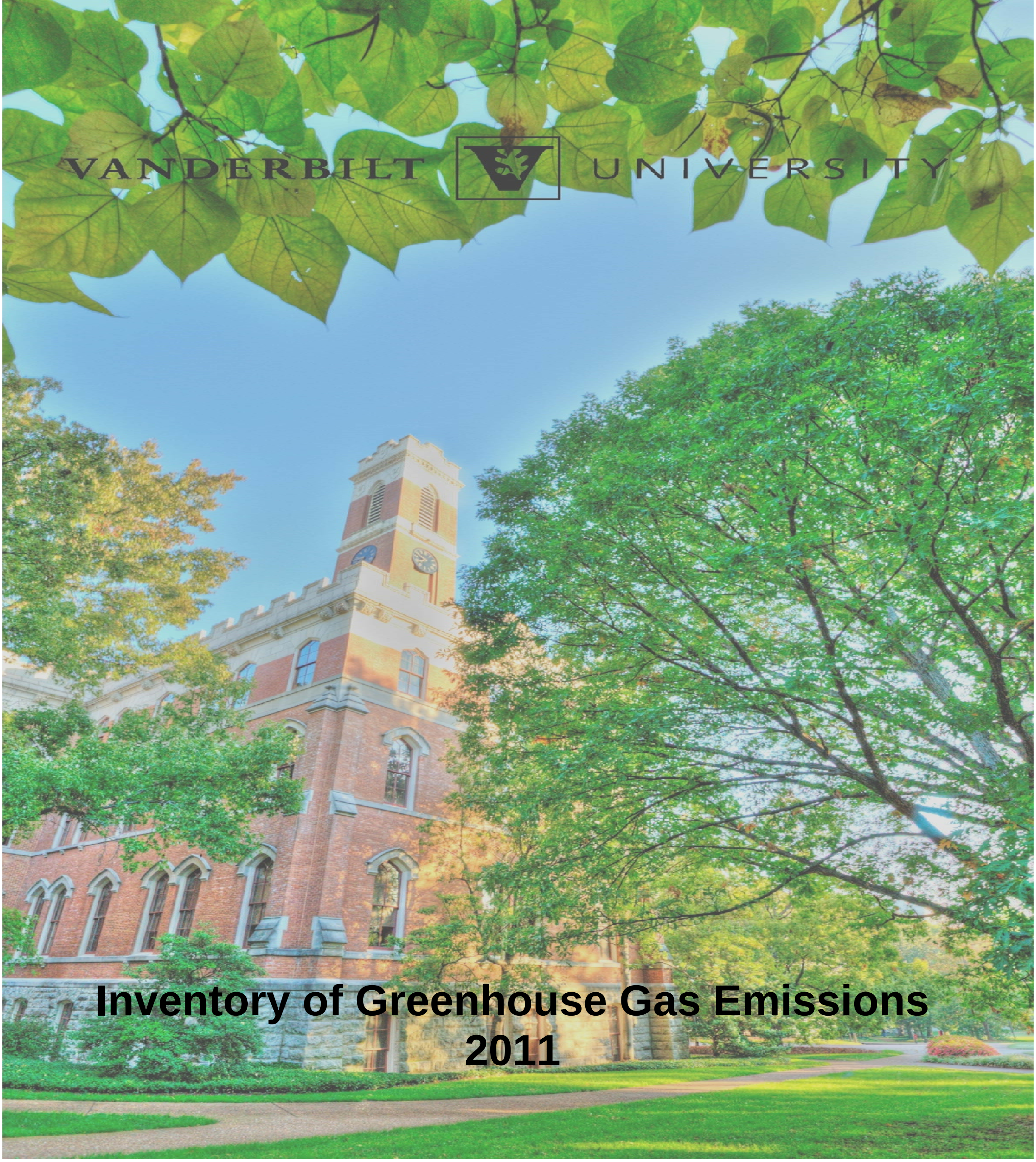

Inventory of Greenhouse Gas Emissions 2011

VANDERBILT UNIVERSITY MEDICAL CENTER

VANDERBILT UNIVERSITY

SustainVU VANDERBILT

Developed By

Andrea George, PhD, CHMM
Director, Sustainability and Environmental Management Office

Steven Gild, MS, CHMM
Environmental Management Systems Coordinator, Sustainability and Environmental Management Office

Tiffany Renfro, LEED AP
Sustainability Outreach Coordinator, Sustainability and Environmental Management Office

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

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

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

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VANDERBILT UNIVERSITY INVENTORY OF GREENHOUSE GAS EMISSIONS 2011

EXECUTIVE SUMMARY

This report is a summary of greenhouse gas (GHG) emissions for Vanderbilt University for the calendar year 2011. This GHG emissions inventory is intended to portray Vanderbilt's current carbon footprint as accurately as possible and to provide trending information to show progress in GHG emissions from 2005-2011. It is not intended to draw comparisons with other institutions. The GHG inventory was developed by Vanderbilt's Sustainability and Environmental Management Office (SEMO).

Background

Vanderbilt emits GHGs through its daily operations, such as energy consumption in campus buildings, burning of coal and natural gas at the on-campus co-generation power plant, the use of fuel to power Vanderbilt's university-owned vehicles and the disposal of waste generated by Vanderbilt. The University released its first GHG inventory report in April 2009 for calendar years 2005-2007[1].

In October 2009, the U.S. Environmental Protection Agency (EPA) issued the *Mandatory Greenhouse Gas Reporting Rule* [40 CFR Part 98], which requires annual reporting of GHG emissions from large sources in the United States. Vanderbilt, along with many other institutions of higher education, is now required to report annual emissions to the EPA[2]. Under the EPA's GHG Reporting Rule, the scope of stationary sources and some emissions factors vary from those utilized in Vanderbilt's initial baseline GHG inventory. Therefore, in an effort to use a single, consistent methodology for calculating and reporting GHG emissions for the university, emissions for Vanderbilt, including those years prior to 2009, were calculated utilizing the EPA's scope and emissions factors for relevant stationary sources. Emissions from sources not covered by the EPA's GHG Reporting Rule

[1] Vanderbilt University's Inventory of Greenhouse Gas Emissions 2005-2007 report is available at http://www.vanderbilt.edu/sustainvu/ or may be requested by emailing SustainVU@vanderbilt.edu.
[2] 30 October 2009. "40 CFR Parts 86, 87, 89 et al. Mandatory Reporting of Greenhouse Gases; Final Rule." U.S. Environmental Protection Agency. Available at http://www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Fullpercent20Version.pdf.

were calculated using emissions factors from the Clean Air – Cool Planet Campus Carbon Calculator™ or emission factors developed for specific on-campus activities.

This report, a supplement to previous reports[3], establishes Vanderbilt's GHG emissions for calendar year 2011 so that the Vanderbilt community can better understand its own unique impact on the environment now and in the past and determine the most effective improvement strategies to implement in the future. Trending data for 2005 through 2011 is provided in Appendix A.

Process & Methodology

The physical boundary for Vanderbilt University's GHG inventory includes the "core" 330 acres of Vanderbilt University property and encompasses academic, residential, research, and patient care buildings located within this area. Off-site buildings, such as satellite medical clinics and the One Hundred Oaks outpatient medical clinics and operations, are not included in this inventory. By including Vanderbilt's patient care facilities (which are typically excluded by other universities in their GHG emissions calculations), Vanderbilt's GHG inventory is unique and largely comprehensive. The core Vanderbilt campus contains over 250 buildings, comprising over 18 million gross square feet of space[4], of which approximately 15 million gross square feet of space receive electricity, steam and chilled water from the main Vanderbilt utility grid and are included in the analysis in this report.

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

Under the EPA's GHG Reporting Rule, facilities which emit 25,000 or more metric tons carbon dioxide equivalent ($MTCO_2E$) per year must submit annual emissions reports. At Vanderbilt, this includes coal and natural gas use at the on-campus co-generation power plant and natural gas use by boilers in individual campus facilities. Therefore, emissions from these sources are calculated

[3] Vanderbilt University's Inventory of Greenhouse Gas Emissions 2005-2011 reports are available at http://www.vanderbilt.edu/sustainvu/ or may be requested by emailing SustainVU@vanderbilt.edu.
[4] December 2011. ReVU: Quick Facts about Vanderbilt. Available http://www.vanderbilt.edu/about/facts/.

using emissions factors established by the EPA. For calendar year 2011, Vanderbilt University emissions from EPA-required sources amounted to 151,078 $MTCO_2E$, which was reported to the EPA on March 26, 2012. For all additional emissions from university activities that are not required to be reported to the EPA, a standardized, publicly available GHG calculator/spreadsheet for universities called the Clean Air – Cool Planet Campus Calculator™ was utilized to store collected data and convert our university-specific data into a common GHG emission unit using established emissions factors for specific activities (i.e., gallons of fuel, commuter miles, tons of waste disposed, etc.). This calculator is the most commonly used among U.S. colleges and universities. Results were compiled for academic and research operations, including medical research functions, and separately for patient care operations, with integrated totals also reported. Upon its completion, this GHG inventory report was presented to a committee of reviewers prior to publication.

Findings

Vanderbilt University's total GHG emissions for calendar years 2005 to 2011 are presented in Table ES.1 and Figure ES.1. Total GHG emissions decreased by 12.3 percent from 2008 to 2011 and by 7.2 percent overall from 2005 to 2011.

Calendar Year	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Total GHGs Emitted by VU ($MTCO_2E$)
2005	296,465	179,260	475,725
2006	295,825	182,548	478,374
2007	308,604	189,958	498,562
2008	313,341	189,985	503,327
2009	288,343	175,896	464,240
2010	284,506	170,754	455,261
2011	272,229	169,389	**441,618**

Table ES.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2011.

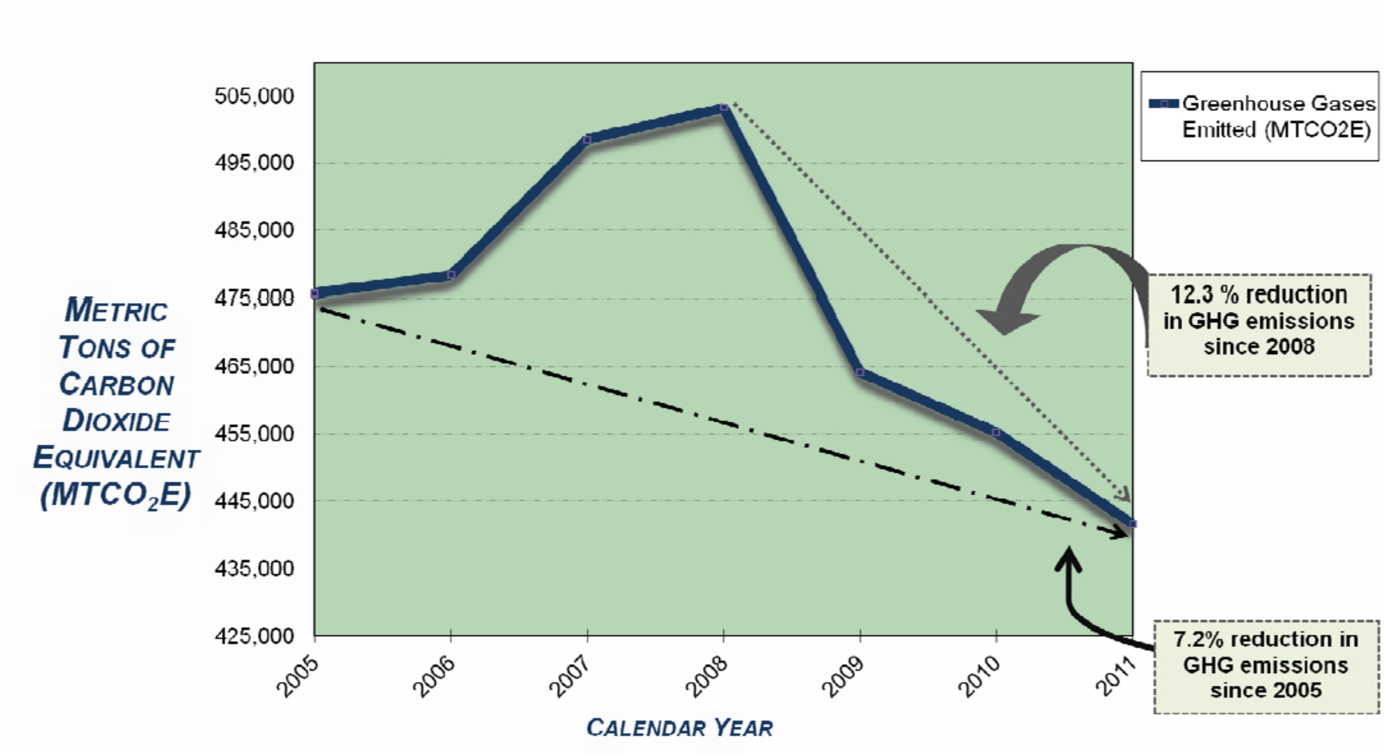

Figure ES.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2011.

Emissions data from 2011, illustrated in Tables A.1, A.3 and A.3 in the appendices, indicates that academic and research areas accounted for 61.6 percent of total GHG emissions while patient care areas accounted for 38.4 percent of total GHG emissions. As in previous reports, the inventory results demonstrate that purchased electricity, coal use at the on-campus co-generation power plant, faculty and staff commuting, and natural gas use at the on-campus co-generation power plant were the most substantial sources of GHG emissions. These accounted for 94 percent of GHG emissions from Vanderbilt University, as is illustrated by emissions sources for calendar year 2011 in Figure ES.2. As the 2011 total GHG emissions reductions illustrate, reducing energy consumption and supporting alternative transportation methods have the most potential to reduce GHG emissions at Vanderbilt.

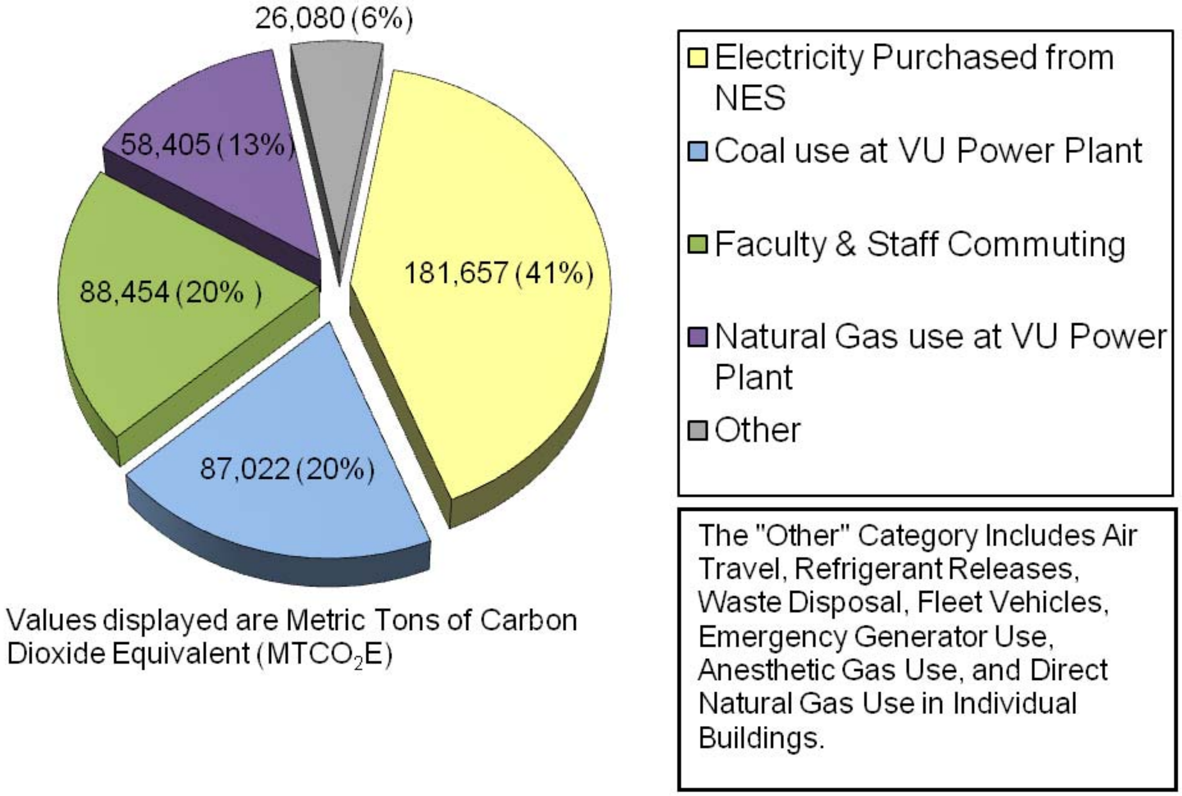

Figure ES.2. GHG Emissions Sources, Calendar Year 2011.

Between 2005 and 2011, Vanderbilt University's GHG emissions have decreased by 20.8 percent on a per gross square foot basis, by 19 percent on a per person basis and by 28 percent per million research dollar awarded to VU, as shown in Tables A.1, A.2 and A.3. Considering that Vanderbilt's on-campus square footage has increased by over two million square feet since 2005, shown in Table A.3., it is clear that VU Plant Operations, VUMC Plant Services, Campus Planning and Construction and VUMC Space and Facilities Planning are significantly improving the energy efficiency of Vanderbilt's buildings in the midst of continued growth.

Interpreting Vanderbilt's Results

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

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

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

- 89 percent of Vanderbilt undergraduate students live in on-campus residence houses, which are supplied using centralized utilities such as chilled water, steam heat, and electricity. Colleges and universities with larger commuter populations and/or off-campus housing would have substantially smaller Scope 1 emissions (on-site sources) and larger Scope 3 emissions (indirect sources).
- Vanderbilt was awarded $587 million[5] in 2011 to conduct scientific and medical research, with a majority of the research occurring in laboratories on campus. Vanderbilt University has over 800 research laboratories, which are significant consumers of energy through the operation of lab equipment.
- The Vanderbilt University Medical Center (VUMC) provides regional health care 24 hours per day, 7 days per week, 365 days per year. Very few universities have on-campus patient care that matches the size and extent of operations of VUMC.

Table ES.2 and Figure ES.3 below illustrate Vanderbilt's normalized emissions in relation to several other universities with large amounts of on-campus research.

[5] According to 2011 research information accessed in December 2011 in ReVU: Quick Facts about Vanderbilt. Available http://www.vanderbilt.edu/about/facts/.

University	Total Emissions ($MTCO_2E$)	Emissions per 1,000 Square Feet	Emissions per Student	Emissions per Person on Campus	Emissions per $1,000 Research Awarded
University of Michigan[6]	720,000	18.46	12.01	9.0	0.58
Duke University – Campus Only[7]	301,758	26.55	20.79	8.55	0.49
Washington University – St. Louis[8]	409,500	28.0	29.10	24.2	0.58
Emory University[9]	305,819	33.98	22.01	11.56	0.57
University of Pennsylvania[10]	294,210	22.32	11.85	6.54	0.29
Vanderbilt University – Academic & Research Areas Only[11]	272,229	29.39	21.43	11.72	0.46

Table ES.2. Comparison of 2011 VU GHG Emissions with Other Universities.

[6] GHG emissions, GSF, and student, faculty, and staff populations for FY 2011 retrieved from 2011 Annual Sustainability Report, http://vpcomm.umich.edu/forum/michigan.php#a2campus, GSF, and student, faculty and staff populations for FY 2011 retrieved from 2011 U-M Facts and Figures, http://vpcomm.umich.edu/forum/michigan.php#a2campus.

[7] GHG emissions, GSF, and student, faculty, and staff populations for 2011 as reported to ACUPCC, http://rs.acupcc.org/ghg/2044/. 2011 research dollars retrieved from Financial Statements 2010/2011, https://finance.duke.edu/resources/docs/financial_reports.pdf.

[8] GHG emissions, GHG emissions per 1,000 GSF, and GHG emissions per person for FY 2009 retrieved from http://www.wustl.edu/initiatives/sustain/assets/GHGEmissions.pdf. Student enrollment for Fall 2011 retrieved from http://www.wustl.edu/about/facts/students/index.html. Research awards for 2011 retrieved from http://www.wustl.edu/about/facts/assets/pdf/FastFacts2011.pdf.

[9] Emissions data for 2010 from http://sustainability.emory.edu/html/dashboard/other-ghg-sources.html. University faculty, staff, and student population and 2011 research dollars from 2011 Academic Profile, http://www.oirpe.emory.edu/institutional_research/academicpercent20profilepercent2020112012percent20. GSF for FY 2007 retrieved from http://sustainability.emory.edu/uploads/articles/2010/10/2010100513595029/GHG_Executive_Summary.pdf. GSF from FY 2007 was used because GSF from FY 2011 could not be located.

[10] GHG emissions, GSF, and student, faculty, and staff populations for 2011 from ACUPCC's website at http://rs.acupcc.org/ghg/2087/. Sponsored projects for 2011 retrieved from http://www.archives.upenn.edu/primdocs/uph/uph4_5/2010fin_report.pdf.

[11] GHG emissions for CY 2011 from academic and research areas only. 2011 research dollars awarded available in Table A.1.

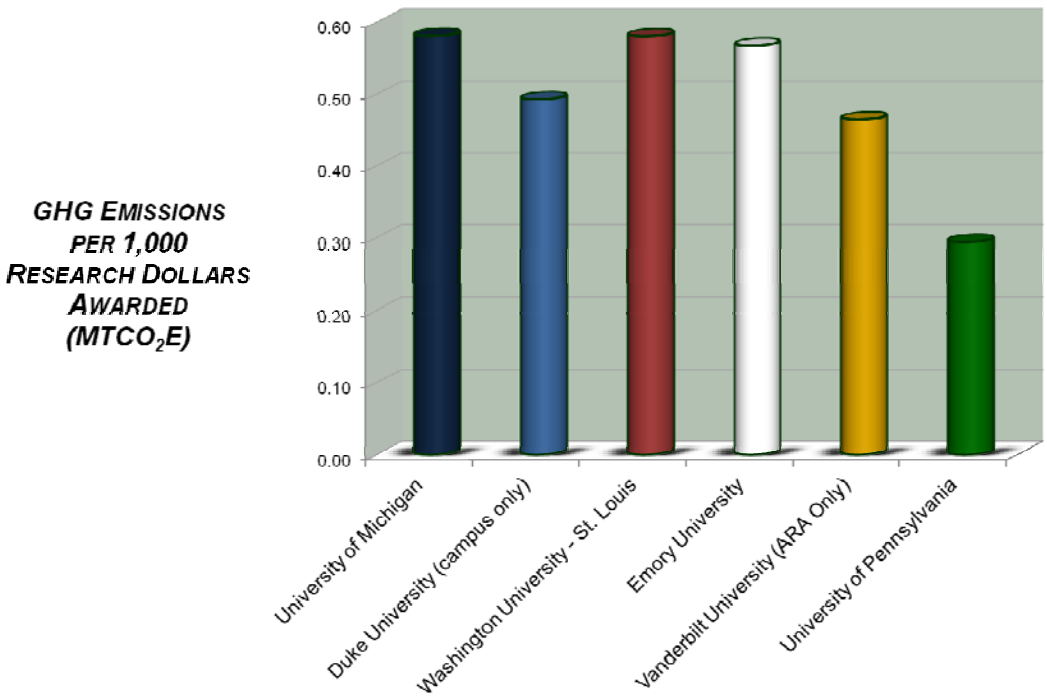

Figure ES.3. Comparison of VU GHG Emissions with Other Universities, by Research Dollars Awarded.

