VANDERBILT UNIVERSITY

Inventory of Greenhouse Gas Emissions
2005-2009

VANDERBILT UNIVERSITY MEDICAL CENTER

VANDERBILT UNIVERSITY

SustainVU
Growing Responsibly

Cover photo by Robert Wheaton

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The Sustainability and Environmental Management Office (SEMO) is a collaborative venture between Vanderbilt Environmental Health and Safety and Vanderbilt University's Plant Operations Department. SEMO's mission is to initiate, promote, coordinate, evaluate and encourage environmental management and sustainability initiatives that improve Vanderbilt's impact on the community and environment.

The Plant Operations Department provides facilities support for all construction, renovation and routine maintenance of University Central space and facilities; housekeeping services for approximately 5.8 million square feet of academic, administrative, residential, and recreational space; grounds care for 330 acres that are a registered arboretum; turf care for athletic fields; and utilities for University Central and the Medical Center.

Campus Planning and Construction (CPC) aims to present a physical environment that meets the programmatic requirements of its customer base while visually expressing the quality to which Vanderbilt University aspires. Functions closely related to the delivery of new facilities are performed by the Facilities Information Services unit within CPC. This group addresses the inventory and management of Vanderbilt's construction document library, GIS mapping and documentation of all utilities, and tracking of floor plans for the Space Inventory and Accounting processes.

The Division of Public Affairs serves as the institution-wide hub for communications, marketing and public policy initiatives. Whether developing unique relationships with and communicating to Vanderbilt's vast array of external and internal constituencies, promoting government and community initiatives, or creating a broader, deeper and more complete understanding of Vanderbilt, each and every activity of the division supports the University's academic missions of teaching, research, service and patient care.

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VANDERBILT UNIVERSITY INVENTORY OF GREENHOUSE GAS EMISSIONS 2005-2009

EXECUTIVE SUMMARY

This report is a summary of greenhouse gas (GHG) emissions for Vanderbilt University for the calendar years 2005, 2006, 2007, 2008, and 2009. This GHG emissions inventory is intended to provide trending information for the development and implementation of future GHG emission reduction strategies. It is not intended to draw comparisons with other institutions. The GHG inventory was conducted by Vanderbilt's Sustainability and Environmental Management Office (SEMO).

Background

On February 23, 2009, Vanderbilt announced that an initial GHG inventory, or carbon footprint, would be developed. Vanderbilt emits GHGs through its daily operations, such as energy consumption in campus buildings, burning of coal and natural gas at the on-campus co-generation power plant, the use of fuel to power Vanderbilt's university-owned vehicles, and the disposal of waste generated by Vanderbilt. The initial baseline inventory capturing average annual GHG emissions for calendar years 2005 to 2007 was released in conjunction with the publication of the University's Environmental Commitment Statement on April 21, 2009[1]. This inventory was developed using methodology and carbon calculators commonly used at that time.

On October 30, 2009, the U.S. Environmental Protection Agency (EPA) issued the *Mandatory Greenhouse Gas Reporting Rule* [40 CFR Part 98], which requires annual reporting of GHG emissions from large sources in the United States. Vanderbilt, along with many other institutions of higher education, will be required to report annual emissions to the EPA for the 2010 calendar year[2]. Under the EPA's GHG Reporting Rule, the scope of stationary sources and some emissions factors vary from those utilized in Vanderbilt's initial baseline GHG inventory. Therefore, in an effort

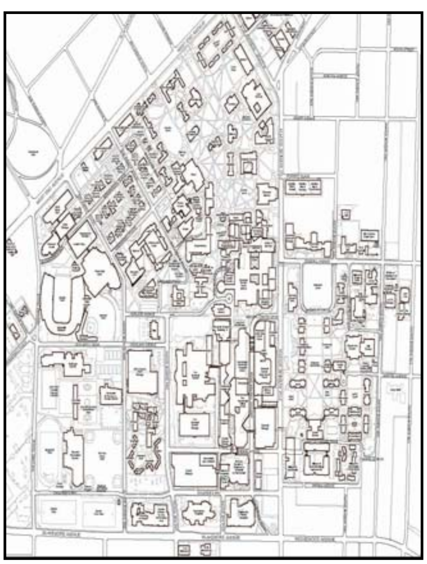
[1] Vanderbilt University's Baseline Greenhouse Gas Inventory Report is available at http://www.vanderbilt.edu/sustainvu or may be requested by emailing SustainVU@vanderbilt.edu.
[2] 30 October 2009. "40 CFR Parts 86, 87, 89 et al. Mandatory Reporting of Greenhouse Gases; Final Rule." U.S. Environmental Protection Agency. Available http://www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

to use a single, consistent methodology for calculating and reporting GHG emissions for the university, emissions from calendar years 2005-2007 (those years included in the original baseline inventory) have been recalculated utilizing the EPA's scope and emissions factors for relevant stationary sources. Emissions from sources not covered by the EPA's GHG Reporting Rule were calculated using emissions factors from the Clean Air – Cool Plant Campus Carbon Calculator™ or emission factors developed for specific on-campus activities. The same methodology was used to determine GHG emissions for the calendar years 2008 and 2009.

This report will establish Vanderbilt's annual GHG emissions from 2005 to 2009 so that the Vanderbilt community can better understand its own unique impact on the environment and determine the most effective improvement strategies to implement in the future. This report replaces the original baseline inventory report published April 21, 2009.

Process & Methodology

The Vanderbilt Sustainability and Environmental Management Office (SEMO), in collaboration with the Plant Operations Department, Campus Planning and Construction, and the Division of Public Affairs, began the planning process for conducting Vanderbilt's GHG emissions baseline inventory at the request of Vanderbilt's Faculty Senate in December 2008. This planning group determined the physical (organizational) boundary of what would be included in the GHG inventory, along with the identification of GHG emission sources at Vanderbilt and the determination of the time period for collecting data retroactively to 2005.



The physical boundary for Vanderbilt University's GHG inventory includes the "core" 330 acres of Vanderbilt University property and encompasses academic, residential, research, and patient care buildings located within this area. Off-site buildings, such as satellite medical clinics and the One Hundred Oaks outpatient medical clinics and operations, are not included in this inventory. By including Vanderbilt's patient care facilities (which are typically excluded by other universities in their GHG emissions calculations), Vanderbilt's GHG inventory is unique and largely comprehensive. The core Vanderbilt campus contains over 230 buildings, comprising over 17 million gross square feet of space[3].

Campus operations that produce GHGs and are included in this inventory are: electricity and steam production at the on-campus, co-generation power plant; electricity purchased from Nashville Electric Service (NES); university-owned vehicle fuel use; refrigerant releases; anesthetic gas use; fuel used in vehicles owned by Vanderbilt University faculty and staff commuting to work; air travel paid for by the university; and disposal of waste generated by Vanderbilt.

Under the EPA's GHG Reporting Rule, facilities which emit 25,000 or more metric tons carbon dioxide equivalent ($MTCO_2E$) per year must submit annual emissions reports. At Vanderbilt, this includes coal and natural gas use at the on-campus co-generation power plant and natural gas use by boilers in individual campus facilities. Therefore, emissions from these sources are calculated using emissions factors established by the EPA. For all additional emissions from university activities that are not required to be reported to the EPA, a standardized, publicly available GHG calculator/spreadsheet for universities called the Clean Air – Cool Plant Campus Calculator™ was utilized to store collected data and convert our university-specific data into a common GHG emission unit using established emissions factors for specific activities (i.e., gallons of fuel, commuter miles, tons of waste disposed, etc.). This calculator is the most commonly used among U.S. colleges and universities. Results were compiled for academic and research operations, including medical research functions, and separately for patient care operations, with integrated totals also reported. Upon its completion, this GHG inventory report was presented to a committee of reviewers prior to publication.

Findings

Vanderbilt University's total GHG emissions for calendar years 2005 to 2009 are presented in Table ES.1 and Figure ES.1. Total GHG emissions decreased by 7.8% from 2008 to 2009 and by 2.4% overall from 2005 to 2009.

[3] February 2010. ReVU: Quick Facts about Vanderbilt. Available http://www.vanderbilt.edu/about/facts/.

Calendar Year	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Total GHGs Emitted by VU ($MTCO_2E$)
2005	296,465	179,260	475,725
2006	295,825	182,548	478,374
2007	308,604	189,958	498,562
2008	313,341	189,985	503,327
2009	288,343	175,896	464,240

Table ES.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2009.

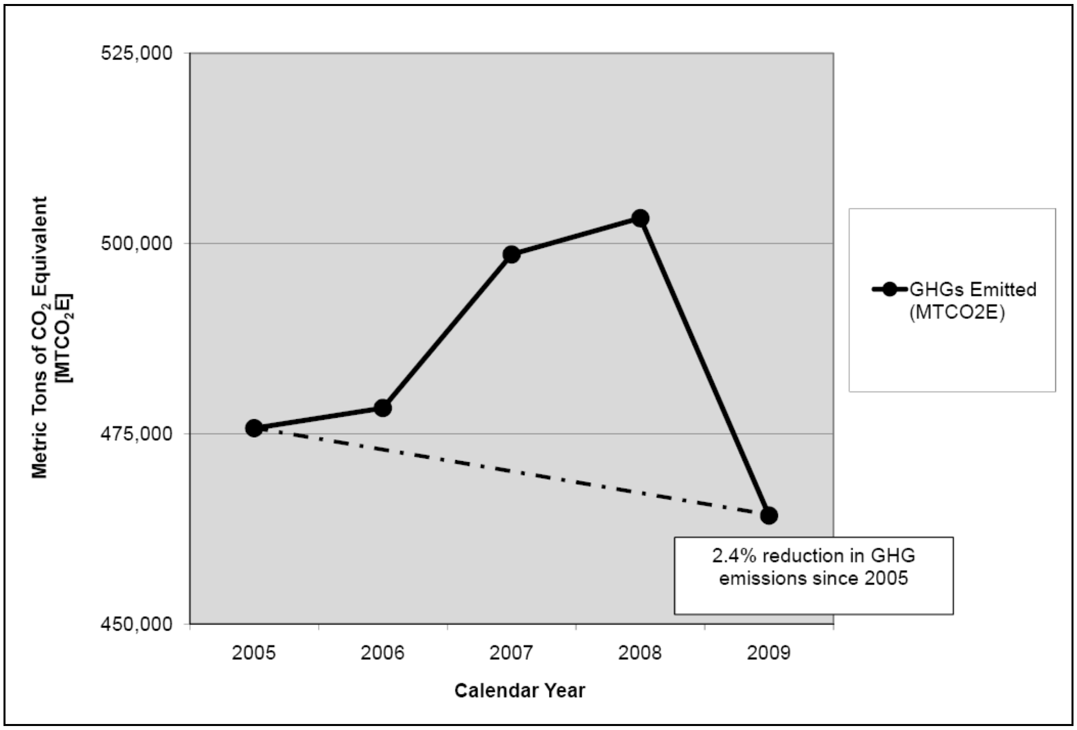


Figure ES.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2009.

Emissions data from the five year period included in this report indicates that each year academic and research areas accounted for approximately 62% of total GHG emissions while patient care areas accounted for approximately 38% of total GHG emissions, as is indicated in Figure ES.2 below.

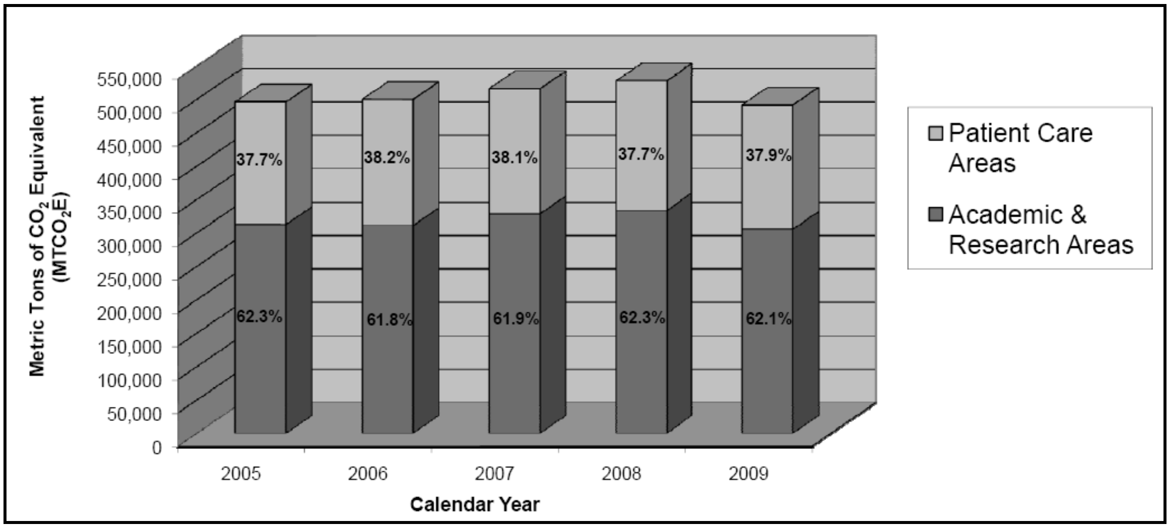


Figure ES.2. Total Vanderbilt GHG Emissions, Calendar Years 2005-2009.

Each year, the inventory results further demonstrate that purchased electricity, coal use at the on-campus co-generation power plant, faculty and staff commuting, and natural gas use at the on-campus co-generation power plant were the most substantial sources of GHG emissions, accounting for 94-96% of annual GHG emissions from Vanderbilt University, as is illustrated by emissions sources for calendar year 2009 in Figure ES.3. For more detail and emission source information for years preceding 2009, please reference Tables C.2, D.2, E.2, and F.2 and Figures C.1, D.1, E.1, and F.1 in the appendix. As the 2009 total GHG emissions reductions illustrate, reducing energy consumption and supporting alternative transportation methods have the most potential to reduce GHG emissions at Vanderbilt.

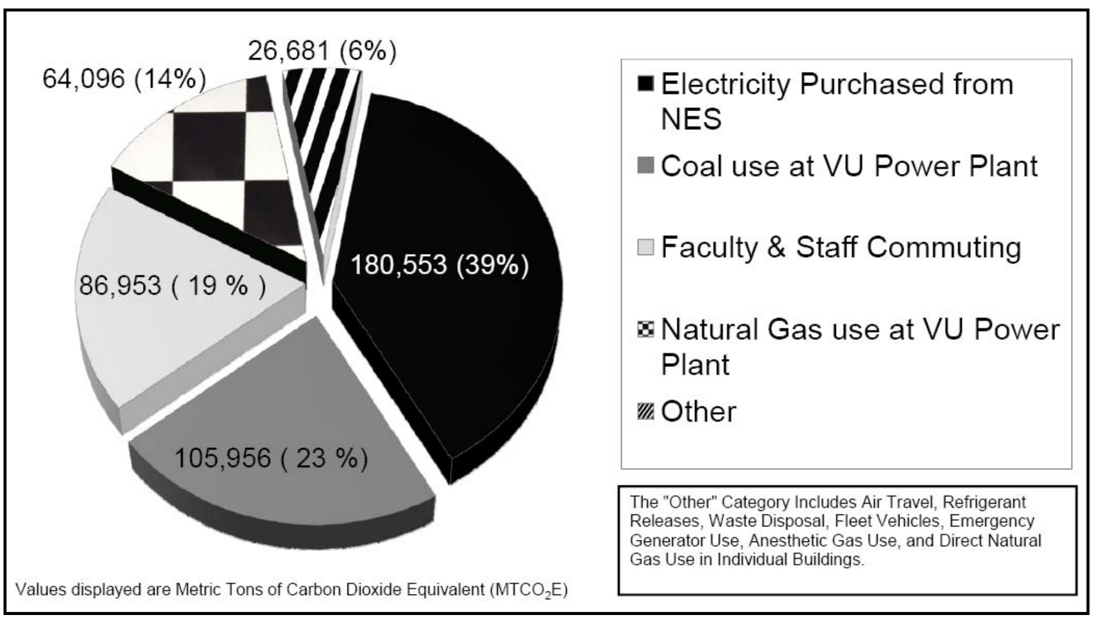


Figure ES.3. GHG Emissions Sources, Calendar Year 2009.

Interpreting Vanderbilt's Results

Only a very small portion of universities nationwide have completed GHG inventory reports and made them publicly available at this time. Thus, Vanderbilt has acted proactively by taking this important step. Additionally, most university GHG inventory reports do not include research and/or patient care activity, making Vanderbilt's report more comprehensive than most and more comprehensive than what is required by the EPA.

While reports exist for a small number of Vanderbilt's peer institutions, drawing comparisons between universities is difficult. Each school has its own defining characteristics and mix of variables even within the shared, primary emissions attributes. Thus, the only useful standard to which Vanderbilt can accurately compare its GHG emissions in the years to come is its own emissions, utilizing consistent interpretations as presented in this initial report. Emphasis has been placed throughout this report in trending and evaluating the five years of Vanderbilt data available instead of comparisons to other institutions

The authors recognize the tendency to place Vanderbilt's results in context with those of other universities, even though this would be misleading. If comparisons are made, then several factors should be considered when comparing the university's GHG emissions to others:

- 90% of Vanderbilt undergraduate students live in on-campus residence houses, which are supplied using centralized utilities such as chilled water, steam heat, and electricity. Colleges and universities with larger commuter populations and/or off-campus housing would have substantially smaller Scope 1 emissions (on-site sources) and larger Scope 3 emissions (indirect sources).
- Vanderbilt was awarded $520 million[4] in 2009 to conduct scientific and medical research, with a majority of the research occurring in laboratories on campus. Vanderbilt University has over 800 research laboratories, which are significant consumers of energy through the operation of lab equipment.
- The Vanderbilt University Medical Center (VUMC) provides regional health care 24 hours per day, 7 days per week, 365 days per year. Very few universities have on-campus patient care that matches the size and extent of operations of VUMC.

[4] According to 2009 research information found in ReVU: Quick Facts about Vanderbilt. Available http://www.vanderbilt.edu/about/facts/.

When compared to other major research institutions, Vanderbilt's GHG emissions compare quite reasonably. Table ES.2 and Figure ES.4 below illustrate Vanderbilt's normalized emissions in relation to several other universities with large amounts of on-campus research.

University	Total Emissions ($MTCO_2E$)	Emissions per 1,000 Square Feet	Emissions per Student	Emissions per Person on Campus	Emissions per $1,000 Research Awarded
University of Michigan[5]	592,000	19.1	14.8	7.6	0.58
Duke University[6]	433,961	31.2	34.1	9.5	0.79
Emory University[7]	419,231	46.6	25.4	20.4	1.19
Washington University – St. Louis[8]	409,500	28.0	29.8	24.2	0.72
University of Pennsylvania[9]	355,829	29.9	18.0	8.8	0.42
Vanderbilt University – Academic & Research Areas Only[10]	288,343	31.3	23.8	12.7	0.55

Table ES.2. Comparison of 2009 VU GHG Emissions with Other Universities.

[5] GHG emissions, GSF, and student, faculty, and staff populations for FY 2009 retrieved from http://www.oseh.umich.edu/pdf/09_report.pdf. 2008-2009 research expenditures from http://mmd.umich.edu/forum/michigan.php.

[6] GHG emissions and GHG emissions per 1,000 GSF for 2007 retrieved from http://sustainability.duke.edu/climate_action/inventory.php. Student population from 2007 retrieved from http://library.duke.edu/uarchives/history/duke_statistics.html. 2009 employment data retrieved from http://www.dukenews.duke.edu/resources/quickfacts.html was utilized because 2007 employment data could not be located. Research awards for FY 2007 retrieved from Duke's 2007 financial report at https://finance.duke.edu/resources/docs/financial_reports08.pdf.

[7] GHG emissions, GSF, and student, faculty, and staff populations for FY 2007 retrieved from http://sustainability.emory.edu/uploads/press/2010/03/2010031214250142/GHG_Executive_Summary.pdf. Research awards for FY 2007 retrieved from Emory's 2007 Annual Report at http://www.emory.edu/president/documents/annualreport.2007.pdf.

[8] GHG emissions, GHG emissions per 1,000 GSF, and GHG emissions per person for FY 2009 retrieved from http://www.wustl.edu/initiatives/sustain/assets/GHGEmissions.pdf. Student population for 2009 retrieved from http://www.wustl.edu/about/facts/students/index.html. Research awards for 2008-2009 retrieved from http://www.wustl.edu/about/facts/rankings/index.html.

[9] GHG emissions, GSF, and student, faculty, and staff populations for 2009 from ACUPCC's website at http://acupcc.aashe.org/ghg/258/. Sponsored projects as of December 2009 retrieved from http://www.upenn.edu/about/facts.php.

[10] GHG emissions for CY 2009 from academic and research areas only. 2009 research dollars awarded.

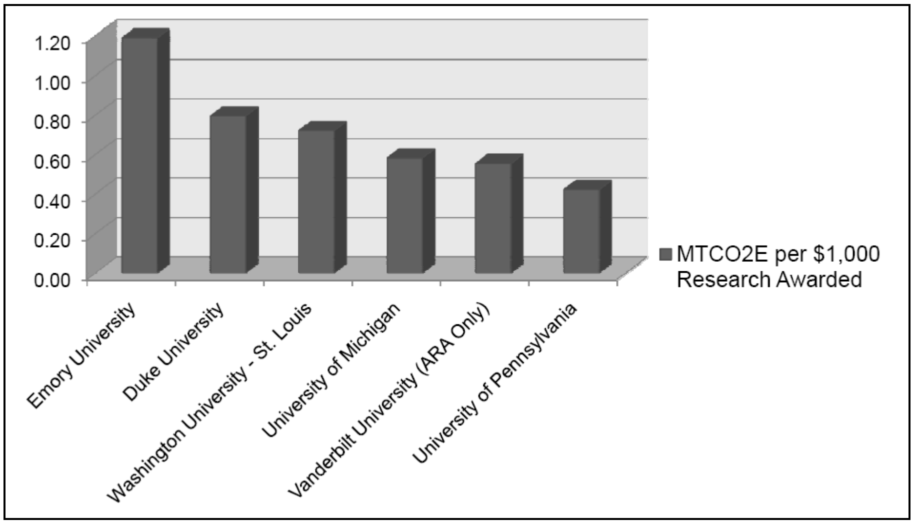


Figure ES.4. Comparison of VU GHG Emissions with Other Universities, by Research Dollars Awarded.

Future Plans

This inventory provides campus stakeholders with a consistent means of calculating annual GHG emissions and sufficiently detailed information to make informed decisions to determine reduction strategies and compare future changes in GHG emissions on campus. Annual emissions inventories will be conducted in the future to measure progress, which will be made publicly available the SustainVU website[11].

In the interim, each member of the Vanderbilt community should take part in reducing GHG emissions at Vanderbilt by:

- Turning off lights, computer equipment, and electronics when leaving a room;
- If you have control of a thermostat, adjusting it to a reasonable temperature (68-70°F in the winter and 75°F in the summer) and dress in layers to moderate your own personal temperature;
- Wasting less by reducing consumption and recycling;
- Walking, biking, carpooling, or taking mass transit to and from work;
- Reducing unnecessary vehicle idling.

More information on ways the Vanderbilt community can save energy can be found on the ThinkOne website[12].

[11] The SustainVU website may be accessed at http://www.vanderbilt.edu/sustainvu.
[12] The ThinkOne website may be accessed at http://www.vanderbilt.edu/sustainvu/thinkone.

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I. BACKGROUND

Vanderbilt University

Vanderbilt University, founded in 1873, is a private, research higher education institution offering undergraduate, graduate and professional degrees to over 12,000 full and part-time students[1]. Comprised of 10 schools and a world-class medical center, Vanderbilt offers students and researchers the opportunity to create an environment that enables them to meet their academic and professional goals. The university is consistently rated as one of the country's top 20 universities with several programs ranking in the top 10. As the largest private employer in Middle Tennessee and the second largest private employer in the state, Vanderbilt University currently has more than 3,000 full-time faculty and a staff of over 19,500[2]. The campus, located near downtown Nashville, spans approximately 330 acres and contains 238 buildings. More than 200 tree species exist on Vanderbilt's grounds, leading to the school's recognition as an arboretum since 1988.

Inventory Development

On February 23, 2009, Vanderbilt University announced that it would calculate its carbon footprint for the first time in conjunction with the creation of an Environmental Commitment Statement. Several campus groups, including the Faculty Senate as well as a number of student organizations and faculty research groups, had expressed interest in measuring Vanderbilt's greenhouse gas (GHG) emissions and enacting a plan for reduction. The Mayor's Green Ribbon Committee also released in early 2009 the results of a similar inventory for Metro Nashville/Davidson County. In December 2008, at the request of the Faculty Senate, the Sustainability and Environmental Management Office (SEMO), the Plant Operations Department, Campus Planning and Construction, and the Division of Public Affairs began gathering information necessary to conduct an initial GHG emissions baseline inventory.

Vanderbilt emits GHGs through its daily operations, such as energy consumption in campus buildings, burning of coal and natural gas at the on-campus co-generation power plant, the use of fuel to power Vanderbilt's university-owned vehicles, and the management of waste generated by Vanderbilt. The initial baseline inventory capturing average annual GHG emissions for calendar years 2005 to 2007 was released in conjunction with the publication of the University's Environmental commitment Statement on April 21, 2009. This inventory was developed using methodology and carbon calculators commonly used at that time.

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[1] According to 2009-2010 enrollment data found in ReVU: Quick Facts about Vanderbilt. Available http://www.vanderbilt.edu/facts.html.

[2] According to 2008-2009 employment information found in ReVU: Quick Facts about Vanderbilt. Available http://www.vanderbilt.edu/facts.html

On October 30, 2009, the EPA issued the *Mandatory Greenhouse Gas Reporting Rule* [40 CFR Part 98], requiring annual reporting of GHG emissions from large sources in the United States who emit more than 25,000 metric tons of carbon dioxide equivalent ($MTCO_2E$) per year. Vanderbilt is subject to this reporting rule because the use of coal and natural gas at the on-campus, co-generation power plant for the production of steam and electricity for campus emits greater than 25,000 $MTCO_2E$ annually. The university will submit its first report covering the calendar year 2010 to the EPA in 2011. Under the EPA's GHG Reporting Rule, the scope and emissions factors of stationary sources vary from those utilized in Vanderbilt's initial baseline GHG inventory. In order to create a single, consistent methodology for calculating and reporting GHG emissions for the university, emissions from calendar years 2005-2007 (those years included in the original baseline inventory) have been recalculated utilizing the EPA's scope and emissions factors for relevant stationary sources. Emissions from all sources not covered by the GHG reporting rule were calculated using methodology from the Clean Air – Cool Plant Campus Carbon Calculator™ or emission factors developed for specific on-campus activities. The same methodology was used to determine GHG emissions for the calendar years 2008 and 2009.

This report will establish Vanderbilt's annual GHG emissions from 2005 to 2009 so that the Vanderbilt community can better understand its own unique impact on the environment and determine the most effective improvement strategies to implement in the future. This report replaces the original baseline inventory report published April 21, 2009.

Greenhouse Gases: Impact and Importance

A carbon footprint is a standard that people and organizations use to quantify the impact they have on the environment, particularly as their behaviors relate to climate change concerns. The six GHGs emitted into the atmosphere that comprise the majority of the "carbon footprint" are the following:

- Carbon Dioxide (CO_2)
- Methane (CH_4)
- Nitrous Oxide (N_2O),
- Hydroflurocarbons (HFCs)
- Perflurocarbons (PFCs)
- Sulfur hexafluoride (SF_6)

Once the amount of emissions of each gas is determined, it is converted to a standard unit of measure, or carbon dioxide equivalents (CO_2E). The sum of all CO_2E emitted by that person or organization is the carbon footprint, usually reported in metric tons as $MTCO_2E$.

Examples of how greenhouse gases are produced:

Carbon Dioxide
Naturally produced: During the carbon cycle (see Figure 1.1)
Human generated: Burning fossil fuels (oil, coal, natural gas)
Methane
Naturally produced: wetlands, oceans and wildfires
Human generated: landfill decay, natural gas and coal systems, raising lifestock and coal mining
Nitrous Oxide
Naturally produced: during bacteria breakdown of nitrogen in the soil and oceans
Human generated: burning fossil fuels, fertilizer use, anesthetic gas, motor racing oxidizer
Hydrofluorocarbons
Human generated: used in refrigeration and fire suppression
Perfluorocarbons
Human generated: primarily used in refrigeration units, byproduct of aluminum production, used medically in eye surgeries and MRIs
Sulfur Hexafluoride
Human generated: used in electric system circuit breakers and in ultrasound imaging

Figures 1.1 and 1.2 illustrate some of the many ways that GHGs interact with the environment.

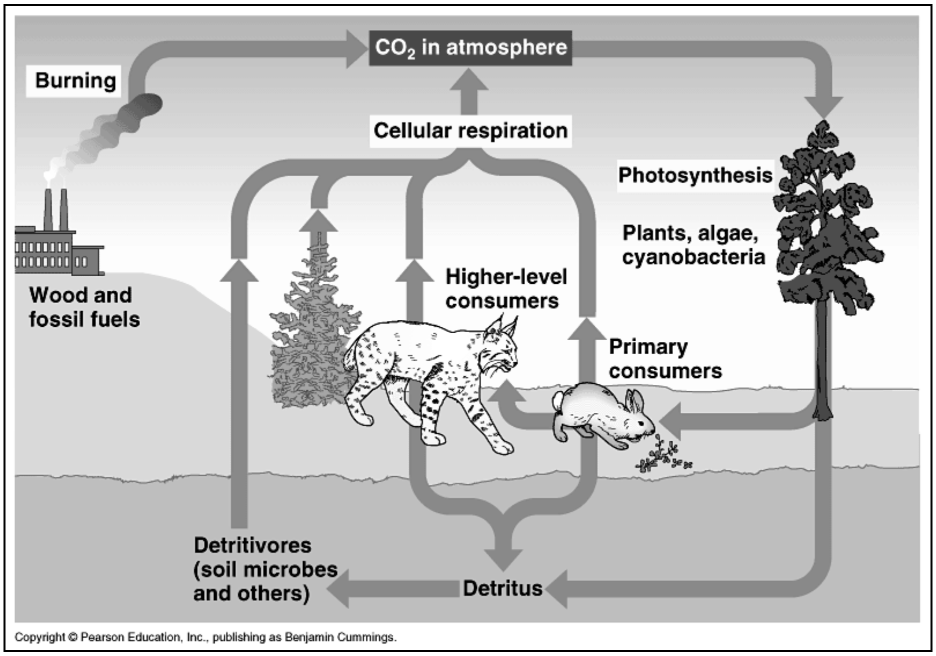

Figure 1.1. The Carbon Cycle[3].

[3] Retrieved 1 September 2010. "The Carbon Cycle." Available http://kentsimmons.uwinnipeg.ca/16cm05/1116/16ecosys.htm.

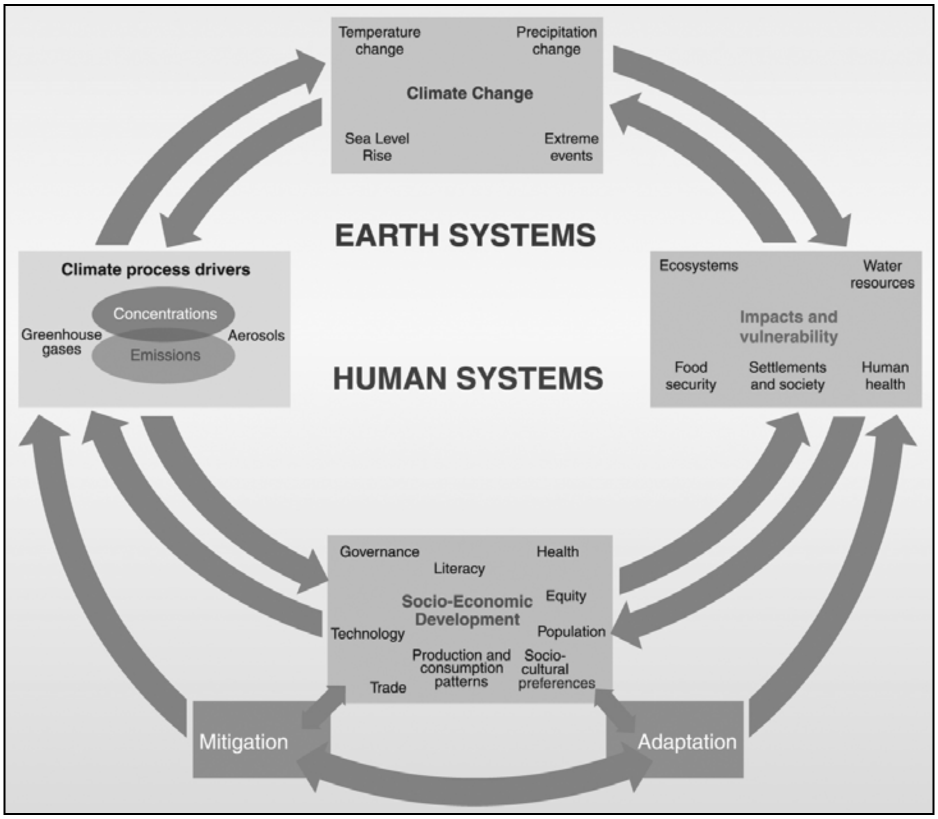

Figure 1.2. Climate Change Drivers, Impacts and Responses[4]

GHGs, once released, trap heat in the atmosphere, acting like a gas blanket. As the concentrations of these gases increase, the earth's temperature could potentially climb higher than previous levels and wind and precipitation patterns could be modified. This phenomenon, termed "climate change," can be identified by shifts in climate properties or a location's characteristics that last for an extended period of time. As a result, the earth, its systems and inhabitants have to adapt to altered climate conditions. The terms "climate change" and "global warming" are often used interchangeably; however, "climate change" has become the preferred phrase that more accurately communicates that there are variations in addition to rising temperatures[5].

