Between 2008 peak and 2015, Vanderbilt University's Greenhouse Gas emissions have decreased by:

27% Overall GHG Emissions

35% per 1,000 sq ft of building space

45% per $1,000 research dollars

33% per student

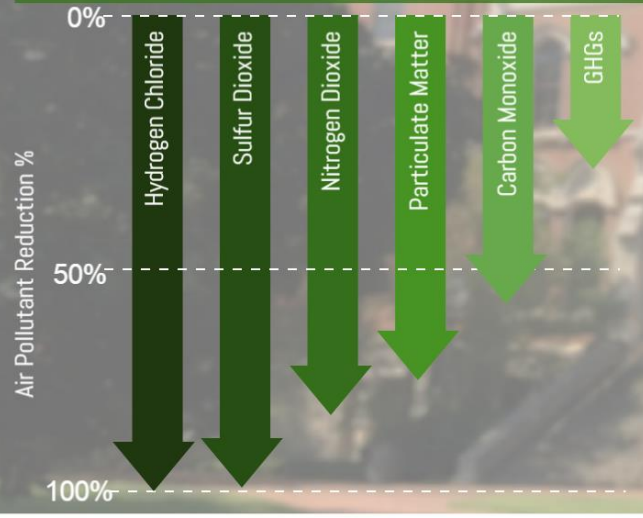
45% per inpatient day

32% per person

50% per ambulatory visit

Vanderbilt's power plant was converted to use 100% natural gas at the end of 2014, making 2015 the first full year that Vanderbilt operated without burning coal!

Reduction in Air Pollutants from the Power Plant Conversion



Vanderbilt added two new solar installations to campus!

40% reduction in natural gas use in the building with a solar hot water heating system

Vanderbilt University Inventory of Greenhouse Gas Emissions 2015

VANDERBILT.

SustainVU

Developed By

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This report is produced collaboratively by the VU Facilities organization and VU Division of Public Affairs.

Facilities

The VU Facilities organization includes the Sustainability and Environmental Management Office, Campus Planning and Construction, Plant Operations, and Real Estate all working collaboratively to build, maintain, manage and operate campus infrastructure in a sustainable and cost-efficient manner to support the overarching academic mission and goals of the university. The three organizations most involved in impacting VU's greenhouse gas emissions are as follows:

> **The Sustainability and Environmental Management Office (SEMO)** supports the Vanderbilt University community and facilities by identifying, inspiring, innovating, and quantifying environmental management and sustainability initiatives that positively impact the campus community, surrounding community, and the environment.
>
> **Plant Operations** provides facilities support for approximately 5.8 million square feet of academic, administrative and dormitory space to include routine maintenance and housekeeping services; grounds care for 330 acres that are a registered arboretum; turf care for athletic fields; and utilities for University Central and the Medical Center. The department has annual budget of approximately $89M and employees 409 employees.
>
> **Campus Planning and Construction (CPC)** supports the development of capital projects that meet the programmatic requirements of its customer base while visually expressing the quality to which Vanderbilt University aspires. Projects include academic, research, housing, athletics, administrative, site and major infrastructure with a focus on value, sustainability and quality of environments for users.

Vanderbilt University's award-winning **Division of Public Affairs** which includes **News and Communications** 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, 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.

Front page graphic created by Chelsea Hamilton.

Published October 31, 2016

VANDERBILT.

SustainVU

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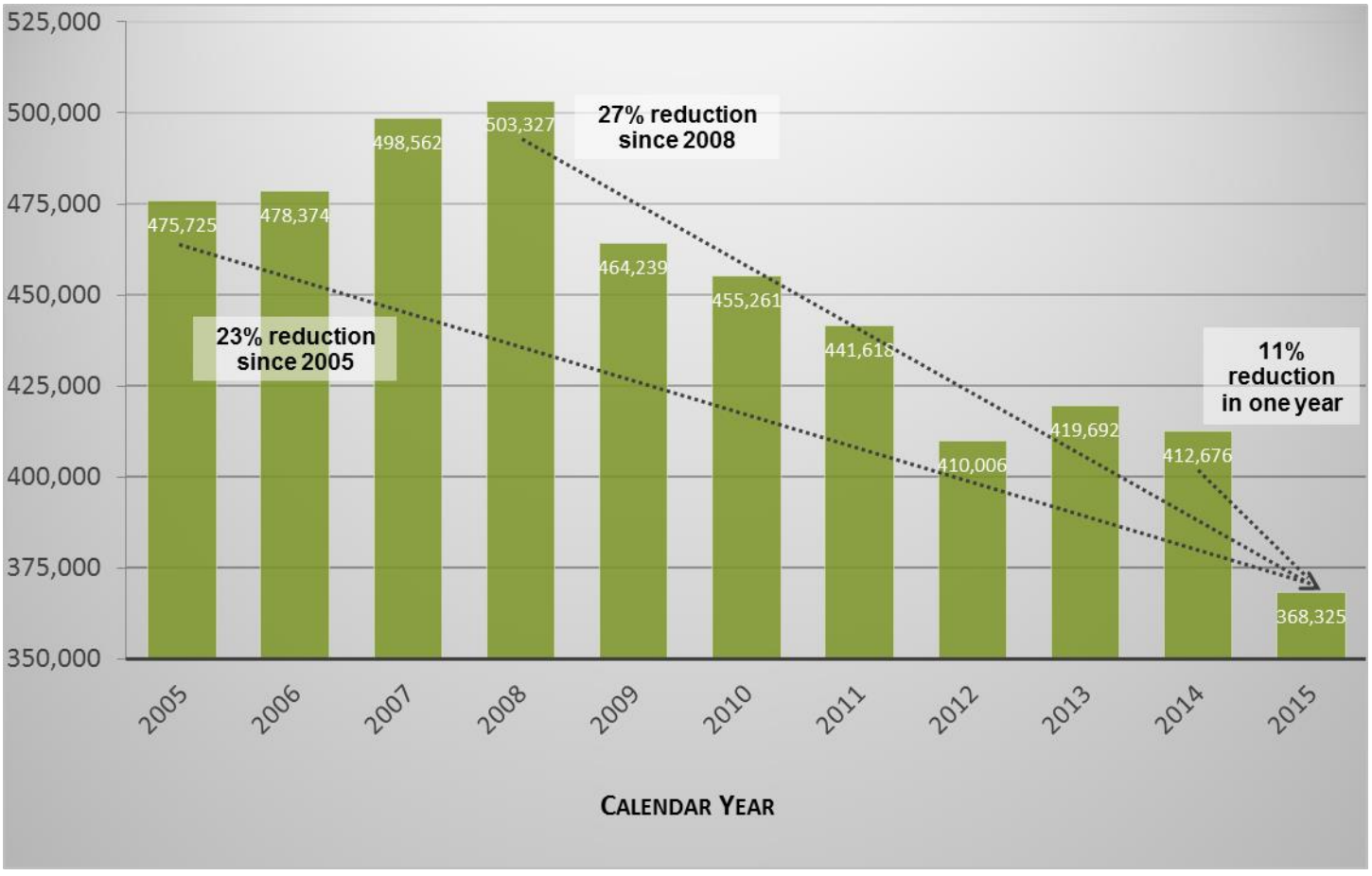
EXECUTIVE SUMMARY

This Greenhouse Gas (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 reductions from 2005-2015. This GHG inventory was developed by Vanderbilt's Sustainability and Environmental Management Office (SEMO).

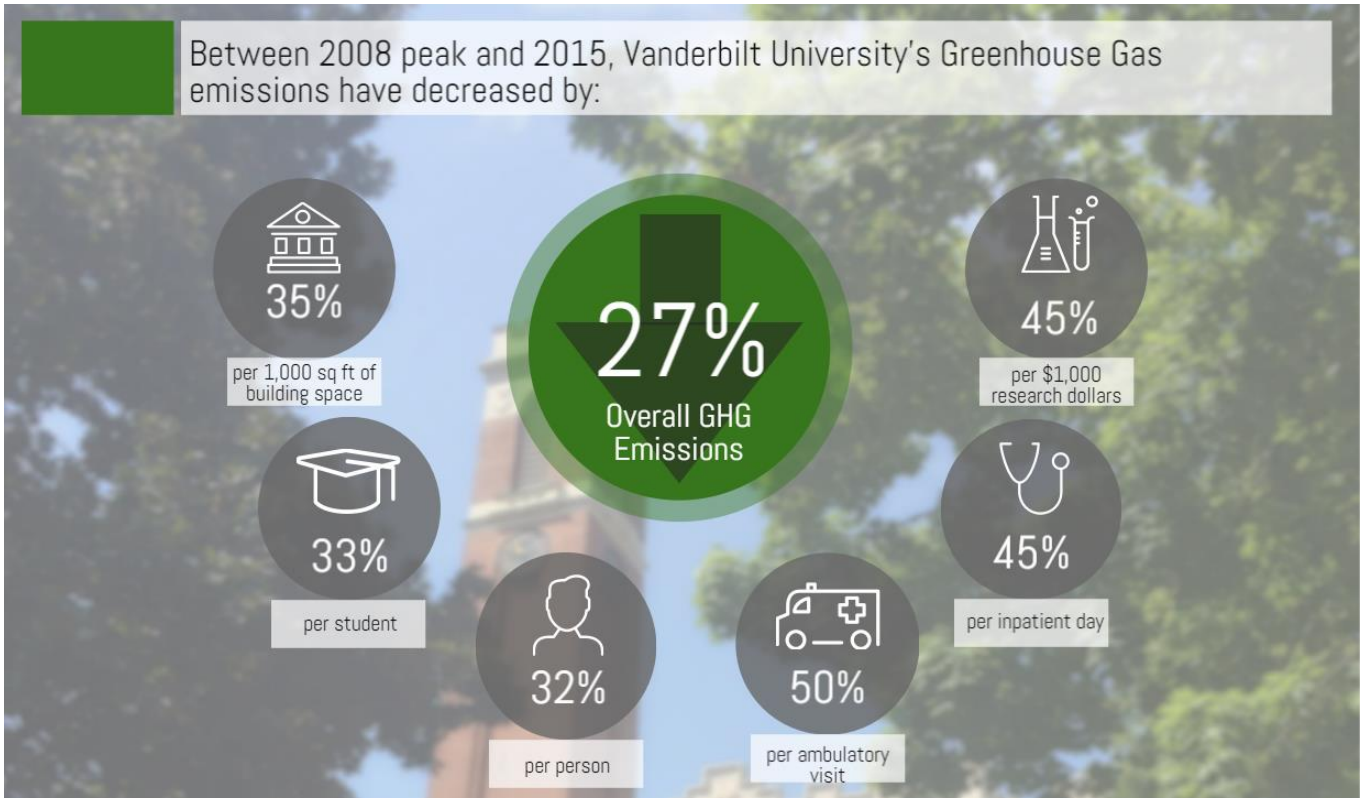
This report, a supplement to previous reports for 2005 to 2014[1], establishes Vanderbilt's GHG emissions for calendar year 2015 so that the Vanderbilt community can better understand its own unique impact on the environment and determine the most effective improvement strategies to implement in the future. Trending data for 2005 through 2015 is provided in Appendix B and discussed below.

Findings



Total Vanderbilt GHG Emissions, Calendar Years 2005-2015.

[1] Vanderbilt University's Inventory of Greenhouse Gas Emissions 2005-2014 is available at www.vanderbilt.edu/sustainvu.



Emission reductions in 2015:

- VU's total GHG emissions for calendar year 2015 were 368,325 Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$), down 27 percent from the 2008 peak, 23% since 2005, and 11% since last year[2].
- While VU achieved significant GHG reductions from the power plant, this was offset somewhat by small increases in the impacts of commuter travel, emergency generator fuel use, and anesthetic gas use in VUMC due to an increase in inpatient visits.
- Coal use at the Vanderbilt Power Plant was discontinued in November 2014. GHG emissions from the VU Power Plant dropped 26% from the coal-burning plant in 2013 to the post-conversion plant fueled by natural gas in 2015[3].
- With the conversion of the power plant completed in 2015, fewer kilowatt-hours were purchased from Tennessee Valley Authority (TVA) as compared to the 2014 calendar year.
- The portion of Vanderbilt University's Scope 1 GHG emissions required to be reported to the Environmental Protection Agency (EPA) for calendar year 2015 was 116,401 $MTCO_2E$.
- GHG emissions from Academic and Research Areas have decreased by 29 percent and from Patient Care Areas have decreased by 24 percent since 2008[4].
- Overall GHG emissions are down 27 percent from the all-time high reached in 2008, even though square footage has increased by 12 percent overall, or by almost two million square feet, since 2008[5].

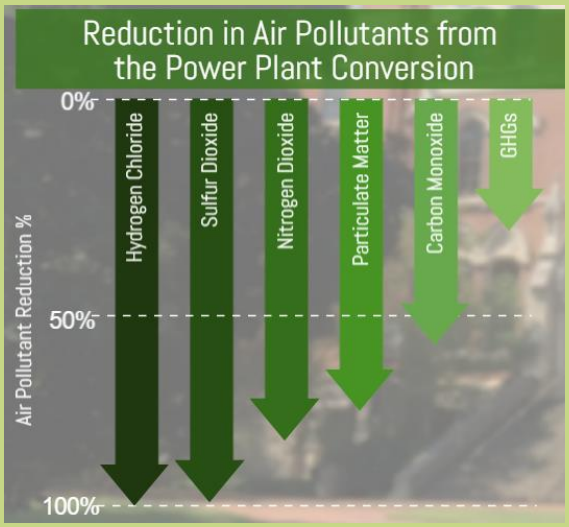
[2] Additional information about the University's total GHG emissions for 2005-2015 can be found in Table B.1 in the appendices.
[3] Additional information about the University's total GHG emissions for 2005-2015 can be found in Table B.1 in the appendices.
[4] Additional information about GHG emissions from Academic and Research Areas and Patient Care Areas can be found in Sections III and IV and Tables B.1, B.2 and B.3 in the appendices.
[5] Additional information about the University's total GHG emissions for 2005-2015 and Gross Square Footage can be found in Table B.3 in the appendices.

Vanderbilt Power Plant Became Coal Free in 2015

2015 was the first year that Vanderbilt University's co-generation power plant was fueled entirely by natural gas although it was still in commissioning mode. The conversion of the power plant began in 2013 and reached a major milestone on November 19, 2014 when the plant burned its last piece of coal!

The conversion of the plant has increased its operational efficiency while also contributing to significant environmental benefits. Greenhouse gas emissions from the power plant have decreased 26% from the coal burning 2013 plant to the post-conversion plant fueled by natural gas in 2015. Emissions of air pollutants have been reduced significantly as well; hydrogen chloride by 100%, sulfur dioxide by 99%, nitrogen dioxide by 83%, particulates by 74%, and carbon monoxide by 56%. Further gains in emission reductions are expected in future years.

The switch to natural gas has eliminated the delivery of 2,300 trucks of coal each year, 15 million pounds of coal ash waste produced by the plant, and the burning of 105 million pounds of coal each year. Other benefits include a reduction of noise pollution, and elimination of associated fuel use and emissions from trucking coal to the power plant[6].



Chancellor Zeppos at Coal Free Celebration, 2015

Future Plans

This inventory has provided campus stakeholders with a consistent means of comparing annual GHG emissions and sufficiently detailed information to make informed decisions to determine the reduction strategies for the past decade. Considerable progress has been made during this time.

Annual emissions inventories will continue to be conducted in the future to measure progress; however, the separation of VU and Vanderbilt University Medical Center (VUMC) into two legally separate entities necessitates a different approach and accounting of emissions. Thus, the annual emissions inventory will continue in the future but will significantly change structure and format and will continue to be made publicly available on the SustainVU website[7].

[6] More information regarding the VU Power Plant Conversion can be found at http://www.vanderbilt.edu/sustainvu/2013/04/vu-power-plant-faq/
[7] www.vanderbilt.edu/sustainvu

I. BACKGROUND

Vanderbilt University

Vanderbilt University, founded in 1873, is a private, non-profit, Carnegie R1 research higher education institution offering undergraduate, graduate and professional degrees to over 12,650 full and part-time students[8]. Comprised of 10 schools and a world-class medical center, Vanderbilt University is ranked as one of the country's top 15 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 3,700 full-time faculty and a staff of over 19,000[9]. The core campus, located near downtown Nashville, Tennessee, spans approximately 330 acres and contains 230 buildings[10]. More than 200 tree species exist on Vanderbilt's grounds, leading to the school's recognition as a national arboretum since 1988.

Photo provided by Robert Wheaton

Inventory Development

Vanderbilt emits Greenhouse Gases (GHG) through its daily operations, such as electricity and steam production at the on-campus co-generation power plant; electricity purchased from Nashville Electric Service (NES); University vehicle fuel use; refrigerant releases; anesthetic gas use; faculty and staff commuting to work; air travel paid for by the University; and disposal of waste generated by Vanderbilt. VU has issued previous reports for the years 2005 to 2014[11]. Trending data summaries for 2005 to 2015 are provided in Appendix B.

Vanderbilt University and Vanderbilt University Medical Center Become Independent Legal Entities

Vanderbilt University embarked on a new journey as an independent legal entity from Vanderbilt University Medical Center (VUMC) on May 1, 2016.

The separation of these two entities will have a significant impact on the way Vanderbilt University reports greenhouse gases in the future. Since 2005, Vanderbilt has reported GHG emissions as a joint entity consisting of Academic and Research Areas (ARA) and Patient Care Areas (PCA). Moving forward, only a portion of ARAs that represent Vanderbilt University post-separation will be reported.

