

Preliminary Greenhouse Gas Emissions Inventory  
of the University of Tennessee, Knoxville  
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## Introduction

With an enrollment of almost 26,500 students, the University of Tennessee, Knoxville has a tremendous impact on the natural environment. Together with the University's role as a leading research institution, the sheer size of the University generates a massive demand for energy and natural resources every year. In the past several years, we have begun to recognize our impact on the environment and reducing this impact has gained more and more consideration. Now, with global climate change becoming a major topic of public concern, the University has more incentive than ever to step up and lead the community in environmental responsibility and stewardship. We have initiated the discussion on sustainability, and are now faced with a vast opportunity to follow through with our rhetoric and truly move towards becoming a sustainable institution.

The University of Tennessee (UT) has made significant strides regarding environmental leadership among peer institutions in the past several years. Often, this progress has been the result of the hard work of dedicated, forward-thinking students, faculty and staff, and their collaboration with a cooperative administration. The University hosts an exceptionally active student organization called Students Promoting Environmental Action in Knoxville, familiarly known as SPEAK. Along with a handful of dedicated faculty and staff, SPEAK has been the driving force in several of the University's environmental initiatives. In 2004, the adoption of a formal Environmental Policy marked one of the first major public commitments to sustainability made by the University. UT's Environmental Policy outlines the University's commitment to environmental stewardship, proclaiming that the University will strive to "serve as a model of environmental stewardship and integrity" and take into consideration the environmental impacts of all decisions made by the University (Committee on the Campus Environment [CCE], 2004).

Furthermore, the policy states that the University will attempt to incorporate energy efficiency and conservation, waste reduction, recycling, and composting measures. Although nonbinding, the recommendations made by this policy represent an important symbolic foundation on which the University can develop a more concrete strategy for sustainable development.

In 2006, the University launched an extensive outreach campaign called Make Orange Green aimed at increasing environmental awareness among UT students. In the past year, the Make Orange Green logo has become a very prevalent and familiar symbol of UT's environmental movement, displayed on "Make Orange Green—Flip It Off" light switch plate covers in nearly every building on campus, banners on lamp posts lining pedestrian areas, and on UT's small fleet of Hybrid vehicles. Along with SPEAK, this program sponsors environmental speakers throughout the year and events such as Earth Month.

One of the greatest successes on the Knoxville campus was the passage of the Student Environmental Initiatives Fee in 2005. After a two-year long student-run campaign, the University adopted a \$5 "green power fee" paid by students as part of the facilities fee. This fee funds multiple energy-saving projects on campus, as well as an annual 6,075,000 kilowatt hour purchase of renewable energy from the Knoxville Utility Board's Green Power Switch® program (Student Environmental Initiatives Fee [SEIF], 2007). After UT's success, several similar campaigns were launched at schools across the state, including Middle Tennessee State University (MTSU), Austin Peay University, and Tennessee Technological University, among others. UT Knoxville truly has led Tennessee state universities in the renewable energy effort, and was the number one purchaser of green power in Tennessee until recently surpassed by MTSU's green power purchase (Southern Energy Network, 2006).

Chancellor Loren Crabtree has taken several steps to strengthen UT's commitment to a sustainable future. First, the Chancellor announced an informal commitment to strive for LEED® certification for all new buildings constructed on UT's campus; this means they will meet the minimum requirements set forth by the United States Green Building Council's Leadership in Energy and Environmental Design (LEED) program. (CCE, personal communication, July 8, 2007) The new Computer Science and Electrical Engineering building will be the first LEED®-certified building on UT's campus, scheduled for completion in 2009 ("Ground Breaking," 2007). Second, in March of 2007 the Chancellor officially signed the Talloires Declaration. Created by the Association of University Leaders for a Sustainable Future (ULSF) in 1990, this document signifies a strong assertion that its signatory universities take responsibility for leadership in sustainability, both by acting as exemplars of environmentally sound practices and by supporting research on sustainable development (2001). To date, 356 universities worldwide have signed onto the Talloires Declaration (ULSF, 2007).

One of the most progressive actions taken by the Chancellor is his signing of the Presidents Climate Commitment. The American College and University Presidents Climate Commitment (ACUPCC) is a comprehensive, binding pledge to achieve carbon neutrality. There are several stringent requirements of this commitment, and it provides a structured timeline to guide universities in developing and implementing carbon-neutral plans. This is perhaps one of the most comprehensive and far-reaching current campaigns to combat anthropogenic global climate change. Even the Kyoto Protocol, the almost universally accepted policy to reduce humanity's climate impact, only seeks to reduce carbon emissions; the Presidents Climate Commitment requires its participating institutions to attain eventual climate neutrality, rather than just a reduction in greenhouse gas emissions (ACUPCC, 2007). This is a

tremendous step for the University to take, and will allow UT Knoxville to truly shine as a leader among its peers for environmental initiative.

One of the first steps outlined by the Presidents Climate Commitment is to conduct a greenhouse gas inventory of the University. In addition to being a requirement of this program, determining the significance of our negative impact on the environment is an essential first step in becoming a more sustainable university. For these reasons, I have conducted a preliminary greenhouse gas inventory of the University of Tennessee based on the Clean Air-Cool Planet Campus Carbon Calculator. By quantifying an estimate of the University of Tennessee's annual carbon footprint, this greenhouse gas inventory will be an essential tool in developing a strategy towards sustainability and eventual carbon neutrality.

## Methods

### *Data collection: 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 and is intended to be a starting point for assessing UT's environmental impact. The carbon emissions 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 kept track of at this University, and other data that are not readily available to students. It will follow in the suggestions section that better ways to keep track of these data be established. This will hopefully prove to be a useful starting point for the implementation team of the Presidents Climate Commitment.

With global climate change being such a prominent topic of discussion and research in the world today, there have been several greenhouse gas inventories and carbon footprint calculators 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.

*Institutional data*

Basic institutional data is 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 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 UT 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 UT’s water and sewer budget

does not differentiate between what is purchased for use as chilled water versus for sewer and other purposes. Therefore, UT'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 UT, 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 UT campus (K. Marlino, personal communication, August 3, 2007). There are no buildings dedicated exclusively to research on UT's campus, but this method should provide an accurate estimation of total research square footage.

### *Electricity*

UT has an on-campus coal-fired steam plant with three boilers that produce steam and a fourth boiler that is attached to a turbine generator. The fourth boiler can be considered cogeneration because it has the capacity to produce both steam and electricity. Two of the boilers use exclusively coal, one can use both coal and natural gas, and the cogeneration boiler uses natural gas ("Steam Plant," [raw data], 2007; T. Ledford, personal communication, March 30, 2007). The Calculator divides on-campus sources into the on-campus cogeneration plant and all other on-campus stationary sources. The steam output, electric efficiency, and steam efficiency of the cogeneration plant required calculations based on data for the turbine generator. The steam efficiency figure is inaccurate because it is not possible to separate the amount of natural gas converted into electricity and that converted into steam. Due to cost constraints of using natural gas and other factors, however, for most years for which I have data (1996-2006), no steam was generated from the cogeneration component so the steam efficiency calculation issue was irrelevant ("Steam Plant" [raw data], 2007).

In addition to coal and natural gas, there is a small amount of distillate oil used in generators on campus; data on the amount of oil used are from monthly invoices of diesel fuel purchases made by Facilities Services (S. Surak, personal communication, August 3, 2007). As encountered with the energy budget data, it was not possible to obtain information on purchased

chilled water due to its grouping with sewer and other water usage data. An additional inconsistency is that the electricity data includes UT's Oak Ridge and Pellissippi campus buildings which cannot be separated out, while these are not included in the other sections of this inventory.

### *Transportation*

The transportation sector of the emissions inventory is broken down into three categories: university fleet, commuter traffic and air travel. The university fleet comprises a gasoline fleet, diesel fleet, and a small electric vehicle fleet. Transportation Services keeps records of the annual dollar amount spent on gasoline rather than the number of gallons they use, therefore the total gasoline usage of the university fleet is difficult to estimate because of an almost daily fluctuating gasoline price. However, the Director of Transportation Services made a rough estimate of annual gallons of gasoline usage, as well as an approximate expenditure of gasoline for Knoxville-based vehicles (M. Moneymaker, personal communication, August 3, 2007). I opted to use the lower estimate provided by Mr. Moneymaker and extrapolated this figure for previous years as well since the University fleet likely has not undergone many fluctuations from year to year. Facilities Services maintains the University's diesel fleet (S. Surak, personal communication, August 3, 2007). In 2006, Facilities Services began purchasing a bio-diesel blend, some of which is B-100 (100 percent ethanol) and the rest of which is a B-20 (20 percent ethanol) blend. Bio-diesel emits approximately twenty to twenty-five percent less carbon dioxide (CO<sub>2</sub>) than does conventional diesel fuel; however, specific emissions factors for bio-diesel are not clearly documented, so the small amount of bio-diesel is included with the regular diesel numbers in the Calculator. This may be an area of potential future research and improvement to

this inventory. Thanks to the Student Environmental Initiatives Fee, there is a small electric fleet of vehicles as well, but the electricity used to power these vehicles is already included in the total electricity purchased for the University.

