corporate help or corporate partnerships are likely to increase. One

significant source for potential help is ALCOA, a founding member of the U.S. Climate Action Partnership, an alliance of nine major U.S.-based companies, and four leading environmental organizations that is working to achieve significant reductions of greenhouse gas emissions. BP, another member of the Climate Action Partnership, has provided grants to educational institutions for energy projects.[28]

Partnerships with State and Local Governments

The Tennessee Department of Environment and Conservation, the Tennessee Department of Transportation, and other state agencies are beginning to work on statewide energy planning. UTK's energy management team would benefit by working closely with these agencies and attempting to form partnerships. Partnerships with city and county governments are also a possibility.

Federal Grants

Two large federal agencies have major facilities in or near Knoxville: TVA and DOE. Both may be sources of grants for energy-saving or carbon-reduction measures. UT Martin, for example, is funding its new $4.4 million power plant, which will use biodiesel fuel made from soybeans, in part with a grant from TVA. The ORNL background papers written for this Energy Plan (see http://cce.utk.edu) were funded by DOE through a $25,000 Rebuild America Grant. DOE's State Energy Program provides about $800,000 annually to institutions in Tennessee. One of these, for example, helped the Sumner County School System construct a geothermal heat pump system.[29] More effective collaboration with TVA, DOE, the U.S. Environmental Protection Agency, the U.S. Department of Agriculture, and other federal agencies could facilitate UT's efforts to achieve energy savings and climate neutrality.

Foundation Grants

Some private foundations may fund energy initiatives at universities.

Sustainability Office

Effective pursuit of opportunities for grants and partnerships will require at least one full-time staff person. This person must be intimately familiar with the latest methods and technologies for energy savings and greenhouse gas reduction and must also be aware of grants and other funding opportunities. The position could likely pay for itself in grant money, and indeed it should be easier to obtain grants for energy or climate neutrality projects if there is a Sustainability Office that is equipped to implement projects.

Appendix 1

Knoxville Campus: Anticipated Building Projects to 2020

Project	Expect On Line	New Square Footage	Location
Anthropology Research Building	2013	3,000	Cherokee Campus
Art & Architecture Addition	2020	40,000	East of A&A
Audiology & Speech Pathology Clinics	2012	90,000	Undetermined
Austin Peay Renovation	2020		
Ayres Hall	2010		
Bailey Education Complex Renovation	2020		
Baker Center	2008	55,000	
Basketball Practice Facility	2007	70,000	
BEES Renovations	2015		
Buehler Hall Renovation	2020		
Cherokee Campus	2011		Cherokee Campus
Clarence Brown Theatre Addition	2015	25,000	West of CBT
College of Nursing Addition	2014	30,000	Undetermined
Crops Genetic Laboratory Renovation	2011		
Dougherty Engineering Renovation & Addition	2020		
Early Learning Center	2007	4,000	Lake Avenue
Earth & Planetary Sciences Renovation	2013	25,000	
Ecology Laboratory Building	2020	50,000	Cherokee Campus
Ellington Plant Sciences Renovation	2012		
Estabrook Hall	2010	100,000	East of Estabrook
Ferris Hall Renovation	2020		
Field House	2012	120,000	Facilities Services site
Forestry Building	2014	100,000	Cherokee Campus
Fraternity Renovations & Additions	2009	30,000	Various
Glocker Business Building	2008	120,000	
Greenhouses	2008		Ag Campus
Henson Hall Renovation & Addition	2020	40,000	
Hesler Biology – Phase II	2009		
Hoskins Library Renovation	2014		
HPER Renovation	2020		
HSS Quadrangle Academic Building	2016	100,000	Southeast of Humanities
Humanities/McClung Tower Renovations	2020		
Intercollegiate Swim Facility	2008	72,000	
Jessie Harris Addition	2013	60,000	North of JHB
Jessie Harris Renovation	2016		
Joint Institute of Advanced Materials Science	2010	100,000	Cherokee Campus

Project	Expect On Line	New Square Footage	Location
Knoxville Place	2008		
Laurel Apartments	2008		
Lindsey Nelson Stadium Addition	2008	10,000	First base
McCord Hall Renovation	2013		
McKenzie-Lawson Addition	2011	160,000	Chamique Holdsclaw
McLeod & Brehm Renovations	2010		
Melrose Hall	2012	130,000	
Min H. Kao Electrical & Computer Engineering Building	2010	190,000	North of Dougherty
Morgan Hall Renovation	2016		
Music Building	2011	145,000	
Neyland Stadium Renovations	2013		
Nielsen Physics Renovation & Addition	2020	40,000	
Panhellenic	2020		
Parking Garage—Cherokee Campus	2010	175,000	Cherokee Campus
Parking Garage—Volunteer & Pat Head Summitt	2010	90,000	
Pasqua Nuclear Engineering Renovation	2020	25,000	
Perkins Hall Addition	2015	40,000	West of Perkins
Research Facility	2015	130,000	Cherokee Campus
Residence Hall	2010	180,000	South of Black Cultural
Softball Stadium	2007		Stephenson Drive
Sorority Complex	2009	175,000	Morgan Hill
Steam Plant	2009		
Strong Hall	2012		
Student Health	2011	60,000	
Support Services Complex	2009		Stephenson Drive
University Center	2011	100,000	
UTIA Office Building	2013	10,000	Ag Campus
Vet Medicine – Digester	2008	10,000	
Vet Medicine—Large Animal Addition	2011	33,000	
Vet Medicine—Small Animal Addition	2008	40,000	
Walters Life Sciences Addition	2014	40,000	North of WLS
Welcome Center	2013	70,000	University Club

Source: Facilities Services. Table is current as of mid-2007.

Appendix 2

Potential Strategies and Methods for Energy and Greenhouse Gas Savings

This appendix alphabetically lists strategies and methods for saving energy and reducing greenhouse gas emissions. This compilation is not a recommendation for UTK; some but not all may be useful for the Knoxville campus.

Carbon Sequestration

Many campuses seeking to move toward carbon neutrality practice carbon sequestration, the removal of carbon from emissions or directly from the atmosphere. The most widely used method is reforestation, either on campus or off. Technologies for direct sequestration of the carbon from power plant emissions (underground storage, for example) are under development but are currently unavailable for campus use, and their long-term effectiveness has yet to be demonstrated.

Changing Electricity Supplier

Given the federal trend toward deregulation over the past couple of decades, it is sometimes possible to lower the cost of electricity and/or provide "greener" options by switching to a different supplier of electricity. This strategy was given detailed consideration, for example, in Middlebury College's document "Carbon Neutrality at Middlebury College."[30]

Climate Neutrality Policy

Climate neutrality is the condition of having no net greenhouse gas emissions. It is achieved by reducing greenhouse gas emissions as much as possible and using carbon offsets or other measures to mitigate the remaining emissions.[31] While climate neutrality policies do not in general have the specific goal of reducing energy consumption, they typically include energy-use reduction plans.

While climate neutrality is a long-term goal, its feasibility has been documented for institutions comparable to UTK. A detailed study at the University of Florida, for example, found that "UF can achieve carbon-neutrality in 20-30 years and show a revenue-positive result in the process."[32] (Carbon neutrality is nominally a narrower concept than climate-neutrality, since it does not explicitly deal with greenhouse gases other than carbon dioxide. Florida's study, however, despite its title, dealt will all the major greenhouse gases.) UTK is committed to achieving climate neutrality by Chancellor Crabtree's signing of the American College & University Presidents' Climate Commitment (ACUPCC; *see* Appendix 4). Over 320 colleges and universities have signed this pledge.[33]

Curricular and Educational Initiatives
Curricular initiatives, designed to ensure that students are well informed about energy and the environment, can help to instill habits of conservation that translate into energy savings for the university as a whole.

