Baseline Inventory of Greenhouse Gas Emissions 2005-2007

VANDERBILT UNIVERSITY

SustainVU
Growing Responsibly

Cover photo by Robert Wheaton

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Produced collaboratively by the Sustainability and Environmental Management Office with the Plant Operations Department, Campus Planning and Construction Department, and the Division of Public Affairs.

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.

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VANDERBILT UNIVERSITY BASELINE INVENTORY OF GREENHOUSE GAS EMISSIONS, 2005-2007

EXECUTIVE SUMMARY

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

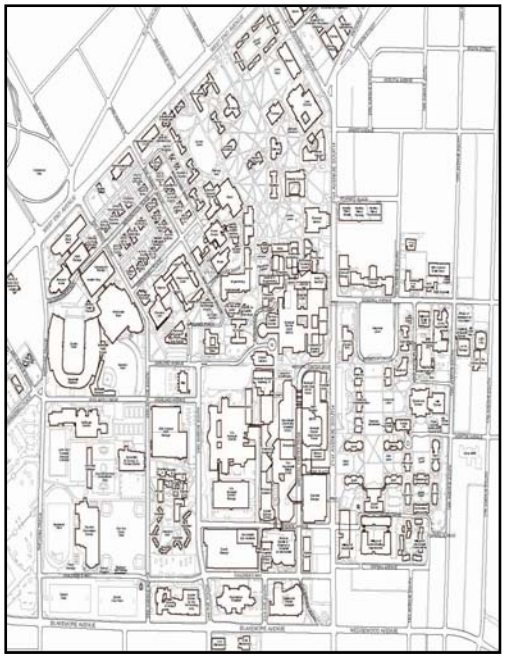
Background

On February 23, 2009, Vanderbilt announced that an initial greenhouse gas inventory would be developed. Because the combination of the variables differs vastly across the communities forming each institution, every university must establish its own greenhouse gas emissions baseline, or carbon footprint. Vanderbilt emits greenhouse gases 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. This report will establish a baseline of Vanderbilt's average annual greenhouse gas emissions from 2005 to 2007 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 inventory is being released in conjunction with the publication of the University's Environmental Commitment Statement.

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 greenhouse gas 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 baseline

greenhouse gas inventory, along with the identification of greenhouse gas emission sources at Vanderbilt and the definition of the baseline time period.



The physical boundary for Vanderbilt University's baseline greenhouse gas 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 greenhouse gas emissions calculations), Vanderbilt's greenhouse gas inventory is unique and largely comprehensive. The core Vanderbilt campus contains over 190 buildings, comprising over 16.5 million gross square feet of space.

Campus operations that produce greenhouse gases 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.

A standardized, publicly available greenhouse gas 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 greenhouse gas 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, the baseline greenhouse gas inventory report was presented to a committee of reviewers prior to publication.

Findings

During the calendar years 2005 to 2007, Vanderbilt University's average yearly greenhouse gas emissions are estimated to be 487,000 metric tons of carbon dioxide equivalent ($MTCO_2E$). Academic and research areas accounted for 302,000 $MTCO_2E$ (62%) of this yearly average; patient care areas accounted for 185,000 $MTCO_2E$ (38%). More detail is provided in Table ES.1 and Figure ES.1.

Source	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Total Emissions by Source ($MTCO_2E$)
Scope 1 Greenhouse Gas Emissions: On-Site Sources			
Coal use at VU Power Plant	76,177	41,018	117,195
Natural Gas use at VU Power Plant	24,408	13,143	37,551
Natural Gas use in Individual Buildings	2,457	1,323	3,780
Diesel-Powered Generators	635	342	977
Refrigerant Releases	133	0	133
Fleet Vehicles	1,822	2,032	3,854
Anesthetic Gas Use	1	3,126	3,127
Subtotal of Scope 1 Emissions:	105,633	60,984	166,617
Scope 2 Greenhouse Gas Emissions: Electricity Purchases			
Electricity Purchased from NES	144,200	77,646	221,846
Scope 3 Greenhouse Gas Emissions: Indirect Sources			
Faculty & Staff Commuting	46,227	44,384	90,611
Air Travel	5,259	-	5,259
Waste Disposal	1,098	1,689	2,787
Subtotal of Scope 3 Emissions:	52,584	46,073	98,657
Total Baseline Emissions, rounded to the nearest 1,000 metric tons:	**302,000**	**185,000**	**487,000**

Table ES.1. Baseline Greenhouse Gas Emissions Inventory Summary, Annual Average, 2005-2007.

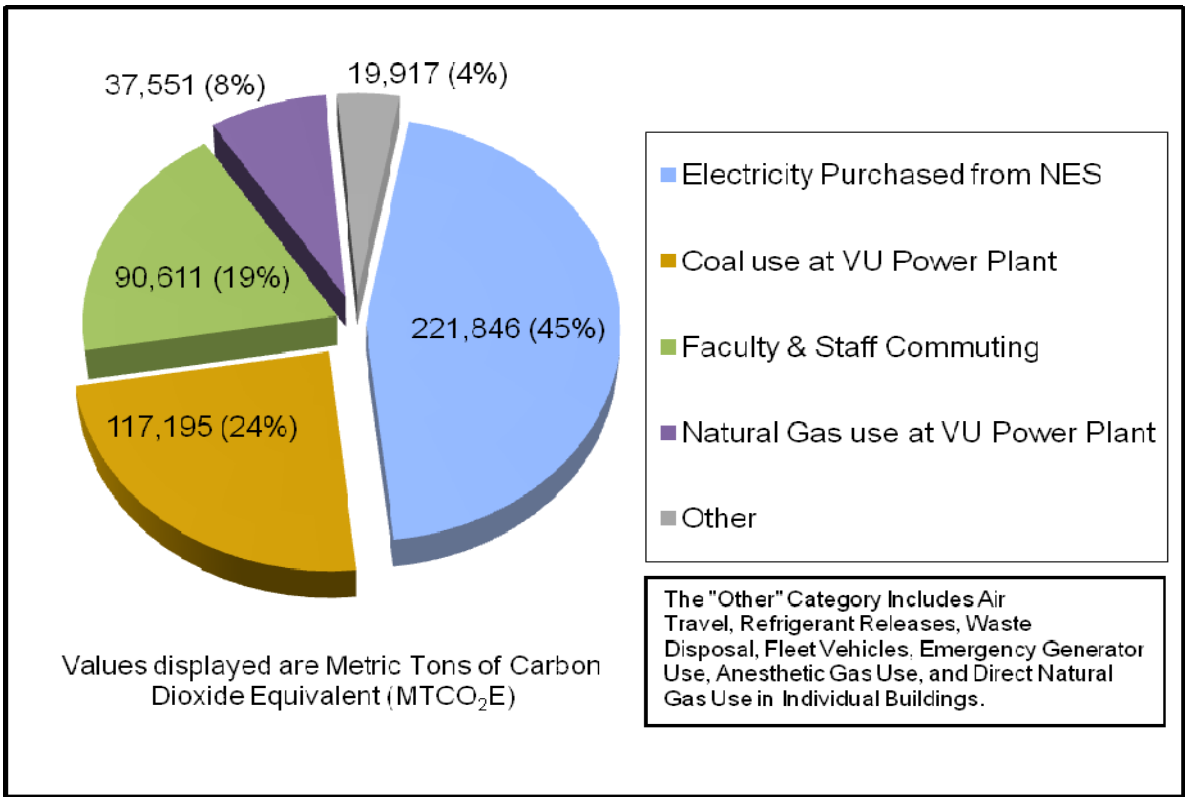


Figure ES.1. Vanderbilt University Baseline Emissions by Source, Annual Average, 2005-2007.

The baseline inventory results illustrate 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 greenhouse gas emissions, accounting for 96% of the annual average greenhouse gas emissions from Vanderbilt University. Thus, reducing energy usage and supporting commuter choice programs have the most potential to reduce greenhouse gas emissions at Vanderbilt University.

Interpreting Vanderbilt's Results

Only a very small portion of universities nationwide have completed greenhouse gas inventory reports and made them publicly available. Thus, Vanderbilt is acting proactively by taking this step. Additionally, most university greenhouse gas 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 greenhouse gas emissions in the years to come is its own baseline, utilizing consistent interpretations as presented in this initial report.

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 greenhouse gas emissions to others:

- 93% of Vanderbilt undergraduate students live in on-campus residence houses, which are supplied using 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 (on-site sources) and larger Scope 3 emissions (indirect sources).
- Vanderbilt was awarded $520 million[1] in 2008 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 huge consumers of energy through the operation of lab equipment.
- The Vanderbilt 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.

When compared to other major research institutions, Vanderbilt's greenhouse gas emissions compare quite reasonably. Table ES.2 below illustrates emissions per $1,000 of research awarded to Vanderbilt University in relation to several other universities with large amounts of on-campus research.

Comparison by Research Awards	
University	**Average $MTCO_2E$ per $1,000 Research Awarded during 2005-2007**
University of Maryland – College Park	1.02
University of Michigan	0.77
Vanderbilt University	0.64
University of Pennsylvania	0.60

Table ES.2. Comparison of VU Greenhouse Gas Emissions with Other Universities, by Research Dollars Awarded.

[1] February 2009. ReVU: Facts about Vanderbilt. Available http://www.vanderbilt.edu/facts.html.