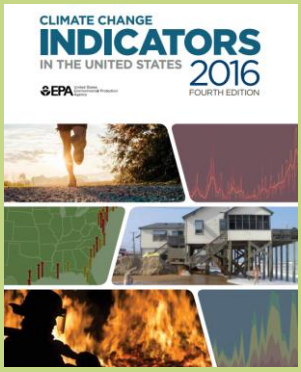
Beginning with the 2016 Inventory, the format and content will change significantly! The GHG Emissions Inventory has included trending data from 2005 to 2015. Because of the significant shift in GHG footprint due to the new organization of the two entities, future data and content will take a new form. This means that 2005-2015 data will be archived, and future data will become a second set of trending data. Future GHG Emissions Inventories will take a new form as well and will include new content and a reorganization of data.

Future reports will be available on Vanderbilt.edu/SustainVU.

[8] According to 2014-2015 enrollment data found in ReVU: Quick Facts about Vanderbilt. Accessed December 2015. Available www.vanderbilt.edu/facts.html.
[9] According to 2015 employment information found in ReVU: Quick Facts about Vanderbilt. Accessed December 2015. Available www.vanderbilt.edu/facts.html
[10] VU facilities data is available online at cpc-fis.vanderbilt.edu/pdf/facilitiesreportbook.pdf.
[11] Vanderbilt University's Inventory of Greenhouse Gas Emissions 2005-2009, 2010, 2011, 2012, 2013, and 2014 reports are available at www.vanderbilt.edu/sustainvu.

The Environmental Protection Agency (EPA)-issued *Mandatory Greenhouse Gas Reporting Rule* [40 CFR Part 98][12] requires annual reporting of GHG emissions from large sources in the United States that emit more than 25,000 metric tons of carbon dioxide equivalent ($MTCO_2E$) per year. Vanderbilt is subject to this reporting rule because of the emissions produced from the current use of natural gas and diesel at the on-campus, co-generation power plant for the production of steam and electricity for campus. Under the GHG reporting rule, the scope and emissions factors of stationary sources varied from those utilized in Vanderbilt's initial baseline GHG inventory because our initial inventory predated the reporting rule. 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 2015, Vanderbilt University emissions from EPA-reported sources amounted to 116,401 $MTCO_2E$, which was reported to the EPA on March 24, 2016. Emissions from all sources not covered by the GHG reporting rule were calculated using methodology from the Clean Air – Cool Planet Campus Carbon Calculator™ (Campus Carbon Calculator) or emissions factors developed for specific on-campus activities.

New EPA Report Defines Climate Change Indicators



The Earth's climate is changing. Temperatures are rising, snow and rainfall patterns are shifting, and more extreme climate events- like heavy rainstorms and record-high temperatures- are already taking place. Scientists are highly confident that many of these observed changes can be linked to the levels of carbon dioxide and other greenhouse gases in our atmosphere, which have increased because of human activities. The EPA report details many climate change indicators. Some highlights of the report include:

- *U.S. Greenhouse Gas Emissions*- In the United States, greenhouse gas emissions caused by human activities increased by 7 percent from 1990 to 2014.
- *U.S. and Global Temperature*- Average temperatures have risen across the contiguous 48 states since 1901. Average global temperatures show a similar trend, and all of the top 10 warmest years on record worldwide have occurred since 1998.

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. 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 shift and become more extreme. These weather pattern shifts result in the migration of plant and animal species to new locales as well as increased frequency of catastrophic natural disasters[13].

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); hydrofluorocarbons (HFCs); perfluorocarbons (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 equivalent (CO_2E). The sum of all CO_2E emitted by that person or organization is the carbon footprint, usually reported in metric tons as $MTCO_2E$.

[12] www.epa.gov/ghgreporting/
[13] *Explaining Extreme Events of 2012 from a Climate Perspective,* September 2013, www.ametsoc.org/2012extremeeventsclimate.pdf.

2015 was the Hottest Year on Record

Scientists reported that 2015 was the hottest year in the historical record by far, breaking a mark set only the year before - a burst of heat that has continued into 2016 and is roiling weather patterns all over the world.

Two American government agencies - NASA, the National Aeronautics and Space Administration, and NOAA, the National Oceanic and Atmospheric Administration - released figures showing that 2015 was the warmest year in a global record that began, in their data, in 1880. The bulk of the record-setting heat, they say, is a consequence of the long-term planetary warming caused by human emissions of greenhouse gases.

When temperatures are averaged at a global scale, the differences between years are usually measured in fractions of a degree. In the NOAA data set, 2015 was 0.29 degrees Fahrenheit warmer than 2014, the largest jump ever over a previous record. "The whole system is warming up, relentlessly," said Gerald A. Meehl, a scientist at the National Center for Atmospheric Research in Boulder, Colo. Read more here.

Vanderbilt Power Production

Vanderbilt's on-campus power plant produces 14% percent of the electricity, all of the steam, and 40 percent of the chilled water consumed by the Vanderbilt community. These utilities are produced by a co-generation combined heat and power (CHP) plant. This plant uses two fuels, natural gas and diesel as emergency fuel, to produce electricity, steam heat and chilled water. In November 2014, the conversion of the plant from coal to natural gas (with diesel fuel as a back-up fuel) was completed, though the plant remained in commissioning mode throughout 2015. This type of power plant is highly efficient because of 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 fuel than Tennessee Valley Authority (TVA) would require to deliver the same amount of electricity to campus.

In 2015, the power plant's on-campus electricity generation met 14% of the University's demand due to periodic interruptions in capacity at the power plant during construction and equipment testing, however Vanderbilt University still purchased less electricity in 2015 compared to 2014. As part of the conversion project, two older generators were removed in early 2014. Additionally, a portable temporary boiler was used in January and February 2015 due to the combination of power plant construction, extremely cold temperatures, and a natural gas curtailment. The remaining 86% of electricity needed to power Vanderbilt's campus was purchased from TVA through Nashville Electric Service (NES). This mix of on-campus generation and purchased electricity also results in Vanderbilt's unique carbon footprint.

Other Operations Resulting in Greenhouse Gas Emissions

Vanderbilt University also produces GHG emissions through fossil fuel use in university fleet vehicles; faculty and staff commuting to work; refrigerant and anesthetic gas releases; air travel paid for by the university; and disposal of waste.

II. VANDERBILT UNIVERSITY ENVIRONMENTAL COMMITMENT

The Vanderbilt University Environmental Commitment Statement presented here is the cornerstone of our Environmental Management System (EMS), which includes the VU GHG emissions inventory. This Environmental Commitment Statement, developed in 2009, was a collaborative product of many stakeholders and campus representatives and was meant to succinctly and uniquely reflect Vanderbilt's culture and values.

III. ACADEMIC AND RESEARCH AREA GREENHOUSE GAS EMISSIONS

Results Summary

Academic and Research Areas (ARAs) at VU encompass typical university activities such as teaching, research, administration, student activities, student housing, dining and athletic facilities. Table 3.1 illustrates annual GHG emissions from ARAs for calendar years 2005 through 2015. Figure 3.1 shows that GHG emissions from ARAs have dropped by 29 percent since the all-time high in 2008 and 12% in one year.

Calendar Year	GHG Emissions from EPA-Reported Sources[14] ($MTCO_2E$)	Other Scope 1 Emissions[15] ($MTCO_2E$)	Scope 2 Emissions ($MTCO_2E$)	Scope 3 Emissions ($MTCO_2E$)	Total GHGs Emitted from ARAs ($MTCO_2E$)	Percent Decrease in GHGs Emitted from Previous Year
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%
2012	95,898	2,381	100,894	52,496	**251,669**	7.6%
2013	100,792	2,437	98,507	58,207	**259,943**	-3.2%
2014	90,389	2,360	101,790	59,776	**254,315**	2.2%
2015	75,661	2,292	88,091	57,521	**223,565**	12.1%

Table 3.1. GHG Emissions from Academic and Research Areas by Type, Calendar Years 2005-2014.

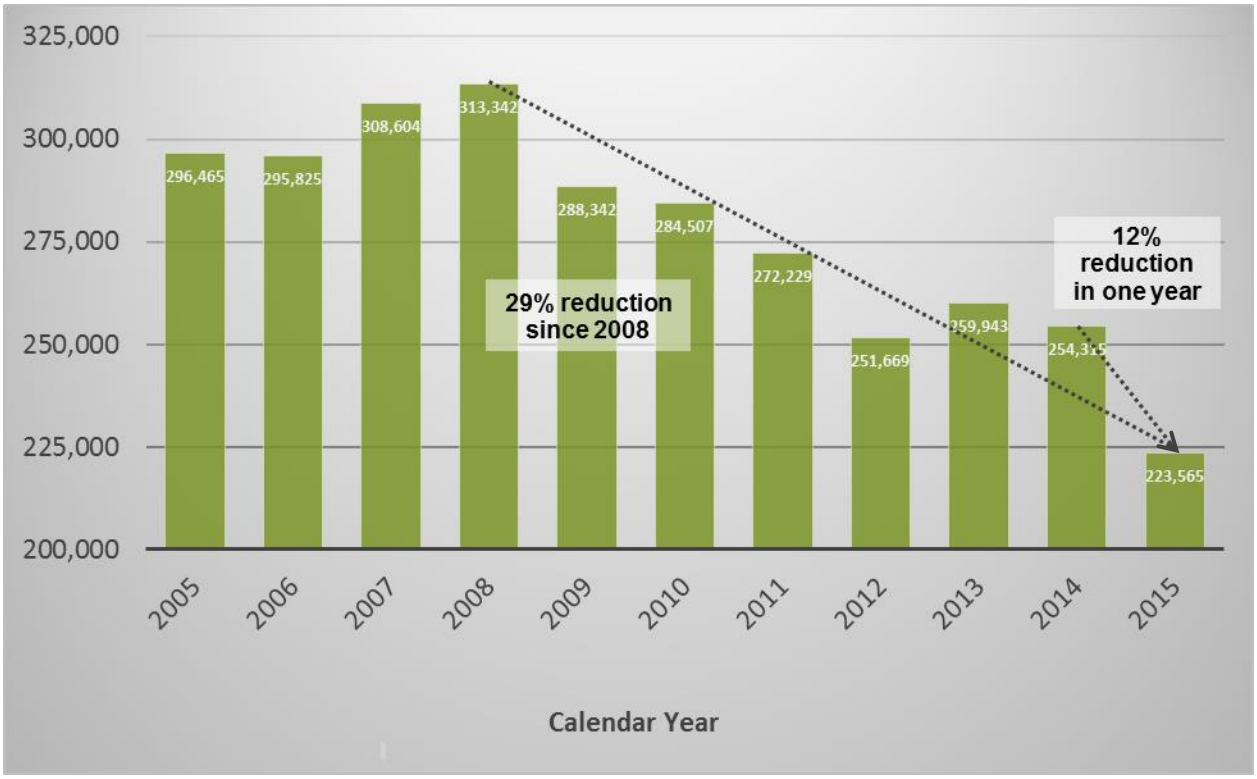


Figure 3.1. GHG Emissions from Academic and Research Areas, Calendar Years 2005-2015.

[14] EPA-reported sources includes diesel use in boilers, natural gas-fired boilers, and natural gas-fired turbines.
[15] Other Scope 1 Emissions includes anesthetic gas use, emergency generators, fleet vehicles and refrigerant releases.

As demonstrated in Figure 3.2 below, major contributors to the emissions from ARAs include purchased electricity (39 percent), natural gas use at the power plant (32 percent), faculty and staff commuting (17 percent), and air travel (8 percent).

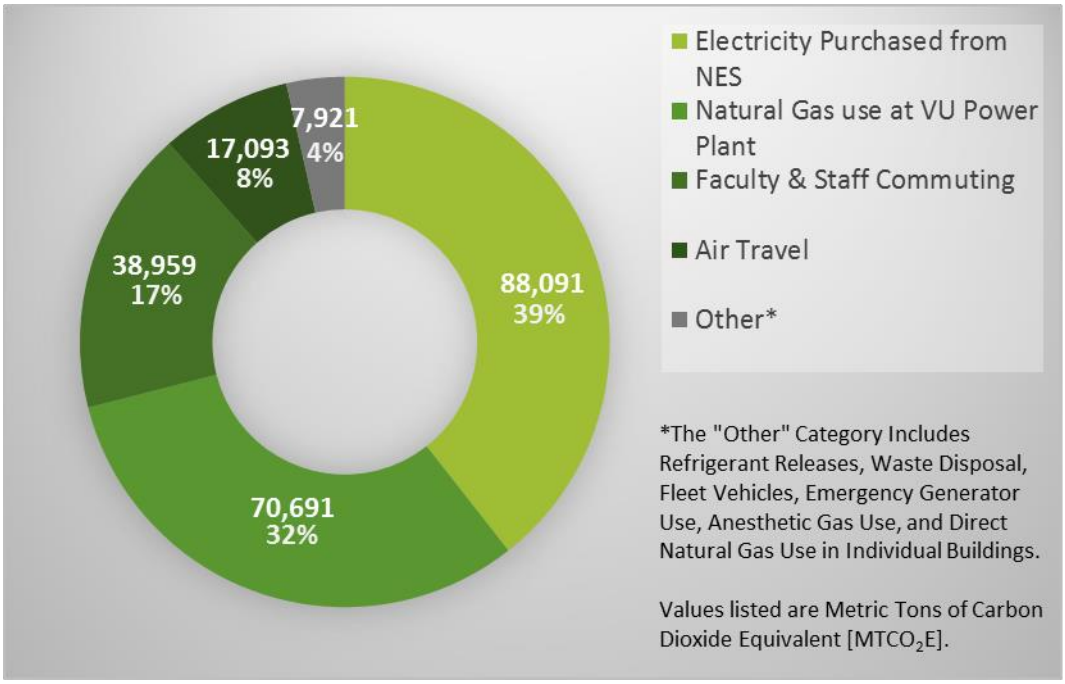


Figure 3.2. GHG Emissions Sources from Academic and Research Areas, Calendar Year 2015.

Scope 1: EPA-Reported Emissions Sources

Individual building steam and electricity usage for calendar year 2015 revealed that approximately 65 percent of the steam and electricity consumed by Vanderbilt was consumed by ARA buildings. In 2015, GHG emissions from EPA-reported emissions sources for ARAs amounted to 75,661 $MTCO_2E$ as shown in Table 3.2.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Diesel Fuel: Power Plant ($MTCO_2E$)	Total VU GHG Emissions from EPA-Reported Sources[16] ($MTCO_2E$)	GHG Emissions from EPA-Reported Sources in ARAs (65 percent 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
2012	85,968	56,798	4,770	--	147,536	95,898
2013	89,490	59,840	5,736	--	155,065	100,792
2014	72,606	59,712	6,351	391	139,060	90,389
2015	0	108,756	5,065	2,580	116,401	75,661

Table 3.2 Academic and Research Areas GHG Emissions from EPA-Reported Stationary Sources, Calendar Years 2005-2015.

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

Currey Tennis Center Solar Installations Made Possible by Vanderbilt Green Fund

The 2015 national champion women's tennis team and men's tennis team are now getting electricity and hot water for showers with a little help from the sun! Two types of solar installations were added to Currey Tennis Center this year which provide green power and hot water to the building, reducing its dependence on fossil fuels.

Both projects were funded by the Vanderbilt Green Fund, a collaborative venture of VU's Sustainability and Environmental Management Office (SEMO), Plant Operations, the Office of the Dean of Students, Vanderbilt Student Government and Students Promoting Environmental Awareness and Responsibility (SPEAR). The Vanderbilt Green Fund provides capital for student-initiated sustainability projects. The solar project was proposed by Marie Casares, a member of the women's tennis team.

A solar-powered hot water heating system using solar panels installed on the roof collect the sun's energy to heat the water for the building. The solar water heaters have decreased natural gas use in the building by 40% compared to last year! Solar panels generate electricity from the sun's energy, which is fed into the building electricity grid. The system is expected to generate 31,000 kWh of electricity annually, enough to power two Tennessee homes for a year. The installation of these systems will result in substantial utility savings moving forward for Currey Tennis Center and Vanderbilt Athletics.

Natural Gas Use at the Power Plant

The burning of natural gas at the on-campus power plant releases carbon dioxide, nitrous oxide and methane. The inventory results illustrate that approximately 65 percent of the overall 108,756 $MTCO_2E$, or 70,961 $MTCO_2E$, is produced from natural gas use at the power plant for ARAs. This equates to 32 percent of the overall 2015 ARAs emissions.

Natural Gas Use in Individual Buildings

Several buildings on campus use natural gas directly from Vanderbilt's natural gas supplier. The consumption of natural gas within individual buildings in ARAs accounts for 3,292 $MTCO_2E$ of 2015 emissions, as shown in Table C.1 of the appendices.

Scope 1: Other Direct Emission Sources

Vanderbilt's direct GHG emissions sources that are not required to be reported to the EPA are shown in Table 3.3 below. See Tables C.2, C.3, C.4 and C.5 in the appendices for more details.

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
2012	116	120	2,128	18	2,381
2013	116	76	2,154	91	2,437
2014	116	225	1,988	31	2,360
2015	120	142	1,975	56	2,292

Table 3.3. Academic and Research Areas Scope 1 Emissions from Other Sources, Calendar Years 2005-2015.

Scope 2: Purchased Electricity Emissions

88,091 $MTCO_2E$ are attributed to electricity purchased for ARAs, as shown in Table 3.4 below. This is the result of the amount of electricity purchased from Nashville Electric Service (NES) and the mix of electricity generation methods employed by Tennessee Valley Authority (TVA). Vanderbilt University purchased 3% less electricity in 2015 compared to 2014. See Tables C.8 and C.9 in the appendices for more details.