Slight temperature changes in one location can cause more extreme conditions all over the world that impact not only humans, but plants and animals as well. Consider the following:

- The frequency of catastrophic natural disasters, such as hurricanes, droughts, floods and wildfires, has increased in recent years[6].

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[4] Retrieved Mar. 2, 2009. "Figure I-1." *AR4 Synthesis Report*. (2007). Intergovernmental Panel on Climate Change. Available http://www.ipcc.ch/publications_and_data/ar4/syr/en/mainssyr-introduction.html.

[5] Feb. 18, 2009. "Climate Change." U.S. Environmental Protection Agency. Available http://www.epa.gov/climatechange/basicinfo.html.

[6] van Aalst, M.K. (2006). The impacts of climate change on the risk of natural disasters. *Disasters 30(1)*, 5-18.

- Spring events, such as germination, flowering, migration and reproduction, are occurring an average of 10 days earlier than they were about 30 years ago, and plants and animals requiring colder climates for survival are traveling north[7].
- It has been estimated that at least 279 plant and animal species have responded to climate change by altering their migration and/or reproduction patterns[8].

According to the Intergovernmental Panel on Climate Change (IPCC), a group of more than 700 scientists from various disciplines around the world, much of the observed increase in average temperatures since the 1950s is likely attributable to an increase in GHG concentrations. In addition, GHG emissions from human activities increased 70 percent from 1970-2004, leading the IPCC to conclude with 95 percent certainty that human activities have largely contributed to global climate change.

Vanderbilt Operations Resulting in Greenhouse Gas Emissions

Vanderbilt emits many of these GHGs through its daily operations, including energy consumption in campus buildings, burning of coal and natural gas at the power plant, use of fuel in university-owned vehicles, and the management of waste generated on campus.

Vanderbilt produces (on campus) 19% of the electricity and all of the steam and chilled water consumed by Vanderbilt's buildings. These utilities are produced by a co-generation combined heat and power (CHP) plant constructed in the center of campus in 1927. (Vanderbilt's original CHP plant was constructed in 1888 at another location on campus.) This plant uses two fuels, coal and natural gas, to produce electricity, steam heat, and chilled water for cooling. This type of power plant is highly efficient because of the flexibility of the fuel system, the variety of utilities produced, and the proximity of the utility production to the utility user. Since a portion of electricity produced at power plants hundreds of miles away is actually lost during the transmission process through the electrical lines (line losses), VU can use much less coal or natural gas than Tennessee Valley Authority (TVA) would require to deliver the same amount of electricity to campus. The remainder of the electricity needed to power Vanderbilt's campus (81% of our demand) is purchased from TVA through Nashville Electric Service (NES). This mix of on-campus generation and purchased electricity also results in uniqueness within Vanderbilt's carbon footprint.

In addition to the mix of Vanderbilt's electricity production, a special class of GHGs not discussed in the previous section were included in this inventory. Typically, nitrous oxide is the only anesthetic gas included in a university's GHG inventory (if it is included at all). At Vanderbilt, our patient care and animal care

[7] Walther, G.R., Post, E., Convey, P., Menzel, A., Parmesan, C., Beebee, T., Fromentin, J.M., Hoegh-Guldber, O., & Bairlein, F. (2002). Ecological responses to recent climate change. *Nature 416*, 389-395.
[8] Parmesan, C. & Yohe, G. (2003). A globally coherent fingerprint of climate change impacts across natural systems. *Nature,* v.421, 37-42.

activities use Isoflurane, Desflurane, and Sevoflurane in significant quantities as anesthetic gases. Because these gases can have Global Warming Potentials (GWPs) of up to 2,000 times that of carbon dioxide, the contribution to VU's carbon footprint from the use of these three gases has been quantified and added to that of the traditional six gases discussed previously in an effort to be as comprehensive as possible.

Recognized technological, social and behavioral changes that positively affect climate change, such as energy conservation, are sensible choices for the Vanderbilt community and beyond, regardless of the ultimate impact of climate change. Presupposed carbon-footprint-mitigation strategies such as conserving energy, implementing renewable fuel sources, and reducing consumption are all actions yielding substantial benefits such as cost reductions, energy independence, human health improvement, and preservation of natural resources.

II. VANDERBILT UNIVERSITY ENVIRONMENTAL COMMITMENT STATEMENT

In December 2006, the Faculty Senate passed a motion stating that the University should develop and promote an Environmental Commitment Statement. Subsequently, Faculty Senator Dr. Ray Burk was invited to the January 2007 Environmental Advisory Committee (EAC) meeting to discuss the potential role of the EAC in leading the development of this statement.

A plan for the EAC to lead the development of the Environmental Commitment Statement was presented to the Faculty Senate in 2007. The EAC discussed the project at their spring 2008 meeting and decided to supplement a subgroup of EAC members with additional interested faculty, staff and students.

In August 2008, a large working group of 23 Vanderbilt University faculty, staff, and students convened in a facilitated session to generate ideas and concepts that would form the basis of a Vanderbilt University Environmental Commitment Statement. Additionally, it was determined that a small subset of volunteers was needed to coalesce concepts and develop a working draft of the commitment statement.

The small working group produced their final version of the Environmental Commitment Statement in February 2009, which was shortly thereafter endorsed by the EAC. On March12, 2009, a motion to endorse the Environmental Commitment Statement was approved by the Faculty Senate. The Environmental Health and Safety Oversight Committee (EHSOC), University Staff Advisory Council (USAC), Medical Center Staff Advisory Council (MCSAC), Students Promoting Environmental Awareness and Responsibility (SPEAR) and Vanderbilt Student Government (VSG) also endorsed the statement.

This Environmental Commitment Statement is a collaborative product of many stakeholders and campus representatives and is meant to succinctly and uniquely reflect Vanderbilt's culture and values. The Vanderbilt University Environmental Commitment Statement presented in Figure 2.1 is also the cornerstone of our Environmental Management System (EMS), which includes the VU GHG emissions inventory.

Vanderbilt University
Environmental Commitment Statement

Vanderbilt University is a local and global community leader committed to environmental stewardship, protecting natural resources, and enhancing quality of life while maintaining academic, medical, social, and economic productivity. Through proactive education, research, and outreach, we strive to:

- Develop and transfer knowledge, increase awareness, and promote lifelong learning about sustainability best practices for the benefit of stakeholders who comprise the Vanderbilt community (students, patients, faculty, staff, alumni, and visitors), as well as the broader Nashville, state, national, and global communities;

- Achieve the highest standards of sustainability through a process of environmental responsibility and accountability at every level of University activity; and

- Consistently implement, monitor, evaluate, and improve our process.

Figure 2.1. VU Environmental Commitment Statement.

III. INVENTORY DEVELOPMENT METHODOLOGY

Boundary Definitions

Prior to conducting Vanderbilt's GHG inventory, the operational, spatial, and temporal boundaries of the inventory were firmly defined. Furthermore, a GHG calculation protocol was established prior to gathering the data for the GHG inventory.

Operational Boundary

Activities at Vanderbilt University that produce GHG emissions include those outlined by the U.S. EPA's Mandatory GHG Reporting Rule [40 CFR Part 98], which applies to facilities generating 25,000 or more $MTCO_2E$ per calendar year, as well as The American College & University Presidents Climate Commitment (ACUPCC) Implementation Guide (September 2007). The boundaries established by the ACUPCC Implementation Guide rely heavily on the methodology established by the World Resources Institute Greenhouse Gas Protocol. As noted by the World Resources Institute (WRI), "identification of operational boundaries helps institutions to categorize their sources of emissions, providing accountability and the prevention of 'double counting'."

The EPA defines GHG emissions as required under the Mandatory GHG Reporting Rule as follows:

- EPA-Required Stationary Sources: Scope 1 – Direct Sources. These are emissions produced by stationary sources that are under direct control of the institution. Vanderbilt's EPA-required stationary sources include coal and natural gas consumption at the on-campus power plant and consumption of natural gas within individual buildings at Vanderbilt.

Throughout this report, the WRI definition of Scope 1 sources will be utilized to capture all other direct source emissions not included in the EPA-required stationary sources definition:

- Other Scope 1: Non-EPA Direct Sources. The remaining Scope 1 emissions that are not designated as stationary sources by the EPA are emissions produced by activities that are under direct control of the institution. Vanderbilt's other Scope 1 emissions include fuel consumption by university-owned vehicles; releases of refrigerants and anesthetic gases; and fuel consumed by Vanderbilt-owned emergency generators.

The WRI Greenhouse Gas Protocol categorizes GHGs into Scopes 2 and 3 as follows:

- Scope 2: Indirect Emissions from Electricity Purchases. These are emissions associated with the generation of electricity that is purchased by Vanderbilt. Scope 2 emissions physically occur at power-generation facilities owned by Vanderbilt's electricity supplier (TVA) and not at the Vanderbilt campus itself. Vanderbilt purchases 81% of the electricity needed to supply campus operations.

- Scope 3: Indirect Emissions by Individuals at Vanderbilt. These are emissions that result from activities by individuals in the Vanderbilt community but are not under the direct control of the university. Scope 3 emissions include fuel use by commuters (faculty, staff, and student commuters), fuel use from air travel, and off-site waste disposal.

GHG emissions associated with the production and delivery of goods and services to Vanderbilt (i.e. "upstream" emissions) were not included in this inventory.

Spatial Boundary – Academic and Research Areas, Patient Care Areas

Vanderbilt University is a unique institution, providing regional health care while simultaneously pursuing robust academic endeavors. To provide the Vanderbilt community with a better understanding of the university's of GHG emissions from these two missions, this report provides a sub-total of GHG emissions associated with academic and research areas which are traditional academic university endeavors, and a separate sub-total for emissions associated with patient care activities. The contrast in the activities in these two areas is worth noting: patient care areas provide medical care on a continuous basis (24 hours a day, 365 days a year), while activities in academic and research areas are associated with an academic calendar. Academic and research areas include academic and administrative buildings, residence halls, athletics facilities, parking garages, common space/multi-purpose areas, and laboratory research space, while patient care areas include hospitals, clinics, and patient and visitor parking garages.

Buildings that were classified as Patient Care buildings for the purposes of this report are listed below in Table 3.1. All other buildings on the "core" 330 acre campus are considered academic and research areas.

Monroe Carell Jr. Children's Hospital	Medical Center North (35% of GSF)[9]
Monroe Carell Jr. Children's Hospital Doctor's Office Tower	Medical Center South (2005-2006)[10]
Vanderbilt University Hospital	Oxford House
Psychiatric Hospital at Vanderbilt	Medical Arts Building
Medical Center East (North Tower)	Zerfoss Health Center
Medical Center East II (South Tower)	Free Electron Laser Building
The Vanderbilt Clinic	Central Garage (2007-2009)[10]
Kim Dayani Center	East Garage
Vanderbilt-Ingram Cancer Center	South Garage
Vanderbilt Eye Institute	Children's Way Garage

Table 3.1. Vanderbilt's Patient Care Buildings.

[9] Approximately 35% of the gross square footage of Medical Center North is utilized by Vanderbilt University Hospital and Vanderbilt Medical Group, with an estimated 65% utilized by the School of Medicine.

[10] Medical Center South was demolished in 2006; Central Garage was constructed in its place in 2007.

The typical definition of Vanderbilt University's "core campus" is the university property that is bounded by Blakemore Avenue to the south, West End Avenue to the northwest, and 21st Avenue South to the east. The Peabody Campus at Vanderbilt is also part of the core 330 acres of Vanderbilt; the Peabody Campus is bounded by 21st Avenue South to the west, Edgehill Avenue to the north, 18th Avenue South to the east, and Capers Avenue to the south. These two areas constitute the "core 330 acres" of Vanderbilt University and encompass the majority of the academic, residential, research, and patient care buildings associated with Vanderbilt. Furthermore, the buildings located within this core 330 acres are serviced by Vanderbilt's on-campus power plant. The core VU campus contains over 230 buildings, encompassing over 17 million gross square feet of space.

Off-site buildings, such as medical clinics located elsewhere in Tennessee, were not included in this inventory. A few buildings located within the core 330 acres of the Vanderbilt campus are not under the direct operational control of the university and do not receive utility services from Vanderbilt; therefore, these buildings were not included in this baseline GHG inventory. Such buildings include the Veteran's Administration Hospital, Stallworth Rehabilitation Hospital, the 2525 Building located on West End Avenue, the Marriott Hotel & parking garage on West End Avenue, and the Village at Vanderbilt Apartments and Townhomes.

Temporal Boundary

The purpose of this inventory is to establish a history of Vanderbilt's annual GHG emissions that can serve as a guide for future GHG-emitting activity. Using the total GHG emissions from a single fiscal or calendar year as a focal point would not accurately represent a 'typical' year of activity at Vanderbilt University due to annual fluctuations in emissions caused by commissioning new buildings, changes in faculty/staff/student populations, and seasonal/climatic variations from year to year, all of which have a direct bearing on Vanderbilt's GHG emissions for a particular year. In an effort to capture these "peaks & valleys" in activities at Vanderbilt, the five-year inventory establishes the annual GHG emissions created by Vanderbilt during the 2005 through 2009 calendar years.

Greenhouse Gas Calculation Protocol

In October 2009, the EPA issued the *Mandatory Greenhouse Gas Reporting Rule* [40 CFR Part 98], requiring annual reporting of GHG emissions from large sources in the United States who emit more than 25,000 $MTCO_2E$ per year. Vanderbilt is subject to this reporting rule because the use of coal and natural gas at the on-campus, co-generation power plant for the production of steam and electricity for campus emits greater than 25,000 $MTCO_2E$ annually. The university will submit its first report covering the calendar year 2010 to the EPA in 2011. Under the EPA's GHG Reporting Rule, the scope and emissions factors of stationary sources vary from those utilized in Vanderbilt's initial baseline GHG inventory. The full text of the

EPA's Final Mandatory GHG Reporting Rule and associated emissions factors and formulas for calculation are available on the EPA's website[11]. In order to create a single, consistent methodology for calculating and reporting GHG emissions for the university, emissions from calendar years 2005-2007 (those years included in the original baseline inventory) have been recalculated utilizing the EPA's scope and emissions factors for relevant stationary sources.

Emissions from all sources not covered by the GHG reporting rule were calculated using methodology from the Clean Air – Cool Plant Campus Carbon Calculator™ or emission factors developed for specific on-campus activities. The Campus Carbon Calculator is publicly available, university-specific, and one of the approved calculators listed in the ACUPCC Implementation Guide. This calculator is the most commonly used calculator among U.S. colleges and universities. The calculator allows for easy entry of collected data and conversion of that data into standard units of metric tons of carbon dioxide equivalents ($MTCO_2E$) based on the Global Warming Potential (GWP) of emitted gases. For example, one metric ton of methane (CH_4) is equal to the emission of 23 metric tons of carbon dioxide (CO_2). Other gases, such as nitrous oxide, refrigerants, and anesthetic gases, have GWPs that are hundreds of times larger than carbon dioxide. The Campus Carbon Calculator is a Microsoft Excel workbook comprising a series of spreadsheets that compute GHG emissions based on specific activity data (i.e. tons of coal combusted, commuter miles, gallons of diesel fuel, etc.), emissions factors associated with that activity, and established GWPs. GWPs of emitted gases and sources included in this report are listed in Tables 3.2 and 3.3 below. The same methodology was used to determine GHG emissions for the calendar years 2008 and 2009.

GHG	Global Warming Potential (GWP)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide	310
Isoflurane	350
Desflurane	989
Sevoflurane	345
Refrigerant 134a (HFC-134a)	1,300

Table 3.2. Global Warming Potentials of GHGs[12].

[11]Full text available for viewing at http://www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Full%20Version.pdf.

[12] GWPs utilized were taken from EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

GHG Source	Emission Factor [$MTCO_2E$ = Metric Tons of Carbon Dioxide Equivalent]	Reference[13]
Coal Combustion	1 ton of coal = 1.685 $MTCO_2E$	A
Natural Gas Combustion	1,000 cubic feet of natural gas = 0.0674 $MTCO_2E$	A
Gasoline	1,000 gallons of gasoline = 8.93 $MTCO_2E$	B
Diesel Fuel	1,000 gallons of diesel fuel = 10.14 $MTCO_2E$	B
Jet A Fuel	1,000 gallons of Jet-A fuel = 9.57 $MTCO_2E$	B
Refrigerant (R-134a)	1 kilogram of R-134a = 1.30 $MTCO_2E$	A
Isoflurane anesthetic gas	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	A
Desflurane anesthetic gas	1 kilogram of Desflurane = 0.989 $MTCO_2E$	A
Sevoflurane anesthetic gas	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	A
Nitrous oxide anesthetic gas	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	A
Purchased Electricity from TVA (2009)	1,000 kilowatt-hours = 0.59138 $MTCO_2E$	B
Purchased Electricity from TVA (2005-2008)	1,000 kilowatt-hours = 0.759487 $MTCO_2E$	B
Air Travel	1,000 air passenger-miles = 0.77 $MTCO_2E$	B
Waste landfilled with landfill gas recovery converted to electricity	1 Ton of waste = 0.1467 $MTCO_2E$	B
Waste landfilled with landfill gas combusted to the atmosphere	1 Ton of waste = 0.2567 $MTCO_2E$	B
Incinerated Waste	1 Ton of waste = 0.22 $MTCO_2E$	B
Medical Waste Autoclaved Off-Site	1 Ton of waste = 0.243 $MTCO_2E$	C

Table 3.3. Emission Factors for GHG Sources.

Greenhouse Gas Data Collection and Inventory Methodology

Data provided to SEMO on a monthly basis was aggregated to establish a yearly total for use in EPA-established formulas and the Campus Carbon Calculator. Once all the necessary data was calculated and/or put into the calculator, a yearly GHG emission number was determined for each of the calendar years (2005, 2006, 2007, 2008, and 2009) covered by this report. A description of the collected data, data sources, and calculations used are provided in this section.

On-Campus Energy Production

Vanderbilt's sources of GHG emissions that are under direct control of the university include the consumption of coal and natural gas at the on-site co-generation power plant, natural gas-fired boilers and heaters located in various Vanderbilt buildings, and diesel fuel consumed in Vanderbilt's emergency generators. Annual consumption of coal and natural gas at the on-campus co-generation power plant and natural gas by individual buildings was provided by the Plant Operations Department and input into formulas provided by the EPA for calculation of annual GHG emissions. Annual consumption of diesel fuel by individual emergency generators was also provided by the Plant Operations Department and input into the Campus Carbon Calculator to compute annual GHG emissions.

[13] References: A – EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]; B – Campus Carbon Calculator, Clean Air – Cool Planet (2006); C – Emission factor developed by SEMO.

Did you know...

…that the university's co-generation power plant actually *reduces* Vanderbilt's greenhouse gas output by almost 100,000 $MTCO_2E$ each year when compared to purchasing 100% of VU's energy from off-campus suppliers? In 2004, the University of Maryland built a co-generation power plant on their campus, reducing their annual greenhouse gas output by 20%!

Vanderbilt's co-generation power plant also burns only low-sulfur coal, which contains a very small percentage of sulfur (less than 1%), reducing the amount of sulfur oxides emitted during combustion.

For more information on the VU co-generation power plant, go to the Energy FAQ section of Vanderbilt's ThinkOne web site at http://www.vanderbilt.edu/sustainvu/thinkone/energyfaq.php.

University-Owned Vehicles

Vanderbilt University owns over 300 vehicles. However, these vehicles are not owned and operated by a centralized university agency; individual departments purchase and operate their own vehicles based on their specific needs. Some departments at Vanderbilt purchase their own fuel in bulk and track the dispensing of that fuel (i.e., Plant Operations), while some departments purchase their fuel from local retail stations and record the volume of fuel purchased (i.e., Vanderbilt Police Department). Departments that track their fuel use provided SEMO with their annual fuel usage (gasoline and/or diesel, in gallons), and this data was directly input to the Campus Carbon Calculator. Fuel dispensed to Vanderbilt shuttle buses and vans is recorded monthly by Central Parking, the contractor which operates these vehicles, and was provided to SEMO for inclusion in this inventory.

Most users of university-owned vehicles at Vanderbilt purchase their fuel at local retail stations using a VU Procurement Card and the volume of fuel purchased is *not* recorded by the vehicle manager. For this portion of university-owned vehicles, two assumptions had to be made in order to estimate the approximate annual fuel use for these vehicles: (1) a Vanderbilt-owned vehicle averages 3,000 miles a year (based on the vehicle-miles logged by the vehicle manager for Information Technology Services), and (2) a university-owned vehicle gets 17 miles per gallon. Based on these two assumptions, SEMO calculated the gallons of fuel consumed by these vehicles and input that fuel amount to the Campus Carbon Calculator.

Annual consumption of fuel by Vanderbilt's LifeFlight helicopters was reported to SEMO by VUMC's Plant Services Department (Special Equipment Repair Shop). SEMO calculated GHG emissions associated with LifeFlight's use of Jet A fuel using an emission factor from WRI's Greenhouse Gas Protocol.

Anesthetic Gases

Vanderbilt uses anesthetic gases in both patient care areas and in animal care areas and research laboratories; however, different types are used for animals and humans. Purchase records for anesthetic gas were provided by the VUMC's Department of Anesthesiology and Vanderbilt's Division of Animal Care. The Campus Carbon Calculator does not provide GWPs for all anesthetic gases, since most universities use little to no anesthetic gas. SEMO calculated Vanderbilt's GHG emissions from anesthetic gas use based on GWP's provided by the EPA's Mandatory Reporting Rule[14].

Anesthetic Gas and Greenhouse Gas Emissions

We typically attribute GHG emissions to sources such as cars, factories, and power plants. But did you know that anesthetic gases also contribute to GHG emissions? Halogenated anesthetics have a global warming potential of up to 2,000 times greater than carbon dioxide (CO_2), which means these gases have the ability to trap a lot of heat in the atmosphere. Less than 5% of the total administered halogenated anesthetic is actually metabolized by the patient, and the majority of the remainder is released through the operating room scavenging system.

Source: "*Hospital Anesthetic Gas Discharges and the Environment*"
January 2005, Blue-Zone Technologies.

Refrigerants

Universities track releases of refrigerants to the atmosphere as required by the EPA. The VU Plant Operations Department and VUMC Plant Services Department keep records of refrigerant releases from chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances. Pounds of refrigerant released were provided to SEMO and directly input to the Campus Carbon Calculator.

Electricity Purchases

The university's co-generation power plant supplies Vanderbilt with 100% of the steam needed for heating buildings and 40% of the chilled water needed for cooling buildings. Excess heat from steam generation is used to create electricity, satisfying 19% of Vanderbilt's annual electricity demand. The remaining 81% of Vanderbilt's electricity demand is obtained through electricity purchased from TVA (through NES). In 2009, 47.1% of TVA's electricity came from coal-fired power plants; 33.7% of TVA's electricity came from nuclear power; 7% came from hydroelectric dams; 6.1% came from natural gas-fired power plants; and 6.1% came from other renewable sources. Figure 3.1 below presents TVA's sources of power generation.

[14] Suppliers of anesthetic gases are required to report their sales/shipments under a separate portion of the EPA's *Mandatory Reporting of Greenhouse Gases; final Rule* [40 CFR Part 98, Subpart C].

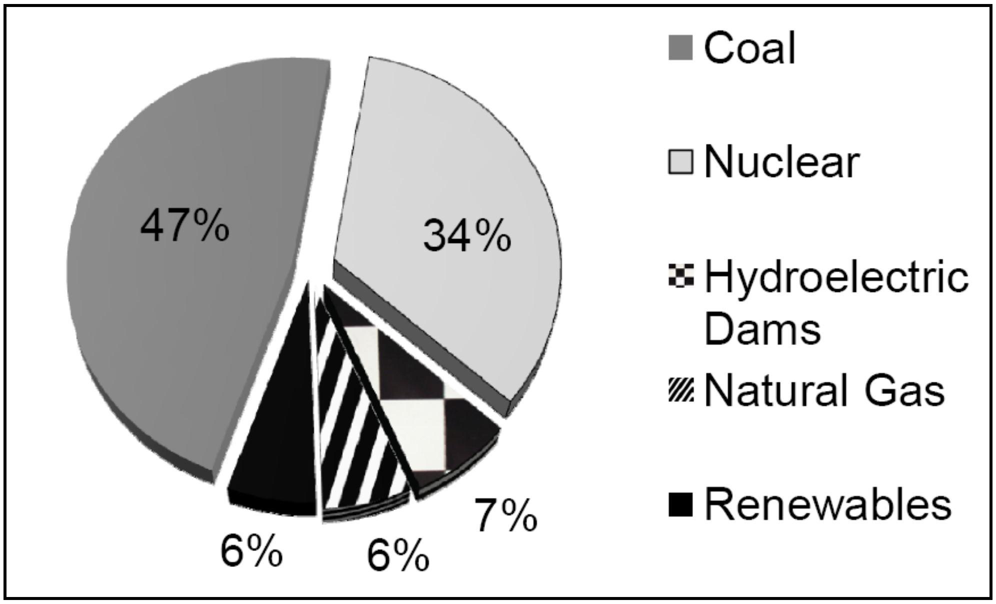

Figure 3.1. TVA's Fuel Mix, Calendar Year 2009[15].

Vanderbilt University purchases electricity from Nashville Electric Service, the local distributor of power generated by the Tennessee Valley Authority (TVA). Monthly consumption of electricity by building was provided by the VU Plant Operations Department. Aggregate annual consumption of electricity in patient care buildings and in academic and research buildings were entered into the Campus Carbon Calculator. The specific methods of electricity generation utilized by TVA is publicly available through TVA web sites; based on that information, the generation methods used by TVA were input to the Campus Carbon Calculator.

Energy Fact: greenhouse gas emissions vary by region

A kilowatt-hour of electricity is the same no matter where you go in the United States (or the world) - but how much greenhouse gas is emitted to create that kilowatt-hour can vary greatly across the country because of regional variations in how that power is produced. For example, according to Nashville Electric Service (NES), the average residence in Nashville consumes around 15,000 kilowatt-hours (KwH) each year, resulting in approximately 7 $MTCO_2E$. However, power suppliers in different regions of the country use different sources of power generation (hydroelectric, wind, solar, coal, oil, natural gas, waste-to-energy, etc.). If a residence in another state consumed 15,000 KwH in a year, how much greenhouse gas would be emitted? According to the Campus Carbon Calculator:

Consuming 15,000 KwH in this state…	*…creates this much greenhouse gas (MTCO₂E)*
Colorado	13
Ohio	10
Georgia	10
Florida	9
Texas	9
North Carolina	8
Tennessee	7
Massachusetts	6
Washington	6

[15] 10 December 2009. "TVA and Energy." The Tennessee Valley Authority. Available http://www.tva.com/abouttva/energy.htm.

Faculty, Staff, and Student Commuter Traffic

Commuter traffic reflects the fuel used by faculty, staff, and students during their regular travels to and from Vanderbilt. This is important to include in Vanderbilt's GHG inventory because Vanderbilt University employs so many people. Based on 2005-2007 commuter data provided by VUMC's Parking and Transportation Services Office, 95% of the university's faculty and staff commuted to Vanderbilt in a single-occupancy vehicle; 3% of faculty and staff commuted via carpool; 1% of faculty and staff commuted via bus; and 1% of faculty and staff used alternate forms for commuting (walk or bike). Regarding Vanderbilt's student population, in 2005, 2006, and 2007 it was assumed that 15% of students commuted to Vanderbilt in a single-occupancy vehicle (primarily graduate students), with 5% commuting via carpool, and the remaining 80% of students walking or biking to Vanderbilt. Based on commuter data for 2008 and 2009 provided by VUMC's Parking and Transportation Services Office, the following changes were made to reflect increased utilization of public and alternative transportation by VU faculty, staff and students:

Population	Percent commuting in a single-occupancy vehicle	Percent commuting in a car/vanpool	Percent commuting via bus or train	Other forms of commuting (walk/bike)	Days per year commuting to campus	Average commuter distance (via automobile)
2008						
Faculty	90%	4%	5%	1%	200	48
Staff	90%	4%	5%	1%	250	48
Student	20%	5%	5%	70%	200	10
2009						
Faculty	89%	4%	6%	1%	200	48
Staff	89%	4%	6%	1%	250	48
Student	20%	5%	6%	70%	200	10

Table 3.4. Assumptions for Faculty, Staff, and Student Commuter Travel, Calendar Years 2008-2009.

A recent study conducted by VUMC's Parking and Transportation Services Office (in conjunction with Vanderbilt's Human Resources Department) revealed that the average one-way commute for Vanderbilt employees is 24 miles. Commuter distance, commuter patterns (described above), and faculty/staff/student populations were input to the Campus Carbon Calculator to determine VU's commuting GHG emissions. To determine the VU employee population associated with patient care areas, SEMO turned to Vanderbilt's Human Resources Department, which was able to approximate how many Medical Center employees work in each building (including off-site buildings). Based on building assignment, separate commuter GHG emission amounts were calculated for academic and research areas and patient care areas. All students and all faculty members (including School of Medicine faculty and School of Nursing faculty) were classified as commuters in the Academic and Research area category for the purpose of this report. Medical Center employees assigned to off-campus locations were not included in the commuter traffic calculations.

Air Travel

Airline tickets purchased through Vanderbilt's travel agency (Caldwell Travel) for university-sponsored travel are tracked and reported to Vanderbilt's Procurement and Disbursements Department. Air travel records for the 2007-2009 calendar years include passenger-miles, which were input to the Campus Carbon Calculator. Air passenger-miles were not recorded prior to 2007[16]. All air travel was assumed to be associated with academic and research activities for purposes of this report. Airline tickets purchased by individual Vanderbilt employees using a Procurement Card or personal credit card could not be captured at this time and included in this inventory.

Waste Management

Data related to the amount of waste generated annually by Vanderbilt was provided by waste vendors and by Vanderbilt Environmental Health and Safety (VEHS). Waste generated by Vanderbilt is disposed of in one of four ways: (1) waste is landfilled, with landfill gas being converted to electricity; (2) waste is landfilled, with landfill gas being combusted to the atmosphere; (3) waste is incinerated, and (4) waste is autoclaved and then landfilled. Each of these disposal methods has a separate impact on VU's GHG emissions. Waste generated by Vanderbilt is disposed off-site by licensed waste management companies.

The volume of solid waste sent to the landfill from the medical center and from the university was reported separately to SEMO by the disposal vendor Allied Waste. All of the solid waste collected from Vanderbilt is disposed of at the Allied Waste landfill in Rutherford County. The Allied Waste landfill has a landfill gas recovery system. A portion of the landfill gas from the Rutherford County landfill is used to generate electricity; the remaining landfill gas is combusted ("flared") to the atmosphere. Based on this information, separate solid waste amounts were input to the Campus Carbon Calculator categories for landfill gas-to-electricity and landfill gas-to-flare. An input category for incinerated waste is provided in the Campus Carbon Calculator. Records for VU's incinerated waste are kept by VEHS.

Medical waste that is not autoclaved on-site is shipped to an autoclave facility operated by a vendor (SteriCycle). There is no input category for autoclaved waste in the Campus Carbon Calculator, nor is there a standard emissions number provided in WRI's Greenhouse Gas Protocol. Using information from SteriCycle[17] and waste industry journals[18], SEMO estimated how much natural gas is needed to autoclave

[16] For calendar years 2005 and 2006, air travel passenger-miles from 2007 were used to calculate emissions from Vanderbilt University air travel.

[17] SEMO communication with SteriCycle representatives John Nicklin, Greg Burkett, Marty Desper, and Dan Sullivan.

[18] Owen, K, Leese, L, Hodson, R, and Uhorchak R. 1997. Non-Incineration Medical Waste Treatment Technologies. Pan-American Health Organization. Chapter 5: "Control of Aerosol (Biological and Non-Biological) and Chemical Exposures and Safety Hazards In Medical Waste Treatment Facilities." Available http://www.bvsde.paho.org/bvsacd/cd48/cap5.pdf.

one ton of medical waste. The GHG emissions associated with autoclaving Vanderbilt's medical waste at an off-site location was then calculated using the GHG emissions factor for natural gas use provided by the Campus Carbon Calculator.

Uncertainties Associated with Greenhouse Gas Inventory Calculations

As noted by the WRI Greenhouse Gas Protocol[19], two types of uncertainties are associated with GHG inventories: *scientific* uncertainty and *estimation* uncertainty. Scientific uncertainty occurs when the science of an actual emission is not sufficiently understood. Estimation uncertainty occurs any time GHG emissions are quantified. Thus all emission estimates are associated with estimation uncertainty. Furthermore, the WRI notes that uncertainty exists in when using a mathematical model such as a GHG calculator. Model uncertainty is due to the uncertainty associated with the mathematical equations (i.e. models) used to characterize the relationships between various parameters and emission processes. The WRI notes that analyzing and quantifying these uncertainties is likely beyond the scope of most institutions when compiling a GHG inventory.