De-lamping
Insuring that no area of the university (indoors or out) is over-illuminated can help to save energy. The Society of Illuminating Engineers has developed a set of standards for foot-candle readings in various types of space. Site surveys can be used to locate areas in which reduction of illumination is warranted.[34]

Discounts for Buying Energy-Efficient Appliances
In dormitory rooms or apartments where students use their own appliances devices, energy savings can be achieved by working with local merchants to offer discounts to students who buy energy efficient appliances, such as those that are EPA EnergyStar rated. The University of New Hampshire, for example, operates such a program.[35]

Distance Learning and Telecommuting
With the increased availability of high-speed communication, more classes are being made available via the internet or other electronic means, lowering the need for transportation, classroom space, on-campus residence, and consequent energy use. The same sorts of savings can be achieved when faculty, staff, and administrators do some portion of their work from home electronically.

Dormitory Energy Competitions
Dormitory energy competitions, which offer prizes to the dormitories or dormitory floors that save the most energy, are a cost-effective means of reducing energy consumption. UTK has used these competitions successfully. At Yale, the competitions at the residential colleges reduced energy consumption by 10.2 percent in one year.[36]

Energy Independence Policies
Some universities aim to acquire or produce enough renewable energy to cover all their energy needs, thus achieving “energy independence.” Four campuses of the University of Wisconsin—Green Bay, Oshkosh, River Falls, and Stevens Point—have begun a pilot program to make their campuses completely energy independent within the next five years. Currently all four campuses produce their own heating and cooling by burning fossil fuels.

Energy Star Policies
EPA’s Energy Star program rates appliances according to their energy efficiency. Those that are especially efficient get Energy Star ratings. Policies of buying only Energy Star rated appliances can save energy. Duke University, for example, has an policy that reads in part “In all areas for which Energy Star ratings exist, the products that Duke purchases will be Energy Star certified or meet the performance requirements for Energy Star certification. In areas for which guidelines are not available, Duke will seek energy

efficient products."[37]

Four-Day Work Week
One way to save energy is to move to a four-day work week. Brevard Community College, for example, is conducting a pilot project along these lines to cut energy costs and save employees money on gas. Most staff will work extended hours Monday through Thursday, and will not work on Fridays. Some essential services like campus security will remain open on Fridays. The pilot project began June 25, 2007, and is to run for six weeks, during which time administrators will monitor productivity rates, employee morale, absenteeism, and overall job satisfaction. The college expects to save up to $35,000 a month as a result of the measure. Reduced work weeks can be coupled with increased use of telecommunication and distance learning.[38]

Fume Hood Management
Laboratory fume hoods may waste a surprising amount of energy. MIT students studying energy use by fume hoods recently determined that the Institute could save up to one million dollars a year through better fume hood management. The students found that many fume hoods are left open when not in use, wasting large amounts of energy. In response, the Institute has launched an educational initiative to inform students about the issue, and to encourage them to close the hoods when they are finished with them.[39]

Green Power Purchasing or Production
As noted in Section II, UTK buys 6,075,000 kWh of green power annually from TVA through the Knoxville Utilities Board, amounting to 2.6 percent of our electricity consumption. TVA's green power sources are wind, photovoltaics, and landfill methane. For comparison, the table below lists the top ten collegiate green power purchasers in the nation as of April, 2007:[40]

Green Power Usage (kWh)	% of Total Electricity	Resources	Provider	Athletic Conference
1. New York University				
118,616,000	100%	Wind	Community Energy	University Athletic Association
2. University of Pennsylvania				
112,000,000	29%	Wind	Community Energy	Ivy League
3. Pennsylvania State University				
83,600,000	20%	Biomass, Small-hydro, Wind	3 Phases Energy, Community Energy, Sterling Planet	Big 10
4. California State University System				
78,333,573	11%	Biomass, Geothermal, Solar, Wind	APS Energy Services, On-site Generation	Numerous
5. Duke University				
54,075,000	31%	Small-hydro,	Sterling Planet, Unknown	Atlantic Coast

Green Power Usage (kWh)	% of Total Electricity	Resources	Provider	Athletic Conference
		Wind		Conference
6. University of California, Santa Cruz				
50,000,000	100%	Small-hydro, Wind	Sterling Planet	Association of Division III Independents
7. The City University of New York				
41,400,000	10%	Wind	New York Power Authority	Numerous
8. Northwestern University				
40,000,000	20%	Wind	3 Phases Energy	Big 10
9. Western Washington University				
38,008,000	100%	Wind	Puget Sound Energy	Great Northwest Athletic Conference
10. University of Utah				
33,333,000	13%	Wind	Sterling Planet	Mountain West

Greenhouse Gas Inventory
A comprehensive inventory of campus greenhouse gas emissions is an essential first step toward the goal of climate neutrality. The Presidents' Climate Commitment (see Section I and Appendix 4) requires a comprehensive inventory—including emissions from electricity, heating, commuting, and air travel—updated annually. The draft implementation guide for the Presidents' Climate Commitment stipulates completion of a comprehensive inventory of greenhouse gas emissions by September 15, 2008. (See Section IV-A and Appendix 5 regarding UTK's inventory.)

Greenhouse Gas Offsets
Greenhouse gas offsets are methods for reducing accumulation of atmospheric greenhouse gases that do not involve reducing one's own emissions. These typically take two forms: direct sequestration and trading. Direct sequestration removes greenhouse gases from the atmosphere. The most common sequestration method is reforestation. (See entry for Carbon Sequestration.) Trading involves paying for and hence obtaining credit for someone else's sequestration or emission reduction activities. Trading for credit is conducted at such institutions as the Chicago Climate Exchange and the California Climate Action Registry.

Heating and Cooling Policies
Heating and cooling policies that establish maximum winter and minimum summer temperatures can be useful in saving energy. Winter heating temperatures at the University of Washington, for example, are set to 68 degrees. Space heaters are prohibited. The university has also lowered water heating temperatures in buildings.[41]

Yale alters the non-business hours operating temperature of many non-residential buildings. During unoccupied hours (typically 8:00 p.m. to 6:00 a.m.) the temperature is set to 60 degrees during the heating season and 80 degrees during the cooling season. The net effect of this policy, which represents, on average, a two degree change from former unoccupied operating temperatures, is an anticipated reduction of 7,800 metric tons of annual carbon emissions and an operating savings of over one million dollars. Yale also asks all personnel to maintain the temperature in their rooms or offices at 70 degrees or less during the heating season and 75 degrees or more during the cooling season.[42]

Students at California State University, Chico, recently voted to adjust the current heating and cooling standards by three degrees so that buildings will not be heated above 65 degrees in the winter or cooled below 81 degrees in the summer. This is among the most energy conserving thermostat settings adopted by a campus. Organizers anticipate that the move will save about $151,000 annually, and reduce the university's greenhouse gas output by 1,100 tons of CO_2.[43]

High-Performance Contracting Policies

High-performance contracting policies require that all contracts let by the university meet high-performance energy standards and other environmental standards—for example, EPA's Energy Star standards for appliances (*see* entry on Energy Star Policies). Harvard, for example, has such a policy and also has created a high-performance building service whose services include "the provision of building system assessments, envelope analysis, occupant comfort assessments, evaluations of energy conservation measures, project costings and funding options, project management for project implementation, staff training and occupant education programs, and the development of standards and guidelines of ongoing building management."[44]

LEED Certification

Leadership in Energy and Environmental Design (LEED) certified buildings must meet fairly stringent energy-efficiency criteria, but certification usually pays for itself fairly quickly in energy savings. LEED certification is more effective than mere sustainable design guidelines, since the latter are more susceptible to "value engineering" budget cuts. For projects that are not certified by LEED or a comparable program, there is typically less of an incentive for design professionals or project managers to ensure full consideration of sustainable design features.