Air travel estimation is optional for this emissions calculator and I opted not to attempt to estimate it at this point. Because air travel provides such enormous emissions, it will be crucial in the future to estimate air travel the University is directly responsible for. This will include air travel by athletics as well as student and faculty travel directly related to conferences and other University functions. It is somewhat ambiguous the extent to which the University is responsible for its faculty and staff attending conferences, as well as which athletic trips are included. One possible method to determine what the University is responsible for is to simply include all air travel paid for by the University, but that may still be a rather cumbersome process. Air travel presents a tremendous challenge and opportunity to further this carbon emissions inventory in the future, but it is beyond the scope of this study.

In order to estimate commuter travel to the University, I relied on a commuter travel survey done by the Knoxville Smart Trips program in 2004. Over four thousand UT students, faculty, and staff responded to this survey about their commuting behavior. Among the questions asked by the survey were the average number of miles roundtrip commute, number of days per week on which respondents commute, and preferred mode of transportation to campus; options provided were driving alone, carpooling, biking, walking, or riding the bus (K. Segars, personal communication, April 16, 2007; *UT Commuter Behavior* [raw data], 2004). From the responses to these questions I calculated the percentage of people that drive, carpool, ride the bus, and walk or bike to campus, as well as the average commute for students, faculty, and staff. Because this was a travel survey of off campus students, I averaged the mean off campus student

commute of 11.08 miles with the on campus student commute of 0 miles for the number of students residing off and on campus, respectively, so that the average commute is representative of all UT students.

I made several assumptions in estimating commuter behavior. For example, the commuter survey did not include a question on the number of times per day participants commute to and from campus. For the inventory, I assumed a value of one roundtrip per day, which indicates a total of two trips. While this may be a reasonable assumption for faculty and staff who generally work throughout the day, it is likely an underestimate for students. Many students commute to and from the University for each of their classes; if class schedules are dispersed throughout the day, many students will commute back and forth to the University several times. However, there is no actual data reflecting this hypothesis so the minimum one roundtrip commute estimate is a practical assumption. Respondents were also asked the number of days per week they chose different modes of transportation for their commute. The number of responses in each category, rather than the number of days reported use, is what I used to estimate the percentage of students, faculty, and staff that drive, ride the bus, carpool, or walk to the University.

The Smart Trips travel survey on which the calculations of commuter travel behavior were based was conducted in 2004. There is no data on commuters prior to or after this survey, so I extrapolated the data to be constant from 1990 to 2006; this almost certainly is not true in real life. Particularly, the percentages of people that ride the bus and carpool versus drive alone has probably changed over the years since the implementation of the Smart Trips program. In addition, the emissions figures used in the calculator may be skewed high because of the implementation of the Clean Fuels program for mass transit in Knoxville initiated in 2004, where

all Knoxville Area Transit (KAT) busses now run on propane or bio-diesel, which produce fewer carbon dioxide emissions than conventional diesel fuel (American Public Transportation Association [APTA], 2004).

### *Agriculture*

The majority of agriculture that is carried out by the Institute of Agriculture is not included in this inventory because it is not located on the Agricultural Campus. As there are no crops grown on the grounds of the agricultural campus, the agriculture data in this inventory includes horticultural data of fertilizer applied to the grounds of campus including maintained lawns, flower beds, and the Agricultural Gardens (J. Hodges, personal communication, July 17, 2007; J. Cottrell, personal communication, July 25, 2007). There are no livestock kept on the Agricultural Campus for agricultural purposes. However, the College of Veterinary Medicine maintains a small resident herd of horses and cows for educational purposes (R. Holland, personal communication, August 6, 2007). I did not include an estimate of the number of animals treated by the Veterinary School, however, because those animals are generally only in residence for a few days and therefore are not considered part of UT's resident livestock population. Agriculture comprises less than one percent of UT's total greenhouse gas emissions so the number of animals treated in the Veterinary School is relatively insignificant.

### *Solid waste*

The University began maintaining solid waste records in 1992 because of the implementation of more stringent landfill regulations through an amendment to the Solid Waste Act in that year (S. Surak, personal communication, April 11, 2007). All of UT's solid waste is

disposed of at the Chestnut Ridge landfill; none of it is incinerated. The Chestnut Ridge facility captures all of its excess methane produced from the landfill, and flares about fifty percent of the excess methane, capturing the remaining fifty percent for on-site electricity cogeneration. About 1,200 cubic feet per minute of methane are flared, and the on-site electrical cogeneration plant produces about 3.2 megawatts of energy. These percentages are based on the cost of running the cogeneration plant. The cogeneration plant was installed in 1992, before which all excess methane was flared (T. Maryanski, personal communication, April 16, 2007). Based on the percentages of methane flared and recovered for electrical generation, I divided UT's solid waste data in half so that half of the methane produced from UT's waste is assumed to be flared and the other half captured for electrical generation.

#### *Refrigeration and other chemicals*

The CA-CP Campus Carbon Calculator concentrates mainly on carbon dioxide emissions, but also examines emissions of the other five chemicals mandated by the Kyoto Protocol: methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>) (CCC manual, p. 6, 2006; International Panel on Climate Change). Refrigerants such as hydrofluorocarbons often have a significantly larger greenhouse gas effect than carbon dioxide. Ironically, when world leaders met at the Montreal Protocol to combat the last global environmental threat, depletion of the ozone layer, they phased out the use of chlorofluorocarbons [CFCs] because of their harmful effects on the ozone layer; these refrigerants were replaced by chemicals such as hydrofluorocarbons [HFCs] that often have thousands of times the global warming potential of CFCs. (T. Ledford, personal communication, April 13, 2007; CA-CP, 2006). Global Warming Potentials (GWPs) are one

measure to quantify the greenhouse effects of certain chemicals in comparison to carbon dioxide, which is assigned a hundred year global warming potential of one. UT uses three of the refrigerants assessed by the Campus Carbon Calculator: HFC-134a, HFC-404a, and HCFC-22. Of these three refrigerants, HFC-134a has a hundred year global warming potential of 1300, HFC-404a has a 100 year GWP of 3,260 and HCFC-22 has one of 1,700 (CA-CP, 2006; T. Ledford, personal communication, April 13, 2007).

UT's refrigerant data is based on annual purchases of each chemical. The quantity of refrigerants purchased each year goes towards replacing coolant that has leaked from existing systems as well as providing initial coolant for new systems. Facilities Services does not keep a record of how much refrigerant is used for each of these purposes. However, new systems are not installed every year and so the majority of the refrigerant purchased is in fact bought for leaks (T. Ledford, personal communication, July 27, 2007). Because of the inability to separate refrigerants bought for leaks, the refrigeration section of the inventory may be slightly skewed high.

### *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.

### *Suggestions for future research*

There are several opportunities to improve upon the data I have collected thus far in future research. For example, the estimate of research square footage is based solely on the reported research projects at UT for the current year; it may be useful to attempt to estimate this number if data is available for previous years. While not an integral part of the inventory because it does not relate to emissions, research square footage is useful in making comparisons, plus it will be beneficial to establish as complete a data set as possible. If there is not an inventory of all research projects and their square footage conducted for previous years, one potential way to resolve this informational gap is to develop a list of buildings whose primary use is for laboratory or research purposes and sum their net square footage for each year.

Another major area for improvement is with the gasoline fleet estimate. Transportation accounts for approximately thirteen percent of UT's emissions, and as the University's primary fleet of vehicles the gasoline fleet is an important contributor of carbon dioxide emissions. It is important that the successors of this project develop a more precise way to gather data about the gasoline fleet of vehicles. This may require Transportation Services to keep track of and provide a monthly report of gasoline usage by UT Knoxville vehicles.

The commuter behavior survey conducted by the Smart Trips program was essential in deriving estimates for transportation to and from the University, and it may be interesting to conduct a follow-up survey to see if the percentage of students, faculty and staff using alternative transportation has in fact increased. It will also be useful to attempt to survey and estimate the number of trips the average off campus UT student makes to and from the University on a daily basis; this could be incorporated into the follow-up survey. Finally, a significant area of future research is to determine the air travel component of the University's transportation emissions. This may be done through collaboration with the University's travel agency. Because this inventory is merely a first attempt at quantifying our carbon impact, the methods and data that I have collected thus far should be examined and adjusted as necessary by the Presidents Climate Commitment implementation team or another qualified body.