Future Plans

This inventory provides campus stakeholders with a consistent means of calculating annual GHG emissions and sufficiently detailed information to make informed decisions to determine reduction strategies and compare future changes in GHG emissions on campus. Annual emissions inventories will be conducted in the future to measure progress, which will be made publicly available on the SustainVU website[12].

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

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

[12] www.vanderbilt.edu/sustainvu

- Reducing unnecessary vehicle idling.

More information on ways the Vanderbilt community can save energy can be found on the ThinkOne website[13].

[13] www.vanderbilt.edu/sustainvu/thinkone

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I. BACKGROUND

Vanderbilt University

Vanderbilt University, founded in 1873, is a private, research higher education institution offering undergraduate, graduate and professional degrees to over 12,700 full and part-time students[1]. Comprised of 10 schools and a world-class medical center, Vanderbilt offers students and researchers the opportunity to create an environment that enables them to meet their academic and professional goals. The university is consistently rated as one of the country's top 20 universities with several programs ranking in the top 10. As the largest private employer in Middle Tennessee and the second largest private employer in the state, Vanderbilt University currently has more than 3,800 full-time faculty and a staff of over 17,000[2]. The campus, located near downtown Nashville, spans approximately 330 acres and contains 250 buildings[3]. More than 200 tree species exist on Vanderbilt's grounds, leading to the school's recognition as an arboretum since 1988.

Inventory Development

Vanderbilt emits GHGs through its daily operations, such as energy consumption in campus buildings, burning of coal and natural gas at the on-campus co-generation power plant, the use of fuel to power Vanderbilt's university-owned vehicles, and the management of waste generated by Vanderbilt. VU has issued previous reports in 2009, quantifying GHG emissions for 2005-2007[4], in 2010 for years 2005-2009[5] and in 2011 for year 2010[6]. Trending data summaries for 2005 to 2011 are provided in Appendix A.

In October 2009, the EPA issued the *Mandatory Greenhouse Gas Reporting Rule* [40 CFR Part 98][7], requiring annual reporting of GHG emissions from large sources in the United States who emit more than 25,000 metric tons of carbon dioxide equivalent ($MTCO_2E$) per year. Vanderbilt is subject to this reporting rule because the use of coal and natural gas at the on-campus co-generation power plant for the production of steam and electricity for campus emits greater than 25,000 $MTCO_2E$ annually. Under the EPA's GHG Reporting Rule, the scope and emissions factors of stationary sources vary from those utilized in Vanderbilt's initial baseline GHG inventory. In order to create a single, consistent methodology for calculating and

[1] According to 2010-2011 enrollment data found in ReVU: Quick Facts about Vanderbilt. Accessed December 2011. Available http://www.vanderbilt.edu/facts.html.
[2] According to 2011 employment information found in ReVU: Quick Facts about Vanderbilt. Accessed June 2011. Available http://www.vanderbilt.edu/facts.html
[3] VU facilities data is available online at cpc-fis.vanderbilt.edu/pdf/facilitiesreportbook.pdf.
[4] Vanderbilt University's Inventory of Greenhouse Gas Emissions 2005-2007 report is available at http://www.vanderbilt.edu/sustainvu/ or may be requested by emailing SustainVU@vanderbilt.edu.
[5] Vanderbilt University's Inventory of Greenhouse Gas Emissions 2005-2009 report is available at http://www.vanderbilt.edu/sustainvu or may be requested by emailing SustainVU@vanderbilt.edu.
[6] Vanderbilt University's Inventory of Greenhouse Gas Emissions 2010 report is available at http://www.vanderbilt.edu/sustainvu or may be requested by emailing SustainVU@vanderbilt.edu.
[7] http://www.epa.gov/ghgreporting/

reporting GHG emissions for the university, emissions for Vanderbilt, including those years prior to 2009, were calculated utilizing the EPA's scope and emissions factors for relevant stationary sources. For calendar year 2011, Vanderbilt University emissions from EPA-required sources amounted to 151,078 $MTCO_2E$, which was reported to the EPA on March 26, 2012. Emissions from all sources not covered by the GHG reporting rule were calculated using methodology from the Clean Air – Cool Planet Campus Carbon Calculator™ or emission factors developed for specific on-campus activities. This report establishes Vanderbilt's GHG emissions from calendar year 2011 so that the Vanderbilt community can better understand its own unique impact on the environment now and in the past and determine the most effective improvement strategies to implement in the future.

Mandatory Greenhouse Gas Reporting Rule: Its Effect on Colleges and Universities

The EPA's *Mandatory Greenhouse Gas Reporting Rule* (MGHGRR) is a comprehensive, nationwide emissions data collection effort that will provide a better understanding of the sources of GHGs, including colleges and universities, and will guide development of federal policies and programs to reduce emissions.

For the 2010 calendar year and beyond, colleges and universities which produce more than 25,000 metric tons of GHGs will be required to report annual emissions to EPA. All data will be made publically available in 2012; this will allow colleges and universities to compare their emissions to those of similar institutions and aid in identifying opportunities to reduce emissions in the future.

Prior to the creation of this rule, no uniform GHG calculation or reporting method was available for institutions of higher education, other than the voluntary reporting system established by the American College & University Presidents Climate Commitment (ACUPCC).

To learn more about MGHGRR, visit http://www.epa.gov/climatechange/emissions/ghgrulemaking.html.

Greenhouse Gases: Impact and Importance

A carbon footprint is a standard that people and organizations use to quantify the impact they have on the environment, particularly as their behaviors relate to climate change concerns. The six GHGs emitted into the atmosphere that comprise the majority of the carbon footprint are: carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydroflurocarbons (HFCs); perflurocarbons (PFCs); and 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 livestock and coal mining
Nitrous Oxide
Naturally produced: during bacteria breakdown of nitrogen in the soil and oceans
Human generated: burning fossil fuels, fertilizer use, anesthetic gas, motor racing oxidizer
Hydrofluorocarbons
Human generated: used in refrigeration and fire suppression
Perfluorocarbons
Human generated: primarily used in refrigeration units, byproduct of aluminum production, used medically in eye surgeries and MRIs
Sulfur Hexafluoride
Human generated: used in electric system circuit breakers and in ultrasound imaging

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

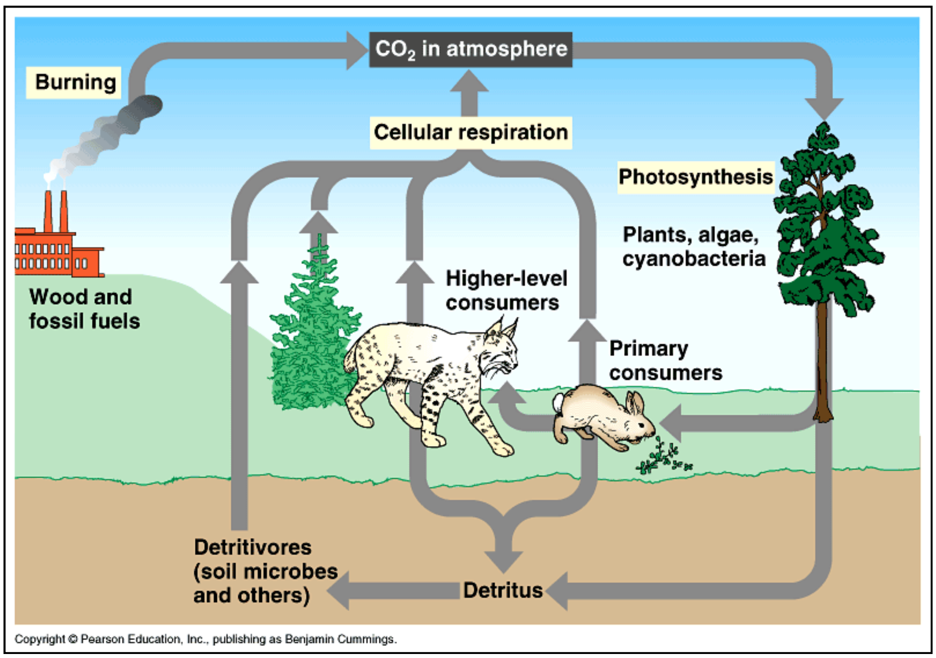

Figure 1.1. The Carbon Cycle[8].

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

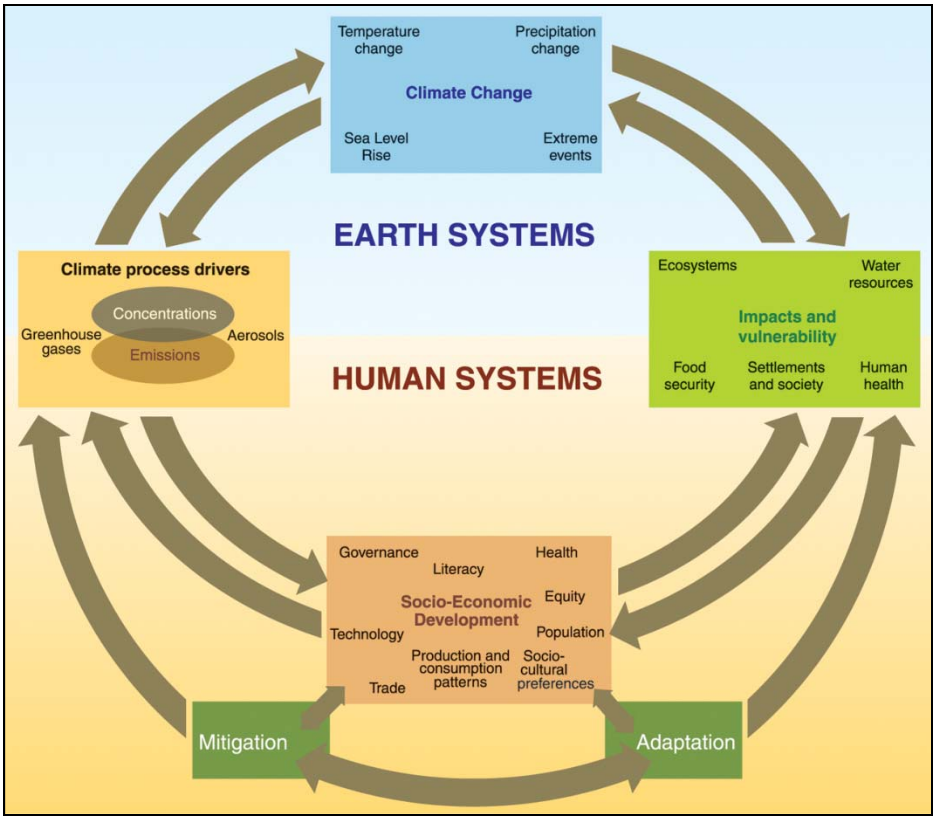

Figure 1.2. Climate Change Drivers, Impacts and Responses[9]

GHGs, once released, trap heat in the atmosphere, acting like a gas blanket. As the concentrations of these gases increase, the earth's temperature could potentially climb higher than previous levels and wind, storm, 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[10].

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[11].

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[9] Retrieved Mar. 2, 2009. "Figure I-1." *AR4 Synthesis Report*. (2007). Intergovernmental Panel on Climate Change. Available http://www.ipcc.ch/publications_and_data/ar4/syr/en/mainssyr-introduction.html.
[10] Feb. 18, 2009. "Climate Change." U.S. Environmental Protection Agency. Available http://www.epa.gov/climatechange/basicinfo.html.
[11] van Aalst, M.K. (2006). The impacts of climate change on the risk of natural disasters. *Disasters 30(1)*, 5-18.

- Spring events, such as germination, flowering, migration and reproduction, are occurring an average of 10 days earlier than they were about 30 years ago, and plants and animals requiring colder climates for survival are traveling north[12].
- 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[13].

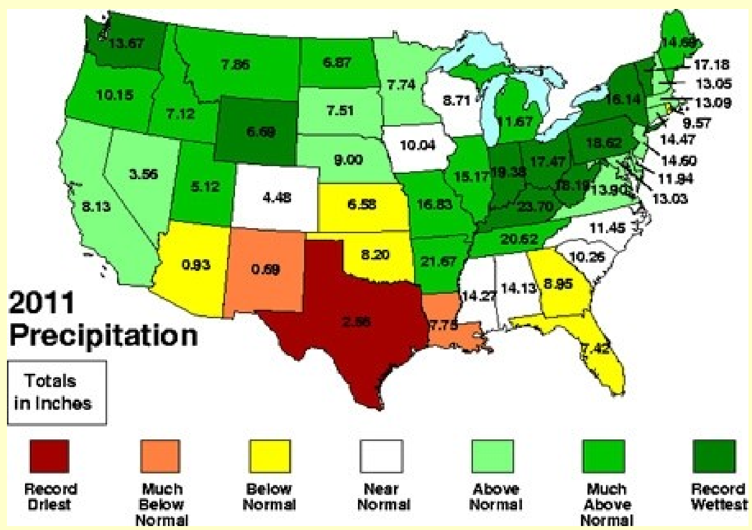
According to the Intergovernmental Panel on Climate Change (IPCC), a group of more than 700 scientists from various disciplines around the world, much of the observed increase in average temperatures since the 1950s is likely attributable to an increase in GHG concentrations. In addition, GHG emissions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

2011 was the Most Extreme Weather Year in Recorded History

According to the National Oceanic and Atmospheric Administration (NOAA), 2011 set a record for the most billion-dollar weather disasters in a single year. There were 12, breaking the old record of nine set in 2009. The aggregate damage from these 12 events totaled at least $52 billion.

Severe weather across much of the nation has raised the question of whether climate change has already begun to influence shorter-term weather patterns, raising the specter of even more extreme years to come as global temperatures continue to rise.

According to climate studies, the answer is yes. The new climate environment created by climate change is making some extreme events, particularly heat waves and heavy rain, more likely to occur and more intense when they do. Read more about extreme weather events of 2011 by visiting the NOAA website: http://www.noaa.gov/extreme2011/.



Spring average precipitation (March-May)
(graphic provided by NOAA)

[12] 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.
[13] 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 GHGs through its daily operations, including energy consumption in campus buildings, burning of coal and natural gas at the power plant, use of fuel in university-owned vehicles, and the management of waste generated on campus.

Vanderbilt produces on campus 20 percent of the electricity and all of the steam and chilled water consumed by Vanderbilt's buildings. These utilities are produced by a co-generation combined heat and power (CHP) plant. This plant uses two fuels, coal and natural gas, to produce electricity, steam heat and chilled water for cooling. This type of power plant is highly efficient because of the flexibility of the fuel system, the variety of utilities produced and the proximity of the utility production to the utility user. Since a portion of electricity produced at power plants hundreds of miles away is actually lost during the transmission process through the electrical lines (line losses), VU can use much less coal or natural gas than Tennessee Valley Authority (TVA) would require to deliver the same amount of electricity to campus. The remainder of the electricity needed to power Vanderbilt's campus (80 percent of the 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.

Tennessee's Energy Supply

Tennessee is notable nationally for the fact that it has generated more electricity than it consumes ever since the time of the Manhattan Project during World War II. Currently, Tennessee ranks 19th among U.S. states in net electricity generation and 20th in total per capita energy consumption. Much of Tennessee's electricity generation can be attributed to the facilities and operations of the Tennessee Valley Authority (TVA). Tennessee's electricity generation collectively accounted for over 48 million metric tons of carbon dioxide emissions in 2010, making it the 18th largest emitter of GHGs.

From U.S. Energy Information Program, http://www.eia.gov/electricity/state/tennessee/, as reported by *Sustaining Tennessee in the Face of Climate Change: Grand Challenges and Great Opportunities,* page 12, http://sustainabletennessee.org/download-report/

In addition to the mix of Vanderbilt's electricity production, a special class of GHGs not discussed in the previous section was included in this inventory. Typically, nitrous oxide is the only anesthetic gas included in a university's GHG inventory (if it is included at all). At Vanderbilt, our patient care and animal care activities use Isoflurane, Desflurane, and Sevoflurane in significant quantities as anesthetic gases. Because these gases can have Global Warming Potentials (GWPs) of up to 2,000 times that of carbon dioxide, the contribution to VU's carbon footprint from the use of these three gases has been quantified and added to that of the traditional six gases discussed previously in an effort to be as comprehensive as possible.

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

II. VANDERBILT UNIVERSITY ENVIRONMENTAL COMMITMENT

In 2009, a working group of faculty, staff and students developed an Environmental Commitment Statement which 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), Environmental Advisory Committee (EAC) and Vanderbilt Student Government (VSG) also endorsed the statement.

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

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.

Vanderbilt's environmental commitment and performance in 2011 led to recognition by the Princeton Review's Green Honor Roll[14], being named a "Green Hero" by the Nashville Post[15], and the receipt of an "A" rating from the Roberts Environmental Center[16] for environmental and social transparency.

[14] Princeton Review's Green Honor Roll: http://www.princetonreview.com/green-honor-roll.aspx.
[15] 2012 Nashville Post Green Heroes: http://nashvillepost.com/category/subjects/green_heroes.
[16] Roberts Environmental Center: http://www.roberts.cmc.edu/.

III. INVENTORY DEVELOPMENT METHODOLOGY

Boundary Definitions

Prior to conducting the first Vanderbilt GHG inventory in 2009, the operational, spatial and temporal boundaries of the inventory were firmly defined. Furthermore, a GHG calculation protocol was established prior to gathering the data for this GHG inventory.

Operational Boundary

Activities at Vanderbilt University that produce GHG emissions include those outlined by the U.S. EPA's Mandatory GHG Reporting Rule [40 CFR Part 98][17], as well as The American College & University Presidents Climate Commitment (ACUPCC) Implementation Guide (2009)[18]. The boundaries established by the ACUPCC Implementation Guide rely heavily on the methodology established by the World Resources Institute Greenhouse Gas Protocol[19]. As noted by the World Resources Institute (WRI), "identification of operational boundaries helps institutions to categorize their sources of emissions, providing accountability and the prevention of 'double counting'."

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

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

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

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

The WRI Greenhouse Gas Protocol[20] categorizes GHGs into Scopes 2 and 3 as follows:

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[17] http://www.epa.gov/ghgreporting/
[18] www2.presidentsclimatecommitment.org/pdf/ACUPCC_IG_Final.pdf
[19] Ohndorf, M. & Gillenwater, M. (2003). "Measurement and Estimation Uncertainty of Greenhouse Gas Emissions." World Resources Institute. Available http://www.ghgprotocol.org/calculation-tools/all-tools.
[20] 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.

- 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 80 percent of the electricity needed to supply campus operations.

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

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

Spatial Boundary – Academic and Research Areas, Patient Care Areas

Vanderbilt University is a unique institution, providing regional health care while simultaneously pursuing robust academic endeavors. To provide the Vanderbilt community with a better understanding of the university's GHG emissions from these two missions, this report provides a subtotal of GHG emissions associated with academic and research areas which are traditional academic university endeavors, and a separate subtotal 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, while activities in academic and research areas are associated with an academic calendar. Academic and research areas include academic and administrative buildings, residence halls, athletics facilities, parking garages, common space/multi-purpose areas, and laboratory research space, while patient care areas include hospitals, clinics, and patient and visitor parking garages.

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

Vanderbilt University Hospital	Oxford House
The Vanderbilt Clinic	Dayani Center
Vanderbilt Children's Hospital & Doctor's Office Tower	Central Garage
Psychiatric Hospital at Vanderbilt	East Garage
Vanderbilt-Ingram Cancer Center	South Garage
Vanderbilt Eye Center	Children's Way Garage
Free Electron Laser Building	Medical Arts Building
Medical Center East (North Tower)	Medical Center East II (South Tower)
Zerfoss Health Center	35percent of Medical Center North

Table 3.1. Vanderbilt's Patient Care Buildings.

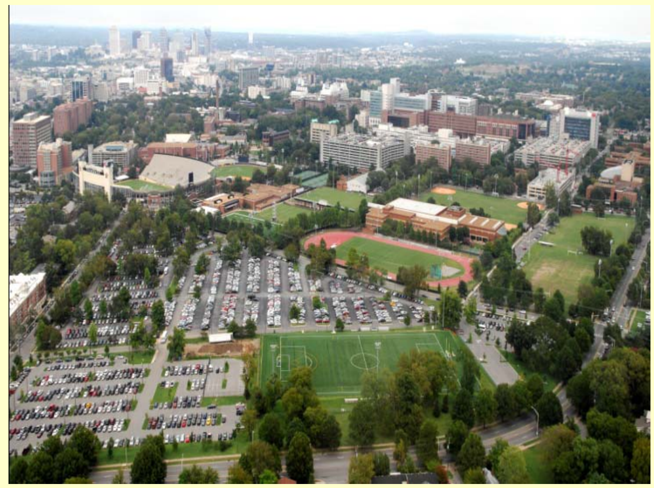
The typical definition of Vanderbilt University's "core campus" is the university property that is bounded by Blakemore Avenue to the south, West End Avenue to the northwest, and 21st Avenue South to the east. The

Peabody Campus at Vanderbilt is also part of the core 330 acres of Vanderbilt; the Peabody Campus is bounded by 21st Avenue South to the west, Edgehill Avenue to the north, 18th Avenue South to the east, and Capers Avenue to the south. These two areas constitute the “core 330 acres” of Vanderbilt University and encompass the majority of the academic, residential, research, and patient care buildings associated with Vanderbilt. Furthermore, the buildings located within this core 330 acres are serviced by Vanderbilt’s on-campus power plant. The core VU campus contains over 250 buildings, encompassing over 15 million gross square feet of space.