In an effort to balance the inherent uncertainties in this inventory with the need for transparency and comprehensiveness, the GHG inventory results for academic and research areas and patient care areas are presented in Sections IV and V as generated from the EPA emissions calculator and the Clean Air-Cool Planet Campus Calculator. For purposes of 'readability,' many of the emission and conversion factors listed in tables in this report and its appendices have been rounded. However, calculations completed to determine emissions utilized full emission and conversion factors.

[19] Ohndorf, M. & Gillenwater, M. (2003). "Measurement and Estimation Uncertainty of Greenhouse Gas Emissions." World Resources Institute. Available http://www.ghgprotocol.org/calculation-tools/all-tools.

IV. ACADEMIC AND RESEARCH AREA GREENHOUSE GAS EMISSIONS

Results Summary

Academic and research areas at VU encompass typical university activities such as teaching, research, administration, student activities, student housing, dining, and athletic facilities. Table 4.1 illustrates annual GHG emissions from academic and research areas for calendar years 2005 through 2009 with more detail discussed below.

Calendar Year	GHG Emissions from EPA-Required Sources[20] ($MTCO_2E$)	Other Scope 1 Emissions[21] ($MTCO_2E$)	Scope 2 Emissions ($MTCO_2E$)	Scope 3 Emissions ($MTCO_2E$)	Total GHGs Emitted from Academic and Research Areas ($MTCO_2E$)
Academic & Research Areas					
2005	95,554	2,446	145,173	49,291	**296,465**
2006	95,045	2,848	145,382	52,550	**295,825**
2007	107,815	2,838	142,045	55,905	**308,604**
2008	108,255	2,598	149,266	53,222	**313,341**
2009	116,192	2,455	117,359	52,336	**288,343**

Table 4.1. GHG Emissions from Academic and Research Areas by Type, Calendar Years 2005-2009.

As demonstrated in Figure 4.1, for the calendar year 2009, major contributors to the emissions from academic and research areas include purchased electricity (41%), coal use at the power plant (24%), faculty and staff commuting (15%), and natural gas use at the power plant (14%).

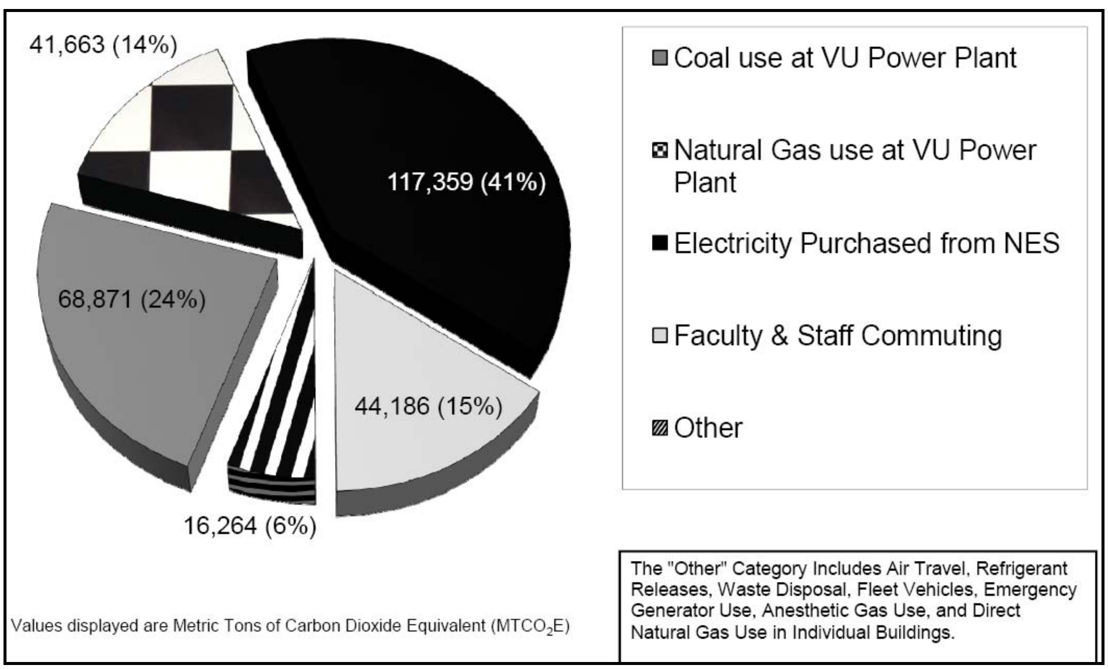

Figure 4.1. GHG Emissions Sources from Academic and Research Areas, Calendar Year 2009.

[20] EPA-required sources includes coal-fired boilers, natural gas-fired boilers, and natural gas-fired turbines.
[21] Other Scope 1 Emissions includes anesthetic gas use, emergency generators, fleet vehicles, and refrigerant releases.

Figure 4.2 illustrates the contribution from direct emissions (Scope 1), emissions from purchased electricity (Scope 2), and indirect emissions (Scope 3) to the overall GHG emissions for Vanderbilt's Academic and Research activities. Vanderbilt University Academic and Research areas were designated according to the criteria outlined in the Methodology section of the report. For Academic and Research area populations for 2005-2009, please reference Tables B.17, C.17, D.17, E.17, and F.17 in the appendices.

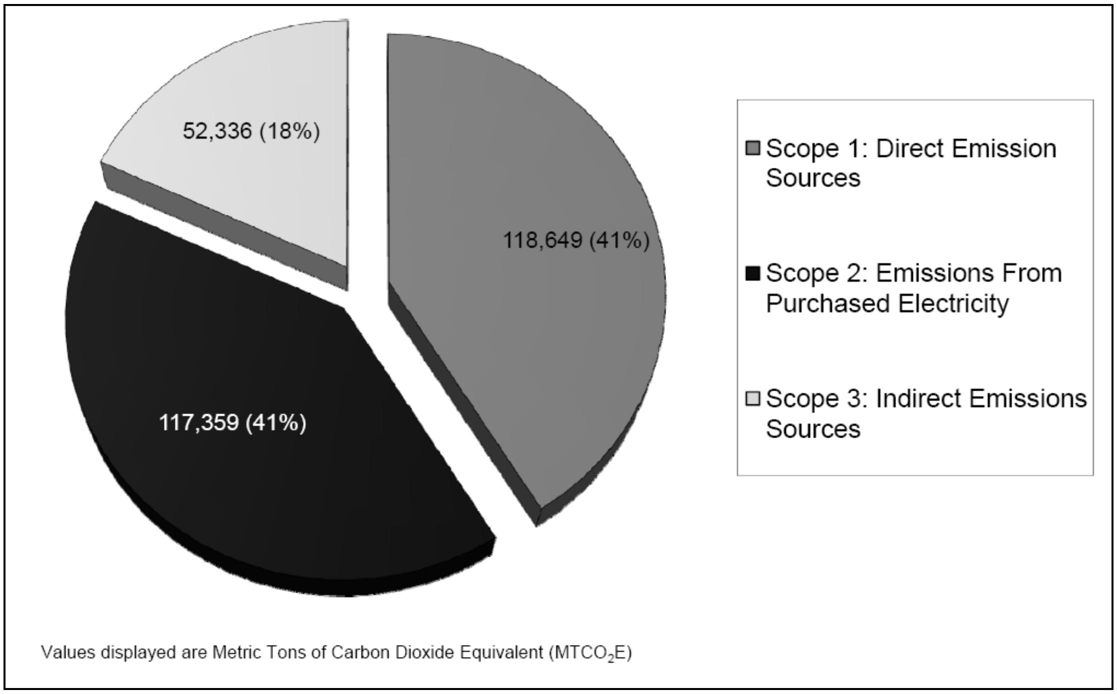

Figure 4.2. Academic and Research Area Emissions by Scope, Calendar Year 2009.

Scope 1: EPA-Required Emissions Sources

The EPA now requires Vanderbilt to report annual GHG emissions from stationary sources which include coal and natural gas consumption at the on-campus, co-generation power plant and consumption of natural gas within individual buildings at Vanderbilt. Individual building monthly steam and electricity usage for calendar years 2005 through 2009 revealed that approximately 65% of the steam and electricity consumed by Vanderbilt was consumed by Academic and Research buildings (including academic and classroom buildings, administrative buildings, residential buildings, athletics areas, outdoor lighting, staff parking garages, and multi-purpose buildings). Therefore, 65% of the GHG emissions associated with the power plant were attributed to Academic and Research areas. In 2009, GHG emissions from EPA-required sources for Academic and Research Areas amounted to 116,192 $MTCO_2E$ as shown in Table 4.2.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Sources[22] ($MTCO_2E$)	GHG Emissions from EPA-Required Sources in Academic and Research Areas (65% of previous column) ($MTCO_2E$)
2005	96,478	51,695	4,988	153,161	99,554
2006	99,582	38,485	8,155	146,222	95,045
2007	111,344	48,258	6,268	165,869	107,815
2008	102,172	51,358	13,017	166,547	108,255
2009	105,956	64,096	8,705	178,758	116,192

Table 4.2 Academic and Research Area GHG Emissions from EPA-Required Stationary Sources, Calendar Years 2005-2009.

Coal and Natural Gas Use at the Power Plant

The on-campus, co-generation power plant burns coal and natural gas to produce electricity, steam, and chilled water for distribution to buildings located on the 330-acre Vanderbilt campus. The burning of coal and natural gas releases carbon dioxide, nitrous oxide, and methane. The inventory results illustrate that 68,871 $MTCO_2E$, or 24%, of 2009 emissions associated with Academic and Research areas result from coal use at the power plant, while 14%, or 41,663 $MTCO_2E$ of 2009 emissions in Academic and Research areas are attributed to the burning of natural gas at the power plant, as shown in Table B.1 of the appendices.

Natural Gas Use in Individual Buildings

Several buildings on campus use natural gas directly from Vanderbilt's natural gas supplier, Piedmont Natural Gas. The consumption of natural gas within individual buildings in Academic and Research areas accounts for 5,658 $MTCO_2E$ of 2009 emissions, as shown in Table B.1 of the appendices.

Scope 1: Other Direct Emission Sources

Vanderbilt's direct GHG emissions sources that are not required to be reported to the EPA include fuel consumption by university-owned vehicles, releases of refrigerants and anesthetic gases, and fuel consumed by emergency generators, as shown in Table 4.3.

Calendar Year	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	VU Fleet Vehicles ($MTCO_2E$)	Anesthetic Gas Use ($MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	550	286	1,609	1	2,446
2006	541	338	1,968	1	2,848
2007	830	137	1,870	1	2,838
2008	282	143	2,159	14	2,598
2009	394	35	2,013	14	2,455

Table 4.3. Academic and Research Area Scope 1 Emissions from Other Sources, Calendar Years 2005-2009.

[22] Emission factors taken from the EPA's *Mandatory Reporting of Greenhouse Gases; final Rule* [40 CFR Part 98, Subpart C].

Diesel-Powered Generators

Vanderbilt owns several diesel-powered emergency generators which release carbon dioxide, nitrous oxide, and methane when in operation. In Academic and Research areas, fuel consumed by diesel-powered generators contributed 394 $MTCO_2E$ to 2009 GHG emissions, as referenced in Table 4.3 above.

Refrigerant Releases

Chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances can release hydrofluorocarbons and perfluorocarbons to the atmosphere. In 2009, release of refrigerant from Academic and Research areas amounted to 27 kilograms of refrigerant, resulting in 35 $MTCO_2E$ of GHG emissions[23], as referenced in Table 4.3.

University-Owned Fleet Vehicles

As noted in the Methodology section of this report, several university departments own and operate vehicles. The Plant Operations Department owns and operates 95 vehicles, which consume both gasoline and diesel fuel. The Vanderbilt Police Department owns and operates 46 gasoline-powered vehicles. The remaining inventory of university vehicles (176) are owned by various departments at Vanderbilt. The employee shuttle bus and van system uses both gasoline and diesel fuel. 2009 GHG emissions from university-owned vehicles in Academic and Research areas amounted to 2,013 $MTCO_2E$, as illustrated in Table 4.4.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations (95 vehicles)	48,484	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	433
Gasoline purchases by VU PD (46 vehicles)	29,748	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	266
Estimate of gasoline purchases by remaining fleet vehicles (176 vehicles) [24]	31,059	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	277
Gasoline use by VUMC Shuttle Busses and Vans	69,196	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	618
Diesel Fuel use by VUMC Shuttle Busses and Vans	40,302	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	409
Diesel Fuel use by Plant Operations	988	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	10
GHG Emissions from Academic & Research Fleet Vehicles:			2,013

Table 4.4. Academic and Research Area GHG Emissions from Vanderbilt Owned Vehicles, Calendar Year 2009.

[23] Emission Factor for R-134A is used as a default emission factor, as some refrigerants do not have a published emission factor/global warming potential (GWP).
[24] Estimate of gasoline purchases is based on ITS fleet vehicle use of 3,000 miles per year at 17 miles per gallon.

Anesthetic Gas Use

The Department of Animal Care utilizes isoflurane as an anesthetic, which has a known GWP and emission factor, as illustrated in Tables 3.2 and 3.3 of this report's Methodology section. Anesthetic gas use in Academic and Research areas resulted in 14 $MTCO_2E$ of 2009 GHG emissions. See Table 4.5 below for more details.

Anesthetic Gas	Department	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane	Animal Care	40.0	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	14

Table 4.5. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2009.

Scope 2: Purchased Electricity Emissions

117,359 $MTCO_2E$, or 41%, of 2009 GHG emissions for Academic and Research areas are attributed to electricity purchased from TVA, as shown in Table 4.6 below. This is the result of the amount of electricity purchased from NES and the mix of electricity generation methods employed by TVA[25].

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65% of previous column) ($MTCO_2E$)
2005	294,070,522	223,343	145,173
2006	294,494,256	223,664	145,382
2007	287,734,887	218,531	142,045
2008	307,162,163	229,640	149,266
2009	305,308,699	180,553	117,359

Table 4.6 GHG Emissions from Purchased Electricity for Academic and Research Areas, Calendar Years 2005-2009.

Scope 3: Indirect Emission Sources

Vanderbilt's indirect emissions include fuel use by commuters (faculty, staff, and student commuters), fuel use from air travel, and waste disposal. Indirect emissions for Academic and Research Areas for calendar years 2005 through 2009 are displayed below in Table 4.7. As shown in Figure 4.3, GHG emissions from Scope 3 activities have decreased 6.4% in the past 2 years.

[25] TVA's published fuel mix for electrical generation for 2005 through 2008 is as follows: coal (64%), nuclear (29%), and hydroelectric dams (7%). TVA's published fuel mix for 2009 electrical generation is as follows: coal (47%), nuclear (34%), hydroelectric dams (7%), natural gas (6%), and renewable (6%).

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Air Travel Emissions[26] ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions in Academic & Research Areas ($MTCO_2E$)
2005	1,022	5,259	43,010	49,291
2006	1,116	5,259	46,175	52,550
2007	1,150	5,259	49,496	55,905
2008	1,360	5,386	46,476	53,222
2009	1,205	6,944	44,186	52,336

Table 4.7. Academic and Research Area Scope 3 GHG Emissions Sources, Calendar Years 2005-2009.

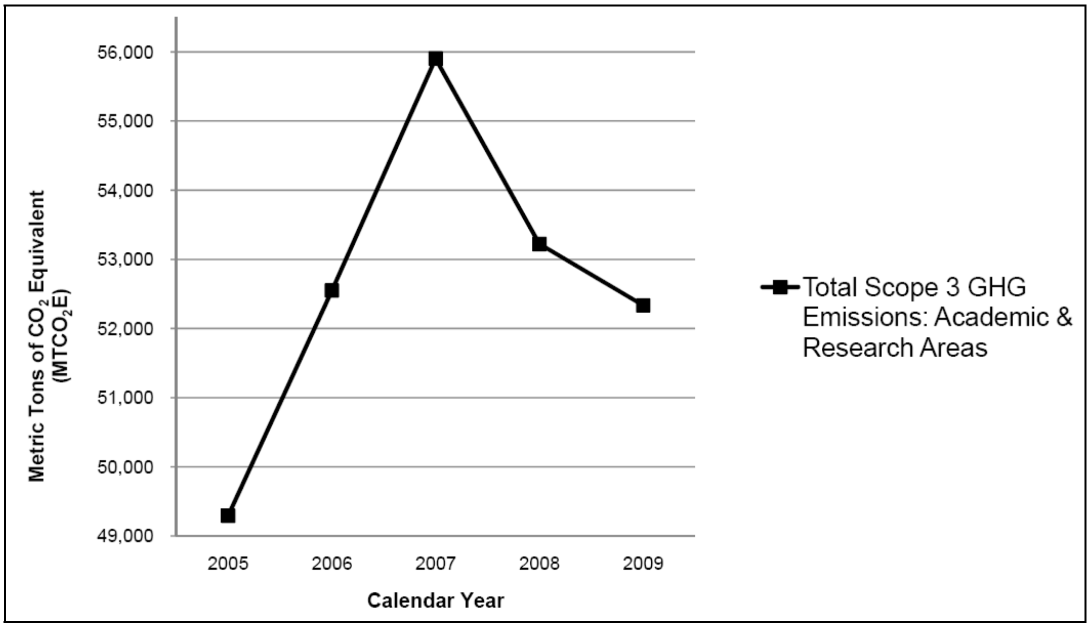

Figure 4.3. Academic and Research Area Scope 3 Emissions, Calendar Years 2005-2009.

Commuter Travel

Faculty and staff in Academic and Research Areas have an average commuting distance of 24 miles (one-way)[27]; for students who do not live on campus, the average one-way commute distance was assumed to be 5 miles. Based on the fuel consumption estimate of 22 miles per gallon (as provided by the Campus Carbon Calculator), Academic and Research commuters consumed 4,855,762 gallons of gasoline and 78,908 gallons of diesel fuel in 2009, resulting in 44,186 $MTCO_2E$ of GHG emissions. See Tables B.15, B.16, and B.17 in the appendices for more details.

[26] Air travel for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.
[27] Average commuting distance established by VUMC Parking and Transportation Services and VU Human Resources.

Air Travel

Vanderbilt University's Procurement Department manages university-sanctioned travel purchased through Caldwell Travel Group. In 2009, 8,939,623 air passenger-miles were traveled. 2009 emissions associated with air travel in Academic and Research areas amounted to 6,944 $MTCO_2E$. See Table B.18 in the appendices for more details.

Waste Management

Waste from Academic and Research areas is landfilled or incinerated. Emissions from waste disposal for Academic and Research areas in 2009 amounted to 1,205 $MTCO_2E$. See Table B.14 in the appendices for more details.

V. PATIENT CARE AREA GREENHOUSE GAS EMISSIONS

Results Summary

Patient care areas at VU encompass hospital buildings and clinical buildings located on Vanderbilt's core 330 acres. Reference Table 3.1 in the Methodology section of this report for a complete listing of buildings included in the patient care area category. Table 5.1 illustrates annual GHG emissions from Patient Care Areas for calendar years 2005 through 2009. For the calendar year 2009, major contributors to the emissions from patient care areas are shown in Figure 5.1.

Calendar Year	GHG Emissions from EPA-Required Sources[28] ($MTCO_2E$)	Other Scope 1 Emissions[29] ($MTCO_2E$)	Scope 2 Emissions ($MTCO_2E$)	Scope 3 Emissions ($MTCO_2E$)	Total GHGs Emitted from Patient Care Areas ($MTCO_2E$)
Patient Care Areas					
2005	53,606	5,864	78,170	41,620	**179,260**
2006	51,178	5,873	78,283	47,215	**182,548**
2007	58,054	5,632	76,486	49,786	**189,958**
2008	58,291	6,817	80,374	44,503	**189,985**
2009	62,565	5,716	63,193	44,420	**175,896**

Table 5.1. GHG Emissions from Patient Care Areas by Type, Calendar Years 2005-2009.

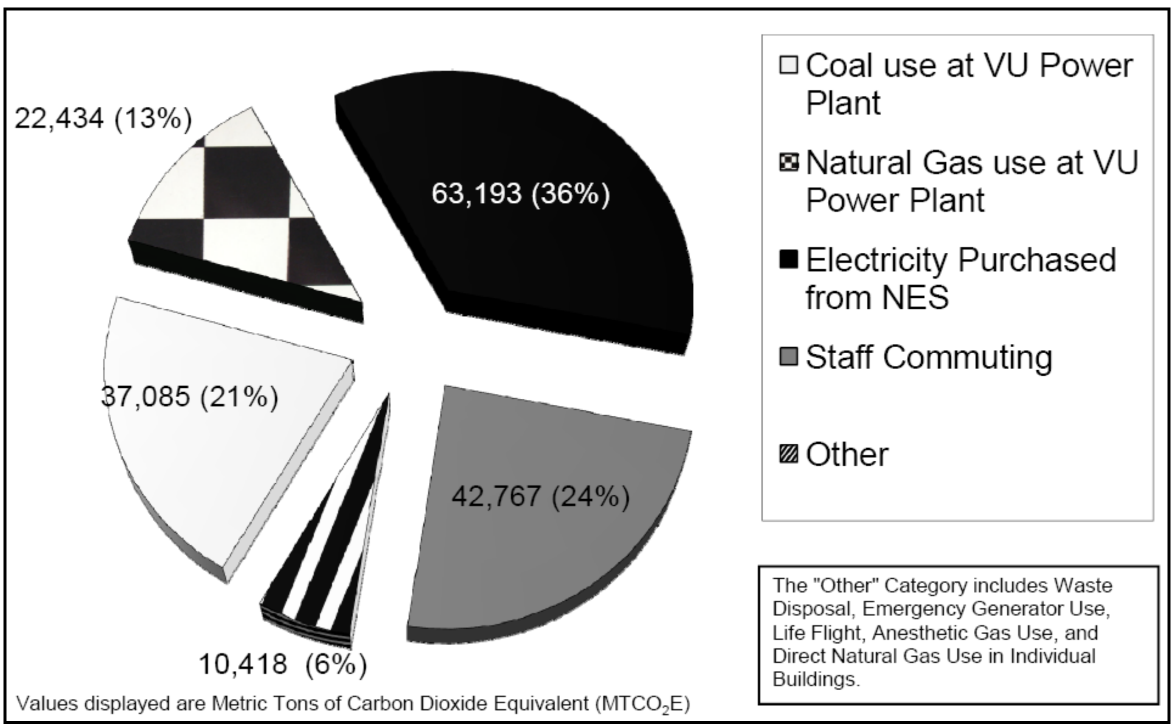

Figure 5.1. GHG Emissions Sources from Patient Care Areas, Calendar Year 2009.

[28] EPA-required sources includes coal-fired boilers, natural gas-fired boilers, and natural gas-fired turbines.
[29] Other Scope 1 Emissions sources includes anesthetic gas use, emergency generators, fleet vehicles, and refrigerant releases.

Figure 5.2 illustrates the contribution from direct emissions (Scope 1), emissions from purchased electricity (Scope 2), and indirect emissions (Scope 3) to overall GHG emissions from Vanderbilt's Patient Care Areas in 2009.

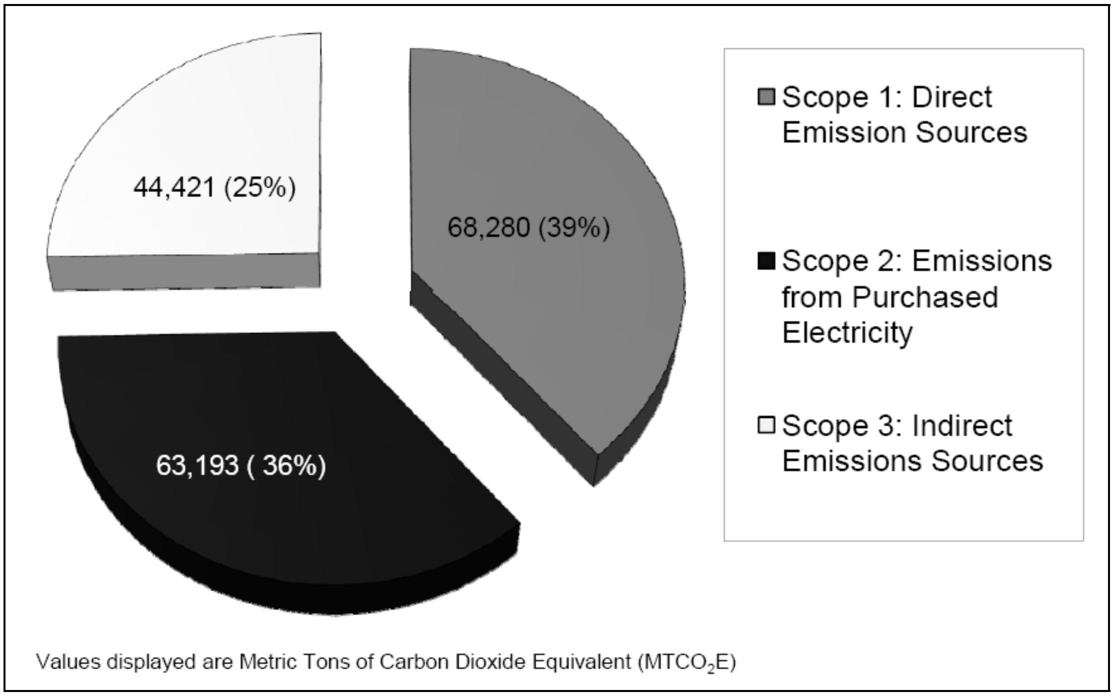

Figure 5.2. GHG Emissions Sources by Scope from Patient Care Areas, Calendar Year 2009.

Vanderbilt University Patient Care Areas were designated according to the criteria outlined in the Methodology section of the report. For Patient Care area populations for 2005-2009, please reference Tables B.17, C.17, D.17, E.17, and F.17 in the appendices.

Scope 1: EPA-Required Emission Sources

The EPA now requires Vanderbilt to report annual GHG emissions from stationary sources which include coal and natural gas consumption at the on-campus, co-generation power plant and consumption of natural gas within individual buildings at Vanderbilt. Individual building monthly steam and electricity usage for calendar years 2005 through 2009 revealed that approximately 35% of the steam and electricity consumed by Vanderbilt was consumed by Patient Care buildings. Therefore, 35% of the GHG emissions associated with the power plant were attributed to Patient Care areas. In 2009, GHG emissions from EPA-required sources for Patient Care Areas amounted to 62,565 $MTCO_2E$, as shown in Table 5.2.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Stationary Sources[30] ($MTCO_2E$)	GHG Emissions from EPA-Required Stationary Sources for Patient Care Areas (35% of previous column) ($MTCO_2E$)
2005	96,478	51,695	4,988	153,161	53,606
2006	99,582	38,485	8,155	146,222	51,178
2007	111,344	48,258	6,268	165,869	58,054
2008	102,172	51,358	13,017	166,547	58,291
2009	105,956	64,096	8,705	178,758	62,565

Table 5.2. Patient Care Area GHG Emissions from EPA-Required Sources, Calendar Years 2005-2009.

Coal and Natural Gas Use at the Power Plant

The on-campus, co-generation power plant burns coal and natural gas to produce electricity, steam, and chilled water for distribution to buildings located on the 330-acre Vanderbilt campus, including patient care buildings. The burning of coal and natural gas releases carbon dioxide, nitrous oxide, and methane. The inventory results illustrate that 37,085 $MTCO_2E$, or 21%, of 2009 emissions associated with Patient Care areas result from coal use at the power plant, while 13%, or 22,434 $MTCO_2E$, of 2009 emissions in Patient Care areas are attributed to the burning of natural gas at the power plant, as illustrated in Table B.1 in the appendices.

Natural Gas Use in Individual Buildings

Several Patient Care buildings use natural gas directly from Vanderbilt's natural gas supplier, Piedmont Natural Gas. The consumption of natural gas within individual Patient Care buildings accounts for 3,047 $MTCO_2E$ of 2009 emissions, as shown in Table B.1 in the appendices.

Scope 1: Other Direct Emission Sources

Vanderbilt's direct emissions sources that are not required to be reported to the EPA include fuel consumption by university-owned vehicles, releases of refrigerants and anesthetic gases, and fuel consumed by emergency generators, as shown in Table 5.3.

[30] Emission factors taken from the EPA's *Mandatory Reporting of Greenhouse Gases; final Rule* [40 CFR Part 98, Subpart C].

Calendar Year	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Fleet Vehicles (Life Flight) ($MTCO_2E$)	Anesthetic Gas Use[31] ($MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	296	189	2,206	3,174	**5,864**
2006	291	397	2,012	3,174	**5,873**
2007	447	131	1,880	3,174	**5,632**
2008	152	0	1,877	4,789	**6,817**
2009	212	0	1,608	3,896	**5,716**

Table 5.3. Patient Care Area Scope 1 Emissions from Other Direct Sources, Calendar Years 2005-2009.

Diesel-Powered Generators

Vanderbilt's Patient Care buildings rely on diesel-powered, emergency generators; these generators release carbon dioxide, nitrous oxide, and methane when in operation. In Patient Care areas, fuel consumed by diesel-powered generators contributed 212 $MTCO_2E$ to 2009 GHG emissions, as referenced in Table 5.3 above.

Refrigerant Releases

Chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances can release hydrofluorocarbons and perfluorocarbons to the atmosphere. In 2009, there were no releases of refrigerant from Patient Care areas, as noted in Table 5.3.

University-Owned Fleet Vehicles

As noted in the Methodology section of this report, annual consumption of fuel by Vanderbilt's LifeFlight helicopters is recorded. As demonstrated in Table 5.4, 2009 GHG emissions from fuel consumption by LifeFlight helicopters amounted to 1,608 $MTCO_2E$.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by Life Flight	168,074	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	1,608

Table 5.4. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2009.

Anesthetic Gas Use

The Department of Anesthesiology utilizes four different types of anesthetic, each with its own GWP and emission factor: Isoflurane, nitrous oxide, Desflurane, and Sevoflurane. See Tables 3.2 and 3.3 in the

[31] Anesthetic gas for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.

Methodology section for more information. In 2009, anesthetic gas use in Patient Care areas resulted in 3,896 $MTCO_2E$ of annual GHG emissions, as referenced in Table 5.5 below.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	6,101	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	1,891
Isoflurane	596	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	209
Desflurane	1,315	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,301
Sevoflurane	1,436	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	496
Total for Anesthesiology/Patient Care Areas			3,896

Table 5.5. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2009[32].

Did You Know…

…VUMC's Multispecialty Anesthesia Division has developed a technology that captures anesthetic gases for reuse? Vanderbilt anesthesiologists James Berry, MD, and Leland Lancaster, MD, were featured in a national news story for their development of the Dynamic Gas Scavenging System, a technology which can have a dramatic impact on both the environment and the economy.

To learn more about the Dynamic Gas Scavenging System and see the national news stories on this innovative technology, visit http://www.vandydreamteam.com/gas_scavenging_system_hits_national_news.

Scope 2: Purchased Electricity Emissions

63,193 $MTCO_2E$, or 36%, of 2009 GHG emissions for Patient Care areas are attributed to electricity purchased from TVA, as shown in Table 5.6 below. This is the result of the amount of electricity purchased from NES and the mix of electricity generation methods employed by TVA.

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35% of previous column) ($MTCO_2E$)
2005	294,070,522	223,343	78,170
2006	294,494,256	223,664	78,283
2007	287,734,887	218,531	76,486
2008	307,162,163	229,640	80,374
2009	305,308,699	180,553	63,193

Table 5.6 GHG Emissions from Purchased Electricity for Patient Care Areas, Calendar Years 2005-2009.

[32] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

Scope 3: Indirect Emissions Sources

Vanderbilt's indirect emissions include commuter fuel use by staff members in patient care buildings and off-site waste disposal. Indirect emissions for patient care areas for calendar years 2005 through 2009 are displayed below in Table 5.7.

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions for Patient Care Areas ($MTCO_2E$)
2005	1,585	40,035	41,620
2006	2,177	45,037	47,215
2007	1,706	48,079	49,786
2008	1,614	42,889	44,503
2009	1,653	42,767	44,420

Table 5.7. Patient Care Area Scope 3 GHG Emissions Sources, Calendar Years 2005-2009.

Figure 5.3 shows a 10% reduction in Scope 3 emissions from Patient Care areas since 2007.