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65 percent 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
2012	311,313,519	155,221	100,894
2013	299,441,016	151,549	98,507
2014	332,824,478	156,601	101,790
2015	324,039,317	135,525	88,091

Table 3.4 GHG Emissions from Purchased Electricity for Academic and Research Areas, Calendar Years 2005-2015.

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 ARAs for calendar years 2005 through 2015 are displayed below in Table 3.5. Starting in 2013, all airline travel for Vanderbilt faculty, staff, was recorded by Concur (Vanderbilt's centralized travel management portal); this change allowed for better capture of travel data that was previously decentralized which resulted in an increased reported amount of travel for 2013-2015 compared to previous years. For more details, see Tables C.10, C.11, C.12, C.13 and C.14 in the appendices.

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Air Travel Emissions[17] ($MTCO_2E$)	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
2012	555	7,272	44,668	52,496
2013	613	12,077	45,517	58,207
2014	679	19,887	39,209	59,776
2015	660	17,903	38,959	57,521

Table 3.5. Academic and Research Areas Scope 3 GHG Emissions Sources, Calendar Years 2005-2015.

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

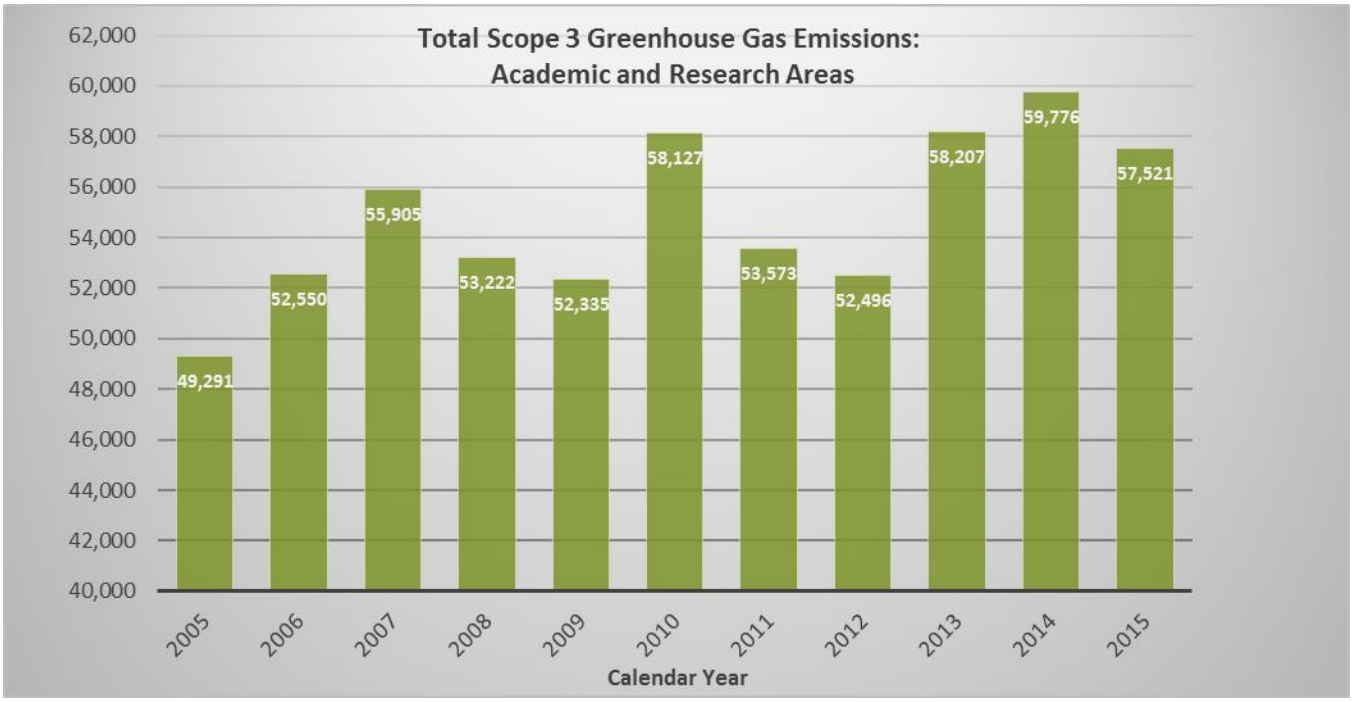


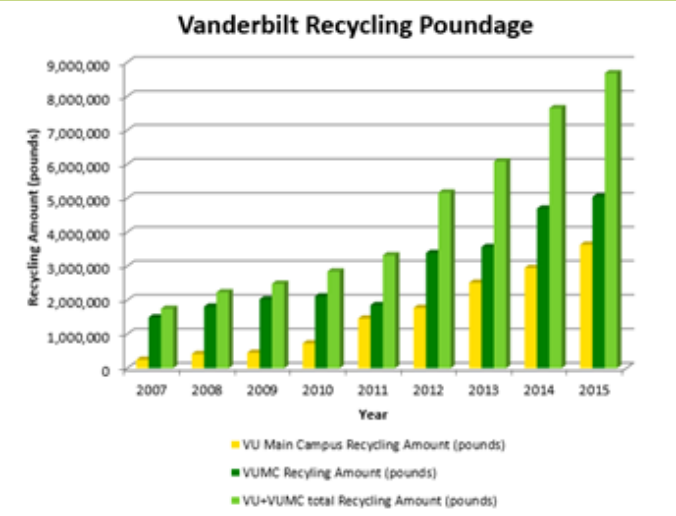
Figure 3.3. Academic and Research Areas Scope 3 Emissions, Calendar Years 2005-2015.

Vanderbilt recycling up 500% since 2007

Once again, Vanderbilt has increased the amount of materials recycled by 15% from 2014 to 2015, now totaling 8.7 million pounds of materials per year. That is the same weight as 19 Statues of Liberty each year! Vanderbilt has increased recycling by almost 500% since 2007.

In 2015, Vanderbilt recycled enough cardboard, plastic, scrap metal, aluminum, glass, bulbs, electronics, and ink/toner cartridges to conserve the equivalent of the following natural resources:

- 77,500 mature trees saved;
- 15,000 cubic yards of landfill airspace, equal to the space inside 135 semi-trailers;
- 18 million kilowatt hours of electricity, which is enough electricity to power 1,500 homes for a year;
- 9,000 barrels of oil which is enough oil to produce 171,000 gallons of gasoline;
- 14,000 metric tons (MTCO2E) of greenhouse gas emissions; and
- 27 million gallons of water, which would fill 41 Olympic sized swimming pools.



Vanderbilt also had a record year for ink and toner cartridge recycling in collaboration with Procurement and Disbursement Services and Guy Brown. VU staff recycled over 13,700 cartridges with a 63% recovery rate in 2015, almost doubling that of 2014. Read more here.

IV. PATIENT CARE AREA GREENHOUSE GAS EMISSIONS

Results Summary

Patient Care Areas (PCAs) at Vanderbilt encompass patient care hospital buildings and clinical buildings located on Vanderbilt's core 330 acres. Table 4.1 illustrates annual GHG emissions from PCAs for calendar years 2005 through 2015 and demonstrates that GHG emissions from PCAs have decreased by 9 percent in the last year. Figure 4.1 shows that GHG emissions from PCAs have been reduced by 24 percent since an all-time high in 2008.

Calendar Year	GHG Emissions from EPA-Reported Sources[18] ($MTCO_2E$)	Other Scope 1 Emissions[19] ($MTCO_2E$)	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
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%**
2012	51,638	7,878	54,327	44,494	**158,337**	**6.5%**
2013	54,273	6,384	53,042	46,050	**159,749**	**-0.9%**
2014	48,671	4,315	54,810	50,565	**158,361**	**0.8%**
2015	40,740	4,457	47,434	52,129	**144,760**	**8.6%**

Table 4.1. GHG Emissions from Patient Care Areas by Type, Calendar Years 2005-2015.

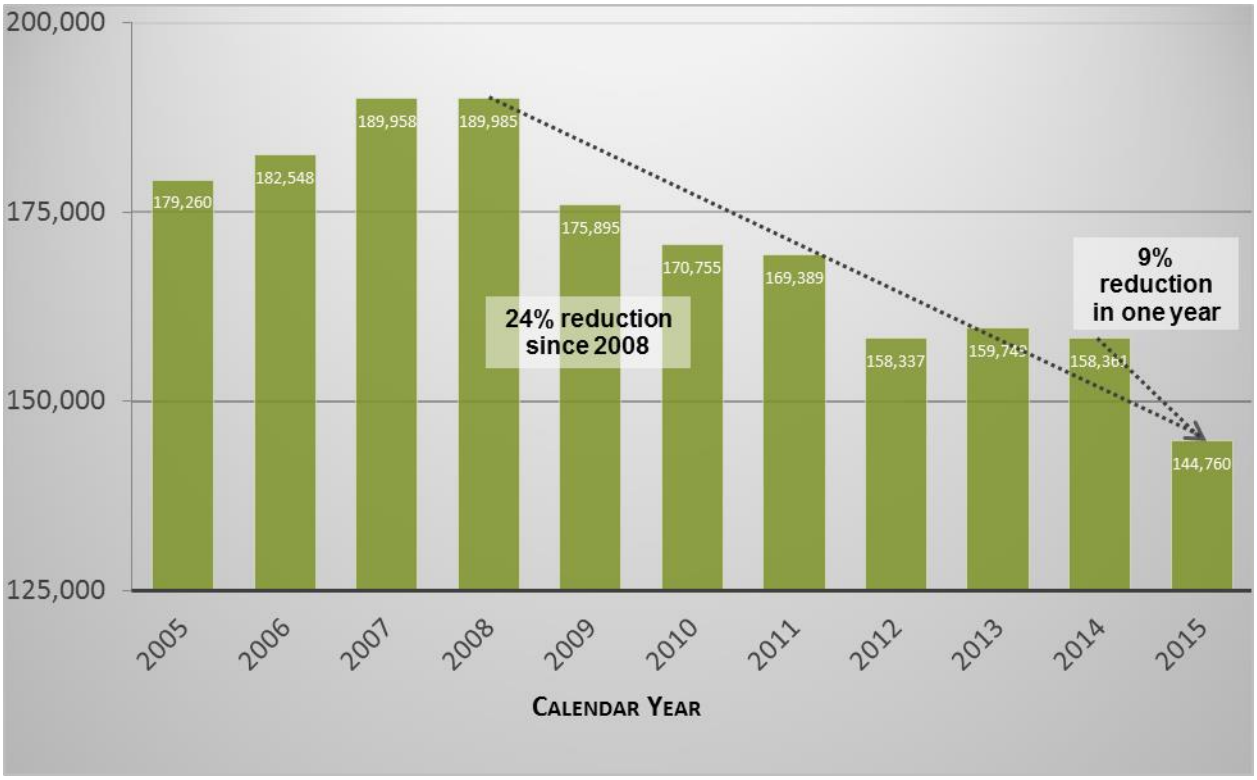


Figure 4.1. GHG Emissions from Patient Care Areas, Calendar Years 2005-2015.

[18] EPA-reported sources includes diesel fuel use in boilers, natural gas-fired boilers, and natural gas-fired turbines.
[19] Other Scope 1 Emissions sources include anesthetic gas use, emergency generators, fleet vehicles, and refrigerant releases.

As demonstrated in Figure 4.2 below, major contributors to the emissions from PCAs include purchased electricity (33 percent), faculty and staff commuting (29 percent), natural gas use at the power plant (26 percent), and air travel (6 percent).

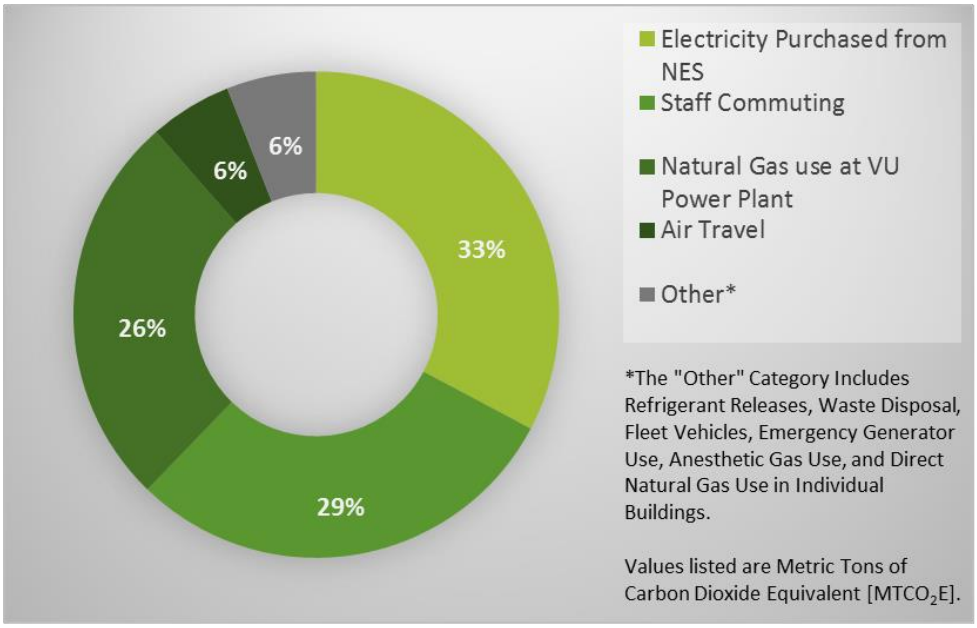


Figure 4.2. GHG Emissions Sources from Patient Care Areas, Calendar Year 2015.

Vanderbilt University PCAs were designated according to the criteria outlined in the Methodology section of the report. For PCA populations for 2015, please reference Table B.4 in the appendices.

Scope 1: EPA-Reported Emission Sources

Individual building steam and electricity usage for calendar years 2005 through 2015 revealed that approximately 35 percent of the steam and electricity consumed by Vanderbilt was consumed in Patient Care buildings. In 2015, GHG emissions from EPA-reported sources for PCAs amounted to 40,740 $MTCO_2E$, as shown in Table 4.2 below.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Diesel Fuel: Power Plant ($MTCO_2E$)	Total VU GHG Emissions from EPA-Reported Stationary Sources[20] ($MTCO_2E$)	GHG Emissions from EPA-Reported 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
2012	85,968	56,798	4,770	--	147,536	51,638
2013	89,490	59,840	5,736	--	155,065	54,273
2014	72,606	59,712	6,351	391	139,060	48,671
2015	0	108,756	5,065	2,580	116,401	40,740

Table 4.2. Patient Care Areas GHG Emissions from EPA-Reported Sources, Calendar Years 2005-2015.

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

Vanderbilt's Power Plant – an Essential Part of Our Campus

Because Vanderbilt University Medical Center is a major regional Level 1 Trauma Medical Center and Children's Hospital and Vanderbilt University houses important experiments and research samples, it is essential to be powered by reliable, uninterruptable energy supply 24 hours a day, 7 days a week, 365 days per year, especially in the event of a widespread emergency or loss of power in the Nashville community. Because of the emergency needs required by our campus and Medical Center, Vanderbilt will continue to have an on-campus power plant for many years to come.

Natural Gas Use at the Power Plant

The on-campus, co-generation power plant previously burned 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. Since November 2014, the power plant has been run exclusively on natural gas as part of the conversion of the power plant, although still in commissioning mode throughout 2015. The burning of natural gas releases carbon dioxide, nitrous oxide and methane. The inventory results illustrate that approximately 35 percent of the overall 108,756 $MTCO_2E$, or 38,065 $MTCO_2E$, are produced from natural gas use at the power plant for PCAs. This equates to 26 percent of the overall 2015 PCA emissions, as shown in Table C.1 of the appendices.

Natural Gas Use in Individual Buildings

Several Patient Care buildings use natural gas directly from Vanderbilt's natural gas supplier. The consumption of natural gas within individual Patient Care buildings accounts for 1,773 $MTCO_2E$ of 2015 emissions, as shown in Table C.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 are shown in Table 4.3, below. Emissions from refrigerant releases and fleet vehicles decreased during the 2014 calendar year. Anesthetic gas use increased 50% in 2015 causing an overall increase in the Scope 1 emissions for 2015. See Tables C.2, C.3, C.6 and C.7 in the appendices for more details.

Calendar Year	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Fleet Vehicles (Life Flight) ($MTCO_2E$)	Anesthetic Gas Use[21] ($MTCO_2E$)	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
2012	389	434	1,834	5,221	7,878
2013	281	745	1,655	3,703	6,384
2014	119	727	1,514	1,956	4,315
2015	140	236	1,140	2,942	4,457

Table 4.3. Patient Care Areas Scope 1 Emissions from Other Direct Sources, Calendar Years 2005-2015.

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

Scope 2: Purchased Electricity Emissions

47,434 $MTCO_2E$ are attributed to electricity purchased for PCAs, as shown in Table 4.4 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 C.8 and C.9 in the appendices for more details.

Calendar Year	Kilowatt-Hours Purchased (KwH)	Total VU Emissions ($MTCO_2E$)	Emissions Associated with PCA (35 percent 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
2012	311,313,519	155,221	54,327
2013	299,441,016	151,549	53,042
2014	332,824,478	156,601	54,810
2015	324,039,317	135,525	47,434

Table 4.4 GHG Emissions from Purchased Electricity for Patient Care Areas, Calendar Years 2005-2015.

