SUSTAINABILITY · UVA
From the Grounds Up

UNIVERSITY OF VIRGINIA

2016 GREENHOUSE GAS INVENTORY REPORT

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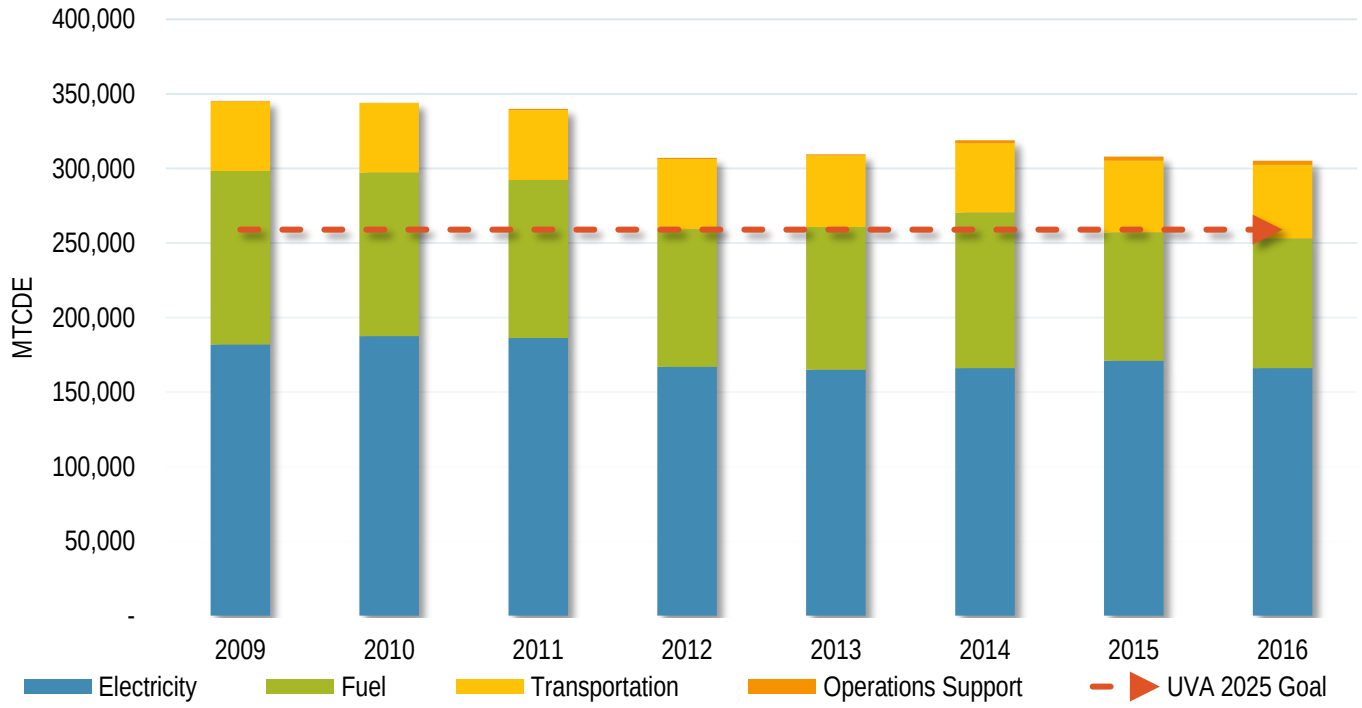
Executive Summary

In 2011, the University of Virginia's Board of Visitors committed to reduce greenhouse gas (GHG) emissions University-wide 25 percent below 2009 levels by 2025. To track progress, UVA's Greenhouse Gas Inventory Report is calculated annually by the Office for Sustainability, and reviewed by others within Facilities Management. This report defines UVA's GHG accounting methodology, documents the current footprint, and analyzes the observed emission trends to target areas for further reductions to meet the 2025 goal.

In Calendar Year 2009, the baseline year for emissions analysis, UVA's GHG emissions footprint was 345,196.4 Metric Tons of Carbon Dioxide Equivalent (MTCDE). In 2016, emissions decreased to 305,030.1 MTCDE, resulting in a. 11.6 percent reduction in emissions compared to 2009.

Figure 1: UVA GHG Emissions by Source, 2009-2016



UVA's 2016 GHG Inventory Report recalculated emission estimates for the entire time-series of reported emissions from 2009 to 2015, resulting in updated totals and percentage reductions from what was reported in previous years. According to the IPCC and the U.S. Inventory of GHG Emissions and Sinks, it is generally accepted as good practice to revise emission estimates from previous years to incorporate improved data collection or analysis methodologies, or to incorporate better and/or more relevant data. The most significant recalculations in UVA's reported GHG emissions were caused by the revised regional electricity emissions factors from EPA's eGRID Database. eGrid periodically updates its emissions factors to reflect changes in plant generation ownership and/or generation process in a specific region. A smaller emissions rate (lbs of emissions / MWh of electricity generated) would imply that the electricity generation process for that region is more efficient or uses a cleaner fuel mix than that of a region with a higher emissions rate.

It is important to note that the GHG emissions include the Health System, which contributes approximately 40 percent of the total emissions produced by the University. Additionally, the expansion to the University's offerings has resulted in growth in both population and building area. Since 2009, there has been a population increase of 2,207 students, faculty, and staff (a 5.2 percent increase). To support the University's growth, 48 facilities have been constructed or acquired since 2009, resulting in an increase of approximately 2.4 million square feet (a 16.2 percent increase) included within the boundaries defined for UVA's GHG inventory. The University's commitment to achieving this goal in light of the continuing expansion is driving heavy investments in expanding sustainability efforts to enhance the University's operations and building portfolio.

Methodology

This CY2016 GHG Inventory was developed using the Campus Carbon Calculator (CCC), version 9.0, formally the Clean-Air Cool Planet (CA-CP) calculator, developed by the University of New Hampshire. The methodologies in this tool are aligned with the recommendations of the American College and University Presidents' Climate Commitment (ACUPCC) guidance, which refers to The Climate Registry's General Reporting Protocol and the World Resource Institutes' Greenhouse Gas Protocol Corporate Accounting and Reporting Standard.

Inventory Boundary

On the most basic level, UVA emissions include any emissions related to the functional operation of the University. The "Operational Control Approach" best aligns with the boundaries established for this inventory – "accounting for GHG emissions from operations under its operational control, which refers to the authority to introduce and implement operating policies at an operation." This boundary includes all major emission sources on campus (Grounds), including purchased electricity, energy usage on Grounds, transportation, and operational support. The Inventory includes all owned properties in the City of Charlottesville, Albemarle County, as well as some remote research buildings in the Commonwealth of Virginia (namely Mountain Lake Biological Station, and Anheuser-Busch Coastal Research Center). These buildings have either electricity provided through a UVA substation, a direct electricity feed and a bill paid by Facilities Management, or thermal energy provided from one of UVA's heating or chiller plants. Leased properties, UVA Foundation properties, the College at Wise, and UVA property in other geographic locations are not currently included in this GHG Inventory boundary.

The CCC calculates GHG emissions from activities that produce carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and refrigerants. Emissions of CH_4, N_2O, and refrigerants are converted to metric tons of carbon dioxide equivalent (MTCDE) using Global Warming Potentials (GWPs) provided by the Intergovernmental Panel on Climate Change's Assessment Reports. This allows UVA to calculate a total carbon emissions Inventory for the University.

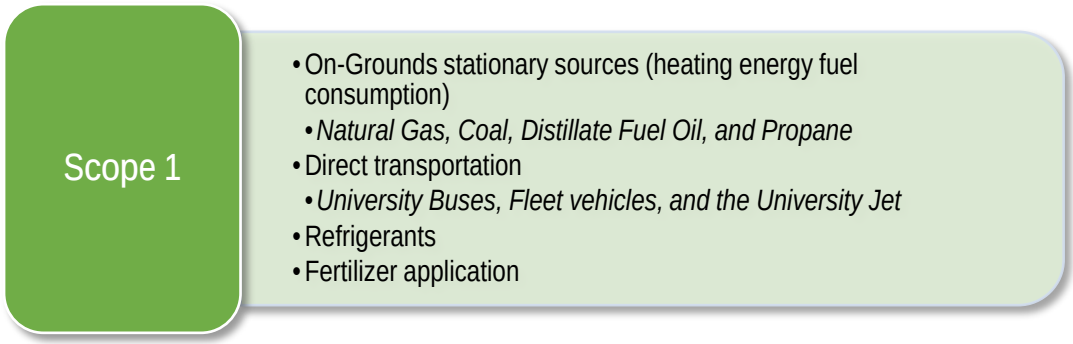
GHG Emission Sources

UVA's GHG emissions are generated from four distinct sources: Electricity, Fuel, Transportation, and Operations Support. Electricity includes purchased electricity as well as transmission and distribution losses. Fuel includes coal, natural gas, distillate oil, and propane used on Grounds. Transportation includes direct emissions from fleet vehicles used as well as student, faculty, and staff commuting. Operations Support includes fertilizer, refrigerants, solid waste, and wastewater emissions, which are all necessary for the functioning of the University. Based on standard GHG accounting protocols and definitions, these emission sources are grouped into three "Scopes" defined on the controllability of each emissions source by the University.

Scope 1

Figure 2 refers to any GHG emissions that are a direct result of operations owned or controlled by the University.

Figure 2: Scope 1 GHG Source Categories



Scope 2

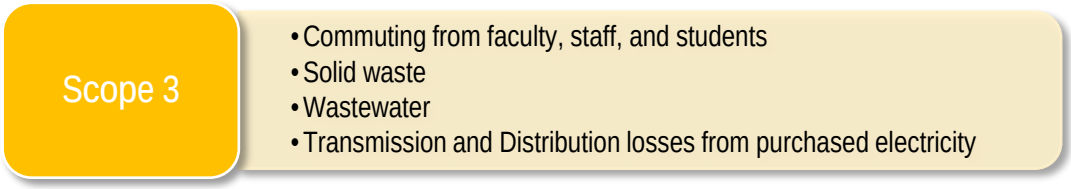
Figure 3 refers to indirect GHG emissions that are a consequence of activities within the organizational boundaries of the institution, but occur at sources owned or controlled by another entity.

Figure 3: Scope 2 GHG Source Categories

Scope 3

Figure 4 refers to all Scope 3 indirect emissions included in UVA's GHG Inventory. It is important to note there are a number of Scope 3 sources not included in UVA's GHG Inventory such as study abroad travel, holiday travel, and business travel. These emission sources have not been included because University-wide reporting methods do not currently exist in the appropriate capacity to generate accurate information. Likewise, GHG emissions from purchased paper is not included in this Inventory because a method of accurately accounting for paper purchasing on a University-wide basis is not available.