LEED has three levels of certification above the standard: silver, gold, and platinum. At Northwestern University all new buildings must be LEED certified at a minimum, but each project is assessed on an individual basis for further certification at the Silver or Gold levels.[45] Yale's new 64,700-square-foot Engineering Research Building achieved a LEED Gold rating in 2006.[46] Sierra Nevada College's 45,000-square-foot Tahoe Center for Environmental Sciences received LEED Platinum certification in the spring of 2007.[47] Likewise, the new "green" Visitor Education Center at the North Carolina Botanical Garden at UNC Chapel Hill is planning to apply for LEED Platinum certification.[48]

Performance Contracting

Performance Contracting (also called Energy Service Contracting) is a strategy whereby a university employs a private contractor to upgrade its energy systems. The cost of the improvements is paid by the university through the energy savings.

The University of South Carolina, for example, has $34 million performance contract with Johnson Controls that will be paid for through energy savings, which are guaranteed throughout the 13-year contract term. The university expects to save nearly $4 million each year, with an estimated $52 million in cumulative savings.[49]

Similarly, the University of North Carolina at Greensboro expects to save nearly $8 million in its utility bills over the next 12 years through a contract with Trane Comfort Solutions, Inc. Through the contract, UNCG will get energy related renovations for five campus buildings, which are guaranteed to reduce utility bills by $7.9 million over the next 12 years. A portion of the savings will be used to repay the $5.8 million cost of the improvements.[50]

Renewable Energy Hedges

A renewable energy hedge is a financial agreement entered into by a renewable energy generator and a power customer that includes the sale of renewable energy credits and is intended to protect both partners against price volatility.

Southern New Hampshire University, for example, has entered into a renewable energy hedge with PPM Energy that will enable the university to stabilize its energy prices for 15 years and offset all of its carbon production. The hedge contract guarantees the university a fixed price for 15 years of 7.6 cents per kilowatt-hour for the 15 million kWh of electricity it will use annually, including the estimated power use of buildings that will be constructed in the next two years. As part of the agreement, the university also will receive 17,500 renewable energy credits per year, enough to offset the 11,400 tons of carbon dioxide the university is projected to generate annually.[51]

Revolving Loan Funds

Revolving loan funds provide university departments with interest-free capital for high performance campus design, operations, maintenance, and occupant behavior projects. Departments agree to repay the fund via savings achieved by project-related reductions in utility consumption, waste removal, or operating costs. Typically, projects are required to have a short payback period—often five years or less.

Harvard’s Green Campus Loan Fund is perhaps the most notable example. The fund has generated a better return for the university than the Harvard Endowment and was recently doubled to $12 million.[52]

Similarly, the University of Colorado Student Union recently established an Energy and Climate Revolving Fund. The $500,000 fund will support student government’s carbon neutrality goal for student-managed buildings by enabling the managers of UCSU buildings to pay for energy efficiency and other measures that reduce greenhouse gas emissions while saving money. UCSU building managers will use the ECRF as a source of low-interest loans to pay for greenhouse gas reduction projects that will ultimately save students’ money in reduced energy costs over time. These savings will then be used to pay back the individual loans, allowing the fund to remain whole and support ongoing and future efficiency projects.[53]

Stadium Lighting Reduction

Some campuses have taken steps to reduce the energy cost associated with stadium lighting. The University of Washington, for example, operates Husky Stadium lighting at 25 percent of its lighting capacity.[54] Assumption College, a Catholic school in Worcester, Massachusetts, is installing an innovative lighting system, called Light Structure Green, in the construction of its new Multi-Sports Stadium. The system uses 40 percent less energy than traditional sports lighting units and cuts the "lighting spill" onto neighboring properties, protecting the evening skies.[55]

Sustainability Officer

Many campuses have a dedicated position to oversee energy use or sustainability generally. A good example is New York University, which created in June 2006 the position of Assistant Vice President for Energy, Engineering & Technical Services. The new Assistant Vice President will "develop and implement a comprehensive energy strategy that includes cogeneration and alternative energy sources, operation of the University's cogeneration plant, identification and implementation of energy conservation projects, and development of engineering standards for NYU's facilities that will improve their energy efficiency and infrastructure reliability."

Similarly, in a move to synthesize sustainable campus operations from the top down, Stanford's Department of Land, Buildings and Real Estate has created a campus sustainability executive director position as part of a radical restructuring of Facilities Operations. The change splits Facilities Operations into two groups. The new executive director will lead the Department of Sustainability and Energy Management (SEM) in overseeing the Utilities Division, which governs energy and water use; Parking and Transportation Services, which runs the transportation demand management programs; and the campus power plant. A second new position, the sustainability programs manager, will be created in the SEM department to help promote outreach activities with the Stanford community. The Department of Buildings and Grounds Maintenance, the second group, will be headed by the current Associate Vice Provost for Facilities and will manage landscaping and building maintenance.[56]

The Association for the Advancement of Sustainability in Higher Education (AASHE – see Section II-B) maintains a directory of Campus Sustainability Officers.

Transportation Alternatives

Though transportation is not, strictly speaking, within the purview of this Energy Plan, it is integral to any climate-reduction package. Use of public transportation (buses) and of non-motorized transportation (walking, biking), and carpooling can save energy as well as reduce carbon emissions and other forms or air pollution. Much can be done to encourage use of transportation alternatives by designing the campus so that automobile use is discouraged and walking, biking, and public transportation are encouraged.

Use-Based Billing

Excessive use of energy can be discouraged by use-based billing. This is the idea of charging units or energy users by the amount of energy they use, in order to provide an incentive for conservation. Use-based billing is possible wherever energy use is directly metered. University of Illinois at Springfield, for example, now charges students who live in campus apartments for their actual utility usage if they use more than 10 percent above the average usage in their apartment building. For the past few years, UI students have been charged an average rate for all utilities.[57] The idea has much wider applicability—for example, to individual departments or other units.

Waste Minimization

Waste minimization helps to reduce overall energy use. Signatories to the Presidents' Climate Commitment must participate in the waste minimization component of RecycleMania, a competition among campuses to increase recycling and reduce waste. The competition takes place annually over a 10-week period and requires contestants to report waste generation in a user-friendly online system. The waste minimization component of the competition rewards the institution that produces the least amount of municipal solid waste (including both recyclables and trash) per person. Signatories wishing to meet this option must also adopt three or more associated measures to reduce waste. A list of these is provided in the draft implementation guide for the Presidents' Climate Commitment.

Window Upgrades

Upgrading windows is a routine measure, but some institutions are considering campus-wide upgrades as a part of major energy-reduction or carbon-neutrality programs.

Appendix 3

Potential Technologies for Energy and Greenhouse Gas Savings

This appendix alphabetically lists technologies for saving energy and reducing greenhouse gas emissions. This compilation is not a recommendation for UTK; some but not all may be useful for the Knoxville campus.

Biofuels
At present the two main biofuels are ethanol, which can be produced from a variety of energy crops, and biodiesel, which can be made directly from soybeans or from waste vegetable oil collected from campus food facilities or local restaurants. Processes currently used to produce these fuels require large inputs of energy, typically from fossil fuels, but future methods of production are likely to be more efficient.

UT is undertaking a major Bioenergy Initiative in conjunction with Oak Ridge National Laboratory and is the Southeastern Sun Grant Center for research on ethanol, funded by the U.S. Department of Energy and the U.S Department of Agriculture. UTK also has a small biodiesel facility run by the College of Engineering; in conjunction with the Southern Alliance for Clean Energy, it is planning a larger facility that will use waste oil from the campus area. (See also Biomass Cofiring.)