Scope 3: Indirect Emissions Sources

Vanderbilt's indirect emissions include commuter fuel use by staff members in Patient Care buildings, work-related air travel, and off-site waste disposal. Indirect emissions for PCAs for calendar years 2005 through 2015 are displayed below in Table 4.5 and Figure 4.3. For the third consecutive year, airline travel paid for by Vanderbilt was captured for PCA staff through the new VU Travel Portal, Concur. Commuter travel emissions increased in 2015 because there were 544 more PCA staff in 2015 than in 2014. For more details, see Tables C.16, C.17, C.18 and C.19 in the appendices.

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Commuter Travel Emissions ($MTCO_2E$)	Air Travel Emissions* ($MTCO_2E$)	Total Scope 3 GHG Emissions for PCA ($MTCO_2E$)
2005	1,585	40,035	NA	41,620
2006	2,177	45,037	NA	47,215
2007	1,706	48,079	NA	49,786
2008	1,614	42,889	NA	44,503
2009	1,653	42,767	NA	44,420
2010	1,861	43,636	NA	45,496
2011	1,991	45,525	NA	47,516
2012	1,367	43,127	NA	44,494
2013	1,515	39,797	4,738	46,050
2014	1,593	40,582	8,390	50,565
2015	1,508	42,664	7,957	52,129

Table 4.5. Patient Care Areas Scope 3 GHG Emissions Sources, Calendar Years 2005-2015.
* Air travel for PCA staff was not available (NA) prior to 2013.

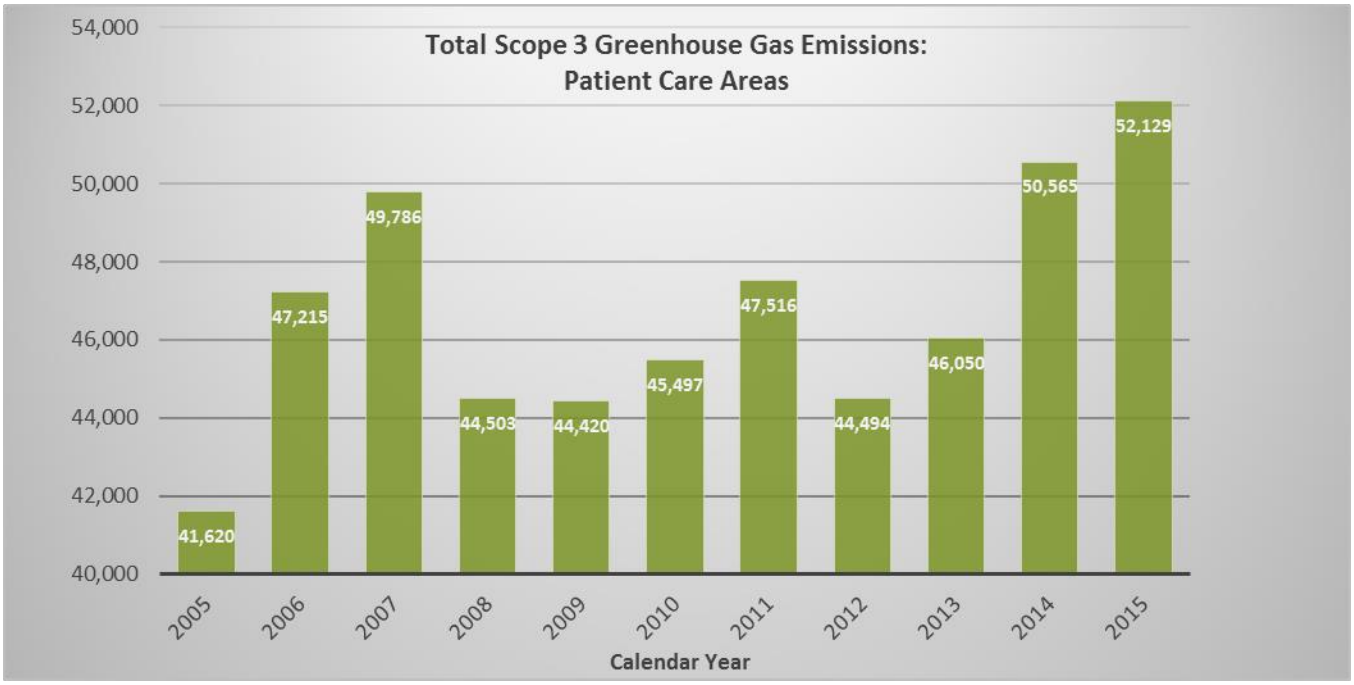


Figure 4.3. Patient Care Areas Scope 3 Emissions, Calendar Years 2005-2015.

V. INVENTORY SUMMARY

Vanderbilt University Emissions Summary

Vanderbilt University's greenhouse gas (GHG) emissions for calendar years 2005 to 2015 are presented in Table 5.1. Total annual GHG emissions for Vanderbilt University during the ten-year period reached a maximum of 503,327 Metric Tons of Carbon Dioxide Equivalent ($MTCO_2E$) in calendar year 2008. GHG emissions for 2015 show a 23 percent decrease in emissions since 2005 and a 27 percent from the peak in 2008 and an 11% drop since last year, as shown in Figure 5.1.

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%**
2012	251,669	158,337	**410,006**	**7.2%**
2013	259,943	159,749	**419,692**	**-2.4%**
2014	246,485	166,191	**412,676**	**1.7%**
2015	223,565	144,760	**368,325**	**10.8%**

Table 5.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2015.

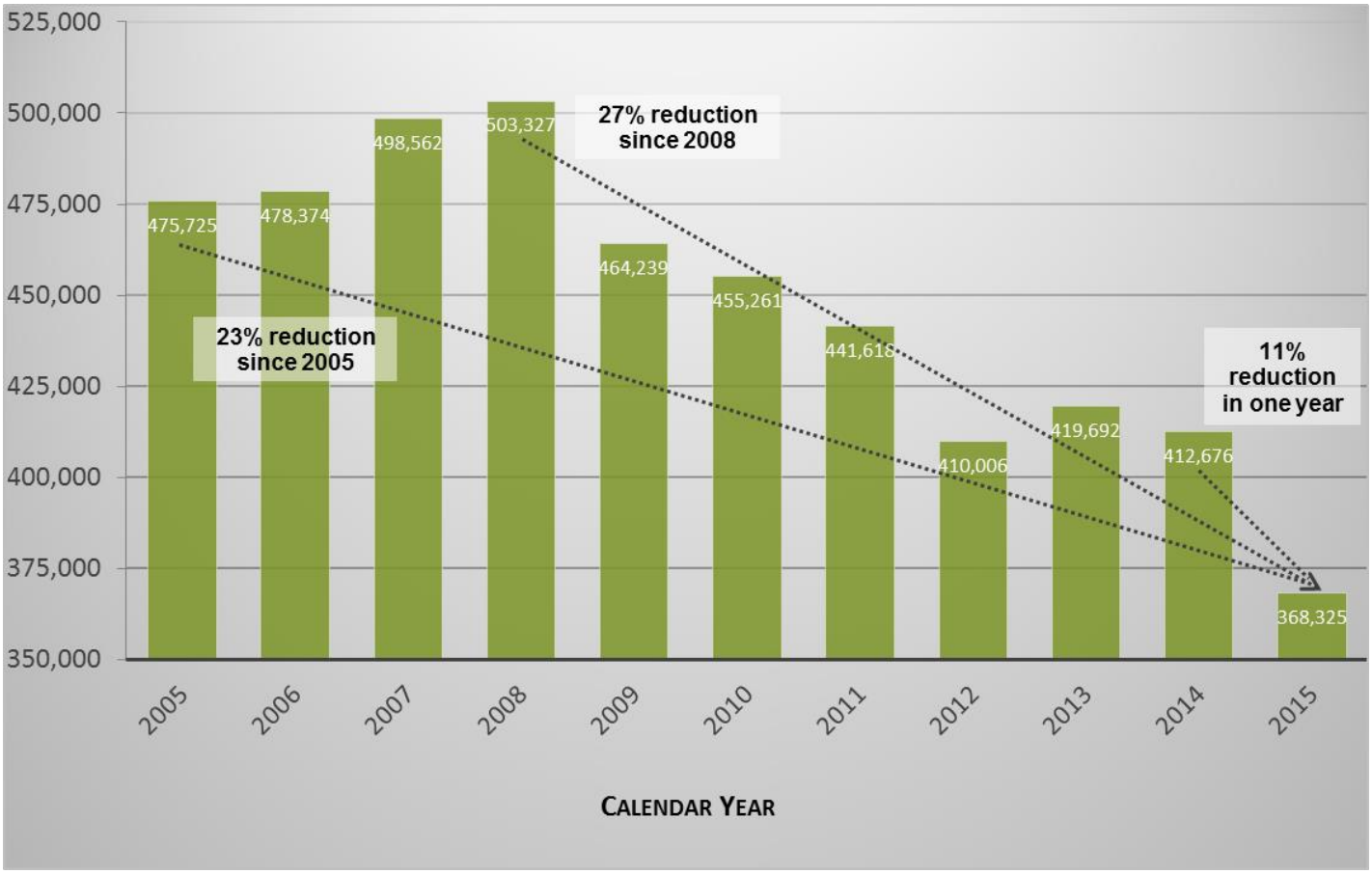


Figure 5.1. Total Vanderbilt GHG Emissions, Calendar Years 2005-2015.

As demonstrated in Figure 5.2, major contributors to Vanderbilt GHGs include purchased electricity (37 percent), natural gas use at the power plant (30 percent), faculty and staff commuting (22 percent) and air travel (7 percent).

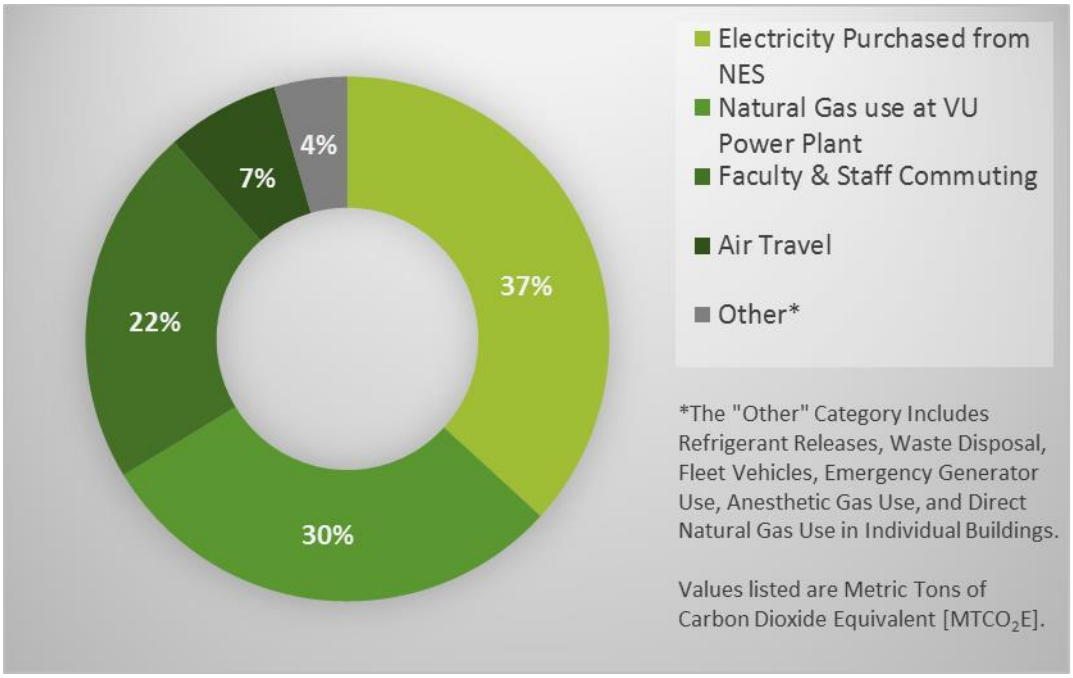


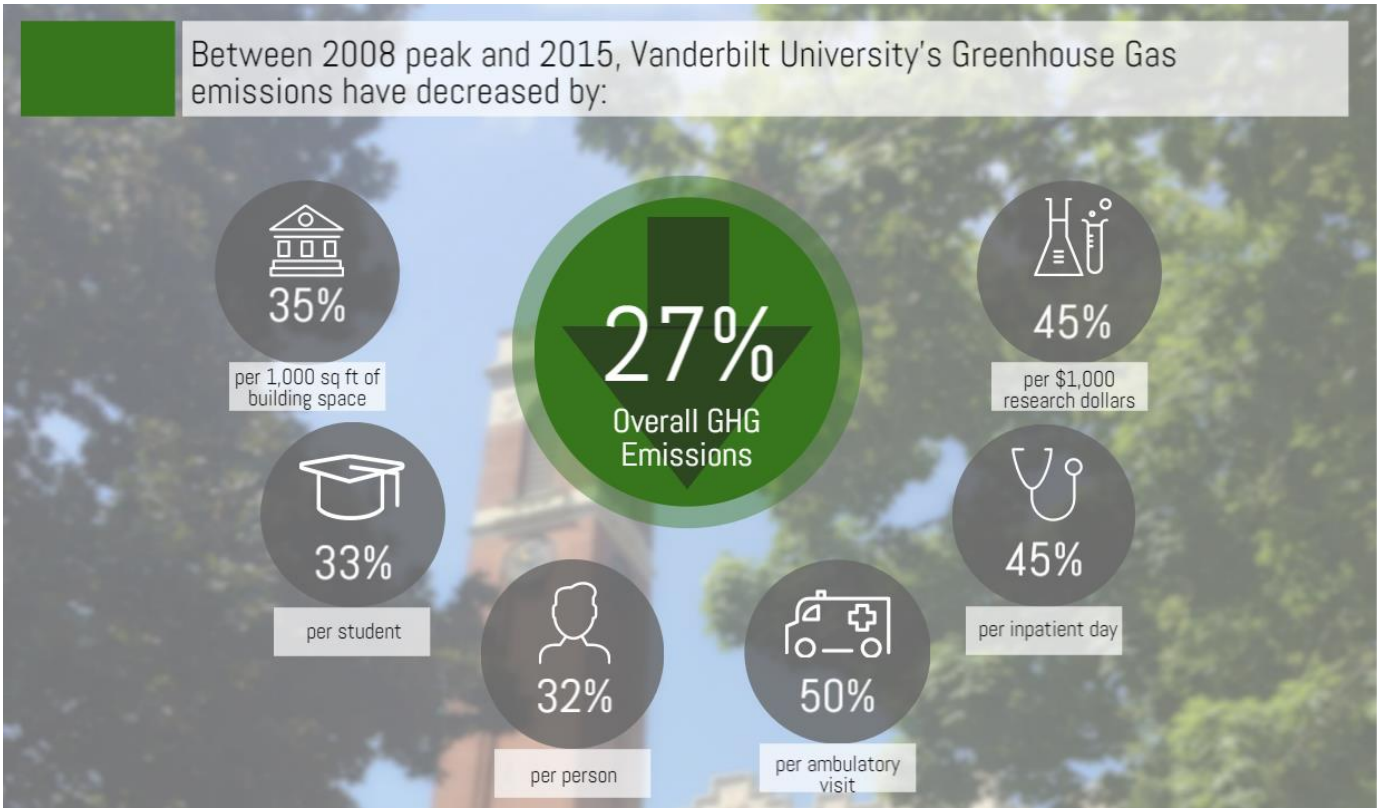
Figure 5.2. GHG Emissions Sources, Calendar Year 2015.

For calendar year 2015, Vanderbilt University emissions from Environmental Protection Agency (EPA)-reported sources amounted to 116,401 $MTCO_2E$. In calendar year 2015, purchased electricity, natural gas use at the on-campus co-generation power plant and commuter travel were the most substantial sources of GHG emissions, accounting for 89 percent of annual GHG emissions from Vanderbilt University as indicated in Figure 5.2. These major sources present the most significant opportunities for improvements in Vanderbilt University's carbon footprint. Thus, Vanderbilt initiated a significant infrastructure improvement project in 2013 to convert VU's on-campus power plant to all-natural gas. The conversion of the plant is now complete, and reached a major milestone in November 2014 when the plant burned its last piece of coal.

GHG emissions from just Vanderbilt's power plant decreased 16% since 2014 and 26% from the coal-burning plant in 2013 to the post-conversion plant fueled by natural gas in 2015. The plant was not yet in steady state and had performance testing throughout 2015 resulting in extra natural gas and diesel fuel use. Additionally, the Nashville area suffered a polar vortex-induced severe cold weather event coupled with curtailment of VU's natural gas supply during January and February 2015 which necessitated the use of a portable temporary boiler. This also contributed a significant additional amount to GHG emissions from the power plant. If the temporary boiler had not been used, then GHG emissions would have been reduced 30% from 2013 to 2015. Further reduction of GHG emissions is anticipated in 2016 as the plant moves out of commissioning and into steady state; however this could be offset to an extent by the installation of the new Turbine #1.

Vanderbilt's overall GHG emissions from all sources in 2015 decreased 11% in one year and 27% from the 2008 peak. While VU achieved significant GHG reductions from the power plant, this was offset somewhat by small increases in the impacts of commuter travel, emergency generator fuel use, and anesthetic gas use in VUMC.

Analysis and Interpretation of 2005-2015 Trending Results



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 has 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.