Vanderbilt’s Campus: Your View and EPA’s View

When a person thinks of “Vanderbilt,” they may focus on one aspect of the university’s operations: their residence hall, research lab, classroom building, administrative office, a medical center location, and so on. EPA defines a *facility* as “one or more contiguous or adjacent properties in actual physical contact or separated solely by a public roadway or other public right-of-way and under common control.” So, that ‘off-campus building’ (like Villages at Vanderbilt) might be part of our campus according to EPA.

Vanderbilt’s campus includes all types of building uses: residence halls, athletic stadiums, research labs, academic buildings, medical care buildings, dining facilities, and much more.



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 (approximately 3 million gross square feet of space) are not under the direct operational control of the university and do not receive utility services from Vanderbilt; therefore, these buildings were not included in this baseline GHG inventory. Such buildings include the Veteran’s Administration Hospital, Stallworth Rehabilitation Hospital, the 2525 Building located on West End Avenue, the Marriott Hotel & parking garage on West End Avenue and the Village at Vanderbilt Apartments and Townhomes.

Temporal Boundary

The purpose of this inventory is to establish a history of Vanderbilt’s annual GHG emissions that can serve as a guide for future GHG-emitting activity. Using the total GHG emissions from a single fiscal or calendar year as a focal point would not accurately represent a ‘typical’ year of activity at Vanderbilt University due to annual fluctuations in emissions caused by commissioning new buildings, changes in faculty/staff/student populations, and seasonal/climatic variations from year to year, all of which have a direct bearing on Vanderbilt’s GHG emissions for a particular year. In an effort to capture these “peaks & valleys” in activities at Vanderbilt, the seven-year inventory establishes the annual GHG emissions created by Vanderbilt during the 2005 through 2011 calendar years.

Greenhouse Gas Calculation Protocol

In October 2009, the EPA issued the *Mandatory Greenhouse Gas Reporting Rule* [40 CFR Part 98], requiring annual reporting of GHG emissions from large sources in the United States who emit more than 25,000 $MTCO_2E$ per year. Vanderbilt is subject to this reporting rule because the use of coal and natural gas at the on-campus co-generation power plant for the production of steam and electricity for campus emits greater than 25,000 $MTCO_2E$ annually. Under the EPA's GHG Reporting Rule, the scope and emissions factors of stationary sources vary from those utilized in Vanderbilt's initial baseline GHG inventory. The full text of the EPA's Final Mandatory GHG Reporting Rule and associated emissions factors and formulas for calculation are available on the EPA's website[21]. In order to create a single, consistent methodology for calculating and reporting GHG emissions for the university, emissions for Vanderbilt, including those years prior to 2009, were calculated utilizing the EPA's scope and emissions factors for relevant stationary sources. For calendar year 2011, Vanderbilt University emissions from EPA-required sources amounted to 151,078 $MTCO_2E$, which was reported to the EPA on March 26, 2012. Emissions from all sources not covered by the GHG reporting rule were calculated using methodology from the Clean Air – Cool Planet Campus Carbon Calculator™ or emission factors developed for specific on-campus activities. The Campus Carbon Calculator is publicly available, university-specific, and one of the approved calculators listed in the ACUPCC Implementation Guide. This calculator is the most commonly used calculator among U.S. colleges and universities, allowing 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. GWPs and emissions factors of emitted gases and sources included in this report are listed in Tables 3.2 and 3.3 below.

[21]Full text available for viewing at http://www.epa.gov/climatechange/emissions/downloads09/GHG-MRR-Fullpercent20Version.pdf.

Global Warming Potential: different gases have different effects

All greenhouse gases have a Global Warming Potential (GWP), a value that is used to compare the extent to which specific compounds trap heat in the atmosphere and consequently their impacts on the environment over time. GWPs are based on the heat-absorbing ability of each gas relative to that of carbon dioxide, as well as how long it takes for each gas to decay in the atmosphere. They may be calculated over 20, 100, or 500 year time periods. For most (but not all) GHGs, the GWP declines as the time period increases. 100-year GWPs are the most commonly utilized in regulatory programs (including EPA programs).

Assigning a GWP to each GHG enables comparison of the effects of emissions and reductions of different gases. For example, nitrous oxide has a GWP of 310, meaning that nitrous oxide is approximately 310 times more heat-absorptive than carbon dioxide.

Greenhouse Gas (GHG)	100-Year Global Warming Potential (GWP)
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous Oxide	310
Isoflurane	350
Desflurane	989
Sevoflurane	345
Refrigerant 134a (HFC-134a)	1,300

Table 3.2. 100-Year Global Warming Potentials of GHGs.

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

GHG Source	Emission Factor [$MTCO_2E$ = Metric Tons of Carbon Dioxide Equivalent]	Reference[22]
Coal Combustion	1 ton of coal = 1.685 $MTCO_2E$	A
Natural Gas Combustion	1,000 therms of natural gas = 5.302 $MTCO_2E$	A
Gasoline	1,000 gallons of gasoline = 8.93 $MTCO_2E$	B
Diesel Fuel	1,000 gallons of diesel fuel = 10.14 $MTCO_2E$	B
Jet A Fuel	1,000 gallons of Jet-A fuel = 9.57 $MTCO_2E$	B
Refrigerant (R-134a)	1 kilogram of R-134a = 1.30 $MTCO_2E$	A
Isoflurane anesthetic gas	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	A
Desflurane anesthetic gas	1 kilogram of Desflurane = 0.989 $MTCO_2E$	A
Sevoflurane anesthetic gas	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	A
Nitrous oxide anesthetic gas	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	A
Purchased Electricity from TVA	1,000 kilowatt-hours = 0.605701 $MTCO_2E$	B
Air Travel	1,000 air passenger-miles = 0.77 $MTCO_2E$	B
Waste landfilled with landfill gas recovery converted to electricity	1 Ton of waste = 0.1745 $MTCO_2E$	B
Waste landfilled with landfill gas combusted to the atmosphere	1 Ton of waste = 0.3055 $MTCO_2E$	B
Incinerated Waste	1 Ton of waste = 0.22 $MTCO_2E$	B
Medical Waste Autoclaved Off-Site	1 Ton of waste = 0.243 $MTCO_2E$	C

Table 3.3. Emission Factors for GHG Sources.

[22] References: A – EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]; B – Campus Carbon Calculator, Clean Air – Cool Planet (2010); C – Emission factor developed by SEMO.

Greenhouse Gas Data Collection and Inventory Methodology

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

On-Campus Energy Production

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

University-Owned Vehicles

Vanderbilt University owns over 300 vehicles. However, these vehicles are not owned and operated by a central 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 dispensing of that fuel (i.e., Plant Operations), while some departments purchase their fuel from local retail stations. 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 VUMC Parking and Transportation Services and was provided to SEMO for inclusion in this inventory.

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

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

Anesthetic Gases

Vanderbilt uses anesthetic gases in both patient care areas and in animal care areas and research laboratories; however, different types are used for animals and humans. Purchase records for anesthetic gas were provided by the VUMC's Department of Anesthesiology and Vanderbilt's Division of Animal Care. The Campus Carbon Calculator does not provide GWPs for all anesthetic gases, since most universities use little to no anesthetic gas. SEMO calculated Vanderbilt's GHG emissions from anesthetic gas use based on GWP's provided by the EPA's Mandatory Reporting Rule[23].

Refrigerants

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

Electricity Purchases

The university's co-generation power plant supplies Vanderbilt with 100 percent of the steam needed for heating buildings and 40 percent of the chilled water needed for cooling buildings. Excess heat from steam generation is used to create electricity, satisfying 20 percent of Vanderbilt's annual electricity demand. The remaining 80 percent of Vanderbilt's electricity demand is obtained through electricity purchased from TVA (through NES). In 2011, 52 percent of TVA's electricity came from coal-fired power plants; 34 percent of TVA's electricity came from nuclear power; 9 percent came from hydroelectric dams; 5 percent came from natural gas-fired power plants; and <1 percent came from other renewable sources. Figure 3.1 below presents TVA's sources of power generation.

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

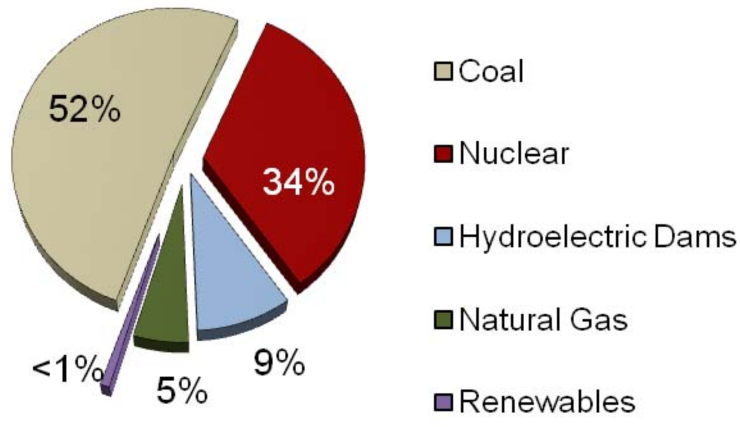
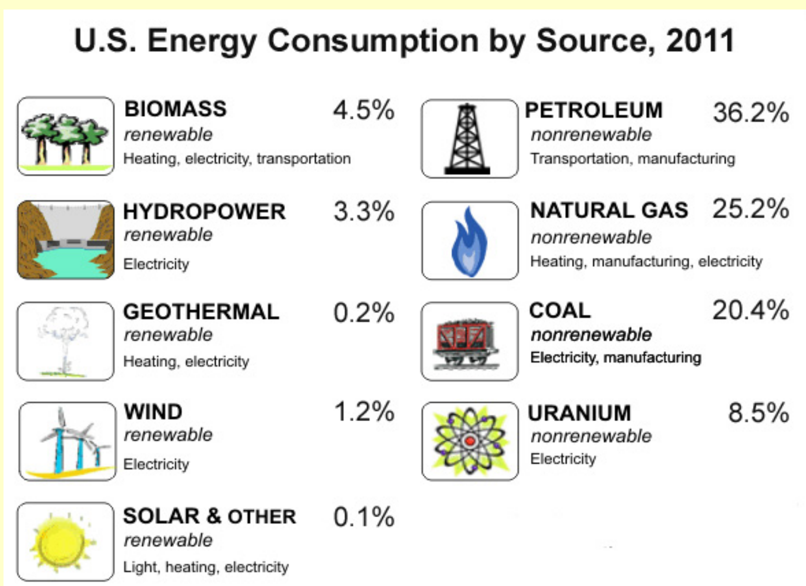


Figure 3.1. TVA's Fuel Mix, Calendar Year 2011[24].

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



U.S. Energy Information Administration, *Monthly Energy Review March 2012,* Table 1.3, preliminary data for 2011.

[24] Page 13 of TVA Annual Report filed with the Securities and Exchange Commission on November 18, 2011. Available http://investor.shareholder.com/tva/secfiling.cfm?filingID=1376986-11-74 .

Energy Fact: greenhouse gas emissions vary by region

A kilowatt-hour of electricity is the same no matter where you go in the United States (or the world) - but how much greenhouse gas is emitted to create that kilowatt-hour can vary greatly across the country because of regional variations in how that power is produced. For example, according to Nashville Electric Service (NES), the average residence in Nashville consumes around 15,000 kilowatt-hours (KwH) each year, resulting in approximately 9.3 $MTCO_2E$. However, power suppliers in different regions of the country use different sources of power generation (hydroelectric, wind, solar, coal, oil, natural gas, waste-to-energy, etc.). If a residence in another state consumed 15,000 KwH in a year, how much greenhouse gas would be emitted? According to the Campus Carbon Calculator:

Consuming 15,000 KwH in this state…	…creates this much greenhouse gas ($MTCO_2E$)
Colorado	12.5
Kansas	12.4
South Dakota	11.2
Wisconsin	10.9
Tennessee	9.3
Alaska	8.8
Texas	8.1
North Carolina	7.1
Massachusetts	5.0
New York	3.4

Greenhouse Gas calculations for electricity use in various states were made using default values provided by US EPA, October 3, 2012.

Faculty, Staff, and Student Commuter Traffic

Commuter traffic reflects the fuel used by faculty, staff, and students during their regular travels to and from Vanderbilt. This is important to include in Vanderbilt's GHG inventory because Vanderbilt University employs so many people. Based on commuter data for 2011 provided by VUMC's Parking and Transportation Services Office and VU's Traffic and Parking Office, the following assumptions were utilized for faculty, staff, and student commuter travel patterns:

Population	Percent commuting in a single-occupancy vehicle	Percent commuting in a car/vanpool	Percent commuting via bus or train	Other forms of commuting (walk/bike)	Days per year commuting to campus	Average commuter distance (via automobile)
Faculty	87%	5%	7%	1%	200	48
Staff	87%	5%	7%	1%	250	48
Student	15%	5%	2%	78%	200	10

Table 3.4. Assumptions for Faculty, Staff, and Student Commuter Travel, Calendar Year 2011.

WeCar Vehicle Sharing Program Comes to Campus

In order to provide faculty, staff and students more vehicle sharing opportunities, the WeCar car sharing program came to Vanderbilt's campus in 2011. This program was added to the already established ZipCar program and provides an easy and cost effective option for faculty and staff who bike, walk or take the bus to work and students on campus without a vehicle in need of a car for a short-term trip. WeCar vehicles can be rented by the hour or even overnight. Read more on SustainVU's transportation page: http://www.vanderbilt.edu/sustainvu/what-we-do/transportation/car-sharing-and-carpooling-options/.

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

Air Travel

Airline tickets purchased through Vanderbilt's travel agency (Caldwell Travel) for university-sponsored travel are tracked and reported to Vanderbilt's Procurement and Disbursements Department. Air travel records for the 2011 calendar year include passenger-miles, which were input to the Campus Carbon Calculator. All air travel was assumed to be associated with academic and research activities for purposes of this report. Airline tickets purchased by individual Vanderbilt employees using a Procurement Card or personal credit card could not be captured at this time and included in this inventory.

Waste Management

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

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

Medical waste that is not autoclaved on-site is shipped to an autoclave facility operated by a vendor (SteriCycle). There is no input category for autoclaved waste in the Campus Carbon Calculator, nor is there a standard emissions number provided in WRI's Greenhouse Gas Protocol[25]. Using information from SteriCycle[26] and waste industry journals[27], SEMO estimated how much natural gas is needed to autoclave one ton of medical waste. The GHG emissions associated with autoclaving Vanderbilt's medical waste at an off-site location was then calculated using the GHG emissions factor for natural gas use provided by the Campus Carbon Calculator.

Uncertainties Associated with Greenhouse Gas Inventory Calculations

As noted by the WRI Greenhouse Gas Protocol[28], two types of uncertainties are associated with GHG inventories: *scientific* uncertainty and *estimation* uncertainty. Scientific uncertainty occurs when the science of an actual emission is not sufficiently understood. Estimation uncertainty occurs any time GHG emissions are quantified. Thus all emission estimates are associated with estimation uncertainty. Furthermore, the WRI notes that uncertainty exists in when using a mathematical model such as a GHG calculator. Model uncertainty is due to the uncertainty associated with the mathematical equations (i.e. models) used to characterize the relationships between various parameters and emission processes. The WRI notes that analyzing and quantifying these uncertainties is likely beyond the scope of most institutions when compiling a GHG inventory.

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[25] 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.

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

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

[28] 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.

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

IV. ACADEMIC AND RESEARCH AREA GREENHOUSE GAS EMISSIONS

Results Summary

Academic and research areas at VU encompass typical university activities such as teaching, research, administration, student activities, student housing, dining and athletic facilities. Table 4.1 illustrates annual GHG emissions from academic and research areas for calendar years 2005 through 2011. Figure 4.2 demonstrates that GHG emissions from Academic and Research areas have dropped by over four percent in the past year and 13 percent since 2008. More detail is discussed below.

Calendar Year	GHG Emissions from EPA-Required Sources[29] ($MTCO_2E$)	Other Scope 1 Emissions[30] ($MTCO_2E$)	Scope 2 Emissions ($MTCO_2E$)	Scope 3 Emissions ($MTCO_2E$)	Total GHGs Emitted from Academic and Research Areas ($MTCO_2E$)	Percent Decrease in GHGs Emitted from Previous Year
Academic & Research Areas						
2005	99,554	2,446	145,173	49,291	**296,465**	-
2006	95,045	2,848	145,382	52,550	**295,825**	0.22%
2007	107,815	2,838	142,045	55,905	**308,604**	-4.32%
2008	108,255	2,598	149,266	53,222	**313,341**	-1.53%
2009	116,192	2,455	117,359	52,336	**288,343**	7.98%
2010	103,781	3,091	119,507	58,127	**284,506**	1.3%
2011	98,201	2,379	118,077	53,573	**272,229**	4.3%

Table 4.1. GHG Emissions from Academic and Research Areas by Type, Calendar Years 2005-2011.

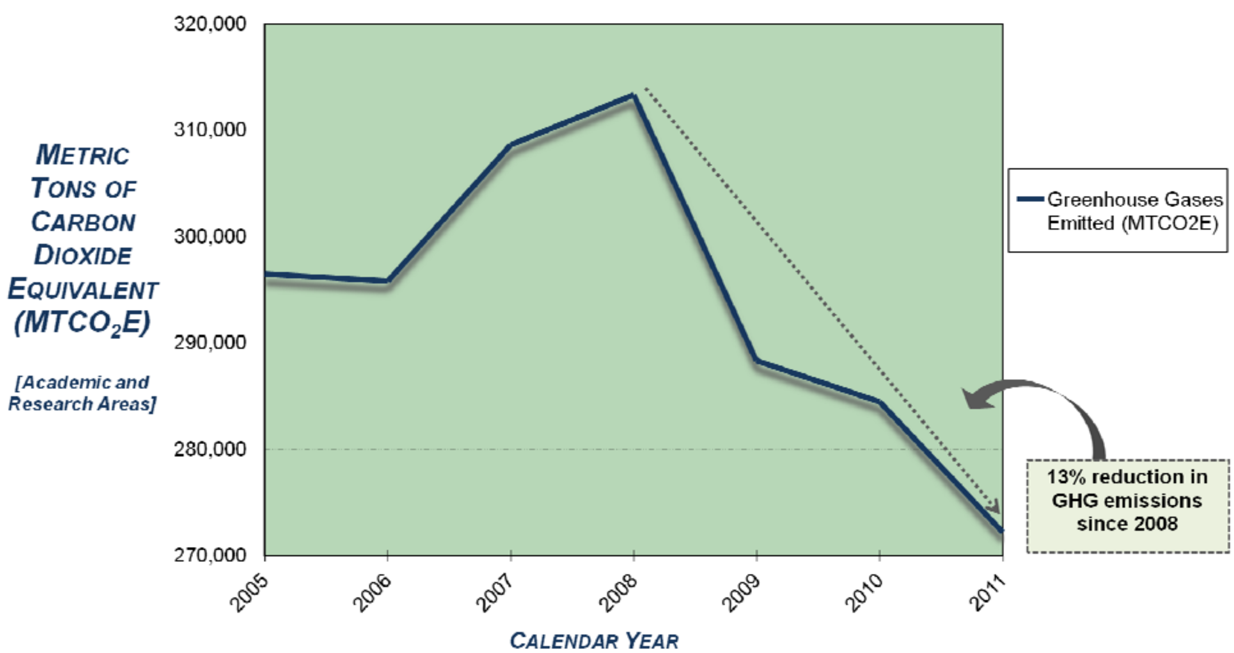

Figure 4.1. GHG Emissions from Academic and Research Areas, Calendar Years 2005-2011.

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

As demonstrated in Figure 4.2 for the calendar year 2011, major contributors to the emissions from academic and research areas include purchased electricity (43 percent), coal use at the power plant (21 percent), faculty and staff commuting (16 percent), and natural gas use at the power plant (14 percent).

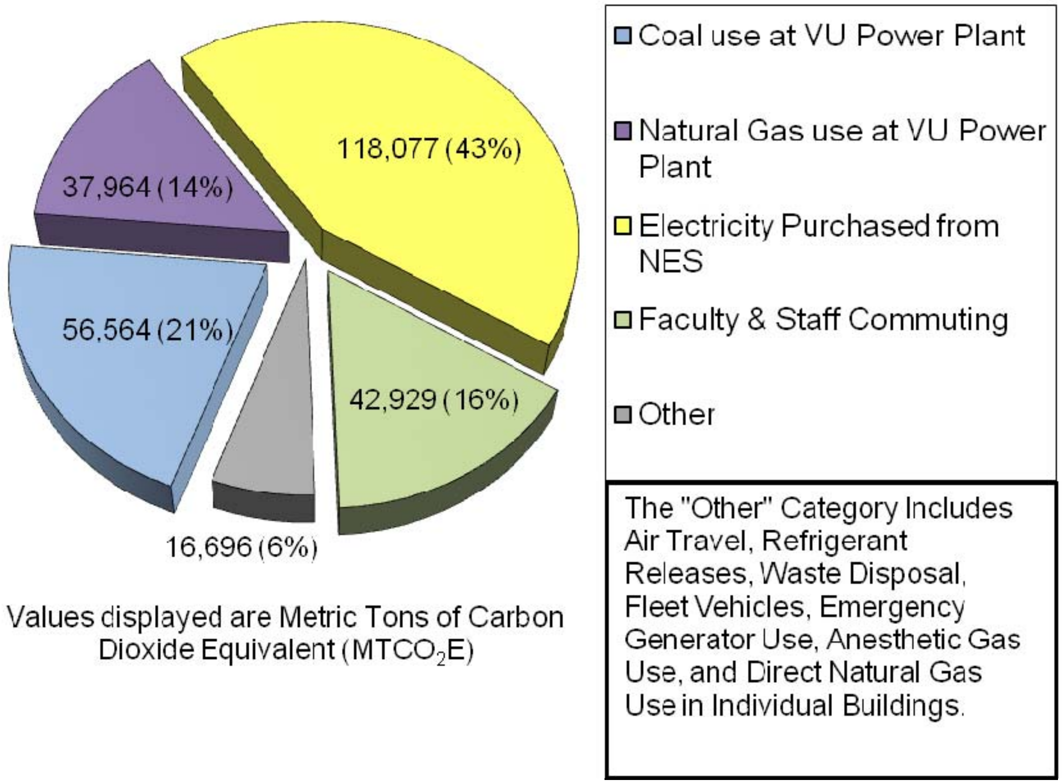

Figure 4.2. GHG Emissions Sources from Academic and Research Areas, Calendar Year 2011.