Biomass Cofiring
Biomass cofiring is the practice of burning plant-derived materials in energy plants (e.g. steam plants) to reduce fossil fuel use. When compared with coal, biomass feedstocks (agriculture residues, dedicated energy crops, forest residues, urban wood waste, and wood mill wastes) have lower emission levels of sulfur or sulfur compounds and can potentially reduce nitrogen oxide emissions. Moreover, the use of biomass crops for energy production may reduce carbon emissions. There are, however, serious questions about the sustainability of biomass co-firing, in part because of tradeoffs between growing biomass crops and food crops.

Capital costs for retrofitting an existing coal-fired boiler are facility-specific and are affected by a host of factors – required boiler modifications, on-site processing requirements (e.g., size reduction, drying, etc.), and requirements for storage and handling. If biomass is blended with the coal, no separate feed system is required, but this tends to limit the amount of biomass that can be accommodated to about two percent of the total heat input. Separate feed systems are much more expensive, but the amount of biomass that can be burned increases to about 15 percent of a unit's total heat input. Estimates are that the capital cost for blending up to two percent biomass would be $50/kW (about $6/lb/hr steam capacity) while for blending up to 15 percent would be around $200/kW (about $24/lb/hr steam capacity).[58]

It is also possible to use biomass alone, though this requires a different sort of boiler. UT Martin plans to use biodiesel made for soybeans in its new on-campus power plant. This $4.4 million plant will be funded partly by a grant from TVA.[59] At Colgate University, a wood boiler provides 60 percent of the steam for campus heat and hot water, using wood chips as fuel. Thirty percent of this fuel is supplied by a regional furniture manufacturer as a by-product of their manufacturing process. The facility claims to produce no net CO_2 emissions.[60]

Biomass Gasification

Biomass can also be converted into a substitute for natural gas. The University of South Carolina, for example, is building a biomass gasification plant for campus heating that will largely eliminate the need for external sources of natural gas. Biomass gasification heats wood chips to about 1,800° F, which releases gases that are burned to generate steam. The university expects the process to be cleaner than natural gas, emitting fewer particulates and greenhouse gases and to produce electricity and natural gas savings of nearly $2 million annually for the campus.[61]

A similar facility using agricultural waste is planned for the University of Minnesota at Morris. The campus expects the biomass gasification facility to heat up to 80 percent of its buildings and to replace approximately $500,000 of natural gas purchases with local corn stover and other agricultural residue from the nearby farms. The estimated project cost is $8,956,000.[62]

Cool Roofs

The simple expedient of using light-colored roofs to reflect sunlight can help reduce cooling costs in the summer. “Coolness” is measured by two properties: solar reflectance and thermal emittance. Both properties are measured from 0 to 1; the higher the value, the "cooler" the roof. But the high reflectance that helps in the summer hurts in the winter by turning away solar energy that would otherwise heat the building. Consequently, the hotter the climate, the more energy that can be saved overall by a cool roof. The EPA recommends cool roofs, especially in the southern part of the United States, as part of its Energy Star program.[63] Smart roofs (see entry below) may in the foreseeable future provide reflectivity ideally adapted to both heating and cooling, but probably at much higher initial cost.

Daylight Harvesting

Daylight harvesting uses light sensors, often in combination with motion sensors (described in a separate entry below), to automatically adjust electric lighting to appropriate levels. The sensors may also control shading devices, which may be transparent but still reduce glare. “Light shelves” in high window areas can bounce sunlight onto white or reflective ceilings, and the windows themselves can be provided with coatings that maximize penetration of visible light while minimizing solar heat gain by filtering the infrared spectrum. Daylight harvesting is a currently available, cost-effective technology that can be used in major renovations and new buildings. It is most efficient when buildings are properly oriented in the design phase.

Desiccant Cooling Systems
Desiccant cooling systems use chemical desiccants to remove moisture from the air. Conventional air-conditioning systems must lower the air temperature below its dew point to dehumidify. This chilled air must then be heated to bring it back to a comfortable level, consuming extra energy and increasing peak energy demands. Compounding the problem, these systems generally become less efficient as the cooling coil temperature is lowered to meet dehumidification requirements. Ventilation air is particularly challenging to conventional systems because of its relatively high humidity content. The inability of conventional cooling equipment to control the humidity loads imposed by ventilation air at a reasonable cost leads to decreased ventilation rates, buildup of indoor air contaminants, and sick-building syndrome. The addition of desiccant components to an HVAC system directly removes the water vapor (latent heat) from the air, overcoming inherent dehumidification limitations of cooling coils. Desiccants enable independent control of temperature and humidity, improving HVAC system efficiency by freeing direct expansion cooling components to run at more efficient operating points.[64]

Desiccant systems are commercially available and can supplement conventional air conditioners, reducing the need for vapor-compression systems to operate for long cycles and at low temperatures in order to handle temperature and humidity. By working together, conventional cooling systems and dessicant systems can tackle the temperature and humidity loads separately and more efficiently. HVAC engineers can then reduce compressor size and eliminate excess chiller capacity.[65]

Energy Management Systems
Energy management systems are centralized, computerized control systems that increase energy efficiency through remote monitoring and adjustment of heating and cooling. The University of British Columbia's Building Management System, for example, now automates about 90 percent of the academic campus, monitoring and controlling heating, cooling, and ventilation within each building. This allows operators and technicians to troubleshoot and adjust any necessary functions from anywhere on campus. It also allows systems to operate to match the exact occupancy of each building, enabling UBC to save energy during such unoccupied periods as nights, weekends, and holidays.[66]

Fuel Cells
Fuel cells are an advanced means of generating energy that can be used to reduce greenhouse gas emissions. Large-scale fuel cell generating facilities may be feasible for campus use. California State University, for example, is building a one-megawatt fuel cell power plant for its Northridge campus to generate base load electricity for its facilities and surplus heat for hot water.[67]

Geothermal Systems
Geothermal heat pumps (GHPs) use the relatively stable temperatures that occur underground to achieve heating and cooling. Most applications do not require supplemental heating. The main disadvantages of the conventional GHP systems relative to air-to-air heat pumps are the extra expense of burying heat exchangers in the earth and the difficulty of locating and making repairs, if needed.

Several near- and long-term technologies could improve the cost-effectiveness of GHP systems. One way of reducing the cost of GHPs is to use a supplemental heat rejecter such as a dry fluid cooler. In this type of system – known as a hybrid – the ground heat exchangers are typically sized to meet the heating load only. During the cooling season, some of the heat that would have been rejected to the ground is rejected to the atmosphere through the fluid cooler.

Recent research has identified another process that can overcome more of the shortfalls in conventional ground-coupled heat pumps and offer even higher efficiencies and peak load reduction capability for residential and small commercial heat pumps. The expense of large underground heat exchangers is bypassed by a revolutionary new process of heat recovery that enables a small heat exchanger with a special desiccant-like material to exchange water naturally present in the environment either in the form of humidity or as adsorbed water. The process is termed selective water sorbents (SWS). By absorbing water from the ambient surroundings (ground or air) during off-peak periods and desorbing water during peak periods, the overall energy profile can be changed to accomplish higher cooling efficiencies and simultaneously reduce peak electric demand. In a ground-coupled situation, the system would use a small, buried container that can rapidly exchange heat through a reversible process of exchanging water between the SWS and its environs. Since water has a large heat of vaporization, small quantities of water transport can move large amounts of energy across small thermal gradients.

Since water is environmentally benign, SWS technology offers the potential for both energy efficiency and environmental benefits. The dynamic sequence of water exchange reduces the footprint and physical size of a ground-coupled heat exchanger, lowering its initial and operating costs, and increasing the potential market. Additional improvements may increase the likelihood of expansion of this energy efficient and green technology as the SWS technology is further developed.