Overall GHG emissions are down 27 percent from the all-time high reached in 2008, even though square footage has increased by 12 percent, or by almost two million square feet, since 2008. Between 2005 and 2015, Vanderbilt University's GHG emissions have decreased by 37 percent on a per gross 1,000 square foot basis, by 35 percent on a per person basis, by 33 percent per student and by 50 percent per 1,000 research dollars awarded to VU. Considering that Vanderbilt on-campus buildings have increased by 3 million square feet since 2005, total population has increased by around 5,400 people since 2005, and research dollars awarded has increased by $227 million since 2005, it is clear that VU Plant Operations, Campus Planning and Construction and VUMC Facilities Management are significantly improving the energy efficiency of Vanderbilt's buildings in the midst of continued growth. Please see Figures 5.3 through 5.8 below for more details.

Vanderbilt Athletics Facilities get Sustainability Update

Two Vanderbilt Athletics facilities recently underwent makeovers to make them more efficient. Hawkins Field, home of Vanderbilt's national championship baseball team, replaced all existing High-Intensity Discharge (HID) fixtures on the field with fewer Light-Emitting Diode (LED) fixtures. 152 HID fixtures were replaced with 98 LED fixtures, improving light quality on the field while reducing the energy used by 60%.

Vanderbilt Stadium also got a sustainability upgrade in time for the 2016 football season. All 74 of the urinals in the stadium were replaced with ultra-low flow fixtures that use only 5% of the water of the replaced fixtures. The upgrade will save 355,000 gallons of water each year!

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 large amounts of energy, results in significant GHG emissions. A single calculation was made based on all Vanderbilt University facilities, totaling over 16 million square feet. For more details on Figure 5.3, please refer to Table B.3 in the appendices.

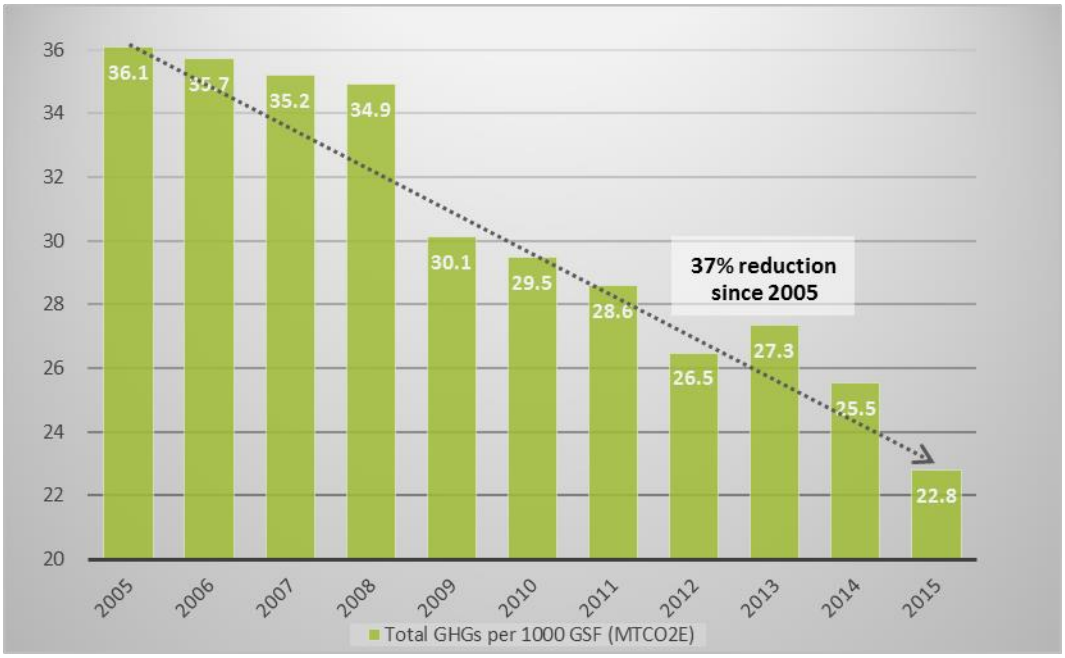


Figure 5.3. Total Vanderbilt GHG Emissions per 1,000 GSF, Calendar Years 2005-2015.

Emissions per Person

The size of the student population and faculty/staff population also directly influences the amount of GHGs emitted from Vanderbilt. More individuals on campus result in more building occupants using electricity and heating/cooling, increased amounts of waste generation and more commuters. For additional information on Figure 5.4 and 5.5, please reference Tables B.1 and B.3 in the appendices.

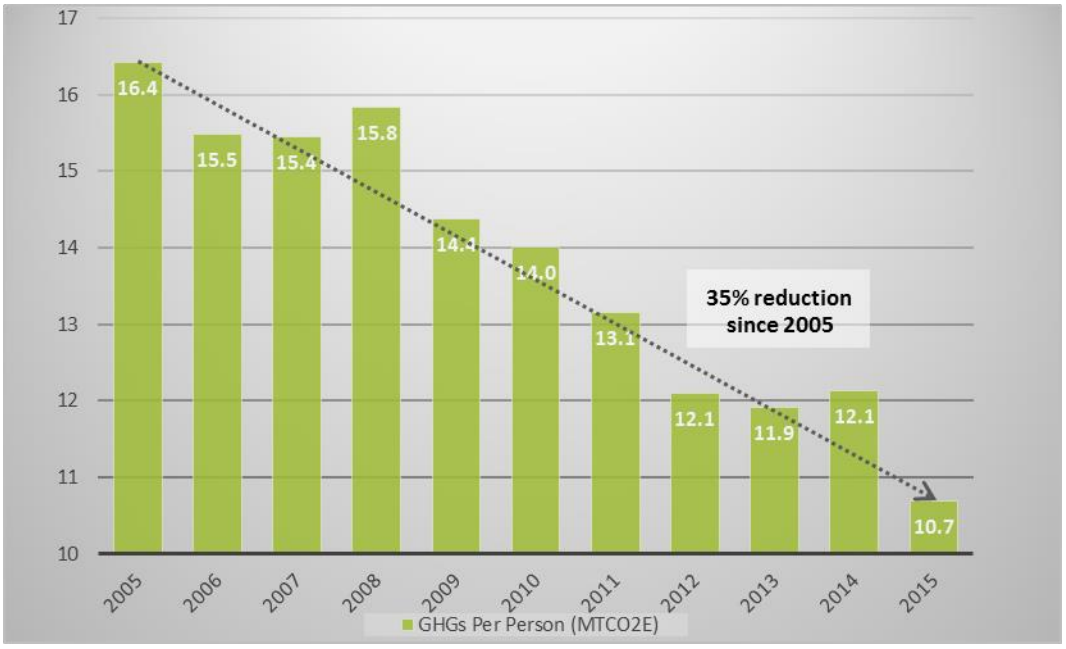


Figure 5.4. Total Vanderbilt GHG Emissions per Person, Calendar Years 2005-2015.

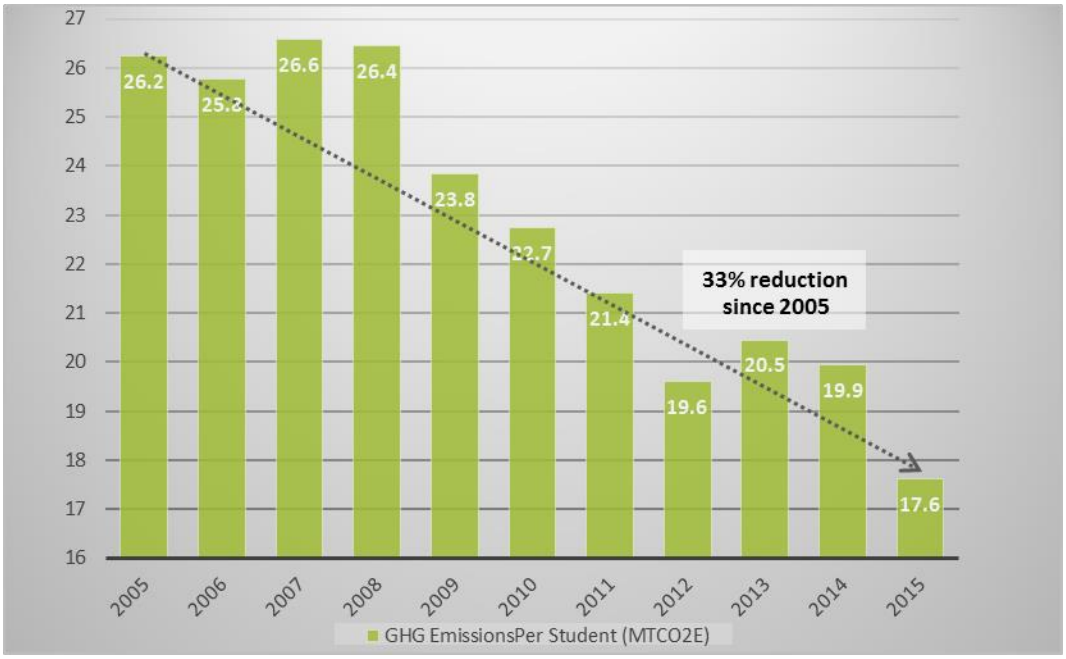


Figure 5.5. Vanderbilt Academic and Research Area GHG Emissions per Student, Calendar Years 2005-2015.

Alumni Hall earns LEED Gold certification

Alumni Hall has achieved LEED Gold certification this year from the U.S. Green Building Council for its recent renovation and addition. Alumni Hall, which was originally constructed in 1924, has been renovated to include many new green features while maintaining much of its historic character.

Alumni Hall was the first historic building at Vanderbilt that has undergone an extensive renovation and achieved LEED Certification. During the renovation, careful attention was paid to ensure historical features of the building were preserved. Alumni Hall brings Vanderbilt's total number of LEED-certified projects to 16. It joins eight other projects on campus that are LEED Gold certified. Read more here.

Emissions per Research Dollars Awarded

Conducting research and operating laboratory facilities require large amounts of energy. The typical laboratory uses four to five times more energy than an equivalent-sized office or classroom[22]. 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. For more details on Figure 5.6, please reference Table B.1 in the appendices.

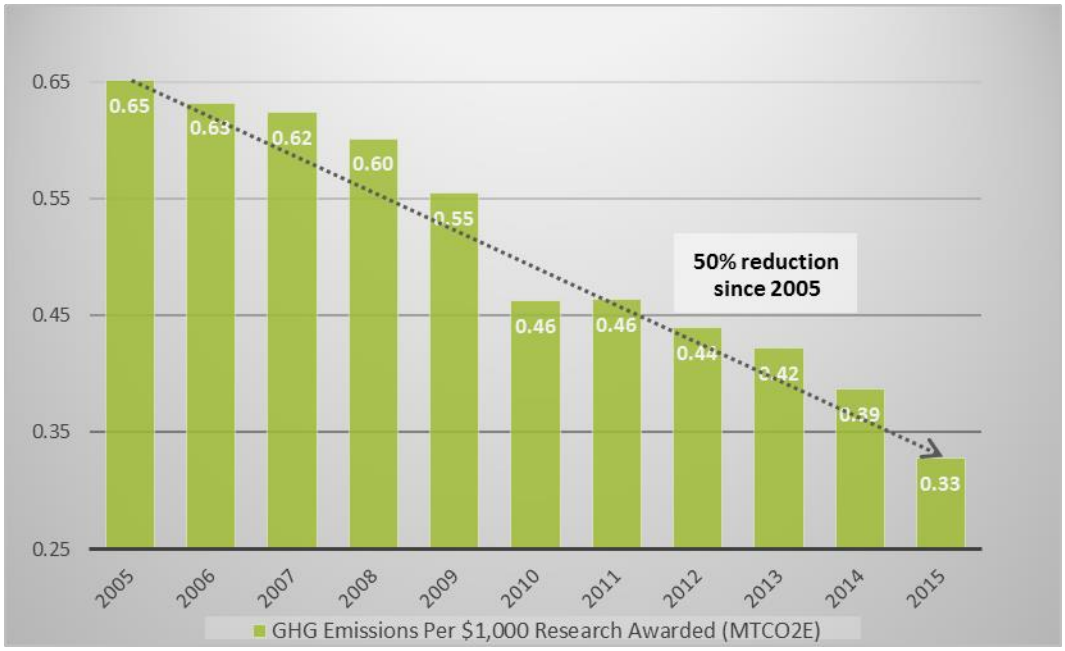


Figure 5.6. Vanderbilt ARA GHG Emissions Per 1,000 Research Dollars Awarded, Calendar Years 2005-2015.

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 (clinic) visit as presented in Figures 5.7 and 5.8, provides a means of interpreting emissions while considering the quality and magnitude of our medical operations on campus. For more details, please reference Table B.2 in the appendices.

Vanderbilt Awarded 2016 Sustainable Transportation Award

Vanderbilt University was awarded the 2016 Sustainable Transportation Award presented jointly by the TDEC and TDOT. Vanderbilt's Alternative Transportation program, a collaboration of the Office of Traffic and Parking, VUMC Parking and Transportation Services, and the Sustainability and Environmental Management Office (SEMO), was awarded the prize.

Vanderbilt University's robust alternative transportation program is a multi-pronged approach to reach as many of the Vanderbilt community as possible and attempts to make using alternative transportation easy and accessible.

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

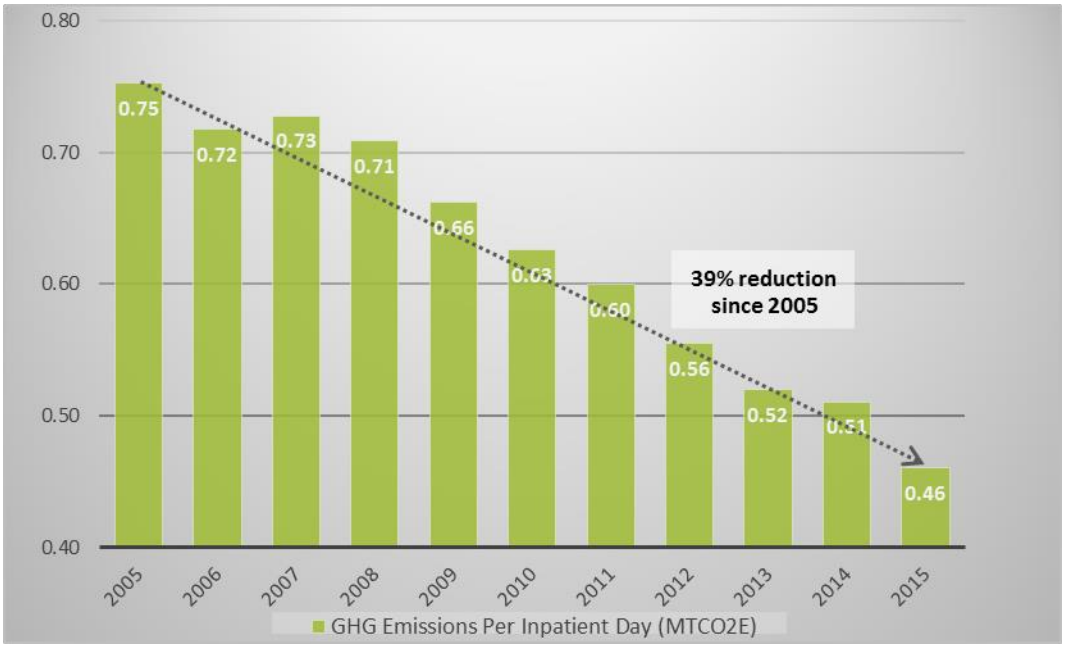


Figure 5.7. Vanderbilt Patient Care GHG Emissions per Inpatient Day, Calendar Years 2005-2015.

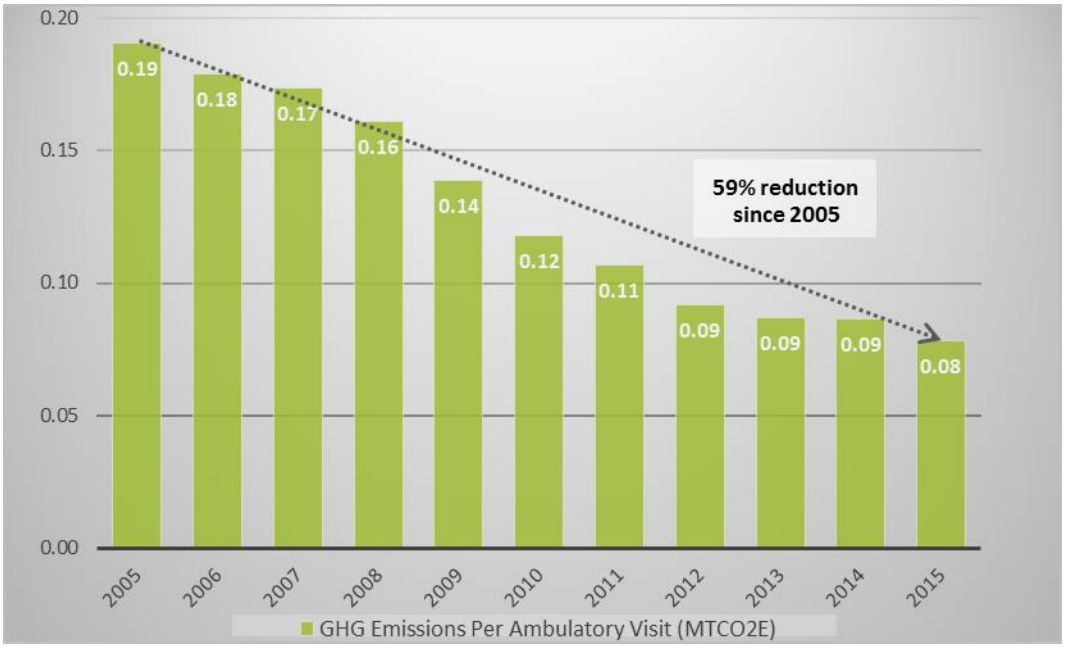


Figure 5.8. Vanderbilt Patient Care GHG Emissions per Ambulatory Visit, Calendar Years 2005-2015.