Figure 4: Scope 3 GHG Source Categories



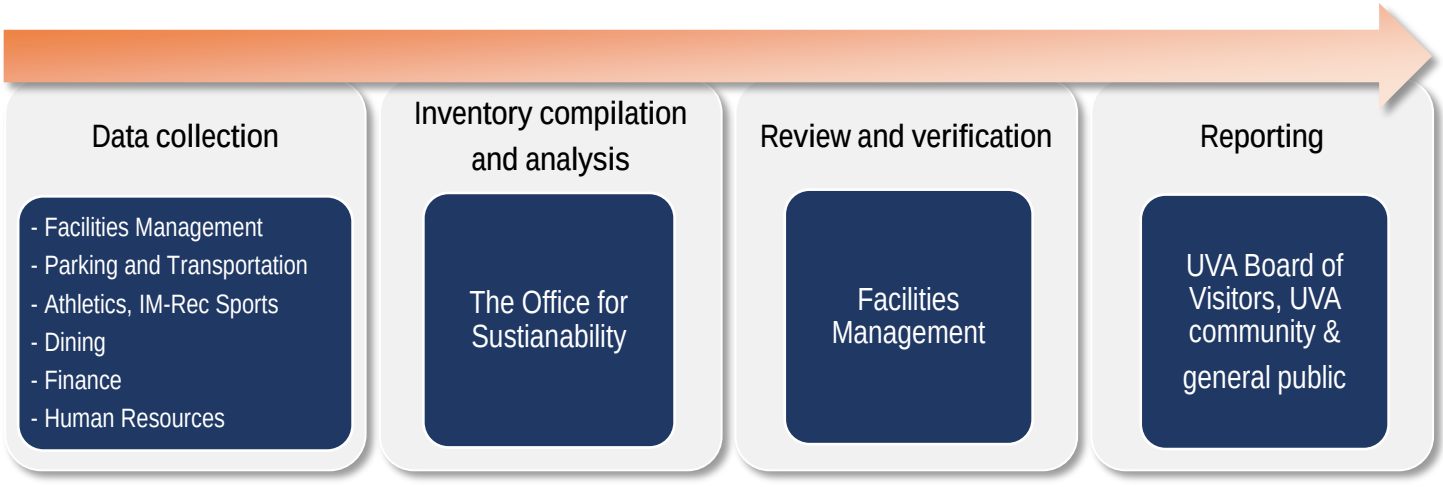
Data Collection

Data input to the CA-CP calculator is derived from a variety of University personnel and sources. Fuel and electricity consumption is metered and records retained by Facilities Management. Direct transportation fuel consumption is maintained by Parking and Transportation. Refrigerant use is sourced from a variety of locations with Facilities Management and Dining being the primary contributors. Fertilizers are used and logged by Landscaping (Facilities Management), Athletics, and Intramural-Recreational Sports (IM-Rec).

Institutional Arrangements

Figure 5 portrays UVA's institutional arrangements regarding the GHG Inventory process.

Figure 5: UVA GHG Inventory Institutional Arrangements



Recalculations

UVA's 2016 GHG Inventory Report recalculated emission estimates for the entire time-series of reported emissions from 2009 to 2015. According to the IPCC[1] and the U.S.Inventory of GHG Emissions and Sinks[2], it is generally accepted as good practice to revise emission estimates from previous years to incorporate improved data collection or analysis methodologies, or to incorporate better and/or more relevant data.

The most significant recalculations in UVA's reported GHG emissions were caused by the revised regional electricity emissions factors from EPA's eGRID Database. EPA's eGRID Database is the preeminent source of air emission data for the electric power sector. Emission data from EPA are carefully integrated with generation data from EIA to produce useful values like pounds of emissions per megawatt-hour of electricity generation (lb/MWh), which allows direct comparison of the environmental attributes of electricity generation.[3] eGrid periodically updates its emissions factors to reflect changes in plant generation ownership and/or generation process in a specific region. A smaller emissions rate (lbs of emissions / MWh of electricity generated) would imply that the electricity generation process for that region is more efficient or uses a cleaner fuel mix than that of a region with a higher emissions rate. Over time, it is expected that the emissions rate of a region will decrease due to new technologies improving the generation process or the increased use of natural gas and/or newewables to replace dirtier fuels, such as coal. It is accurate then, for eGRID to take these changes into consideration and produce revised emission factors, so users, such as UVA, can more accurately calculcate their GHG footprint and track progress towards reduction goals.

1 Intergovernmental Panel on Climate Change, 2006 Guidelines for GHG Inventories, General Guidance and Reporting, Time Series Consistency: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_5_Ch5_Timeseries.pdf
2 U.S. Inventory of GHG Emissions and Sinks: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks
3 Emissions & Generation Resource Integrated Database: https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid

2016 GHG Emissions Summary

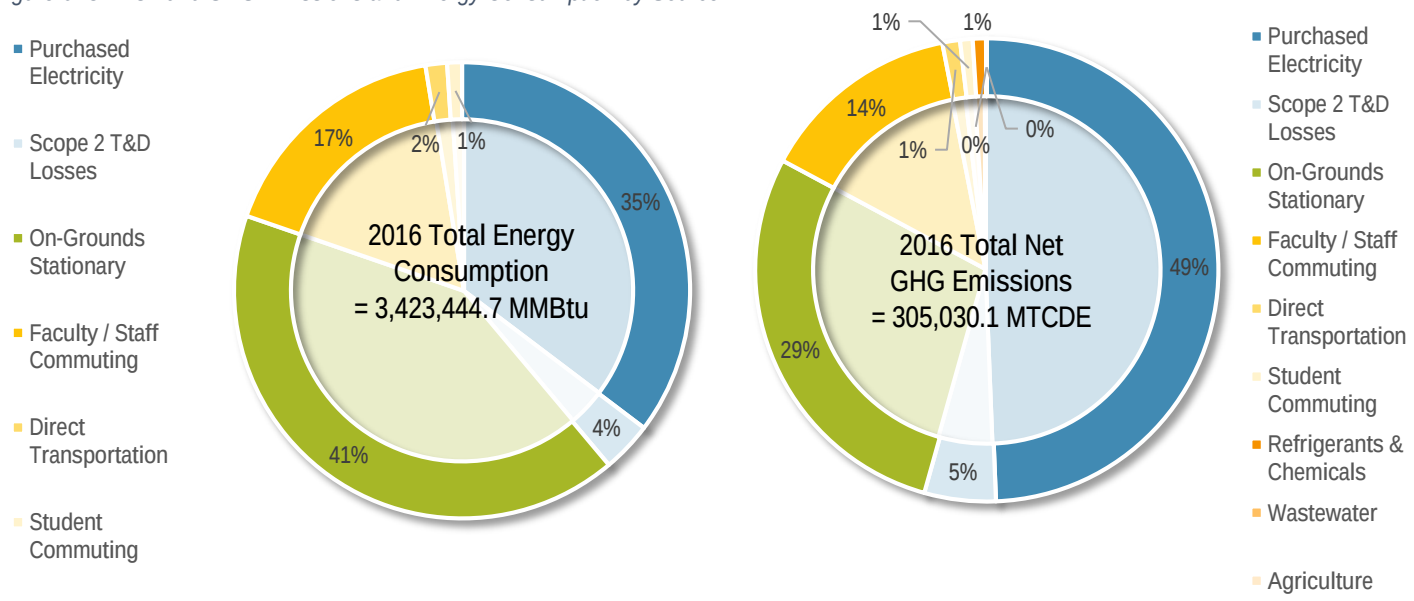
The University of Virginia generated 305,030.1 MTCDE of emissions in 2016, an 11.6 percent reduction in net total emissions since 2009 and a 0.9 percent reduction relative to 2015. The reduction relative to 2015 is largely a result of a reduction in total electricity consumption, reduced coal consumption on-Grounds, a shorter heating season, and energy efficiency activities in existing buildings. Table 1 and Figure 6 below reports UVA's 2016 GHG emissions and energy consumption by both source and scope.

Table 1: UVA's 2016 GHG Emissions and Energy Consumption by Source and Scope

GHG Scope	Energy Consumption (MMBtu)	Carbon Dioxide Equivalent (Metric Tons)	% of total Gross Emissions	% Change from 2015	% Change from 2009
Scope 1 Totals	1,470,431.3	93,517.5	30.6%	0.7%	-22.3%
On-Grounds Stationary	1,418,227.5	86,917.5	28.5%	0.9%	-25.3%
Direct Transportation	52,203.8	3,766.5	1.2%	-2.4%	3.1%
Refrigerants & Chemicals	NO	2,814.7	0.9%	-0.8%	572.8%
Agriculture	NO	18.7	0.0%	-28.8%	-49.8%
Scope 2 Totals	1,208,667.6	150,711.7	49.4%	-2.9%	-8.9%
Purchased Electricity	1,208,667.6	150,711.7	49.4%	-2.9%	-8.9%
Scope 3 Totals	744,345.8	60,800.9	20.0%	1.7%	2.6%
Faculty / Staff Commuting	586,418.4	43,011.3	14.1%	3.4%	6.4%
Student Commuting	35,898.2	2,670.8	0.9%	1.8%	7.4%
Solid Waste	NO	(245.5)		3.6%	9.6%
Wastewater	NO	148.2	0.0%	-7.0%	-34.3%
Scope 2 T&D Losses	122,029.2	15,216.1	5.0%	-2.9%	-7.0%
Total Net	3,423,444.7	305,030.1		-0.9%	-11.6%

NO = Not Occurring
Note: Totals may not sum due to independent rounding

Figure 6: UVA's 2016 GHG Emissions and Energy Consumption by Source



By Scope

When broken down by Scope, UVA's largest contributor to overall net emissions is Scope 2, which accounts for purchased electricity. Since 2009, Scope 2 has consistently accounted for approximately 50 percent of UVA's total net emissions inventory with 2016 following the trend at 49.4 percent. Scope 1 emissions contributed the second most (30.7 percent) while Scope 3 emissions contributed the remainder (19.9 percent). Both Scope 1 and 2 emissions have decreased since 2009, by 22.3 and 8.9 percent, respectively, while Scope 3 emissions have increased by 2.6 percent.