A number of colleges and universities are installing geothermal systems. At Eastern Connecticut State University, for example, a geothermal system was included as part of the renovation of a 30-year-old, 72,000-square-foot, nine-story residence hall. The dorm, which was not air conditioned, is now air conditioned and heated with less energy than it used before the renovation.[68] Lipscomb University’s new Ezell Center includes a $1.2 million geothermal heating and cooling system that is expected to save between $70,000 and $90,000 annually in energy costs. The system uses 40 to 60 percent less energy than a standard heat pump. This is the first of many planned geothermal installations for Lipscomb.[69] A geothermal well system is planned for the new “green” Visitor Education Center at UNC Chapel Hill.[70]

Green Roofs

Green roofs are roofs on which vegetation is grown. They can reduce urban heat islands by providing shade and evapotranspiration (the release of water from plants to the surrounding air). They also reduce storm sewer loads by assimilating large amounts of rainwater, absorb air pollution, collect airborne particulates, and protect underlying roof material by eliminating exposure to the sun's ultraviolet radiation and to daily temperature fluctuations. Moreover, they insulate a building from extreme temperatures, mainly by keeping the interior cool in the summer. Finally, the vegetation on green roofs can sequester carbon.[71]

Hybrid Lighting

Hybrid lighting systems use fiber optics to channel sunlight to luminaries during daylight hours. At night they rely on sensor-controlled electric lamps. The current optimal fiber length is 50 feet or less. Typically this translates to the top two floors of a commercial building.[72] ORNL has been a leader in developing hybrid lighting systems. Now under development, this technology may become useful within a decade or so.

Hydrogen Fuel

Hydrogen is a clean fuel whose only emission product is water. But because production of hydrogen fuel currently consumes more energy that is created by its use, hydrogen is best regarded as an energy carrier, not an energy source. In addition, there are many technical challenges with its storage and use. It is conceivable, however, that hydrogen fuel might have some applications on campuses within the next 25 years.

Integrated Energy Systems

Integrated energy systems allow the exhaust of one piece of equipment to be supplied as an input energy source to another, lowering the overall energy consumed. In addition, integrated systems allow the common use of components for multiple purposes, which can result in lower first costs for systems. Multifunctional equipment and integrated systems offer the opportunity for a significant increase in efficiency improvement. For example, an integrated water heating/space cooling system that uses heat pumping to meet space heating, air conditioning, and water heating needs could be 70 percent more efficient than the combined efficiencies of systems in use today.[73]

Several of these concepts are already being implemented at UTK, most notably the generation of steam from electricity production, known as combined heat and power (CHP). As equipment has improved, smaller sizes of equipment have become economic. This allows utilization in individual buildings or elsewhere on campus that are not connected to the steam system and may not previously have proven suitable. Improved integration can lower the barriers and foster the acceptance of high efficiency technologies. Possibilities include:

- Combined heat pump space heating, cooling, water heating, and dehumidification.
- Cool air from heat-pump water heating used for space cooling.
- Exhaust heat from refrigeration and freezing used for space heating and/or hot water.
- Exhaust heat from distributed electricity generation used for space heating, water heating, and other thermal energy needs.

The highest and most consistent energy savings from distributed energy resources occur when the thermal exhaust from the electric generation is used for other purposes at the site such as heating, cooling, dehumidification, or steam. Smaller individual integrated systems may also facilitate the use of biofuels. While the volume necessary for cofiring in the steam boilers may be beyond the amount available locally, smaller systems may be able to use locally available biomass or provide a crucial demonstration system before expanding to a larger use of biofuels.[74]

Methane as Fuel
Waste methane is a potential energy source. TVA, for example, uses waste methane from the Chestnut Ridge landfill in Anderson County to generate electricity for its Green Power Switch program. Not all of this landfill's methane production, however, is currently being used for power. KUB's Kuwahee Wastewater Treatment Plant, which is adjacent to UTK campus, also produces waste methane. Use of this methane in the steam plant may be infeasible due to low energy content and flow, but perhaps other uses are feasible.

Motion (Occupancy) Sensors
Motion (occupancy) sensors save energy by automatically dimming lights when a room is empty and increasing the lighting when someone enters. This not only reduces the amount of electricity spent for artificial lighting, but it also reduces the amount of heat produced by the lights and therefore reduces air conditioning costs in warm weather. Occupancy sensors can be used alone or integrated with temperature sensors and other monitoring devices into an energy management system that also controls heating, ventilation, and air conditioning. Sensors being installed at Georgetown University are expected to have a payback period of as little as two years.[75] Many other universities have extensive programs of installing sensors. Sensors need to be installed so as to compatible with eventual integration into a centralized energy management system. (See entry for Energy Management Systems.)

Natural Gas as Fuel
Since natural gas is a hydrocarbon, while coal is essentially elemental carbon, combustion of natural gas releases less carbon dioxide per unit of energy than does combustion of coal. With regard to greenhouse gas emissions, natural gas is therefore currently preferable to coal for steam and power generation.

Passive Solar Water Heating
Solar thermal panels trap sunlight that is used directly to heat water. This technology generally works best on a small scale.

Guilford College recently installed twelve solar thermal panels on one of its residence halls. The panels, which cost $30,000, are expected provide all of the hot water for the building and to save more than $86,000 during the life of the system.[76]

Governor's State University in Illinois has installed a huge system consisting of 64 four-by-ten-foot solar collectors that pre-heat water for its swimming pool and provide domestic hot water for most of the rest of the university. The system has a life expectancy of 30 years and is expected to save the university $10,000 annually at current natural gas prices. To fund the system, GSU was awarded renewable energy grants of $150,000 from the Illinois Department of Commerce and Economic Opportunity and $65,323 from the Illinois Clean Energy Community Foundation, totaling 70 percent of the cost of the solar thermal installation.[77]

Photovoltaic Generation

At present for many applications, photovoltaic generation must be subsidized in order to be cost-effective, but it is likely to become cost-effective for many more applications over the next 25 years. Despite their current cost, photovoltaic systems may still be advantageous because they are environmentally relatively benign, and especially because in operation they are carbon neutral.

A number of universities have found creative ways to make photovoltaic installations cost-effective even in a purely economic sense. The national leader is Cal State's East Bay campus, whose solar array tops four buildings and generates about 1.45 million kWh a year. The university has received a record $3.4 million rebate from Pacific Gas & Electric for this installation.[78]

Three Massachusetts campuses are employing a different strategy—Clean Renewable Energy Bonds from the U.S. Internal Revenue Service—to help fund their photovoltaic systems. Salem State College will install a 68 kW system, Springfield Technical Community College will install an 82 kW system, and Mount Wachusett Community College will install a 100 kW system. The bonds, which are essentially zero-interest loans, are available through the U.S Energy Policy Act of 2005 as an alternative for public institutions unable to take advantage of tax credits for clean energy. The solar installations will also receive financial support from Massachusetts Technology Collaborative's Renewable Energy Trust.[79]

Smart roofs

Smart roofs are roofs that utilize nano- and micro-technologies to change the reflectance and infra-red emissivity of roof materials as a function of temperature in order to retain heat in winter and reflect heat in summer. This is a developing technology, not yet available, but likely to become available in the next 25 years. An improvement in the roof's ability to modify heat flux based on air temperature has substantial potential for energy savings. Simulations have shown that a roof with a reflectivity of 85 percent above 65°F and five percent below 65 degrees provides estimated energy savings of 5-10¢/sq ft-yr over the best available commercial roofing material and from 10-20¢/sq ft-yr over standard shingles in a wide variety of climates. A smart roof would consist of four layers. The first layer is the roof substrate whether metal, concrete, thermoplastic membrane or wood. The second layer is a customized polymer layer with a top surface that has a specially designed indentation pattern. The third layer is an opaque material used to fill the nanoscale indentations on the polymer surface. The fourth layer is a clear coating providing both physical and UV protection. The composite can be manufactured as a laminate that overlays the existing roof or that becomes part of the manufacturing process for the respective roof product. As a result, it is not expected to add any weight penalty versus existing roof materials.[80]

Solar Heating and Cooling
Passive solar design can reduce heating bills in buildings; similarly, design mindful of the sun's orientation can reduce cooling bills. There are, in addition, active systems that collect sunlight to heat water that can then be used for heating and cooling. These work best in very hot and sunny climates. Cochise College and Arizona Public Service Co. are constructing a system that consists of sun-tracking mirrors that focus sunlight on an ethylene glycol solution. The ethylene glycol in turn will heat water that will be used in the college's new central heating and cooling system. When needed for cooling, the hot water will operate an absorption chiller. The system is expected to save $15,000 annually in heating and cooling bills. For the first ten years, this saving will be split between the college and the utility; thereafter it will all go to the college.