## Results

Based on the data I have collected and the calculations of the Campus Carbon Calculator (2006), UT'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*

<b>Fiscal Year</b>	<b>Scope 1</b>	<b>Scope 2</b>	<b>Scope 3</b>	<b>Gross Emissions</b>	<b>Offsets</b>	<b>Net Emissions</b>
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 UT'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*

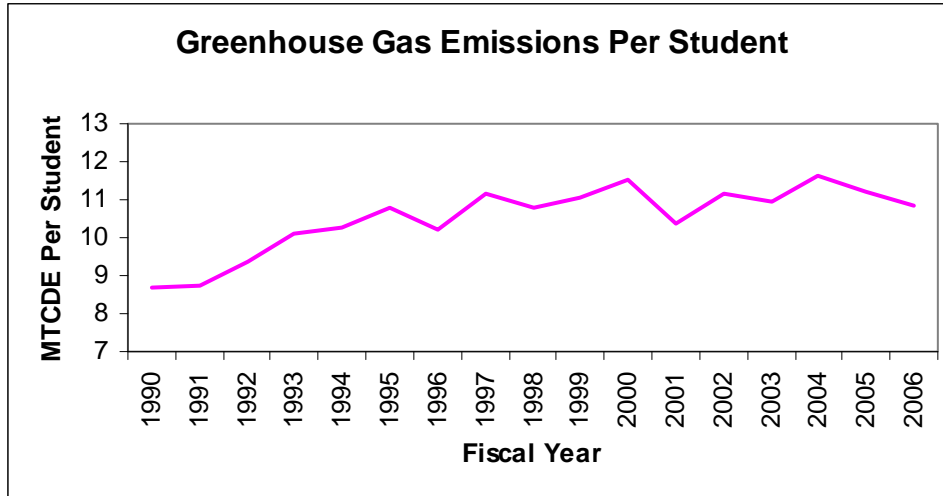


Figure 2 shows the total greenhouse gas emissions of the University from 1990 to 2006, with each sector cumulatively stacking to generate a trend line for total emissions of the University. Although the first ten years represented by this graph do not include refrigeration data, the overall trend line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

Figure 2

*Total Greenhouse Gas Emissions, 1990-present*

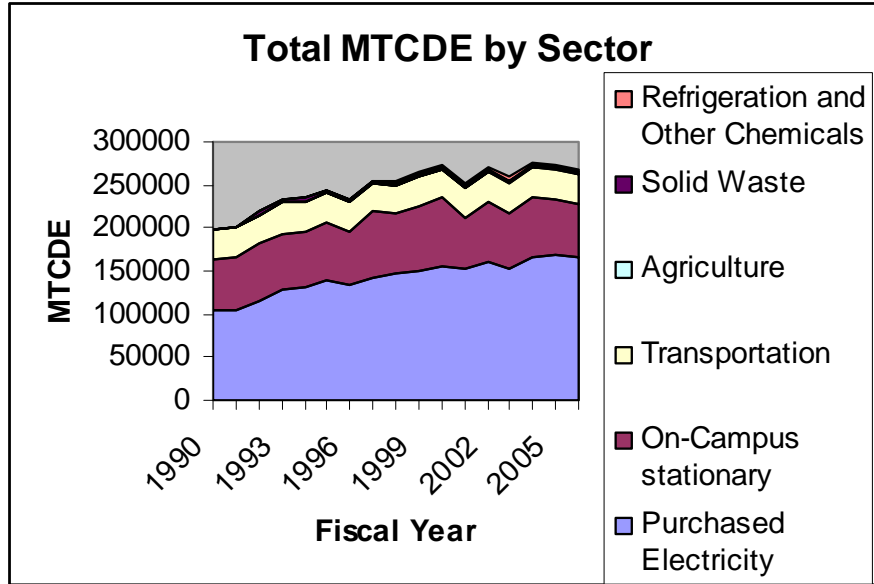
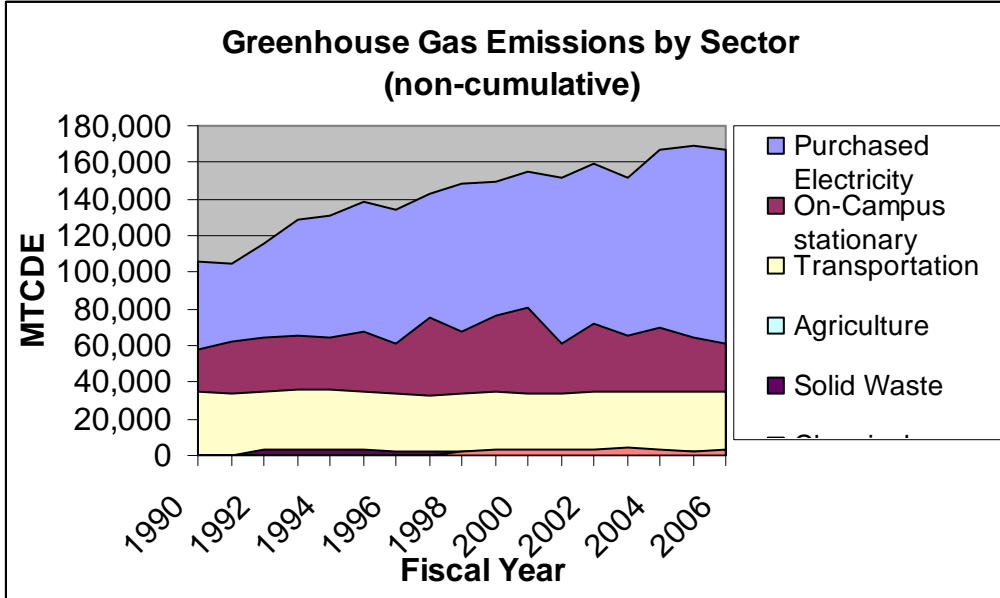


Figure 3 demonstrates the trends of each sector's greenhouse gas emissions from 1990 to 2006. Figure 3 shows that emissions due to transportation, agriculture and solid waste have remained relatively stable over the past 16 years, while emissions from purchased electricity have continuously grown. Emissions 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*

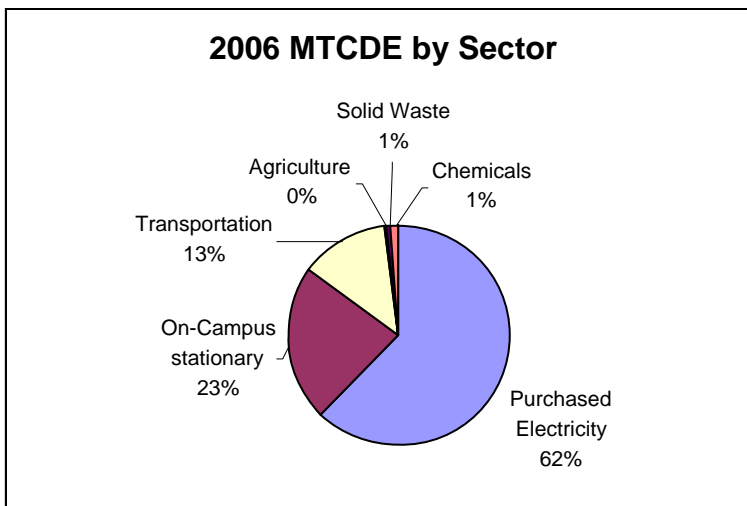


(CCC, 2006).

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 UT’s total emissions in 2006.

Figure 4

*2006 Emissions by Sector in MTCDE*



(Campus Carbon Calculator, 2006).

### *Energy*

Purchased electricity is by far the largest contributor to UT's carbon footprint, accounting for approximately 166,506 metric tons of carbon dioxide equivalent or 62 percent of greenhouse gas emissions in 2006. On-campus stationary sources, which includes all coal and natural gas burned in the UT steam plant, account for the second largest greenhouse gas emissions contribution of 23 percent, with approximately 60,767 MTCDE of emissions in 2006. Figures 5 through 10 show annual coal, electricity, and total energy use as well as these figures per capita from 1990 through 2006, based on the "Annual Usage Metrics" raw data file (2007). These figures indicate that total and per capita coal use have fluctuated throughout the years with an average upward trend, total and per capita energy use has steadily but gradually increased, and total and per capita energy usage has steadily increased as well.