Figure 7: UVA GHG Emissions by Scope, 2009-2016

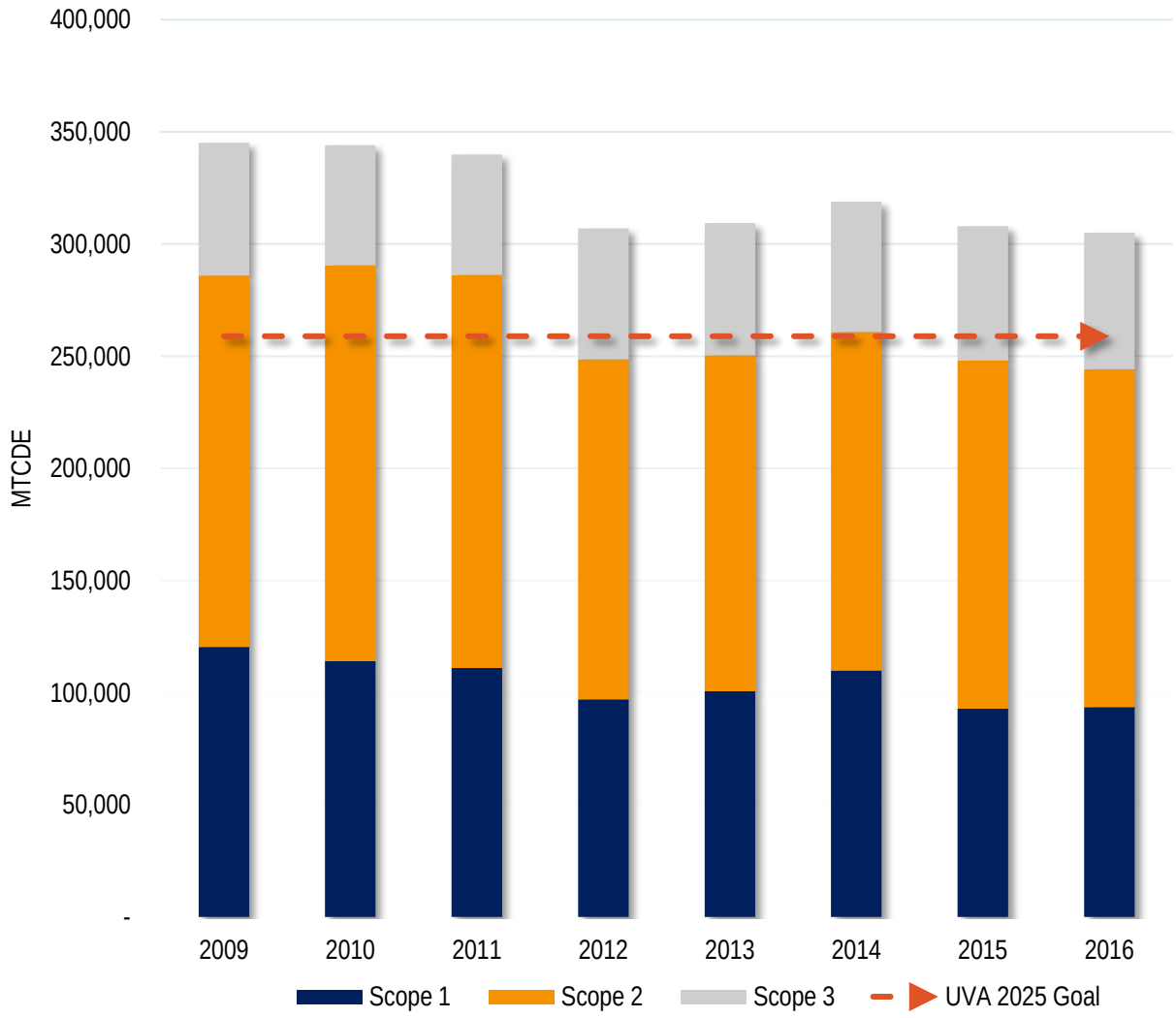


Table 2: UVA GHG Emissions by Scope (MTCDE), 2009-2016

GHG Scope	2009	2010	2011	2012	2013	2014	2015	2016
Scope 1	120,407.6	114,082.2	110,925.7	96,985.6	100,544.8	109,889.1	92,898.5	93,517.5
Scope 2	165,510.0	176,499.4	175,362.2	151,627.8	149,806.9	150,853.9	155,199.7	150,711.7
Scope 3	59,278.8	53,396.6	53,592.3	58,345.6	58,990.2	58,108.8	59,805.8	60,800.9
Total Net Emissions	345,196.4	343,978.2	339,880.2	306,959.1	309,342.0	318,851.8	307,904.1	305,030.1

By Source

In 2016, emissions from electricity, including purchased electricity and its associated transmission and distribution losses, accounted for 54.4 percent of total net emissions. Electricity has consistently remained the largest contributor to overall emissions, contributing an annual average of 54.0 percent of total net emissions since 2009. Emissions associated with fuel consumption account for the second largest part of UVA's 2016 GHG inventory at 28.5 percent while Transportaion and Operations Support accounted for 16.2 and 0.9 percent, respectively. Electricity and fuel emissions have decreased since 2009 by 8.8 and 25.3 percent, respectively while Transportation and Operations Support emissions have increased from 2009 by 6.2 and 498.4 percent, respectively.

Figure 8: UVA GHG Emissions by Source, 2009-2016

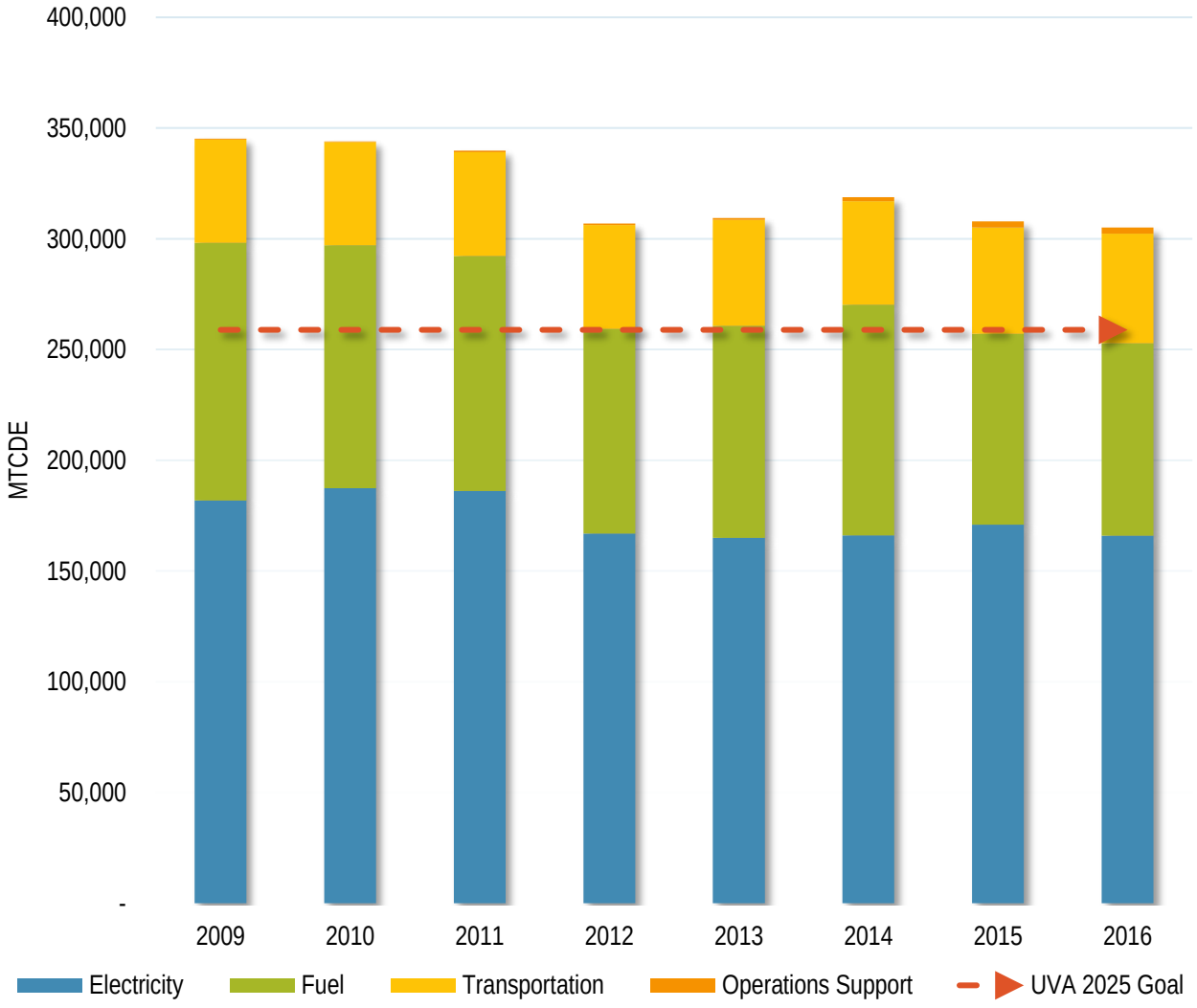


Table 3: UVA GHG Emissions by Source (MTCDE), 2009-2016

GHG Scope	2009	2010	2011	2012	2013	2014	2015	2016
Electricity	181,879.1	187,408.4	186,201.0	166,936.5	164,931.7	166,084.4	170,868.9	165,927.8
Fuel	116,298.5	109,720.7	106,095.9	92,332.0	95,827.9	104,140.6	86,174.1	86,917.5
Transportation	46,561.5	46,560.7	46,767.4	46,973.4	47,766.1	46,713.7	48,074.8	49,448.6
Operations Support	457.2	288.4	815.9	717.2	816.4	1,913.1	2,786.2	2,736.2
Total Net Emissions	345,196.4	343,978.2	339,880.2	306,959.1	309,342.0	318,851.8	307,904.1	305,030.1

Electricity

Electricity consumption continues to be the largest source of greenhouse gas emissions at the University. In 2016, purchased electricity and its associated transmission and distribution losses accounted for 165,927.8 MTCDE, or 54.4 percent of total UVA emissions. This was a 4,941.1 MTCDE (2.9 percent) decrease from 2015 and a 15,951.4 MTCDE (8.8 percent) decrease from 2009 levels. UVA purchases the vast majority of electricity from Dominion Virginia Power. This electricity is used primarily for cooling and core electrical services such as lighting and plug loads. Transmission and distribution (T&D) losses stem from electricity (calculated as a percentage of total electricity consumption), and are included in this category despite being tracked as part of Scope 3 emissions.