Solid State lighting
Solid-state lighting uses the emission of semi-conductor diodes to directly produce light, rather than resistance heating of a wire as in incandescent lamps or excitation of a gas as in fluorescent lamps. Advances in this technology over the last two decades have contributed to a gradual market penetration in colored and some specialty white-light markets. As industry and government investment continues to improve the performance and reduce the costs associated with this technology, solid state lighting is expected to start competing with conventional light sources for market share in general illumination applications. The scientific and research communities forecast that as the performance of light emitting diodes (LEDs) and organic light emitting diodes (OLEDs) improves, their costs will simultaneously decrease. Energy savings will result from consumers choosing solid state sources in general illumination (white-light) applications such as offices, retail establishments, and homes.[81]

Some universities are already using LEDs in general illumination applications. University of Arkansas, for example, is installing new six-inch LED recessed light fixtures in the Chancellor's Residence. The LED lighting technology is expected to save the University between $400 and $800 per month compared to incandescent lighting sources. In a 20-year life-cycle cost comparison, including initial costs, the LED lighting will save up to $319,000 compared to incandescent, and $61,000 over fluorescent sources. Payback of the initial investment is estimated to be a little over one year from energy savings and reduced maintenance costs.[82]

Vending Misers
Vending misers are devices that increase the energy efficiency of vending machines. By monitoring both occupancy levels in the area around the vending machine and ambient temperate changes, they allow only enough power to keep the cooled product inside at the right temperature and have it ready to dispense when someone is in the vicinity. The University of Washington, Yale, and several other campuses have installed these devices on vending machines and de-activating lighting from vending machines (reduces machine's electricity consumption by 30-40 percent).[83]

Wind Turbines

Wind turbines generate electricity without carbon emissions. The list of universities that operate on-campus wind turbines is long.[84] Some institutions also operate off-campus turbines. Colorado State University, for example, has plans to offset its entire Fort Collins campus energy use by building a wind farm in northern Colorado that will generate more power than the university consumes. The CSU Green Power Project, which is to be completed within eight years, will also serve as an outdoor laboratory for researchers in energy systems, environmental studies, and related fields. The Colorado State University Research Foundation recently finalized a deal with Wind Holding LLC to develop the facility on the university's 11,000-acre Maxwell Ranch near the Wyoming border. The project will generate a minimum of 65 megawatts or about 25 wind turbines with the potential of up to 200 megawatts. At peak demand, Colorado State currently uses about 16 megawatts of power. Since the CSU Green Power Project is expected to generate more wind power than the electrical needs of campus, it could produce up to $30 million in additional revenue for the university over the life of the project, which is about 25 years.[85]

Some universities (including UTK) purchase electricity from utilities with Green Power programs that rely partly on wind turbines. Most notable is New York University, one hundred percent of whose electricity is wind-generated.

Appendix 4

Goals of the American College & University Presidents' Climate Commitment

What follows is the text of the American College & University Presidents' Climate Commitment, which was signed for UTK by Chancellor Loren Crabtree in 2006. Signatories pledge to:

1. Initiate the development of a comprehensive plan to achieve climate neutrality as soon as possible.
    a. Within two months of signing this document, create institutional structures to guide the development and implementation of the plan.
    b. Within one year of signing this document, complete a comprehensive inventory of all greenhouse gas emissions (including emissions from electricity, heating, commuting, and air travel) and update the inventory every other year thereafter.
    c. Within two years of signing this document, develop an institutional action plan for becoming climate neutral, which will include:
        i. A target date for achieving climate neutrality as soon as possible.
        ii. Interim targets for goals and actions that will lead to climate neutrality.
        iii. Actions to make climate neutrality and sustainability a part of the curriculum and other educational experience for all students.
        iv. Actions to expand research or other efforts necessary to achieve climate neutrality.
        v. Mechanisms for tracking progress on goals and actions.
2. Initiate two or more of the following tangible actions to reduce greenhouse gases while the more comprehensive plan is being developed.
    a. Establish a policy that all new campus construction will be built to at least the U.S. Green Building Council's LEED Silver standard or equivalent.
    b. Adopt an energy-efficient appliance purchasing policy requiring purchase of Energy Star certified products in all areas for which such ratings exist.
    c. Establish a policy of offsetting all greenhouse gas emissions generated by air travel paid for by our institution.
    d. Encourage use of and provide access to public transportation for all faculty, staff, students, and visitors at our institution
    e. Within one year of signing this document, begin purchasing or producing at least 15 percent of our institution's electricity consumption from renewable sources.

f. Establish a policy or a committee that supports climate and sustainability shareholder proposals at companies where our institution's endowment is invested.

g. Participate in the Waste Minimization component of the national RecycleMania competition, and adopt three or more associated measures to reduce waste. (Note: this option was not available in early versions of the commitment.)

3. Make the action plan, inventory, and periodic progress reports publicly available by providing them to the Association for the Advancement of Sustainability in Higher Education (AASHE) for posting and dissemination.

AASHE (see Section II-B) has published a draft implementation guide for this Commitment, which is expected to be finalized in the summer of 2007.

Appendix 5

2007 UTK Greenhouse Gas Inventory

The following is a summary of a preliminary inventory conducted by Leslie Chinery, an undergraduate honors student at UTK. For the full version, see www.cce.utk.edu .

Methods

Processes and Limitations

This carbon emissions inventory includes the University of Tennessee, Knoxville campus and the Agricultural campus. It does not include the Space Institute in Tullahoma, the Health Science Center in Memphis, or the Institute of Agriculture because they are not within the boundaries of the Knoxville campus.

This study is not meant to be an absolute and conclusive compilation of data; as an undergraduate honors thesis it does not necessarily have the scope and completeness of many greenhouse gas inventories conducted at other institutions by teams of students, faculty, and staff. It is intended to be a starting point for assessing UTK's carbon emissions impact. The inventory should be maintained and scrutinized by a qualified body such as the Committee on the Campus Environment, comprised of students, faculty, and staff from diverse academic and professional backgrounds, who can correct any informational gaps or inconsistencies. There are several fields of data that simply were not recorded at UTK, and other data that are not readily available to students.

Several greenhouse gas inventories and carbon footprint calculators have been developed using several different parameters and calculation methods. The Clean Air–Cool Planet Campus Carbon Calculator is one of the most widely used and most reliable greenhouse gas inventories among college institutions (Clean Air-Cool Planet [CA-CP], 2006). A comprehensive data analysis tool, it outlines what data to obtain and then transforms the data into a "carbon footprint" in metric tons of carbon dioxide equivalent, or MTCDE. For this study, data were collected back to 1990 or as early as available. Emissions factors and calculations are based upon Intergovernmental Panel on Climate Change (IPCC) calculations established for national greenhouse gas inventories, but Clean Air-Cool Planet has made special adaptations specific to the university sector (CA-CP, 2006).