Figure 5

*Total Coal Usage in Tons, 1990-2006*

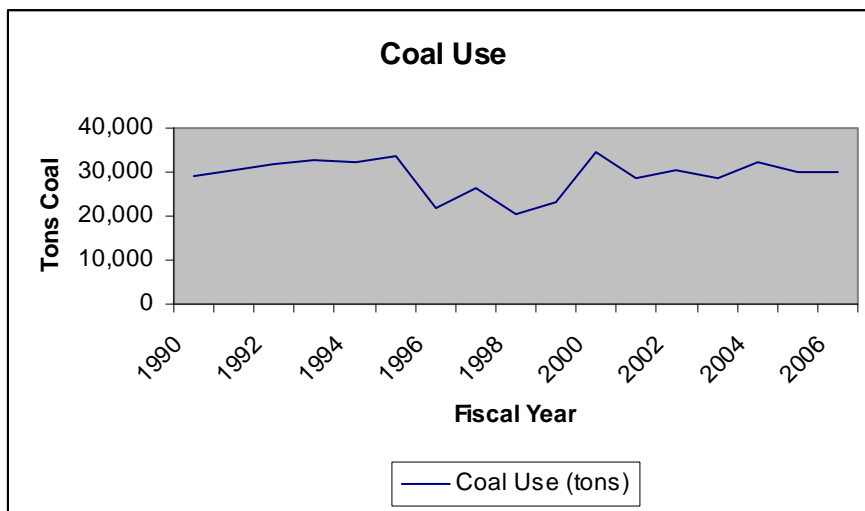


Figure 6

*Per Capita Coal Usage in Tons, 1990-2006*

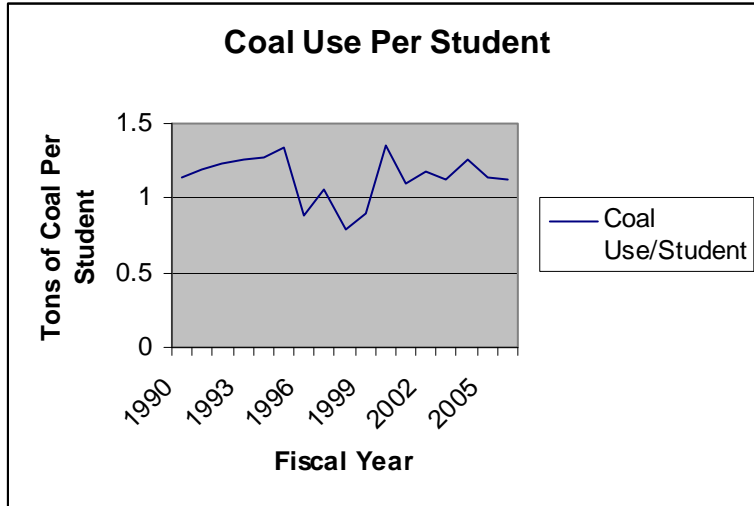


Figure 7

*Total Electricity Usage in Kilowatt Hours, 1990-2006*

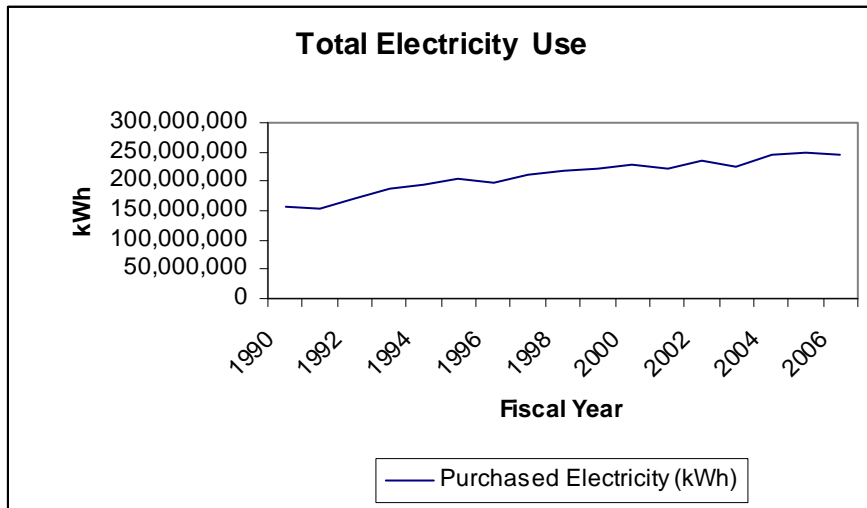
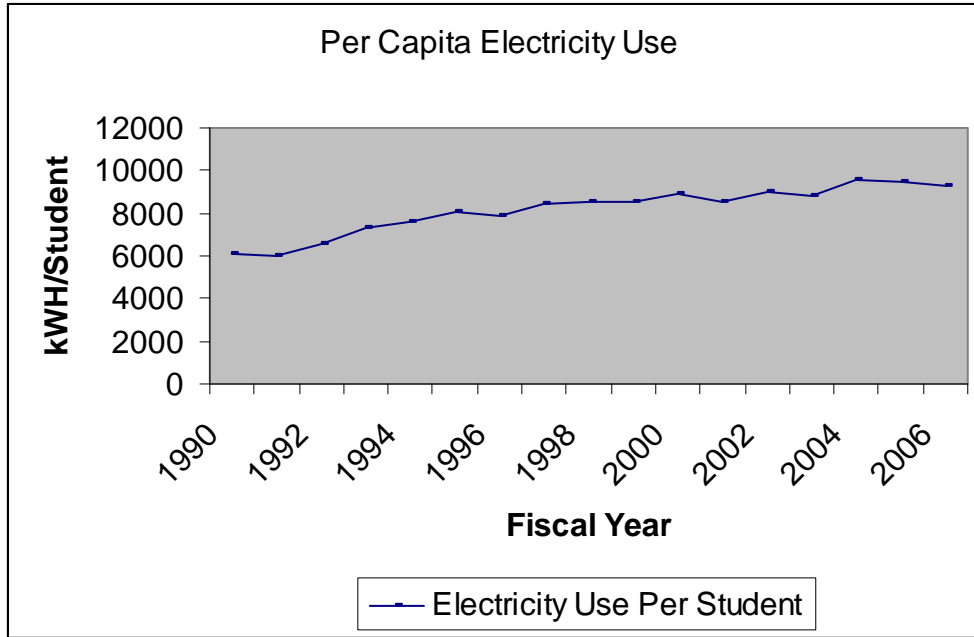


Figure 8

*Per Capita Electricity Usage in Kilowatt Hours, 1990-2006*



The small decline in electricity use in the past two years could be a result of energy efficiency and conservation efforts following the implementation of the Student Environmental Initiatives Fee.

Figure 9

*Total Energy Usage of UT, Measured in Million British Thermal Units, 1990-2006*

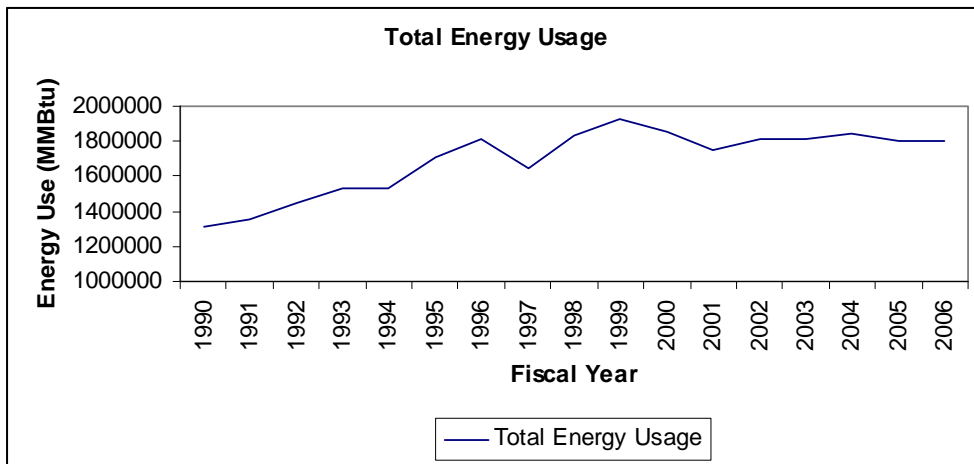


Figure 10

*Per Capita Energy Use in MMBtu, 1990-2006*

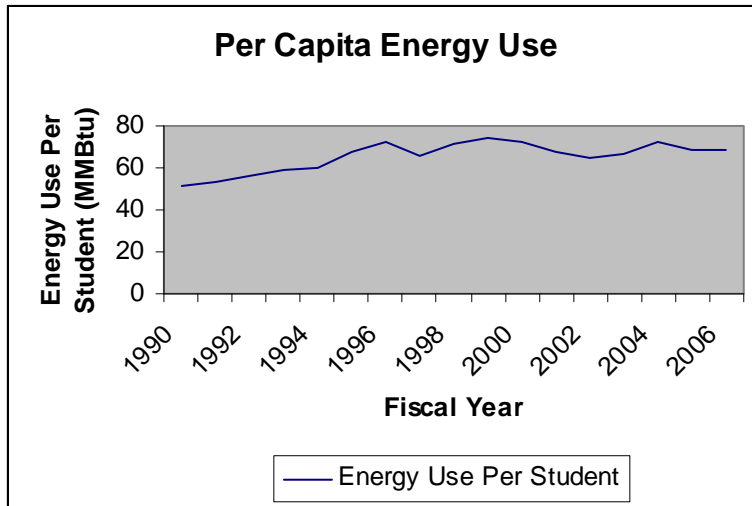
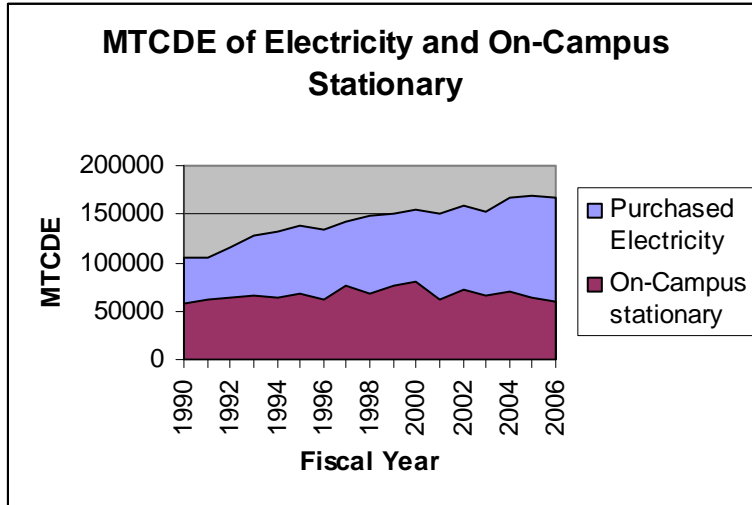


Figure 11 shows the individual trend lines of carbon emissions due to purchased electricity and to on-campus stationary sources. The contribution of on-campus stationary sources to greenhouse gas emissions appears to have been relatively stable from 1990 to 2006 with minor fluctuations, while the emissions contribution of purchased electricity has steadily increased. With coal producing approximately 60 percent of the Southeast's electricity, it is no wonder that the electricity that UT purchases has such a significant carbon impact.