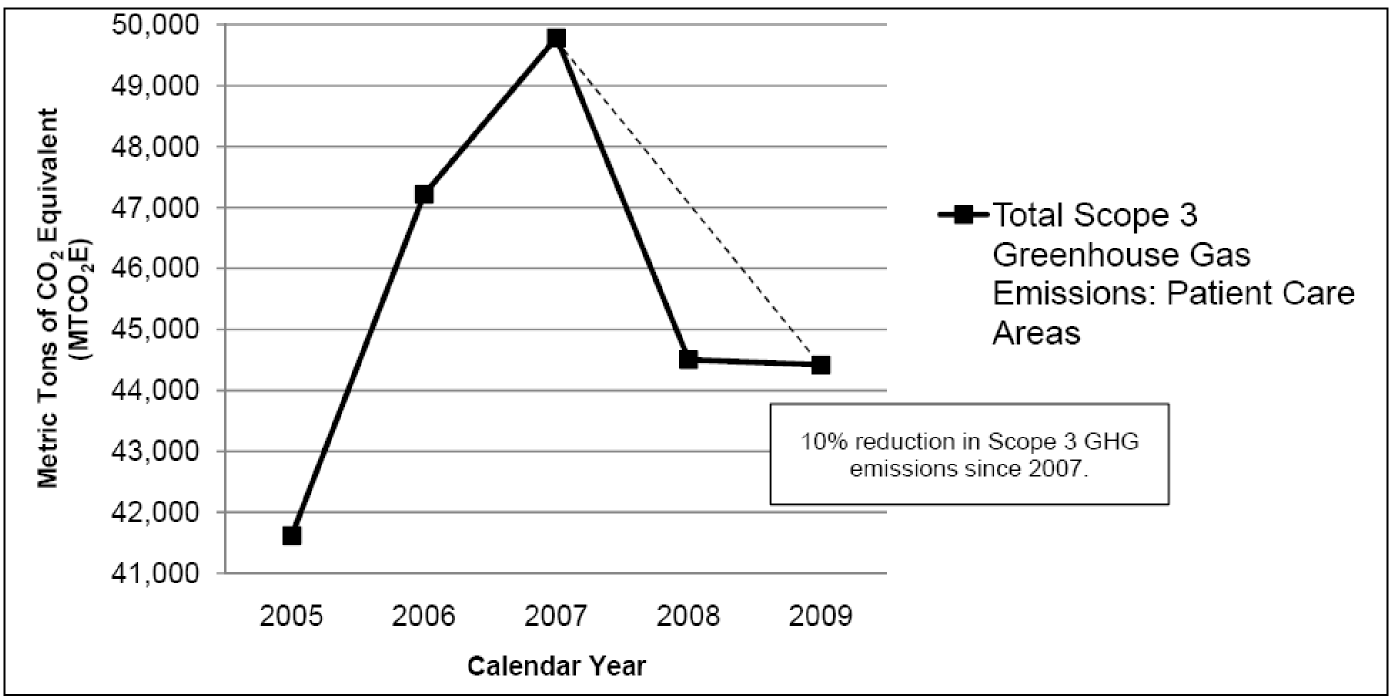

Figure 5.3. Patient Care Area Scope 3 Emissions, Calendar Years 2005-2009.

Commuter Travel

The average commuting distance for a Vanderbilt employee is 24 miles (one-way) [33]. Based on the fuel consumption estimate of 22 miles per gallon (as provided by the Campus Carbon Calculator), Patient Care commuters consumed 4,737,106 gallons of gasoline and 43,500 gallons of diesel fuel per year in 2009, resulting in 42,767 $MTCO_2E$ of GHG emissions. See Tables B.21, B.22, and B.23 in the appendices for more details.

Waste Management

Waste from Patient Care areas is landfilled, incinerated, or autoclaved. Vanderbilt's on-site autoclaves operate on steam provided by the VU co-generation power plant; therefore, the GHG emissions associated with the on-site autoclaves are already included in the EPA-required sources emissions for Patient Care areas. Average yearly emissions for landfilled or incinerated waste disposal from Patient Care areas in 2009 amounted to 1,653 $MTCO_2E$. See Table B.20 in the Appendices for more details.

[33] Average commuting distance established by VUMC Parking and Transportation Services and VU Human Resources.

VI. INVENTORY SUMMARY

Vanderbilt University Emissions Summary

Vanderbilt University's GHG emissions for calendar years 2005 to 2009 are presented in Table 6.1. Total annual GHG emissions for Vanderbilt University during the five-year period of this report reached a maximum of approximately 503,000 $MTCO_2E$ in calendar year 2008 and a minimum of approximately 464,000 $MTCO_2E$ in calendar year 2009, decreasing by 7.8% from the previous year and 2.4% overall since 2005.

Calendar Year	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Total GHGs Emitted by VU ($MTCO_2E$)
2005	296,465	179,260	**475,725**
2006	295,825	182,548	**478,374**
2007	308,604	189,958	**498,562**
2008	313,341	189,985	**503,327**
2009	288,343	175,896	**464,240**

Table 6.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2009.

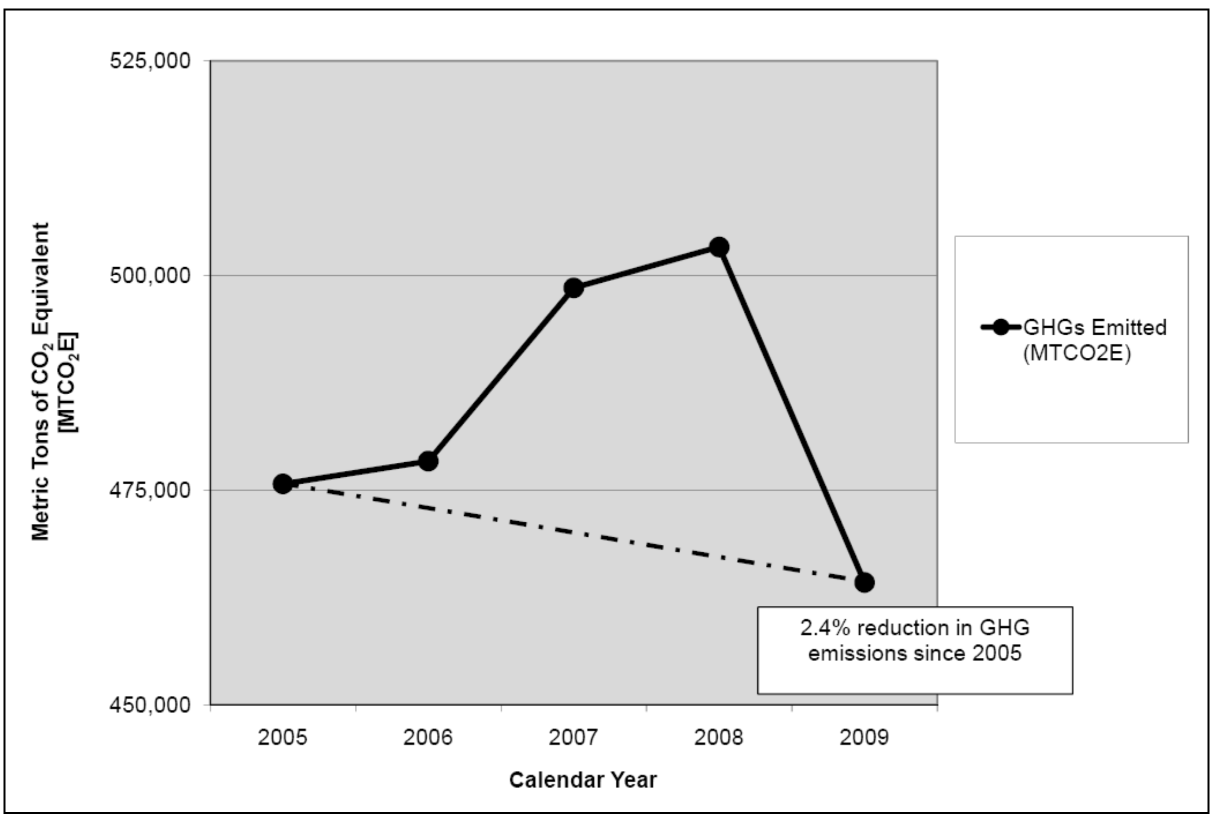

Figure 6.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2009.

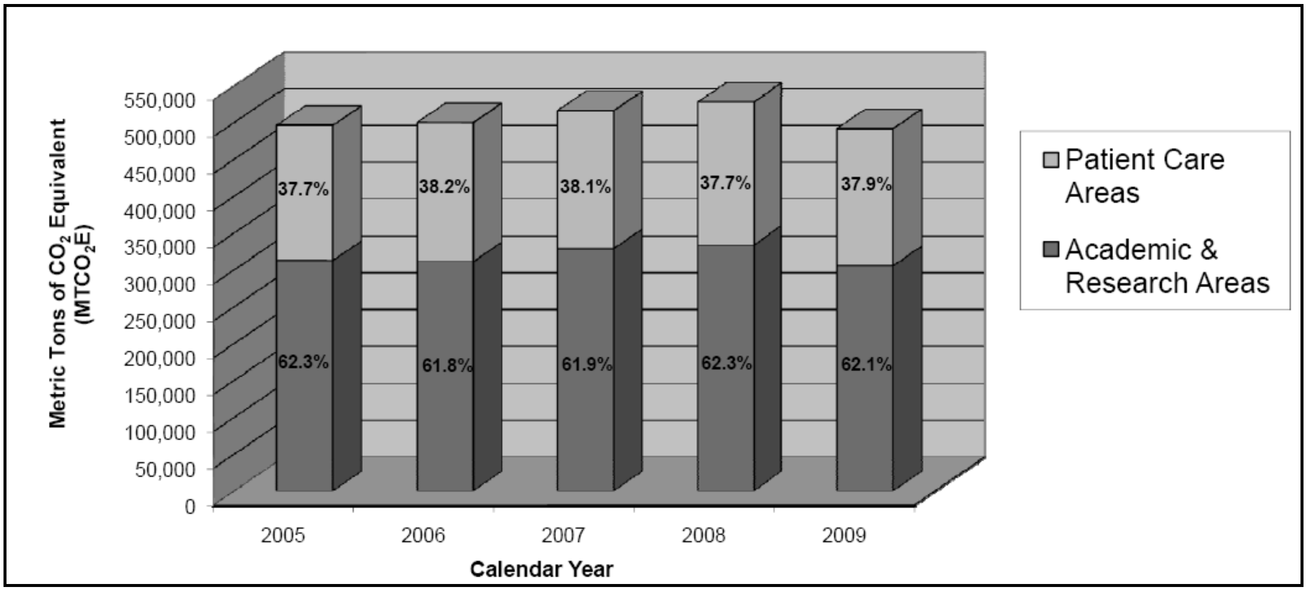

Figure 6.2. Total Vanderbilt GHG Emissions, Calendar Years 2005-2009.

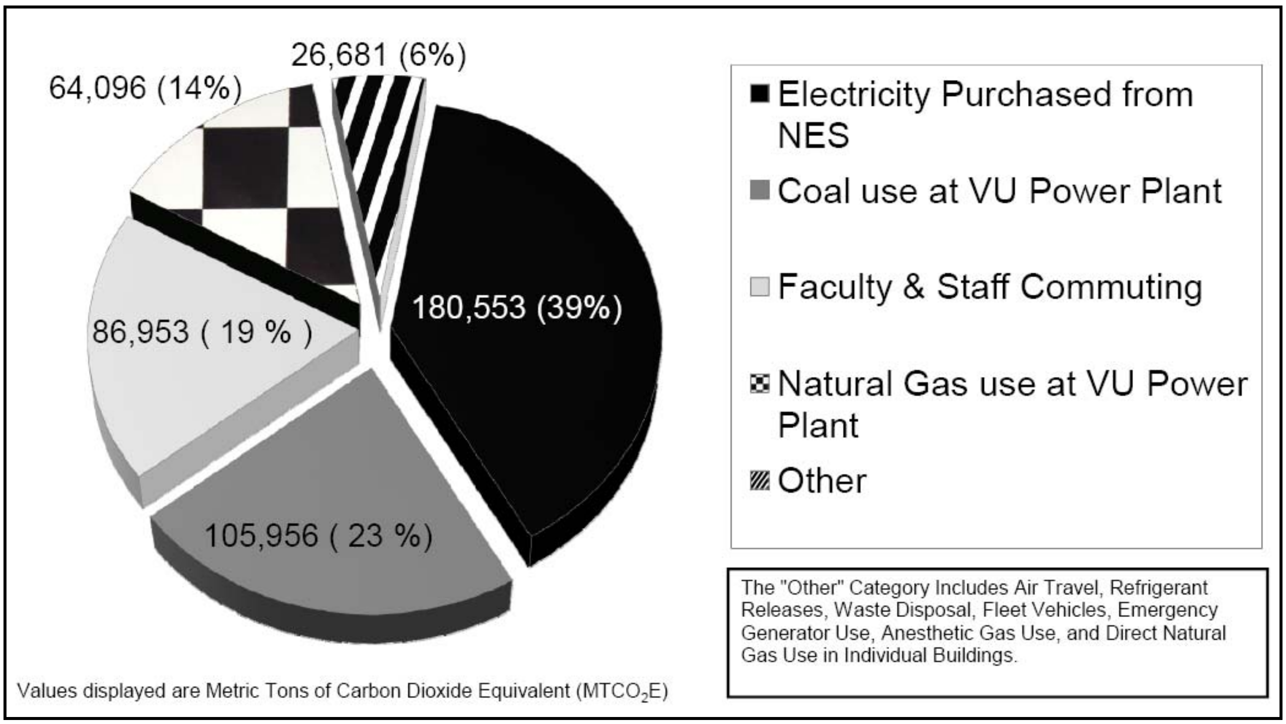

Figure 6.3. GHG Emissions Sources, Calendar Year 2009.

Emissions data from the five year period included in this report indicates that each year, approximately 62% of total GHG emissions are attributable to academic and research areas; the remaining 38% of total GHG emissions are attributable to patient care areas.

Each year, purchased electricity, coal use at the on-campus co-generation power plant, commuter travel, and natural gas use at the on-campus co-generation power plant were the most substantial sources of GHG emissions, accounting for 94-96% of annual GHG emissions from Vanderbilt University. These major sources present the most significant opportunities for improvements in Vanderbilt University's carbon footprint.

Overall GHG emissions typically increase as college campuses grow, even if buildings are being used more efficiently or the campus community is working to conserve resources. It is important to account for this growth when evaluating GHG emissions data by analyzing the emissions data in relation to pertinent institutional metrics, such as campus population, student enrollment, gross square feet of building space, research dollars awarded, or patient visits. Growth of these institutional metrics can have a very positive impact on Vanderbilt and Middle Tennessee, so normalization of GHG emissions based on these metrics can allow for periodic comparisons and evaluation for improvements in efficiency and conservation while also accounting for the growth of the university.

Analysis and Interpretation of 2005-2009 Trending Results

The figures below illustrate Vanderbilt's GHG emissions as they relate to several institutional metrics. Some metrics have been calculated for all Vanderbilt areas (Figures 6.4 and 6.5) whereas others have been calculated separately for Academic and Research areas (Figures 6.6 and 6.7) and Patient Care Areas (Figures 6.8 and 6.9), as applicable. Please reference Tables A.1-A.5 in the appendices for more information.

- Calculating GHG emissions per gross square foot (GSF) of space provides a normalized method of interpreting emissions in light of Vanderbilt's size. Heating and cooling building space, which requires energy, results in significant GHG emissions. A single calculation was made based on all Vanderbilt University populations, totaling over 30,000 persons, including students, faculty, patient care staff, and academic and research staff. For more details please refer to Tables A.3 and A.4 in the appendices. Figure 6.4 shows a significant reduction in GHG emissions per 1,000 GSF over the past five years, even though several large new buildings have been built. The trending results illustrate a 17% improvement in building energy efficiency during this time.
- The size of the student population and faculty/staff population also directly influence the amount of GHGs emitted from Vanderbilt. More individuals on campus result in more building occupants, increased amounts of waste generation, and more commuters. GHG emissions per person have decreased approximately 10% during the past five years as shown in Figure 6.5. GHG emissions per student are down from 26.3 $MTCO_2E$ in 2005 to 23.8 $MTCO_2E$ in 2009 as shown in Figure 6.6. For additional information, please reference Tables A.1, A.3, and A.5 in the appendices.
- Conducting research and operating laboratory facilities require large amounts of energy. Therefore, universities receiving substantial amounts of research dollars (like Vanderbilt) use those dollars to operate laboratories and advanced technology to make scientific discoveries that benefit humankind. These activities can increase GHG emissions on a per-person basis and a per-square-foot basis

because of energy-intensive, research activities. The typical laboratory used four to five times more energy than an equivalent-sized office or classroom[34]. While Vanderbilt University's research awards increased from $455 million in 2005 to $520 in 2009, GHG emissions per 1,000 research dollars decreased 15% as shown in Figure 6.7. For more details, please reference Table A.1 in the appendices.

- Patient care facilities, such as the Vanderbilt University Medical Center, that provide health care 24 hours per day, 7 days per week, 365 days per year, can substantially contribute GHG emissions. Few universities have on-campus patient care activities that match the size and extent of operations of Vanderbilt Medical Center. Thus, calculating GHG emissions per inpatient day and ambulatory visit provides a means of interpreting emissions while considering the quality and magnitude of our medical operations on-campus. GHG emissions per both inpatient days and ambulatory (clinic) visits have trended consistently downward since 2005 as shown in Figures 6.8 and 6.9. For more details, please reference Table A.2 in the appendices.

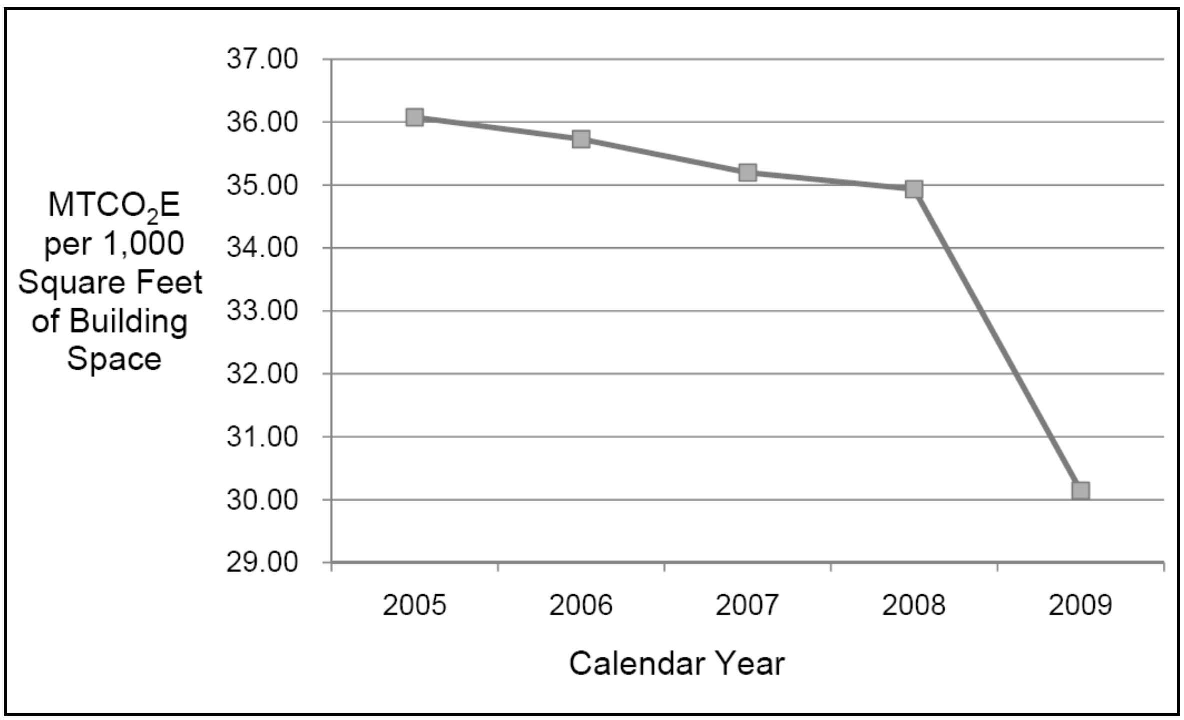

Figure 6.4. Total Vanderbilt GHG Emissions Per 1,000 GSF, Calendar Years 2005-2009.

[34] Avimm, D. (2007). This Man Wants to Green Your Lab. *Science*, v.318, 39-41.

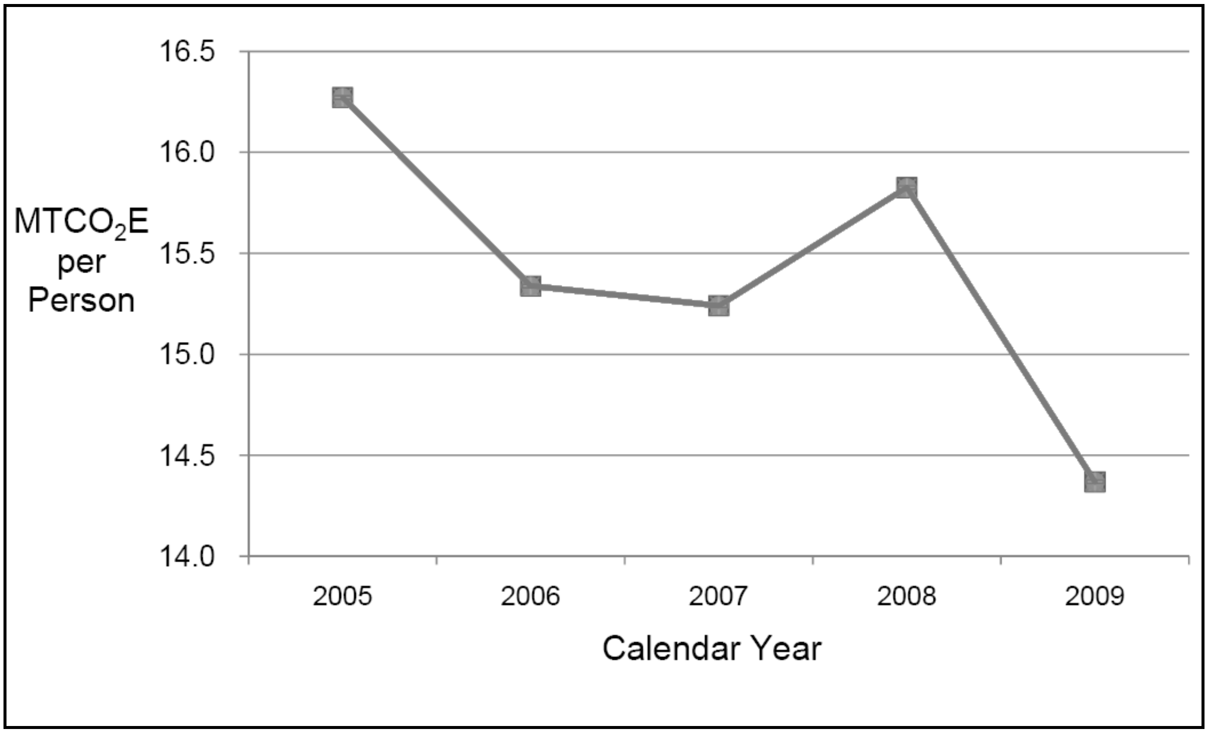

Figure 6.5. Total Vanderbilt GHG Emissions Per Person, Calendar Years 2005-2009.

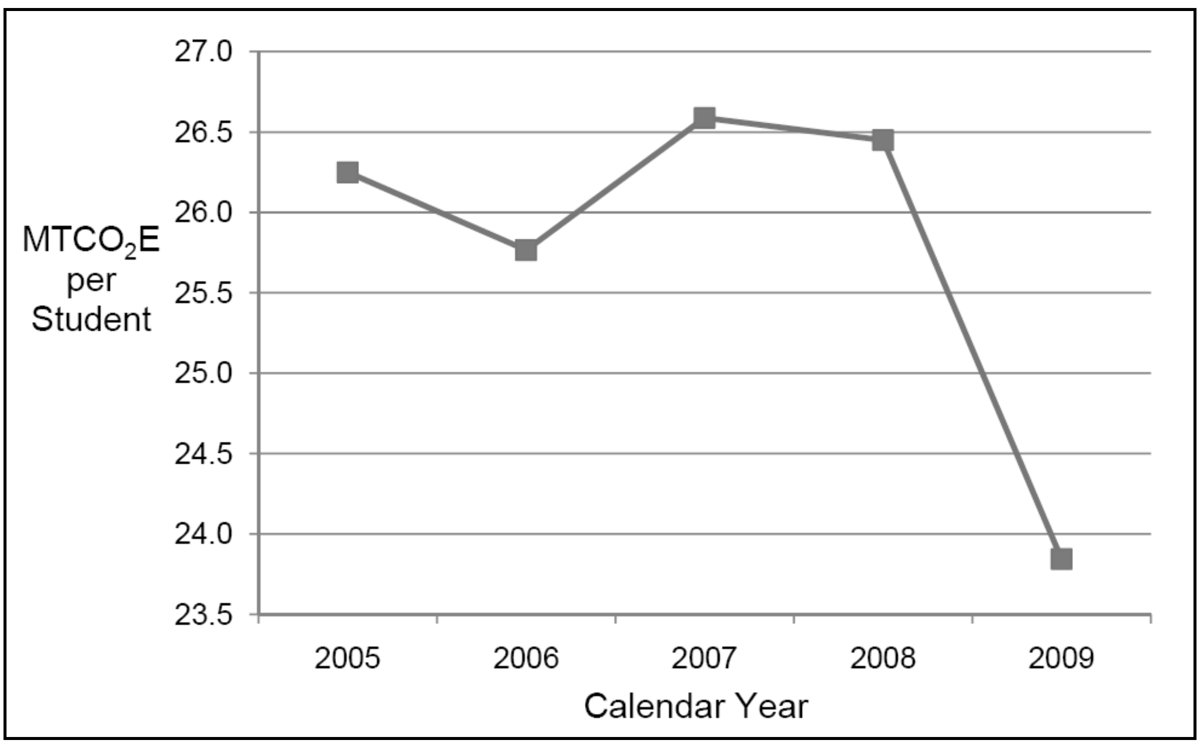

Figure 6.6. Vanderbilt Academic and Research Area GHG Emissions Per Student, Calendar Years 2005-2009.

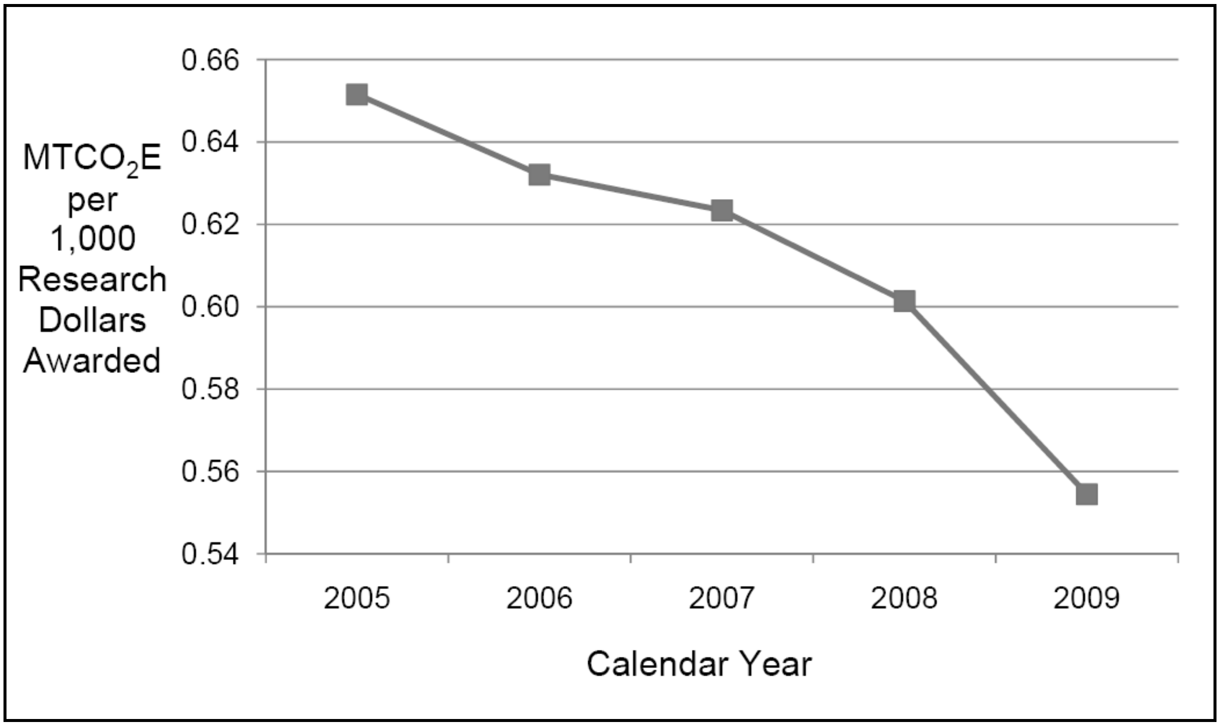

Figure 6.7. Vanderbilt Academic and Research Area GHG Emissions Per 1,000 Research Dollars Awarded, Calendar Years 2005-2009.

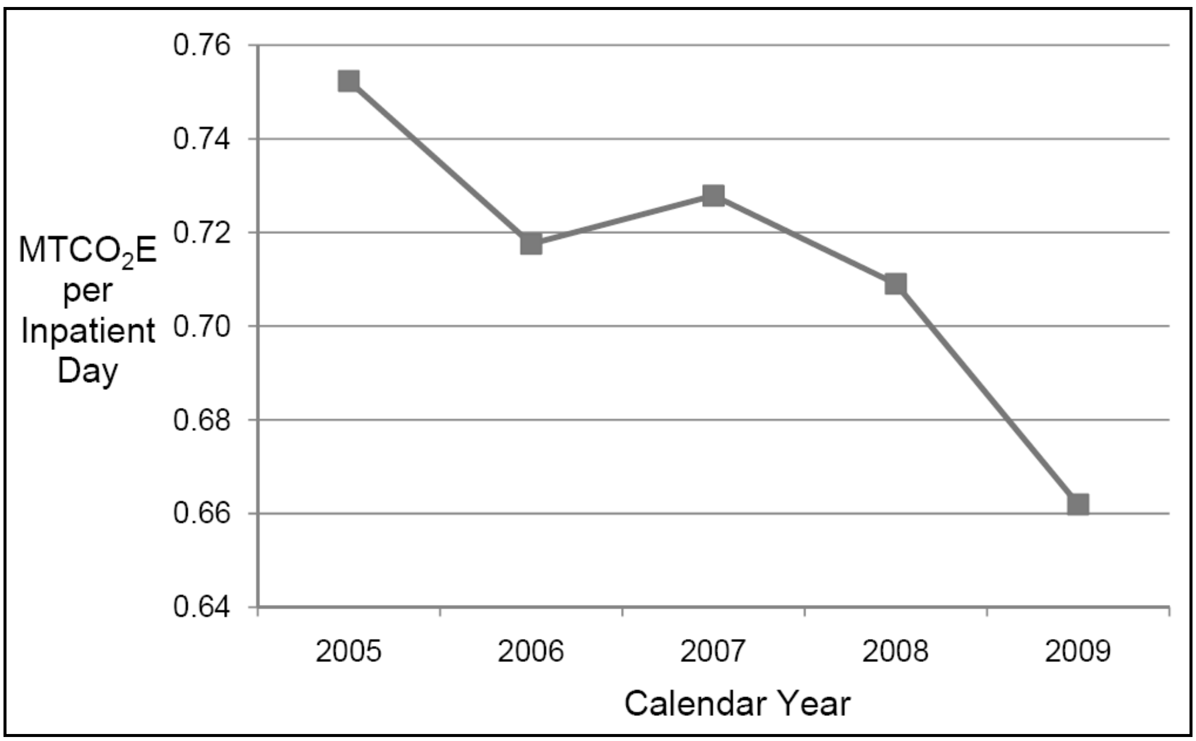

Figure 6.8. Vanderbilt Patient Care Area GHG Emissions Per Inpatient Day, Calendar Years 2005-2009.

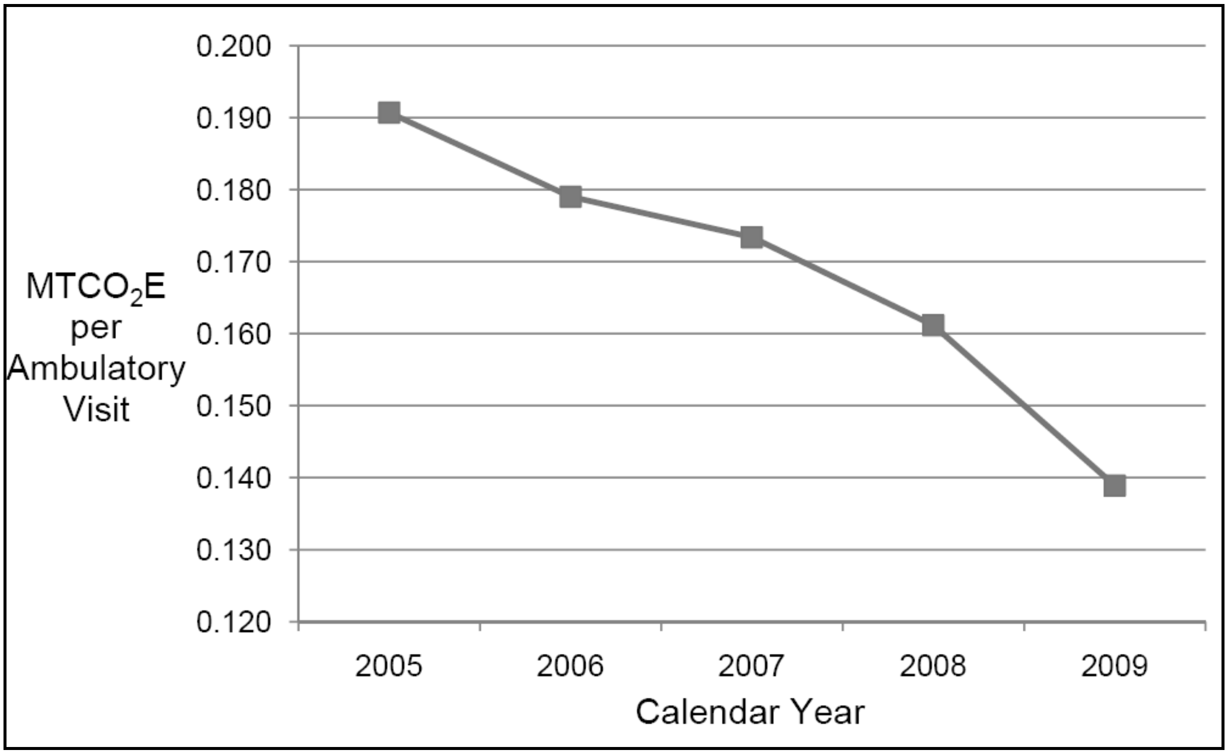

Figure 6.9. Vanderbilt Patient Care Area GHG Emissions Per Ambulatory Visit, Calendar Years 2005-2009.