The Campus Carbon Calculator (CCC) divides greenhouse gas emissions into three scopes: 1) direct emissions produced on-site, 2) direct emissions produced off-site, and 3) indirect emissions such as commuting to the university. To ease data collection, the Calculator segregates data into seven distinct areas, including institutional data, electricity, transportation, agriculture, solid waste, refrigeration and other chemicals, and offsets. Following is an explanation of the methodology used to obtain data for each section as well as limitations of this research.

Data

Basic institutional data are broken into three parts: budget, population, and physical size. The budget data includes operating budget of the university, research dollars, and the energy budget. The operating budget is defined by Clean Air-Cool Planet (CA-CP) as “all sources of funding the university has financial control of” or “the cost to operate the institution” (CA-CP Campus Carbon Calculator (CCC) manual, 2006, p. 6). The Office of the Vice Chancellor for Finance and Administration directed me to the annual *Budget Document* kept by their office for the university’s operating budget and research dollars (K. Valero, personal communication, August 2, 2007). The total operating budget of the university is the total current unrestricted and restricted expenditures and transfers for both Educational and General (E&G) and Auxiliary funds (UT, *Budget Document*, 1990-2007). The expenditures figures are a more accurate representation of the university’s true operating budget than are revenue data, because expenditures represent the actual amount of money spent for all purposes by the university (L. Zorn, personal communication, April 23, 2007; J. Paxton, personal communication, August 8, 2007).

The energy budget is defined as the “combined budget for electricity, steam and chilled water, and any on-campus stationary sources (heating, cooking, etc.),” excluding the cost of “energy for transportation [and] purchase of water” (CA-CP, 2006). Terry Ledford, Senior Project Manager for Facilities Services, maintains a document with the total amount and cost of energy used by the UTK steam plant from 1979 to the present (personal communication, March 30, 2007; *Annual Usage Metrics* [raw data], 2007). The total energy budget used in this inventory includes the total annual cost of electricity, coal, natural gas, and steam. The CCC includes chilled water in the energy budget; however, the record of UTK’s water and sewer budget does not differentiate between what is purchased for use as chilled water versus for sewer and other purposes. Therefore, UTK’s energy budget does not include chilled water. To make the budget data meaningful, the Campus Carbon Calculator adjusts all three budgets for inflation using 2003 dollars as a base year (CA-CP, 2006)

The Office of Institutional Research publishes an annual Fact Book report, which includes basic university population data on students, faculty, and staff (Office of Institutional Research [OIRA], 1990-2006). As the Fact Book includes only the fall and spring semesters, Lynn Zorn of the Office of Institutional Research [OIRA] created a report on summer school students from 1990 to 2006 (L. Zorn, personal communication, May 3, 2007). The faculty population data include the total number of faculty on the Knoxville campus, full and part time; staff data include the total number of employees minus the total number of faculty (OIRA, 1990-2006). From 2002-2005, the OIRA included the Institute of Agriculture, College of Veterinary Medicine, Space Institute, and Health Science Center in the Fact Book, whereas in previous years these institutions were omitted. The 2006 data also included the Health Science Center and Space Institute. Lynn

Zorn resolved these inconsistencies by developing a synopsis of Knoxville-only employees for the years in question (L. Zorn, personal communication, July 30, 2007). Also, the College of Agriculture and the College of Veterinary Medicine are not included in the population data in any of the Fact Book publications, but are included in the energy data.

The Strategic Planning and Operations Office maintains data on the physical size of UTK, including total square footage of building space on Knoxville's campus (K. Marlino, personal communication, August 2, 2007). The square footage data includes buildings on the Knoxville campus, Agricultural campus, and College of Veterinary Medicine. The university does not specifically keep track of a "research square footage" number, so this number is a summation of the net square footage of all current research projects on the UTK campus (K. Marlino, personal communication, August 3, 2007). There are no buildings dedicated exclusively to research on UTK's campus, but this method should provide an accurate estimation of total research square footage.

Data were gathered and/or estimated for the following:

- Electricity
- On-campus stationary sources
- Transportation (university fleet and commuter traffic; air travel was not included)
- Agriculture (exclusive of the Institute of Agriculture)
- Solid waste
- Refrigerants and other chemicals

Offsets

In addition to greenhouse gas emissions, this inventory also includes actions taken by the University to offset GHG emissions. The three offsets included by the Campus Carbon Calculator are Renewable Energy Credits, Composting, and Forest Preservation. Renewable Energy Credits (RECs) are certificates purchased representing that a certain amount of renewable energy has been produced (CCC manual, p. 13, 2006). The university directly purchases renewable energy from the Knoxville Utility Board through the Tennessee Valley Authority's (TVA) Green Power Switch® program; this purchase is included under the Renewable Energy Credits column in the Offsets section. In addition to purchasing renewable energy, the university began composting its leaves as well as other green waste in 2004 (S. Surak, personal communication, April 9, 2007). While the university has received endowments including forested land and owns several acres of forest, none of these holdings were obtained for the purpose of offsetting carbon emissions and are not on the Knoxville or Agricultural campuses, so therefore are not included in the Offsets section of this preliminary inventory.

Results

Based on the data collected and the calculations of the Campus Carbon Calculator (2006), UTK's approximate net greenhouse gas footprint was 263,374 metric tons of carbon dioxide equivalents (MTCDE) for the 2006-2007 fiscal year (CCC, 2006). Table 1 describes greenhouse gas emissions in MTCDE for 2000 to 2006 and the breakup of emissions by scope. Numbers in parentheses indicate a negative value. This estimation does not include emissions due to university air travel; once air travel is factored in, net emissions will increase significantly.

Table 1: *Summary of Greenhouse Gas Emissions in MTCDE for 2000-2006*

Fiscal Year	**Scope 1 (Onsite)**	**Scope 2 (Offsite)**	**Scope 3 (Indirect)**	**Gross Emissions**	**Offsets**	**Net Emissions**
2000-2001	84,348	154,491	31,878	270,717		270,717
2001-2002	65,098	151,529	32,179	248,806		248,806
2002-2003	75,075	159,429	32,692	267,196		267,196
2003-2004	69,980	151,795	33,280	255,055		255,055
2004-2005	76,348	167,344	32,946	276,638	(12)	276,638
2005-2006	70,702	165,145	33,513	273,489	(4,162)	269,360
2006-2007	67,477	162,377	33,521	267,503	(4,164)	263,374

(CCC, 2006).

While not all data were available before 2004, the sections with the most significant carbon emissions have a complete data set for the term 1990 to 2006. It appears that UTK's greenhouse gas emissions have begun to decrease in the past two years, although this may be a temporary reduction. Greenhouse gas emissions per student appear to have begun to exhibit a downward trend as well, as demonstrated by Figure 1.

Figure 1: *GHG Emissions per Student, in MTCDE*

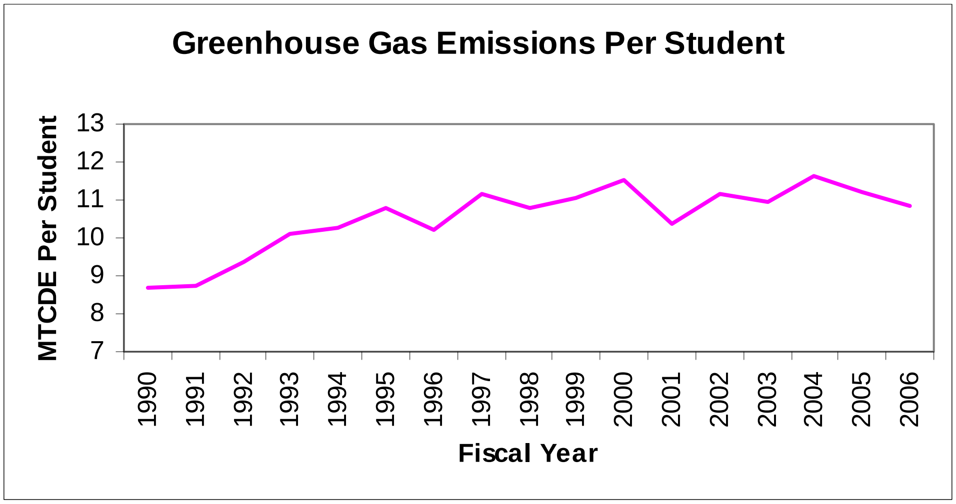


Figure 2 shows the total greenhouse gas emissions of the University from 1990 to 2006, with each sector cumulatively stacking to generate a trend line for total emissions of the university. Although the first ten years represented by this graph do not include refrigeration data, the overall trend line is accurate because refrigeration accounts for only one percent of total emissions.