Figure 11

*Electricity and Stationary Sources MTCDE, 1990-2006*



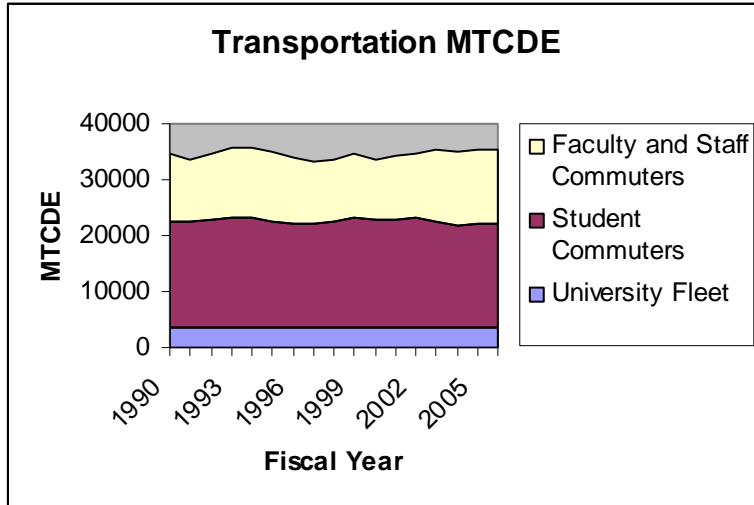
(Campus Carbon Calculator, 2006)

### *Transportation*

Transportation is the third largest portion of total greenhouse gas emissions, with 35,252 MTCDE accounting for approximately 13 percent of total emissions in 2006. Once air travel is factored in, transportation will likely account for a higher portion of greenhouse gas emissions. Figure 12 shows the percentage of transportation emissions caused by the University fleet, student commuters, and faculty and staff commuters. Emissions due to the University fleet, student commuters, and faculty and staff have remained relatively stable and proportionate from 1990 to 2006, with student commuters accounting for the highest emissions, followed by faculty and staff commuters and then the University fleet.

Figure 12

*University Fleet and Commuter Travel Percentages of Transportation GHG Emissions*

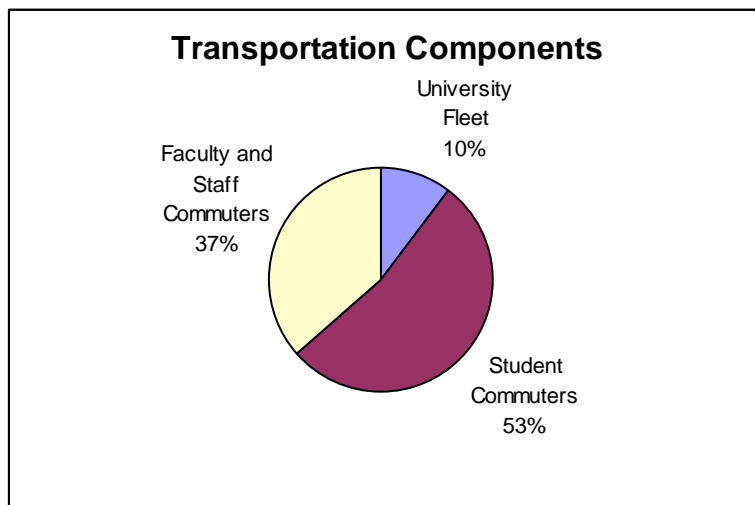


(Campus Carbon Calculator, 2006)

Figure 13 provides a very clear breakdown of the percentage of transportation emissions caused by each sector. While student commuters have a lower average commute and tend to use alternative forms of transportation more than their faculty and staff counterpart (see Table A3), the sheer number of students cause student commuters to have the greatest impact on the transportation emissions of the University. In 2006, student commuters were responsible for emitting approximately 18,708 metric tons of carbon dioxide equivalent into the atmosphere; faculty and staff commuters were responsible for another 12,943 MTCDE of emissions (CCC, 2006).

Figure 13

*Percentage of Transportation Emissions Due to University Fleet vs. Commuter Travel in 2006*



#### *Agriculture, Solid Waste and Refrigeration and Other Chemicals*

Both Refrigeration and Other Chemicals and Solid Waste account for approximately one percent each of total annual greenhouse gas emissions, and are therefore comparatively insignificant contributors to UT's carbon footprint. Refrigerants purchased by the University of Tennessee in 2006 were responsible for about 2,957 MTCDE of emissions; Solid Waste emissions total 1,870 MTCDE. Agriculture accounts for even fewer emissions, with its 151 MTCDE accounting for less than one percent of UT's total carbon emissions (CCC, 2006).

#### *Offsets*

In 2006, purchased renewable energy and composting offset approximately 1.6 percent of the University's gross emissions. Of the 4,164 MTCDE total offsets, the renewable energy purchase accounted for 4,129 MTCDE. While not included in the Campus Carbon Calculator's greenhouse gas inventory, recycling is also an important preventative measure for reducing greenhouse gas emissions. For example, in 2006 almost one thousand tons of recyclables were collected at UT, which prevented a total of about 2,630 metric tons of carbon dioxide equivalent

from entering the atmosphere that would have been generated had those recyclables entered a landfill (S. Surak, personal communication, August 8, 2007; EPA, *WARM*, 2006).

*Where UT stands: Comparison to other universities*

Table 2 provides a brief summary of a few carbon emissions inventories conducted at other higher education institutions. However, developing a meaningful comparison between these schools has implications for further research to fully understand and contrast each University's different calculation methods and omissions. The considerable variations among institutions are likely a result of more comprehensive emissions inventories having been conducted at some institutions but not others.

<i>Institution</i>	<i>Year</i>	<i>Net MTCDE</i>	<i>Per Student MTCDE</i>	<i>Undergraduate Enrollment</i>
<b>University of Tennessee</b>	<b>2006</b>	<b>263,374</b>	<b>10.83</b>	<b>26,476</b>
College of Charleston	2001	38,712	Not Reported	9,820
Yale University	2002	284,663	25.1	5,300
Oberlin College	2000	50,417	16.8	2,800
Harvard University	2006	385,668	10.7	6,715

(Source: College of Charleston, 2001; Buttazzoni et al., 2005; CA-CP, 2006; Harvard University, 2006)

## Discussion

The largest source of the University of Tennessee's carbon emissions by far is our purchased electricity. Electricity is primarily used for lighting, air conditioning, heating, office equipment, computers, and laboratories ("Annual Usage Metrics," [raw data], 2007). There are already several measures in place to reduce UT's use of electricity, many of which are funded by the Student Environmental Initiatives Fee. Facilities Services is also taking several actions to conserve energy, including shutting down heating, ventilation, and air conditioning (HVAC) systems during unoccupied periods, such as at night in academic buildings.

One of the largest efficiency and conservation efforts made by the University has been renovating lighting fixtures across campus. Facilities Services now exclusively purchases compact fluorescent bulbs that use up to 75 percent less energy than conventional incandescent bulbs, and as incandescent bulbs burn out on campus they are systematically replaced with compact fluorescents (CFLs) (T. Ledford, personal communication, October 2006). UT's annual Light Bulb Exchange allows students in residence halls to exchange their incandescent bulbs for compact fluorescents for free; incandescent bulbs collected are then sent to a recycling facility. Working closely with the 2006 Light Bulb Exchange, SPEAK was among the top University participants in the EPA Energy Star® Change a Light campaign (T. Rasmussen, personal communication, March 30, 2007). SPEAK collected a total of 1,023 pledges to change 3,122 light bulbs, the majority of which were actually exchanged by Facilities Services. Bulbs exchanged by this program were responsible for saving 880,404 kWh of energy, \$88,040 in energy costs, and preventing 1,389,290 pounds of greenhouse gas emissions. Facilities

Services is also installing LED lights in exit signs across campus to replace incandescent bulbs, which use up to 90 percent less energy (“Annual Usage Metrics,” 2007).