Figure 4.3 illustrates the contribution from direct emissions (Scope 1), emissions from purchased electricity (Scope 2), and indirect emissions (Scope 3) to the overall GHG emissions for Vanderbilt's Academic and Research activities. Vanderbilt University Academic and Research areas were designated according to the criteria outlined in the Methodology section of the report. For Academic and Research area populations for 2011, please reference Table B.18 in the appendices.

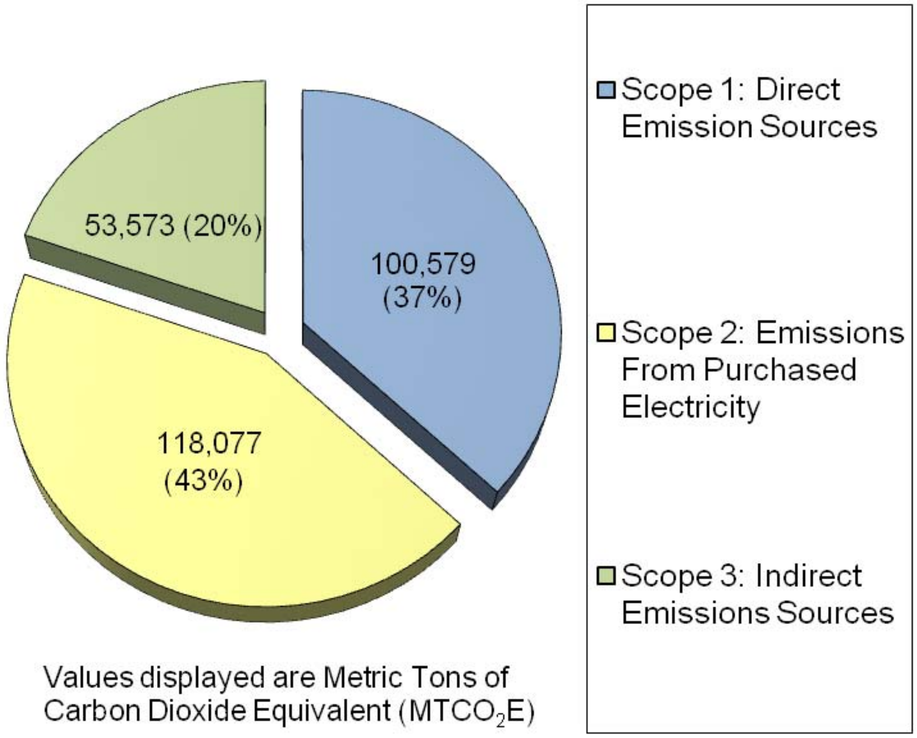

Figure 4.3. Academic and Research Area Emissions by Scope, Calendar Year 2011.

Scope 1: EPA-Required Emissions Sources

The EPA now requires Vanderbilt to report annual GHG emissions from stationary sources which include coal and natural gas consumption at the on-campus, co-generation power plant and consumption of natural gas within individual buildings at Vanderbilt. For calendar year 2011, Vanderbilt University emissions from EPA-required sources amounted to 151,078 $MTCO_2E$, which was reported to the EPA on March 26, 2012. Individual building monthly steam and electricity usage for calendar year 2011 revealed that approximately 65 percent of the steam and electricity consumed by Vanderbilt was consumed by Academic and Research buildings (including academic and classroom buildings, administrative buildings, residential buildings, athletics areas, outdoor lighting, staff parking garages, and multi-purpose buildings). Therefore, 65 percent of the GHG emissions associated with the power plant were attributed to Academic and Research areas. In 2011, GHG emissions from EPA-required sources for Academic and Research Areas amounted to 98,201 $MTCO_2E$ as shown in Table 4.2.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Sources[31] ($MTCO_2E$)	GHG Emissions from EPA-Required Sources in Academic and Research Areas (65percent of previous column) ($MTCO_2E$)
2005	96,478	51,695	4,988	153,161	99,554
2006	99,582	38,485	8,155	146,222	95,045
2007	111,344	48,258	6,268	165,869	107,815
2008	102,172	51,358	13,017	166,547	108,255
2009	105,956	64,096	8,705	178,758	116,192
2010	92,090	62,835	4,738	159,663	103,781
2011	87,022	58,405	5,651	151,078	98,201

Table 4.2 Academic and Research Area GHG Emissions from EPA-Required Stationary Sources, Calendar Years 2005-2011.

Coal and Natural Gas Use at the Power Plant

The on-campus co-generation power plant burns coal and natural gas to produce electricity, steam, and chilled water for distribution to buildings located on the 330-acre Vanderbilt campus. The burning of coal and natural gas releases carbon dioxide, nitrous oxide, and methane. The inventory results illustrate that 65 percent of the overall 87,022 $MTCO_2E$, or 56,564 $MTCO_2E$, are produced from coal use at the power plant for Academic and Research areas. This equates to 21 percent of the overall 2011 Academic and Research area emissions. Additionally, 65 percent of the 58,405 $MTCO_2E$ resulting from natural gas use, or 37,964 $MTCO_2E$, equates to 14 percent of the overall Academic and Research area emissions, as shown in Table B.1 of the appendices.

Natural Gas Use in Individual Buildings

Several buildings on campus use natural gas directly from Vanderbilt's natural gas supplier, Piedmont Natural Gas. The consumption of natural gas within individual buildings in Academic and Research areas accounts for 3,673 $MTCO_2E$ of 2011 emissions, as shown in Table B.1 of the appendices.

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

LEED Certified Buildings and Vanderbilt

Due to the ever-changing nature of Vanderbilt's campus, renovations and building improvements are always in the works.

Vanderbilt University's Central Library has been awarded gold certification for its environmentally friendly recognition from the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Green Building Rating System.

The recognition makes the Central Library the first Vanderbilt campus recognition to achieve this high honor. Vanderbilt University has a total of 12 LEED-certified buildings as of 2011, including:

Certified: Chef James Bistro, Vanderbilt Health One Hundred Oaks
Silver: Crawford House, Sutherland House, Gillette House, Benson Hall, Library Archives
Gold: The Commons Center, Stambaugh House, Hank Ingram House, Murray House, Central Library

Scope 1: Other Direct Emission Sources

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

Calendar Year	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	VU Fleet Vehicles ($MTCO_2E$)	Anesthetic Gas Use ($MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	550	286	1,609	1	2,446
2006	541	338	1,968	1	2,848
2007	830	137	1,870	1	2,838
2008	282	143	2,159	14	2,598
2009	394	35	2,013	14	2,455
2010	119	1,019	1,935	19	3,091
2011	110	41	2,210	18	2,379

Table 4.3. Academic and Research Area Scope 1 Emissions from Other Sources, Calendar Years 2005-2011.

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 110 $MTCO_2E$ to 2011 GHG emissions, as referenced in Table 4.3 above.

Refrigerant Releases

Chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances can release hydrofluorocarbons and perfluorocarbons to the atmosphere. In 2011, release of refrigerant from Academic and Research areas amounted to 31 kilograms of refrigerant, resulting in 41 $MTCO_2E$ of GHG emissions[32], as referenced in Table 4.3.This number was greatly reduced from the 1,1019 $MTCO_2E$ of GHG emissions associated with refrigerant releases in 2010 due to increased efforts by VU Plant Operations and VUMC Plant Services to minimize refrigerant losses. Both groups hired dedicated chilled water technicians that perform robust preventative maintenance on systems which minimizes downtime and reduces the costs associated with refrigerant replacement and loss of chilled water for critical equipment.

University-Owned Fleet Vehicles

As noted in the Methodology section of this report, several university departments own and operate vehicles. The Plant Operations Department and the Vanderbilt Police Department owns and operates numerous vehicles, which consume both gasoline and diesel fuel. The remaining inventory of university vehicles (221) are owned by various departments at Vanderbilt. The employee shuttle bus and van system uses both gasoline and diesel fuel. 2011 GHG emissions from university-owned vehicles in Academic and Research areas amounted to 2,210 $MTCO_2E$, as illustrated in Table 4.4.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations	53,502	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	478
Gasoline purchases by VU PD and Vandy Vans	36,993	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	330
Estimate of gasoline purchases by remaining fleet vehicles (221 vehicles) [33]	39,000	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	348
Gasoline use by VUMC Shuttle Buses and Vans	82,870	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	740
Diesel Fuel use by VUMC Shuttle Buses and Vans	27,951	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	283
Diesel Fuel use by Plant Operations	2,949	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	30
GHG Emissions from Academic & Research Fleet Vehicles:			2,210

Table 4.4. Academic and Research Area GHG Emissions from Vanderbilt Owned Vehicles, Calendar Year 2011.

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

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

Vanderbilt Replaces Gasoline-Powered Trucks with Zero Emissions Electric Carts

Recycling Cart used by VU's Sustainability and Environmental Management Office (SEMO)

Electric carts are now commonly seen on Vanderbilt's campus. Plant Operations has been aggressively replacing gasoline-powered pickup trucks with zero emissions electric carts over the last few years.

Electric carts cost half of a traditional gas vehicle, can be configured for many uses, have zero GHG emissions, have virtually no long-term fuel costs, reduce noise pollution, and allow access to tighter locations.

The most recent addition to the electric vehicle fleet is a modified cart used by student workers to collect recycling from VU's residence halls.

Anesthetic Gas Use

The Department of Animal Care utilizes Isoflurane as an anesthetic, which has a known GWP and emission factor, as illustrated in Tables 3.2 and 3.3 of this report's Methodology section. Anesthetic gas use in Academic and Research areas resulted in 19 $MTCO_2E$ of 2011 GHG emissions. See Table 4.5 below for more details.

Anesthetic Gas	Department	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane	Animal Care	53.6	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	19

Table 4.5. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2011.

Scope 2: Purchased Electricity Emissions

118,077 $MTCO_2E$, or 43 percent, of 2011 GHG emissions for Academic and Research areas are attributed to electricity purchased from TVA, as shown in Table 4.6 below. This is the result of the amount of electricity purchased from NES and the mix of electricity generation methods employed by TVA. See Tables B.11 and B.12 in the appendices for more details.

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65percent of previous column) ($MTCO_2E$)
2005	294,070,522	223,343	145,173
2006	294,494,256	223,664	145,382
2007	287,734,887	218,531	142,045
2008	307,162,163	229,640	149,266
2009	305,308,699	180,553	117,359
2010	303,543,739	183,857	119,507
2011	313,049,916	181,657	118,077

Table 4.6 GHG Emissions from Purchased Electricity for Academic and Research Areas, Calendar Years 2005-2011.

Scope 3: Indirect Emission Sources

Vanderbilt's indirect emissions include fuel use by commuters (faculty, staff and student commuters), fuel use from air travel, and waste disposal. Indirect emissions for Academic and Research Areas for calendar years 2005 through 2011 are displayed below in Table 4.7. As shown in Figure 4.4, GHG emissions from Scope 3 activities unfortunately increased 11.1percent in 2010 due to increased commuter and air travel but a small decrease was seen in 2011. Due to budget constraints, work-related travel was limited in 2008 and 2009.

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Air Travel Emissions[34] ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions in Academic & Research Areas ($MTCO_2E$)
2005	1,022	5,259	43,010	49,291
2006	1,116	5,259	46,175	52,550
2007	1,150	5,259	49,496	55,905
2008	1,360	5,386	46,476	53,222
2009	1,205	6,944	44,186	52,335
2010	1,761	9,719	46,646	58,127
2011	1,651	8,993	42,929	53,573

Table 4.7. Academic and Research Area Scope 3 GHG Emissions Sources, Calendar Years 2005-2011.

[34] Air travel for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.

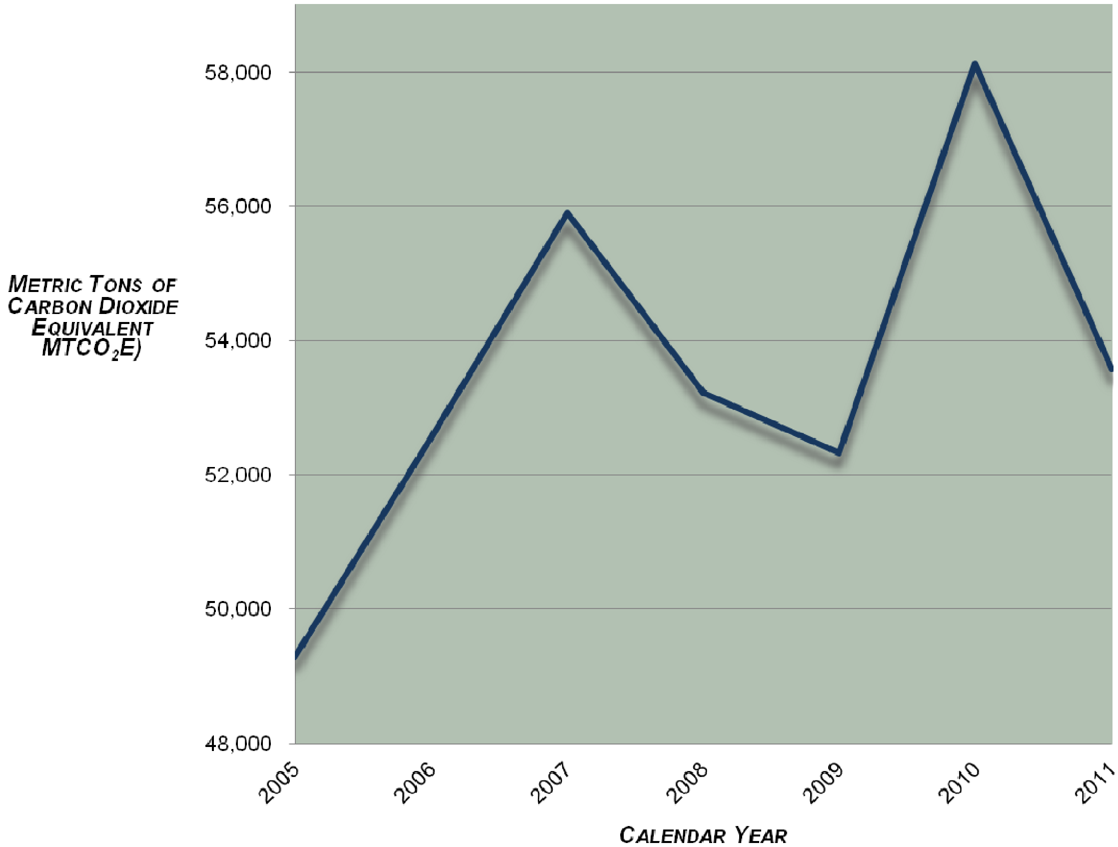

Figure 4.4. Academic and Research Area Scope 3 Emissions, Calendar Years 2005-2011.

Commuter Travel

Faculty and staff in Academic and Research Areas have an average commuting distance of 24 miles (one-way)[35]. For students who do not live on campus, the average one-way commute distance was assumed to be 5 miles. Based on the fuel consumption estimate of 22 miles per gallon (as provided by the Campus Carbon Calculator), Academic and Research commuters consumed 4,734,869 gallons of gasoline and 61,407 gallons of diesel fuel in 2011, resulting in 42,929 $MTCO_2E$ of GHG emissions. See Tables B.13, B.14, and B.15 in the appendices for more details.

Air Travel

Vanderbilt University's Procurement Department manages university-sanctioned travel purchased through Caldwell Travel Group. In 2011, 11,577,033 air passenger-miles were traveled. 2011 emissions associated with air travel in Academic and Research areas amounted to 8,993 $MTCO_2E$. See Table B.16 in the appendices for more details.

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

Waste Management

Waste from Academic and Research areas is landfilled or incinerated. Emissions from waste disposal for Academic and Research areas in 2011 amounted to 1,651 $MTCO_2E$. See Table B.17 in the appendices for more details.

V. PATIENT CARE AREA GREENHOUSE GAS EMISSIONS

Results Summary

Patient care areas at VU encompass hospital buildings and clinical buildings located on Vanderbilt's core 330 acres. Reference Table 3.1 in the Methodology section of this report for a complete listing of buildings included in the patient care area category. Table 5.1 illustrates annual GHG emissions from Patient Care Areas for calendar years 2005 through 2011. Figure 5.1 shows that GHG emissions from Patient Care areas have dropped by more than 10 percent since 2008.

Calendar Year	GHG Emissions from EPA-Required Sources[36] ($MTCO_2E$)	Other Scope 1 Emissions[37] ($MTCO_2E$)	Scope 2 Emissions ($MTCO_2E$)	Scope 3 Emissions ($MTCO_2E$)	Total GHGs Emitted from Patient Care Areas ($MTCO_2E$)	Percent Decrease in GHGs Emitted from Previous Year
Patient Care Areas						
2005	53,606	5,864	78,170	41,620	**179,260**	**-**
2006	51,178	5,873	78,283	47,215	**182,548**	**-1.8%**
2007	58,054	5,632	76,486	49,786	**189,958**	**-4.1%**
2008	58,291	6,817	80,374	44,503	**189,985**	**-0.01%**
2009	62,565	5,716	63,193	44,420	**175,896**	**7.4%**
2010	55,882	5,026	64,350	45,497	**170,754**	**2.9%**
2011	52,877	5,416	63,580	47,516	**169,389**	**0.8%**

Table 5.1. GHG Emissions from Patient Care Areas by Type, Calendar Years 2005-2011.

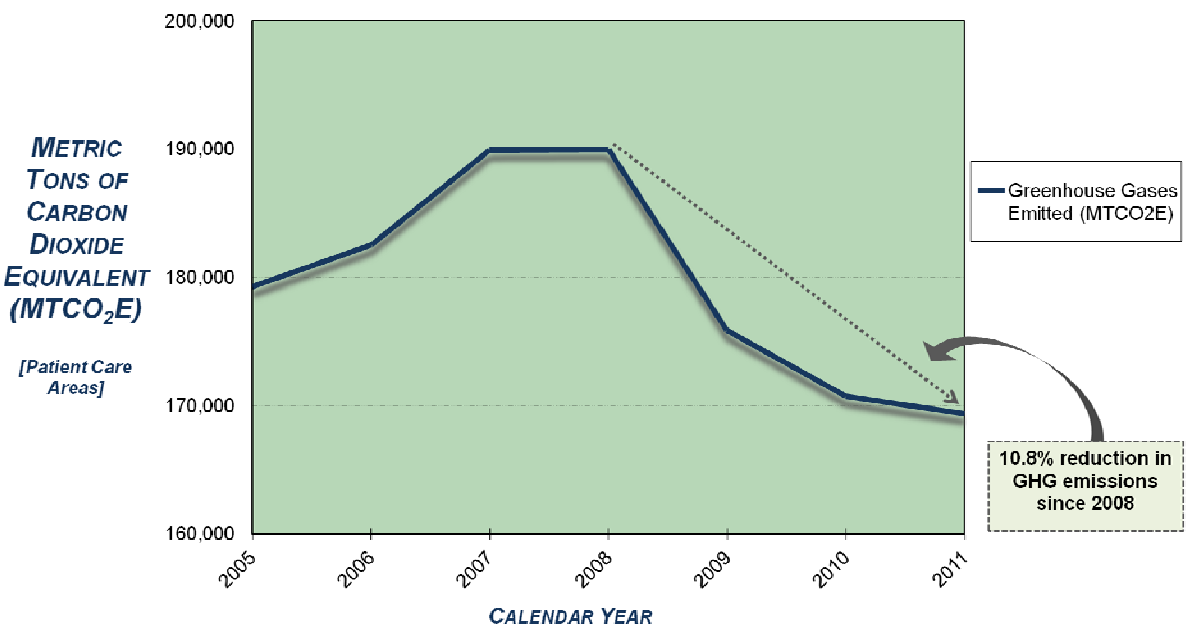

Figure 5.1. GHG Emissions from Patient Care Areas, Calendar Years 2005-2011.

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[36] EPA-required sources includes coal-fired boilers, natural gas-fired boilers, and natural gas-fired turbines.

[37] Other Scope 1 Emissions sources include anesthetic gas use, emergency generators, fleet vehicles, and refrigerant releases.

For the calendar year 2011, major contributors to the emissions from patient care areas are shown in Figure 5.2.

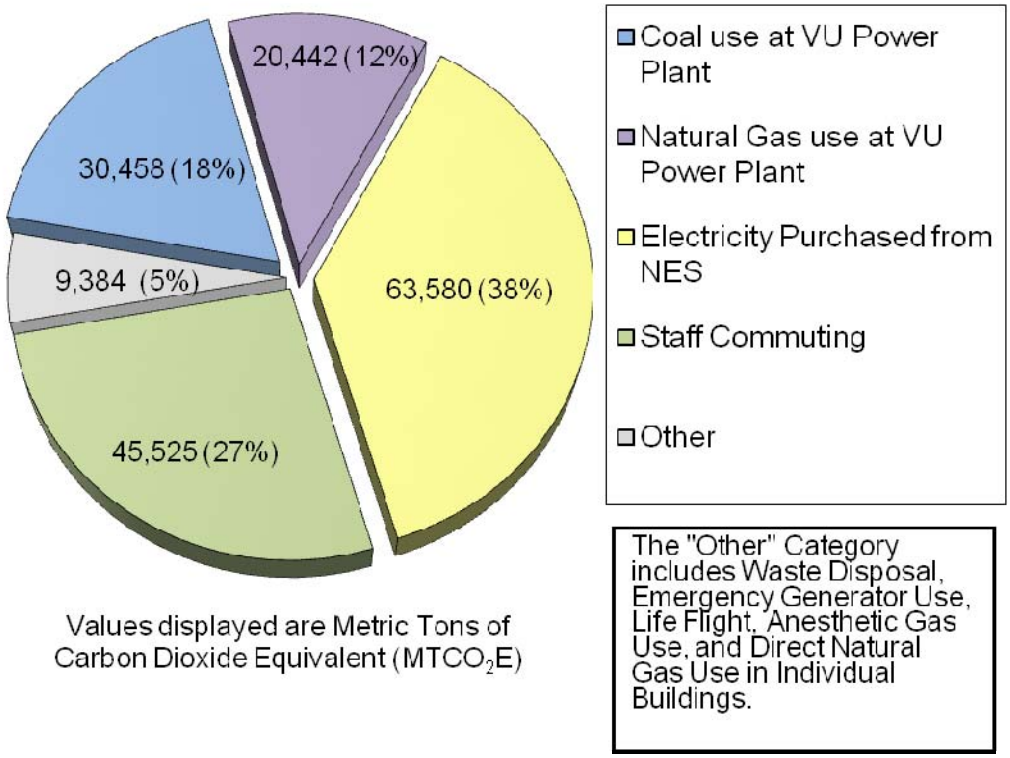


Figure 5.2. GHG Emissions Sources from Patient Care Areas, Calendar Year 2011.