There is currently no standardized methodology for calculating university carbon footprints. Therefore, our own baseline emissions presented in this report provide the only applicable standard to which Vanderbilt can assess its greenhouse gas emissions in the years to come.

Future Plans

This first inventory provides a baseline to enable campus stakeholders to have sufficiently detailed information to make informed decisions to determine reduction strategies and compare future changes in greenhouse gas emissions on campus. Annual emissions inventories will be conducted in the future to measure progress, which will be made publicly available on www.vanderbilt.edu/sustainvu.

In the interim, each member of the Vanderbilt community should take part in reducing greenhouse gas 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 at www.vanderbilt.edu/sustainvu/thinkone.

I. BACKGROUND

Vanderbilt University

Vanderbilt University, founded in 1873, is a private, research 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 2,800 full-time faculty and a staff of over 21,500[2]. The campus, located near downtown Nashville, spans approximately 330 acres and contains over 190 buildings. More than 200 tree species exist on Vanderbilt's grounds, leading to the school's recognitions as an arboretum since 1988.

Baseline 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 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, SEMO, the Plant Operations Department, Campus Planning and Construction and the Division of Public Affairs began gathering information necessary to conduct this initial greenhouse gas emissions baseline inventory.

Because Vanderbilt University is a community like no other with distinctive characteristics, it is necessary to establish its own greenhouse gas emissions baseline, or carbon footprint. Vanderbilt emits greenhouse gases 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. This report establishes a baseline of Vanderbilt's average annual greenhouse gas

[1] According to 2008-2009 enrollment data found in ReVU: Facts about Vanderbilt. Available http://www.vanderbilt.edu/facts.html

[2] Employment information found in ReVU: Facts about Vanderbilt. Available http://www.vanderbilt.edu/facts.html

emissions so that the Vanderbilt community can better understand the University's current impact on the environment and determine the best improvement strategies to implement in the future.

Greenhouse Gases: Impact and Importance

A carbon footprint is a standard that people and organizations are using to quantify the impact they have on the environment, particularly as their behaviors relate to climate change concerns. The six greenhouse gases 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 cows 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 greenhouse gases interact with the environment.

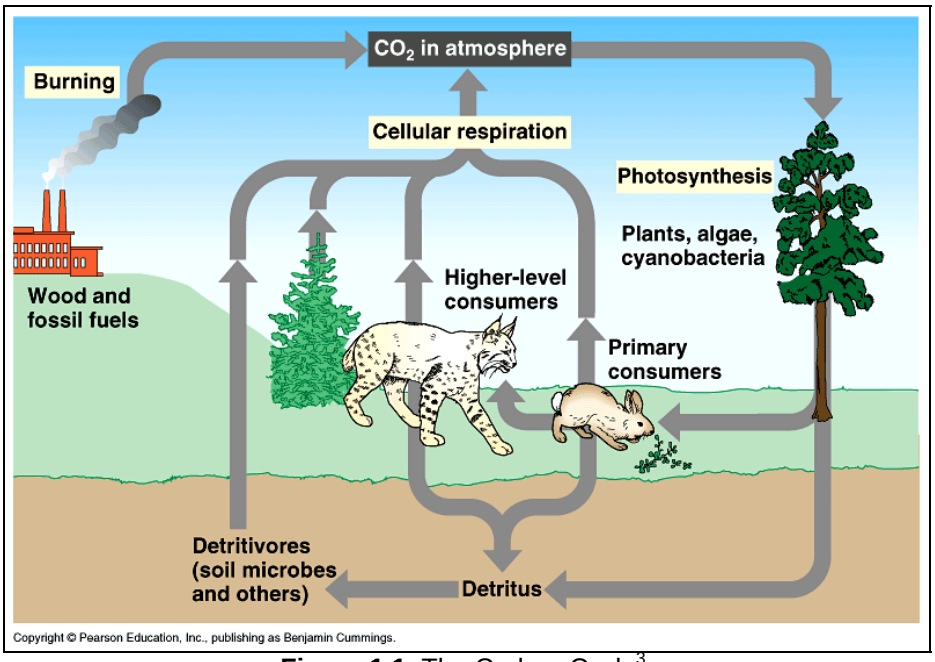


Figure 1.1. The Carbon Cycle[3].

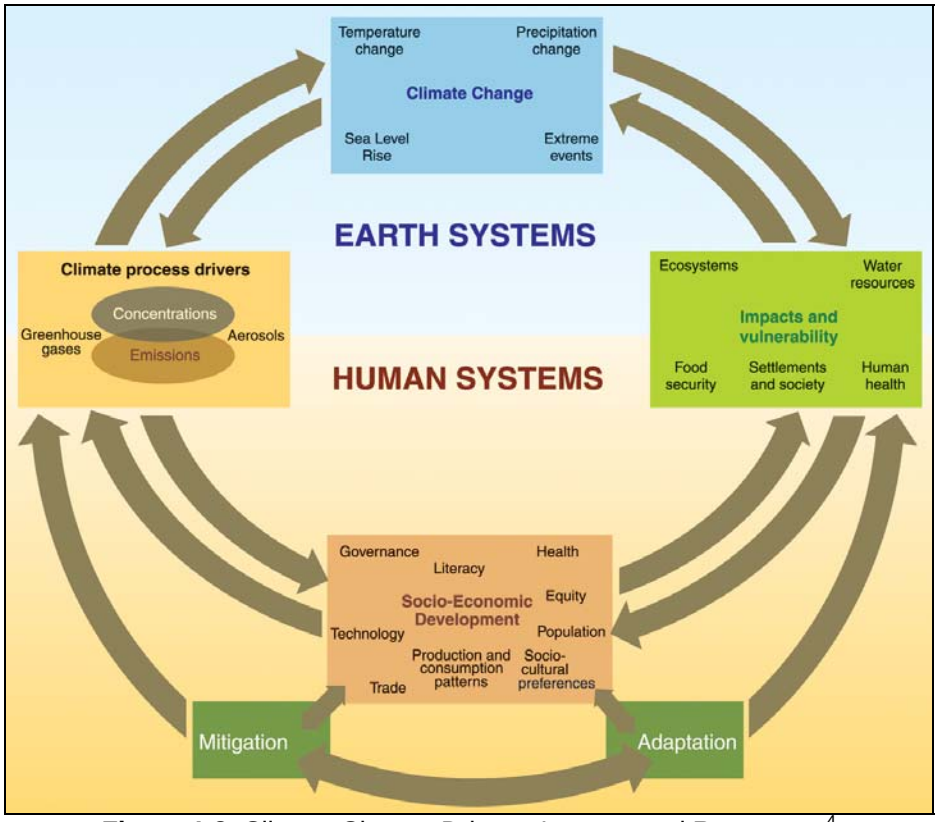


Figure 1.2. Climate Change Drivers, Impacts and Responses[4]

[3] Retrieved Mar. 2, 2009. "The Carbon Cycle." Available http://io.uwinnipeg.ca/~simmons/16cm05/1116/54-17-CarbonCycle-L.gif

[4] Retrieved Mar. 2, 2009. "Figure I-1." *AR4 Synthesis Report*. (2007). Intergovernmental Panel on Climate Change. Available http://www.ipcc.ch/graphics/graphics.htm.

Greenhouse gases, 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].
- 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 greenhouse gas concentrations. In addition, greenhouse gas 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.

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[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.
[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.

Vanderbilt Operations Resulting in Greenhouse Gas Emissions

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

Vanderbilt produces on-site, 21% 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 steam 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 the end user. The remainder of the electricity needed to power Vanderbilt's campus (79% 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 greenhouse gases not discussed in the previous section were included in this baseline inventory. Typically, nitrous oxide is the only anesthetic gas included in a university's greenhouse gas inventory (if it is included at all). However here at Vanderbilt, our patient care and animal care 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 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 December of 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 greenhouse gas 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. BASELINE INVENTORY DEVELOPMENT METHODOLOGY

Boundary Definitions

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

Operational Boundary

Activities at Vanderbilt University that produce greenhouse gas emissions include those outlined by 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 WRI Greenhouse Gas Protocol categorizes greenhouse gas emissions into three Scopes, as follows:

- Scope 1: Direct Emissions. These are emissions produced by activities that are under direct control of the institution. Vanderbilt's direct (Scope 1) emissions include coal and natural gas consumption at the on-campus power plant; consumption of natural gas within individual buildings at Vanderbilt; fuel consumption by university-owned vehicles; releases of refrigerants and anesthetic gases; and fuel consumed by Vanderbilt-owned emergency generators. 21% of VU electricity and 100% of steam and chilled water needs are produced by the on-campus, co-generation power plant.

- 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 79% 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.

Greenhouse gas emissions associated with the production and delivery of goods and services to Vanderbilt (i.e. "upstream" emissions) were not included in this baseline greenhouse gas 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 greenhouse gas emissions from these two missions, this report provides a sub-total of greenhouse gas emissions associated with academic and research areas, 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 administrative buildings, residence halls, athletics facilities, parking garages for staff, and common space/multi-purpose areas while Patient Care areas include hospitals, clinics, and parking garages reserved for patients and visitors.

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.