In addition to changing individual light bulbs, UT is also undertaking building-wide lighting renovations, paid for by the Student Environmental Initiatives Fee and the donated labor of Facilities Services. One of the largest lighting renovations projects is for Stokely Management Center, which houses mainly business offices. With the current lighting system, there are two light switches per floor that each control half of the light fixtures. Because of this, the Stokely building is almost continuously illuminated, whether at noon or at midnight, the middle of June or the middle of December. The \$125,000 annual five year, five-phase project is replacing the vintage, dual control lighting system with contemporary efficient lighting fixtures controlled by individual light switches (*Student Environmental Initiatives Fee [SEIF] Projects*, 2007). Facilities Services is also purchasing and installing lighting motion sensors, as well as retrofitting older buildings with obsolete lighting systems, with surplus revenue from the Student Environmental Initiatives Fee.

The second largest contributor to UT’s greenhouse gas emissions is stationary sources, which accounted for 23 percent of emissions in 2006. These emissions result from coal and natural gas burned in the on-campus steam plant. At UT, steam is produced mainly for heating buildings and water, as well as for cooking. Conservation measures taken by the University to reduce both coal and steam usage are again shutting off HVAC systems when buildings are not in use, lowering temperatures of domestic water heaters, and renovating steam valve controls for increased efficiency (*SEIF Projects*, 2007).

One action UT has undertaken to reduce transportation emissions is switching primarily to a B-20 blend bio-diesel fuel for the diesel fleet. However, because of the small size of the

diesel fleet this is only amounts to a small reduction. The major transportation milestone undertaken by the University is actively promoting the use of alternative transportation to and around campus. Based on the Knoxville Smart Trips commuter behavior survey (2004), the average commute for off-campus students is 11.08 miles, with faculty and staff commuting slightly larger distances of 10.84 and 12.9 miles, respectively. Fortunately, Knoxville's award-winning mass transportation system provides easy access to the UT campus. There are numerous trolley and bus routes that service the UT Knoxville campus with destinations including downtown, west Knoxville, and areas with a high concentration of off-campus UT student residences, such as the Fort Sanders area. Also, there are two exclusively on-campus bus routes provide that free transportation around the Knoxville and Agricultural campuses. The University of Tennessee is an active member of the Knoxville Regional Transportation Planning Organization's Smart Trips commuting program, and even earned an EPA award for being one of the "Best Workplaces for Commuters(sm)" in 2005 (*Smart Trips*, 2007).

While agriculture and solid waste only account for approximately one percent each of UT's net carbon emissions, the University is taking several proactive measures to reduce the impacts of these sectors. Facilities Services applies slow release nitrogen fertilizer twice per year on lawn areas and three to four times a year on flowerbeds. By using better quality slow-released fertilizer, the University is preventing significant amounts of nitrogen leaching into the soil after rain events, and also reducing the required number of fertilizer applications each year. UT has an outstanding Recycling Program as well, which diverts over 600 tons of recyclables from being entering landfills every year (Facilities Services, "UT Recycles," n.d.).

### *Presidents Climate Commitment*

Signatories of the Presidents Climate Commitment are required to take three actions within the first few years of signing, with an eventual requirement of achieving carbon neutrality. The University's timeline officially starts September 15, 2007. After this point, the University must develop a committee or other body to develop and oversee the implementation process within two months. Within a year, the University must have a completed greenhouse gas inventory. Finally, within two years of signing, the University must develop a strategy and target date to attain carbon neutrality and have successfully completed two tangible actions mandated by the ACUPCC (*Implementation Guide*, pp. 6-7, 2007). Because the carbon emissions inventory that I have conducted is only an initial estimate of greenhouse gas emissions, it will be up to the oversight committee to ensure that the greenhouse gas inventory is in fact comprehensive and complete, and in compliance with World Resources Institute (WRI) Greenhouse Gas Protocol and IPCC guidelines.

The ACUPCC outlines seven possible "tangible actions" the University can take to fulfill its two year action deadline. These are to: (a) establish an explicit green building policy, (b) adopt an Energy Star procurement policy, (c) offset all air travel emissions through an official policy, (d) encourage public transportation use, (e) purchase at least 15 percent renewable energy within one year, (f) support climate-friendly investing, and (g) participate in RecycleMania and adopt at least three additional waste reduction measures (ACUPCC, 2007). I will now briefly explain where UT stands on each of these tangible actions, suggest potential future steps to complete these actions, and provide an example of successful policies implemented at peer institutions. I have tried to highlight schools in the Southeast whenever possible.

### *Green Building Policy*

To fulfill this requirement, the University must establish an explicit policy that all new construction meet the minimum standards of LEED® Silver certification (ACUPCC, p. 10, 2007). LEED® stands for Leadership in Energy and Environmental Design, and is a set of guidelines established by the United States Green Building Council [USGBC]. Construction projects amass points based on energy and water efficiency, sustainable building materials and site development, and indoor environmental quality and can receive a rating of silver, gold, or platinum (USGBC, “What is LEED?,” n.d). For example, points can be awarded for proper stormwater management, soil erosion and sediment controls, recycling, and providing bike storage facilities.

As mentioned previously, the Chancellor has made an informal commitment that the University will make efforts to attain LEED® certification for all new campus building projects. By adopting this as an official University policy, the University could easily fulfill the green building requirement of the ACUPCC. Southeastern schools that have adopted a formal green building policy include Clemson University, the University of North Carolina at Chapel Hill, Emory University, and Duke University, among others (AASHE, 2007). The University of South Carolina has also made tremendous progress in sustainable building with their green dormitory projects (University of South Carolina, 2006).

#### *Energy Star Procurement Policy*

To fulfill the Energy Star Procurement Policy action, the University must adopt a purchasing policy that requires energy-efficient Energy Star® certified products wherever available; if desired, a clause specifying “where financially feasible” may be added (ACUPCC, p. 11, 2007). The EPA Energy Star® ratings extend from appliances such as washing machines,

air conditioning, and computers to windows, light bulbs, and insulation (EPA, *Energy Star*, n.d.). As mentioned before, UT's Facilities Services now exclusively purchases Energy Star® compact fluorescent light bulbs. However, there is no formal policy requiring all appliances be Energy Star® certified in place at UT at this time. Peer institutions that have adopted formal sustainable purchasing policies include the University of North Carolina at Asheville, the University of South Carolina, and Northwestern University (AASHE, 2007). One great opportunity to promote Energy Star products is with incoming freshmen, through orientation, green dormitory demonstrations, and incentives such as student discounts for purchasing energy efficient appliances.

#### *Air Travel Offsetting*

The University has the option of implementing a policy to offset all University-sponsored air travel emissions (ACUPCC, p. 11, 2007). The first necessary step in undertaking this action is to determine the amount of air travel the University is responsible for, which may be done by the University travel agency. The College of the Atlantic has formally committed to offset all of its air travel emissions with the purchase of renewable energy credits (ACUPCC, 2007).

#### *Provision of Public Transportation*

The University has made the most progress with the tangible action of actively promoting the use of public transportation by providing access and incentives such as free bus passes or significant discount rates for students, faculty, and staff (ACUPCC, p. 12, 2007). All trolley routes are free, and Parking Services offers semester Knoxville Area Transit (KAT) bus passes for under \$40, which is significantly discounted from the normal adult pass fare of \$40 per

month (Knoxville Area Transit, 2007). As described previously, the University is already taking several steps to fulfill the public transportation tangible action. Areas for improvement include further discouraging the use of cars on campus by measures such as increasing the cost of parking permits, disallowing or limiting the number of freshmen that can have cars, or limiting public vehicle access through main areas of the campus.

### *Green Power Purchasing*

The University may opt to purchase at least 15 percent of our electricity from renewable energy sources within one year of signing the Presidents Climate Commitment (ACUPCC, p. 12, 2007). Green power purchases must be Green-e® certified and come from solar, wind, biomass, geothermal, bio-diesel, or “low impact hydropower” that is produced either through a utility company or on-campus (ACUPCC, pp. 12-13, 2007). The implication of this proposed action for UT is that by September 15, 2008 fifteen percent of our energy must come from renewable sources. Our current annual green power purchase of 6,075,000 kilowatt hours (40,500 blocks of 150 kWh each) accounts for about 2.5 percent of our annual electricity consumption.

In the 2006-2007 fiscal year, UT’s annual electricity purchase was 244,975,745 kilowatt hours, 2.48 percent of which was green power. Based on UT’s electricity usage in 2006, to reach the 15% figure required for the ACUPCC tangible action, we would need to purchase approximately 36,746,362 total kilowatt hours of green power at cost of \$979,902.98. This is an annual increase of 30,671,362 kilowatt hours (204,476 blocks) at an additional cost of \$817,902.98 per year. The Student Environmental Initiatives Fee raises about \$428,000 per year with \$144,000 allocated for the purchase of green power; the remainder is spent on efficiency projects (*SEIF Projects*, 2007). Therefore, the University would have to come up with over

\$800,000 annually to pay for this increased green power purchase. To break this down on a per-student basis, in 2006 UT had an enrollment of 26,476; on average about 9,253 kilowatt hours is used per student per year. The average cost of green power per student is currently \$5.46. In order to reach this 15 percent goal solely by increasing our green power purchase, the annual per student cost of green power would have to increase to \$37.01. Alternatively, at our current green power purchase of 6,075,000 kWh per year, to have 15 percent of our total electricity purchased be green power we would need to reduce energy consumption by 75% of current levels. This is clearly not a practical immediate goal for the University.