Figure 5.3 illustrates the contribution from direct emissions (Scope 1), emissions from purchased electricity (Scope 2), and indirect emissions (Scope 3) to overall GHG emissions from Vanderbilt's Patient Care Areas in 2011.

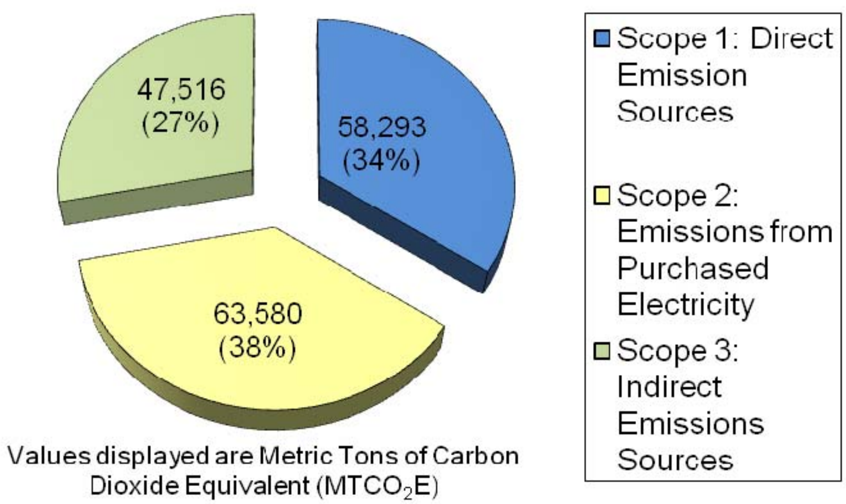


Figure 5.3. GHG Emissions Sources by Scope from Patient Care Areas, Calendar Year 2011.

Vanderbilt University Patient Care Areas were designated according to the criteria outlined in the Methodology section of the report. For Patient Care area populations for 2011, please reference Table B.18 in the appendices.

Scope 1: EPA-Required Emission Sources

The EPA now requires Vanderbilt to report annual GHG emissions from stationary sources which include coal and natural gas consumption at the on-campus, co-generation power plant and consumption of natural gas within individual buildings at Vanderbilt. For calendar year 2011, Vanderbilt University emissions from EPA-required sources amounted to 151,078 $MTCO_2E$, which was reported to the EPA on March 26, 2012. Individual building monthly steam and electricity usage for calendar years 2005 through 2011 revealed that approximately 35 percent of the steam and electricity consumed by Vanderbilt was consumed by Patient Care buildings. Therefore, 35 percent of the GHG emissions associated with the power plant were attributed to Patient Care areas. In 2011, GHG emissions from EPA-required sources for Patient Care Areas amounted to 52,877 $MTCO_2E$, a 15 percent decrease from the all time recorded high in 2009 GHG emissions, as shown in Table 5.2.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Stationary Sources[38] ($MTCO_2E$)	GHG Emissions from EPA-Required Stationary Sources for Patient Care Areas (35 percent of previous column) ($MTCO_2E$)
2005	96,478	51,695	4,988	153,161	53,606
2006	99,582	38,485	8,155	146,222	51,178
2007	111,344	48,258	6,268	165,869	58,054
2008	102,172	51,358	13,017	166,547	58,291
2009	105,956	64,096	8,705	178,758	62,565
2010	92,090	62,835	4,738	159,663	55,882
2011	87,022	58,405	5,651	151,078	52,877

Table 5.2. Patient Care Area GHG Emissions from EPA-Required Sources, Calendar Years 2005-2011.

Coal and Natural Gas Use at the Power Plant

The on-campus co-generation power plant burns coal and natural gas to produce electricity, steam, and chilled water for distribution to buildings located on the 330-acre Vanderbilt campus, including patient care buildings. The burning of coal and natural gas releases carbon dioxide, nitrous oxide, and methane. The inventory results illustrate that 35 percent of the overall 87,022 $MTCO_2E$, or 30,458 $MTCO_2E$, are produced from coal use at the power plant for Patient Care areas. This equates to 18 percent of the overall 2011 Patient Care area emissions. Additionally, 35 percent of the 58,405 $MTCO_2E$ resulting from natural gas use,

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

or 20,442 $MTCO_2E$, equates to 12 percent of the overall Patient Care area emissions, as shown in Table B.1 of the appendices.

Natural Gas Use in Individual Buildings

Several Patient Care buildings use natural gas directly from Vanderbilt's natural gas supplier, Piedmont Natural Gas. The consumption of natural gas within individual Patient Care buildings accounts for 1,978 $MTCO_2E$ of 2011 emissions, as shown in Table B.1 in the appendices.

Scope 1: Other Direct Emission Sources

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

Calendar Year	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Fleet Vehicles (Life Flight) ($MTCO_2E$)	Anesthetic Gas Use[39] ($MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	296	189	2,206	3,174	**5,864**
2006	291	397	2,012	3,174	**5,873**
2007	447	131	1,880	3,174	**5,632**
2008	152	0	1,877	4,789	**6,817**
2009	212	0	1,608	3,896	**5,716**
2010	438	609	1,531	2,449	**5,026**
2011	315	98	1,643	3,360	**5,416**

Table 5.3. Patient Care Area Scope 1 Emissions from Other Direct Sources, Calendar Years 2005-2011.

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 315 $MTCO_2E$ to 2011 GHG emissions, as referenced in Table 5.3 above.

Refrigerant Releases

Chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances can release hydrofluorocarbons and perfluorocarbons to the atmosphere. In 2011, release of refrigerants from Patient Care areas amounted to 75 kilograms of refrigerant, resulting in 98 $MTCO_2E$ of GHG emissions[40], as noted in Table 5.3. This number was greatly reduced from the 609 $MTCO_2E$ of GHG emissions associated with

[39] Anesthetic gas for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.
[40] Emission Factor for R-134A is used as a default emission factor, as some refrigerants do not have a published emission factor/global warming potential (GWP).

refrigerant releases in 2010 due to increased efforts by VU Plant Operations and VUMC Plant Services to minimize refrigerant losses. Both groups hired dedicated chilled water technicians that perform robust preventative maintenance on systems which minimizes downtime and reduces the costs associated with refrigerant replacement and loss of chilled water for critical equipment.

University-Owned Fleet Vehicles

As noted in the Methodology section of this report, annual consumption of fuel by Vanderbilt's LifeFlight helicopters is recorded. As demonstrated in Table 5.4, 2011 GHG emissions from fuel consumption by LifeFlight helicopters amounted to 1,643 $MTCO_2E$.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by LifeFlight	171,729	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	1,643

Table 5.4. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2011.

Anesthetic Gas Use

The Department of Anesthesiology utilizes four different types of anesthetic, each with its own GWP and emission factor: Isoflurane, Nitrous Oxide, Desflurane, and Sevoflurane. See Tables 3.2 and 3.3 in the Methodology section for more information. In 2011, anesthetic gas use in Patient Care areas resulted in 3,360 $MTCO_2E$ of annual GHG emissions, as referenced in Table 5.5 below.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	4,540	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	1,407
Isoflurane	337	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	118
Desflurane	1,193	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,180
Sevoflurane	1,899	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	655
Total for Anesthesiology/Patient Care Areas			3,360

Table 5.5. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2011[41].

Scope 2: Purchased Electricity Emissions

63,580 $MTCO_2E$, or 38 percent, of 2011 GHG emissions for Patient Care areas are attributed to electricity purchased from TVA, as shown in Table 5.6 below. This is the result of the amount of electricity purchased from NES and the mix of electricity generation methods employed by TVA.

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

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35percent of previous column) ($MTCO_2E$)
2005	294,070,522	223,343	78,170
2006	294,494,256	223,664	78,283
2007	287,734,887	218,531	76,486
2008	307,162,163	229,640	80,374
2009	305,308,699	180,553	63,193
2010	303,543,739	183,857	64,350
2011	313,049,916	181,657	63,580

Table 5.6 GHG Emissions from Purchased Electricity for Patient Care Areas, Calendar Years 2005-2011.

Scope 3: Indirect Emissions Sources

Vanderbilt's indirect emissions include commuter fuel use by staff members in patient care buildings and off-site waste disposal. Indirect emissions for patient care areas for calendar years 2005 through 2011 are displayed below in Table 5.7.

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions for Patient Care Areas ($MTCO_2E$)
2005	1,585	40,035	41,620
2006	2,177	45,037	47,215
2007	1,706	48,079	49,786
2008	1,614	42,889	44,503
2009	1,653	42,767	44,420
2010	1,861	43,636	45,496
2011	1,991	45,525	47,516

Table 5.7. Patient Care Area Scope 3 GHG Emissions Sources, Calendar Years 2005-2011.

As shown in Figure 5.4, GHG emissions from Scope 3 activities in Patient Care areas have unfortunately increased 4.2 percent in the last year due to increased commuter travel and waste disposal in 2011.

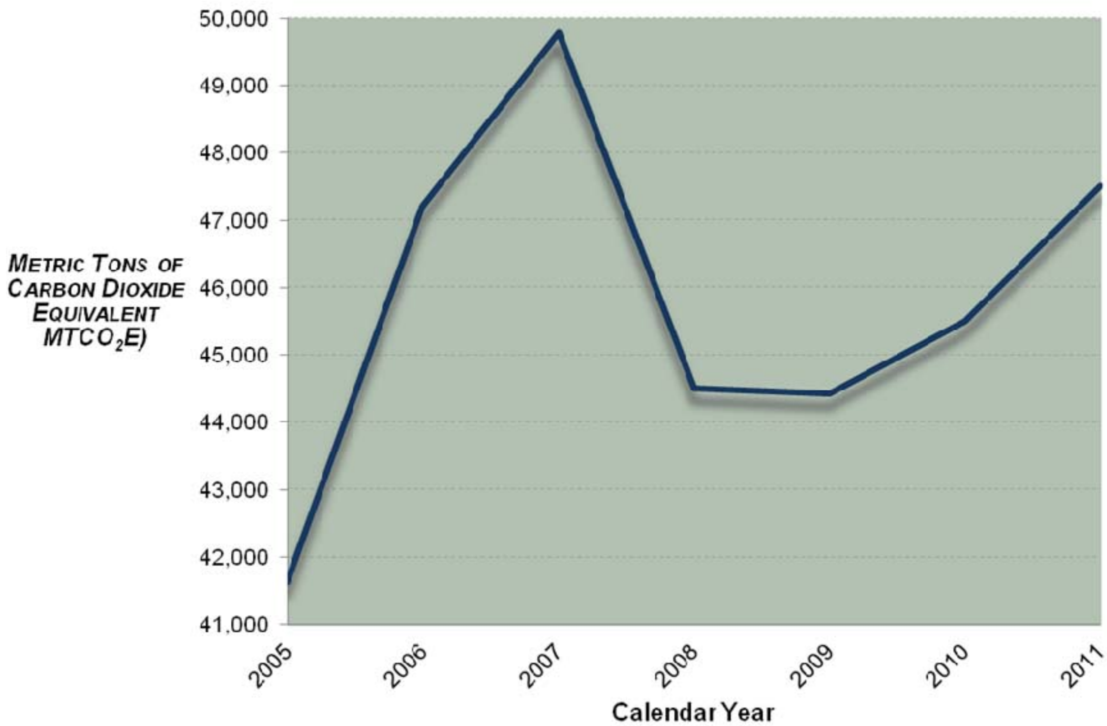


Figure 5.4. Patient Care Area Scope 3 Emissions, Calendar Years 2005-2011.

Commuter Travel

The average commuting distance for a Vanderbilt employee is 24 miles (one-way) [42]. Based on the fuel consumption estimate of 22 miles per gallon (as provided by the Campus Carbon Calculator), Patient Care commuters consumed 5,038,081 gallons of gasoline and 50,305 gallons of diesel fuel in 2011, resulting in 45,525 $MTCO_2E$ of GHG emissions. See Tables B.20, B.21, and B.22 in the appendices for more details.

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

Electric Car Charging Stations Come To Campus

Traffic & Parking and Medical Center Parking and Transportation Services have recently rolled out nineteen electric vehicle charging stations that are open to the Vanderbilt and Nashville communities.

Vanderbilt University teamed up with the Electric Power Research Institute and the Tennessee Valley Authority to build an integrated solar-assisted electric vehicle charging station on campus known as a Smart Modal Area Recharge Terminal, or TVA SMART™ station. The station can charge up to ten electric vehicles at a time and is located at the corner of 21st Avenue and Broadway.

Five stations were donated by Schneider Electric and are located on Vanderbilt's main campus. Four charging stations are part of the ECOtality project, a federally funded initiative to support a publicly available electric vehicle charging grid, and are located in VUMC parking garages and are free to patients and visitors. These stations will be used as a "topping off" charge to help decrease range anxiety.

Waste Management

Waste from Patient Care areas is landfilled, incinerated, or autoclaved. Vanderbilt's on-site autoclaves operate on steam provided by the VU co-generation power plant; therefore, the GHG emissions associated with the on-site autoclaves are already included in the EPA-required sources emissions for Patient Care areas. Average yearly emissions for landfilled or incinerated waste disposal from Patient Care areas in 2011 amounted to 1,991 $MTCO_2E$. See Table B.19 in the appendices for more details.

VI. INVENTORY SUMMARY

Vanderbilt University Emissions Summary

Vanderbilt University's GHG emissions for calendar years 2005 to 2011 are presented in Table 6.1. Total annual GHG emissions for Vanderbilt University during the seven-year period reached a maximum of 503,327 $MTCO_2E$ in calendar year 2008 and a minimum of 441,618 $MTCO_2E$ in calendar year 2011, decreasing by 3.0 percent from the previous year, 7.2 percent overall since 2005, and 12.3 percent from the all time high in 2008.

Calendar Year	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Total GHGs Emitted by VU ($MTCO_2E$)	Percent Decrease in GHGs From Previous Year
2005	296,465	179,260	**475,725**	**-**
2006	295,825	182,548	**478,374**	**-0.6%**
2007	308,604	189,958	**498,562**	**-4.2%**
2008	313,341	189,985	**503,327**	**-1.0%**
2009	288,343	175,896	**464,240**	**7.8%**
2010	284,506	170,755	**455,261**	**1.9%**
2011	272,229	169,389	**441,618**	**3.0%**

Table 6.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2011.

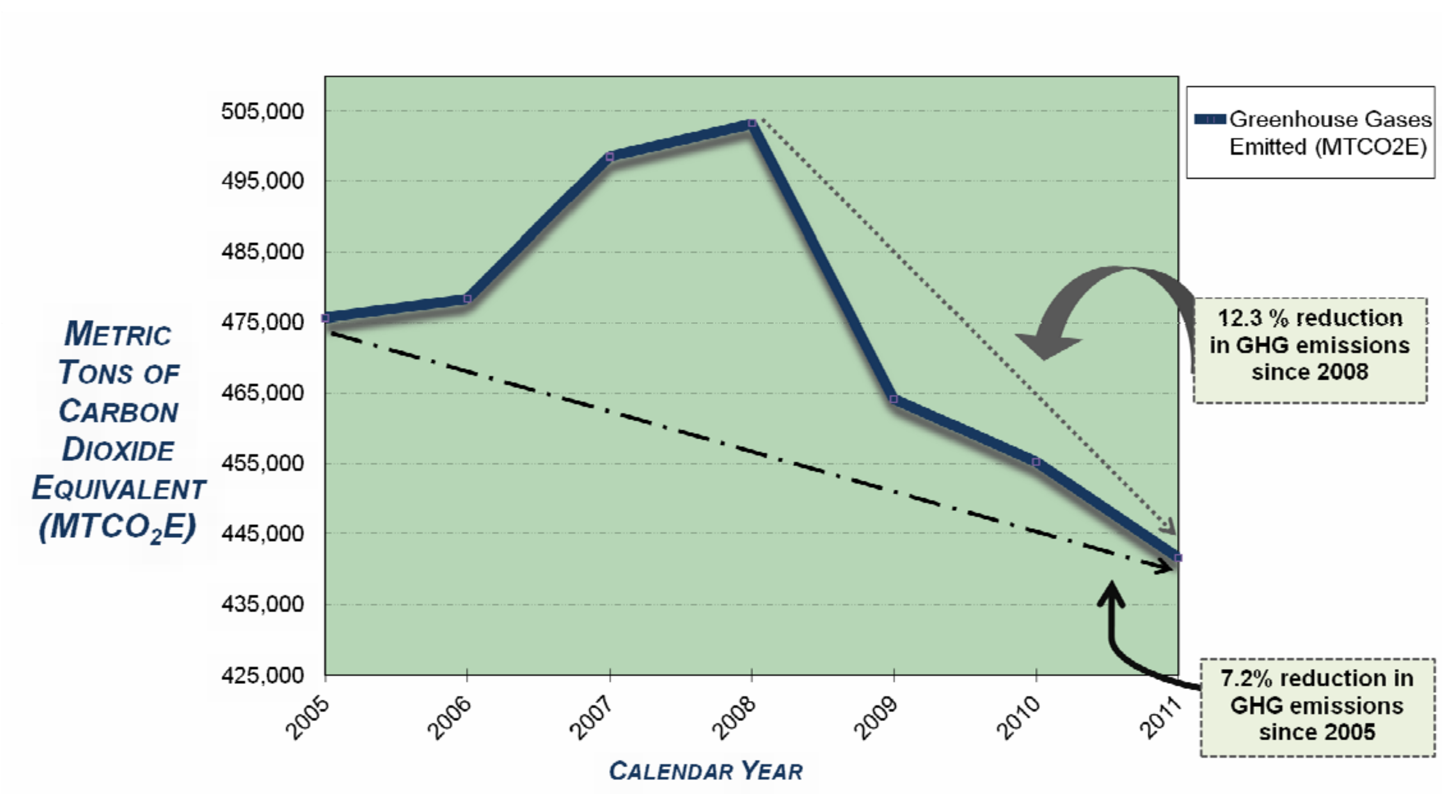


Figure 6.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2011.

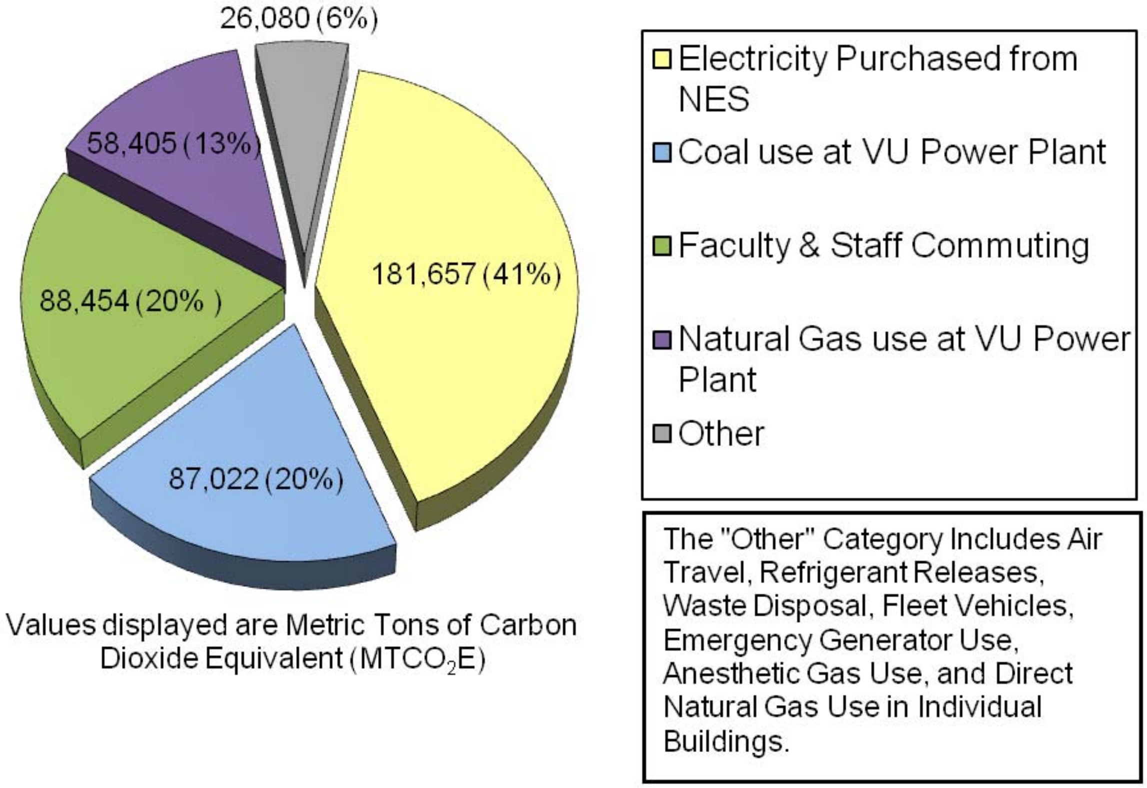


Figure 6.2. GHG Emissions Sources, Calendar Year 2011.

The EPA now requires Vanderbilt to report annual GHG emissions from stationary sources which include coal and natural gas consumption at the on-campus, co-generation power plant and consumption of natural gas within individual buildings at Vanderbilt. For calendar year 2011, Vanderbilt University emissions from EPA-required sources amounted to 151,078 $MTCO_2E$, which was reported to the EPA on March 26, 2012.

Emissions data from calendar year 2011 indicate that approximately 61.6 percent of total GHG emissions are attributable to academic and research areas; the remaining 38.4 percent of total GHG emissions are attributable to patient care areas.

In calendar year 2011, purchased electricity, coal use at the on-campus co-generation power plant, commuter travel, and natural gas use at the on-campus co-generation power plant were the most substantial sources of GHG emissions, accounting for 94 percent of annual GHG emissions from Vanderbilt University. These major sources present the most significant opportunities for improvements in Vanderbilt University's carbon footprint.