Figure 9: UVA Electricity GHG Emissions by Source, 2009-2016, and 2016 Snapshot

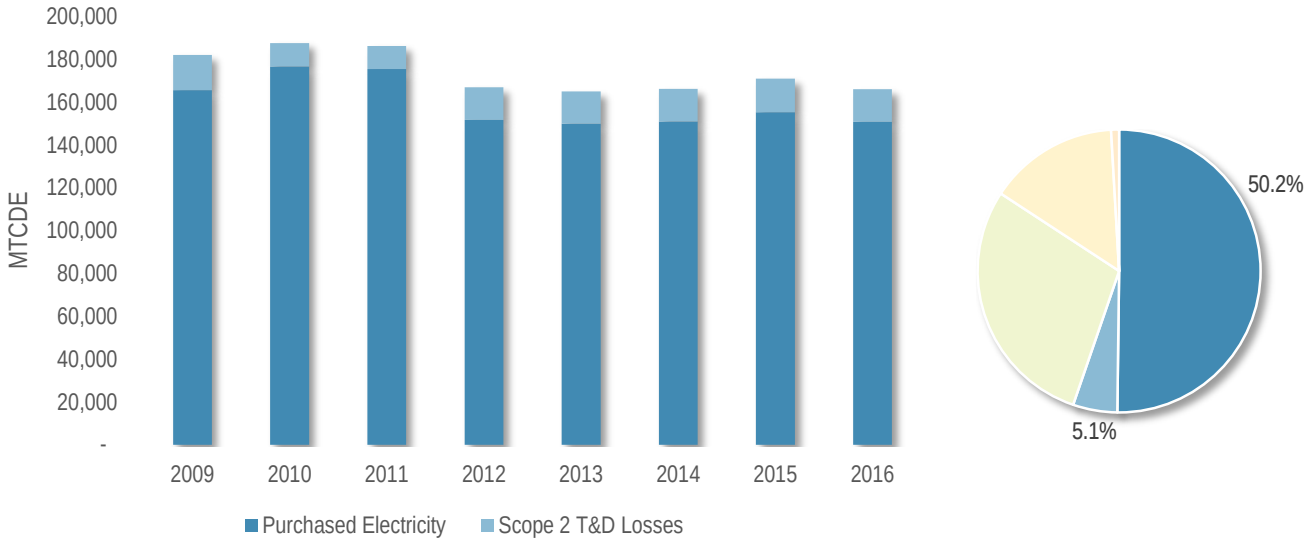


Table 4: UVA Electricity Emissions (MTCDE) Trends, 2009-2016

Purchased Electricity	2009	2015	2016	% change from '15	% change from '09
Purchased Electricity	165,510.0	155,199.7	150,711.7	-2.9%	-8.9%
T&D Losses	16,369.1	15,669.2	15,216.1	-2.9%	-7.0%
Total Electricity Emissions	181,879.1	170,868.9	165,927.8	-2.9%	-8.8%

As seen in Table 5 below, there has been a 1.1 percent increase in total purchased electricity compared to 2009. Over the same period, however, total emissions attributed to purchased electricity have seen an 8.9 percent decrease. This discrepancy is due to a decrease in EPA's eGRID emissions factors and represents a transition to a cleaner regional electric grid fuel mix from 2009 to 2016.

Table 5: UVA Electricity Consumption (MMBtu) Trends, 2009-2016

Purchased Electricity	2009	2015	2016	% change from '15	% change from '09
Purchased Electricity	1,195,928.7	1,244,660.4	1,208,667.6	-2.9%	1.1%
T&D Losses	118,278.7	125,663.1	122,029.2	-2.9%	3.2%
Total Electricity Consumption	1,314,207.3	1,370,323.4	1,330,697	-2.9%	1.3%

Despite the increase in purchased electricity, UVA continues to implement initiatives to curb the use of electricity on-Grounds. In 2016 UVA saw continued success in implementing LED lighting technology in exterior lighting, building retrofits through Delta Force projects, and in new construction and renovation projects. Additionally, continuous reminders of building occupant energy awareness along with specialized events throughout the year have contributed to UVA's goal. These activities have helped UVA offset the expected consumption and emissions from the approximately 48 new facilities, or 2.7 million square feet, added by the University since 2009.

Cooling

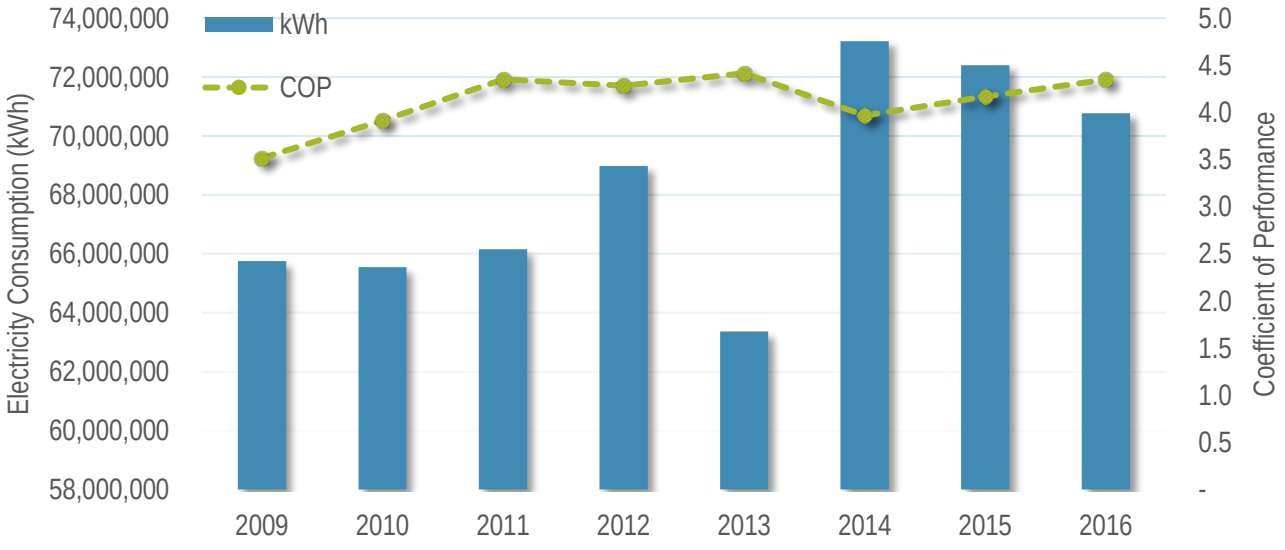
Much of UVA's electricity consumption is used to cool buildings. The primary means of cooling buildings on-Grounds is through chilled water produced by electrically driven, water-cooled chillers housed in chiller plants across Grounds. A variety of other direct-expansion cooling systems are employed by UVA's portfolio, ranging from window-mounted air conditioning units, to dedicated building-level chillers. However, energy use of these non-centralized cooling systems are captured by building level electricity meters and cannot be isolated.

Since 2009, electricity consumed by the central chiller plants has increased by over 5 million kWh, or 7.6 percent. This is a direct result of connecting more facilities, either new facilities or previously stand-alone buildings, to a central chiller plant. Consumption has continued to decrease from 2014 however, from approximately 73.2 million kWh to 70.8 million kWh. From 2015, specifically, the electricity consumption from chiller plants has decreased by approximately 1.6 million kWh, or 2.2 percent. Examples of projects that had a significant impact on energy efficiency at the chiller plants include expanding the Automatic Tube Cleaning System at the South Chiller plant, interconnecting the Newcomb and Central Grounds chilled water loops, operating and maintaining the newly renovated North Grounds Mechanical plant, upgrading the South Chiller Plant cooling towers, and collaborating with engineering students to review operation of the Thermal Storage tank. Since 2009, chiller plant efficiencies, or coefficients of performance (COP), have improved by 23.7 percent. This information is communicated below in Table 6 and Figure 10.

Table 6: UVA Chiller Plant Consumption (kWh) and Emissions (MTCDE) Trends, 2009-2016

	2009	2015	2016	% change '15	% change '09
Total Electricity Consumed (kWh) by Chiller Plants	65,755,529.1	72,399,623.9	70,770,860.3	-2.2%	7.6%
Total Chiller Plant Emissions	34,058.6	38,589.8	38,039.5	-1.4%	11.7%
Chiller Plant COP	3.5	4.2	4.3	4.4%	23.7%

Figure 10: UVA Chiller Plant Consumption and Coefficients of Performance, 2009-2016



Fuel (On-Grounds Stationary Sources)

The majority of UVA's Scope 1 emissions stem from On-Campus Stationary fuels used for heating. These sources include coal, natural gas, distillate oil, and propane gas. In 2016, these sources accounted for 89,917.5 MTCDE, or 28.5 percent of UVA's total net emissions. This was a 743.4 MTCDE (0.9 percent) increase from 2015 and a 29,381.0 MTCDE (25.3 percent) decrease from 2009 levels. UVA successfully diminished coal use to 18.9 percent of the total heating energy source, replacing it with natural gas to continue to meet heating demand. More significantly, the heating plant completely eliminated the use of coal during the summer months (June-September), continuing a practice that occurred in both 2015 and 2009. The fuel switch from coal to natural gas continues to provide UVA with the largest overall emissions reductions from 2009 due to the cleaner combustion of natural gas. UVA aims to eliminate the use of coal in the Main Heating Plant by 2025.