This analysis over the past decade illustrates that Vanderbilt University's GHG emissions are trending in the right direction, both overall and when normalized by all important institutional metrics. Despite 2015 being named the hottest year on record, GHG emissions continued to decrease for many of these metrics. Overall GHG emissions in 2015 represent our all-time low in emissions since 2005. GHG emissions did uptick slightly (by 2%) in 2013 due to a shift in increased on-campus fuel use and decreased purchased electricity in order to save money coupled with better tracking of Vanderbilt-funded airline travel for faculty, staff and students. However, emissions decreased again with the conversion of the power plant in 2014 and 2015.

Interpreting Vanderbilt's Results Compared to Other Universities

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, often the most useful standard to which Vanderbilt can accurately compare its GHG emissions from year to year is its own previous emissions inventory, utilizing consistent interpretations as presented in this report.

The authors recognize the interest in placing 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 $682 million[23] in 2015 (a $25 million increase from 2014) 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[24]).
- 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 small physical footprint and connected medical center and campus buildings, an omission of patient care buildings was not seen as appropriate.

The most common methods for 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 2015 GHG emissions compared from the limited number of colleges and universities having such data available, as listed in Table 5.2; these universities were selected based upon one or more of the following attributes:

- The university completed and published a GHG inventory;
- Included in the Top 25 US News and World Report for 2015;
- 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 in Table 5.2 is provided in Table B.13 in the appendices.

[23] According to data found in ReVU: Quick Facts about Vanderbilt. Accessed December 2015. Available at www.vanderbilt.edu/facts.html.
[24] Avimm, D. (2007). This Man Wants to Green Your Lab. *Science*, v.318, 39-41.

University	Total Emissions ($MTCO_2E$)	Emissions per $1,000 Research Awarded
Cornell University[25]	241,445	0.30
Duke University[26]	274,593	0.27
Emory University[27]	289,129	0.52
Harvard[28]	306,202	0.38
North Carolina State University	233,628	0.52
Rice University[29]	108,443	1.06
Stanford University[30]	177,338	0.20
University of Chicago[31]	114,896	0.24
University of North Carolina- Chapel Hill[32]	497,717	0.52
University of Pennsylvania[33]	294,210	0.35
Vanderbilt University[34]	**223,565**	**0.33**
Wake Forest[35]	63363	0.36
Washington University- St. Louis[36]	355,300	0.50
Yale University + Yale Medical Center[37]	181,259	0.28

Table 5.2. Comparison of Vanderbilt University GHG Emissions with Other Universities.

As previously mentioned, conducting research and operating laboratory facilities require large amounts of energy and therefore increase GHG emissions on a per $1,000 research awarded. When compared to other major research institutions, Vanderbilt's GHG emissions fall in the middle of the cohort for both overall emissions and emissions per research dollar awarded. Figures 5.9 and 5.10 illustrate Vanderbilt's GHG emissions and GHG emissions per $1,000 in research awarded in relation to several other research entities.

[25] GHG emissions as reported to AASHE-STARS in 2016; 2015 research dollars retrieved from http://www.bestcolleges.com.
[26] GHG emissions as reported to ACUPCC in 2016; 2015 research dollars retrieved from http://www.bestcolleges.com.
[27] GHG emissions as reported to AASHE-STARS in 2014; 2015 research dollars retrieved from http://www.bestcolleges.com.
[28] GHG emissions as reported to EPA in 2015; 2015 research dollars retrieved from Harvard Fact Book.
[29] GHG emissions as reported to ACUPCC in 2014; 2015 research dollars retrieved from Rice At a Glance.
[30] GHG emissions for 2014 retrieved from Stanford Emissions Inventory; 2015 research dollars retrieved from Stanford Facts.
[31] GHG emissions as reported to EPA in 2015; 2015 research dollars retrieved from University of Chicago At a Glance.
[32] GHG emissions as reported to AASHE-STARS in 2012; 2015 research dollars retrieved from http://www.bestcolleges.com.
[33] GHG emissions as reported to ACUPCC in 2012; 2015 research dollars retrieved from http://www.bestcolleges.com.
[34] GHG emissions for CY 2015 from ARAs only.
[35] GHG emissions as reported to AASHE-STARS in 2014; 2015 research dollars retrieved from National Science Foundation.
[36] GHG emissions as reported to AASHE-STARS in 2011; 2015 research dollars retrieved from http://www.bestcolleges.com.
[37] GHG emissions as reported to EPA in 2015; 2015 research dollars retrieved from http://www.bestcolleges.com.

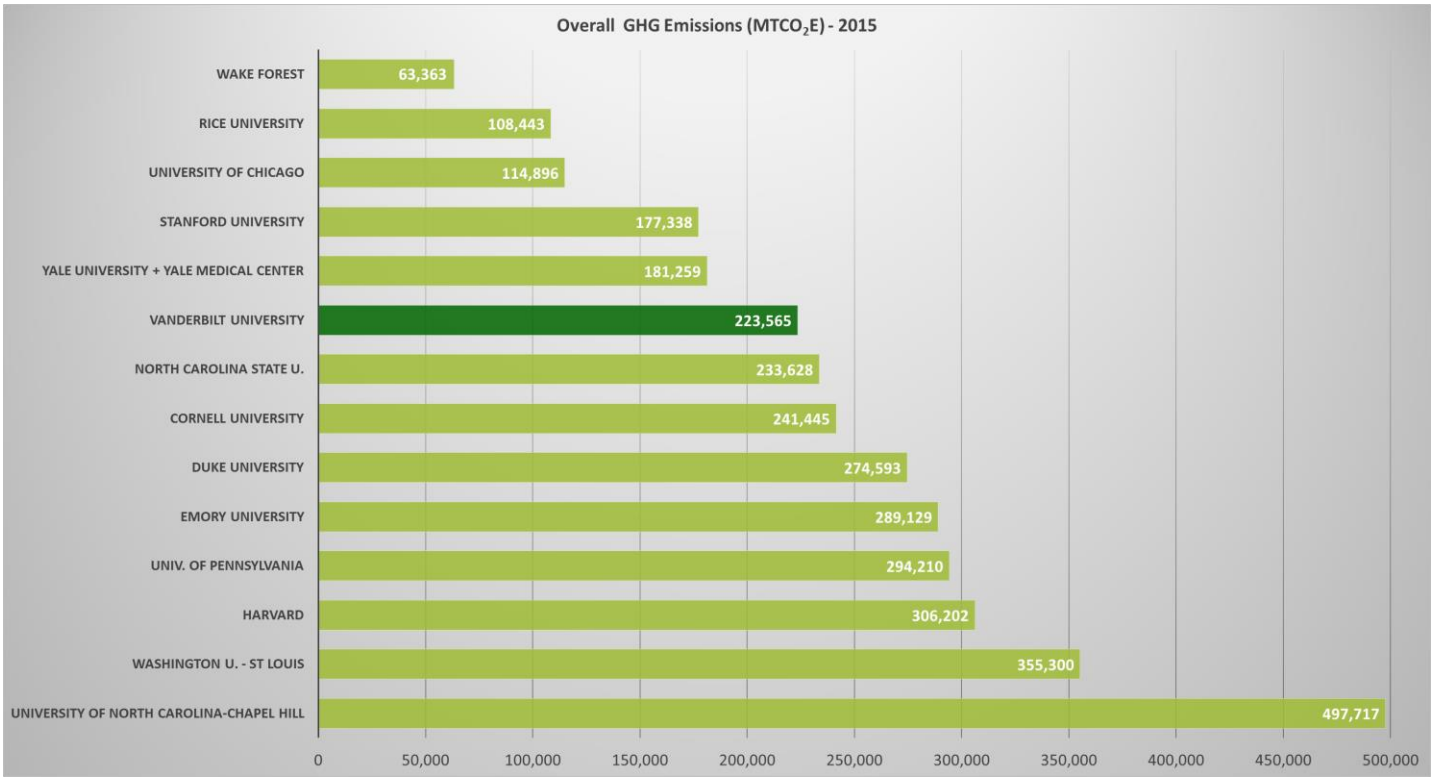


Figure 5.9. Comparison of Vanderbilt University GHG Emissions with Other Universities, 2015.

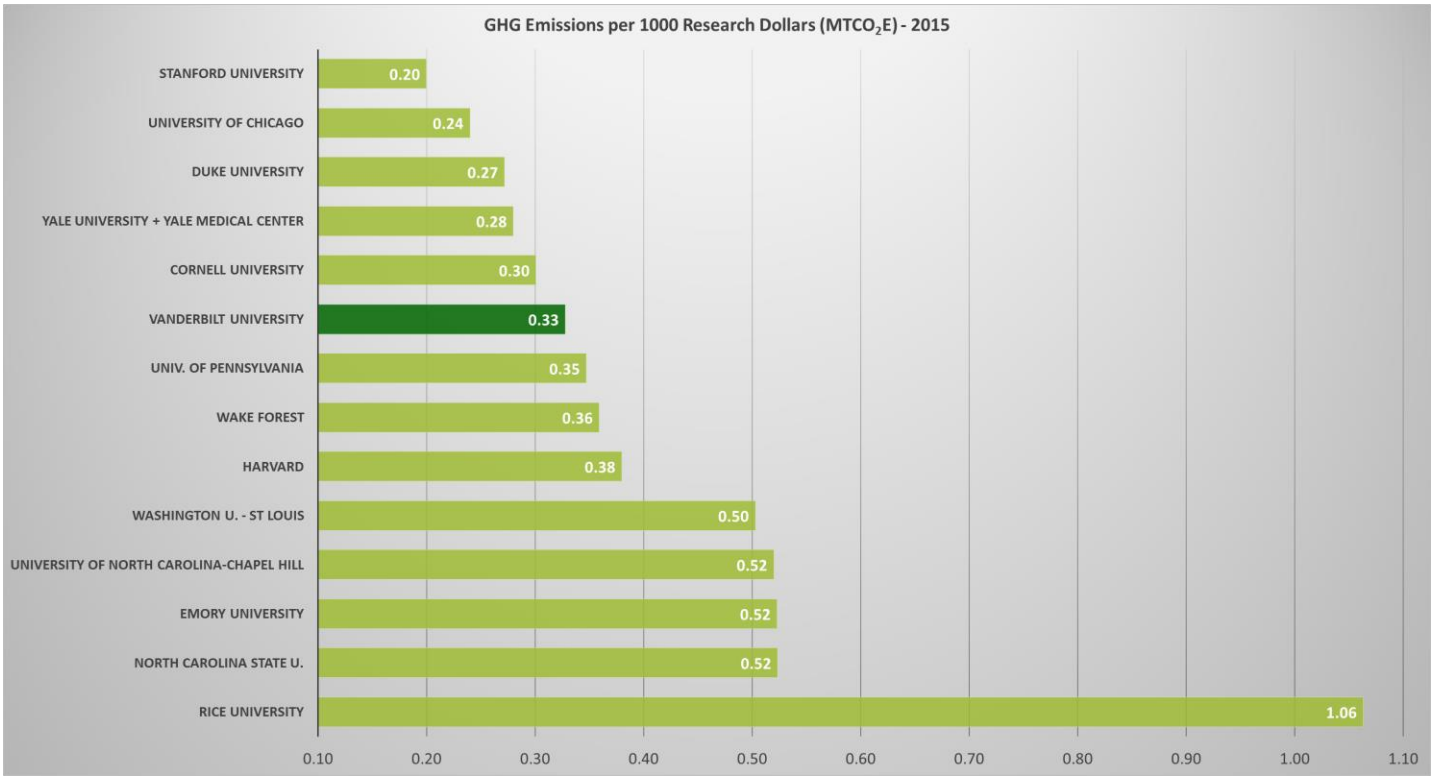


Figure 5.10. Comparison of Vanderbilt University GHG Emissions with Other Universities, Per $1,000 Research Dollars Awarded, 2015.

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 always 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 accurately assess its GHG emissions trending data in years past and the years to come.

This inventory has provided campus stakeholders with a consistent means of comparing annual GHG emissions and sufficiently detailed information to make informed decisions to determine reduction strategies for the past decade. Considerable progress has been made during this time.

Annual emissions inventories will continue to be conducted in the future to measure progress; however, the separation of VU and Vanderbilt University Medical Center (VUMC) into two legally separate entities necessitates a different approach and accounting of emissions. Thus, the annual emissions inventory will continue in the future but will significantly change structure and format and will continue to be made available on the SustainVU website.

Vanderbilt University is currently underway on a campus land use planning initiative, FutureVU. FutureVU is driven by a holistic view of Vanderbilt's identity and mission as it informs the use of our land and buildings. Its end result will be an actionable plan that improves Vanderbilt's collegiate environment, supports trans-institutional discovery, builds community and connectivity, promotes equity and inclusion, and is a beacon for sustainable living.

Suggestions on how the University community can continue to reduce its energy consumption can be found at Vanderbilt's ThinkOne website[38]. 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 website 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.

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

APPENDIX A: INVENTORY DEVELOPMENT METHODOLOGY

Boundary Definitions

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

Operational Boundary

Activities at Vanderbilt University that produce GHG emissions include those outlined by the EPA's *Mandatory GHG Reporting Rule* [40 CFR Part 98][39], as well as The American College & University Presidents Climate Commitment (ACUPCC) Implementation Guide (2012)[40]. The boundaries established by the ACUPCC Implementation Guide rely heavily on the methodology established by the World Resources Institute Greenhouse Gas Protocol[41]. 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-Reported Stationary Sources: Scope 1 – Direct Sources. These are emissions produced by stationary sources that are under direct control of the institution. Vanderbilt's EPA-reported stationary sources include diesel fuel 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-reported 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[42] categorizes GHGs into Scopes 2 and 3 as follows:

- Scope 2: Indirect Emissions from Electricity Purchases. These are emissions associated with the generation of electricity that is purchased by Vanderbilt. Scope 2 emissions physically occur at power-generation facilities owned by Vanderbilt's electricity supplier and not at the Vanderbilt campus itself. In 2015, Vanderbilt purchased 86 percent of the electricity needed to supply campus operations.

[39] http://www.epa.gov/ghgreporting/
[40] http://secondnature.org/climate-guidance/commitments-implementation-guide/
[41] 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.
[42] http://www.ghgprotocol.org/

- 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 Research Areas, Patient Care Areas

Vanderbilt University is a diverse institution, providing regional health care while simultaneously pursuing robust academic endeavors. As such, this report provides a subtotal of GHG emissions associated with Academic Research Areas (ARAs), which are traditional academic university endeavors, and a separate subtotal for emissions associated with Patient Care Activities (PCAs). The contrast in the activities in these two areas is worth noting: Patient Care Areas (PCAs) provide medical care on a continuous basis, while activities in ARAs are associated with an academic calendar. ARAs include academic and administrative buildings, residence halls, athletics facilities, parking garages, common space/multi-purpose areas and laboratory research space, while PCAs include hospitals, clinics and patient and visitor parking garages.

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 encompass the majority of the academic, residential, research and patient care buildings associated with Vanderbilt, and the buildings located within this core 330 acres are serviced by Vanderbilt's on-campus power plant. The core VU campus contains over 230 buildings, encompassing over 15 million gross square feet of space.

Buildings that are classified as Patient Care buildings include Vanderbilt University Hospital, The Vanderbilt Clinic, Vanderbilt Children's Hospital & Doctor's Office Tower, Psychiatric Hospital at Vanderbilt, Vanderbilt-Ingram Cancer Center, Vanderbilt Eye Center, Free Electron Laser Building, Medical Center East (North Tower), Zerfoss Health Center, Oxford House, Dayani Center, Central Garage, East Garage, South Garage, Children's Way Garage, Medical Arts Building, Medical Center East II (South Tower) and 40 percent of Medical Center North. All other buildings on the "core" 330 acre campus are considered ARAs.

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 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 reductions. 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, this eleven-year inventory establishes the annual GHG emissions created by Vanderbilt during the 2005 through 2015 calendar years.

Greenhouse Gas Data Collection and Inventory Methodology

On-Campus Energy Production

Vanderbilt's sources of GHG emissions that are under direct control of the University include the consumption of diesel fuel and natural gas at the on-campus, 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 natural gas at the on-campus, co-generation power plant and natural gas by individual buildings was provided by Plant Operations 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 Plant Operations and input to the Clean Air – Cool Planet Campus Carbon Calculator™ to compute annual GHG emissions.

University Vehicles

Vanderbilt University leases and owns over 320 vehicles. Most departments at Vanderbilt purchase their own fuel in bulk and track dispensing of that fuel; on rare occasions, employees obtain fuel from local retail stations. Departments that track their fuel use provide their annual fuel usage and that data is directly input into the Campus Carbon Calculator. Fuel dispensed to Vanderbilt shuttle buses and vans is recorded monthly by Vanderbilt University Medical Center (VUMC) Parking and Transportation Services and is included in this inventory.

Some University vehicles at Vanderbilt obtain fuel at local retail stations using a VU One Card, and the volume of fuel purchased is *not* recorded by the vehicle manager. For this portion of University vehicles, two assumptions were made in order to estimate the approximate annual fuel use for these vehicles: (1) a University vehicle averages 4,500 miles a year (based on the vehicle-miles logged by the vehicle manager for VU Information Technology), and (2) a University vehicle gets 24 miles per gallon which the default value provided in the Clean Air – Cool Planet Campus Carbon

Calculator™. From this, the gallons of fuel consumed by these vehicles was calculated and input into the Campus Carbon Calculator.