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

Analysis and Interpretation of 2005-2011 Trending Results

The figures below illustrate Vanderbilt's GHG emissions as they relate to several institutional metrics. Some metrics have been calculated for all Vanderbilt areas (Figures 6.3 and 6.4) whereas others have been calculated separately for Academic and Research areas (Figures 6.5 and 6.6) and Patient Care Areas (Figures 6.7 and 6.8), as applicable. Please reference Tables A.1-A.5 in the appendices for more information. Overall GHG emissions are down 3 percent from last year and 12.3 percent from the all-time high reached in 2008, even though square footage has increased by 6.7 percent, or 1,038,954 square feet, since 2008.

Emissions per Gross Square Foot

Calculating GHG emissions per gross square foot (GSF) of space provides a normalized method of interpreting emissions in light of Vanderbilt's size and building energy efficiency. Heating and cooling building space, which requires energy, results in significant GHG emissions. A single calculation was made based on all Vanderbilt University facilities, totaling over 15,000,000 square feet. For more details please refer to Table A.3 in the appendices. Figure 6.3 shows a 20.8 percent reduction in GHG emissions per 1,000 GSF over the past seven years, even though several large new buildings have been built. This has resulted from significant investments by VU Plant Operations and VUMC Plant Services to improve existing building energy efficiency as well as LEED certification of new and renovation construction projects.

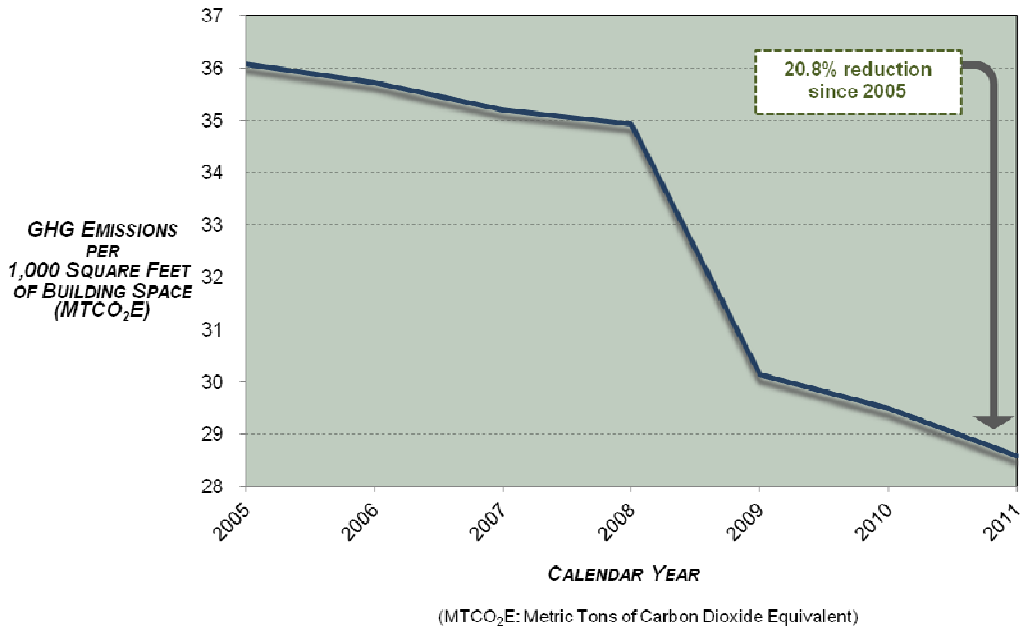


Figure 6.3. Total Vanderbilt GHG Emissions Per 1,000 GSF, Calendar Years 2005-2011.

Emissions per Person

The size of the student population and faculty/staff population also directly influence the amount of GHGs emitted from Vanderbilt. More individuals on campus result in more building occupants, increased amounts of waste generation and more commuters. GHG emissions per person have decreased 19 percent during the past seven years as shown in Figure 6.4. GHG emissions per student are down 18 percent from 26.2 $MTCO_2E$ in 2005 to 21.4 $MTCO_2E$ in 2011 as shown in Figure 6.5. For additional information, please reference Tables A.1, A.3, and A.5 in the appendices.

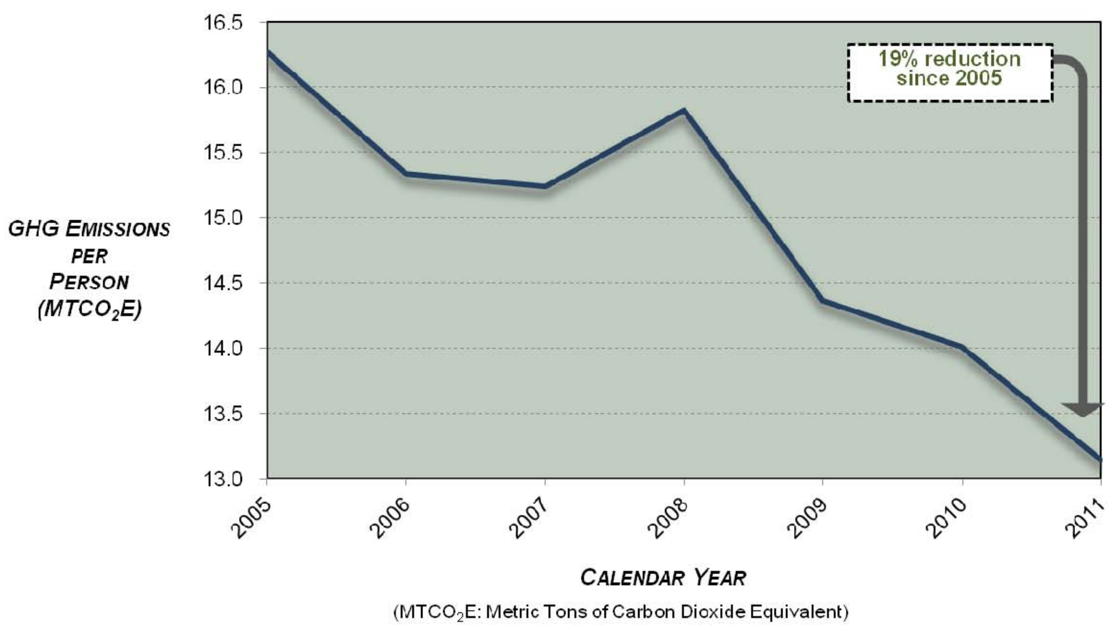


Figure 6.4. Total Vanderbilt GHG Emissions Per Person, Calendar Years 2005-2011.

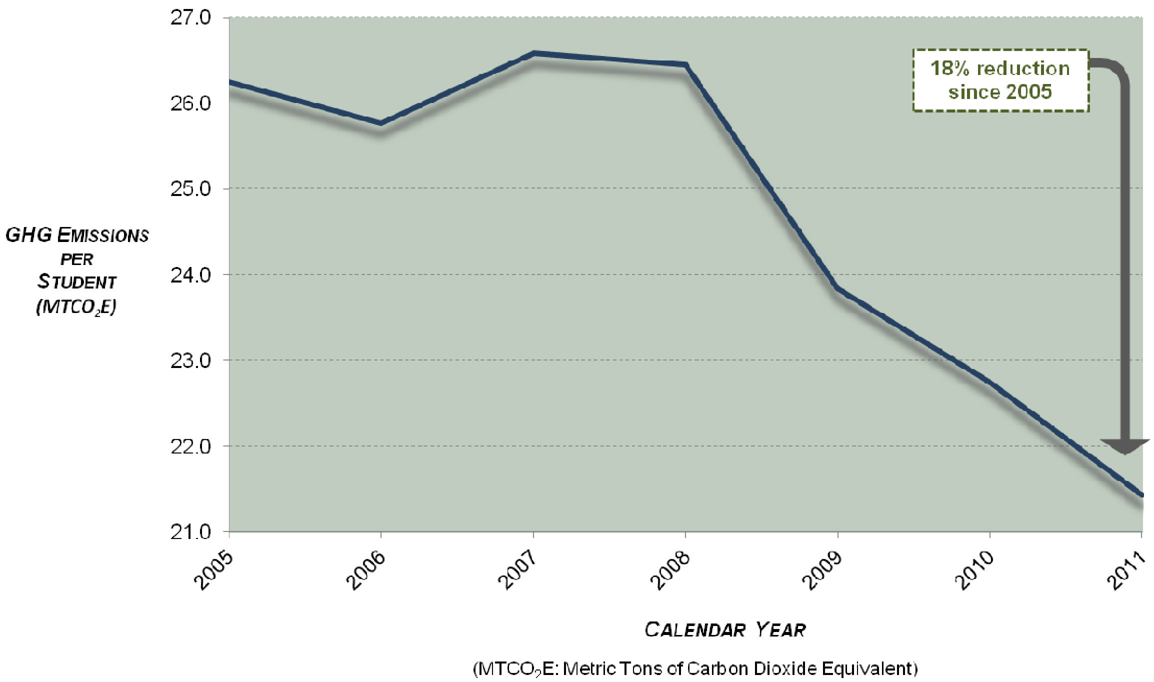
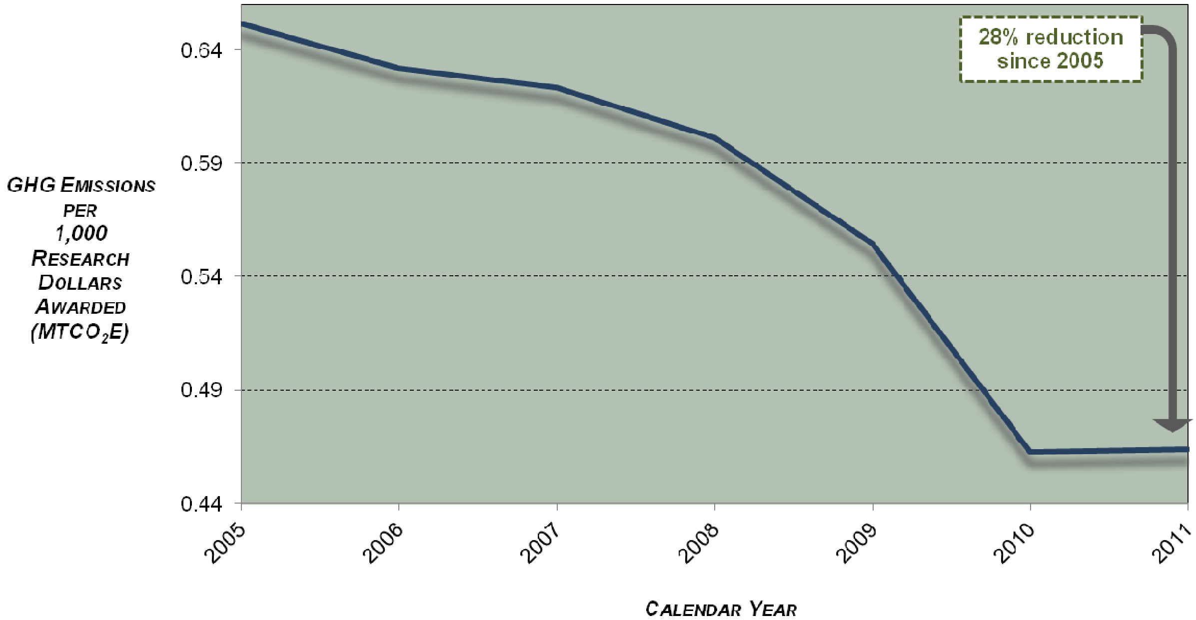


Figure 6.5. Vanderbilt Academic and Research Area GHG Emissions Per Student, Calendar Years 2005-2011.

Emissions per Research Dollars Awarded

Conducting research and operating laboratory facilities require large amounts of energy. Universities receiving substantial amounts of research dollars (like Vanderbilt) use those dollars to operate laboratories and advanced technology to make scientific discoveries that benefit humankind. These activities can increase GHG emissions on a per-person basis and a per-square-foot basis because of energy-intensive, research activities. The typical laboratory used four to five times more energy than an equivalent-sized office or classroom[43]. While Vanderbilt University's research awards increased from $455 million in 2005 to $587 million in 2011, GHG emissions per 1,000 research dollars decreased 28 percent as shown in Figure 6.6. This is an impressive improvement in the energy efficiency of VU's research buildings. For more details, please reference Table A.1 in the appendices.

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



($MTCO_2E$: Metric Tons of Carbon Dioxide Equivalent)

Figure 6.6. Vanderbilt Academic and Research Area GHG Emissions Per 1,000 Research Dollars Awarded, Calendar Years 2005-2011.

Emissions per Inpatient Day and Ambulatory Visit

Patient care facilities, such as the Vanderbilt University Medical Center, that provide health care 24 hours per day, 7 days per week, 365 days per year, can substantially contribute to GHG emissions. Few universities have on-campus patient care activities that match the size and extent of operations of Vanderbilt University Medical Center. Thus, calculating GHG emissions per inpatient day and ambulatory visit provides a means of interpreting emissions while considering the quality and magnitude of our medical operations on-campus. GHG emissions per both inpatient days and ambulatory (clinic) visits have trended consistently downward, decreasing 20 percent and 44 percent, respectively, since 2005 despite increases in the number of inpatient days and ambulatory visits as shown in Figures 6.7 and 6.8. For more details, please reference Table A.2 in the appendices.

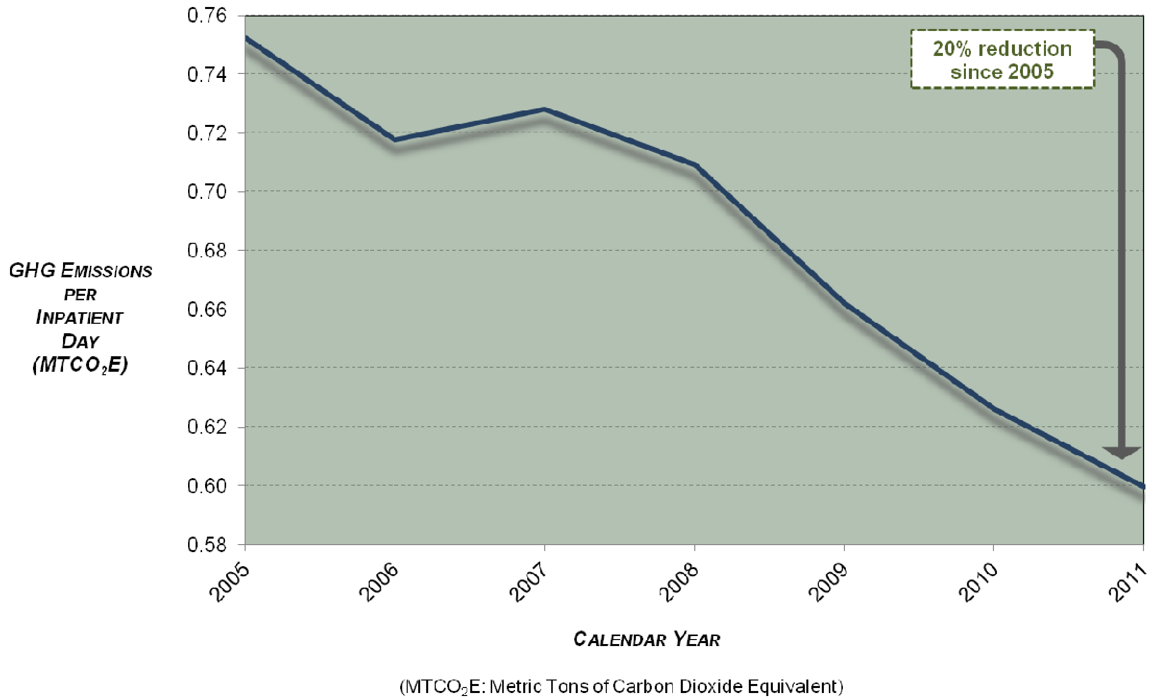


Figure 6.7. Vanderbilt Patient Care Area GHG Emissions Per Inpatient Day, Calendar Years 2005-2011.

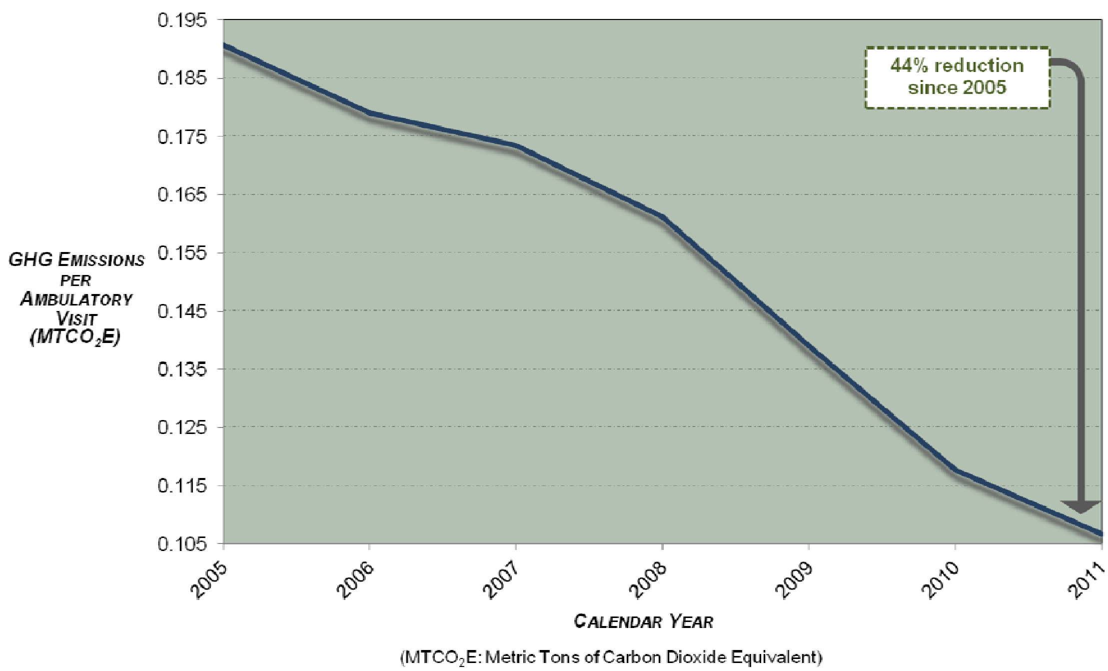


Figure 6.8. Vanderbilt Patient Care Area GHG Emissions Per Ambulatory Visit, Calendar Years 2005-2011.

This seven-year analysis illustrates that Vanderbilt University's GHG emissions are trending in the right direction, both overall and when normalized by all important institutional metrics. Despite 2011 being named one of the hottest years on record and having the most extreme weather events ever recorded, GHG emissions continued to decrease. Between 2005 and 2011, Vanderbilt University's GHG emissions have decreased by 20.8 percent on a per gross square foot basis, by 19 percent on a per person basis and by 28 percent per million research dollar awarded to VU. Considering that Vanderbilt's on-campus square footage has increased by over 15 percent, total population has increased by 13 percent and millions of research dollars awarded has increased by 22.5 percent since 2005, it is clear that VU Plant Operations, VUMC Plant Services, Campus Planning and Construction and VUMC Space and Facilities Planning are significantly improving the energy efficiency of Vanderbilt's buildings in the midst of continued growth.

Interpreting Vanderbilt's Results Compared to Other Universities

There are over 2,800 colleges and universities offering Bachelor's and Advanced degrees in the United States[44]. Only a small portion of these universities have completed GHG inventory reports and made them publicly available. Thus, Vanderbilt has acted proactively by taking this step forward. Additionally, most university GHG inventory reports do not include research and/or patient care activity, making Vanderbilt's report more comprehensive than most.

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

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

- 89 percent of Vanderbilt undergraduate students live in on-campus residence houses, which are supplied with centralized utilities such as chilled water, heat, electricity, and air conditioning. Colleges and universities with larger commuter populations and/or off-campus housing would have potentially smaller Scope 1 emissions and larger Scope 3 emissions.
- Vanderbilt was awarded $587 million[45] in 2011 to conduct scientific and medical research, with a majority of the research occurring in laboratories. Vanderbilt University has over 800 research laboratories which are large consumers of energy through the operation of lab equipment such as fume hoods, biosafety cabinets, computers, and autoclaves (four to five times that of the same size office or classroom[46]).

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[44] Information obtained from the Department of Education's National Center for Education Statistics IPEDS Data Center at http://nces.ed.gov/ipeds/datacenter/Default.aspx on July 28, 2011. Search included public and private 4-year schools awarding Bachelor's and Advanced degrees. Search excluded 2-year schools awarding Certificate and Associate's degrees. Including the latter, there are over 7,100.

[45] According to data found in ReVU: Quick Facts about Vanderbilt. Accessed December 2011. Available at http://www.vanderbilt.edu/facts.html.

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

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

As discussed above, the most common methods for successfully reporting GHG emissions is to analyze GHG emissions based on institutional metrics (GSF, full-time student enrollment, total campus population, research awards, inpatient days, and ambulatory visits). Because efforts to draw comparisons are inevitable, we attempted to determine how Vanderbilt's calendar year 2011 GHG emissions compared from the limited number of colleges and universities having such data available (as listed in Table 6.2); these universities were selected based upon one or more of the following measures:

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

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

University	Total Emissions ($MTCO_2E$)	Emissions per 1,000 Square Feet	Emissions per Student	Emissions per Person on Campus	Emissions per $1,000 Research Awarded
University of Michigan[47]	720,000	18.46	12.01	9.0	0.58
Duke University – Campus Only[48]	301,758	26.55	20.79	8.55	0.49
Washington University – St. Louis[49]	409,500	28.0	29.10	24.2	0.58
Emory University[50]	305,819	33.98	22.01	11.56	0.57
University of Pennsylvania[51]	294,210	22.32	11.85	6.54	0.29
Vanderbilt University – Academic & Research Areas Only[52]	272,229	29.39	21.43	11.72	0.46

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

As previously mentioned, conducting research and operating laboratory facilities require large amounts of energy. Schools receiving substantial amounts of research awards (like Vanderbilt) use those dollars to operate laboratories and advanced technology to make scientific discoveries that benefit humankind. These activities can increase GHG emissions on a per-person basis and a per-square-foot basis because of energy-intensive, research activities. When compared to other major research institutions, Vanderbilt's GHG emissions compare quite well, with the lowest overall emissions and one of the lowest emissions per student and per research dollars awarded. Figures 6.9 and 6.10 illustrate Vanderbilt's GHG emissions and GHG emissions per $1,000 in research awarded in relation to several other research entities.