This five-year analysis illustrates that Vanderbilt University's GHG emissions are trending in the right direction, both overall and when normalized by all important institutional metrics.

Future Plans

This inventory provides historical data and trending information that will enable campus stakeholders to have sufficiently detailed information to make informed decisions to determine reduction strategies and compare future improvements in GHG emissions on campus. The next step in this process will be for Vanderbilt University to develop a written action plan identifying and prioritizing reduction strategies. Subsequent annual calculations of emissions will be conducted in the future to measure progress, which will be made publicly available.

Suggestions on how the university community can reduce its energy consumption can be found at Vanderbilt's ThinkOne web site[35]. Specific energy conservation information for patient care areas, research areas, offices and classrooms, and residence halls can be found at ThinkOne and are a significant, no-cost first step in reducing Vanderbilt's carbon footprint.

[35] The ThinkOne website may be accessed at http://www.vanderbilt.edu/sustainvu/thinkone.

Vanderbilt continues to take significant steps to reduce GHG emissions, such as expanded waste reduction, recycling and commuter support programs (more information can be found on Vanderbilt's SustainVU web site[36]). The SustainVU web site also has information on the university's green building program, Vanderbilt's efforts to improve energy efficiency in existing buildings, and academic research related to GHG emissions. All information related to Vanderbilt's GHG emissions reports and future updates and commitment statement will be publicly available on this site.

Interpreting Vanderbilt's Results Compared to Other Universities

There are over 2,800 colleges and universities offering Bachelor's and Advanced degrees in the United States[37]. Only a small portion of these universities have completed GHG inventory reports and made them publicly available. Thus, Vanderbilt is acting proactively by taking this step. Additionally, most university GHG inventory reports do not include research and/or patient care activity, making Vanderbilt's report more comprehensive than most.

While reports exist for a small number of Vanderbilt's peer institutions, drawing comparisons between universities is difficult. Each school has its own defining characteristics and mix of variables even within the shared, primary emissions' attributes. Thus, the only useful standard to which Vanderbilt can accurately compare its GHG emissions in the years to come is its own previous emissions inventory, utilizing consistent interpretations as presented in this report.

The authors recognize the tendency to place VU's results in context with those of other universities. At Vanderbilt, several factors should be considered when comparing VU's GHG emissions to others:

- 90% of Vanderbilt undergraduate students live in on-campus residence houses, which are supplied with centralized utilities such as chilled water, heat, electricity, and air conditioning. Colleges and universities with larger commuter populations and/or off-campus housing would have potentially smaller Scope 1 emissions and larger Scope 3 emissions.
- Vanderbilt was awarded $520 million[38] in 2009 to conduct scientific and medical research, with a majority of the research occurring in laboratories. Vanderbilt University has over 800 research laboratories which are large consumers of energy through the operation of lab equipment such as fume hoods, biosafety cabinets, computers, and autoclaves (four to five times that of the same size office or classroom[39]).

[36] The SustainVU website may be accessed at http://www.vanderbilt.edu/sustainvu.
[37] Information obtained from the Department of Education's National Center for Education Statistics IPEDS Data Center at http://nces.ed.gov/ipeds/datacenter/Default.aspx on September 10, 2010. Search included public and private 4-year schools awarding Bachelor's and Advanced degrees. Search excluded 2-year schools awarding Certificate and Associate's degrees. Including the latter, there are over 7,000.
[38] According to data found in ReVU: Quick Facts about Vanderbilt. Available http://www.vanderbilt.edu/facts.html.
[39] Avimm, D. (2007). This Man Wants to Green Your Lab. *Science*, v.318, 39-41.

- The Vanderbilt University Medical Center provides regional health care 24 hours per day, 7 days per week, 365 days per year. Very few universities have on-campus patient care that matches the size and extent of operations of Vanderbilt Medical Center. Moreover, universities that *do* have an associated medical center (such as University of North Carolina – Chapel Hill and University of Pennsylvania) excluded their medical centers from their GHG inventory. Due to Vanderbilt's inability to pro-rate out its distribution of centralized utilities and its on-site, co-generated power, an omission of patient care buildings was not seen as appropriate.

As discussed above, the most common methods for successfully reporting GHG emissions is to analyze GHG emissions based on institutional metrics (GSF, full-time student enrollment, total campus population, research awards, inpatient days, and ambulatory visits). Because efforts to draw comparisons are inevitable, we attempted to determine how Vanderbilt's calendar year 2009 GHG emissions compared from the limited number of colleges and universities having such data available (as listed in Table 6.2); these universities were selected based upon one or more of the following measures:

- The university completed and published a GHG inventory;
- Similar climate and/or geographic location;
- Similar operational size;
- Similar campus population size;
- Similar activities (i.e., research and patient care);
- Inclusion of Scope 1, Scope 2 and Scope 3 emissions sources; and/or
- Comprehensiveness of emissions inventory.

Additional information on the peer institutions listed below is provided in Table A.13 in the appendices.

University	Total Emissions ($MTCO_2E$)	Emissions per 1,000 Square Feet	Emissions per Student	Emissions per Person on Campus	Emissions per $1,000 Research Awarded
University of Michigan[40]	592,000	19.1	14.8	7.6	0.58
Duke University[41]	433,961	31.2	34.1	9.5	0.79
Emory University[42]	419,231	46.6	25.4	20.4	1.19
Washington University – St. Louis[43]	409,500	28.0	29.8	24.2	0.72
University of Pennsylvania[44]	355,829	29.9	18.0	8.8	0.42
Vanderbilt University – Academic & Research Areas Only[45]	288,343	31.3	23.8	12.7	0.55

Table 6.2. Comparison of Vanderbilt University GHG Emissions with Other Universities.

As previously mentioned, conducting research and operating laboratory facilities require large amounts of energy. Schools receiving substantial amounts of research awards (like Vanderbilt) use those dollars to operate laboratories and advanced technology to make scientific discoveries that benefit humankind. These activities can increase GHG emissions on a per-person basis and a per-square-foot basis because of energy-intensive, research activities. When compared to other major research institutions, Vanderbilt's GHG emissions compare quite well and are 50% less than Emory University. Figure 6.10 illustrates emissions per $1,000 in research awarded to Vanderbilt University in relation to several other research entities.

[40] GHG emissions, GSF, and student, faculty, and staff populations for FY 2009 retrieved from http://www.oseh.umich.edu/pdf/09_report.pdf. 2008-2009 research expenditures from http://mmd.umich.edu/forum/michigan.php.

[41] GHG emissions and GHG emissions per 1,000 GSF for 2007 retrieved from http://sustainability.duke.edu/climate_action/inventory.php. Student population from 2007 retrieved from http://library.duke.edu/uarchives/history/duke_statistics.html. 2009 employment data retrieved from http://www.dukenews.duke.edu/resources/quickfacts.html was utilized because 2007 employment data could not be located. Research awards for FY 2007 retrieved from Duke's 2007 financial report at https://finance.duke.edu/resources/docs/financial_reports08.pdf.

[42] GHG emissions, GSF, and student, faculty, and staff populations for FY 2007 retrieved from http://sustainability.emory.edu/uploads/press/2010/03/2010031214250142/GHG_Executive_Summary.pdf. Research awards for FY 2007 retrieved from Emory's 2007 Annual Report at http://www.emory.edu/president/documents/annualreport.2007.pdf.

[43] GHG emissions, GHG emissions per 1,000 GSF, and GHG emissions per person for FY 2009 retrieved from http://www.wustl.edu/initiatives/sustain/assets/GHGEmissions.pdf. Student population for 2009 retrieved from http://www.wustl.edu/about/facts/students/index.html. Research awards for 2008-2009 retrieved from http://www.wustl.edu/about/facts/rankings/index.html.

[44] GHG emissions, GSF, and student, faculty, and staff populations for 2009 from ACUPCC's website at http://acupcc.aashe.org/ghg/258/. Sponsored projects as of December 2009 retrieved from http://www.upenn.edu/about/facts.php.

[45] GHG emissions for CY 2009 from academic and research areas only. 2009 research dollars awarded.

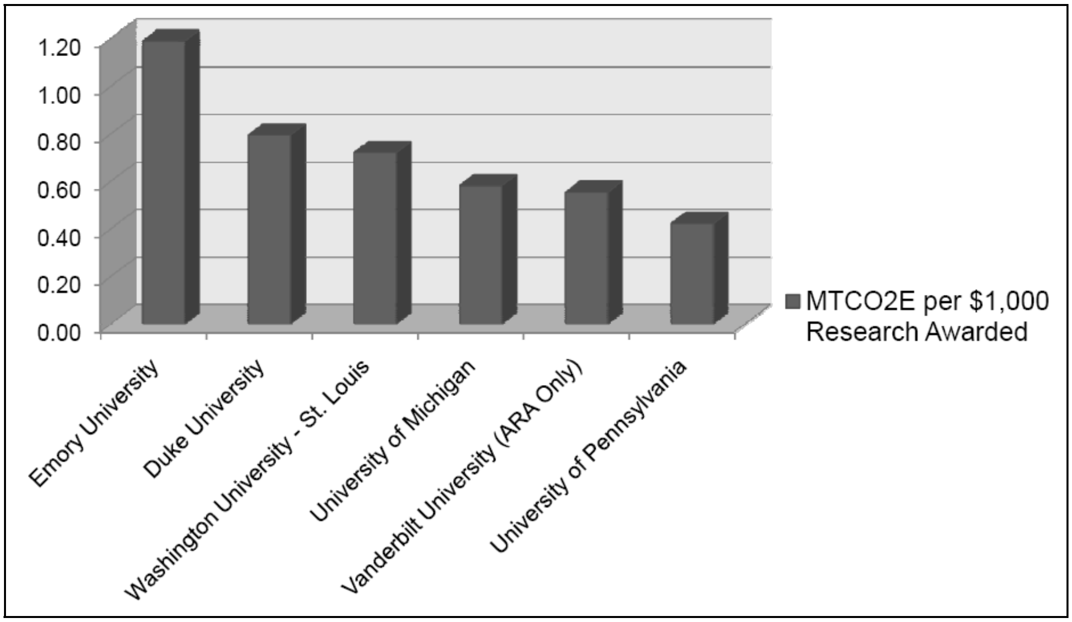

Figure 6.10. Comparison of Vanderbilt University GHG Emissions with Other Universities, by Research Dollars Awarded.

Vanderbilt University recognizes its comparisons to peers; however, GHG inventory reports have been completed and made publicly available for only a small number of universities. Moreover, many GHG inventory reports do not include research and/or patient care activity, making Vanderbilt's report more inclusive than most that have been published. Direct evaluations between universities are challenging, as each school possesses unique qualities and features and as there is currently no standardized methodology for calculating university carbon footprints. Therefore, our own emissions presented in this report provide the only applicable standard to which Vanderbilt can assess its GHG emissions in the years to come.

VII. APPENDIX A: 2005-2009 Report Data and Calculations

Calendar Year	GHG Emissions from Academic & Research Areas ($MTCO_2E$)	Gross Square Feet (GSF) - Academic & Research Areas	GHG Emissions per 1,000 GSF	Number of Students	GHG Emissions Per Student	Millions of Research dollars Awarded[46]	GHG Emissions per $1,000 Research Awarded
2005	296,465	8,228,419	36.0	11,294	26.2	$455	0.65
2006	295,825	8,416,644	35.1	11,481	25.8	$468	0.63
2007	308,604	9,039,821	34.1	11,607	26.6	$495	0.62
2008	313,341	9,165,093	34.2	11,847	26.4	$521	0.60
2009	288,343	9,208,635	31.3	12,093	23.8	$520	0.55

Table A.1. GHG Normalization Metrics for Academic & Research Areas, Calendar Years 2005-2009.

Calendar Year	GHG Emissions from Patient Care Areas	GSF – Patient Care Areas	GHG Emissions per 1,000 GSF	Inpatient Days[47]	GHG Emissions per Inpatient Days	Ambulatory Visits[47]	GHG Emissions per Ambulatory Visits
2005	179,260	4,957,823	36.2	238,266	0.75	940,018	0.191
2006	182,548	4,972,220	36.7	254,396	0.72	1,019,715	0.179
2007	189,958	5,124,754	37.1	260,977	0.73	1,095,559	0.173
2008	189,985	5,243,043	36.2	267,947	0.71	1,178,841	0.161
2009	175,896	6,192,303	28.4	265,733	0.66	1,266,255	0.139

Table A.2. GHG Normalization Metrics for Patient Care Areas, Calendar Years 2005-2009.

Calendar Year	Total GHG Emissions	Total GSF	GHG Emissions per 1,000 GSF	Total VU Population	GHG Emissions per Person
2005	475,725	13,186,242	36.08	29,237	16.3
2006	478,374	13,388,864	35.73	31,189	15.3
2007	498,562	14,164,575	35.20	32,712	15.2
2008	503,327	14,408,136	34.93	31,805	15.8
2009	464,240	15,400,938	30.14	32,308	14.4

Table A.3. GHG Normalization Metrics for Vanderbilt University, Calendar Years 2005-2009.

Calendar Year	Students[48]	Faculty[49]	Academic & Research Staff[50]	Academic & Research Population (students + faculty + staff)	Patient Care Staff[51]	Total On-Campus Population
2005	11,294	2,861	6,542	20,697	8,540	29,237
2006	11,481	3,004	7,097	21,582	9,607	31,189
2007	11,607	3,222	7,627	22,456	10,256	32,712
2008	11,847	3,358	7,073	22,278	9,527	31,805
2009	12,093	3,526	7,102	22,721	9,587	32,308

Table. A.4. Population Data Used for Normalization Metrics, Calendar Years 2005-2009.

46 According to 2005-2009 research information found in ReVU: Quick Facts about Vanderbilt. Each year, the previous year's data is replaced with data from the most current year. Email SustainVU@vanderbilt.edu for more information.
47 VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
48 VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
49 VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
50 Calculated using data from VU Human Resources (employees by Building, Academic and Research Staff).
51 Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Calendar Year	Academic GSF	Patient Care GSF	Total GSF
2005	8,228,419	4,957,823	13,186,242
2006	8,416,644	4,972,220	13,388,864
2007	9,039,821	5,124,754	14,164,575
2008	9,165,093	5,243,043	14,408,136
2009	9,208,635	6,192,303	15,400,938

Table A.5. GSF Data Used for Normalization Metrics, Calendar Years 2005-2009.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Sources ($MTCO_2E$)
2005	96,478	51,695	4,988	153,161
2006	99,582	38,485	8,155	146,222
2007	111,344	48,258	6,268	165,869
2008	102,172	51,358	13,017	166,547
2009	105,956	64,096	8,705	178,758

Table A.6. Total VU GHG Emissions from EPA-Required Sources, Calendar Years 2005-2009.

Calendar Year	Academic and Research Areas (65% of total EPA-required sources emissions) ($MTCO_2E$)	Patient Care Areas (35% of total EPA-required sources emissions) ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Sources ($MTCO_2E$)
2005	99,554	53,606	153,161
2006	95,045	51,178	146,222
2007	107,815	58,054	165,869
2008	108,255	58,291	166,547
2009	116,192	62,565	178,758

Table A.7. Allocation of GHG Emissions from EPA-Required Sources to Academic and Research Areas and Patient Care Areas, Calendar Years 2005-2009.

Calendar Year	Fleet Vehicles ($MTCO_2E$)	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Anesthetic Gas Use[52] $MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	1,609	550	286	1	2,446
2006	1,968	541	338	1	2,848
2007	1,870	830	137	1	2,838
2008	2,159	282	143	14	2,598
2009	2,013	394	35	14	2,455

Table A.8. Academic and Research Area Scope 1 Emissions from Other Sources, Calendar Years 2005-2009.

[52] Anesthetic Gas for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.

Calendar Year	Fleet Vehicles (Life Flight) ($MTCO_2E$)	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Anesthetic Gas Use[53] ($MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	2,206	296	189	3,174	5,864
2006	2,012	291	397	3,174	5,873
2007	1,880	447	131	3,174	5,632
2008	1,877	152	0	4,789	6,817
2009	1,608	212	0	3,896	5,716

Table A.9. Patient Care Area Scope 1 Emissions from Other Sources, Calendar Years 2005-2009.

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65% of total scope 2 emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35% of total scope 2 emissions) ($MTCO_2E$)
2005	294,070,522	223,343	145,173	78,170
2006	294,494,256	223,664	145,382	78,283
2007	287,734,887	218,531	142,045	76,486
2008	307,162,163	229,640	149,266	80,374
2009	305,308,699	180,553	117,359	63,193

Table A.10. GHG Emissions from Purchased Electricity, Calendar Years 2005-2009[54].

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Air Travel Emissions[55] ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions: Academic & Research Areas ($MTCO_2E$)
2005	1,022	5,259	43,010	49,291
2006	1,116	5,259	46,175	52,550
2007	1,150	5,259	49,496	55,905
2008	1,360	5,386	46,476	53,222
2009	1,205	6,944	44,186	52,336

Table A.11. Scope 3 Emissions from Academic and Research Areas, Calendar Years 2005-2009.

[53] Anesthetic Gas for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.
[54] TVA's published fuel mix for electrical generation for 2005-2008 is as follows: Coal (64%), Nuclear (29%), and Hydroelectric Dams (7%). TVA's published fuel mix for electrical generation for 2009 is as follows: Coal (47%), Nuclear (34%), Hydroelectric Dams (7%), Natural Gas (6%), and Renewables (6%). Vanderbilt's academic and research areas account for 65% of Vanderbilt's energy usage, while patient care areas account for 35% of Vanderbilt's energy usage, based on electricity and steam distribution data for the 2005-2009 calendar years.
[55] Air travel for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions: Patient Care Areas ($MTCO_2E$)
2005	1,585	40,035	41,620
2006	2,177	45,037	47,215
2007	1,706	48,079	49,786
2008	1,614	42,889	44,503
2009	1,653	42,767	44,420

Table A.12. Scope 3 Emissions from Patient Care Areas, Calendar Years 2005-2009.

University	Total Emissions ($MTCO_2E$)	GSF	Number of Students	Campus Population	Millions of Research Dollars Awarded
University of Michigan[56]	592,000	31,000,000	40,000	78,000	$1,017
Duke University[57]	433,961	Not reported	12,741	45,589	$546
Emory University[58]	419,231	9,000,000	16,492	20,566	$353
Washington University – St. Louis[59]	409,500	Not reported	13,761	Not reported	$567
University of Pennsylvania[60]	355,829	11,912,086	19,816	40,486	$843
Vanderbilt University – Academic & Research Areas Only[61]	288,343	9,208,635	12,093	22,721	$520

Table A.13. GHG Emissions and Related Metrics Reported by other Universities.

[56] GHG emissions, GSF, and student, faculty, and staff populations for FY 2009 retrieved from http://www.oseh.umich.edu/pdf/09_report.pdf. 2008-2009 research expenditures from http://mmd.umich.edu/forum/michigan.php.

[57] GHG emissions and GHG emissions per 1,000 GSF for 2007 retrieved from http://sustainability.duke.edu/climate_action/inventory.php. Student population from 2007 retrieved from http://library.duke.edu/uarchives/history/duke_statistics.html. 2009 employment data retrieved from http://www.dukenews.duke.edu/resources/quickfacts.html was utilized because 2007 employment data could not be located. Research awards for FY 2007 retrieved from Duke's 2007 financial report at https://finance.duke.edu/resources/docs/financial_reports08.pdf.

[58] GHG emissions, GSF, and student, faculty, and staff populations for FY 2007 retrieved from http://sustainability.emory.edu/uploads/press/2010/03/2010031214250142/GHG_Executive_Summary.pdf. Research awards for FY 2007 retrieved from Emory's 2007 Annual Report at http://www.emory.edu/president/documents/annualreport.2007.pdf.

[59] GHG emissions, GHG emissions per 1,000 GSF, and GHG emissions per person for FY 2009 retrieved from http://www.wustl.edu/initiatives/sustain/assets/GHGEmissions.pdf. Student population for 2009 retrieved from http://www.wustl.edu/about/facts/students/index.html. Research awards for 2008-2009 retrieved from http://www.wustl.edu/about/facts/rankings/index.html.

[60] GHG emissions, GSF, and student, faculty, and staff populations for 2009 from ACUPCC's website at http://acupcc.aashe.org/ghg/258/. Sponsored projects as of December 2009 retrieved from http://www.upenn.edu/about/facts.php.

[61] GHG emissions for CY 2009 from academic and research areas only. 2009 research dollars awarded.

VI. APPENDIX B: 2009 Calendar Year Data and Calculations

Source	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$)
EPA-Required Sources			
Coal use at VU Power Plant	68,871	37,085	105,956
Natural Gas use at VU Power Plant	41,663	22,434	64,096
Natural Gas use in Individual Buildings	5,658	3,047	8,705
Subtotal of EPA-Required Emissions:	116,192	62,565	178,757
Other Scope 1 Emissions Sources			
Diesel-Powered Generators	394	212	606
Refrigerant Releases	35	0	35
Fleet Vehicles	2,013	1,608	3,621
Anesthetic Gas Use	14	3,896	3,910
Subtotal of Other Scope 1 Emissions:	2,455	5,716	8,171
Scope 2 GHG Emissions: Electricity Purchases			
Electricity Purchased from NES	117,359	63,193	180,553
Scope 3 GHG Emissions: Indirect Sources			
Faculty & Staff Commuting	44,186	42,767	86,953
Air Travel	6,944	-	6,944
Waste Disposal	1,205	1,653	2,858
Subtotal of Scope 3 Emissions:	52,336	44,420	96,756
Total emissions associated with each area per year:	**288,343**	**175,896**	**464,240**

Table B.1. Total Vanderbilt GHG Emissions, Calendar Year 2009.

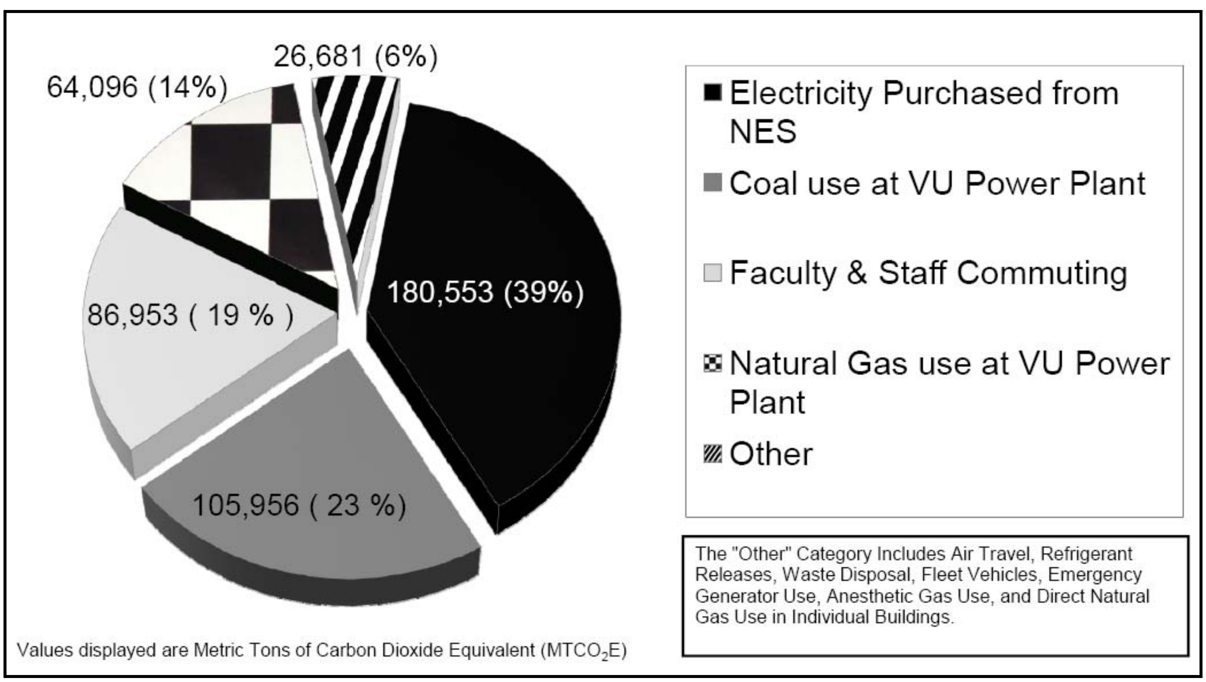

Figure B.1. Vanderbilt GHG Emissions Sources, Calendar Year 2009.

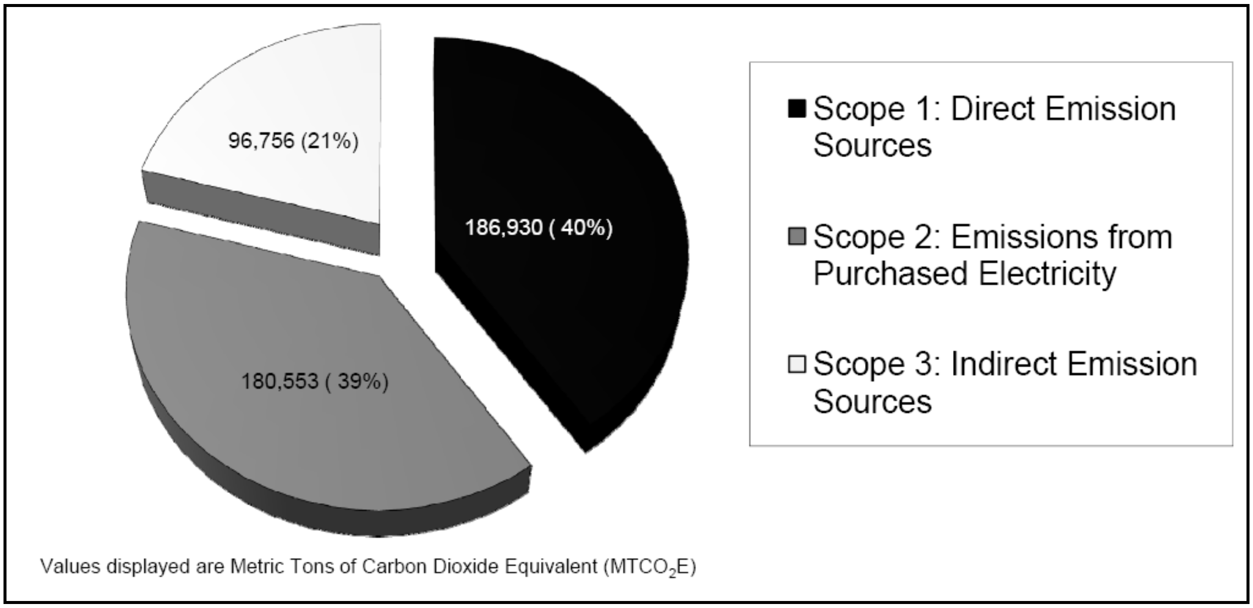

Figure B.2. Vanderbilt GHG Emissions Sources by Scope, Calendar Year 2009.

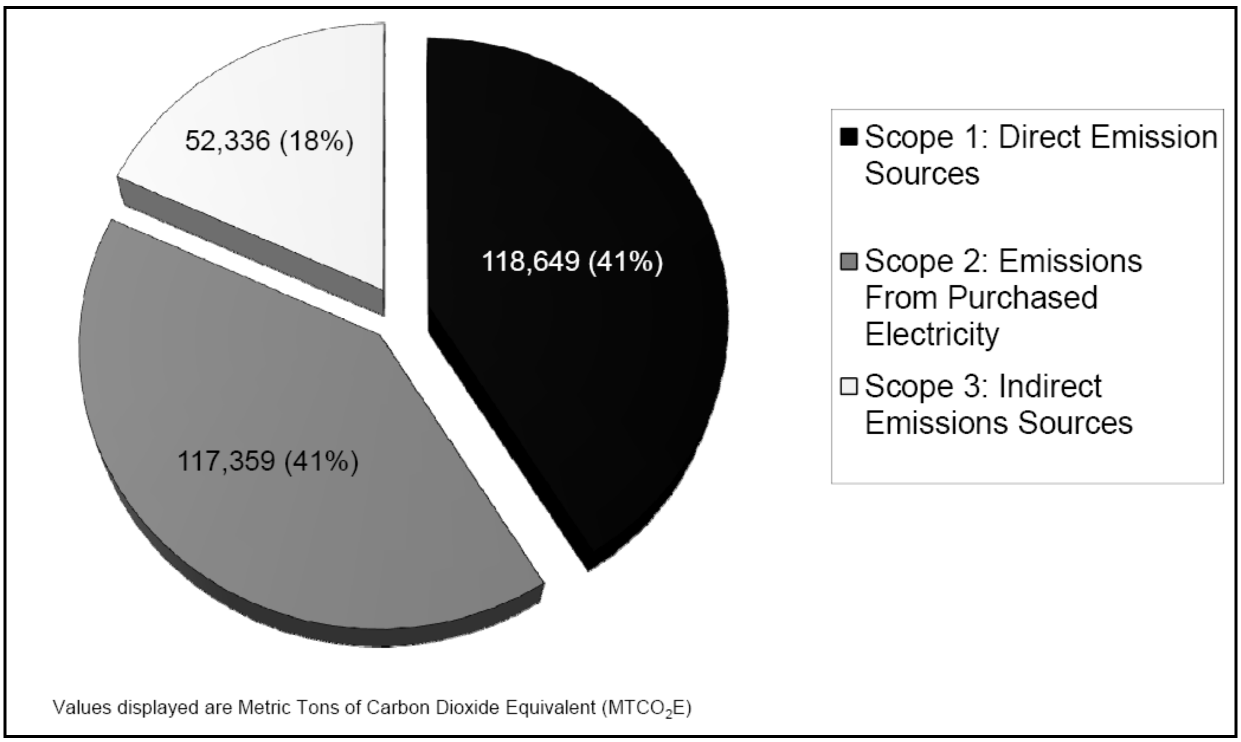

Figure B.3. Vanderbilt Academic and Research Area GHG Emissions Sources by Scope, Calendar Year 2009.

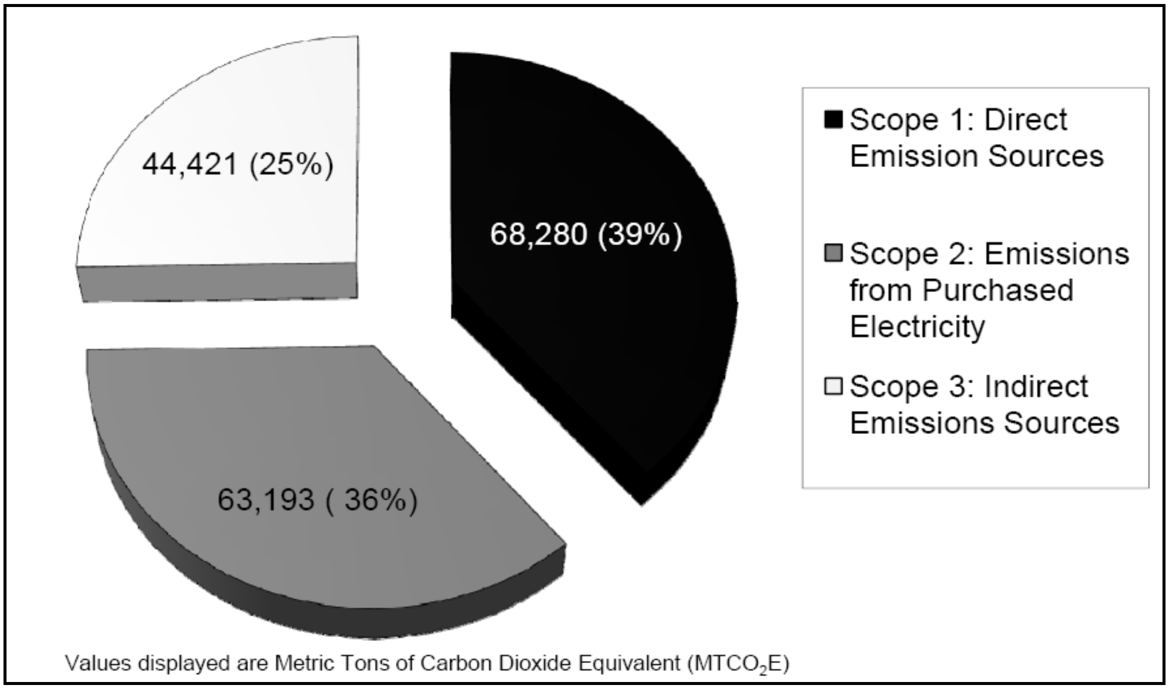

Figure B.4. Vanderbilt Patient Care Area GHG Emissions Sources by Scope, Calendar Year 2009.