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

Table 3.1. Vanderbilt's Patient Care Buildings

The standard 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

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

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 190 buildings, encompassing over 16.5 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 greenhouse gas 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 baseline of Vanderbilt's average annual greenhouse gas emissions that can serve as a benchmark for future greenhouse gas-emitting activity. Using the total greenhouse gas emissions from a single fiscal or calendar year as a baseline would not represent a true baseline 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 greenhouse gas emissions for a particular year. In an effort to capture these "peaks & valleys" in activities at Vanderbilt, the baseline inventory established in this report is the *average annual* greenhouse gas emissions created by Vanderbilt during the 2005, 2006, and 2007 calendar years.

Greenhouse Gas Calculation Protocol

Vanderbilt's greenhouse gas emissions were calculated using the Campus Carbon Calculator developed by Clean Air – Cool Planet™ (Version 5.0, 2006). 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 greenhouse gas 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.

Greenhouse Gas Data Collection and Inventory Methodology

As noted above, data related to specific activities at Vanderbilt were the basis in determining the university's greenhouse gas emissions. The Campus Carbon Calculator allows for the input of data on an annual basis. Data provided to SEMO on a monthly basis was aggregated to establish a yearly total for use in the Campus Carbon Calculator. Once all the necessary data was put into the calculator, a yearly greenhouse gas emission number was determined for each of the baseline calendar years (2005, 2006, and 2007). The annual emission numbers were added together and divided by the number of years (3) to produce an annual average of greenhouse gas emissions for Vanderbilt University. A description of the collected data, data sources, and calculations used are provided in this section.

On-Campus Energy Production

Vanderbilt's sources of greenhouse gas emissions located on the campus (and which 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, natural gas, and diesel fuel for each of these sources (power plant, individual buildings, and individual emergency generators) was provided by the Plant Operations Department and directly input to the Campus Carbon Calculator.

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%!

For more information on the VU co-generation power plant, click here to go to the Energy FAQ section of Vanderbilt's ThinkOne web site.

Vanderbilt's Sources of Electricity

The university's co-generation power plant supplies Vanderbilt with 100% of the steam needed for heating buildings. Excess heat from steam generation is used to create electricity, satisfying 21% of Vanderbilt's annual electricity demand.

The remaining 79% of Vanderbilt's electricity demand is obtained through electricity purchased from TVA (through NES). As noted in the Methodology section of this report, 64% of TVA's electricity comes from coal-fired power plants, with 29% of TVA's electricity coming from nuclear power and 7% coming from hydroelectric dams.

When TVA's electricity sources are combined with Vanderbilt's on-site capabilities, a better picture of VU's electricity sources can be presented, as shown in Figure 3.1 below.

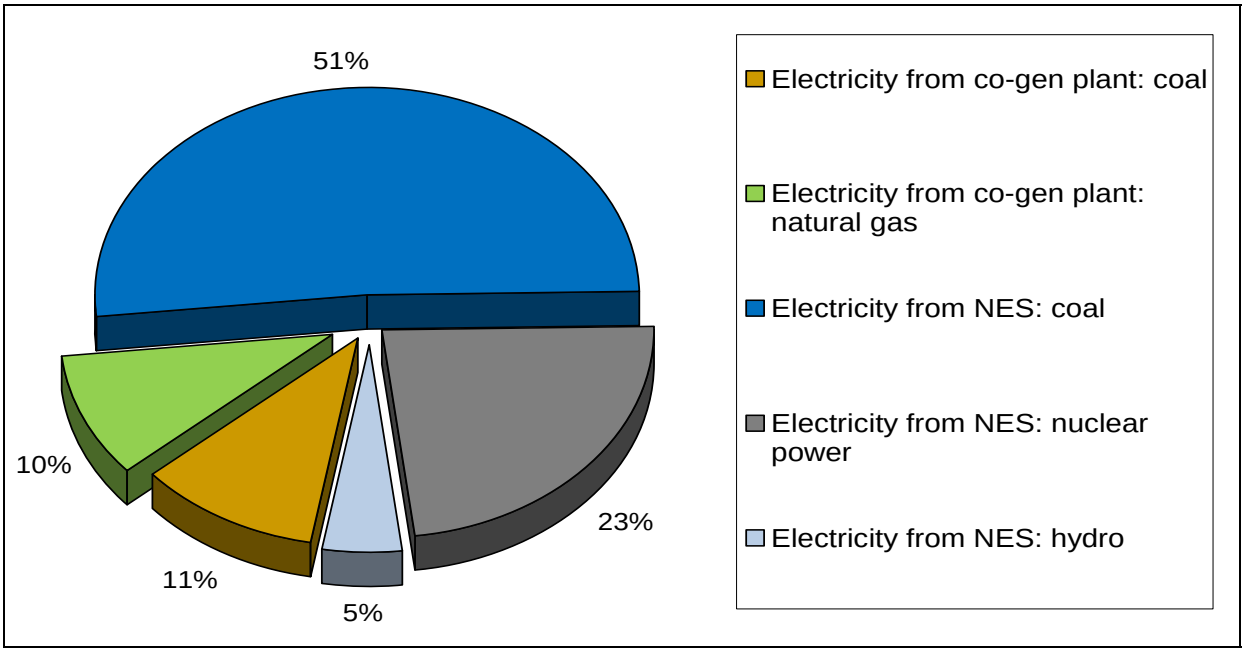

Figure 3.1. Vanderbilt's Sources of Electricity.

University-Owned Vehicles

Vanderbilt University owns over 280 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 major 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 22 miles per gallon (the default value used by the Campus Carbon Calculator). 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 greenhouse gas emissions associated with LifeFlight's use of Jet A fuel using an emission factor from WRI's Greenhouse Gas Protocol.

Anesthetic Gases

Vanderbilt uses different kinds of anesthetic gases in patient care areas than in animal care areas/research laboratories. 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 greenhouse gas emissions from anesthetic gas use based on GWP's provided by WRI's Greenhouse Gas Protocol.

Anesthetic Gas and Greenhouse Gas Emissions

We typically attribute greenhouse gas emissions to sources such as cars, factories, and power plants. But did you know that anesthetic gases also contribute to greenhouse gas 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

Large universities keep track of releases of refrigerants to the atmosphere as required by the Environmental Protection Agency. The university's Plant Operations Department and VU Medical Center's 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

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 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. Approximately 64% of TVA's power generation comes from coal-fired power plants; 29% of TVA's power is generated at nuclear power plants; and 7% of TVA's power comes from hydroelectric dams. Less than 1% of TVA's electricity comes from renewable sources and from purchases of power generated by other regional power

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, the average residence in Nashville consumes around 15,000 kilowatt-hours (KwH) each year*, resulting in approximately 10 metric tons of CO_2E emissions. 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 ($MTCO_2E$)*
Ohio	15
Georgia	12
Florida	10
Texas	10
Tennessee	10
North Carolina	9
Massachusetts	7
Colorado	6
Washington	5

* Nashville Electric Service, *Residential Rates* web page.

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. Based on commuter data provided by VUMC's Parking and Transportation Services Office, it was assumed that in the years 2005-2007 95% of the university's faculty and staff commute to Vanderbilt in a single-occupancy vehicle; 3% of faculty and staff commute via carpool; 1% of faculty and staff commute via bus; and 1% of faculty and staff use alternate forms for commuting (walk or bike). Regarding Vanderbilt's student population, it was assumed that 15% of students commute 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.

A recent study conducted by Vanderbilt Medical Center'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 greenhouse gas 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 greenhouse gas emission amounts were calculated for patient care areas and academic and research 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 calendar year include passenger-miles, which were input to the Campus Carbon Calculator. Air passenger-miles were not recorded prior to 2007. 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 baseline inventory.

Waste Management

Data related to the amount of waste generated annually by Vanderbilt was provided by waste vendors and by 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 greenhouse gas 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. According to Allied Waste's gas recovery records, approximately 32% of the landfill gas from the Rutherford County landfill is used to generate electricity; the remaining 68% of 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 and waste industry journals, SEMO estimated how much natural gas is needed to autoclave one ton of medical waste. The greenhouse gas emissions associated with autoclaving Vanderbilt's medical waste at an off-site location was then calculated using the greenhouse gas 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[11], two types of uncertainties are associated with greenhouse gas 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 greenhouse gas 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 greenhouse gas 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 greenhouse gas inventory.

In an effort to balance the inherent uncertainties in this inventory with the need for transparency and comprehensiveness, the baseline greenhouse gas inventory results for Academic and Research Areas and Patient Care Areas are presented in Sections IV and V as generated from the Clean Air-Cool Planet Campus Calculator. These calculated results have then been presented as estimations rounded to the nearest 1,000 $MTCO_2E$ in the summary presented in Section VI and in the Executive Summary for the report.

[11] 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, student activities, student housing, dining, and athletic facilities. The academic and research-related component of Vanderbilt University generates an estimated 302,000 $MTCO_2E$ in an average year during the baseline period, as shown in Table 4.1. This amount is 62% of the university's total carbon footprint. Major contributors to the emissions from academic and research areas are shown in Figure 4.1 while a summary of the contribution from each Scope is shown in Figure 4.2.

Greenhouse Gas Source	Academic & Research Areas ($MTCO_2E$)
Coal Use at VU Power Plant	76,177
Natural Gas use at VU Power Plant	24,408
Natural Gas use in Individual Buildings	2,457
Diesel-Powered Generators	635
Refrigerant Releases	133
University-Owned Vehicles	1,822
Anesthetic Gas Use	1
Electricity Purchased from NES	144,200
Faculty & Staff Commuting	46,227
Air Travel	5,259
Off-site Waste Disposal	1,098
Total greenhouse gas emissions per year, rounded to the nearest 1,000:	**302,000**

Table 4.1. Baseline Greenhouse Gas Emissions Inventory Summary, Academic & Research Areas, Yearly Average, 2005-2007.