Figure 11: UVA On-Grounds Stationary Combustion Emissions (MTCDE) Trends, 2009-2016, and 2016 Snapshot

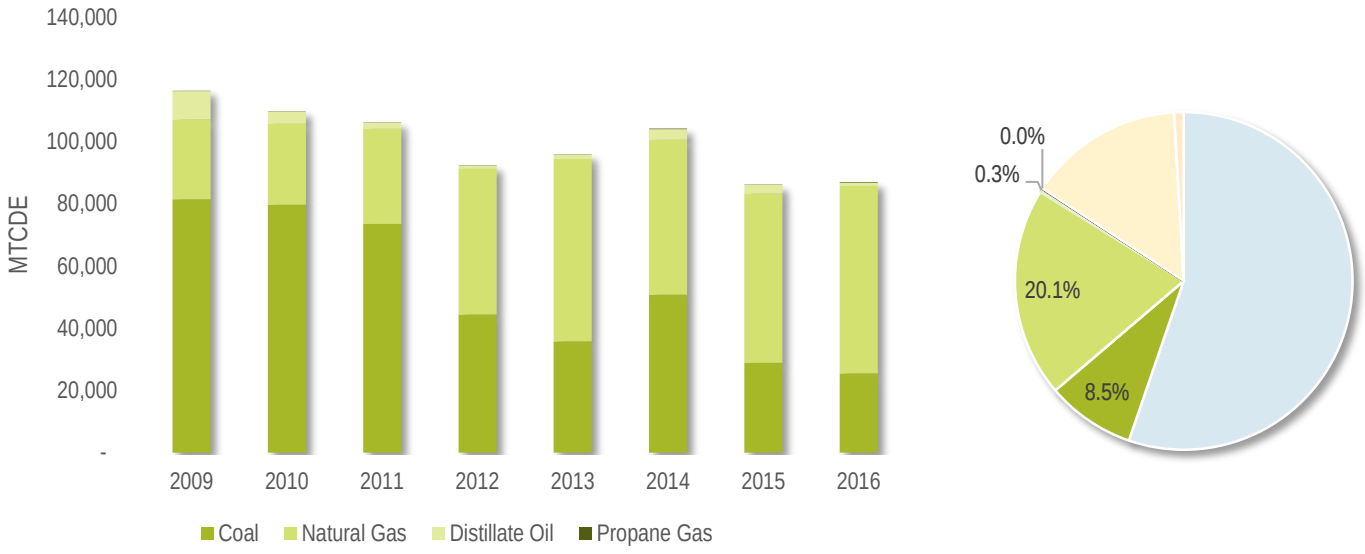


Table 7: UVA On-Grounds Stationary Combustion Emissions (MTCDE) Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Coal	81,444.7	28,830.1	25,479.1	-11.6%	-68.7%
Natural Gas	25,608.0	54,425.7	60,306.8	10.8%	135.5%
Distillate Oil	9,110.4	2,733.7	1,012.0	-63.0%	-88.9%
Propane Gas	135.4	184.7	119.7	-35.2%	-11.6%
Total On-Grounds Fuel Emissions	116,298.5	86,174.1	86,917.5	0.9%	-25.3%

When observed over time, it is apparent how significant natural gas has become in UVA's fuel mix, increasing from 32.9 percent of total heating energy in 2009 to 80.0 percent in 2016. Alternatively, coal's contribution to UVA's overall heating energy has decreased significantly from 58.6 percent in 2009 to 18.9 percent in 2016. Although it has decreased considerably since 2009, coal use at UVA has fluctuated between 2009 and 2016. The most recent and significant fluctuation in coal use between 2009 and 2016 occurred in 2014 when UVA experienced a much colder than normal winter, resulting in a shortage of the natural gas supply during this time. In response to this shortage, UVA's gas service to the Main Heating Plant combusted additional coal to continue to meet peak demand.

While fuel switching has significantly reduced emissions from on-Grounds Stationary Combustion, additional actions also contributed to this success. Some other emission reduction activities include the replacement of boilers at the North Grounds Mechanical Plant with low temperature hot water generators and heat recovery chillers, the burner replacements at Massie Road Plant, and the continued

improvements spearheaded by the Delta Force program. Table 8 below shows the changes in UVA's fuel consumption from 2009 through 2016.

Table 8: UVA On-Grounds Stationary Fuel Consumption (MMBtu) Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Coal	857,263.4	303,696.3	268,397.4	-11.6%	-68.7%
Natural Gas	481,505.3	1,023,679.1	1,134,295.3	10.8%	135.6%
Distillate Oil	122,436.2	36,761.2	13,608.5	-63.0%	-88.9%
Propane Gas	2,177.4	2,973.6	1,926.4	-35.2%	-11.5%
Total On-Grounds Fuel Consumption	1,463,382.2	1,367,110.2	1,418,227.5	3.7%	-3.1%

Transportation

Transportation emissions includes the impacts of the University's vehicle fleet, categorized as Direct Transportation, as well as the impact of UVA's faculty, staff, and student commuting practices. The UVA vehicle fleet portion of emissions includes the University-owned Transit System buses, cars, maintenance vehicles, and the University jet. These vehicles are considered under Scope 1 emissions because the University has direct control of these sources. On the other hand, the emissions associated with faculty, staff, and student commuting are included in Scope 3 because they are not under the direct control of UVA. These emissions are estimated from the approximate miles students, faculty, and staff travel to and from the University each day. This information is collected through a University-wide survey that is conducted every two to three years. The next survey will be administered in 2017. As seen in Figure 12 and Table 9 below, transportation emissions accounted for 49,448.6 MTCDE, or 16.2 percent of total 2016 UVA emissions. This was a 1,373.8 MTCDE (2.9 percent) increase from 2015 and a 2,887.1 MTCDE (6.2 percent) increase from 2009 levels.

Figure 12: UVA Transportation Emissions (MTCDE) Trends, 2009-2016, and 2016 Snapshot

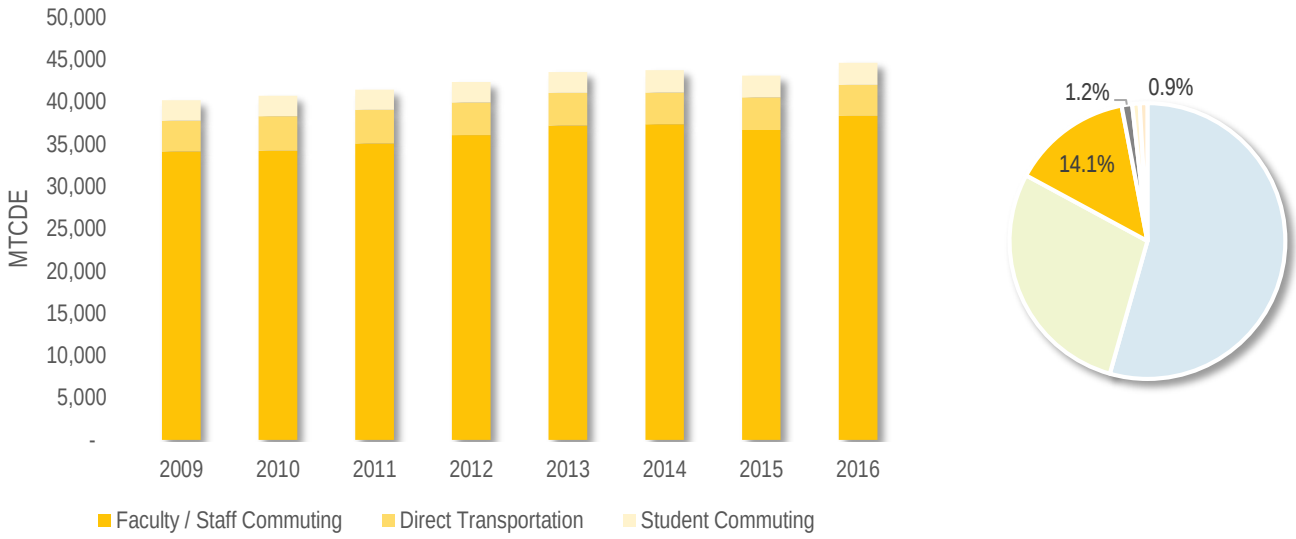


Table 9: UVA Transportation Emissions (MTCDE) Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Faculty Commuting	40,421.1	41,589.9	43,011.3	3.4%	6.4%
Direct Transportation	3,653.4	3,860.6	3,766.5	-2.4%	3.1%
Student Commuting	2,487.0	2,624.3	2,670.8	1.8%	7.4%
Total Transportation Emissions	46,561.5	48,074.8	49,448.6	2.9%	6.2%

As the University continues to grow in population and physical size, emissions from transportation become harder to address. For example, although UVA observed a 2.4 percent reduction in emissions from direct transportation this past year, the emissions UVA has direct control over, transportation emissions from faculty and student commuting increased by 3.4 and 1.8 percent, respectively. Since 2009, UVA has established campaigns and incentives to promote more sustainable commuting practices while continuing to offer complementary programs such as the University Transit Service and a partnership with Charlottesville Area Transit (CAT). These programs aim to help faculty, staff, and students get to destinations once arriving on-Grounds. The Cavpool program for example, is the most common sustainable, non-single occupant vehicle, commuting program at UVA for faculty and staff while other programs, such as UVA's bicycle sharing program, are more recent additions to commuting options. UVA will continue to explore other options to reduce the impact commuting has on GHG emissions.

Operations Support

Operations support includes the emissions generated from the release of refrigerants and other chemicals into the atmosphere, off gassing from fertilizers, and emissions associated with treating wastewater. This category also includes the mitigation of methane production by landfilling solid waste to facilities that capture the methane and use for power generation, equaling a negative emissions value. While operations support is the smallest contributor to overall emissions at UVA, accounting for 0.9 percent of total 2016 emissions, its impact has increased by 498.4 percent since 2009. As such, operational support emissions are easily the fastest growing emissions source at UVA.

The primary contributor to operational support emissions is the release of refrigerants and chemicals in appliances like air conditioners. As UVA continues to centralize cooling by connecting buildings with previously stand-alone chillers to central chilled water plants, the global warming potential of the refrigerants employed for building conditioning are being reduced due to advances in technology used by the newer equipment in the plants. Additionally, the centralization of the chillers will result in more frequent monitoring for refrigerant leaks by individuals likely to see and prevent problems before they become major issues.