Annual consumption of fuel by Vanderbilt's LifeFlight helicopters is reported by VUMC Facilities Management. GHG emissions associated with LifeFlight's use of Jet-A fuel were calculated using an emission factor from WRI's Greenhouse Gas Protocol[43].

Anesthetic Gases

Vanderbilt uses anesthetic gases in both PCAs 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 VUMC's Department of Anesthesiology and Vanderbilt's Division of Animal Care. The Campus Carbon Calculator does not provide Global Warming Potentials (GWP) for all anesthetic gases, since most universities use little to no anesthetic gas. Vanderbilt's GHG emissions from anesthetic gas use were calculated based on GWPs provided by the EPA's *Mandatory GHG Reporting Rule*[44].

Refrigerants

Universities track releases of refrigerants to the atmosphere as required by the EPA. VU Plant Operations and VUMC Facilities Management records of refrigerant releases from chillers, air conditioning units, walk-in coolers and freezers, and various types of appliances. Pounds of refrigerants released were provided and directly input into 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 14 percent of Vanderbilt's annual electricity demand. The remaining 86 percent of Vanderbilt's electricity demand is obtained through electricity purchased from TVA (through NES). In 2015, 34 percent of TVA's electricity came from coal-fired power plants; 34 percent came from nuclear power; 9 percent came from hydroelectric dams; 11 percent came from natural gas-fired power plants; and <1 percent came from other renewable sources[45]. Figure A.1 below presents TVA's sources of power generation.

[43] www.ghgprotocol.org
[44] 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].
[45] Page 12 of TVA Annual Report filed with the Securities and Exchange Commission on November 20, 2015. Available at http://www.snl.com/irw/Doc/4063363/Index?did=34600175

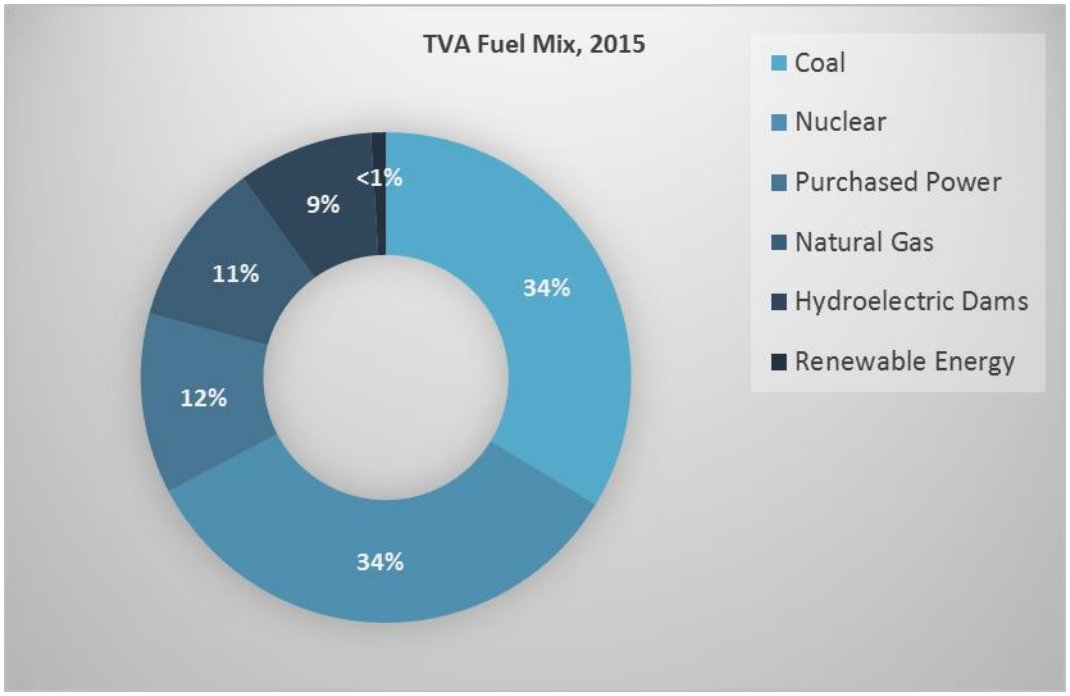


Figure A.1. TVA's Fuel Mix, Calendar Year 2015[46].

Vanderbilt University purchases electricity from NES, the local distributor of power generated by TVA. Monthly consumption of electricity by building was provided by VU Plant Operations. Aggregate annual consumption of electricity in PCA buildings and in ARA buildings were entered into the Campus Carbon Calculator. The specific methods of electricity generation used by TVA were input to the Campus Carbon Calculator.

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. Table A.1 below shows assumed travel patterns based on commuter data[47]:

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 per day, via automobile (miles)
Faculty	86%	6%	6%	2%	150	48
Staff	86%	6%	6%	2%	250	48
Student	10%	8%	2%	80%	150	10

Table A.1. Assumptions for Faculty, Staff and Student Commuter Travel, Calendar Year 2015.

It was determined that faculty and staff in ARAs have an average commuting distance of 24 miles (one-way) and students who do not live on campus have an average commuting distance of 5 miles (one-way)[48].
Commuter distance, commuter patterns and faculty/staff/student populations were input to the Campus Carbon Calculator to determine Vanderbilt's commuting GHG emissions. The University employee population associated with

[46] Page 12 of TVA Annual Report filed with the Securities and Exchange Commission on November 20, 2015. Available at http://www.snl.com/irw/Doc/4063363/Index?did=34600175.
[47] Assumptions based on 2015 data provided by VUMC Parking and Transportation Services and VU Traffic and Parking.
[48] Average commuting distance established by VUMC Parking and Transportation Services and VU Human Resources.

PCAs was provided by Vanderbilt's Human Resources Department. Based on building assignment, separate commuter GHG emission amounts were calculated for ARAs and PCAs. All students and all faculty members (including School of Medicine faculty and School of Nursing faculty) were classified as commuters in the ARA 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

All University-sponsored travel is now recorded by Vanderbilt's travel management tool, Concur, for all faculty, staff and students on Vanderbilt-funded travel. Passenger-miles traveled in the 2015 calendar year were captured in Concur and input to the Campus Carbon Calculator. Air travel miles were proportioned based on the percent of the Vanderbilt population included in ARA and PCA calculations. Since all airline travel is now being tracked, Scope 3 GHG emissions that include air travel emissions increased significantly since 2012 as a result of this new tracking system.

Waste Management

Data related to the amount of waste generated annually by Vanderbilt was provided by VU's 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 Vanderbilt'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 VUMC and from the University was reported separately by the disposal vendor, Waste Management. Solid waste removed from Vanderbilt is disposed of at a Waste Management landfill in Camden, Tennessee. According to Waste Management, 61 percent of landfill gas from this landfill is used to generate electricity, and the remaining 39 percent is "flared" to the atmosphere. Therefore, 61 percent of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emissions factor that is different from the emissions factor developed for flared landfill gas. 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 external, vendor-operated autoclave facility. 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[49]. Using information from SteriCycle[50] and waste industry journals[51], an estimate as to how much natural gas is needed to autoclave one ton of medical waste was created. 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.

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[49] www.ghgprotocol.org
[50] SEMO communication with SteriCycle representatives John Nicklin, Greg Burkett, Marty Desper, and Dan Sullivan.
[51] 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.

Uncertainties Associated with Greenhouse Gas Inventory Calculations

As noted by the WRI Greenhouse Gas Protocol[52], 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 when using a mathematical model such as a GHG calculator. Model uncertainty is due to the uncertainty associated with the mathematical equations (i.e. models) used to characterize the relationships between various parameters and emission processes. The WRI notes that analyzing and quantifying these uncertainties is likely beyond the scope of most institutions when compiling a GHG inventory.

In an effort to balance the inherent uncertainties in this inventory with the need for transparency and comprehensiveness, the GHG inventory results for academic and research areas and patient care areas are presented in Sections III and IV 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.

[52] 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.

APPENDIX B: 2005-2015 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[53]	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
2012	251,669	9,296,428	27.1	12,836	19.6	$572	0.44
2013	259,943	9,109,729	28.5	12,710	20.5	$616	0.42
2014	254,315	9,810,460	25.9	12,757	19.9	$657	0.39
2015	223,565	9,790,758	22.8	12,686	17.6	$682	0.33

Table B.1. GHG Normalization Metrics for Academic & Research Areas, Calendar Years 2005-2015.

Calendar Year	GHG Emissions from Patient Care Areas	GSF – Patient Care Areas	GHG Emissions per 1,000 GSF	Inpatient Days[54]	GHG Emissions per Inpatient Days	Ambulatory Visits[54]	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
2012	158,337	6,183,728	25.6	285,270	0.56	1,725,901	0.092
2013	159,749	6,241,504	25.6	307,292	0.52	1,833,337	0.087
2014	158,361	6,356,787	24.9	310,119	0.51	1,834,856	0.086
2015	144,760	6,357,189	22.8	314,288	0.46	1,855,068	0.078

Table B.2. GHG Normalization Metrics for Patient Care Areas, Calendar Years 2005-2015.

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
2012	410,006	15,480,155	26.49	33,890	12.1
2013	419,692	15,351,233	27.34	35,248	11.9
2014	412,676	16,167,248	25.53	34,022	12.1
2015	368,325	16,147,947	22.81	34,441	10.7

Table B.3. GHG Normalization Metrics for Vanderbilt University, Calendar Years 2005-2015.

[53] According to 2005-2015 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.
[54] VU Financial Report 2015, http://financialreport.vanderbilt.edu/.

Calendar Year	Students[55]	Faculty[56]	Academic & Research Staff[57]	Academic & Research Population (students + faculty + staff)	Patient Care Staff[58]	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
2012	12,836	3,990	6,733	23,559	10,331	33,890
2013	12,710	4,102	8,530	25,342	9,906	35,248
2014	12,757	4,147	7,032	23,936	10,086	34,022
2015	12,686	4,179	6,946	23,811	10,630	34,441

Table. B.4. Population Data Used for Normalization Metrics, Calendar Years 2005-2015.

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
2012	9,296,428	6,183,728	15,480,155
2013	9,109,729	6,241,504	15,351,233
2014	9,810,460	6,356,787	16,167,248
2015	9,790,758	6,357,189	16,147,947

Table B.5. GSF Data Used for Normalization Metrics, Calendar Years 2005-2015.

Calendar Year	Coal Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Power Plant ($MTCO_2E$)	Natural Gas Use: Boilers in Individual Buildings ($MTCO_2E$)	Diesel Fuel Use: Power Plant (MTCO2E)	Total VU GHG Emissions from EPA-Reported Sources ($MTCO_2E$)
2005	96,478	51,695	4,988	n/a	153,161
2006	99,582	38,485	8,155	n/a	146,222
2007	111,344	48,258	6,268	n/a	165,869
2008	102,172	51,358	13,017	n/a	166,547
2009	105,956	64,096	8,705	n/a	178,758
2010	92,090	62,835	4,738	n/a	159,663
2011	87,022	58,405	5,651	n/a	151,078
2012	85,968	56,798	4,770	n/a	147,536
2013	89,490	59,840	5,736	n/a	155,065
2014	72,606	59,712	6,351	391	139,060
2015	0	108,756	5,065	2,580	116,401

Table B.6. Total VU GHG Emissions from EPA-Reported Sources, Calendar Years 2005-2015.

[55]VU Financial Report 2015, http://financialreport.vanderbilt.edu/.
[56] VU Financial Report 2015, http://financialreport.vanderbilt.edu/.
[57] Calculated using data from VU Human Resources (employees by Building, Academic and Research Staff).
[58] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).

Calendar Year	Academic Research Areas (65 percent of total EPA-reported sources emissions) ($MTCO_2E$)	Patient Care Areas (35 percent of total EPA-reported sources emissions) ($MTCO_2E$)	Total VU GHG Emissions from EPA-Reported 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
2012	95,898	51,637	147,536
2013	100,792	54,273	155,065
2014	90,389	48,671	139,060
2015	75,661	40,740	116,401

Table B.7. Allocation of GHG Emissions from EPA Stationary Sources to Academic and Research Areas and Patient Care Areas, Calendar Years 2005-2015.

Calendar Year	Fleet Vehicles ($MTCO_2E$)	Diesel-powered Emergency Generators ($MTCO_2E$)	Refrigerant Releases ($MTCO_2E$)	Anesthetic Gas Use[59] ($MTCO_2E$)	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
2012	2,128	116	120	18	2,381
2013	2,154	116	76	91	2,437
2014	1,988	116	225	31	2,360
2015	1,975	120	142	56	2,292

Table B.8. Academic and Research Areas Scope 1 Emissions from Other Sources, Calendar Years 2005-2015.

Calendar Year	Fleet Vehicles (Life Flight) ($MTCO_2E$)	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	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
2012	1,834	389	434	5,221	7,878
2013	1,655	281	745	3,703	6,384
2014	1,514	119	727	1,956	4,315
2015	1,140	140	236	2,942	4,457

Table B.9. Patient Care Areas Scope 1 Emissions from Other Sources, Calendar Years 2005-2015.

[59] Anesthetic Gas for 2005 and 2006 is not readily available. 2007 data has been used for those two calendar years.
[60] 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 (65 percent of total scope 2 emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35 percent 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
2012	311,313,519	155,221	100,894	54,327
2013	299,441,016	151,549	98,507	53,042
2014	332,824,478	156,601	101,790	54,810
2015	324,039,317	135,525	88,091	47,434

Table B.10. GHG Emissions from Purchased Electricity, Calendar Years 2005-2015[61].

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Air Travel Emissions[62] ($MTCO_2E$)	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
2012	555	7,272	44,668	52,496
2013	613	12,077	45,517	58,207
2014	679	19,887	39,209	59,776
2015	660	17,903	38,959	57,521

Table B.11. Scope 3 Emissions from Academic and Research Areas, Calendar Years 2005-2015.

[61] TVA's published fuel mix for electrical generation for 2005 through 2008 is as follows: coal (64 percent), nuclear (29 percent), and hydroelectric dams (7 percent). TVA's published fuel mix for 2009 electrical generation is as follows: coal (47 percent), nuclear (34 percent), hydroelectric dams (7 percent), natural gas (6 percent), and renewable (6 percent). TVA's published fuel mix for 2010 electrical generation is as follows: coal (51 percent), nuclear (36 percent), hydroelectric dams (9 percent), natural gas (4 percent), and renewable (<1 percent). TVA's published fuel mix for 2011 electrical generation is as follows: coal (52 percent), nuclear (34 percent), hydroelectric dams (9 percent), natural gas (5 percent), and renewable (<1 percent). TVA's published fuel mix for 2012 electrical generation is as follows: coal (41 percent), nuclear (38 percent), hydroelectric dams (9 percent), natural gas (12 percent), and renewables (<1 percent). TVA's published fuel mix for 2013 electrical generation is as follows: coal (43 percent), nuclear (36 percent), hydroelectric dams (9 percent), natural gas (12 percent), and renewables (<1 percent). TVA's published fuel mix for 2014 electrical generation is as follows: coal (44 percent), nuclear (38 percent), hydroelectric dams (9 percent), natural gas (9 percent), and renewables (<1 percent). TVA's published fuel mix for 2015 electrical generation is as follows: coal (34 percent), nuclear (34 percent), hydroelectric dams (9 percent), natural gas (11 percent), purchased electricity (12 percent), and renewable (<1 percent).

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

Calendar Year	Waste Disposal Emissions ($MTCO_2E$)	Commuter Travel + Air 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
2012	1,367	43,127	44,494
2013	1,515	44,535	46,050
2014	1,593	48,972	50,565
2015	1,508	42,664	52,129

Table B.12. Scope 3 Emissions from Patient Care Areas, Calendar Years 2005-2015.

University	Total Emissions (MTCO2E)	Emissions per $1,000 Research Awarded
Cornell University[63]	241,445	0.30
Duke University[64]	274,593	0.27
Emory University[65]	289,129	0.52
Harvard[66]	306,202	0.38
North Carolina State University	233,628	0.52
Rice University[67]	108,443	1.06
Stanford University[68]	177,338	0.20
University of Chicago[69]	114,896	0.24
University of North Carolina- Chapel Hill[70]	497,717	0.52
University of Pennsylvania[71]	294,210	0.35
Vanderbilt University[72]	223,565	0.33
Wake Forest[73]	63363	0.36
Washington University- St. Louis[74]	355,300	0.50
Yale University + Yale Medical Center[75]	181,259	0.28

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

[63] GHG emissions as reported to AASHE-STARS in 2016; 2015 research dollars retrieved from http://www.bestcolleges.com.
[64] GHG emissions as reported to ACUPCC in 2016; 2015 research dollars retrieved from http://www.bestcolleges.com.
[65] GHG emissions as reported to AASHE-STARS in 2014; 2015 research dollars retrieved from http://www.bestcolleges.com.
[66] GHG emissions as reported to EPA in 2015; 2015 research dollars retrieved from Harvard Fact Book.
[67] GHG emissions as reported to ACUPCC in 2014; 2015 research dollars retrieved from Rice At a Glance.
[68] GHG emissions for 2014 retrieved from Stanford Emissions Inventory; 2015 research dollars retrieved from Stanford Facts.
[69] GHG emissions as reported to EPA in 2015; 2015 research dollars retrieved from University of Chicago At a Glance.
[70] GHG emissions as reported to AASHE-STARS in 2012; 2015 research dollars retrieved from http://www.bestcolleges.com.
[71] GHG emissions as reported to ACUPCC in 2012; 2015 research dollars retrieved from http://www.bestcolleges.com.
[72] GHG emissions for CY 2015 from ARAs only.
[73] GHG emissions as reported to AASHE-STARS in 2014; 2015 research dollars retrieved from National Science Foundation.
[74] GHG emissions as reported to AASHE-STARS in 2011; 2015 research dollars retrieved from http://www.bestcolleges.com.
[75] GHG emissions as reported to EPA in 2015; 2015 research dollars retrieved from http://www.bestcolleges.com.