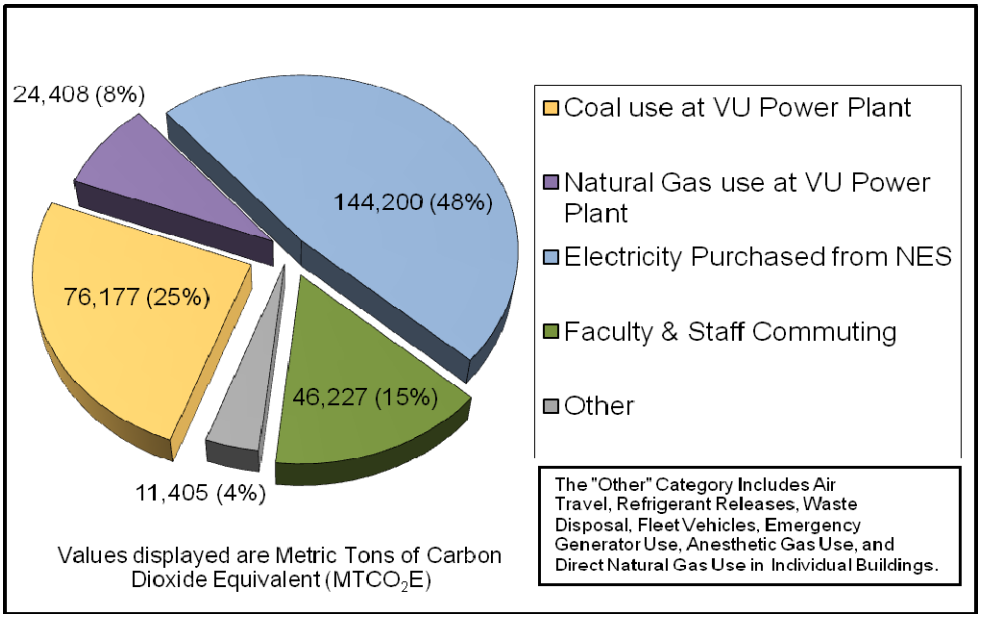

Figure 4.1. Academic and Research Areas Baseline Average Yearly Emissions by Source, 2005-2007.

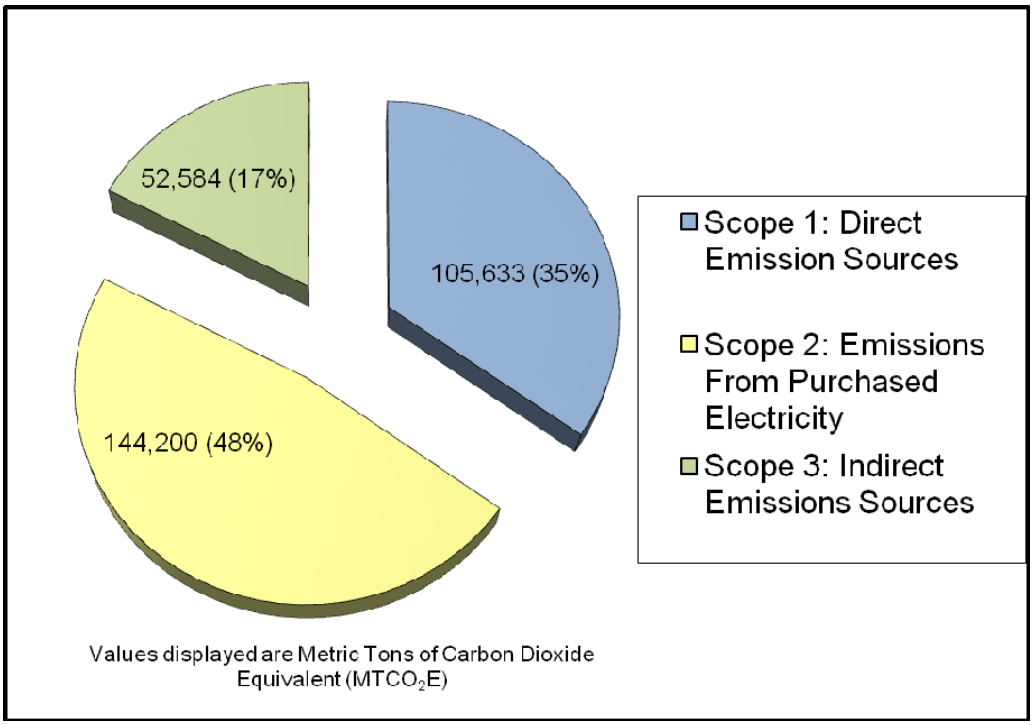

Figure 4.2. Academic and Research Areas Baseline Average Yearly Emissions by Scope, 2005-2007.

Scope 1: On-Site Sources

Vanderbilt's direct (Scope 1) greenhouse gas emission sources include coal and natural gas consumption at the on-campus, co-generation power plant, consumption of natural gas within individual buildings at Vanderbilt, fuel consumption by university-owned vehicles, releases of refrigerants and anesthetic gases, and fuel consumed by emergency generators. A review of monthly steam and electricity usage by building for the calendar years 2005 through 2007 revealed that approximately 65% of the steam and electricity consumed by Vanderbilt was consumed by Academic and Research buildings (including administrative buildings, residential buildings, athletics areas, outdoor lighting, staff parking garages, and multi-purpose buildings). Therefore, 65% of the greenhouse gas emissions associated with the power plant were attributed to Academic and Research areas. Overall, the average yearly greenhouse gas emissions from Scope 1 Sources for Academic and Research amounted to 105,633 $MTCO_2E$, or 35%, of the carbon footprint for Academic and Research areas, as shown in Table 4.2.

Source	Academic & Research Areas ($MTCO_2E$)
Scope 1 Greenhouse Gas Emissions: On-Site Sources	
Coal Use at VU Power Plant	76,177
Natural Gas use at VU Power Plant	24,408
Natural Gas use in Individual Buildings	2,457
Diesel-Powered Generators	635
Refrigerant Releases	133
University-Owned Vehicles	1,822
Anesthetic Gas Use	1
Total of Scope 1 Emissions:	105,633

Table 4.2. Scope 1 Greenhouse Gas Emissions Sources, Academic & Research Areas.

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 baseline inventory results illustrate that 76,177 $MTCO_2E$, or 25%, of average yearly emissions associated with Academic and Research areas result from coal use at the power plant, while 8%, or 24,408 $MTCO_2E$ of these average yearly emissions in Academic and Research areas are attributed to the burning of natural gas at the power plant. See Table 4.3 below for more details.

Source	Year			Three-Year Average	Emission Factor	Baseline Emissions per Source ($MTCO_2E$)	Emissions for Academic Areas (65%) ($MTCO_2E$)
	2005	2006	2007				
Coal use at VU Power Plant (Tons)	57,249	59,091	66,070	60,803	1 Ton of coal = 1.927 $MTCO_2E$	117,195	76,177
Natural gas use at VU Power Plant [MMBTU]	767,000	571,000	716,000	684,667	1 MMBTU = 0.0548 $MTCO_2E$	37,551	24,408
Natural gas use in individual buildings [MMBTU]	74,000	121,000	93,000	96,000	1 MMBTU = 0.039 $MTCO_2E$	3,780	2,457
Diesel-powered generators (gallons)	83,441	82,089	125,889	97,140	1 gallon of diesel fuel = 0.01006 $MTCO_2E$	977	635
Refrigerant Releases (pounds)	166	257	94	172	1 pound of R-22 refrigerant = 0.773 $MTCO_2E$	133[12]	133

Table 4.3. Calculation of Stationary Scope 1 Emissions Sources, 2005-2007.

[12] All refrigerant releases occurred in Academic and Research areas, as described below.

Natural Gas Use in Individual Buildings

Several buildings on campus receive 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 2,457 $MTCO_2E$ of average yearly emissions in the baseline inventory. See Tables 4.2 and 4.3 above for more details.

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 635 $MTCO_2E$ to average yearly greenhouse gas emissions, as referenced in Tables 4.2 and 4.3 above.

Refrigerant Releases

Accidental releases of refrigerant from chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances can release hydrofluorocarbons and perfluorocarbons to the atmosphere. The average annual release of refrigerant from Academic and Research areas was 172 pounds of R-22 refrigerant, resulting in 133 $MTCO_2E$ of greenhouse gas emissions, as referenced in Tables 4.2 and 4.3.

University-Owned Vehicles

As noted in the Methodology section of this report, several university departments own and operate vehicles. The Plant Operations Department owns and operates 111 vehicles, which consume both gasoline and diesel fuel. The Vanderbilt Police Department owns and operates 40 gasoline-powered vehicles. The remaining inventory of university vehicles (130) are owned by various departments at Vanderbilt. The employee shuttle bus and van system uses both gasoline and diesel fuel. Total average yearly greenhouse gas emissions from university-owned vehicles in Academic and Research areas amounted to 1,822 $MTCO_2E$. See Table 4.4 below for more details.