Figure 13: UVA Operations Support Emissions (MTCDE) Trends, 2009-2016, and 2016 Snapshot

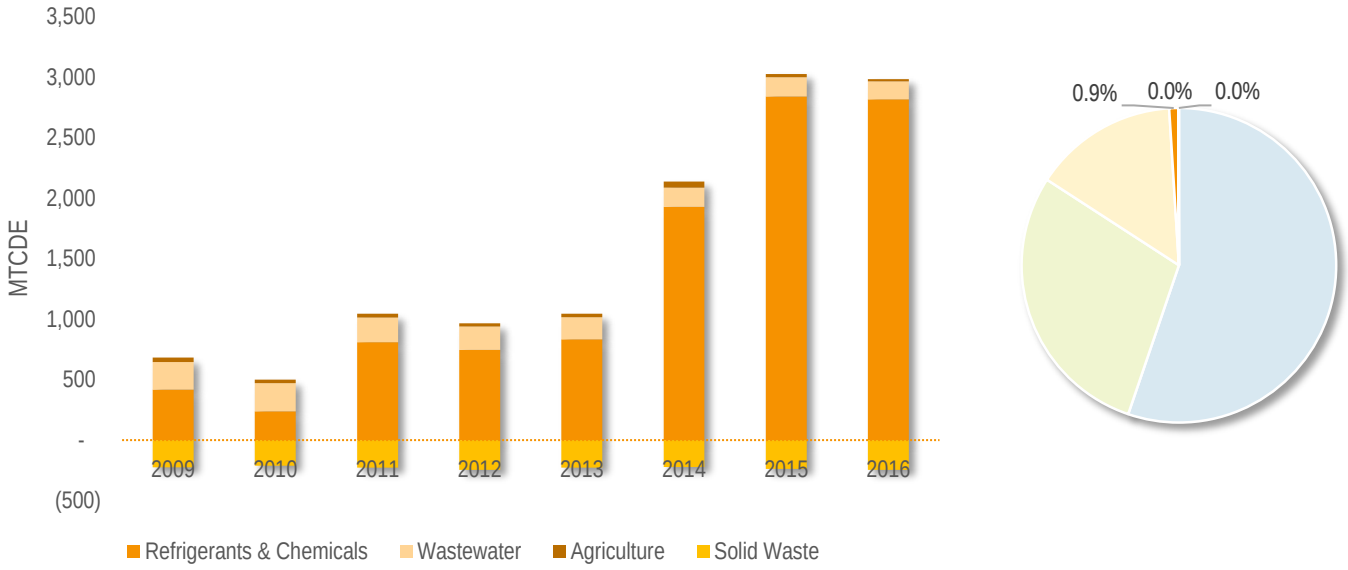


Table 10: UVA Operations Support Emissions (MTCDE) Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Refrigerants & Chemicals	418.39	2,837.5	2,814.7	-0.8%	572.8%
Wastewater	225.59	159.3	148.2	-7.0%	-34.3%
Agriculture	37.27	26.3	18.7	-28.8%	-49.8%
Solid Waste	(224.04)	(236.9)	(245.5)	3.6%	9.6%
Total Operations Support Emissions	457.21	2,786.2	2,736.2	-1.8%	498.4%

Normalization

UVA's goal to reduce GHG emissions 25 percent from 2009 levels by 2025 is an absolute goal rather than an intensity goal. Therefore, tracking progress towards the goal does not consider external variables such as the physical growth in building area, increased population of the University, nor year-to-year deviations in weather. However, to better understand the impacts of the actions taken to curb emissions as well as the impact these variables have on operations, the following section presents normalized emissions information based on change in building area, change in population, and changes in weather.

Building Footprint

The University of Virginia spans roughly 1,700 acres within the City of Charlottesville and Albemarle County. The expansion of the University's academic and medical offerings has resulted in significant growth in both population and building area. To support the University's growth, 48 facilities have been constructed or acquired since 2009, resulting in an increase of 2.4 million square feet, or 16.2 percent.

Table 11 below documents UVA's gross square footage trends as well as UVA's emissions, energy use, and electricity consumption by square footage. Both the increased population and building square footage are included within the boundaries defined for UVA's GHG inventory. Total emissions per square foot, energy use per square foot, and electricity consumption per square foot have decreased by 23.8, 13.2 and 12.9 percent, respectively from 2009. Energy use per square foot and electricity consumption per square foot both decreased despite an increase in both gross square footage and consumption, implying that the newly constructed buildings at UVA may be more efficient than the older buildings. This decrease can also be attributed to the energy efficiency projects being implemented in existing buildings through University programs such as Delta Force.

Table 11: UVA Building Portfolio and Intensity Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Gross Square Footage	14,985,310.0	16,685,105.0	17,419,578.0	4.4%	16.2%
Emissions (kgCDE)	345,196,364.5	307,904,057.2	305,030,064.9	-0.9%	-11.6%
Energy Consumption (MMBtu)	3,415,572.6	3,393,262.6	3,423,444.7	0.9%	0.2%
Electricity Consumption (kWh)	382,331,180.8	386,305,306.9	387,007,536.8	0.2%	1.2%
Emissions per GSF (kgCDE/GSF)	*23.0*	*18.5*	*17.5*	*-5.1%*	*-24.0%*
Energy per GSF (MMBtu/GSF)	*0.2*	*0.2*	*0.2*	*-3.4%*	*-13.8%*
Electricity per GSF (kWh/GSF)	*25.5*	*23.2*	*22.2*	*-4.0%*	*-12.9%*

New Construction

As mentioned above, UVA has grown significantly in size since 2009. The added emissions from the physical growth of the University make meeting the GHG reduction goal more challenging than if the emissions were not considered. On the other hand, however, achieving this goal despite the added growth will also by more impressive than if the emissions were not considered. Regardless, it is important to understand the GHG emissions impact of newly constructed buildings to fully understand how influential programs such as Delta Force are on reducing the environmental footprint of existing buildings' operations. One way to accomplish this is using a top-down approach: applying the annually reported emission intensity figure to the 2009 square footage year over year.

Figure 14 below, shows that using this top-down approach, assuming no physical building space was added to UVA since 2009, total new emissions would be 262,404.2 MTCDE. This total is only 1.4 percent greater than our 25 percent reduction goal from 2009, ultimately showing that UVA would have been close to meeting its 2025 GHG reduction goal in 2016 had no buildings been added.

Figure 14: Estimated GHG Emissions without growth compared to reported GHG Emissions: Top-Down Approach

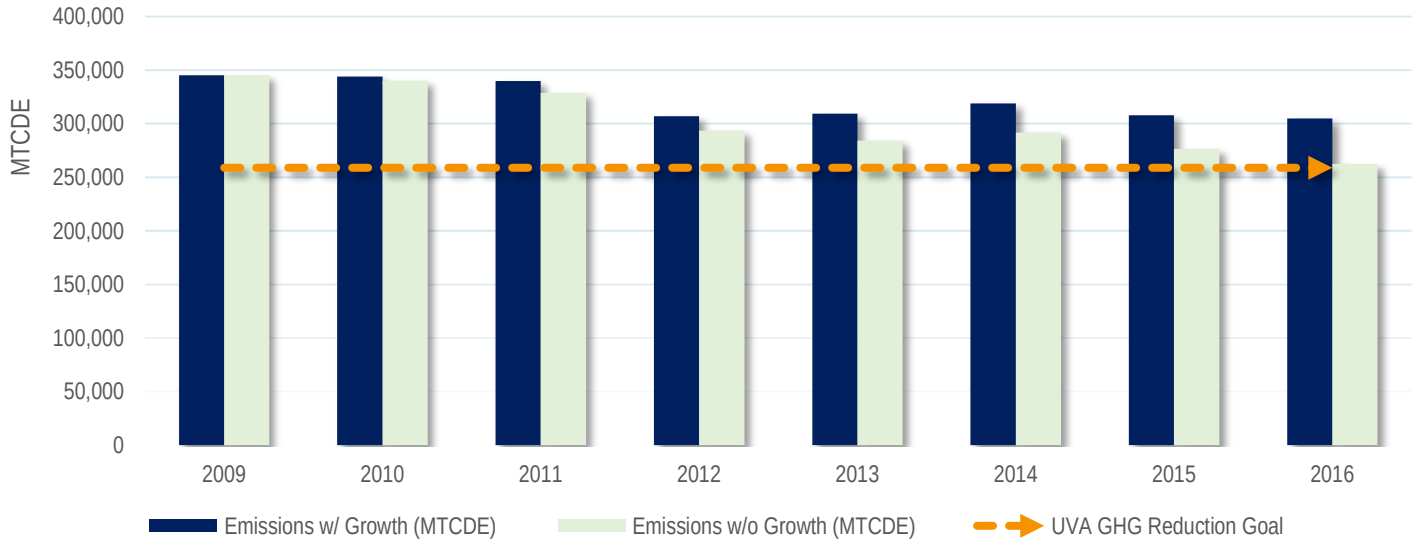


Table 12: Estimated GHG Emissions without growth compared to reported GHG Emissions: Top-Down Approach

	2009	2010	2011	2012	2013	2014	2015	2016
Emissions w/ Growth (MTCDE)	345,196.4	343,978.2	339,880.2	306,959.1	309,342.0	318,851.8	307,904.1	305,030.1
Emissions per GSF (kgCDE/GSF)	23.0	22.7	22.0	19.6	19.0	19.5	18.5	17.5
Emissions w/o Growth (MTCDE)	345,196.4	340,067.3	328,938.8	293,634.5	284,386.5	291,900.6	276,536.3	262,404.2
Difference %	0.0%	-1.1%	-3.2%	-4.3%	-8.1%	-8.5%	-10.2%	-14.0%

This method is an acceptable, but less accurate, way to calculate estimated emissions without growth. This method, however, does not account for the possibility that the newly constructed buildings are the main drivers in the decreasing emissions intensity (MTCDE/GSF) over time. One could assume that newer buildings are constructed to higher standards and perform more efficiently than the older existing buildings on-Grounds, leading to an overall decrease in emissions intensity across UVA. To account for this likely possibility, one could perform a bottom-up approach by calculating GHG emissions at the building level and subtracting the emissions from the newly constructed buildings from total net emissions. By removing the new building GHG emissions, this method also highlights the energy efficiency efforts, including Delta Force projects and awareness and individual action campaigns, implemented in existing buildings since 2009. Figure 15 below shows that using this bottom-up approach, assuming no physical building space was added to UVA since 2009.