GHG Emissions from On-Campus Coal Combustion at the Co-Generation Power Plant					
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
62,873	0.001	17.25	97.02		105,224
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
62,873	0.001	17.25	0.01	11	228
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
62,873	0.001	17.25	0.0015	2	504
Total GHG Emissions from On-Campus Coal Combustion ($MTCO_2E$):					**105,956**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Coal Combustion (65% of total emissions) ($MTCO_2E$):					**68,871**
Patient Care Area Emissions from On-Campus Coal Combustion (35% of total emissions) ($MTCO_2E$):					**37,085**

Table B.2. Calculations for GHG Emissions from On-Campus Coal Combustion, Calendar Year 2009[62].

[62] Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Coal Combustion: Coal (tons) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Tons of Coal listed is the same amount reported in Vanderbilt's 2009 Annual Air Emissions Report.

GHG Emissions from Natural Gas Combustion at the Co-Generation Power Plant					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
951,000,000	0.001	0.00127	53.02		64,036
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
951,000,000	0.001	0.00127	0.0009	1.1	22.8
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
951,000,000	0.001	0.00127	0.0001	0.1	37.4
Total GHG Emissions from On-Campus Natural Gas Combustion ($MTCO_2E$):					**64,096**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Natural Gas Combustion (65% of total emissions) ($MTCO_2E$):					**41,663**
Patient Care Area Emissions from On-Campus Natural Gas Combustion (35% of total emissions) ($MTCO_2E$):					**22,434**

Table B.3. Calculations for GHG Emissions from On-Campus Natural Gas Combustion at the Co-Generation Power Plant, Calendar Year 2009[63].

GHG Emissions from Natural Gas Consumption in Individual Buildings					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
129,161,300	0.001	0.00127	53.02		8,697
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
129,161,300	0.001	0.00127	0.0009	0.148	3.1
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
129,161,300	0.001	0.00127	0.0001	0.016	5.1
Total GHG Emissions from Natural Gas Combustion in Buildings ($MTCO_2E$):					**8,705**
Partitioning of Emissions					
Academic & Research Area Emissions from Natural Gas Consumption in Buildings (65% of total emissions) ($MTCO_2E$):					**5,658**
Patient Care Area Emissions from On-Campus Natural Gas Consumption in Buildings (35% of total emissions) ($MTCO_2E$):					**3,047**

Table B.4. Calculations for GHG Emissions from On-Campus Natural Gas Consumption in Individual Buildings, Calendar Year 2009[64].

[63] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt's 2009 Annual Air Emissions Report.

[64] Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations (95 vehicles)	48,484	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	433
Gasoline purchases by VU PD (46 vehicles)	29,748	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	266
Estimate of gasoline purchases by remaining fleet vehicles (176)[65]	31,059	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	277
Gasoline use by VUMC Shuttle Busses and Vans	69,196	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	618
Diesel Fuel use by VUMC Shuttle Busses and Vans	40,302	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	409
Diesel Fuel use by Plant Operations	988	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	10
GHG Emissions from Academic & Research Fleet Vehicles ($MTCO_2E$):			2,013

Table B.5. GHG Emissions from Academic and Research Area Fleet Vehicles, Calendar Year 2009.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by Life Flight:	168,074	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	1,608

Table B.6. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2009.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane use by Animal Care	40.0	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	14

Table B.7. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2009[66].

Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt's 2009 Annual Air Emissions Report.

[65] Estimate of gasoline purchases is based on ITS fleet vehicle use of 3,000 miles per year at 17 miles per gallon.

[66] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	6,101	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	1,891
Isoflurane	596	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	209
Desflurane	1,315	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,301
Sevoflurane	1,436	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	496
Total for Anesthesiology/Patient Care Areas			3,896

Table B.8. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2009[67].

Diesel fuel consumed by emergency generators (gallons)	Emission Factor	Amount * Emission Factor = $MTCO_2E$	Academic Areas (65% of total emissions) ($MTCO_2E$)	Patient Care Areas (35% of total emissions) ($MTCO_2E$)
59,745	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	606	394	212

Table B.9. GHG Emissions from Emergency Generators, Calendar Year 2009.

Source	Volume Released (kilograms)	Emission Factor	$MTCO_2E$
Refrigerant Releases - Academic Areas	27	1 kilogram of refrigerant = 1.3 $MTCO_2E$	35
Refrigerant Releases - Patient Care Areas	0	1 kilogram of refrigerant = 1.3 $MTCO_2E$	0

Table B.10. GHG Emissions from Refrigerant Releases, Calendar Year 2009[68].

Kilowatt-Hours Purchased (KwH)	Emission Factor per 1,000 KwH ($MTCO_2E$)	Total Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65% of total emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35% of total emissions) ($MTCO_2E$)
305,308,699	0.59138	180,553	117,359	63,193

Table B.11. GHG Emissions from Electricity Purchases, Calendar Year 2009[69].

[67] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].
[68] Emission Factor for R-134A is used as a default emission factor, as some refrigerants do not have a published emission factor/global warming potential (GWP).
[69] Emission Factor based on TVA's published fuel mix for electrical generation: Coal (47%), Nuclear (34%), Hydroelectric Dams (7%), Natural Gas (6%), and Renewables (6%).

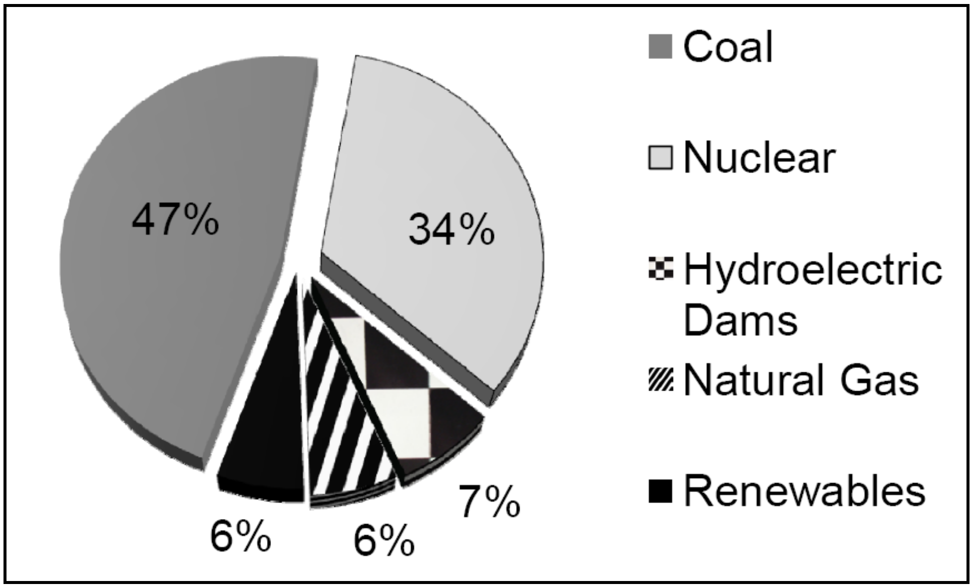

Figure B.5. TVA Fuel Mix, Calendar Year 2009.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	377	1 Ton of waste = 0.1467 $MTCO_2E$	55.4
Waste landfilled with landfill gas combusted to the atmosphere	4,460	1 Ton of waste = 0.2567 $MTCO_2E$	1,145.0
Incinerated Waste	22	1 Ton of waste = 0.22 $MTCO_2E$	4.8
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,205**

Table B.12. Academic and Research Area GHG Emissions from Waste Disposal, Calendar Year 2009[70].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[71]
Faculty	89%	4%	6%	1%	200	48
Staff	89%	4%	6%	1%	250	48
Student	20%	5%	6%	70%	200	10

Table B.13. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas, Calendar Year 2009.

[70] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 7.8% of landfill gas from this landfill was used to generate electricity in 2009; the remaining 92.2% was "flared" to the atmosphere. Therefore, 7.8% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[71] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

Faculty and Staff Commuter Miles for Academic & Research Areas	Commuter Miles for Students	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
103,549,680	6,893,010	4,855,762	78,908

Table B.14. Estimated Fuel Consumption for Academic & Research Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2009[72].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,855,762	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	43,386
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
78,908	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	800
GHG Emissions Associated with Commuter Travel: Academic & Research Areas ($MTCO_2E$)		**44,186**

Table B.15. Academic and Research Area GHG Emissions from Commuter Travel, Calendar Year 2009.

Air Passenger-Miles traveled in 2009[73]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
8,939,623	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	6,944

Table B.16. Academic and Research Area GHG Emissions from Air Travel, Calendar Year 2009.

Cohort	Population Size
Faculty Members[74]	3,526
Students[75]	12,093
University Central Staff[76]	4,407
Research & Administrative Staff in Medical Center[77]	2,695
Total Number of Staff Members, Academic & Research	7,102
Patient Care Staff in Medical Center[78]	9,587
Off-Site Medical Center Staff[79]	2,664

Table B.17. Population of Students, Faculty, and Staff, Calendar Year 2009.

[72] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.
[73] Passenger-miles traveled provided by Caldwell Travel Group.
[74] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf. Faculty member population includes faculty from the School of Medicine and School of Nursing.
[75] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
[76] From *Quick Facts about Vanderbilt University, 2009*.
[77] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff). Research & Administrative Staff in the Medical Center includes on-campus medical center employees that do not have direct contact with patients.
[78] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[79] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	498	1 Ton of waste = 0.1467 $MTCO_2E$	73
Waste landfilled with landfill gas combusted to the atmosphere	5,889	1 Ton of waste = 0.2567 $MTCO_2E$	1,512
Incinerated Waste	100	1 Ton of waste = 0.22 $MTCO_2E$	22
Medical Waste Autoclaved Off-Site	190	1 Ton of waste = 0.243 $MTCO_2E$	46
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,653**

Table B.18. Patient Care Area GHG Emissions from Waste Disposal, Calendar Year 2009[80].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[81]
Staff	89%	4%	6%	1%	250	48

Table B.19. Assumptions for Staff Commuter Travel for Patient Care Areas, Calendar Year 2009.

Staff Commuter Miles for Patient Care Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
106,415,700	4,737,106	43,500

Table B.20. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2009[82].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,737,106	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	42,326
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
43,500	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	441
GHG Emissions Associated with Commuter Travel: Patient Care Areas ($MTCO_2E$)		**42,767**

Table B.21. Patient Care Area GHG Emissions from Commuter Travel, Calendar Year 2009.

80 Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 7.8% of landfill gas from this landfill was used to generate electricity in 2009; the remaining 92.2% was "flared" to the atmosphere. Therefore, 7.8% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

81 Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

82 The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

VII. APPENDIX C: 2008 Calendar Year Data and Calculations

Source	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$)
EPA-Required Sources			
Coal use at VU Power Plant	66,412	35,760	102,172
Natural Gas use at VU Power Plant	33,383	17,975	51,358
Natural Gas use in Individual Buildings	8,461	4,556	13,017
Subtotal of EPA-Required Emissions:	108,255	58,291	166,547
Other Scope 1 Emissions Sources			
Diesel-Powered Generators	282	152	433
Refrigerant Releases	143	0	143
Fleet Vehicles	2,159	1,877	4,036
Anesthetic Gas Use	14	4,789	4,803
Subtotal of Other Scope 1 Emissions:	2,598	6,817	9,415
Scope 2 GHG Emissions: Electricity Purchases			
Electricity Purchased from NES	149,266	80,374	229,640
Scope 3 GHG Emissions: Indirect Sources			
Faculty & Staff Commuting	46,476	42,889	89,365
Air Travel	5,386	0	5,386
Waste Disposal	1,360	1,614	2,973
Subtotal of Scope 3 Emissions:	53,222	44,503	97,725
Total emissions associated with each area per year:	**313,341**	**189,985**	**503,327**

Table C.1. Total Vanderbilt GHG Emissions, Calendar Year 2008.

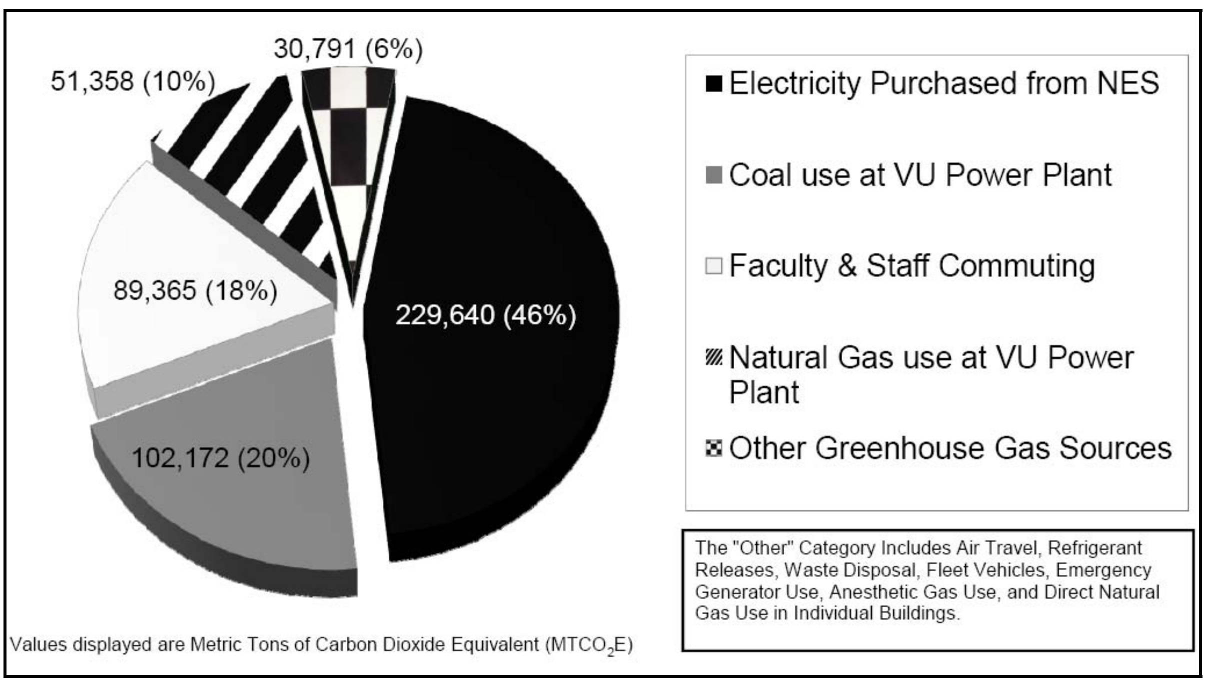

Figure C.1. Vanderbilt GHG Emissions Sources, Calendar Year 2008.

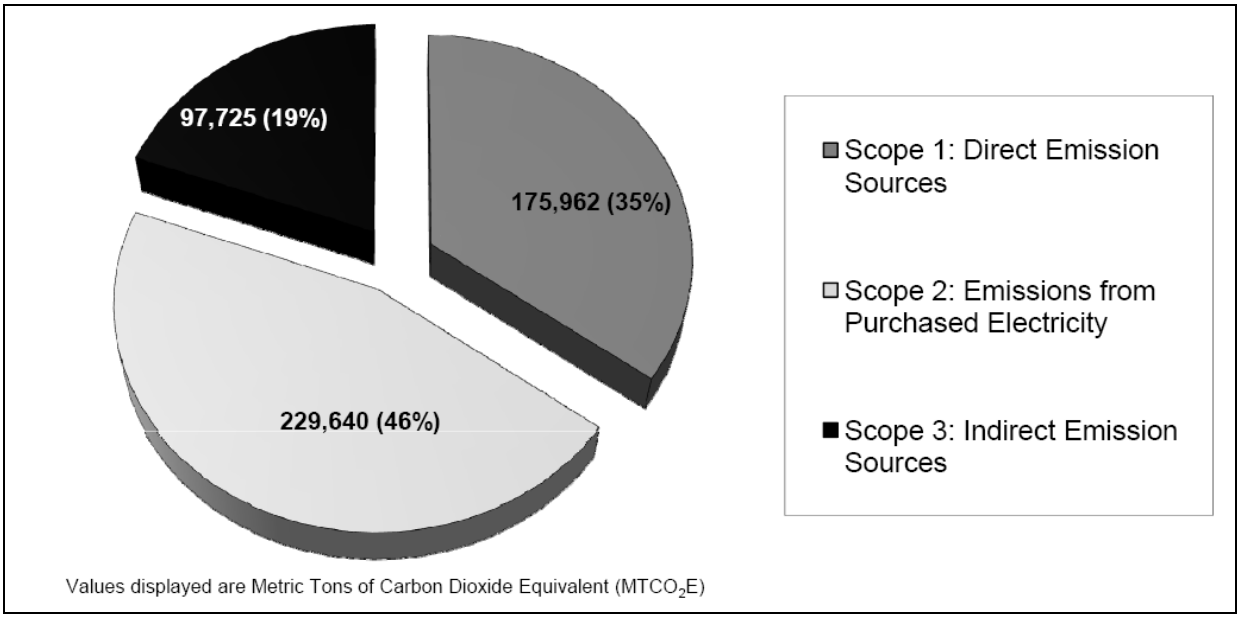

Figure C.2. Vanderbilt GHG Emissions Sources by Scope, Calendar Year 2008.

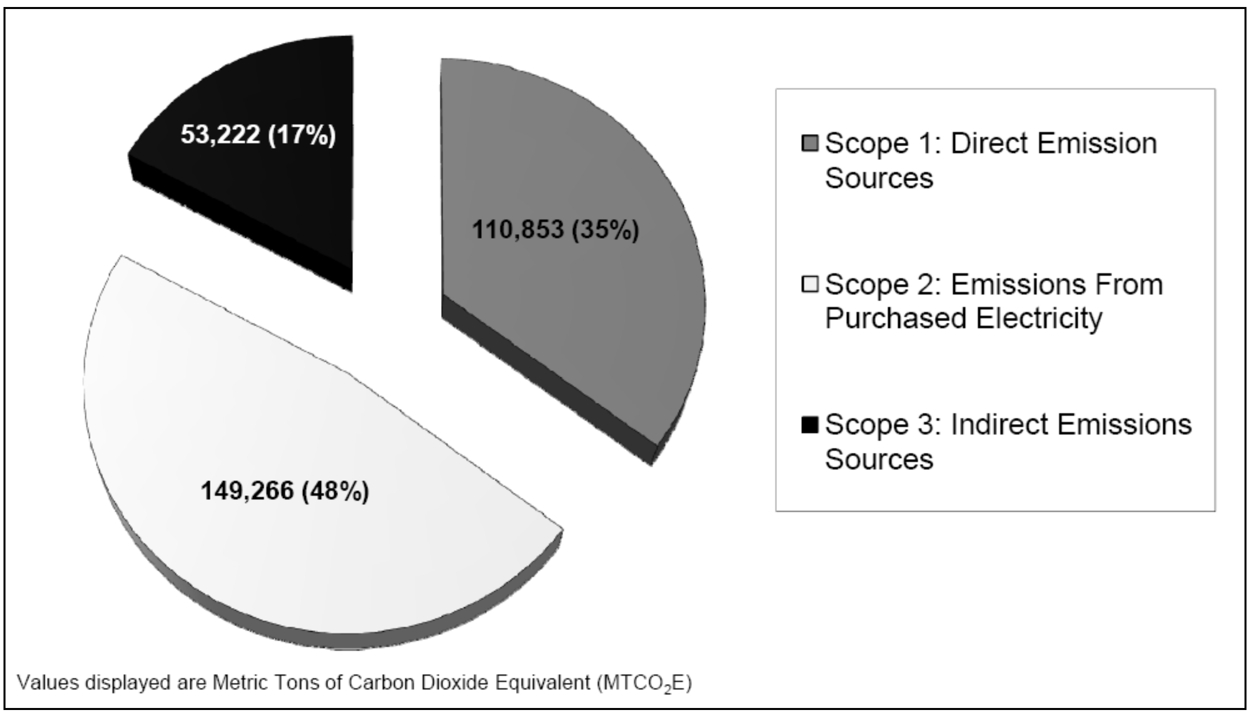

Figure C.3. Vanderbilt Academic and Research Area GHG Emissions Sources by Scope, Calendar Year 2008.

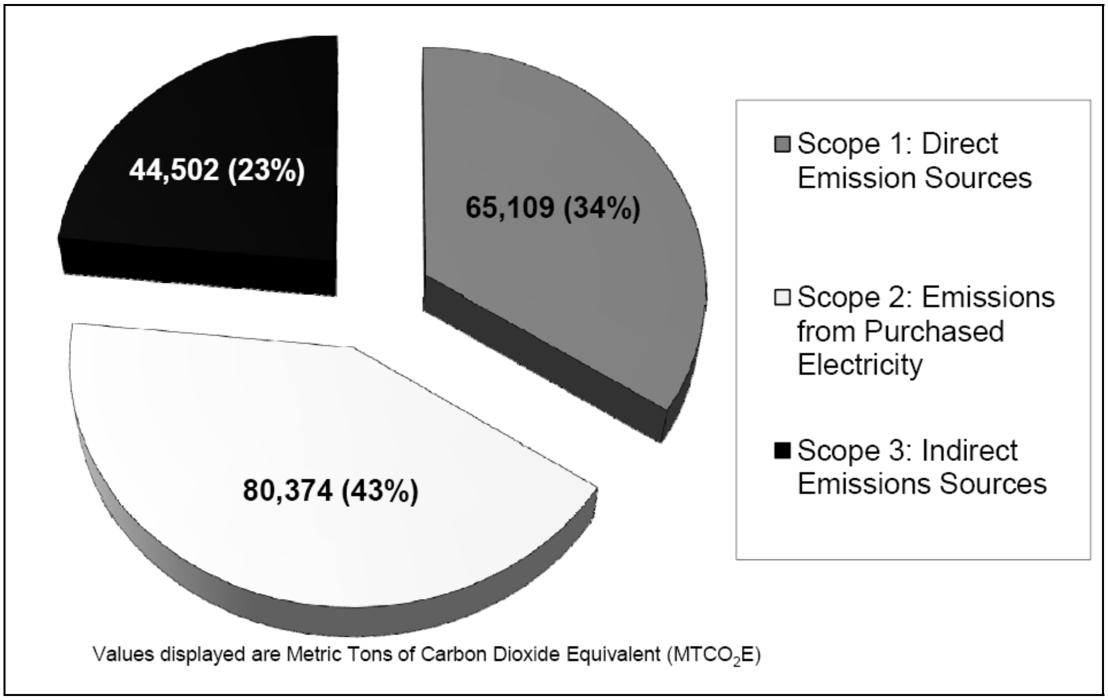

Figure C.4. Vanderbilt Patient Care Area GHG Emissions Sources by Scope, Calendar Year 2008.

GHG Emissions from On-Campus Coal Combustion at the Co-Generation Power Plant					
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
60,628	0.001	17.25	97.02		101,466
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
60,628	0.001	17.25	0.01	10	220
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
60,628	0.001	17.25	0.0015	2	486
Total GHG Emissions from On-Campus Coal Combustion ($MTCO_2E$):					**102,172**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Coal Combustion (65% of total emissions) ($MTCO_2E$):					**66,412**
Patient Care Area Emissions from On-Campus Coal Combustion (35% of total emissions) ($MTCO_2E$):					**35,760**

Table C.2. Calculations for GHG Emissions from On-Campus Coal Combustion, Calendar Year 2008[83].

[83] Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Coal Combustion: Coal (tons) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Tons of Coal listed is the same amount reported in Vanderbilt' 2008 Annual Air Emissions Report.

GHG Emissions from Natural Gas Combustion at the Co-Generation Power Plant					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
762,000,000	0.001	0.00127	53.02		51,310
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
762,000,000	0.001	0.00127	0.0009	0.9	18.3
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
762,000,000	0.001	0.00127	0.0001	0.1	30.0
Total GHG Emissions from On-Campus Natural Gas Combustion ($MTCO_2E$):					**51,358**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Natural Gas Combustion (65% of total emissions) ($MTCO_2E$):					**33,383**
Patient Care Area Emissions from On-Campus Natural Gas Combustion (35% of total emissions) ($MTCO_2E$):					**17,975**

Table C.3. Calculations for GHG Emissions from On-Campus Natural Gas Combustion at the Co-Generation Power Plant, Calendar Year 2008[84].

GHG Emissions from Natural Gas Consumption in Individual Buildings					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
193,131,600	0.001	0.00127	53.02		13,005
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
193,131,600	0.001	0.00127	0.0009	0.221	4.6
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
193,131,600	0.001	0.00127	0.0001	0.025	7.6
Total GHG Emissions from Natural Gas Combustion in Buildings ($MTCO_2E$):					**13,017**
Partitioning of Emissions					
Academic & Research Area Emissions from Natural Gas Consumption in Buildings (65% of total emissions) ($MTCO_2E$):					**8,461**
Patient Care Area Emissions from On-Campus Natural Gas Consumption in Buildings (35% of total emissions) ($MTCO_2E$):					**4,556**

Table C.4. Calculations for GHG Emissions from On-Campus Natural Gas Consumption in Individual Buildings, Calendar Year 2008[85].

[84] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2008 Annual Air Emissions Report.

[85] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural

Fleet Component	Volume Consumed (Gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations (95 vehicles)	65,185	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	582
Gasoline purchases by VU PD (46 vehicles)	43,966	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	393
Estimate of gasoline purchases by remaining fleet vehicles (176)[86]	31,059	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	277
Gasoline use by VUMC Shuttle Busses and Vans	55,950	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	500
Diesel Fuel use by VUMC Shuttle Busses and Vans	38,410	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	389
Diesel Fuel use by Plant Operations	1,766	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	18
GHG Emissions from Academic & Research Fleet Vehicles ($MTCO_2E$):			2,159

Table C.5. GHG Emissions from Academic and Research Area Fleet Vehicles, Calendar Year 2008.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by Life Flight	196,098	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	1,877

Table C.6. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2008.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane use by Animal Care	40.0	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	14

Table C.7. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2008[87].

Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2008 Annual Air Emissions Report.

[86] Estimate of gasoline purchases is based on ITS fleet vehicle use of 3,000 miles per year at 17 miles per gallon.

[87] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	9,437	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	2,925
Isoflurane	526	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	184
Desflurane	1,296	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,282
Sevoflurane	1,153	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	398
Total for Anesthesiology/Patient Care Areas			4,789

Table C.8. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2008[88].

Diesel fuel consumed by emergency generators (gallons)	Emission Factor	Amount * Emission Factor = $MTCO_2E$	Academic Areas (65% of total emissions) ($MTCO_2E$)	Patient Care Areas (35% of total emissions) ($MTCO_2E$)
42,741	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	433	282	152

Table C.9. GHG Emissions from Emergency Generators, Calendar Year 2008.

Source	Volume Released (kilograms)	Emission Factor	$MTCO_2E$
Refrigerant Releases - Academic Areas	110	1 kilogram of refrigerant = 1.3 $MTCO_2E$	143
Refrigerant Releases - Patient Care Areas	0	1 kilogram of refrigerant = 1.3 $MTCO_2E$	-

Table C.10. GHG Emissions from Refrigerant Releases, Calendar Year 2008[89].

Kilowatt-Hours Purchased (KwH)	Emission Factor per 1,000 KwH ($MTCO_2E$)	Total Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65% of total emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35% of total emissions) ($MTCO_2E$)
307,162,163	0.74762	229,640	149,266	80,374

Table C.11. GHG Emissions from Electricity Purchases, Calendar Year 2008[90].

[88] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

[89] Emission Factor for R-134A is used as a default emission factor, as some refrigerants do not have a published emission factor/global warming potential (GWP).

[90] Emission Factor based on TVA's published fuel mix for electrical generation: Coal (63%), Nuclear (29%), Hydroelectric Dams (8%).

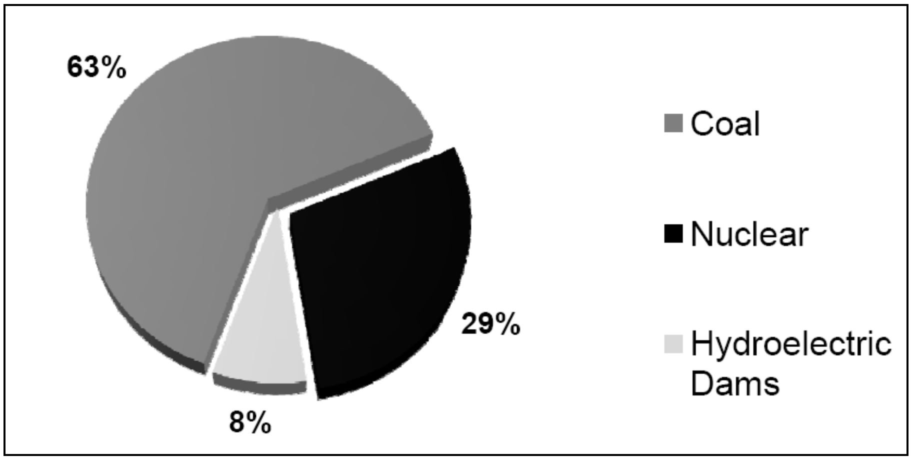

Figure C.5. TVA Fuel Mix, Calendar Year 2008.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	466	1 Ton of waste = 0.1467 $MTCO_2E$	68.4
Waste landfilled with landfill gas combusted to the atmosphere	5,017	1 Ton of waste = 0.2567 $MTCO_2E$	1,287.8
Incinerated Waste	15	1 Ton of waste = 0.22 $MTCO_2E$	3.3
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,360**

Table C.12. Academic and Research Area GHG Emissions from Waste Disposal, Calendar Year 2008[91].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[92]
Faculty	90%	4%	5%	1%	200	48
Staff	90%	4%	5%	1%	250	48
Student	20%	5%	5%	70%	200	10

Table C.13. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas, Calendar Year 2008.

Faculty and Staff Commuter Miles for Academic & Research Areas	Commuter Miles for Students	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
109,263,636	6,752,790	5,119,011	72,756

Table C.14. Estimated Fuel Consumption for Academic & Research Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2008[93].

[91] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 8.5% of landfill gas from this landfill was used to generate electricity in 2008; the remaining 91.5% was "flared" to the atmosphere. Therefore, 8.5% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[92] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

[93] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
5,119,011	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	45,738
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
72,756	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	738
GHG Emissions Associated with Commuter Travel: Academic & Research Areas ($MTCO_2E$)		**46,476**

Table C.15. Academic and Research Area GHG Emissions from Commuter Travel, Calendar Year 2008.

Air Passenger-Miles traveled in 2008[94]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
6,933,760	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	5,386

Table C.16. Academic and Research Area GHG Emissions from Air Travel, Calendar Year 2008.

Cohort	Population Size
Faculty Members[95]	3,358
Students[96]	11,847
University Central Staff[97]	4,402
Research & Administrative Staff in Medical Center[98]	2,671
Total Number of Staff Members, Academic & Research	7,073
Patient Care Staff in Medical Center[99]	9,527
Off-Site Medical Center Staff[100]	2,285

Table C.17. Population of Students, Faculty, and Staff, Calendar Year 2008.

[94] Passenger-miles traveled provided by Caldwell Travel Group.
[95] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf. Faculty member population includes faculty from the School of Medicine and School of Nursing.
[96] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
[97] From *Quick Facts about Vanderbilt University, 2008*.
[98] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff). Research & Administrative Staff in the Medical Center includes on-campus medical center employees that do not have direct contact with patients.
[99] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[100] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	531	1 Ton of waste = 0.1467 $MTCO_2E$	78
Waste landfilled with landfill gas combusted to the atmosphere	5,714	1 Ton of waste = 0.2567 $MTCO_2E$	1,467
Incinerated Waste	78	1 Ton of waste = 0.22 $MTCO_2E$	17
Medical Waste Autoclaved Off-Site	213	1 Ton of waste = 0.243 $MTCO_2E$	52
		Total $MTCO_2E$ Emitted from Waste Disposal:	**1,614**

Table C.18. Patient Care Area GHG Emissions from Waste Disposal, Calendar Year 2008[101].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanp ool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[102]
Staff	90%	4%	5%	1%	250	48

Table C.19. Assumptions for Staff Commuter Travel for Patient Care Areas, Calendar Year 2008.

Staff Commuter Miles for Patient Care Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
106,607,130	4,759,189	36,023

Table C.20. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2008[103].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,759,189	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	42,523
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
36,023	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	365
GHG Emissions Associated with Commuter Travel: Patient Care Areas ($MTCO_2E$)		**42,889**

Table C.21. Patient Care Area GHG Emissions from Commuter Travel, Calendar Year 2008.

[101] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 8.5% of landfill gas from this landfill was used to generate electricity in 2008; the remaining 91.5% was "flared" to the atmosphere. Therefore, 8.5% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[102] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

[103] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

VIII. APPENDIX D: 2007 Calendar Year Data and Calculations

Source	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$)
EPA-Required Sources			
Coal use at VU Power Plant	72,373	38,970	111,344
Natural Gas use at VU Power Plant	31,367	16,890	48,258
Natural Gas use in Individual Buildings	4,074	2,194	6,268
Subtotal of EPA-Required Emissions:	107,815	58,054	178,757
Other Scope 1 Emissions Sources			
Diesel-Powered Generators	830	447	1,277
Refrigerant Releases	137	131	268
Fleet Vehicles	1,870	1,880	3,750
Anesthetic Gas Use	1	3,174	3,174
Subtotal of Other Scope 1 Emissions:	2,838	5,632	8,469
Scope 2 GHG Emissions: Electricity Purchases			
Electricity Purchased from NES	142,045	76,486	218,531
Scope 3 GHG Emissions: Indirect Sources			
Faculty & Staff Commuting	49,496	48,079	97,576
Air Travel	5,259	-	5,259
Waste Disposal	1,150	1,706	2,856
Subtotal of Scope 3 Emissions:	55,905	49,786	105,691
Total emissions associated with each area per year:	**308,604**	**189,958**	**498,562**

Table D.1. Total Vanderbilt GHG Emissions, Calendar Year 2007.