Because UT is located in a valley, it seems impractical to attempt to capture any significant amount of electricity from wind power on campus. The on-campus wind and solar demonstration paid for the Student Environmental Initiatives Fee exists mainly for educational purposes, and has produced a mere 970 kilowatt hours since its construction in 2005 (T. Ledford, personal communication, March 30, 2007). However, there are almost 200 buildings on campus that could potentially be prime locations for the installation of larger solar array demonstrations. The feasibility and cost-effectiveness of utilizing solar power on campus will be an interesting area of investigation in the future, but is unlikely to be a significant source of neither power nor a short-term possibility for increasing green power use at UT.

While a potential long-term goal, it appears extremely infeasible for UT to accomplish the 15 percent renewable power goal within one year. It is impractical to achieve this 15 percent renewable energy quota either by energy reduction or increased green power purchase alone; it will be mandatory to reduce energy consumption through efficiency and conservation as well as incorporating an increase in UT's green power purchase and potentially on-site renewable

production. Through a combination of efficiency, conservation, and increased renewable purchases, it is reasonable for the University to attempt to meet this goal in the longer term. The University may evaluate feasible green power purchasing policies through those implemented at other higher education institutions; two examples of successful and far-reaching renewable energy policies are those of Duke University and New York University.

### *Climate Friendly Investing*

The University also has the option of establishing a policy that encourages shareholder investment in sustainable and greenhouse gas reducing actions (ACUPCC, p. 13, 2007). To my knowledge, the University of Tennessee has no such investment policy in place, but this is an interesting option to consider. Stanford University and Dartmouth College are two universities that currently have sustainable investment policies.

### *Waste Minimization*

Finally, the University can participate in the RecycleMania waste reduction competition and adopt at least three additional approved waste reduction measures. The University of Tennessee participated in RecycleMania's 2007 competition and placed 27 out of 77 for increasing recycling and reducing waste at the source (with a cumulative recycling rate of 28.53%), 92 out of 175 in per capita recycling rates, and 22 out of 178 for gross tonnage of recyclables collected (RecycleMania, 2007).

UT has made significant progress in other waste reduction measures on campus. For example, UT's relatively new VolPrint program discourages unlimited printing with a two cent per page charge and double-sided print settings on almost every computer in the library and in

computer labs around campus. Prior to VolPrint's implementation, students were allowed unlimited free printing. Also, UT recently implemented the "Good Sports Always Recycle" program, so that all cups sold in Neyland Stadium are now made from plastics number one or two and can be recycled in the several hundred recycling bins placed around the stadium, which has drastically increased stadium recycling rates (Facilities Services, *UT Recycles, UT Cares*, n.d.). As mentioned previously, the "UT Recycles, UT Cares" recycling program has been a tremendous leader in solid waste reduction.

UT Dining Services' Green Dining Initiative is now leading the way in UT's waste reduction efforts. In the 2006-2007 year, UT Dining developed a pilot green dining program for Presidential Courtyard and Morrill dining facilities, which if successful will mean expansion of the program to dining halls across campus. Among the initiatives implemented in this campaign, unveiled during Earth Week on April 19, 2007 are: biodegradable straws, napkins, and utensils; green cleaning products certified through Green Seal® that are environmentally benign and use small amounts of concentrated chemicals that are diluted on-site to reduce packaging; and composting food waste in the dining hall (C. Roberts, personal communication, January 12, 2007; Facilities Services, *Green Cleaning*, n.d.). Providing reusable mugs for incoming freshmen is yet another program under consideration to further reduce waste.

There are innumerable additional actions the University can take to reduce our climate impact. Because electricity is by far the largest contributor to UT's greenhouse gas emissions, conservation and efficiency measures will likely have the largest impact on reducing our carbon footprint, as well as utilizing a higher percentage of renewable energy sources. The first step to developing a plan for reducing electricity consumption is to determine where we use the most electricity and implement reduction measures accordingly. There are over 220 buildings on the

Knoxville campus, including 13 on-campus dormitories that house between 6000 and 7000 students a year; accurately monitoring electricity and steam use on a building by building basis in buildings such as dormitories is an excellent opportunity for integrating energy conservation and education.

Oberlin College has implemented a very unique program that monitors energy use in individual dormitories in real time, so that residents can see exactly how much energy they are using along with its associated environmental and economic costs. Coupled with energy competitions among dorms, this program has seen enormous success as students strive to reduce their energy consumption as much as possible by eliminating “phantom power” loads and turning off lights and computers when not in use (Oberlin College, 2007). The Oberlin College monitoring system was made possible by the Lucid Design Group through their Building Dashboard™ product, which monitors energy use in real-time so that building inhabitants can make informed and effective energy conservation choices; this group works with the institution through consultation planning, installation, and support (Lucid Design, 2007). There is a tremendous opportunity for UT to follow Oberlin’s example and consider the feasibility of installing a similar electricity monitoring system to examine resource use for both dormitory and nonresidential buildings; incorporating technology such as this in campus buildings even provides points towards LEED® certification. As well as reducing energy use, a monitoring system such as the one installed at Oberlin College is a tremendous educational tool for how personal choices affect energy consumption.

In the twenty-first century, this generation will be faced with significant universal challenges such as global climate change, scarce water resources, and the exhaustion of nonrenewable energy resources. As a university, we are faced with a unique opportunity to have

a real impact in confronting these challenges. The first step to reducing our impact on the natural environment is to understand what impact we have. This preliminary greenhouse gas emissions inventory establishes a tangible goal towards which the University can strive. The next step is to develop a realistic plan of action to achieve our goal of carbon neutrality. In bypassing temporary, short-term solutions and adhering to sustainable energy policies such as energy efficiency, conservation, and renewable energy, the University can be assertive in reducing our greenhouse gas emissions and genuinely start “Changing the Future Today.”

## References

- American Association for Sustainability in Higher Education [AASHE]. (2006). *AASHE digest 2006: A review of campus sustainability news*. Retrieved July 18, 2007, from <http://www.aashe.org/publications/digest.php>
- American Association for Sustainability in Higher Education [AASHE]. (2007) Retrieved July 22, 2007, from <http://www.aashe.org>
- American College & University Presidents Climate Commitment [ACUPCC]. (June 13, 2007). *Implementation guide: Draft for comment version 1.0* (June 13, 2007). Retrieved July 29, 2007, from <http://www.presidentsclimatecommitment.org/pdf/ACUPCCdraft11G.pdf>
- American Public Transportation Association. (2004, October 14). *KAT receives national recognition as APTA 2004 outstanding public transportation system* [Press release]. Retrieved August 4, 2007, from [http://www.apta.com/media/releases/awards\\_04/kat.cfm](http://www.apta.com/media/releases/awards_04/kat.cfm)
- Buttazzoni, M., Campbell, K., Carter, B., Dunn, S., Eyler, T., Kwong Liew, W., et al. (October 2005). *Inventory and analysis of Yale University's greenhouse gas emissions*. Hartford, CT: Yale University, Yale Climate Initiative Team. Retrieved July 26, 2007, from [http://environment.yale.edu/957/inventory\\_and\\_analysis\\_of\\_yale\\_universitys/](http://environment.yale.edu/957/inventory_and_analysis_of_yale_universitys/)
- Clean Air-Cool Planet. (2006). *Campus Carbon Calculator (Version 5.0)* [Computer software and manual]. Retrieved March 23, 2007, from <http://www.cleanair-coolplanet.org/toolkit/>
- College of Charleston (2001). *College of Charleston Greenhouse Gas Audit*. Charleston, SC. Retrieved August 7, 2007, from <http://www.cofc.edu/sustainability/CollegeofCharlestonGHG.pdf>

- Committee on the Campus Environment (CCE) (2004, April 22). *The Environmental Policy of the University of Tennessee, Knoxville*. Retrieved July 29, 2007, from the University of Tennessee Committee on the Campus Environment Web site:  
<http://www.cce.utk.edu/policy.htm>
- Dautremont-Smith, J., Hummel, S., & Walton, J. (2007). *AASHE digest 2006: A review of campus sustainability news*. Retrieved August 2, 2007, from <http://www.aashe.org>
- Facilities Services (n.d.). *Green cleaning*. University of Tennessee, Knoxville. Retrieved August 6, 2007, from <http://www.pp.utk.edu/GreenCleaning/default.htm>
- Facilities Services (n.d.). *Steam plant*. University of Tennessee, Knoxville. Retrieved August 6, 2007, from <http://www.pp.utk.edu/Shops/Steam/default.htm>
- Facilities Services (n.d.). *UT recycles, UT cares: Waste reduction plan results*. University of Tennessee, Knoxville. Retrieved August 4, 2007, from  
<http://www.pp.utk.edu/Recycle/recycleTotals.htm>
- Harvard University (2006). *Harvard Green Campus Initiative*. Retrieved August 7, 2007, from  
<http://www.greencampus.harvard.edu/ggi/index.php>
- International Panel on Climate Change (n.d.). Retrieved August 4, 2007, from [www.ipcc.ch](http://www.ipcc.ch)
- Knoxville Area Transit (August 2007). Retrieved July 28, 2007, from  
<http://www.ci.knoxville.tn.us/kat/>
- Knoxville Regional Transportation Planning Organization. (n.d.). *Smart Trips*. Retrieved July 28, 2007 from <http://smartrtrips.knoxtrans.org>