Figure 15: Estimated GHG Emissions without growth compared to reported GHG Emissions: Bottom-Up Approach

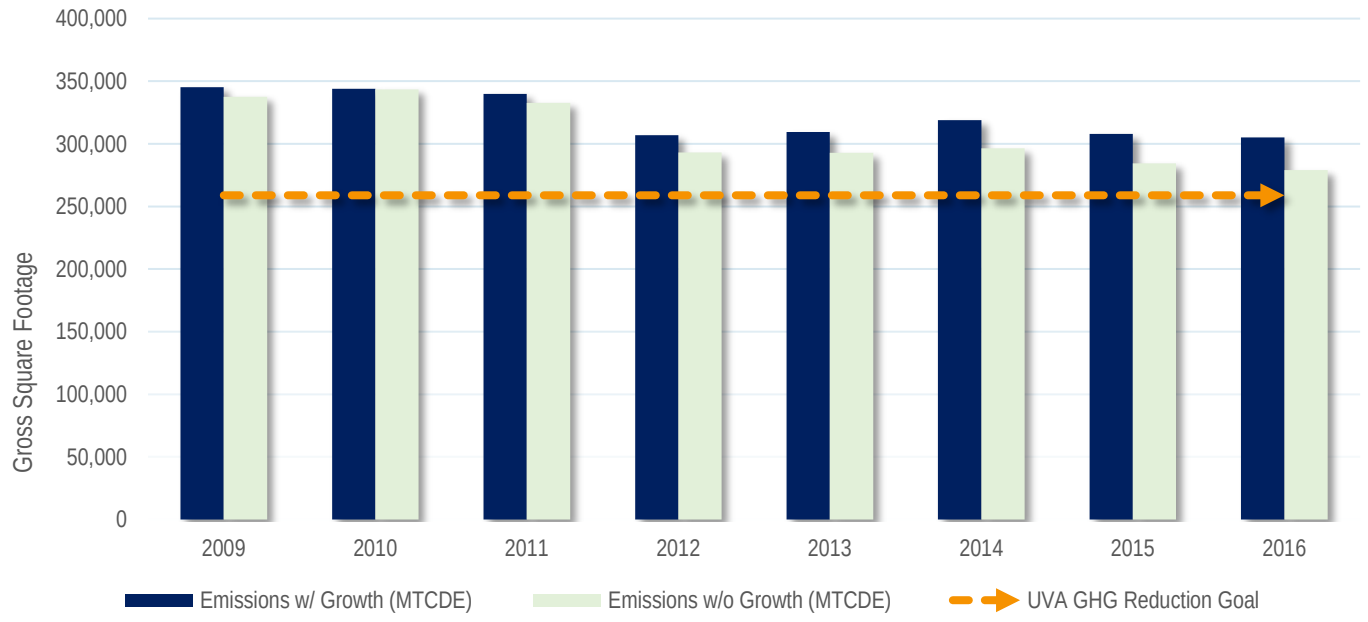


Table 13: Estimated GHG Emissions without growth compared to reported GHG Emissions: Bottom-Up Approach

	2009	2010	2011	2012	2013	2014	2015	2016
Emissions w/ Growth (MTCDE)	345,196.4	343,978.2	339,880.2	306,959.1	309,342.0	318,851.8	307,904.1	305,030.1
Emissions w/o Growth (MTCDE)	337,509.0	343,409.2	332,574.7	293,009.6	292,910.8	296,514.5	284,354.7	279,135.6
Difference (%)	-2.2%	-0.2%	-2.1%	-4.5%	-5.3%	-7.0%	-7.6%	-8.5%
Emissions w/o Growth per GSF (kgCDE/GSF)	22.5	22.9	22.2	19.6	19.5	19.8	19.0	18.6

This bottom-up approach to calculate estimated emissions without growth is likely more accurate than the top-down method and proves that existing buildings have become more efficient over time due to on-Grounds energy efficiency and awareness efforts. Additionally, by calculating the emissions without growth per square foot intensity it is apparent that the newly constructed buildings also contributed to the actual observed intensity reduction seen between 2009 and 2016. The emissions without growth per square foot intensity in 2016 was 18.6 kgCDE/GSF accounting for approximately 80.0 percent percent of the 24.0 percent observed reduction in total emissions intensity. This means that the new buildings constructed between 2009 and 2016 helped bring the observed emissions intensity down further from 18.6 to 17.5 kgCDE/GSF. In the near future, UVA hopes to continue to increase the efficiency of new buildings by developing and releasing Green Building Standards that will mandate newly constructed buildings to perform at a pre-determined percent lower than the projected baseline of the building.

Population Growth

With the physical expansion of the University, the population has also grown. The University's population has fluctuated between 2009 and 2016, but overall UVA has observed a 8.8 percent increase in the population of students, staff, and faculty.[4] This growth is expected to continue in the future. UVA's Institutional Assessment & Studies (IAS) is tasked with developing projections of future enrollment and their study indicates a greater influx of students in the next several years. As more students, faculty, and staff operate on-Grounds, UVA expects to observe more emissions, energy use, and waste. Table 14 below presents UVA's population trends as

[4] Population Numbers Reported by the UVA Office of Institutional Assessment and Studies

well as emissions, energy use, electricity consumption, or full-time equivalent (FTE). One FTE employee is defined as one 8 hour/per day employee. Part-time employees are assumed to work 4 hours/per day and are therefore considered as one half of a FTE. This assumption is similarly used for students and part time students. For example, in 2016, UVA's IAS claims that 21,503 students were enrolled full time while 888 students were enrolled part time, including both graduate and undergraduate studies. Therefore, for the GHG Inventory calculation purposes, it is assumed there were a total of 21,947 students at UVA in 2016 (21,503+[888/2]).

Based on the observed trends over time, the 7.9 percent increase in total population from 2009 to 2016 did not have a significant impact on overall emissions, as emissions decreased by 11.6 percent since 2009. Energy and electricity consumption, on the other hand, both increased, by 0.2 and 1.2 percent, respectively, albeit at a smaller rate than population. When normalized by population, however, the emissions, energy, and electricity intensities at UVA all decreased. This implies that population growth did not have a significant impact on overall emissions and energy consumption and UVA has become more efficient from 2009 to 2016 on a per capita basis.

Table 14: UVA Population and Intensity Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Students	20,346	21,535	21,947	1.9%	7.9%
Staff	12,962	14,179	14,696	3.6%	13.4%
Faculty	3,063	2,874	2,922	1.7%	-4.6%
Total Population (FTE)	36,371	38,587	39,565	2.5%	8.8%
Total Emissions (MTCDE)	345,196.4	307,904.1	305,030.1	-0.9%	-11.6%
Energy Consumption (MMBtu)	3,415,572.6	3,393,262.6	3,423,444.7	0.9%	0.2%
Electricity Consumption (MWh)	382,331.2	386,305.3	387,007.5	0.2%	1.2%
Emissions per Person (MTCDE/FTE)	9.5	8.0	7.7	-3.4%	-18.8%
Energy per Person (MMBtu/FTE)	93.9	87.9	86.5	-1.6%	-7.9%
Electricity per Person (MWh/FTE)	10.5	10.0	9.8	-2.3%	-6.9%

Effect on Transportation

While overall emissions may not have been significantly impacted by population growth, certain GHG sources, such as commuting, are. Commuting emissions are estimated through a University-wide survey that is conducted every two to three years. The survey collects information on commuting practices such as commting mode (e.g., bike, walk, carpool, bus, etc.) and approximate commuting distance to and from the University. The next survey will be administered in 2017.

More faculty and staff working at UVA and more students attending UVA have resulted in more commuting emissions. Since 2009, faculty and staff population has increased by 12.8 percent. Faculty and staff commuting emissions and commuting mileage have also increased at a similar rate by 12.4 and 13.9 percent, respectively. When normalized by population, however, emissions per full time employee (FTE) has actually decreased by 0.4 percent and mileage per FTE has increased by only 0.9 percent. This implies that despite a large population increase in faculty and staff, they have slightly improved their commuting efficiency. This could be a result of a number of UVA activities such as the Cavpool program, the improving efficiency standards for vehicles nationwide, or a combination of multiple variables. Table 15 below documents faculty and staff population and emission intensity trends from 2009 to 2016.

Since 2009, student population and student commuting mileage both increased by 7.9 percent while student commuting emissions increased by 7.4 percent. The increase in commuting mileage and emissions is a direct result of the larger student population on-Grounds. When normalized by population, however, emissions per student decreased slightly by 0.4 percent. This implies that students are commuting through slightly more efficient modes of travel since 2009, such as driving single-occupant vehicles rather than carpooling, riding the University Buses, or practicing carbon-free means of travel such as walking or biking. Table 16 below documents student population and emission intensity trends from 2009 to 2016.

Since the fleet is not significantly affected by population growth, it was not included in the per capita analysis. Overall, direct transportation has seen a 3.1 percent increase in emissions since 2009.

Table 15: UVA Faculty/Staff Population and Commuting Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Total Faculty/Staff Population	16,025	17,052	17,618	3.3%	9.9%
Commuting Emissions	40,421.1	41,589.9	43,011.3	3.4%	6.4%
Commuting Mileage	110,132,914.8	114,845,241.0	118,780,510.5	3.4%	7.9%
Emissions per FTE (MTCDE/FTE)	*2.5*	*2.4*	*2.4*	*0.1%*	*-3.2%*
Mileage per FTE (Miles/FTE)	*6,872.8*	*6,735.0*	*6,742.2*	*0.1%*	*-1.9%*

Table 16: UVA Student Population and Commuting Trends, 2009-2016

	2009	2015	2016	% change from '15	% change from '09
Total Student Population	20,346	21,535	21,947	1.9%	7.9%
Commuting Emissions	2,487.0	2,624.3	2,670.8	1.8%	7.4%
Commuting Mileage	7,650,096.0	8,096,972.0	8,252,072.0	1.9%	7.9%
Emissions per Student (MTCDE/Student)	*0.1*	*0.1*	*0.1*	*-0.1%*	*-0.4%*
Mileage per Student (Miles/Student)	*376.0*	*376.0*	*376.0*	*0.0%*	*0.0%*

Weather

Weather generally affects energy use by increasing or decreasing the heating and cooling loads on buildings. Heating and Cooling Degree Days (HDD and CDD, respectively) are calculated values used to determine the weather's impact on energy use. This calculated value uses average daily temperature to quantify the relative hotness and coldness of a given period of time. Typically, a colder winter would lead to more heating degree days while a hotter summer would lead to more cooling degree days. As displayed in Figure 16 and Figure 17, there have been a significant swing in heating and cooling days throughout UVA's GHG reporting period.