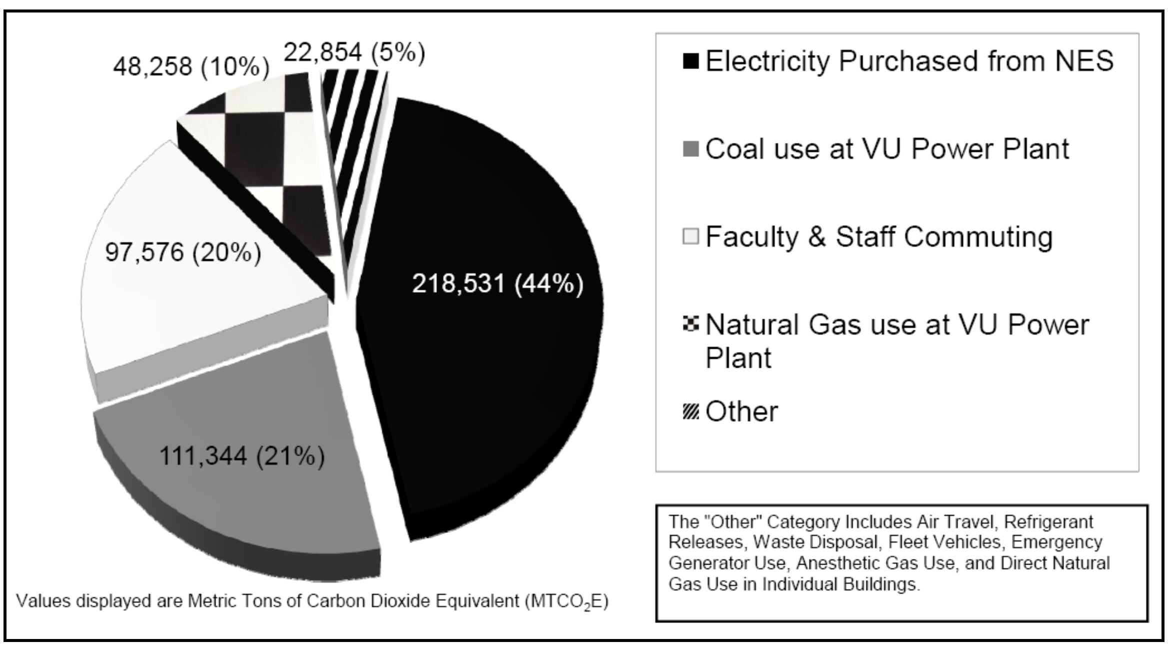

Figure D.1. Vanderbilt GHG Emissions Sources, Calendar Year 2007.

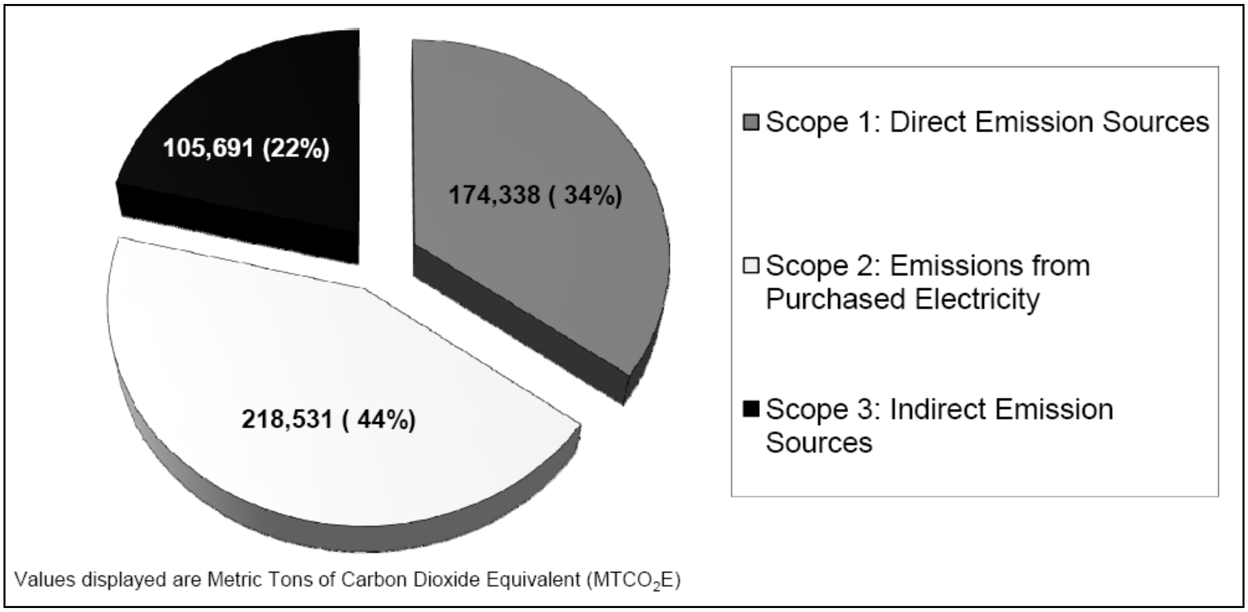

Figure D.2. Vanderbilt GHG Emissions Sources by Scope, Calendar Year 2007.

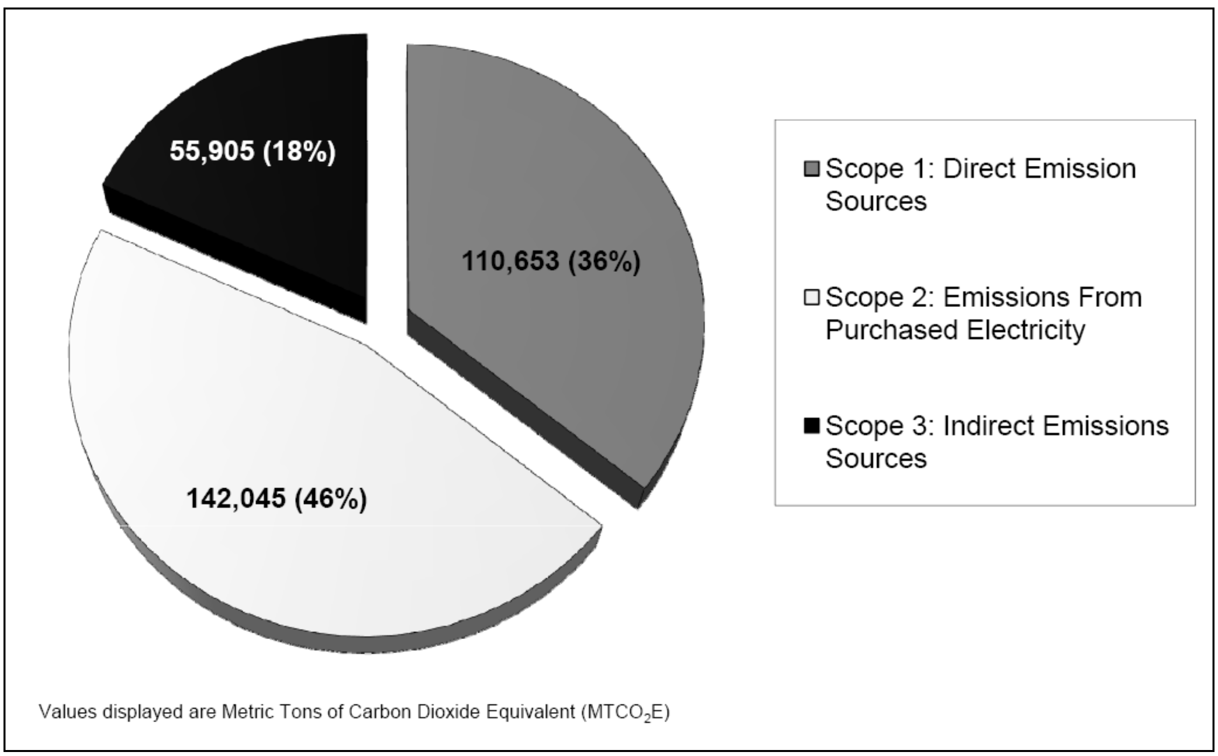

Figure D.3. Vanderbilt Academic and Research Area GHG Emissions Sources by Scope, Calendar Year 2007.

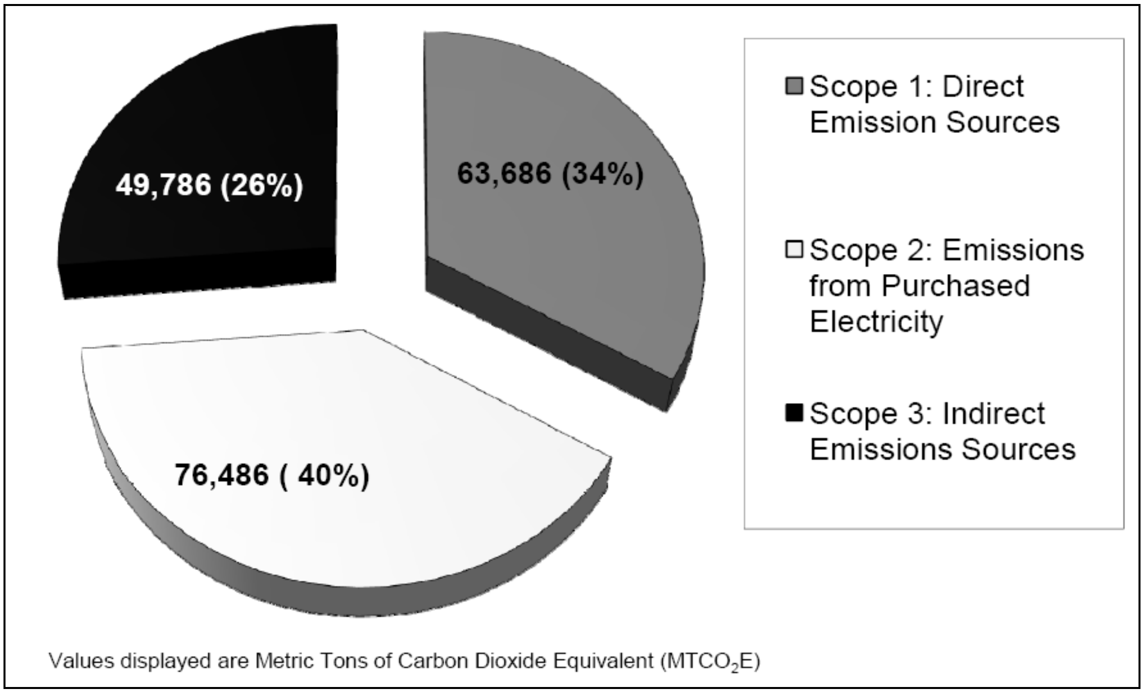

Figure D.4. Vanderbilt Patient Care Area GHG Emissions Sources by Scope, Calendar Year 2007.

GHG Emissions from On-Campus Coal Combustion at the Co-Generation Power Plant					
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
66,070	0.001	17.25	97.02		110,574
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
66,070	0.001	17.25	0.01	11	239
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
66,070	0.001	17.25	0.0015	2	530
Total GHG Emissions from On-Campus Coal Combustion ($MTCO_2E$):					**111,344**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Coal Combustion (65% of total emissions) ($MTCO_2E$):					**72,373**
Patient Care Area Emissions from On-Campus Coal Combustion (35% of total emissions) ($MTCO_2E$):					**38,970**

Table D.2. Calculations for GHG Emissions from On-Campus Coal Combustion, Calendar Year 2007[104].

104 Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Coal Combustion: Coal (tons) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Tons of Coal listed is the same amount reported in Vanderbilt's 2007 Annual Air Emissions Report.

GHG Emissions from Natural Gas Combustion at the Co-Generation Power Plant					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
716,000,000	0.001	0.00127	53.02		48,212
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
716,000,000	0.001	0.00127	0.0009	0.8	17.2
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
716,000,000	0.001	0.00127	0.0001	0.1	28.2
Total GHG Emissions from On-Campus Natural Gas Combustion ($MTCO_2E$):					**48,258**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Natural Gas Combustion (65% of total emissions) ($MTCO_2E$):					**31,367**
Patient Care Area Emissions from On-Campus Natural Gas Combustion (35% of total emissions) ($MTCO_2E$):					**16,890**

Table D.3. Calculations for GHG Emissions from On-Campus Natural Gas Combustion at the Co-Generation Power Plant, Calendar Year 2007[105].

GHG Emissions from Natural Gas Consumption in Individual Buildings					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
193,131,600	0.001	0.00127	53.02		6,262
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
193,131,600	0.001	0.00127	0.0009	0.106	2.2
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
193,131,600	0.001	0.00127	0.0001	0.012	3.7
Total GHG Emissions from Natural Gas Combustion in Buildings ($MTCO_2E$):					**6,268**
Partitioning of Emissions					
Academic & Research Area Emissions from Natural Gas Consumption in Buildings (65% of total emissions) ($MTCO_2E$):					**4,074**
Patient Care Area Emissions from On-Campus Natural Gas Consumption in Buildings (35% of total emissions) ($MTCO_2E$):					**2,194**

Table D.4. Calculations for GHG Emissions from On-Campus Natural Gas Consumption in Individual Buildings, Calendar Year 2007[106].

[105] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2007 Annual Air Emissions Report.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations	63,782	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	570
Gasoline purchases by VU PD	28,959	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	259
Estimate of gasoline purchases by remaining fleet vehicles (130 vehicles)[107]	22,941	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	205
Gasoline use by VUMC Shuttle Busses and Vans	41,948	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	375
Diesel Fuel use by VUMC Shuttle Busses and Vans	43,660	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	443
Diesel Fuel use by Plant Operations	1,972	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	20
GHG Emissions from Academic & Research Fleet Vehicles ($MTCO_2E$):			1,870

Table D.5. GHG Emissions from Academic and Research Area Fleet Vehicles, Calendar Year 2007.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by Life Flight	196,448	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	1,880

Table D.6. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2007.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane use by Animal Care	1.8	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	1

Table D.7. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2007[108].

[106] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2007 Annual Air Emissions Report.

[107] Estimate of gasoline purchases is based on ITS fleet vehicle use of 3,000 miles per year at 17 miles per gallon.

[108] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	4,177	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	1,295
Isoflurane	475	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	166
Desflurane	1,540	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,523
Sevoflurane	549	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	189
Total for Anesthesiology/Patient Care Areas			3,174

Table D.8. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2007[109].

Diesel fuel consumed by emergency generators (gallons)	Emission Factor	Amount * Emission Factor = $MTCO_2E$	Academic Areas (65% of total emissions) ($MTCO_2E$)	Patient Care Areas (35% of total emissions) ($MTCO_2E$)
125,889	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	1,277	830	447

Table D.9. GHG Emissions from Emergency Generators, Calendar Year 2007.

Source	Volume Released (kilograms)	Emission Factor	$MTCO_2E$
Refrigerant Releases - Academic Areas	105	1 kilogram of refrigerant = 1.3 $MTCO_2E$	137
Refrigerant Releases - Patient Care Areas	101	1 kilogram of refrigerant = 1.3 $MTCO_2E$	131

Table D.10. GHG Emissions from Refrigerant Releases, Calendar Year 2007[110].

Kilowatt-Hours Purchased (KwH)	Emission Factor per 1,000 KwH ($MTCO_2E$)	Total Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65% of total emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35% of total emissions) ($MTCO_2E$)
287,734,887	0.74762	218,531	142,045	76,486

Table D.11. GHG Emissions from Electricity Purchases, Calendar Year 2007[111].

[109] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].
[110] Emission Factor for R-134A is used as a default emission factor, as some refrigerants do not have a published emission factor/global warming potential (GWP).
[111] Emission Factor based on TVA's published fuel mix for electrical generation: Coal (63%), Nuclear (29%), Hydroelectric Dams (8%).

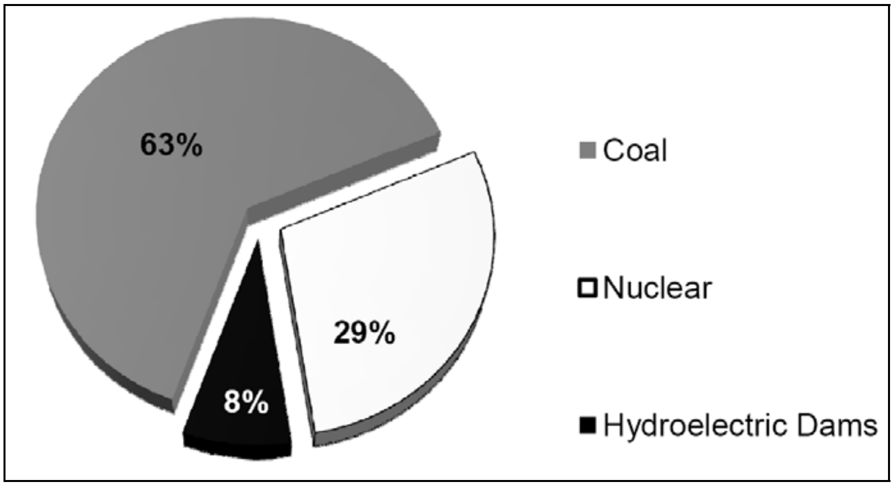

Figure D.5. TVA Fuel Mix, Calendar Year 2007.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	1,638	1 Ton of waste = 0.1467 $MTCO_2E$	240.3
Waste landfilled with landfill gas combusted to the atmosphere	3,482	1 Ton of waste = 0.2567 $MTCO_2E$	893.8
Incinerated Waste	73	1 Ton of waste = 0.22 $MTCO_2E$	16.1
		Total $MTCO_2E$ Emitted from Waste Disposal:	**1,150**

Table D.12. Academic and Research Area GHG Emissions from Waste Disposal, Calendar Year 2007[112].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[113]
Faculty	95%	3%	1%	1%	200	48
Staff	95%	3%	1%	1%	250	48
Student	15%	5%	0%	80%	200	10

Table D.13. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas, Calendar Year 2007.

Faculty and Staff Commuter Miles for Academic & Research Areas	Commuter Miles for Students	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
118,475,406	4,062,450	5,530,847	7,717

Table D.14. Estimated Fuel Consumption for Academic & Research Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2007[114].

[112] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 32% of landfill gas from this landfill is used to generate electricity; the remaining 68% is "flared" to the atmosphere. Therefore, 32% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.
[113] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.
[114] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
5,530,847	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	49,418
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
7,717	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	78
GHG Emissions Associated with Commuter Travel: Academic & Research Areas ($MTCO_2E$)		**49,496**

Table D.15. Academic and Research Area GHG Emissions from Commuter Travel, Calendar Year 2007.

Air Passenger-Miles traveled in 2007[115]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
6,769,829	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	5,259

Table D.16. Academic and Research Area GHG Emissions from Air Travel, Calendar Year 2007.

Cohort	Population Size
Faculty Members[116]	3,222
Students[117]	11,607
University Central Staff[118]	4,391
Research & Administrative Staff in Medical Center[119]	3,236
Total Number of Staff Members, Academic & Research	7,627
Patient Care Staff in Medical Center[120]	10,256
Off-Site Medical Center Staff[121]	2,045

Table D.17. Population of Students, Faculty, and Staff, Calendar Year 2007.

115 Passenger-miles traveled provided by Caldwell Travel Group.
116 VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
117 VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
118 From *Quick Facts for VU, 2007.*
119 Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
120 Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
121 Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	2,364	1 Ton of waste = 0.1467 $MTCO_2E$	347
Waste landfilled with landfill gas combusted to the atmosphere	5,024	1 Ton of waste = 0.2567 $MTCO_2E$	1,290
Incinerated Waste	73	1 Ton of waste = 0.22 $MTCO_2E$	16
Medical Waste Autoclaved Off-Site	221	1 Ton of waste = 0.243 $MTCO_2E$	54
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,706**

Table D.18. Patient Care Area GHG Emissions from Waste Disposal, Calendar Year 2007[122].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[123]
Staff	95%	3%	1%	1%	250	48

Table D.19. Assumptions for Staff Commuter Travel for Patient Care Areas, Calendar Year 2007.

Commuter Miles for Patient Care Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
119,010,624	5,373,958	6,205

Table D.20. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2007[124].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
5,373,958	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	48,016
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
6,205	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	63
GHG Emissions Associated with Commuter Travel: Patient Care Areas ($MTCO_2E$)		**48,079**

Table D.21. Patient Care Area GHG Emissions from Commuter Travel, Calendar Year 2007.

[122] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 32% of landfill gas from this landfill is used to generate electricity; the remaining 68% is "flared" to the atmosphere. Therefore, 32% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[123] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

[124] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

IX. APPENDIX E: 2006 Calendar Year Data and Calculations

Source	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$)
EPA-Required Sources			
Coal use at VU Power Plant	64,729	34,854	99,582
Natural Gas use at VU Power Plant	25,015	13,470	38,485
Natural Gas use in Individual Buildings	5,301	2,854	8,155
Subtotal of EPA-Required Emissions:	95,045	51,178	146,222
Other Scope 1 Emissions Sources			
Diesel-Powered Generators	541	291	832
Refrigerant Releases	338	397	735
Fleet Vehicles	1,968	2,012	3,980
Anesthetic Gas Use	1	3,174	3,174
Subtotal of Other Scope 1 Emissions:	2,848	5,873	8,721
Scope 2 GHG Emissions: Electricity Purchases			
Electricity Purchased from NES	145,382	78,283	223,664
Scope 3 GHG Emissions: Indirect Sources			
Faculty & Staff Commuting	46,175	45,037	91,212
Air Travel	5,259	-	5,259
Waste Disposal	1,116	2,177	3,293
Subtotal of Scope 3 Emissions:	52,550	47,215	99,764
Total emissions associated with each area per year:	**295,825**	**182,548**	**478,374**

Table E.1. Total Vanderbilt GHG Emissions, Calendar Year 2006.

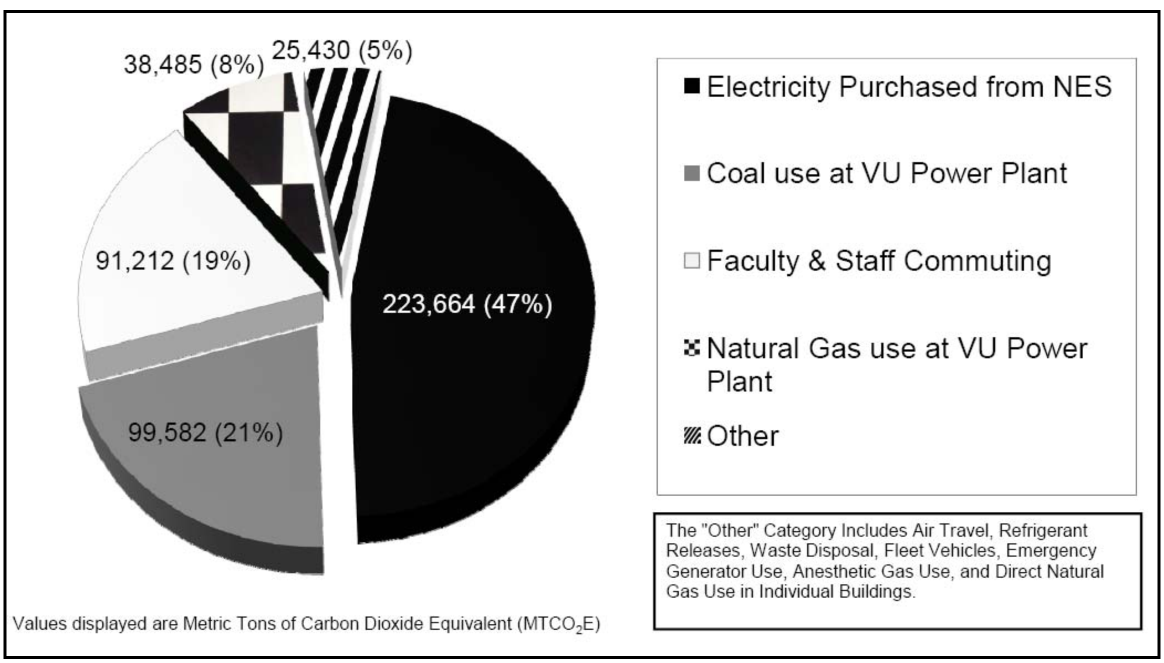

Figure E.1. Vanderbilt GHG Emissions Sources, Calendar Year 2006.

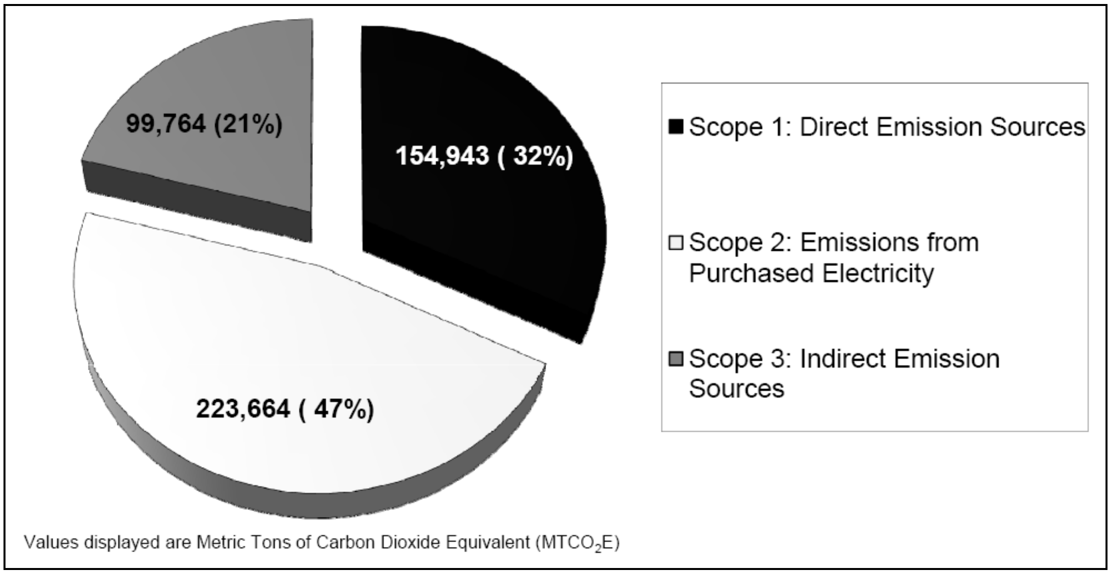

Figure E.2. Vanderbilt GHG Emissions Sources by Scope, Calendar Year 2006.

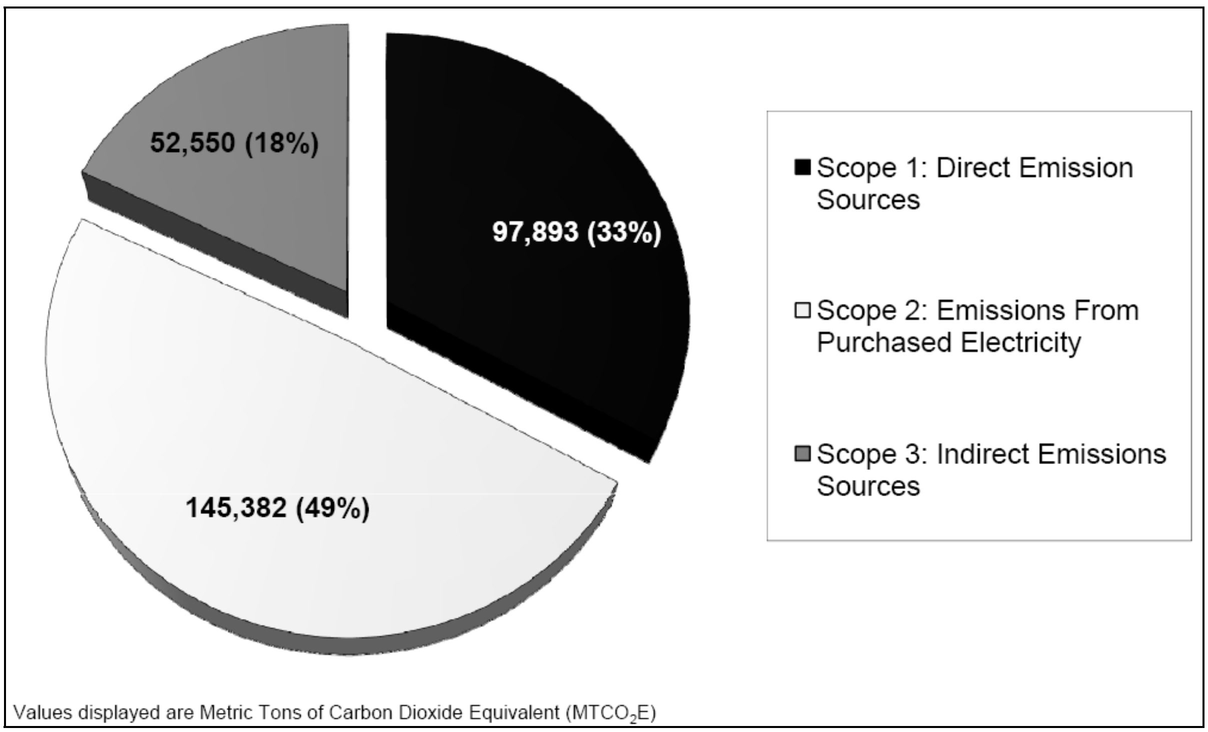

Figure E.3. Vanderbilt Academic and Research Area GHG Emissions Sources by Scope, Calendar Year 2006.

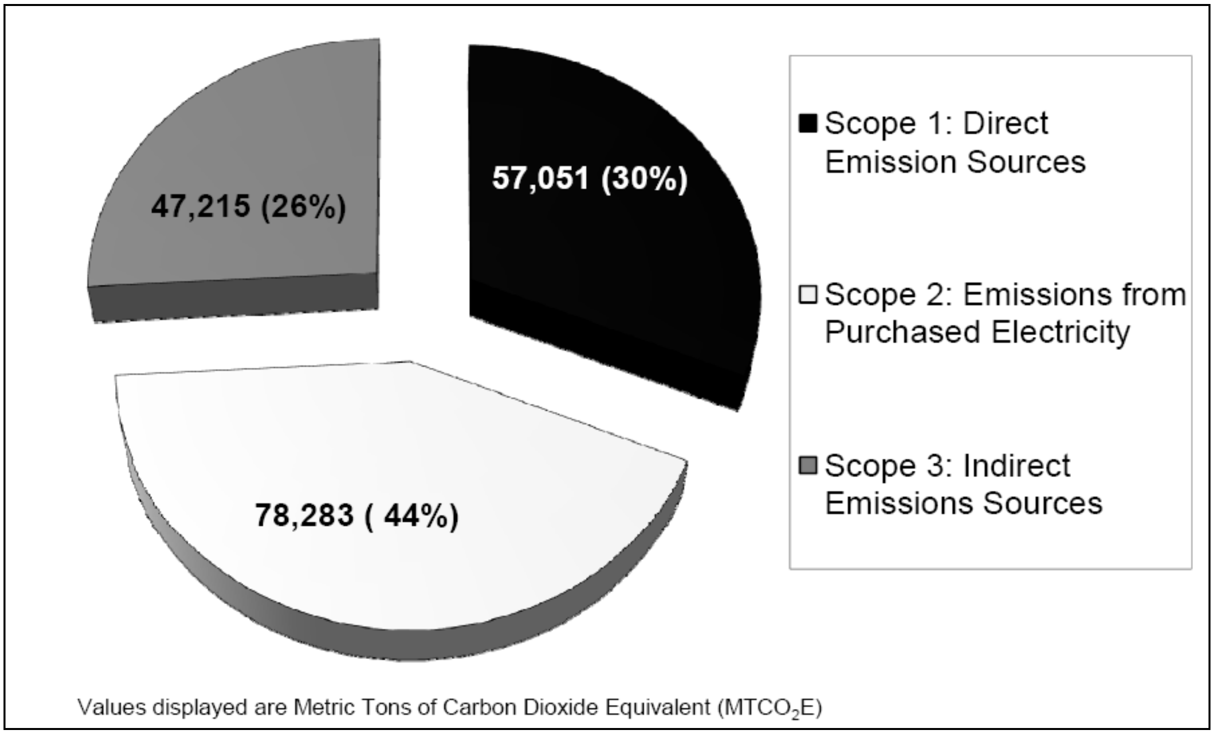

Figure E.4. Vanderbilt Patient Care Area GHG Emissions Sources by Scope, Calendar Year 2006.

GHG Emissions from On-Campus Coal Combustion at the Co-Generation Power Plant					
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
59,091	0.001	17.25	97.02		98,894
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
59,091	0.001	17.25	0.01	10	214
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
59,091	0.001	17.25	0.0015	2	474
Total GHG Emissions from On-Campus Coal Combustion ($MTCO_2E$):					**99,582**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Coal Combustion (65% of total emissions) ($MTCO_2E$):					**64,729**
Patient Care Area Emissions from On-Campus Coal Combustion (35% of total emissions) ($MTCO_2E$):					**34,854**

Table E.2. Calculations for GHG Emissions from On-Campus Coal Combustion, Calendar Year 2006[125].