Fleet Component	Type of Fuel	Average Annual Volume (Gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to University-owned vehicles through Plant Operations (111 vehicles)[13]	Gasoline	66,284	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	592
Gasoline purchases by VUPD (40 vehicles)[9]	Gasoline	28,959	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	259
Estimate of gasoline purchases by remaining University-owned vehicles (130 vehicles)[14]	Gasoline	22,941	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	205
Gasoline use by VUMC shuttle buses and vans[15]	Gasoline	38,284	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	342
Diesel fuel use by VUMC shuttle buses and vans[11]	Diesel	39,847	1,000 gallons of diesel fuel consumed = 10.14 $MTCO_2E$	404
Diesel fuel use by Plant Operations[9]	Diesel	1,972	1,000 gallons of diesel fuel consumed = 10.14 $MTCO_2E$	20
Baseline Greenhouse Gas Emissions from Academic and Research Area University-Owned Vehicles				**1,822**

Table 4.4. Greenhouse Gas Emissions from Vanderbilt Owned Vehicles.

Anesthetic Gas Use

The Department of Animal Care utilizes isoflurane as an anesthetic, which has a known GWP. Anesthetic gas use in Academic and Research areas resulted in 0.63 $MTCO_2E$ of average annual greenhouse gas emissions (rounded up to 1.0 $MTCO_2E$ in other tables). See Table 4.5 below for more details.

Anesthetic Gas	Department	Volume Used in 2007 (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane	Animal Care	1.8	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	0.63

Table 4.5. Greenhouse Gas Emissions from Anesthetic Gas Use, Academic and Research Areas.

[13] Fuel use from direct sales and VUPD vehicles is based on actual 2007 fuel use; fuel use data for 2005 and 2006 is not available.
[14] Estimate of gasoline purchases is based on ITS vehicle use of 3,000 miles per year at 17 miles per gallon.
[15] Fuel use by VUMC shuttle buses and vans is based on a three-year average (2005-2007).

Scope 2: Purchased Electricity

144,200 $MTCO_2E$, or 48%, of the average yearly greenhouse gas emissions for Academic and Research areas are attributed to electricity purchased from TVA, as shown in Table 4.6 below. This amount is a 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 Scope 2 Emissions[16] ($MTCO_2E$)	Scope 2 Emissions for Academic & Research Areas (65%) ($MTCO_2E$)
2005	294,070,522	223,343	145,173
2006	294,494,256	223,664	145,382
2007	287,734,887	218,531	142,045
Three-Year Average	**292,099,888**	**221,846**	**144,200**

Table 4.6 Greenhouse Gas Emissions from Purchased Electricity for Academic and Research Areas, 2005-2007.

Scope 3: Indirect Sources

Vanderbilt's indirect emissions include fuel use by commuters (faculty, staff, and student commuters), fuel use from air travel, and off-site waste disposal. 17%, or 52,584 $MTCO_2E$, of average yearly greenhouse gas emissions for Academic and Research areas are attributed to Scope 3 sources, as illustrated below in Table 4.7.

Source	Academic & Research Areas ($MTCO_2E$)
Scope 3 Greenhouse Gas Emissions: Indirect Sources	
Faculty & Staff Commuting	46,227
Air Travel	5,259
Off-site Waste Disposal	1,098
Total of Scope 3 Emissions:	52,584

Table 4.7. Scope 3 Greenhouse Gas Emissions Sources, Academic & Research Areas.

Vanderbilt University Academic and Research areas were designated according to the criteria outlined in the Methodology section of the report. For the calendar years 2005-2007, Academic and

[16] Emission factor used: 1,000 kilowatt-hours (KwH) of electricity from TVA = 0.759487 $MTCO_2E$.

Research area population averages were as follows: 11,461 students, 3,029 faculty[17] and 7,088 staff[18] in Academic and Research areas[19]. For more details see Table A.2 in the Appendix.

Commuter Travel

Faculty and staff in Academic and Research areas have an average commute distance of 24 miles (one-way)[20]; 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 area commuters consume and average of 5,165,550 gallons of gasoline and 7,193 gallons of diesel fuel per year, resulting in 46,227 $MTCO_2E$ of greenhouse gas emissions. See Tables A.1 through A.4 of the Appendix for more details.

Air Travel

Vanderbilt University's Procurement Department manages university-sanctioned travel purchased through Caldwell Travel Group. In 2007, 6,769,829 air passenger-miles were traveled. This number was utilized as the average annual air passenger-miles, as air passenger-miles were not recorded prior to 2007. The average annual emissions associated with air travel in Academic and Research areas amounted to 5,259 $MTCO_2E$. See Table A.5 of the Appendix for more details.

Waste Management

Waste from Academic and Research areas is landfilled or incinerated. Average yearly emissions from waste disposal in Academic and Research areas amounted to 1,098 $MTCO_2E$. See Table A.6 in the Appendix for more details.

[17] Faculty member population includes faculty from the School of Medicine and School of Nursing.
[18] Staff member population includes medical center employees are not in patient care buildings.
[19] Student, Faculty and Staff numbers found in ReVU: Facts about Vanderbilt.
[20] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

V. PATIENT CARE AREA GREENHOUSE GAS EMISSIONS

Results Summary

Patient care areas at VU encompass hospital buildings (VUH, VCH, PHV) and clinical buildings located on Vanderbilt's core 330 acres (VCH Doctor's Tower, Medical Center East, The Vanderbilt Clinic, etc.). The patient-care-related component of Vanderbilt University generates an estimated 185,000 $MTCO_2E$ in an average year during the baseline period, as shown in Table 5.1. This amount is 38% of the university's total carbon footprint. Major contributors to the emissions from patient care areas are shown in Figure 5.1 while a summary of the contribution from each Scope is shown in Figure 5.2.

Greenhouse Gas Source	Patient Care Areas ($MTCO_2E$)
Coal Use at VU Power Plant	41,018
Natural Gas use at VU Power Plant	13,143
Natural Gas use in Individual Buildings	1,323
Diesel-Powered Generators	342
Refrigerant Releases	0
LifeFlight	2,032
Anesthetic Gas Use	3,126
Electricity Purchased from TVA	77,646
Staff Commuting	44,384
Off-site Waste Disposal	1,689
Total greenhouse gas emissions per year, rounded to the nearest 1,000:	**185,000**

Table 5.1. Baseline Greenhouse Gas Emissions Inventory Summary, Patient Care Areas, Annual Average, 2005-2007.

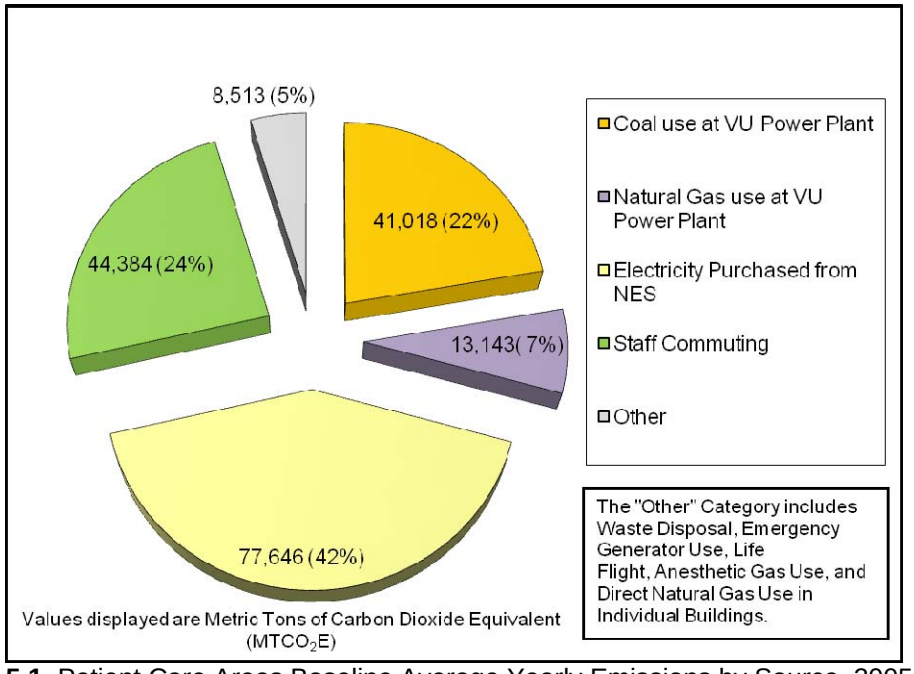

Figure 5.1. Patient Care Areas Baseline Average Yearly Emissions by Source, 2005-2007.