- Knoxville Regional Transportation Planning Organization. (2006, August 31). *Smart Trips wins second national award* [Press release]. Retrieved August 4, 2007, from [http://smartrtrips.knoxtrans.org/press/ut\\_bwc\\_2005.pdf](http://smartrtrips.knoxtrans.org/press/ut_bwc_2005.pdf)
- Ledford, T. (2007). "Annual Usage Metrics" [Raw data file]. Knoxville, TN.
- Ledford, T. (2007). "Steam Plant" [Raw data file]. Knoxville, TN.
- Lucid Design Group. (2007). *Building dashboard*. Retrieved August 8, 2007, from <http://www.luciddesigngroup.com/>
- Marlino, K. (2007). *UT square footage* [Data file]. Knoxville, TN
- Oberlin College. (2007). *Campus energy monitoring system*. Retrieved August 8, 2007, from <http://www.oberlin.edu/dormenergy/>
- Office of Institutional Research (1990-1996). *Fact book*. Knoxville: University of Tennessee.
- Office of Institutional Research. (1997-2006). *Fact book*. Knoxville: University of Tennessee. Retrieved April 24, 2007 from <http://oira.tennessee.edu/stats.html>
- Office of the President. (1990-2007). *Budget document*. Knoxville: University of Tennessee.
- Southern Energy Network (2006, June 30). *Tennessee Board of Regents approves student green power & energy efficiency fee for MTSU & TTU* [Press release]. Retrieved August 4, 2007, from <http://www.climateaction.net/tbr/>.
- RecycleMania (2007). Retrieved August 5, 2007 from <http://www.recyclemaniacs.org>
- Smart Trips (2004). *UT travel behavior survey* [Data file]. Knoxville, TN.
- United States Department of Energy, Energy Information Administration. Retrieved July 25, 2007, from [www.eia.doe.gov](http://www.eia.doe.gov)
- United States Environmental Protection Agency. (n.d.). *Energy Star Program*. Retrieved August 4, 2007, from <http://www.energystar.gov>

- United States Environmental Protection Agency. (November 2004). *Unit conversions, emissions factors, and other reference data*. Retrieved March 23, 2007, from <http://www.epa.gov/appdstar/pdf/brochure.pdf>
- United States Environmental Protection Agency. (August 2006). *Waste Reduction Model (WARM) (Version 8)*. Retrieved August 8, 2007, from [http://www.epa.gov/climatechange/wycd/waste/calculators/Warm\\_Form.html](http://www.epa.gov/climatechange/wycd/waste/calculators/Warm_Form.html)
- United States Green Building Council [USGBC]. *Leadership in Energy and Environmental Design*. Retrieved February 9, 2007, from [www.usgbc.org](http://www.usgbc.org)
- University Leaders for a Sustainable Future [ULSF]. (2001). *Talloires declaration*. Retrieved July 29, 2007, from [http://www.ulsf.org/programs\\_talloires.html](http://www.ulsf.org/programs_talloires.html)
- University Leaders for a Sustainable Future. (2007). *Talloires Declaration institutional signatory list as of July 31, 2007*. Retrieved July 29, 2007, from [http://www.ulsf.org/programs\\_talloires\\_signatories.html](http://www.ulsf.org/programs_talloires_signatories.html)
- University of South Carolina. (2006). *University housing*. Retrieved August 3, 2007, from <http://www.housing.sc.edu/sustainmain.asp>
- University of Tennessee (2007). *Ground broken on new engineering building* [Press Release]. Retrieved August 1, 2007, from <http://www.engr.utk.edu/news/releases/groundbreak.html>
- UTK Student Environmental Initiatives Fee Priority List (April 4, 2008)*. Presented at the Student Environmental Initiatives Fee Oversight Committee Meeting, Knoxville, TN.
- Zorn, L. (2007). *KnoxEmployees2002-2006* [Data file]. Knoxville, TN.
- Zorn, L. (2007). *Summer Enrollment 1990-2006* [Data file]. Knoxville, TN.

## Appendix A: Data

Table A1

*Basic Population Data*

<b>Fiscal Year</b>	<b>Total Student Enrollment</b>	<b>Full Time Students</b>	<b>Part Time Students</b>	<b>On-campus residency*</b>
1990-1991	25,414	19,404	6,010	6,776
1991-1992	25,598	19,638	5,960	6,551
1992-1993	25,998	19,885	6,113	6,530
1993-1994	25,890	19,385	6,505	6,331
1994-1995	25,412	19,534	5,878	6,177
1995-1996	25,251	19,364	5,887	6,363
1996-1997	25,086	19,686	5,400	6,657
1997-1998	25,039	20,057	4,982	6,765
1998-1999	25,612	20,719	4,893	6,788
1999-2000	25,981	21,645	4,336	6,869
2000-2001	25,474	21,427	4,047	6,667
2001-2002	26,033	21,940	4,093	6,730
2002-2003	25,933	21,863	4,070	6,310
2003-2004	25,215	21,353	3,862	6,075
2004-2005	25,632	21,947	3,685	6,574
2005-2006	26,197	22,579	3,618	6,703
2006-2007	26,476	22,937	3,539	6,807

\*Does not include University-owned married or graduate student housing, which is generally located off-campus.

Table A2

*Electricity Emissions in Metric Tons of Carbon Dioxide Equivalent (MTCDE)*

<b>Fiscal Year</b>	<b>Total MTCDE</b>	<b>MTCDE per student</b>
1990	105,603	8.69
1991	105,100	8.72
1992	115,974	9.39
1993	128,357	10.12
1994	131,212	10.27
1995	138,302	10.77
1996	133,952	10.21
1997	143,219	11.14
1998	148,275	10.81
1999	149,846	11.03
2000	154,491	11.54
2001	151,529	10.37
2002	159,429	11.18
2003	151,795	10.95
2004	167,344	11.63
2005	169,274	11.21
2006	166,506	10.83

Table A3

*Percentage of Commuters Using Different Modes of Transportation*

<b>Mode of Transportation</b>	<b>Students</b>	<b>Faculty</b>	<b>Staff</b>
Drive Alone	64.4	81.1	83.3
Carpool/Vanpool	10.1	8.2	11.3
Bus	9.2	3.6	2.8
Bike	3.1	4.0	0.9
Walk	13.2	3.0	1.7

Figure A4  
*Total and Per Capita Electricity Use, 1990-2006*

<b>Year</b>	<b>Purchased Electricity kWh</b>	<b>Electricity Use/Student</b>
1990	155,371,175	6113.606
1991	154,631,635	6040.77
1992	170,630,171	6563.204
1993	188,847,792	7294.237
1994	193,048,731	7596.755
1995	203,479,827	8058.288
1996	197,080,382	7856.19
1997	210,714,106	8415.436
1998	218,153,153	8517.615
1999	220,464,333	8485.598
2000	227,298,332	8922.758
2001	222,941,427	8563.801
2002	234,563,915	9044.997
2003	223,331,935	8857.106
2004	246,208,960	9605.531
2005	249,049,225	9506.784
2006	244,975,745	9252.748

Source: Ledford, T, "Steam Plant" [Raw data file].

## Appendix B: List of contacts

## Section 1: Institutional Data

- A. Budget – Office of Vice Chancellor of Finance and Administration, Denise Barlow
  - a. Contact: Karen Valero
- B. Population - Office of Institutional Research – Fact Book
  - a. Contact: Lynn Zorn
- C. Physical Size – Strategic Planning and Operations Office
  - a. Contact: Kim Marlino

## Section 2: Electricity

- A. Terry Ledford, Senior Project Manager for Facilities Services

## Section 3: Transportation

- A. University Fleet: Michael Moneymaker, Director of Transportation Services
- B. Commuter Travel: Kelley Segars, Knoxville Smart Trips
- C. Air Travel

## Section 4: Agriculture

- A. Fertilizer Application: Jason Cottrell, John Hodges (Research Director for the East Tennessee Research and Education Center)
- B. Animal Agriculture (Veterinary Medicine): Robert Holland, head of Large Animal Clinical Sciences

## Section 5: Solid Waste

- A. Sarah Surak, Facilities Services Public Relations Manager
- B. Jay Price, Facilities Services Environmental Coordinator

## Section 6: Refrigeration and other Chemicals

- A. Terry Ledford

## Section 7: Offsets

- A. RECs- Terry Ledford (green power purchase)
- B. Composting – Sarah Surak

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