[125] Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Coal Combustion: Coal (tons) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Tons of Coal listed is the same amount reported in Vanderbilt's 2006 Annual Air Emissions Report.

GHG Emissions from Natural Gas Combustion at the Co-Generation Power Plant					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
571,000,000	0.001	0.00127	53.02		38,449
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
571,000,000	0.001	0.00127	0.0009	0.7	13.7
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
571,000,000	0.001	0.00127	0.0001	0.1	22.5
Total GHG Emissions from On-Campus Natural Gas Combustion ($MTCO_2E$):					**38,485**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Natural Gas Combustion (65% of total emissions) ($MTCO_2E$):					**25,015**
Patient Care Area Emissions from On-Campus Natural Gas Combustion (35% of total emissions) ($MTCO_2E$):					**13,470**

Table E.3. Calculations for GHG Emissions from On-Campus Natural Gas Combustion at the Co-Generation Power Plant, Calendar Year 2006[126].

GHG Emissions from Natural Gas Consumption in Individual Buildings					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
121,000,000	0.001	0.00127	53.02		8,148
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
121,000,000	0.001	0.00127	0.0009	0.138	2.9
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
121,000,000	0.001	0.00127	0.0001	0.015	4.8
Total GHG Emissions from Natural Gas Combustion in Buildings ($MTCO_2E$):					**8,155**
Partitioning of Emissions					
Academic & Research Area Emissions from Natural Gas Consumption in Buildings (65% of total emissions) ($MTCO_2E$):					**5,301**
Patient Care Area Emissions from On-Campus Natural Gas Consumption in Buildings (35% of total emissions) ($MTCO_2E$):					**2,854**

Table E.4. Calculations for GHG Emissions from On-Campus Natural Gas Consumption in Individual Buildings, Calendar Year 2006[127].

[126] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2006 Annual Air Emissions Report.

Fleet Component	Volume Consumed (Gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations	81,631	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	729
Gasoline purchases by VU PD[128]	28,959	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	259
Estimate of gasoline purchases by remaining fleet vehicles (130 vehicles)[129]	22,941	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	205
Gasoline use by VUMC Shuttle Busses and Vans	38,776	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	346
Diesel Fuel use by VUMC Shuttle Busses and Vans	40,358	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	409
Diesel Fuel use by Plant Operations[130]	1,972	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	20
GHG Emissions from Academic & Research Fleet Vehicles ($MTCO_2E$):			1,968

Table E.5. GHG Emissions from Academic and Research Area Fleet Vehicles, Calendar Year 2006.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by Life Flight	210,208	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	2,012

Table E.6. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2006.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane use by Animal Care	1.8	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	1

Table E.7. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2006[131].

[127] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2006 Annual Air Emissions Report.
[128] 2007 fuel usage data is utilized here; 2006 fuel usage data is not available.
[129] Estimate of gasoline purchases is based on ITS fleet vehicle use of 3,000 miles per year at 17 miles per gallon.
[130] 2007 fuel usage data is utilized here; 2006 fuel usage data is not available.
[131] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

Anesthetic Gas	Volume Used[132] (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	4,177	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	1,295
Isoflurane	475	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	166
Desflurane	1,540	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,523
Sevoflurane	549	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	189
Total for Anesthesiology/Patient Care Areas			3,174

Table E.8. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2006[133].

Diesel fuel consumed by emergency generators (gallons)	Emission Factor	Amount * Emission Factor = $MTCO_2E$	Academic Areas (65% of total emissions) ($MTCO_2E$)	Patient Care Areas (35% of total emissions) ($MTCO_2E$)
82,089	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	832	541	291

Table E.9. GHG Emissions from Emergency Generators, Calendar Year 2006.

Source	Volume Released (kilograms)	Emission Factor	$MTCO_2E$
Refrigerant Releases - Academic Areas	260	1 kilogram of refrigerant = 1.3 $MTCO_2E$	338
Refrigerant Releases - Patient Care Areas	305	1 kilogram of refrigerant = 1.3 $MTCO_2E$	397

Table E.10. GHG Emissions from Refrigerant Releases, Calendar Year 2006[134].

Kilowatt-Hours Purchased (KwH)	Emission Factor per 1,000 KwH ($MTCO_2E$)	Total Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65% of total emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35% of total emissions) ($MTCO_2E$)
294,494,256	0.74762	223,664	145,382	78,283

Table E.11. GHG Emissions from Electricity Purchases, Calendar Year 2006[135].

[132] 2007 usage data is utilized here; 2006 usage data is not available.
[133] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].
[134] Emission Factor for R-134A is used as a default emission factor, as some refrigerants do not have a published emission factor/global warming potential (GWP).
[135] Emission Factor based on TVA's published fuel mix for electrical generation: Coal (63%), Nuclear (29%), Hydroelectric Dams (8%).

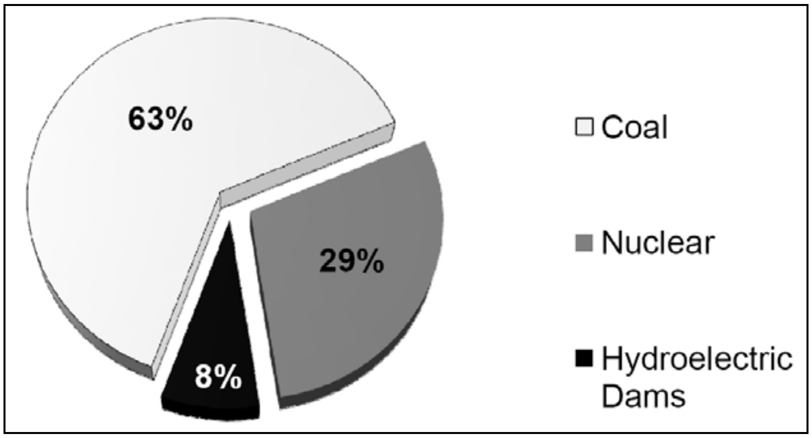

Figure E.5. TVA Fuel Mix, Calendar Year 2006.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	1,590	1 Ton of waste = 0.1467 $MTCO_2E$	233.3
Waste landfilled with landfill gas combusted to the atmosphere	3,379	1 Ton of waste = 0.2567 $MTCO_2E$	867.4
Incinerated Waste	71	1 Ton of waste = 0.22 $MTCO_2E$	15.6
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,116**

Table E.12. Academic and Research Area GHG Emissions from Waste Disposal, Calendar Year 2006[136].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[137]
Faculty	95%	3%	1%	1%	200	48
Staff	95%	3%	1%	1%	250	48
Student	15%	5%	0%	80%	200	10

Table E.13. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas, Calendar Year 2006.

Faculty and Staff Commuter Miles for Academic & Research Areas	Commuter Miles for Students	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
110,297,322	4,018,550	5,159,759	7,184

Table E.14. Estimated Fuel Consumption for Academic & Research Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2006[138].

[136] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 32% of landfill gas from this landfill is used to generate electricity; the remaining 68% is "flared" to the atmosphere. Therefore, 32% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[137] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

[138] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
5,159,759	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	46,102
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
7,184	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	73
GHG Emissions Associated with Commuter Travel: Academic & Research Areas ($MTCO_2E$)		**46,175**

Table E.15. Academic and Research Area GHG Emissions from Commuter Travel, Calendar Year 2006.

Air Passenger-Miles traveled[139]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
6,769,829	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	5,259

Table E.16. Academic and Research Area GHG Emissions from Air Travel, Calendar Year 2006.

Cohort	Population Size
Faculty Members[140]	3,004
Students[141]	11,481
University Central Staff[142]	4,164
Research & Administrative Staff in Medical Center[143]	2,933
Total Number of Staff Members, Academic & Research	7,097
Patient Care Staff in Medical Center[144]	9,607
Off-Site Medical Center Staff[145]	1,715

Table E.17. Population of Students, Faculty, and Staff, Calendar Year 2006.

[139] 2007 air passenger-miles is utilized here; 2006 air travel data is not available. Passenger-miles traveled provided by Caldwell Travel Group.
[140] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
[141] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
[142] From *Quick Facts for VU, 2006*.
[143] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[144] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[145] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	2,222	1 Ton of waste = 0.1467 $MTCO_2E$	326
Waste landfilled with landfill gas combusted to the atmosphere	6,945	1 Ton of waste = 0.2567 $MTCO_2E$	1,783
Incinerated Waste	81	1 Ton of waste = 0.22 $MTCO_2E$	18
Medical Waste Autoclaved Off-Site	208	1 Ton of waste = 0.243 $MTCO_2E$	51
Total $MTCO_2E$ Emitted from Waste Disposal:			**2,177**

Table E.18. Patient Care Area GHG Emissions from Waste Disposal, Calendar Year 2006[146].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[147]
Staff	95%	3%	1%	1%	250	48

Table E.19. Assumptions for Staff Commuter Travel for Patient Care Areas, Calendar Year 2006.

Staff Commuter Miles for Patient Care Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
111,479,628	5,033,894	5,812

Table E.20. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2006[148].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
5,033,894	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	44,978
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
5,812	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	59
GHG Emissions Associated with Commuter Travel: Patient Care Areas ($MTCO_2E$)		**45,037**

Table E.21. Patient Care Area GHG Emissions from Commuter Travel, Calendar Year 2006.

[146] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 32% of landfill gas from this landfill is used to generate electricity; the remaining 68% is "flared" to the atmosphere. Therefore, 32% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[147] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

[148] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

IX. APPENDIX F: 2005 Calendar Year Data and Calculations

Source	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$)
EPA-Required Sources			
Coal use at VU Power Plant	62,711	33,767	96,478
Natural Gas use at VU Power Plant	33,602	18,093	51,695
Natural Gas use in Individual Buildings	3,242	1,746	4,988
Subtotal of EPA-Required Emissions:	95,554	53,606	153,161
Other Scope 1 Emissions Sources			
Diesel-Powered Generators	550	296	846
Refrigerant Releases	286	189	475
Fleet Vehicles	1,609	2,206	3,815
Anesthetic Gas Use	1	3,174	3,174
Subtotal of Other Scope 1 Emissions:	2,446	5,864	8,311
Scope 2 GHG Emissions: Electricity Purchases			
Electricity Purchased from NES	145,173	78,170	223,343
Scope 3 GHG Emissions: Indirect Sources			
Faculty & Staff Commuting	43,010	40,035	83,044
Air Travel	5,259	-	5,259
Waste Disposal	1,022	1,585	2,607
Subtotal of Scope 3 Emissions:	49,291	41,620	90,910
Total emissions associated with each area per year:	**296,465**	**179,260**	**475,725**

Table F.1. Total Vanderbilt GHG Emissions, Calendar Year 2005.

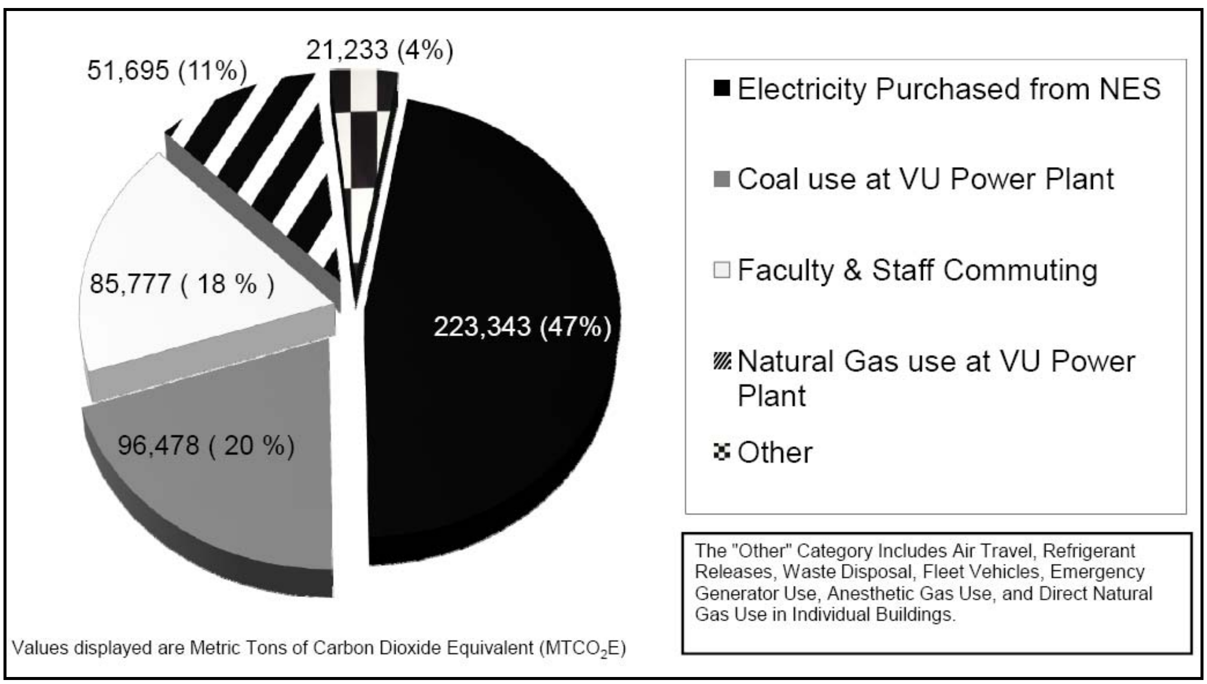

Figure F.1. Vanderbilt GHG Emissions Sources, Calendar Year 2005.

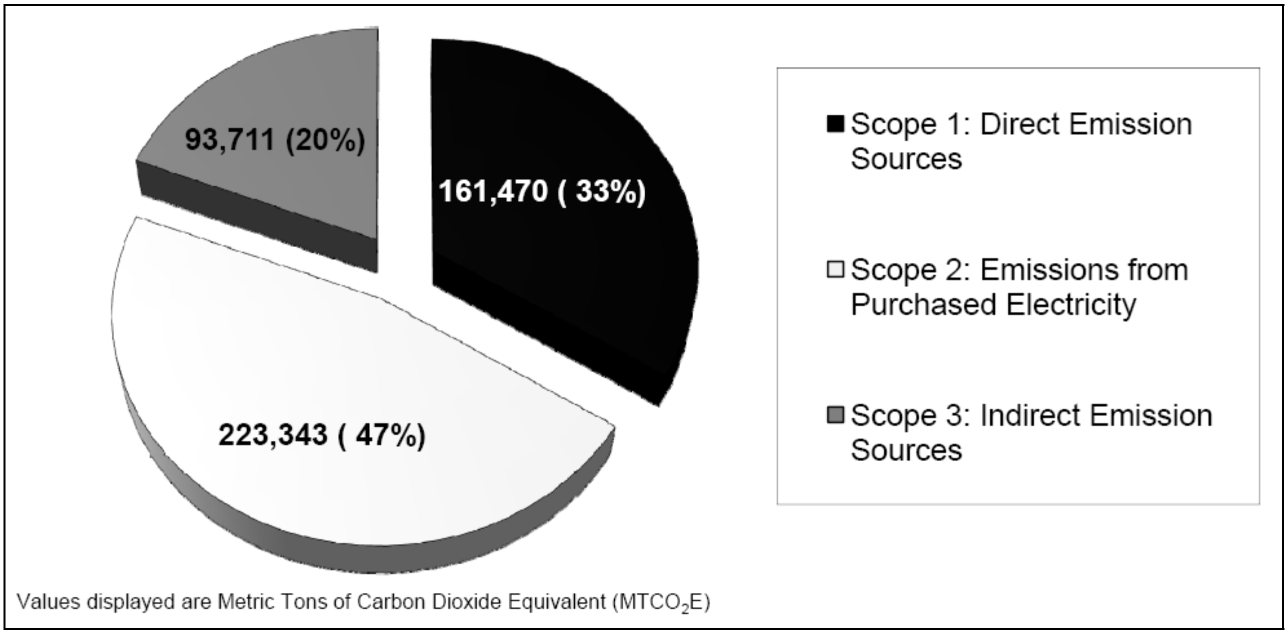

Figure F.2. Vanderbilt GHG Emissions Sources by Scope, Calendar Year 2005.

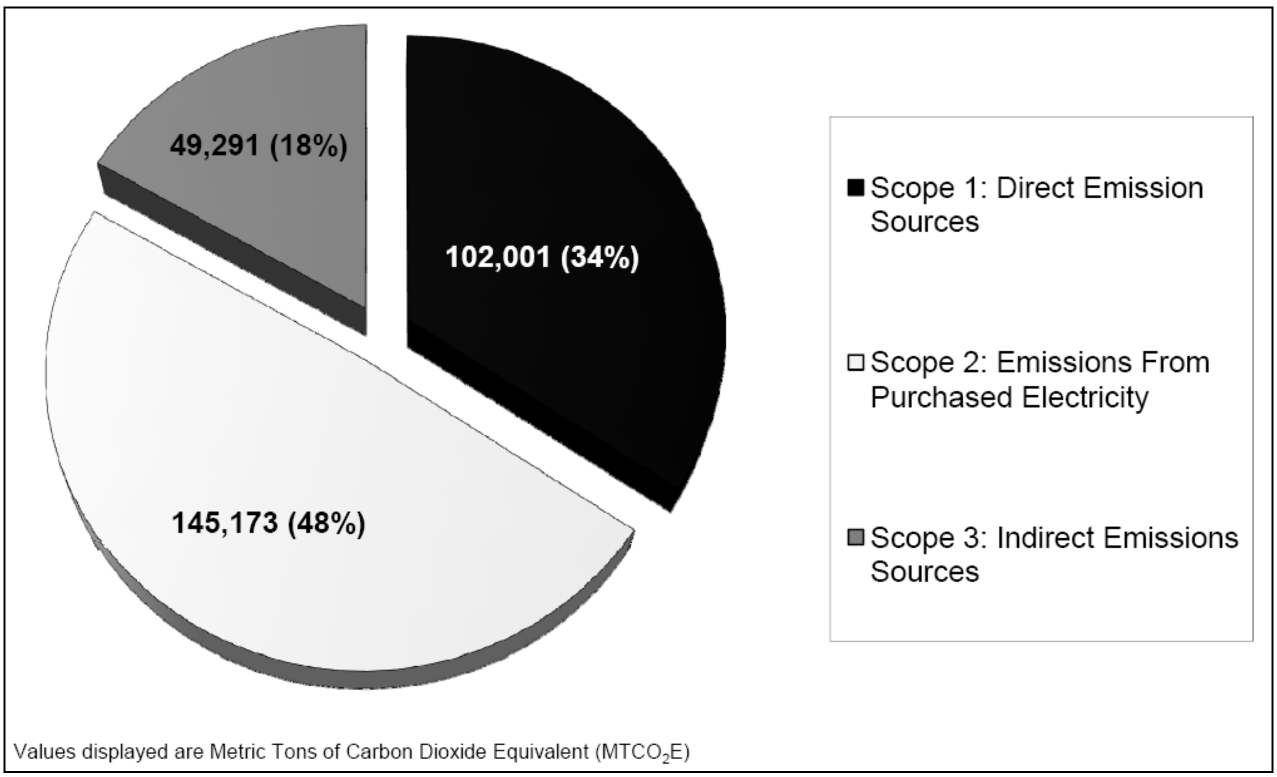

Figure F.3. Vanderbilt Academic and Research Area GHG Emissions Sources by Scope, Calendar Year 2005.

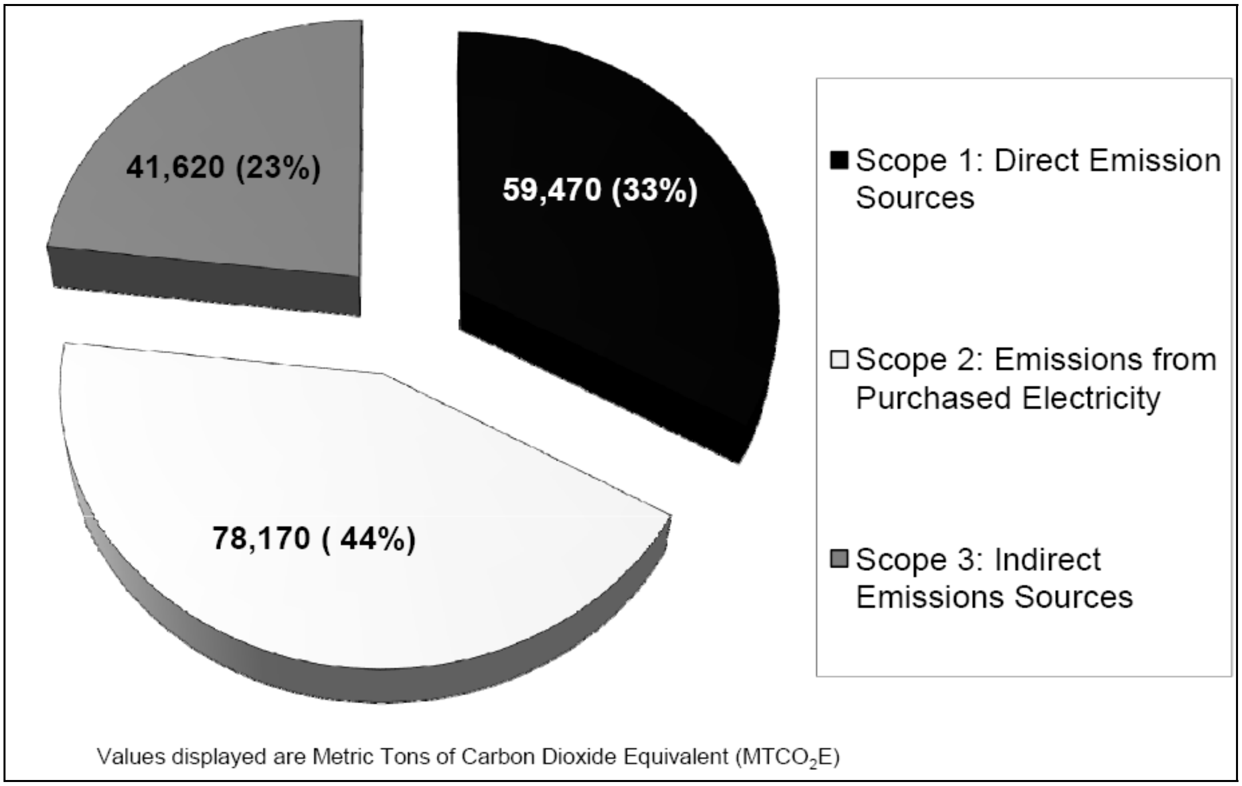

Figure F.4. Vanderbilt Patient Care Area GHG Emissions Sources by Scope, Calendar Year 2005.

GHG Emissions from On-Campus Coal Combustion at the Co-Generation Power Plant					
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
57,249	0.001	17.25	97.02		95,812
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
57,249	0.001	17.25	0.01	10	207
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
57,249	0.001	17.25	0.0015	1	454
Total GHG Emissions from On-Campus Coal Combustion ($MTCO_2E$):					**96,478**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Coal Combustion (65% of total emissions) ($MTCO_2E$):					**62,711**
Patient Care Area Emissions from On-Campus Coal Combustion (35% of total emissions) ($MTCO_2E$):					**33,767**

Table F.2. Calculations for GHG Emissions from On-Campus Coal Combustion, Calendar Year 2005[149].

[149] Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Coal Combustion: Coal (tons) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Tons of Coal listed is the same amount reported in Vanderbilt's 2005 Annual Air Emissions Report.

GHG Emissions from Natural Gas Combustion at the Co-Generation Power Plant					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
767,000,000	0.001	0.00127	53.02		51,646
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
767,000,000	0.001	0.00127	0.0009	0.9	18.4
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
767,000,000	0.001	0.00127	0.0001	0.1	30.2
Total GHG Emissions from On-Campus Natural Gas Combustion ($MTCO_2E$):					**51,695**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Natural Gas Combustion (65% of total emissions) ($MTCO_2E$):					**33,602**
Patient Care Area Emissions from On-Campus Natural Gas Combustion (35% of total emissions) ($MTCO_2E$):					**18,093**

Table F.3. Calculations for GHG Emissions from On-Campus Natural Gas Combustion at the Co-Generation Power Plant, Calendar Year 2005[150].

GHG Emissions from Natural Gas Consumption in Individual Buildings					
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)		CO_2 Emissions (Metric Tons)
74,000,000	0.001	0.00127	53.02		4,983
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
74,000,000	0.001	0.00127	0.0009	0.085	1.8
Natural Gas *(cubic feet)*	Kilograms to metric ton conversion	High Heat Value (Default EPA value)	Emission Factor (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
74,000,000	0.001	0.00127	0.0001	0.009	2.9
Total GHG Emissions from Natural Gas Combustion in Buildings ($MTCO_2E$):					**4,988**
Partitioning of Emissions					
Academic & Research Area Emissions from Natural Gas Consumption in Buildings (65% of total emissions) ($MTCO_2E$):					**3,242**
Patient Care Area Emissions from On-Campus Natural Gas Consumption in Buildings (35% of total emissions) ($MTCO_2E$):					**1,746**

Table F.4. Calculations for GHG Emissions from On-Campus Natural Gas Consumption in Individual Buildings, Calendar Year 2005[151].

[150] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2005 Annual Air Emissions Report.

[151] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural

Fleet Component	Volume Consumed[152] (Gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations	51,617	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	461
Gasoline purchases by VU PD[153]	28,959	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	259
Estimate of gasoline purchases by remaining fleet vehicles (130 vehicles)[154]	22,941	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	205
Gasoline use by VUMC Shuttle Busses and Vans	34,129	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	305
Diesel Fuel use by VUMC Shuttle Busses and Vans	35,523	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	360
Diesel Fuel use by Plant Operations[155]	1,972	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	20
GHG Emissions from Academic & Research Fleet Vehicles ($MTCO_2E$):			1,609

Table F.5. GHG Emissions from Academic and Research Area Fleet Vehicles, Calendar Year 2005.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by Life Flight	230,463	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	2,206

Table F.6. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2005.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane use by Animal Care	1.8	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	1

Table F.7. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2005[156].

Gas Combustion: Natural Gas (cubic feet) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Cubic feet of Natural Gas listed is the same amount reported in Vanderbilt' 2005 Annual Air Emissions Report.

152 Estimate of gasoline purchases is based on ITS fleet vehicle use of 3,000 miles per year at 17 miles per gallon.

153 2007 fuel usage data is utilized here; 2005 fuel usage data is not available.

154 Estimate of gasoline purchases is based on ITS fleet vehicle use of 3,000 miles per year at 17 miles per gallon.

155 2007 fuel usage data is utilized here; 2005 fuel usage data is not available.

156 Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].

Anesthetic Gas	Volume Used[157] (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	4,177	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	1,295
Isoflurane	475	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	166
Desflurane	1,540	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,523
Sevoflurane	549	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	189
Total for Anesthesiology/Patient Care Areas			3,174

Table F.8. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2005[158].

Diesel fuel consumed by emergency generators (gallons)	Emission Factor	Amount * Emission Factor = $MTCO_2E$	Academic Areas (65% of total emissions) ($MTCO_2E$)	Patient Care Areas (35% of total emissions) ($MTCO_2E$)
83,441	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	846	550	296

Table F.9. GHG Emissions from Emergency Generators, Calendar Year 2005.

Source	Volume Released (kilograms)	Emission Factor	$MTCO_2E$
Refrigerant Releases - Academic Areas	220	1 kilogram of refrigerant = 1.3 $MTCO_2E$	286
Refrigerant Releases - Patient Care Areas	145	1 kilogram of refrigerant = 1.3 $MTCO_2E$	189

Table F.10. GHG Emissions from Refrigerant Releases, Calendar Year 2005[159].

Kilowatt-Hours Purchased (KwH)	Emission Factor per 1,000 KwH ($MTCO_2E$)	Total Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65% of total emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35% of total emissions) ($MTCO_2E$)
294,070,522	0.74762	223,343	145,173	78,170

Table F.11. GHG Emissions from Electricity Purchases, Calendar Year 2005[160].

[157] 2007 usage data is utilized here; 2005 usage data is not available.
[158] Calculations and Values for Anesthetics taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C].
[159] Emission Factor for R-134A is used as a default emission factor, as some refrigerants do not have a published emission factor/global warming potential (GWP).
[160] Emission Factor based on TVA's published fuel mix for electrical generation: Coal (63%), Nuclear (29%), Hydroelectric Dams (8%).

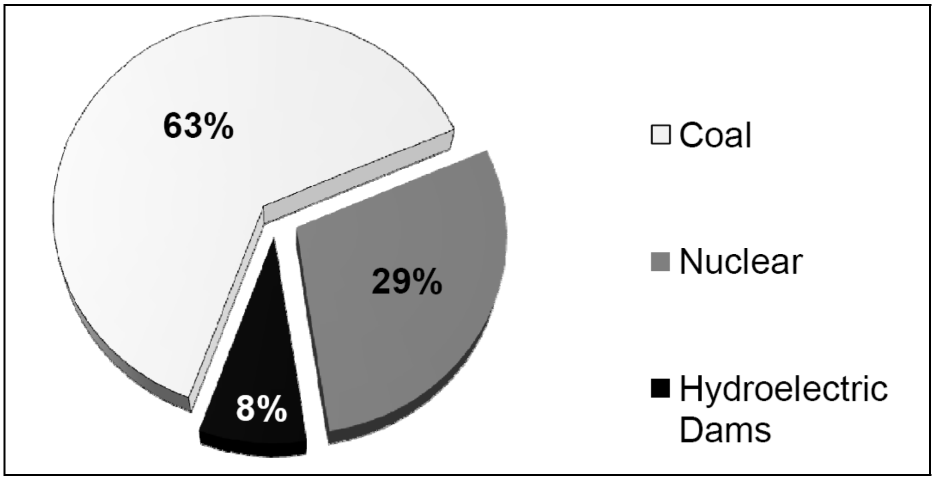

Figure F.5. TVA Fuel Mix, Calendar Year 2005.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	1,456	1 Ton of waste = 0.1467 $MTCO_2E$	213.6
Waste landfilled with landfill gas combusted to the atmosphere	3,094	1 Ton of waste = 0.2567 $MTCO_2E$	794.2
Incinerated Waste	65	1 Ton of waste = 0.22 $MTCO_2E$	14.3
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,022**

Table F.12. Academic and Research Area GHG Emissions from Waste Disposal, Calendar Year 2005[161].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[162]
Faculty	95%	3%	1%	1%	200	48
Staff	95%	3%	1%	1%	250	48
Student	15%	5%	0%	80%	200	10

Table F.13. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas, Calendar Year 2005.

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[161] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 32% of landfill gas from this landfill is used to generate electricity; the remaining 68% is "flared" to the atmosphere. Therefore, 32% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[162] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

Faculty and Staff Commuter Miles for Academic & Research Areas	Commuter Miles for Students	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
102,525,588	3,972,900	4,806,043	6,678

Table F.14. Estimated Fuel Consumption for Academic & Research Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2005[163].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,806,043	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	42,942
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
6,678	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	68
GHG Emissions Associated with Commuter Travel: Academic & Research Areas ($MTCO_2E$)		**43,010**

Table F.15. Academic and Research Area GHG Emissions from Commuter Travel, Calendar Year 2005.

Air Passenger-Miles traveled[164]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
6,769,829	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	5,259

Table F.16. Academic and Research Area GHG Emissions from Air Travel, Calendar Year 2005.

Cohort	Population Size
Faculty Members[165]	2,861
Students[166]	11,294
University Central Staff[167]	3,918
Research & Administrative Staff in Medical Center[168]	2,624
Total Number of Staff Members, Academic & Research	6,542
Patient Care Staff in Medical Center[169]	8,540
Off-Site Medical Center Staff[170]	1,517

Table F.17. Population of Students, Faculty, and Staff, Calendar Year 2005.

[163] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.
[164] 2007 air passenger-miles is utilized here; 2005 air travel data is not available. Passenger-miles traveled provided by Caldwell Travel Group.
[165] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
[166] VU Financial Report 2009, http://financialreport.vanderbilt.edu/reports/FY2009%20Financial%20Report.pdf.
[167] From Quick Facts for VU, 2005.
[168] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[169] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[170] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	2,186	1 Ton of waste = 0.1467 $MTCO_2E$	321
Waste landfilled with landfill gas combusted to the atmosphere	4,646	1 Ton of waste = 0.2567 $MTCO_2E$	1,193
Incinerated Waste	84	1 Ton of waste = 0.22 $MTCO_2E$	18
Medical Waste Autoclaved Off-Site	217	1 Ton of waste = 0.243 $MTCO_2E$	53
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,585**

Table F.18. Patient Care Area GHG Emissions from Waste Disposal, Calendar Year 2005[171].

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[172]
Staff	95%	3%	1%	1%	250	48

Table F.19. Assumptions for Staff Commuter Travel for Patient Care Areas, Calendar Year 2005.

Staff Commuter Miles for Patient Care Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
99,098,160	4,474,805	5,167

Table F.20. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2005[173].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,474,805	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	39,982
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
5,167	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	52
GHG Emissions Associated with Commuter Travel: Patient Care Areas ($MTCO_2E$)		**40,035**

Table F.21. Patient Care Area GHG Emissions from Commuter Travel, Calendar Year 2005.

[171] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 32% of landfill gas from this landfill is used to generate electricity; the remaining 68% is "flared" to the atmosphere. Therefore, 32% of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emission factor that is different from the emission factor developed for flared landfill gas.

[172] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

[173] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.