[47] GHG emissions, GSF, and student, faculty, and staff populations for FY 2011 retrieved from 2011 Annual Sustainability Report, http://vpcomm.umich.edu/forum/michigan.php#a2campus, GSF, and student, faculty and staff populations for FY 2011 retrieved from 2011 U-M Facts and Figures, http://vpcomm.umich.edu/forum/michigan.php#a2campus.

[48] GHG emissions, GSF, and student, faculty, and staff populations for 2011 as reported to ACUPCC, http://rs.acupcc.org/ghg/2044/. 2011 research dollars retrieved from Financial Statements 2010/2011, https://finance.duke.edu/resources/docs/financial_reports.pdf.

[49] GHG emissions, GHG emissions per 1,000 GSF, and GHG emissions per person for FY 2009 retrieved from http://www.wustl.edu/initiatives/sustain/assets/GHGEmissions.pdf. Student enrollment for Fall 2011 retrieved from http://www.wustl.edu/about/facts/students/index.html. Research awards for 2011 retrieved from http://www.wustl.edu/about/facts/assets/pdf/FastFacts2011.pdf.

[50] Emissions data for 2010 from http://sustainability.emory.edu/html/dashboard/other-ghg-sources.html. University faculty, staff, and student population and 2011 research dollars from 2011 Academic Profile, http://www.oirpe.emory.edu/institutional_research/academicpercent20profilepercent2020112012percent20. GSF for FY 2007 retrieved from http://sustainability.emory.edu/uploads/articles/2010/10/2010100513595029/GHG_Executive_Summary.pdf. GSF from FY 2007 was used because GSF from FY 2011 could not be located.

[51] GHG emissions, GSF, and student, faculty, and staff populations for 2011 from ACUPCC's website at http://rs.acupcc.org/ghg/2087/. Sponsored projects for 2011 retrieved from http://www.archives.upenn.edu/primdocs/uph/uph4_5/2010fin_report.pdf.

[52] GHG emissions for CY 2011 from academic and research areas only. 2011 research dollars awarded.

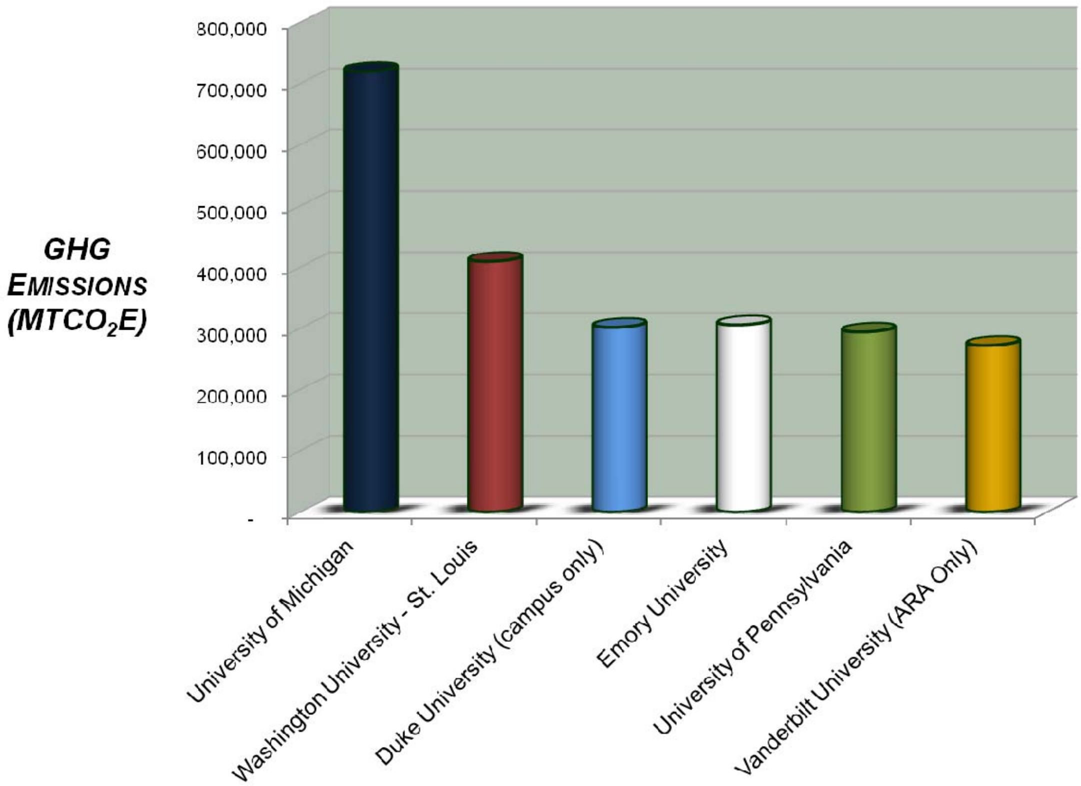

Figure 6.9. Comparison of Vanderbilt University GHG Emissions with Other Universities.

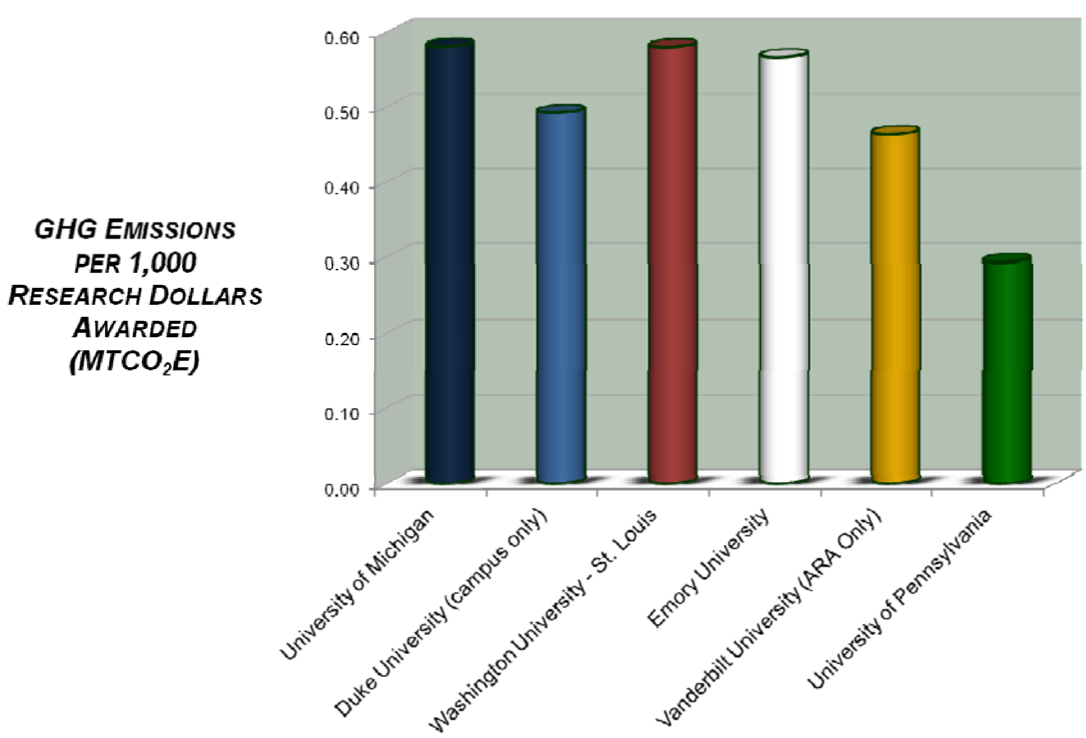

Figure 6.10. Comparison of Vanderbilt University GHG Emissions with Other Universities, by Research Dollars Awarded.

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

Future Plans

This inventory, as well as previous ones, provides historical data and trending information that has enabled campus stakeholders to have sufficiently detailed information to make informed decisions to determine reduction strategies and compare future improvements in GHG emissions on campus. As the positive downward trend in all areas of GHG emissions indicates, VU is substantially investing in improving its carbon footprint. To monitor this positive progress, subsequent annual calculations of emissions will be conducted in the future, 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[53]. 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. The most cost-effective and environmentally-friendly way to reduce our use of nonrenewable energy sources is to first reduce our demand for energy. The kilowatt not needed is the most environmentally-friendly kilowatt of all. It will take the entire Vanderbilt community working together to reduce Vanderbilt's reliance on nonrenewable energy sources.

The SustainVU web site also has information on Vanderbilt's green building program, efforts to improve energy and water efficiency in existing buildings, commuter choice programs, waste and recycling initiatives, and academic research related to GHG emissions, all of which contribute to reductions in institutional emissions. All information related to Vanderbilt's GHG emissions reports and future updates and commitment statement will be publicly available on this site.

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

VII. APPENDIX A: 2005-2011 Trending Data and Calculations

Calendar Year	GHG Emissions from Academic & Research Areas ($MTCO_2E$)	Gross Square Feet (GSF) - Academic & Research Areas	GHG Emissions per 1,000 GSF	Number of Students	GHG Emissions Per Student	Millions of Research dollars Awarded[54]	GHG Emissions per $1,000 Research Awarded
2005	296,465	8,228,419	36.0	11,294	26.2	$455	0.65
2006	295,825	8,416,644	35.1	11,481	25.8	$468	0.63
2007	308,604	9,039,821	34.1	11,607	26.6	$495	0.62
2008	313,341	9,165,093	34.2	11,847	26.4	$521	0.60
2009	288,343	9,208,635	31.3	12,093	23.8	$520	0.55
2010	284,506	9,257,242	30.7	12,506	22.7	$615	0.46
2011	272,229	9,263,363	29.4	12,704	21.4	$587	0.46

Table A.1. GHG Normalization Metrics for Academic & Research Areas, Calendar Years 2005-2011.

Calendar Year	GHG Emissions from Patient Care Areas	GSF – Patient Care Areas	GHG Emissions per 1,000 GSF	Inpatient Days[55]	GHG Emissions per Inpatient Days	Ambulatory Visits[55]	GHG Emissions per Ambulatory Visits
2005	179,260	4,957,823	36.2	238,266	0.75	940,018	0.191
2006	182,548	4,972,220	36.7	254,396	0.72	1,019,715	0.179
2007	189,958	5,124,754	37.1	260,977	0.73	1,095,559	0.173
2008	189,985	5,243,043	36.2	267,947	0.71	1,178,841	0.161
2009	175,896	6,192,303	28.4	265,733	0.66	1,266,255	0.139
2010	170,754	6,183,728	27.6	272,731	0.63	1,450,196	0.118
2011	169,389	6,183,728	27.4	282,547	0.60	1,586,395	0.107

Table A.2. GHG Normalization Metrics for Patient Care Areas, Calendar Years 2005-2011.

Calendar Year	Total GHG Emissions	Total GSF	GHG Emissions per 1,000 GSF	Total VU Population	GHG Emissions per Person
2005	475,725	13,186,242	36.08	29,237	16.3
2006	478,374	13,388,864	35.73	31,189	15.3
2007	498,562	14,164,575	35.20	32,712	15.2
2008	503,327	14,408,136	34.93	31,805	15.8
2009	464,240	15,400,938	30.14	32,308	14.4
2010	455,261	15,440,970	29.48	32,487	14.0
2011	441,618	15,447,090	28.59	33,591	13.1

Table A.3. GHG Normalization Metrics for Vanderbilt University, Calendar Years 2005-2011.

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54 According to 2005-2011 research information found in ReVU: Quick Facts about Vanderbilt. Each year, the previous year's data is replaced with data from the most current year. Email SustainVU@vanderbilt.edu for more information.
55 VU Financial Report 2011, http://financialreport.vanderbilt.edu/.

Calendar Year	Students[56]	Faculty[57]	Academic & Research Staff[58]	Academic & Research Population (students + faculty + staff)	Patient Care Staff[59]	Total On-Campus Population
2005	11,294	2,861	6,542	20,697	8,540	29,237
2006	11,481	3,004	7,097	21,582	9,607	31,189
2007	11,607	3,222	7,627	22,456	10,256	32,712
2008	11,847	3,358	7,073	22,278	9,527	31,805
2009	12,093	3,526	7,102	22,721	9,587	32,308
2010	12,506	3,733	6,667	22,906	9,581	32,487
2011	12,704	3,844	6,676	23,224	10,367	33,591

Table. A.4. Population Data Used for Normalization Metrics, Calendar Years 2005-2011.

Calendar Year	Academic GSF	Patient Care GSF	Total GSF
2005	8,228,419	4,957,823	13,186,242
2006	8,416,644	4,972,220	13,388,864
2007	9,039,821	5,124,754	14,164,575
2008	9,165,093	5,243,043	14,408,136
2009	9,208,635	6,192,303	15,400,938
2010	9,257,242	6,183,728	15,440,970
2011	9,263,363	6,183,728	15,447,090

Table A.5. GSF Data Used for Normalization Metrics, Calendar Years 2005-2011.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Sources ($MTCO_2E$)
2005	96,478	51,695	4,988	153,161
2006	99,582	38,485	8,155	146,222
2007	111,344	48,258	6,268	165,869
2008	102,172	51,358	13,017	166,547
2009	105,956	64,096	8,705	178,758
2010	92,090	62,835	4,738	159,663
2011	87,022	58,405	5,651	151,078

Table A.6. Total VU GHG Emissions from EPA-Required Sources, Calendar Years 2005-2011.

56 VU Financial Report 2011, http://financialreport.vanderbilt.edu/.
57 VU Financial Report 2011, http://financialreport.vanderbilt.edu/.
58 Calculated using data from VU Human Resources (employees by Building, Academic and Research Staff).
59 Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Calendar Year	Academic and Research Areas (65percent of total EPA-required sources emissions) ($MTCO_2E$)	Patient Care Areas (35percent of total EPA-required sources emissions) ($MTCO_2E$)	Total VU GHG Emissions from EPA-Required Sources ($MTCO_2E$)
2005	99,554	53,606	153,161
2006	95,045	51,178	146,222
2007	107,815	58,054	165,869
2008	108,255	58,291	166,547
2009	116,192	62,565	178,758
2010	103,781	55,882	159,663
2011	98,201	52,877	151,078

Table A.7. Allocation of GHG Emissions from EPA-Required Sources to Academic and Research Areas and Patient Care Areas, Calendar Years 2005-2011.

Calendar Year	Fleet Vehicles ($MTCO_2E$)	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Anesthetic Gas Use[60] $MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	1,609	550	286	1	2,446
2006	1,968	541	338	1	2,848
2007	1,870	830	137	1	2,838
2008	2,159	282	143	14	2,598
2009	2,013	394	35	14	2,455
2010	1,935	119	1,019	19	3,091
2011	2,210	110	41	18	2,379

Table A.8. Academic and Research Area Scope 1 Emissions from Other Sources, Calendar Years 2005-2011.

Calendar Year	Fleet Vehicles (Life Flight) ($MTCO_2E$)	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Anesthetic Gas Use[61] ($MTCO_2E$)	GHG Emissions from Other Direct Emission Sources ($MTCO_2E$)
2005	2,206	296	189	3,174	5,864
2006	2,012	291	397	3,174	5,873
2007	1,880	447	131	3,174	5,632
2008	1,877	152	0	4,789	6,817
2009	1,608	212	0	3,896	5,716
2010	1,531	438	609	2,449	5,026
2011	1,643	315	98	3,360	5,416

Table A.9. Patient Care Area Scope 1 Emissions from Other Sources, Calendar Years 2005-2011.

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

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65percent of total scope 2 emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35percent of total scope 2 emissions) ($MTCO_2E$)
2005	294,070,522	223,343	145,173	78,170
2006	294,494,256	223,664	145,382	78,283
2007	287,734,887	218,531	142,045	76,486
2008	307,162,163	229,640	149,266	80,374
2009	305,308,699	180,553	117,359	63,193
2010	303,543,739	183,857	119,507	64,350
2011	313,049,916	181,657	118,077	63,580

Table A.10. GHG Emissions from Purchased Electricity, Calendar Years 2005-2011[62].

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Air Travel Emissions[63] ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions: Academic & Research Areas ($MTCO_2E$)
2005	1,022	5,259	43,010	49,291
2006	1,116	5,259	46,175	52,550
2007	1,150	5,259	49,496	55,905
2008	1,360	5,386	46,476	53,222
2009	1,205	6,944	44,186	52,335
2010	1,761	9,719	46,646	58,127
2011	1,651	8,993	42,928	53,573

Table A.11. Scope 3 Emissions from Academic and Research Areas, Calendar Years 2005-2011.

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Total Scope 3 GHG Emissions: Patient Care Areas ($MTCO_2E$)
2005	1,585	40,035	41,620
2006	2,177	45,037	47,215
2007	1,706	48,079	49,786
2008	1,614	42,889	44,503
2009	1,653	42,767	44,420
2010	1,861	43,636	45,496
2011	1,991	45,525	47,516

Table A.12. Scope 3 Emissions from Patient Care Areas, Calendar Years 2005-2011.

[62] TVA's published fuel mix for electrical generation for 2005 through 2008 is as follows: coal (64percent), nuclear (29percent), and hydroelectric dams (7percent). TVA's published fuel mix for 2009 electrical generation is as follows: coal (47percent), nuclear (34percent), hydroelectric dams (7percent), natural gas (6percent), and renewable (6percent). TVA's published fuel mix for 2010 electrical generation is as follows: coal (51percent), nuclear (36percent), hydroelectric dams (9percent), natural gas (4percent), and renewable (<1percent). TVA's published fuel mix for 2011 electrical generation is as follows: coal (52percent), nuclear (34percent), hydroelectric dams (9percent), natural gas (5percent), and renewable (<1percent).

[63] Air travel for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.

University	Total Emissions ($MTCO_2E$)	GSF	Number of Students	Campus Population	Millions of Research Dollars Awarded
University of Michigan[64]	720,000	39,000,000	59,933	80,000	$1,240
Duke University[65]	301,758	11,365,660	14,516	35,281	$613
Washington University – St. Louis[66]	409,500	Not reported	14,070	Not reported	$706
Emory University[67]	305,819	9,000,000	13,893	26,456	$539.7
University of Pennsylvania[68]	294,210	13,181,289	24,832	44,985	$1,003
Vanderbilt University – Academic & Research Areas Only[69]	272,229	9,263,363	12,704	23,224	$587

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

[64] GHG emissions, GSF, and student, faculty, and staff populations for FY 2011 retrieved from 2011 Annual Sustainability Report, http://vpcomm.umich.edu/forum/michigan.php#a2campus, GSF, and student, faculty and staff populations for FY 2011 retreived from 2011 U-M Facts and Figures, http://vpcomm.umich.edu/forum/michigan.php#a2campus.

[65] GHG emissions, GSF, and student, faculty, and staff populations for 2011 as reported to ACUPCC, http://rs.acupcc.org/ghg/2044/. 2011 research dollars retrieved from Financial Statements 2010/2011, https://finance.duke.edu/resources/docs/financial_reports.pdf.

[66] GHG emissions, GHG emissions per 1,000 GSF, and GHG emissions per person for FY 2009 retrieved from http://www.wustl.edu/initiatives/sustain/assets/GHGEmissions.pdf. Student enrollment for Fall 2011 retrieved from http://www.wustl.edu/about/facts/students/index.html. Research awards for 2011 retrieved from http://www.wustl.edu/about/facts/assets/pdf/FastFacts2011.pdf.

[67] Emissions data for 2010 from http://sustainability.emory.edu/html/dashboard/other-ghg-sources.html. University faculty, staff, and student population and 2011 research dollars from 2011 Academic Profile, http://www.oirpe.emory.edu/institutional_research/academicpercent20profilepercent2020112012percent20. GSF for FY 2007 retrieved from http://sustainability.emory.edu/uploads/articles/2010/10/2010100513595029/GHG_Executive_Summary.pdf. GSF from FY 2007 was used because GSF from FY 2011 could not be located.

[68] GHG emissions, GSF, and student, faculty, and staff populations for 2011 from ACUPCC's website at http://rs.acupcc.org/ghg/2087/. Sponsored projects for 2011 retrieved from http://www.archives.upenn.edu/primdocs/uph/uph4_5/2010fin_report.pdf.

[69] GHG emissions for CY 2011 from academic and research areas only. 2011 research dollars awarded.

VI. APPENDIX B: 2011 Calendar Year Data and Calculations

Source	Academic & Research Areas ($MTCO_2E$)	Patient Care Areas ($MTCO_2E$)	Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$)
EPA-Required Sources			
Coal use at VU Power Plant	56,564	30,458	87,022
Natural Gas use at VU Power Plant	37,964	20,442	58,405
Natural Gas use in Individual Buildings	3,673	1,978	5,651
Subtotal of EPA-Required Emissions:	98,201	52,878	151,078
Other Scope 1 Emissions Sources			
Diesel-Powered Generators	110	315	425
Refrigerant Releases	41	98	139
Fleet Vehicles	2,210	1,643	3,853
Anesthetic Gas Use	18	3,360	3,378
Subtotal of Other Scope 1 Emissions:	2,379	5,416	7,795
Scope 2 GHG Emissions: Electricity Purchases			
Electricity Purchased from NES	118,077	63,580	181,657
Scope 3 GHG Emissions: Indirect Sources			
Faculty & Staff Commuting	42,929	45,525	88,454
Air Travel	8,993	-	8,993
Waste Disposal	1,651	1,991	3,642
Subtotal of Scope 3 Emissions:	53,573	47,516	101,089
Total emissions associated with each area per year:	**272,229**	**169,389**	**441,618**

Table B.1. Total Vanderbilt GHG Emissions, Calendar Year 2011.