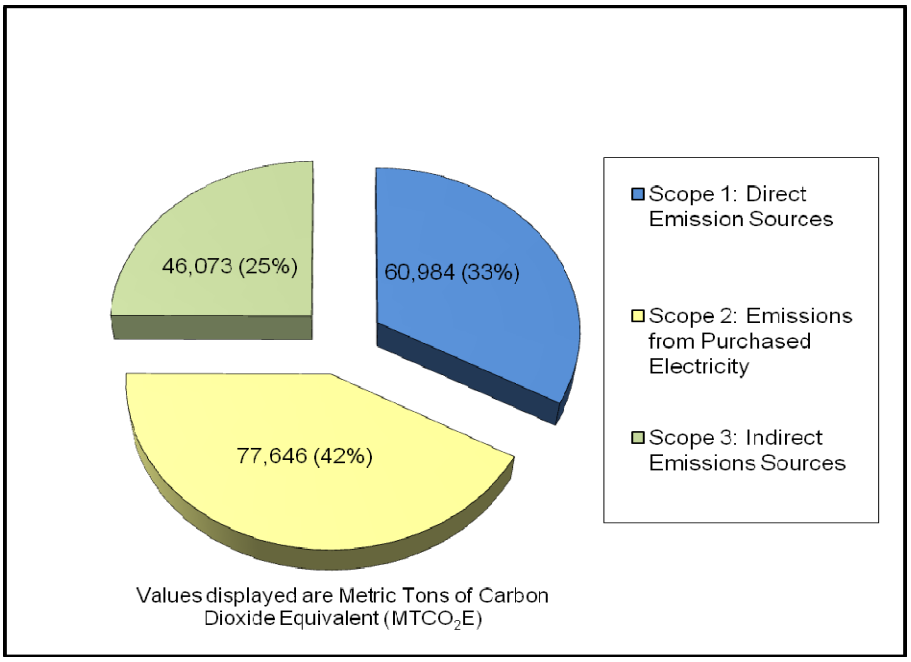

Figure 5.2. Patient Care Areas Baseline Average Yearly Emissions by Scope, 2005-2007.

Scope 1: On-Site Sources

Vanderbilt's direct (Scope 1) greenhouse gas emission sources for patient care areas include coal and natural gas consumption at the on-campus, co-generation power plant, consumption of natural gas within individual buildings at Vanderbilt, releases of anesthetic gases, and fuel consumed by emergency generators. A review of monthly steam and electricity usage by building for the calendar years 2005 through 2007 revealed that approximately 35% of the steam and electricity consumed by Vanderbilt was consumed by Patient Care buildings. Therefore, 35% of the greenhouse gas emissions associated with the power plant were attributed to Patient Care areas. Overall, the average yearly greenhouse gas emissions from Scope 1 Sources for Patient Care areas amounted to 60,984 $MTCO_2E$, or 33%, of the carbon footprint for Patient Care areas, as shown in Table 5.2 below.

Source	Patient Care Areas ($MTCO_2E$)
Scope 1 Greenhouse Gas Emissions: On-Site Source	
Coal Use at VU Power Plant	41,018
Natural Gas use at VU Power Plant	13,143
Natural Gas use in Individual Buildings	1,323
Diesel-Powered Generators	342
Refrigerant Releases	0
LifeFlight	2,032
Anesthetic Gas Use	3,126
Total of Scope 1 Emissions:	60,984

Table 5.2. Scope 1 Greenhouse Gas Emissions Sources, Patient Care Areas.

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 baseline inventory results illustrate that 41,018 $MTCO_2E$, or 22%, of average yearly emissions associated with Patient Care areas result from coal use at the power plant, while 7%, or 13,143 $MTCO_2E$, of these average yearly emissions in Patient Care areas are attributed to the burning of natural gas at the power plant. See Tables 5.3 below for more details.

Source	Year			Three-Year Average	Emission Factor	Baseline Emissions per Source ($MTCO_2E$)	Emissions for Patient Care Areas (35%) ($MTCO_2E$)
	2005	2006	2007				
Coal use at VU Power Plant (Tons)	57,249	59,091	66,070	60,803	1 Ton of coal = 1.927 $MTCO_2E$	117,195	41,108
Natural gas use at VU Power Plant [MMBTU]	767,000	571,000	716,000	684,667	1 MMBTU = 0.0548 $MTCO_2E$	37,551	13,143
Natural gas use in individual buildings [MMBTU]	74,000	121,000	93,000	96,000	1 MMBTU = 0.039 $MTCO_2E$	3,780	1,323
Diesel-powered generators (gallons)	83,441	82,089	125,889	97,140	1 gallon of diesel fuel = 0.01006 $MTCO_2E$	977	342

Table 5.3. Calculation of Stationary Scope 1 Emissions Sources, Patient Care Areas, 2005-2007.

Natural Gas Use in Individual Buildings

Several Patient Care buildings receive natural gas directly from Vanderbilt's natural gas supplier, Piedmont Natural Gas. The consumption of natural gas within individual Patient Care buildings accounts for 1,323 $MTCO_2E$ of average yearly emissions in the baseline inventory. See Table 5.3 above for more details.

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 342 $MTCO_2E$ to average yearly greenhouse gas emissions, as referenced in Table 5.3 above.

Refrigerant Releases

Accidental releases of refrigerant from chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances can release hydrofluorocarbons and perfluorocarbons to the atmosphere. Releases of refrigerant from Patient Care areas during the three baseline years (2005-2007) were releases of R-123 refrigerant, which does not have a known Global Warming Potential (GWP). Therefore, no greenhouse gas emissions from refrigerant releases are associated with Patient Care areas for this baseline inventory.

University-Owned Vehicles

Total average yearly greenhouse gas emissions from fuel consumption by LifeFlight helicopters amounted to 2,032 $MTCO_2E$. See Table 5.4 below for more details.

Fleet Component	Type of Fuel	Average Annual Volume (Gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Life Flight	Jet A Fuel	212,373	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	2,032

Table 5.4. Greenhouse Gas Emissions from LifeFlight

Anesthetic Gas Use

The Department of Anesthesiology utilizes four different types of anesthetic, each with its own GWP: Isoflurane, nitrous oxide, Desflurane, and Sevoflurane. Anesthetic gas use in Patient Care areas resulted in 3,126 $MTCO_2E$ of average annual greenhouse gas emissions, as referenced in Table 5.5 below.

Anesthetic Gas	Volume Used in 2007 (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	4,177	1 kilogram of Nitrous Oxide = 0.296 $MTCO_2E$	1,236
Isoflurane	475	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	166
Desflurane	1,540	1 kilogram of Desflurane = 0.575 $MTCO_2E$	886
Sevoflurane	549	1 kilogram of Sevoflurane = 1.526 $MTCO_2E$	838
Total for Anesthesiology/Patient Care Areas			**3,126**

Table 5.5. Greenhouse Gas Emissions from Anesthetic Gas Use, Patient Care Areas.

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 recently 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.

Click here to learn more about the Dynamic Gas Scavenging System and see the national news stories on this innovative technology.

Scope 2: Purchased Electricity

77,646 $MTCO_2E$, or 42%, of the average yearly greenhouse gas emissions for Patient Care areas are attributed to electricity purchased from TVA, as shown in Table 5.6 below. This amount is a 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 Scope 2 Emissions[21] ($MTCO_2E$)	Scope 2 Emissions for Patient Care Areas ($MTCO_2E$)
2005	294,070,522	223,343	78,170
2006	294,494,256	223,664	78,283
2007	287,734,887	218,531	76,486
Three-Year Average	**292,099,888**	**221,846**	**77,646**

Table 5.6 Greenhouse Gas Emissions from Purchased Electricity for Patient Care Areas, 2005-2007.

Scope 3: Indirect Sources

Vanderbilt's indirect emissions include commuter fuel use by staff members in patient care buildings and off-site waste disposal. 25%, or 46,073 $MTCO_2E$, of average yearly greenhouse gas emissions for Patient Care areas are attributed to Scope 3 sources, as illustrated in Table 5.7 below.

Source	Patient Care Areas ($MTCO_2E$)
Scope 1 Greenhouse Gas Emissions: On-Site Sources	
Faculty & Staff Commuting	44,384
Air Travel	-
Off-site Waste Disposal	1,689
Total of Scope 3 Emissions:	46,073

Table 5.7. Scope 3 Greenhouse Gas Emissions Sources, Patient Care Areas

[21] Emission factor used: 1,000 kilowatt-hours (KwH) of electricity from TVA = 0.759487 $MTCO_2E$.

Vanderbilt University Patient Care Areas were designated according to the criteria outline in the Methodology section of the report. For the calendar years 2005-2007, the average staff population who work in patient care was 9,468[22]. For more detail see table A.8 in the Appendix.

Commuter Travel

The average commute distance for a Vanderbilt employee is 24 miles (one-way) [23]. Based on the fuel consumption estimate of 22 miles per gallon (as provided by the Campus Carbon Calculator), Patient Care commuters consumed an average of 4,960,886 gallons of gasoline and 5,728 gallons of diesel fuel per year, resulting in 44,384 $MTCO_2E$ of greenhouse gas emissions. See Tables A.7 through A.10 of the Appendix 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 greenhouse gas emissions associated with the on-site autoclaves are already included in the Scope 1 emissions for Patient Care areas. Average yearly emissions for landfilled or incinerated waste disposal from Patient Care areas amounted to 1,689 $MTCO_2E$. See Table A.11 in the Appendix for more details.

[22] Includes all staff members that work in patient care areas as provided by VU Human Resources.
[23] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.

VI. INVENTORY SUMMARY

Vanderbilt University Inventory Summary

Total average annual greenhouse gas emissions during the baseline period at Vanderbilt University were estimated to be 487,000 $MTCO_2E$, as shown in Table 6.1. 302,000 $MTCO_2E$, or 62%, of average yearly greenhouse gas emissions are attributable to Academic and Research areas; the remaining 38%, or 184,000 $MTCO_2E$, are attributable to Patient Care areas. The major sources of emissions at Vanderbilt include: purchased electricity (46%); coal use at the on-campus, co-generation power plant (24%); commuter travel (19%); and natural gas use at the on-campus, co-generation power plant (8%). These major sources present the most significant opportunities for improvements in Vanderbilt University's current carbon footprint. Additionally, emission contributions by scope are presented in Figure 6.1 and discussed below:

- Direct sources (Scope 1 sources) of Vanderbilt's greenhouse gas emissions (including on-site coal use, natural gas use, diesel-powered generators, refrigerant releases, university-owned vehicles and anesthetic gas use) were responsible for 166,616 $MTCO_2E$, or 34% of average annual greenhouse gas emissions.
- Vanderbilt's electricity purchases (Scope 2 sources) were responsible for 221,846 $MTCO_2E$, or 46% of average annual greenhouse gas emissions.
- Indirect sources (Scope 3 sources) of greenhouse gas emissions (including faculty and staff commuting, air travel and waste disposal) were responsible for 98,657 $MTCO_2E$, or 20% of average annual greenhouse gas emissions.