Figure 2: *Total Greenhouse Gas Emissions, 1990-present*

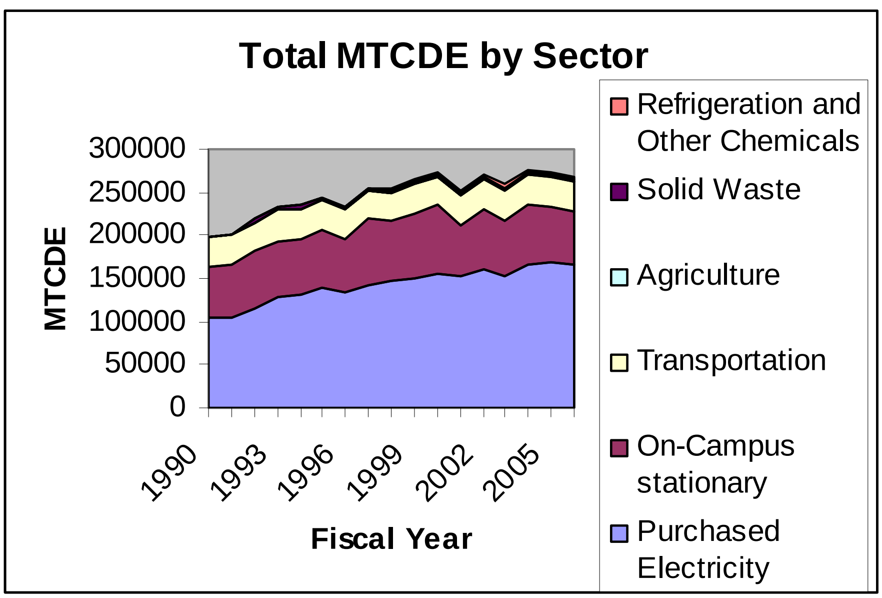
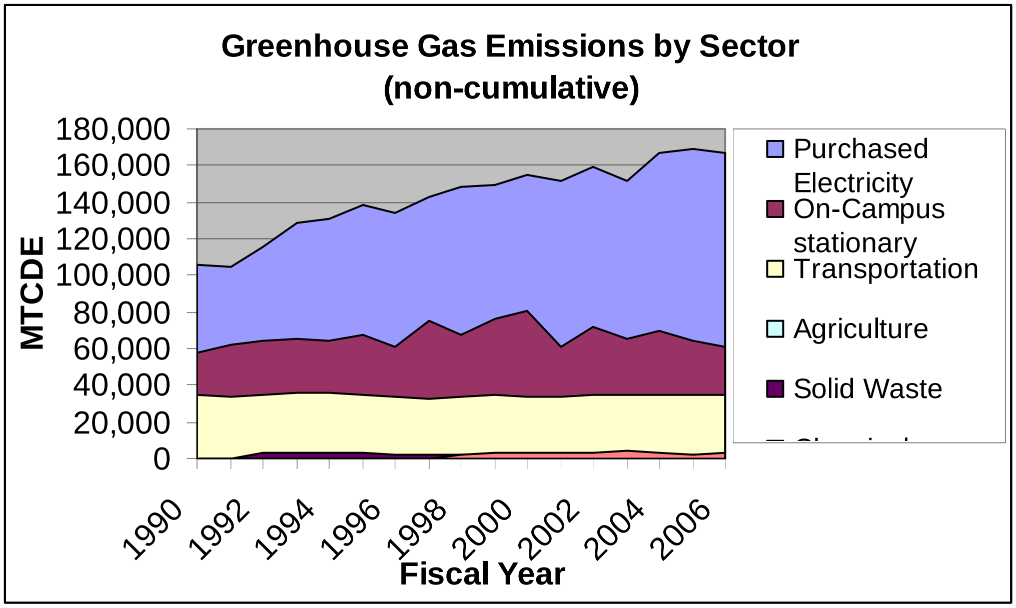


Figure 3 demonstrates the trends of each sector's greenhouse gas emissions from 1990 to 2006. Figure 3 shows that emissions due to transportation, agriculture, and solid waste have remained relatively stable over the past 16 years, while emissions from purchased electricity have continuously grown. Emissions due to on-campus stationary sources have fluctuated over the 16 year period, but appear to have stabilized in the past few years. The major fluctuations in on-campus stationary emissions may be due to the vastly changing cost of natural gas during these years.

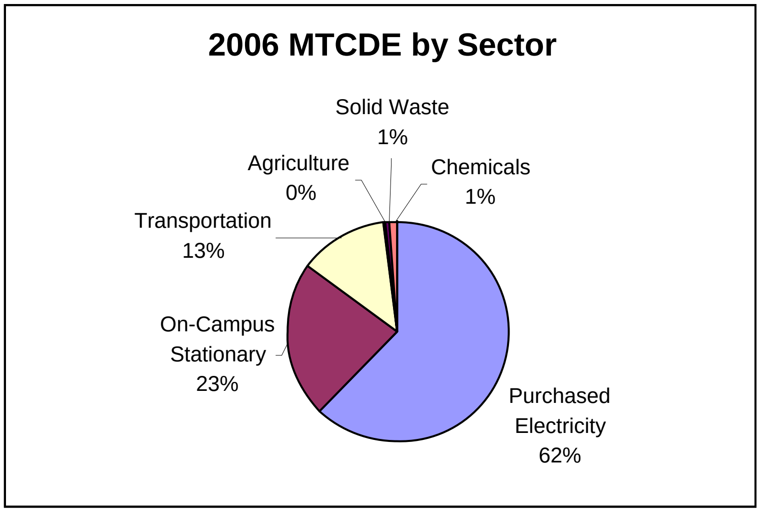
Figure 3: *Greenhouse Gas Emissions by Sector, 1990-2006*



(CCC, 2006).

Finally, Figure 4 shows the breakdown of carbon dioxide equivalent (MTCDE) greenhouse gas emissions by sector in the 2006 fiscal year. Purchased electricity, on-campus stationary sources, and transportation together accounted for approximately 98 percent of UTK's total emissions in 2006.

Figure 4: *2006 Emissions by Sector in MTCDE*



(Campus Carbon Calculator, 2006).

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Facilities Services also provided a 12-month total of emissions from the steam plant for sulfur dioxide, carbon monoxide, PM-10, hydrogen fluoride, and other emissions. For various emissions calculations concerning UTK's use of TVA-generated electricity, sources included:
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[21] The draft implementation guide for the Presidents' Climate Commitment requires signatories to create an institutional structure to guide the development and implementation of this of a climate neutrality plan by November 15, 2007.
[22] Required by the draft implementation guide for the Presidents' Climate Commitment.
[23] These actions are required by the draft implementation guide for the Presidents' Climate Commitment.

[24] An increase to 15 percent of total energy use is one of seven actions, at least two of which are required of all signatories of the Presidents' Climate Commitment.
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