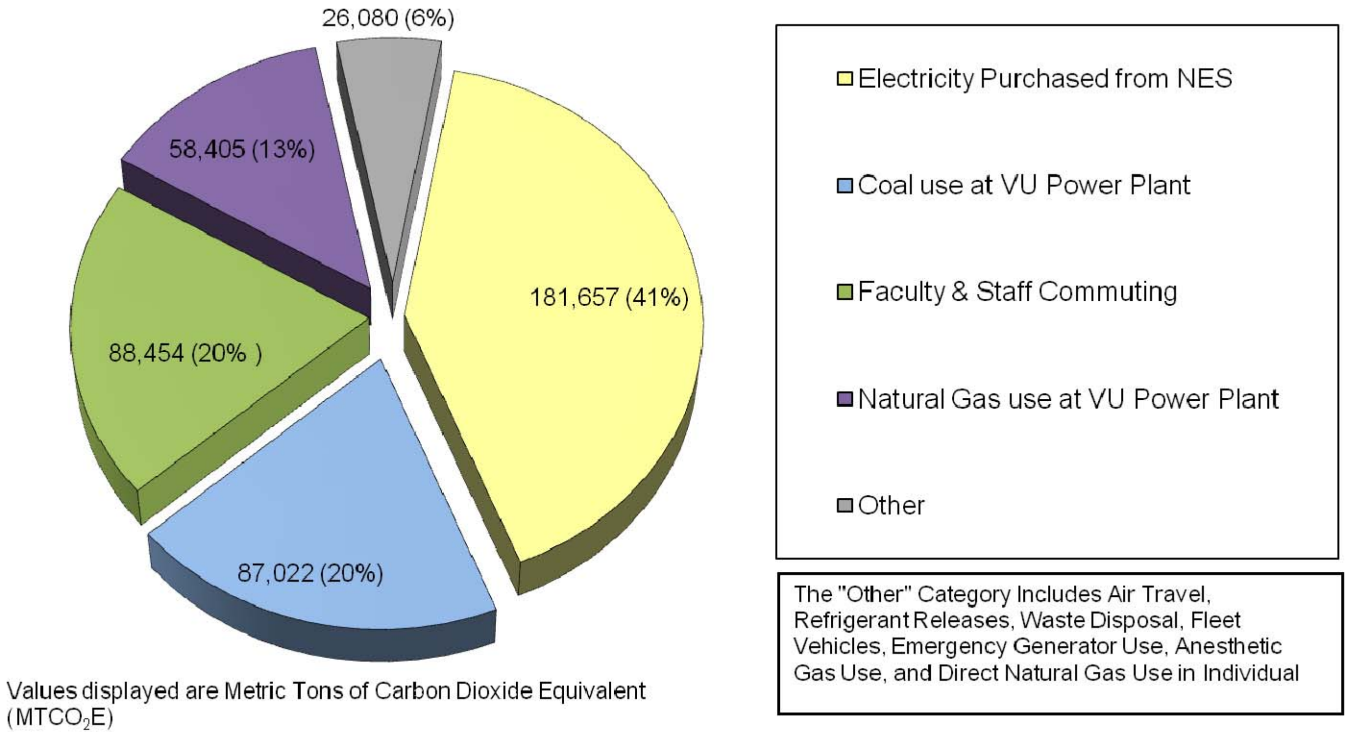

Figure B.1. Vanderbilt GHG Emissions Sources, Calendar Year 2011.

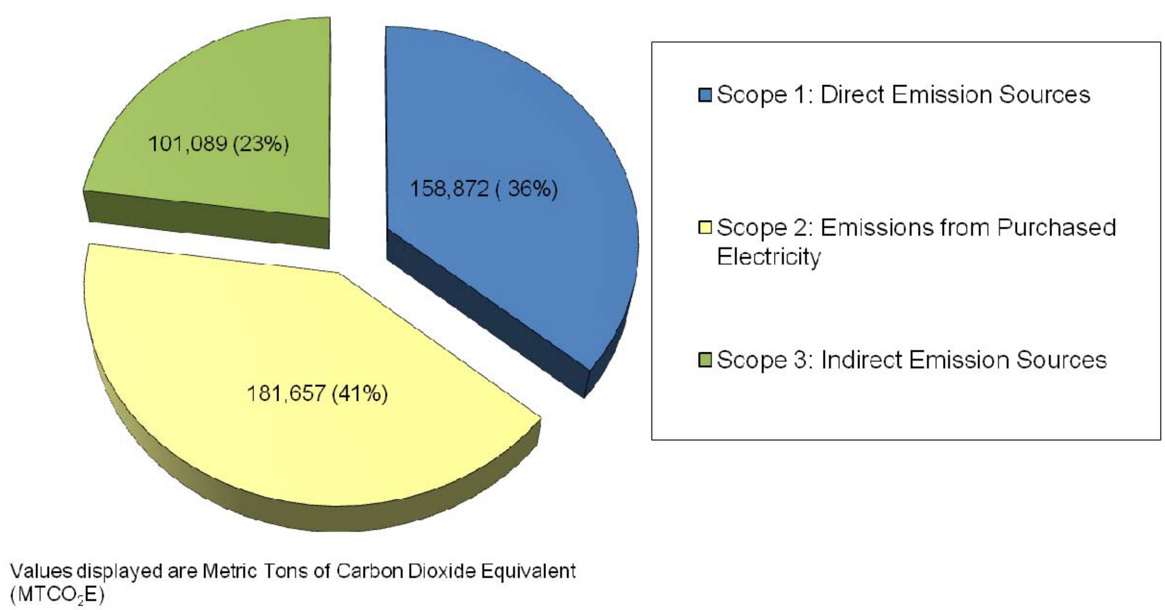

Figure B.2. Vanderbilt GHG Emissions Sources by Scope, Calendar Year 2011.

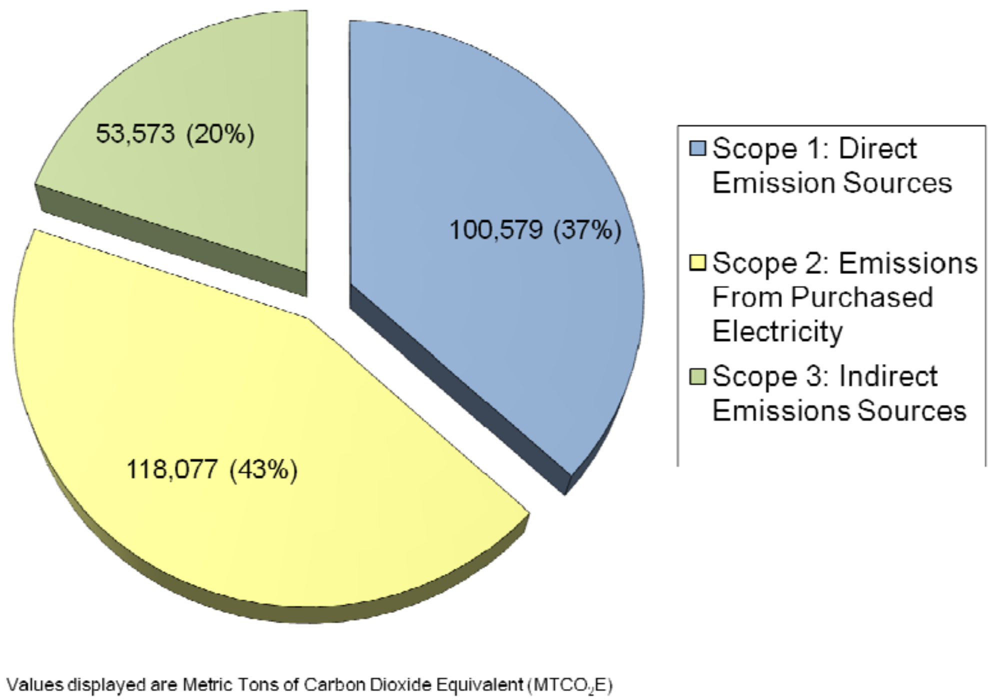

Figure B.3. Vanderbilt Academic and Research Area GHG Emissions Sources by Scope, Calendar Year 2011.

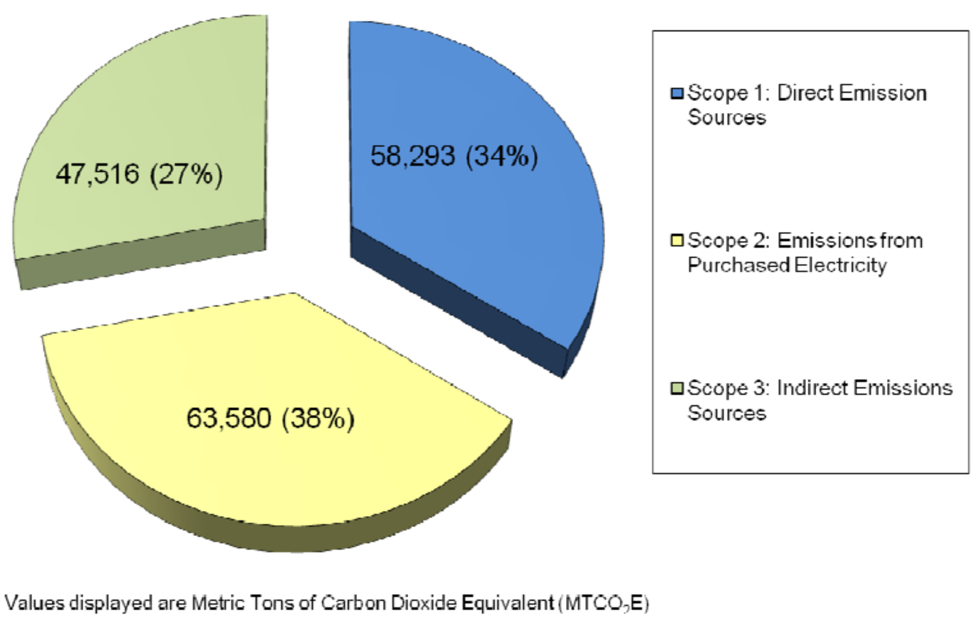

Figure B.4. Vanderbilt Patient Care Area GHG Emissions Sources by Scope, Calendar Year 2011.

GHG Emissions from On-Campus Coal Combustion at the Co-Generation Power Plant					
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (mmbtu/short ton) (Default EPA value)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA value)		CO_2 Emissions (Metric Tons)
51,611	0.001	17.25	97.02		86,376
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (mmbtu/short ton) (Default EPA value)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA value)	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
51,611	0.001	17.25	0.01	9	206
Coal *(short tons or English tons)*	Kilograms to metric ton conversion	High Heat Value (mmbtu/short ton) (Default EPA value)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA value)	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
51,611	0.001	17.25	0.0015	1	440
Total GHG Emissions from On-Campus Coal Combustion ($MTCO_2E$):					**87,022**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Coal Combustion (65percent of total emissions) ($MTCO_2E$):					**56,564**
Patient Care Area Emissions from On-Campus Coal Combustion (35percent of total emissions) ($MTCO_2E$):					**30,458**

Table B.2. Calculations for GHG Emissions from On-Campus Coal Combustion, Calendar Year 2011[70].

GHG Emissions from Natural Gas Combustion at the Co-Generation Power Plant					
Natural Gas (Therms)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA Value)	Convert Therms to MMBTU	Convert Kilograms to Metric Tons		CO_2 Emissions (Metric Tons)
11,004,940	53.02	0.1	0.001		58,348.19
Natural Gas (Therms)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA Value)	Convert Therms to MMBTU	Convert Kilograms to Metric Tons	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
11,004,940	0.001	0.1	0.001	1.1	22.11
Natural Gas (Therms)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA Value)	Convert Therms to MMBTU	Convert Kilograms to Metric Tons	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
11,004,940	0.0001	0.1	0.001	0.1	34.12
Total GHG Emissions from On-Campus Natural Gas Combustion ($MTCO_2E$):					**58,405**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Natural Gas Combustion (65percent of total emissions) ($MTCO_2E$):					**37,963**
Patient Care Area Emissions from On-Campus Natural Gas Combustion (35percent of total emissions) ($MTCO_2E$):					**20,442**

Table B.3. Calculations for GHG Emissions from On-Campus Natural Gas Combustion at the Co-Generation Power Plant, Calendar Year 2011[71].

[70] Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Coal Combustion: Coal (tons) * metric ton conversion * High Heat Value * Emission Factor = Tons of Emissions. Tons of Coal listed is the same amount reported in Vanderbilt's 2011 Annual Air Emissions Report.

[71] Greenhouse Gas Emissions Calculations and Values taken from the EPA's Mandatory Reporting of Greenhouse Gases; Final Rule [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (therms) * Emission Factor * MMBTU conversion * Metric Ton conversion = Tons of Emissions. Therms of natural gas listed are the same amount reported in Vanderbilt's Reporting of Greenhouse Gas Emissions to EPA. For the years 2005-2009, GHG calculations for natural gas consumption were based on cubic feet of natural gas * heat value, which is equivalent to therms.

GHG Emissions from Natural Gas Consumption in Individual Buildings					
Natural Gas (Therms)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA Value)	Convert Therms to MMBTU	Convert Kilograms to Metric Tons		CO_2 Emissions (Metric Tons)
1,064,699	53.02	0.1	0.001		5,645.03
Natural Gas (Therms)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA Value)	Convert Therms to MMBTU	Convert Kilograms to Metric Tons	CH_4 Emissions (Metric Tons)	CO_2e (Metric Tons of CH_4 * 21)
1,064,699	0.001	0.1	0.001	0.10647	2.24
Natural Gas (Therms)	Emission Factor ($kgCO_2$/mmbtu) (Default EPA Value)	Convert Therms to MMBTU	Convert Kilograms to Metric Tons	N_2O Emissions (Metric Tons)	CO_2e (Metric Tons of N_2O * 310)
1,064,699	0.0001	0.1	0.001	0.0106	3.3
Total GHG Emissions from Natural Gas Consumption in Buildings ($MTCO_2E$):					**5,651**
Partitioning of Emissions					
Academic & Research Area Emissions from Natural Gas Consumption in Buildings (65percent of total emissions) ($MTCO_2E$):					**3,673**
Patient Care Area Emissions from Natural Gas Consumption in Buildings (35percent of total emissions) ($MTCO_2E$):					**1,978**

Table B.4. Calculations for GHG Emissions from On-Campus Natural Gas Consumption in Individual Buildings, Calendar Year 2011[72].

Fleet Component	**Volume Consumed (gallons)**	**Emission Factor**	**Emissions from Fleet Component ($MTCO_2E$)**
Direct sale of gasoline to fleet vehicles through Plant Operations	53,502	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	478
Gasoline purchases by VU PD and Vandy Vans	36,993	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	330
Estimate of gasoline purchases by remaining fleet vehicles (221)[73]	36,900	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	348
Gasoline use by VUMC Shuttle Buses and Vans	82,870	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	740
Diesel Fuel use by VUMC Shuttle Buses and Vans	27,951	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	283
Diesel Fuel use by Plant Operations	2,949	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	30
GHG Emissions from Academic & Research Fleet Vehicles ($MTCO_2E$):			2,210

Table B.5. GHG Emissions from Academic and Research Area Fleet Vehicles, Calendar Year 2011.

[72] Greenhouse Gas Emissions Calculations and Values taken from the EPA's *Mandatory Reporting of Greenhouse Gases; Final Rule* [40 CFR Part 98, Subpart C]. EPA Formula for Calculating Greenhouse Gas Emissions from Natural Gas Combustion: Natural Gas (therms) * Emission Factor * MMBTU conversion * Metric Ton conversion = Tons of Emissions. Therms of Natural Gas listed is the same amount reported in Vanderbilt's Reporting of Greenhouse Gas Emissions to EPA. . For the years 2005-2009, GHG calculations for natural gas consumption were based on cubic feet of natural gas * heat value, which is equivalent to therms.

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

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by Life Flight:	171,729	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	1,643

Table B.6. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2011.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Isoflurane use by Animal Care	50.7	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	18

Table B.7. Academic and Research Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2011[74].

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	4,540	1 kilogram of Nitrous Oxide = 0.310 $MTCO_2E$	1,407
Isoflurane	337	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	118
Desflurane	1,193	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1,180
Sevoflurane	1,899	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	655
Total for Anesthesiology/Patient Care Areas			3,360

Table B.8. Patient Care Area GHG Emissions from Anesthetic Gas Use, Calendar Year 2011[75].

Source	Volume Consumed (gallons)	Emission Factor	$MTCO_2E$
Diesel fuel consumed by emergency generators – Academic Areas	10,858	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	110
Diesel fuel consumed by emergency generators – Patient Care Areas	31,019	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	315

Table B.9. GHG Emissions from Emergency Generators, Calendar Year 2011.

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

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

Source	Volume Released (kilograms)	Emission Factor	$MTCO_2E$
Refrigerant Releases - Academic Areas	31	1 kilogram of refrigerant = 1.3 $MTCO_2E$	41
Refrigerant Releases - Patient Care Areas	75	1 kilogram of refrigerant = 1.3 $MTCO_2E$	98

Table B.10. GHG Emissions from Refrigerant Releases, Calendar Year 2011[76].

Kilowatt-Hours Purchased (KwH)	Emission Factor per 1,000 KwH ($MTCO_2E$)	Total Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65percent of total emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35percent of total emissions) ($MTCO_2E$)
313,049,916	0.605701	181,657	118,077	63,580

Table B.11. GHG Emissions from Electricity Purchases, Calendar Year 2011[77].

Year	Coal	Nuclear	Hydroelectric Dams	Natural Gas	Renewables
2005	64%	29%	7%	-	-
2006	64%	29%	7%	-	-
2007	64%	29%	7%	-	-
2008	64%	29%	7%	-	-
2009	47%	34%	7%	6%	6%
2010	51%	36%	9%	4%	<1%
2011	52%	34%	9%	5%	<1%

Table B.12. TVA's published fuel mix for electrical generation for Calendar Years 2005 through 2011.

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

[77] Emission Factor based on TVA's published fuel mix for electrical generation: Coal (52 percent), Nuclear (34 percent), Hydroelectric Dams (9 percent), Natural Gas (5 percent), and Renewables (<1 percent).

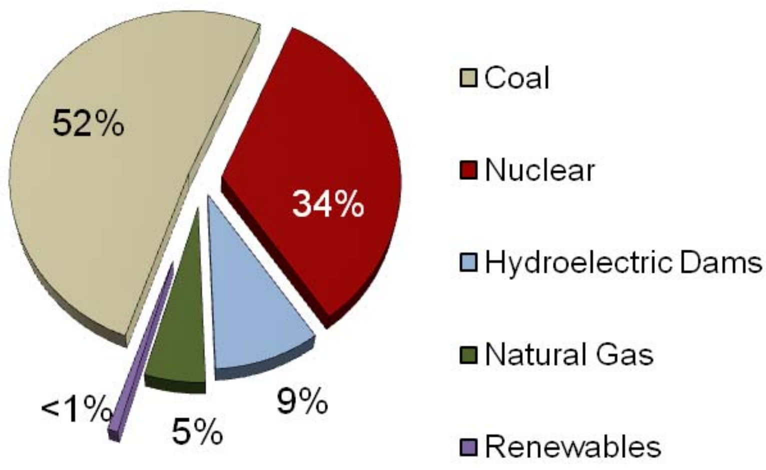

Figure B.5. TVA Fuel Mix, Calendar Year 2011.

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[78]
Faculty	87%	5%	7%	1%	200	48
Staff	87%	5%	7%	1%	250	48
Student	15%	5%	2%	78%	200	10

Table B.13. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas, Calendar Year 2011.

Faculty and Staff Commuter Miles for Academic & Research Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
151,627,970	4,734,869	61,407

Table B.14. Estimated Fuel Consumption for Academic and Research Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2011[79].

[78] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.
[79] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,734,869	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	42,306
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
61,407	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	623
GHG Emissions Associated with Commuter Travel: Academic & Research Areas ($MTCO_2E$)		**42,929**

Table B.15. Academic and Research Area GHG Emissions from Commuter Travel, Calendar Year 2011.

Air Passenger-Miles traveled in 2011[80]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
11,577,033	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	8,993

Table B.16. Academic and Research Area GHG Emissions from Air Travel, Calendar Year 2011.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	1,572	1 Ton of waste = 0.1745 $MTCO_2E$	274.2
Waste landfilled with landfill gas combusted to the atmosphere	4,473	1 Ton of waste = 0.3055 $MTCO_2E$	1,366.5
Incinerated Waste	47	1 Ton of waste = 0.22 $MTCO_2E$	10.4
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,651**

Table B.17. Academic and Research Area GHG Emissions from Waste Disposal, Calendar Year 2011[81].

[80] Passenger-miles traveled provided by Caldwell Travel Group.
[81] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 26 percent of landfill gas from this landfill is used to generate electricity; the remaining 74 percent is "flared" to the atmosphere. Therefore, 26 percent 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.

Cohort	Population Size
Students[82]	12,704
Faculty Members[83]	3,844
University Central Staff[84]	3,968
Research & Administrative Staff in Medical Center[85]	2,708
Total Academic & Research Area Population	23,224
Total Patient Care Area Staff on campus [86]	10,367
Off-Site Patient Care Staff[87]	3,716

Table B.18. Population of Students, Faculty, and Staff, Calendar Year 2011.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	1,809	1 Ton of waste = 0.1745 $MTCO_2E$	316
Waste landfilled with landfill gas combusted to the atmosphere	5,149	1 Ton of waste = 0.3055 $MTCO_2E$	1,570
Incinerated Waste	97	1 Ton of waste = 0.22 $MTCO_2E$	21
Medical Waste Autoclaved Off-Site	342	1 Ton of waste = 0.243 $MTCO_2E$	83
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,991**

Table B.19. Patient Care Area GHG Emissions from Waste Disposal, Calendar Year 2011[88].

[82] VU Financial Report 2011, http://financialreport.vanderbilt.edu/.
[83] VU Financial Report 2011, http://financialreport.vanderbilt.edu/. Faculty member population includes faculty from the School of Medicine and School of Nursing.
[84] From *Quick Facts about Vanderbilt University, 2011*. Retrieved December 2011. Available at http://www.vanderbilt.edu/facts.html.
[85] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff). Research & Administrative Staff in the Medical Center includes on-campus medical center employees that do not have direct contact with patients.
[86] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[87] Determined using data from VU Human Resources (employees by Building). “Off-Site” employees include those that work at One Hundred Oaks, clinics in other counties, etc.
[88] Solid waste removed from Vanderbilt is disposed of at an Allied Waste landfill in Rutherford County, Tennessee. According to Allied Waste, 26 percent of landfill gas from this landfill is used to generate electricity; the remaining 74 percent is "flared" to the atmosphere. Therefore, 26 percent 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.

	Percent commuting in a single-occupancy vehicle	Percent commuting in a carpool/vanpool	Percent commuting via bus or train	Other Forms of Commuting (walk/bike)	Days per year commuting to campus	Average Commute Distance (via automobile)[89]
Staff	87%	5%	7%	1%	250	48

Table B.20. Assumptions for Staff Commuter Travel for Patient Care Areas, Calendar Year 2011.

Staff Commuter Miles for Patient Care Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
108,447,339	5,038,081	50,305

Table B.21. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2011[90].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
5,038,081	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	45,051
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
50,305	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	510
GHG Emissions Associated with Commuter Travel: Patient Care Areas ($MTCO_2E$)		**45,525**

Table B.22. Patient Care Area GHG Emissions from Commuter Travel, Calendar Year 2011.

[89] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.
[90] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 22 miles per gallon.