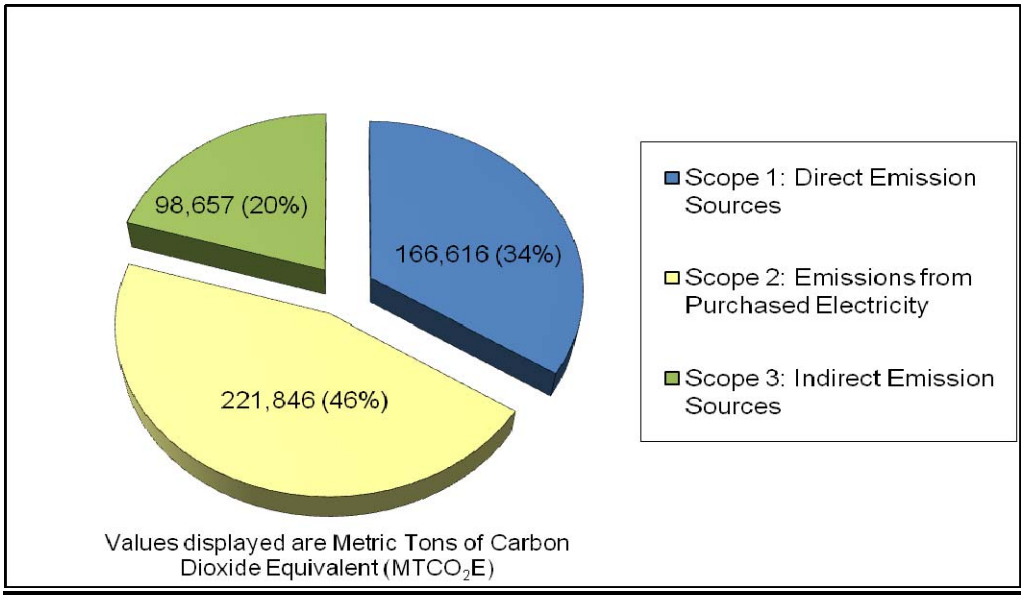

Figure 6.1. Vanderbilt University Baseline Emissions by Scope, Annual Average, 2005-2007.

A common method for reporting greenhouse gas emissions on a recurring basis is to analyze greenhouse gas emissions based on institutional metrics, such as emissions per gross square feet of building space, student enrollment, amount of research dollars awarded to a university, and total campus population (faculty, staff, and students). Growth of these institutional metrics can have a positive impact on Vanderbilt and Middle Tennessee, so normalization of greenhouse gas emissions based on these metrics can allow for periodic comparisons and evaluations while also accounting for growth of the university.

- Calculating greenhouse gas emissions per gross square foot 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 greenhouse gas emissions.
- The size of the student population and faculty/staff population also directly influence the amount of greenhouse gases emitted from Vanderbilt. More individuals on campus indicate more building occupants, increased amounts of waste generation, and more commuters.
- 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 greenhouse gas 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[24].

Table 6.1 below illustrates Vanderbilt's greenhouse gas emissions as they relate to several institutional metrics. These metrics have been calculated for all Vanderbilt areas (Academic and Research areas *plus* Patient Care Areas) with additional calculations provided for each of these separate areas.

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

	Greenhouse Gas Emissions ($MTCO_2E$)	Emissions per 1,000 gross square feet (GSF) ($MTCO_2E$)	Emissions per student ($MTCO_2E$)	Emissions per person on campus ($MTCO_2E$)	Emissions per $1,000 in research awarded ($MTCO_2E$)
Vanderbilt University (All Areas)	487,000	35.0	42.5	15.7	N/A
Vanderbilt University (Academic and Research Areas Only)	302,000	34.0	26.4	14.0	0.64
Vanderbilt University (Patient Care Areas Only)	185,000	36.8	N/A	19.5	N/A

Table 6.1. Institutional Metrics Related to Vanderbilt University's Greenhouse Gas Emissions.

- Greenhouse gas emissions per square foot of building space. Vanderbilt's greenhouse gas emissions per 1,000 gross square feet (GSF) of building space was 35 $MTCO_2E$ per 1,000 GSF. Separate calculations were made for Academic and Research Areas and Patient Care Areas based on the GSF of each of those areas; please see Table A.12 in the appendix for more details.
- Greenhouse gas emissions per student and per person. Vanderbilt's greenhouse gas emissions on a per student basis is over 26 $MTCO_2E$ per student when using emissions created only within Academic and Research Areas. As noted in this report, Vanderbilt University has a population of faculty, staff and students that totals more than 30,000 persons; when the entire university population is taken into consideration, greenhouse gas emissions on a per person basis is considerably less (approximately 14 $MTCO_2E$ per person). Moreover, the per-person emissions calculation for Patient Care Areas does not include the student or faculty populations. Therefore, separate values for Patient Care Areas and Academic & Research areas are provided in Table 6.1 above, with more details provided in Table A.12 of the Appendix.
- Greenhouse gas emissions per research awards. Vanderbilt's greenhouse gas emissions from Academic and Research Areas per $1,000 in research awards was 0.64 $MTCO_2E$ as referenced in Table 6.1 above.

Future Plans

This first inventory provides a baseline that enables campus stakeholders to have sufficiently detailed information to make informed decisions to determine reduction strategies and compare future improvements in greenhouse gas emissions on campus. The next step in this process should 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 (www.vanderbillt.edu/sustainvu/thinkone). 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.

Vanderbilt has already taken a number of significant steps to reduce greenhouse gas emissions that will be quantified in the upcoming 2008 annual update. These include expanded waste reduction, recycling and commuter support programs (more information can be found on Vanderbilt's SustainVU web site, www.vanderbilt.edu/sustainvu). 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 greenhouse gas emissions. All information related to Vanderbilt's greenhouse gas emissions reports and future updates and commitment statement will be publicly available on the SustainVU web site.

Interpreting Vanderbilt's Results

There are over 2,700 colleges and universities offering Bachelor's and Advanced degrees in the United States[25]. Only a small portion of these universities have completed greenhouse gas inventory reports and made them publicly available. Thus, Vanderbilt is acting proactively by taking this step. Additionally, most university greenhouse gas inventory reports do not include research and/or patient care activity, making Vanderbilt's report more comprehensive than most.

[25] Information obtained from the Department of Education's National Center for Education Statistics. http://nces.ed.gov/collegenavigator/. 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 6,826 schools.

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 greenhouse gas emissions in the years to come is its own baseline, utilizing consistent interpretations as presented in this initial 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 greenhouse gas emissions to others:

- 93% of Vanderbilt undergraduate students live in on-campus residence houses, which are supplied using 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[26] in 2008 to conduct scientific and medical research, with a majority of the research occurring in laboratories. Vanderbilt University has over 800 research laboratories which are huge 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[27]).
- The Vanderbilt 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 greenhouse gas 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.

[26] February 2009. ReVU: Facts about Vanderbilt. Available http://www.vanderbilt.edu/facts.html.
[27] Avimm, D. (2007). This Man Wants to Green Your Lab. *Science*, v.318, 39-41.

As noted above, the most common methods for successfully reporting greenhouse gas emissions is to analyze greenhouse gas emissions based on institutional metrics (GSF, full-time student enrollment, total campus population, and research awards). Because efforts to draw comparisons are inevitable, we attempted to determine how Vanderbilt's greenhouse gas 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 greenhouse gas 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.

University	Total Emissions ($MTCO_2E$)	Emissions per 1,000 Square Feet ($MTCO_2E$)	Emissions per Student ($MTCO_2E$)	Emissions per Person on Campus ($MTCO_2E$)
Universities With On-Campus Patient Care Activity				
University of Michigan[28]	687,000	22.0	17.2	8.8
Vanderbilt University (including Patient Care Areas)	487,000	35.0	42.5	15.7
Duke University	433,961	31.2	33.4	9.2
University of Florida	432,136	24.8	9.2	7.3
Universities Without On-Campus Patient Care Activity (or Patient Care Areas not included)				
University of North Carolina - Chapel Hill	518,469	29.6	20.0	13.1
University of Cincinnati	372,310	31.0	14.1	10.9
Georgia Institute of Technology	370,253	28.1	19.8	14.8
University of Pennsylvania	355,829	29.9	18.3	8.9
University of Maryland - College Park	351,145	27.6	10.8	8.6
Cornell University	319,000	21.4	16.1	10.7
Vanderbilt University (Academic & Research Areas Only)	302,000	34.0	26.4	14.0
Yale University[29]	284,663	22.6	25.9	13.6
Harvard University[30]	230,616	15.6	N/R[31]	11.3

Table 6.2. Comparison of Vanderbilt University Greenhouse Gas Emissions with Other Universities[32].