Figure 16: UVA Calendar Year Cooling Degree Days, 2009-2016

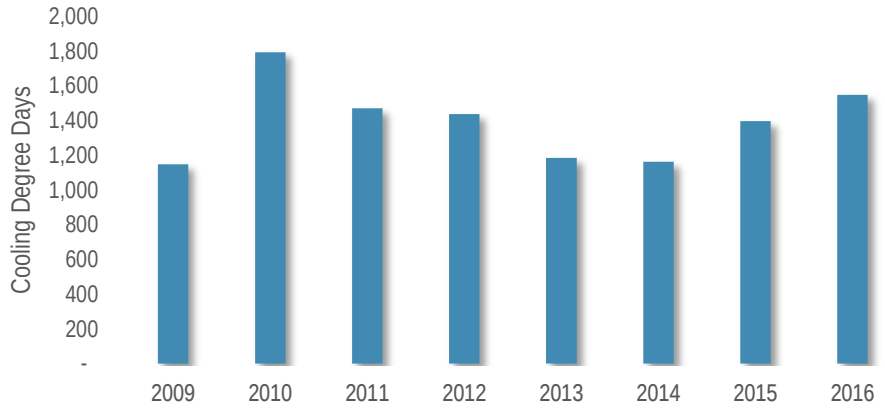
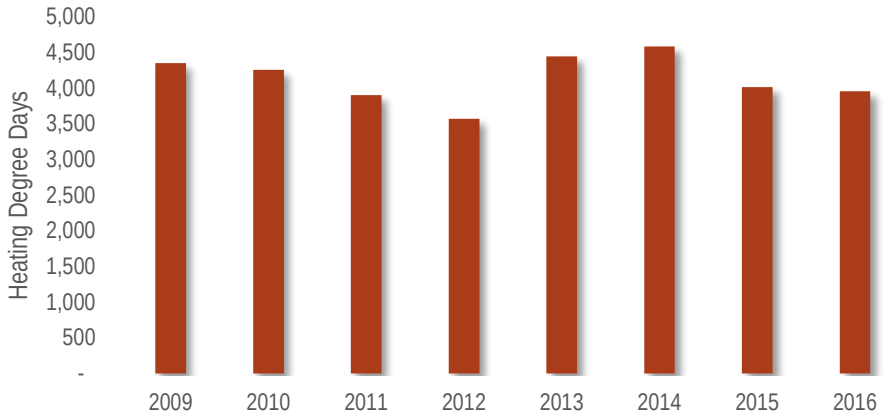


Figure 17: UVA Calendar Year Heating Degree Days, 2009-2016



Cooling

The observed average daily temperatures in 2016 were the second highest in the years between 2009 to 2016 as evidenced by the number of CDDs reported in Figure 16. These warmer temperatures resulted in more energy being used by chilled water plants to cool buildings. As seen in Table 17, UVA's chiller plants emitted 38,039.5 MTCDE in 2016, a 1.4 percent decrease from 2015 and an 11.7 percent increase from 2009. However, by normalizing chiller plant emissions against CDDs, UVA can accurately understand UVA's chiller plants' efficiencies and isolate the emissions generated from chillers the changes in weather. This normalization shows that UVA has observed an 11.0 percent reduction in chiller plant emissions per CDD since 2015 and a 17.1 percent reduction from 2015. Additionally, when normalizing chiller plant emissions by the amount of energy consumed by the chiller plants (MTCDE per MMBTU), UVA also observes a decrease. In 2016, UVA generated 0.036 MTCDE per energy units consumed at the chiller plants, a 3.4 percent reduction from 2015 and a 16.1 percent reduction from 2009.

Table 17: UVA GHG Emissions from Cooling, Analysis and Trends, 2009-2016

	2009	2015	2016	% change '15	% change '09
Cooling Degree Days (CDD)	1,148.0	1,396.0	1,546.5	10.8%	34.7%
Chiller Plant Energy Sold (MMBTU)	788,804.0	1,029,286.5	1,050,248.5	2.0%	33.1%
Total Emissions (MTCDE)	34,058.6	38,589.8	38,039.5	-1.4%	11.7%
MTCDE/CDD	*29.7*	*27.6*	*24.6*	*-11.0%*	*-17.1%*
MTCDE/MMBTU	*0.0432*	*0.0375*	*0.0362*	*-3.4%*	*-16.1%*

Heating

In 2016, UVA observed the warmest winter since 2012 and had less need for heating. While weather is a partial cause for the observed emissions reduction in on-Grounds Stationary fossil fuel consumption, UVA also successfully diminished coal use to 18.9 percent of the total heating energy source, replacing it with natural gas to continue to meet heating demand. Both the absolute reduction in stationary combustion emissions as well as in heating emissions per HDD, have decreased substantially. Table 18 below documents the changes observed in both absolute emissions and HDD normalized emissions.

Table 18: UVA GHG Emissions from Heating, Analysis and Trends, 2009-2016

	2009	2015	2016	% change '15	% change '09
Heating Degree Days (HDD)	4,349	4,012	3,952	-1.5%	-9.1%
On-Grounds Stationary (MTCDE)	116,298.5	86,174.1	86,917.5	0.9%	-25.3%
MTCDE/HDD	*26.7*	*21.5*	*22.0*	*2.4%*	*-17.8%*

Moving Forward

UVA is committed to reducing GHG emissions and energy use across Grounds and meeting the University-wide GHG emissions reduction goal of 25 percent below 2009 levels by 2025. UVA's GHG Action Plan outlines specific emissions reductions strategies as well as provides the UVA community and its partners with a transparent roadmap for how the University will implement these projects and meet the goal.

The reduction strategies presented in UVA's GHG Action Plan were developed by analyzing the GHG Inventory and determining projects that would affect the largest contributors to overall GHG emissions on-Grounds. For example, purchased electricity (and its associated transmission and distribution losses), accounting for 50.3 percent of UVA's 2016 total GHG footprint, is being targeted through efficiency activities such as, plant-level (both chilled water and heating) efficiency projects, retro-commissioning projects such as Delta Force, and re-lamping projects across Grounds. Additionally, on-Grounds stationary combustion is being targeted through the incremental replacement of coal at the University's main heating plant with natural gas. Further reductions can be achieved with more aggressive reductions of coal use, the greater utilization of alternative energy, additional plant efficiency projects, and continuing to expand and implement energy efficiency projects. For more information regarding UVA's planned emissions reduction activities, please refer to UVA's GHG Action Plan.

Appendix A: Total MTCDE Raw Data and Summations

Table 19: UVA 2009 GHG Emissions by Source and Scope

GHG Scope	Energy Consumption (MMBtu)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	CDE (Metric Tons)	Percent of Total Gross Emissions
Scope 1 Totals	1,516,424.7	119,124,352.4	13,346.3	1,782.5	120,407.6	34.9%
On-Grounds Stationary	1,463,382.2	115,532,967.8	12,898.7	1,486.7	116,298.5	33.7%
Direct Transportation	53,042.5	3,591,384.7	447.6	170.7	3,653.4	1.1%
Refrigerants & Chemicals	NO	NO	NO	NO	418.4	0.1%
Agriculture	NO	NO	NO	125.1	37.3	0.0%
Scope 2 Totals	1,195,928.7	164,810,023.3	3,319.7	2,070.4	165,510.0	47.9%
Purchased Electricity	1,195,928.7	164,810,023.3	3,319.7	2,070.4	165,510.0	47.9%
Scope 3 Totals	703,219.3	58,135,289.0	459.9	3,798.6	59,278.8	17.2%
Faculty / Staff Commuting	551,510.1	39,377,892.1	8,357.2	2,799.7	40,421.1	11.7%
Student Commuting	33,430.5	2,457,504.5	203.5	81.8	2,487.0	0.7%
Solid Waste	NO	NO	(8,961.6)	NO	(224.0)	
Wastewater	NO	NO	532.5	712.3	225.6	0.1%
Scope 2 T&D Losses	118,278.7	16,299,892.4	328.3	204.8	16,369.1	4.7%
Total Gross	3,415,572.6	342,069,664.7	26,087.5	7,651.6	345,420.4	
Total Net	3,415,572.6	342,069,664.7	17,125.9	7,651.6	345,196.4	

NO = Not Occurring
Note: Totals may not sum due to independent rounding

Table 20: UVA 2015 GHG Emissions by Source and Scope

GHG Scope	Energy Consumption (MMBtu)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	CDE (Metric Tons)	Percent of Total Gross Emissions
Scope 1 Totals	1,420,626.5	89,604,121.5	8,563.9	814.7	92,898.5	30.1%
On-Grounds Stationary	1,367,110.2	85,807,154.8	8,106.4	551.4	86,174.1	28.0%
Direct Transportation	53,516.3	3,796,966.6	457.5	175.1	3,860.6	1.3%
Refrigerants & Chemicals	NO	NO	NO	NO	2,837.5	0.9%
Agriculture	NO	NO	NO	88.1	26.3	0.0%
Scope 2 Totals	1,244,660.4	154,471,174.3	3,455.0	2,154.8	155,199.7	50.4%
Purchased Electricity	1,244,660.4	154,471,174.3	3,455.0	2,154.8	155,199.7	50.4%
Scope 3 Totals	727,975.6	58,716,303.6	(43.7)	3,659.8	59,805.8	19.5%
Faculty / Staff Commuting	567,038.4	40,527,487.7	8,493.3	2,852.6	41,589.9	13.5%
Student Commuting	35,274.2	2,593,139.9	215.3	86.6	2,624.3	0.9%
Solid Waste	NO	NO	(9,477.2)	NO	(236.9)	
Wastewater	NO	NO	376.1	503.1	159.3	0.1%
Scope 2 T&D Losses	125,663.1	15,595,676.0	348.8	217.6	15,669.2	5.1%
Total Gross	3,393,262.6	302,791,599.4	21,452.4	6,629.3	308,141.0	
Total Net	3,393,262.6	302,791,599.4	11,975.2	6,629.3	307,904.1	

NO = Not Occurring
Note: Totals may not sum due to independent rounding

Table 21: UVA 2016 GHG Emissions by Source and Scope

GHG Scope	Energy Consumption (MMBtu)	CO_2 (kg)	CH_4 (kg)	N_2O (kg)	CDE (Metric Tons)	Percent of Total Gross Emissions
Scope 1 Totals	1,470,431.3	90,272,195.7	8,507.3	731.1	93,517.5	30.6%
On-Grounds Stationary	1,418,227.5	86,567,474.0	8,066.7	497.9	86,917.5	28.5%
Direct Transportation	52,203.8	3,704,721.7	440.6	170.3	3,766.5	1.2%
Refrigerants & Chemicals	NO	NO	NO	NO	2,814.7	0.9%
Agriculture	NO	NO	NO	62.8	18.7	0.0%
Scope 2 Totals	1,208,667.6	150,004,217.8	3,355.1	2,092.5	150,711.7	49.4%
Purchased Electricity	1,208,667.6	150,004,217.8	3,355.1	2,092.5	150,711.7	49.4%
Scope 3 Totals	744,345.8	59,696,234.1	(126.7)	3,717.7	60,800.9	20.0%
Faculty / Staff Commuting	586,418.4	41,912,559.9	8,784.0	2,950.3	43,011.3	14.1%
Student Commuting	35,898.2	2,638,989.8	219.5	88.2	2,670.8	0.9%
Solid Waste	NO	NO	(9,818.7)	NO	(245.5)	
Wastewater	NO	NO	349.8	467.9	148.2	0.0%
Scope 2 T&D Losses	122,029.2	15,144,684.4	338.7	211.3	15,216.1	5.0%
Total Gross	3,423,444.7	299,972,647.7	21,554.3	6,541.2	305,275.5	
Total Net	3,423,444.7	299,972,647.7	11,735.7	6,541.2	305,030.1	

NO = Not Occurring

Note: Totals may not sum due to independent rounding