APPENDIX C: 2015 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-Reported Sources			
Natural Gas use at VU Power Plant	70,691	38,065	108,756
Natural Gas use in Individual Buildings	3,292	1,773	5,065
Diesel use at VU Power Plant	1,677	903	2,580
Subtotal of EPA-Reported Emissions:	75,660	40,741	116,401
Other Scope 1 Emissions Sources			
Emergency Generators	120	140	259
Refrigerant Releases	142	236	378
Fleet Vehicles	1,975	1,140	3,115
Anesthetic Gas Use	56	2,942	2,998
Subtotal of Other Scope 1 Emissions:	2,293	4,458	6,750
Scope 2 GHG Emissions: Electricity Purchases			
Electricity Purchased from NES	88,091	47,434	135,525
Scope 3 GHG Emissions: Indirect Sources			
Faculty & Staff Commuting	38,959	42,664	81,623
Air Travel	17,903	7,957	25,859
Waste Disposal	660	1,508	2,168
Subtotal of Scope 3 Emissions:	57,522	52,129	109,650
Total emissions associated with each area per year:	**223,565**	**144,760**	**368,325**

Table C.1. Total Vanderbilt GHG Emissions, Calendar Year 2015.

Source	Volume Consumed (gallons)	Emissions Factor	$MTCO_2E$
Diesel fuel consumed by emergency generators – Academic Areas	11,794	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	120
Diesel fuel consumed by emergency generators – Patient Care Areas	13,759	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	140

Table C.2. GHG Emissions from Emergency Generators, Calendar Year 2015.

Source	Volume Released (kilograms)	Emission Factor	$MTCO_2E$
Refrigerant Releases - Academic Areas	109	1 kilogram of refrigerant = 1.3 $MTCO_2E$	142
Refrigerant Releases – Patient Care Areas	182	1 kilogram of refrigerant = 1.3 $MTCO_2E$	236

Table C.3. GHG Emissions from Refrigerant Releases, Calendar Year 2015[76].

[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).

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Direct sale of gasoline to fleet vehicles through Plant Operations	93,519	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	835
Gasoline purchases by VU PD and Vandy Vans	731	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	7
Estimate of gasoline purchases by remaining fleet vehicles (30 vehicles) [77]	5,625	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	50
Gasoline use by VUMC Shuttle Buses and Vans	105,803	1,000 gallons of gasoline consumed = 8.93 $MTCO_2E$	945
Diesel Fuel use by VUMC Shuttle Buses and Vans	11,615	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	118
Diesel Fuel use by Plant Operations	2,071	1,000 gallons of diesel consumed = 10.14 $MTCO_2E$	21
GHG Emissions from Academic & Research Fleet Vehicles:			1,975

Table C.4. Academic and Research Areas GHG Emissions from Vanderbilt Owned Vehicles, Calendar Year 2015.

Anesthetic Gas	Department	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	Animal Care	187	1 kilogram of Nitrous= 0.298 $MTCO_2E$	56

Table C.5. Academic and Research Areas GHG Emissions from Anesthetic Gas Use, Calendar Year 2015.

Fleet Component	Volume Consumed (gallons)	Emission Factor	Emissions from Fleet Component ($MTCO_2E$)
Jet-A Fuel used by LifeFlight	119,075	1,000 gallons of Jet A Fuel consumed = 9.57 $MTCO_2E$	1,140

Table C.6. GHG Emissions from Patient Care Fleet Vehicles (LifeFlight), Calendar Year 2015.

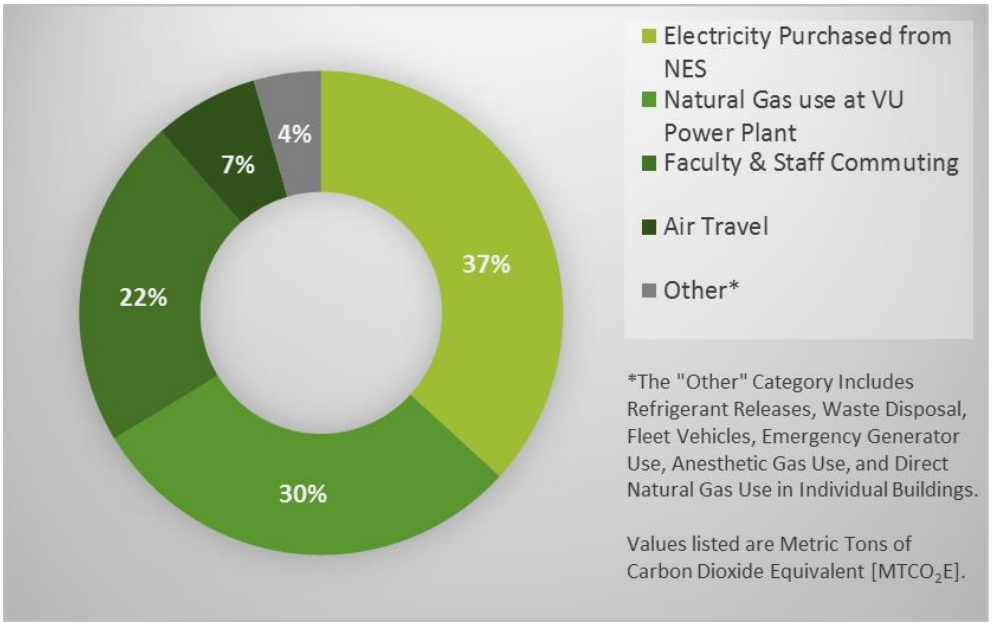

Figure C.1. Vanderbilt GHG Emissions Sources, Calendar Year 2015.

[77] Estimate of gasoline purchases is based on VU IT fleet vehicle use of 4,500 miles per year at 24 miles per gallon.

Anesthetic Gas	Volume Used (kilograms)	Emission Factor	Emissions from Anesthetic Gas Use ($MTCO_2E$)
Nitrous Oxide	7,767	1 kilogram of Nitrous Oxide = 0.298 $MTCO_2E$	2,315
Isoflurane	530	1 kilogram of Isoflurane = 0.350 $MTCO_2E$	186
Desflurane	1.2	1 kilogram of Desflurane = 0.989 $MTCO_2E$	1
Sevoflurane	1,277	1 kilogram of Sevoflurane = 0.345 $MTCO_2E$	441
Total for Anesthetic Gas Use – Patient Care Areas			2,942

Table C.7. Patient Care Areas GHG Emissions from Anesthetic Gas Use, Calendar Year 2015[78].

Kilowatt-Hours Purchased (KwH)	Emission Factor per 1,000 KwH ($MTCO_2E$)	Total Emissions ($MTCO_2E$)	Emissions Associated with Academic & Research Areas (65 percent of total emissions) ($MTCO_2E$)	Emissions Associated with Patient Care Areas (35 percent of total emissions) ($MTCO_2E$)
324,039,317	0.418235	135,525	88,091	47,434

Table C.8. GHG Emissions from Electricity Purchases, Calendar Year 2015[79].

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%
2012	41%	38%	9%	12%	<1%
2013	43%	36%	9%	12%	<1%
2014	44%	38%	9%	9%	<1%
2015	34%	34%	9%	11%	<1%

Table C.9. TVA's published fuel mix for electrical generation for Calendar Years 2005 through 2015.

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

[79] Emission Factor based on TVA's published fuel mix for electrical generation: coal (34 percent), nuclear (34 percent), hydroelectric dams (9 percent), natural gas (11 percent), purchased electricity (12 percent), and renewables (<1 percent).

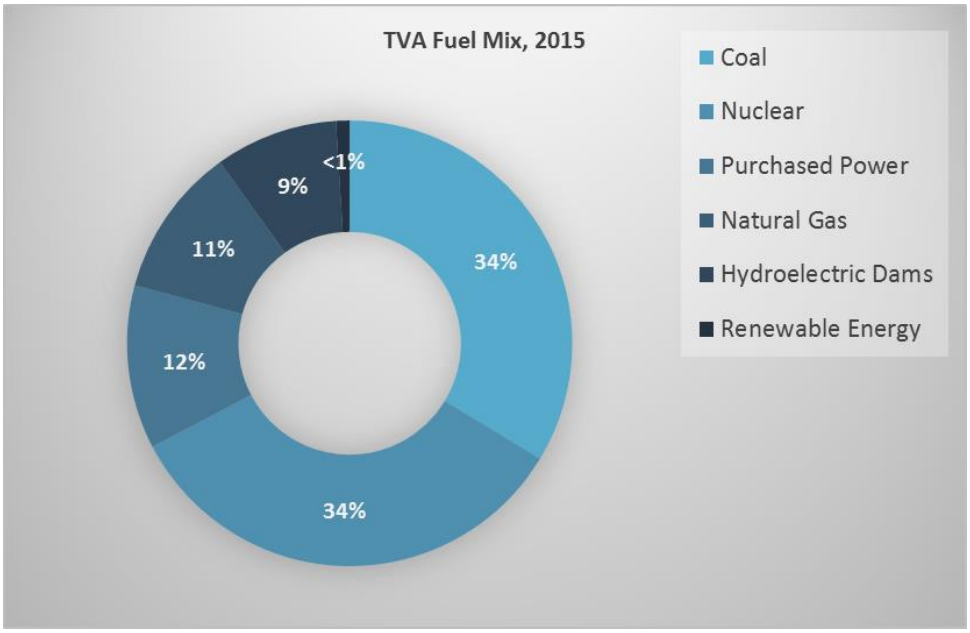

Figure C.2. TVA Fuel Mix, Calendar Year 2015.

	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)[80]
Faculty	86%	6%	6%	2%	150	48
Staff	86%	6%	6%	2%	250	48
Student	10%	8%	2%	80%	150	10

Table C.10. Assumptions for Faculty, Staff, and Student Commuter Travel for Academic & Research Areas, Calendar Year 2015.

Faculty and Staff Commuter Miles for Academic & Research Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
105,236,297	4,309,904	44,224

Table C.11. Estimated Fuel Consumption for Academic and Research Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2015[81].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,309,904	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	38,510
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
44,224	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	448
GHG Emissions Associated with Commuter Travel: Academic & Research Areas ($MTCO_2E$)		**38,959**

Table C.12. Academic and Research Areas GHG Emissions from Commuter Travel, Calendar Year 2015.

[80] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.
[81] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 24 miles per gallon.

Air Passenger-Miles recorded for 2015 x 0.63 [82]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
23,250,275	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	17,903

Table C.13. Academic and Research Areas GHG Emissions from Air Travel, Calendar Year 2015.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	1,729	1 Ton of waste = 0.1745 $MTCO_2E$	302
Waste landfilled with landfill gas combusted to the atmosphere	1,105	1 Ton of waste = 0.3055 $MTCO_2E$	338
Incinerated Waste	93	1 Ton of waste = 0.22 $MTCO_2E$	20.4
Total $MTCO_2E$ Emitted from Waste Disposal:			**660**

Table C.14. Academic and Research Areas GHG Emissions from Waste Disposal, Calendar Year 2015[83].

Cohort	Population Size
Students[84]	12,686
Faculty Members[85]	4,179
University Central Staff[86]	4,075
Research & Administrative Staff in Medical Center[87]	2,871
Total Academic & Research Area Population	23,811
Total PCA Staff on campus [88]	10,630
Off-Site Patient Care Staff[89]	3,475

Table C.15. Population of Students, Faculty, and Staff, Calendar Year 2015.

[82] Passenger-miles traveled provided by VU Finance Travel Specialist/Concur System.
[83] Solid waste removed from Vanderbilt is disposed of at a Waste Management landfill in Camden, Tennessee. According to Waste Management, 61 percent of landfill gas from this landfill is used to generate electricity, and the remaining 39 percent is "flared" to the atmosphere. Therefore, 61 percent of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emissions factor that is different from the emissions factor developed for flared landfill gas.
[84]VU Financial Report 2015, http://financialreport.vanderbilt.edu/.
[85]VU Financial Report 2015, http://financialreport.vanderbilt.edu/. Faculty member population includes faculty from the School of Medicine and School of Nursing.
[86] From *Quick Facts about Vanderbilt University, 2015*. Retrieved December 2014. Available at http://www.vanderbilt.edu/facts.html.
[87] 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.
[88] Calculated using data from VU Human Resources (employees by Building, Medical Center Staff).
[89] 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.

Disposal Method	Solid Waste Disposal (Tons)	Emission Factor	Waste Disposed * Emission Factor = $MTCO_2E$
Waste landfilled with landfill gas recovery converted to electricity	3,925	1 Ton of waste = 0.1745 $MTCO_2E$	685
Waste landfilled with landfill gas combusted to the atmosphere	2,509	1 Ton of waste = 0.3055 $MTCO_2E$	765
Incinerated Waste	7	1 Ton of waste = 0.22 $MTCO_2E$	2
Medical Waste Autoclaved Off-Site	231	1 Ton of waste = 0.243 $MTCO_2E$	56
Total $MTCO_2E$ Emitted from Waste Disposal:			**1,508**

Table C.16. Patient Care Areas GHG Emissions from Waste Disposal, Calendar Year 2015[90].

	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)[91]
Staff	86%	6%	6%	2%	250	48

Table C.17. Assumptions for Staff Commuter Travel for Patient Care Areas, Calendar Year 2015.

Staff Commuter Miles for Patient Care Areas	Gasoline Consumed (gallons)	Diesel Fuel Consumed (gallons)
115,121,276	4,730,283	39,205

Table C.18. Estimated Fuel Consumption for Patient Care Areas by Commuters Based on Commuter Miles Traveled, Calendar Year 2015[92].

Gasoline Consumed (estimated gallons)	Emission Factor	GHG Emissions ($MTCO_2E$)
4,730,283	8.93 $MTCO_2E$ per 1,000 gallons of gasoline consumed	42,266
Diesel Fuel Consumed (estimated gallons)	**Emission Factor**	**GHG Emissions ($MTCO_2E$)**
39,205	10.14 $MTCO_2E$ per 1,000 gallons of diesel consumed	398
GHG Emissions Associated with Commuter Travel: Patient Care Areas ($MTCO_2E$)		**42,664**

Table C.19. Patient Care Areas GHG Emissions from Commuter Travel, Calendar Year 2015.

[90] Solid waste removed from Vanderbilt is disposed of at a Waste Management landfill in Camden, Tennessee. According to Waste Management, 61 percent of landfill gas from this landfill is used to generate electricity, and the remaining 39 percent is "flared" to the atmosphere. Therefore, 61 percent of Vanderbilt's solid waste volume is multiplied by a greenhouse gas emissions factor that is different from the emissions factor developed for flared landfill gas.
[91] Average Commute Distance established by VUMC Parking and Transportation Services and VU Human Resources.
[92] The fuel consumption estimate is based on a standard value provided by Clean Air - Cool Planet of 24 miles per gallon.

Air Passenger-Miles recorded for 2015 x 0.28 [93]	Emission Factor	(Passenger-miles/1000) * Emission Factor = $MTCO_2E$
10,333,455	0.77 $MTCO_2E$ per 1,000 passenger-miles travelled	7,957

Table C.20. Patient Care Areas GHG Emissions from Air Travel, Calendar Year 2015.

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)
20,475,720	53.06	0.1	0.001		108,644
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 * 25)
20,475,720	0.001	0.1	0.001	2.05	51
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 * 298)
20,475,720	0.0001	0.1	0.001	0.20	61
Total GHG Emissions from On-Campus Natural Gas Combustion ($MTCO_2E$):					**108,756**
Partitioning of Emissions					
Academic & Research Area Emissions from On-Campus Natural Gas Combustion (65 percent of total emissions) ($MTCO_2E$):					**70,691**
PCA Emissions from On-Campus Natural Gas Combustion (35 percent of total emissions) ($MTCO_2E$):					**38,065**

Table C.21. Calculations for GHG Emissions from On-Campus Natural Gas Combustion at the Co-Generation Power Plant, Calendar Year 2015[94].

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)
953,589	53.06	0.1	0.001		5,060
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 * 25)
953,589	0.001	0.1	0.001	0.10	2
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 * 298)
953,589	0.0001	0.1	0.001	0.01	3
Total GHG Emissions from Natural Gas Consumption in Buildings ($MTCO_2E$):					**5,065**
Partitioning of Emissions					
Academic & Research Area Emissions from Natural Gas Consumption in Buildings (65 percent of total emissions) ($MTCO_2E$):					**3,292**
Patient Care Areas Emissions from Natural Gas Consumption in Buildings (35 percent of total emissions) ($MTCO_2E$):					**1,773**

Table C.22. Calculations for GHG Emissions from On-Campus Natural Gas Consumption in Individual Buildings, Calendar Year 2015[95].

[93] Passenger-miles traveled provided by VU Finance Travel Specialist/Concur System.

[94] 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 2005-2012, GHG calculations for natural gas consumption were based on cubic feet of natural gas * heat value, which is equivalent to therms.

[95] 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 2005-2012, GHG calculations for natural gas consumption were based on cubic feet of natural gas * heat value, which is equivalent to therms.