[28] Emissions data obtained at http://www.oseh.umich.edu/stewardship/08_report.pdf.
[29] Emissions data obtained at http://www.xylophone.net/yci/downloads/index.html.
[30] Cambridge/Allston Campus only reported. Emissions data obtained at http://www.greencampus.harvard.edu/ggi/documents/FY07Report.pdf.
[31] N/R indicates Not Reported.
[32] All greenhouse gas emissions from ACUPCC as of 3/30/09 except where indicated.

Comparison by Research Awards	
University	**Average $MTCO_2E$ per $1,000 Research Awarded during 2005-2007**
University of Maryland – College Park	1.02
University of Michigan	0.77
Vanderbilt University	0.64
University of Pennsylvania	0.60

Table 6.3. Comparison of Vanderbilt University Greenhouse Gas Emissions with Other Universities, by Research Dollars Awarded.

Additional information on the peer institutions listed above is provided in Table A.13 of the Appendix.

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 greenhouse gas 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 greenhouse gas emissions compare quite reasonably. Table 6.3 above illustrates emissions per $1,000 in research awarded to Vanderbilt University in relation to several other research entities.

Vanderbilt University recognizes its comparisons to peers; however, greenhouse gas inventory reports have been completed and made publicly available for only a small number of these universities. Moreover, many greenhouse gas 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 baseline emissions presented in this report provide the only applicable standard to which Vanderbilt can assess its greenhouse gas emissions in the years to come.

VI. APPENDIX

Population	Percent Commuting in a Single-Occupancy Vehicle	Percent Commuting in a Carpool/Vanpool	Percent Commuting via Bus	Other Forms of Commuting (walk/bike)	Days per year Commuting to campus	Average Commute Distance (via automobile)[33] (miles)
Faculty	95%	3%	1%	1%	200	48
Staff	95%	3%	1%	1%	250	48
Student	15%	5%	0%	80%	200	10

Table A.1. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas.

Year	Faculty Members [34]	Staff Members [35]	Students
2005	2,861	6,542	11,294
2006	3,004	7,097	11,481
2007	3,222	7,627	11,607
Three-Year Average	**3,029**	**7,088**	**11,461**

Table A.2. Baseline Population of Students, Faculty, and Staff for Academic and Research Areas[36].

Year	Faculty & Staff Commuter Miles for Academic & Research Areas	Commuter Miles for Students	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
2005	102,525,588	3,972,900	4,806,043	6,678
2006	110,297,322	4,018,550	5,159,759	7,184
2007	118,475,406	4,062,450	5,530,847	7,717
Three-Year Average of Fuel Consumption			**5,165,550**	**7,193**

Table A.3. Estimated Fuel Consumption for Academic and Research Areas by Commuters Based on Commuter Miles Traveled[37].

Gasoline Consumed (Three-Year Average)	Emission Factor	Gasoline Use by Commuters ($MTCO_2E$)
5,165,550	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	46,154
Diesel Fuel Consumed (Three-Year Average)	**Emission Factor**	**Diesel Use by Commuters ($MTCO_2E$)**
7,193	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	73
Greenhouse Gas Emissions Associated with Commuter Travel in Academic & Research Areas		**46,227**

Table A.4. Greenhouse Gas Emissions Calculations Related to Commuter Travel for Academic & Research Areas

[33] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.
[34] Faculty member population includes faculty from the School of Medicine and School of Nursing.
[35] Staff member population includes medical center employees that are not considered hospital/clinical staff by VU Human Resources.
[36] Student, Faculty and Staff numbers found in ReVU: Facts about Vanderbilt.
[37] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

Air Passenger-Miles Traveled (2007)[38]	Emissions Factor	(Passenger-Miles/1000) X Emissions Factor = $MTCO_2E$
6,769,829	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	**5,259**

Table A.5. Greenhouse Gas Calculations for Air Travel.

Disposal Method	Solid Waste Disposal: Three-Year Average for 2005-2007 (Tons)	Emission Factor	Emissions from Solid Waste Disposal ($MTCO_2E$)
Waste landfilled with landfill gas recovery converted to electricity[39]	1,562	1 Ton of waste = 0.1467 $MTCO_2E$	229
Waste landfilled with landfill gas combusted to the atmosphere	3,318	1 Ton of waste = 0.2567 $MTCO_2E$	852
Incinerated Waste	77	1 Ton of waste = 0.22 $MTCO_2E$	17
		Total $MTCO_2E$ Emitted from Waste Disposal	**1,098**

Table A.6. Calculation of Academic and Research Area Greenhouse Gas Emissions from Waste Disposal.

Percent commuting in a single-occupancy vehicle	Percent commuting in a Carpool/Vanpool	Percent commuting via bus	Other Forms of Commuting (walk/bike)	Days per year Commuting to Campus	Average Commute Distance (via automobile)[40] (miles)
95%	3%	1%	1%	250	48

Table A.7. Assumptions for Commuter Travel for Patient Care Areas.

Year	Staff Members in Patient Care Areas[41]
2005	8,540
2006	9,607
2007	10,256
Three-Year Average	**9,468**

Table A.8. Staff members in patient care areas, 2005-2007.

[38] Passenger-miles traveled provided by VU Procurement & Disbursement Department from Caldwell Travel Group. Air Passenger-Miles data was not collected prior to 2007.

[39] 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.

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

[41] Patient care staff members by building was provided by VU Human Resources for calendar years 2005-2007.

Year	Commuter Miles for Patient Care Staff	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
2005	99,098,160	4,474,805	5,167
2006	111,479,628	5,033,894	5,812
2007	119,010,624	5,373,958	6,205
Three-year average of fuel consumption:		**4,960,886**	**5,728**

Table A.9. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled[42]

Gasoline Consumed (three-year average)	Emission Factor	Gasoline Use by Commuters ($MTCO_2E$)
4,960,886	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	44,326
Diesel Fuel Consumed (three-year average)	**Emission Factor**	**Diesel Use by Commuters ($MTCO_2E$)**
5,728	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	58
Greenhouse Gas Emissions Associated with Commuter Travel in Patient Care Areas		**43,504**

Table A.10. Greenhouse Gas Emissions Calculations Related to Commuter Travel for Patient Care Areas

Disposal Method	Solid Waste Disposal: Three-year average for 2005-2007 (Tons)	Emission Factor	Emissions from Solid Waste Disposal ($MTCO_2E$)
Waste landfilled with landfill gas recovery converted to electricity[43]	2,328	1 Ton of waste = 0.1467 $MTCO_2E$	342
Waste landfilled with landfill gas combusted to the atmosphere	4,948	1 Ton of waste = 0.2567 $MTCO_2E$	1,270
Incinerated Waste	43	1 Ton of waste = 0.22 $MTCO_2E$	9
Medical Waste Autoclaved Off-Site	282	1 Ton of waste = 0.243 $MTCO_2E$	68
		Total $MTCO_2E$ Emitted from Waste Disposal:	**1,689**

Table A.11. Greenhouse Gas Calculations for Waste Disposal Patient Care Areas

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

[43] Solid waste removed from Vanderbilt Medical Center 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.

	Total Emissions ($MTCO_2E$)	Emissions per 1,000 GSF ($MTCO_2E$)	Emissions per student ($MTCO_2E$)	Emissions per person on campus ($MTCO_2E$)	Emissions per $1,000 Research Awarded ($MTCO_2E$)	Gross Square Feet (GSF)	Number of Full-Time Students	Total Campus Population (Faculty + Staff + Students)	Research Dollars Awarded (Thousands)
Vanderbilt University	487,120	35.0	42.5	15.7	N/A	13,920,358	11,461	31,047	$472,967
Vanderbilt University (Ac and Res. Only)	302,417	34.0	26.4	14.0	0.64	8,902,092	11,461	21,579	$472,967
Vanderbilt University (Pateint Care Only)	184,704	36.8	N/A	19.5	N/A	5,018,266	N/A	9,468	N/A

Table A.12. Greenhouse Gas Emissions and Related Metrics for Vanderbilt University (Three year averages).

School	Total Emissions ($MTCO_2E$)	Emissions per 1,000 GSF ($MTCO_2E$)	Emissions per student ($MTCO_2E$)	Emissions per person on campus ($MTCO_2E$)	GSF	Number of Students	Campus Population
University of Michigan	687,000	22.0	17.2	8.8	31,170,301	40,000	78,086
Duke University	433,961	31.2	33.4	9.2	13,895,307	13,002	47,344
University of Florida	432,136	24.8	9.2	7.3	17,436,606	47,178	59,551
University of North Carolina - Chapel Hill	518,469	29.6	20.0	13.1	17,500,000	25,895	39,669
University of Cincinnati	372,310	31.0	14.1	10.9	12,005,219	26,393	34,158
Georgia Institute of Technology	370,253	28.1	19.8	14.8	13,189,240	18,742	25,073
University of Pennsylvania	355,829	29.9	18.3	8.9	11,912,086	19,492	40,017
University of Maryland - College Park	351,145	27.6	10.8	8.6	12,700,000	32,467	41,048
Cornell University	319,000	21.4	16.1	10.7	14,900,000	19,800	29,941
Yale University	284,663	22.6	25.9	13.6	12,600,000	11,000	21,000
Harvard University	230,616	15.6	Not Reported	11.3	14,773,195	Not Reported	20,346

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