University of Pittsburgh

Department of Civil and Environmental Engineering

FINAL REPORT

Greenhouse Gas Inventory of University of Pittsburgh for FY 2017

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Preface

This report presents the greenhouse gas inventory results for University of Pittsburgh (Pitt) for FY 2017.

The authors acknowledge the contribution of Rich Heller from Facilities Management Department of Pitt, who provided valuable data that allowed us to complete the inventory. In addition, we sincerely thank all other Pitt staff members who provided us data and shared important information regarding their sustainable practices.

Executive Summary

The objective of this report is to assess the Greenhouse Gas (GHG) Inventory for the Pittsburgh Campus of the University of Pittsburgh (Pitt). The report presents a fiscal year (FY) 2017 GHG emissions inventory from direct and indirect activities of Pitt. This is Pitt's fourth GHG inventory document since its initiation in 2008, and it builds on and compares to the previous three inventories [1,2,3]. We anticipate that the report will serve as a guideline for any committee or group aiming to reduce the emissions of Pitt in the future. Understanding current GHG emissions is a necessary step towards developing strategies to lower future GHG emissions.

Pitt has set specific goals related to its sustainability. A Sustainability Plan was published in January 2018 and details goals for 15 categories that fall into three overarching ideas: Exploration, Community & Culture, and Stewardship [4]. Most of these goals are on a timeline parallel to the Pittsburgh 2030 District, which Pitt is a member. The Pittsburgh 2030 District Goals are to reduce water consumption, energy consumption, and CO_2 transportation emissions by 50% by 2030 [5]. Pitt intentionally aligned goals within the Sustainability Plan with those of the 2030 District, as well as adding many more.

For this study, fiscal year 2017 was selected as the temporal boundary with the goal of comparing results to FY 2008, 2011, and 2014 GHG inventories. There have been numerous changes in campus infrastructure over the years, with a potential to change source distribution and GHG emissions. One of the most significant projects has been the construction of the state of the art Carrillo Street Steam Plant (CSSP). The CSSP is an ultra- low NOx control plant, considered one of the cleanest heating plants of any higher educational institutions in the United States [6]. Reaching full operation in FY14, the CSSP services Pitt and the University of Pittsburgh Medical Center (UPMC), meeting 64% of Pitt's steam demand. The construction of this plant allows the university to steadily decrease its dependence on coal, impacting its GHG profile.

The overall distribution of GHG emissions by source remained similar to previous years as shown in Figure 1. Table 1 shows greenhouse gas emissions totals for the four inventoried fiscal years with sources corresponding to source distributions shown in Figure 1. The most significant shift happened due to Pitt's switch to consuming primarily CSSP's steam for heating. Due to this switch, the distribution in GHG emissions for heating has shifted from 20% purchased steam and 0% on-site generated steam in 2008, to 11% and 8.3% in 2011, to 10% and 14% in 2014, to the latest 8% and 12% in 2017.

It should be noted that this inventory saw a shift in the tool used to evaluate the greenhouse gas emissions of the campus. *Previously, a tool called Clean Air-Cool Planet was used; this Excel-based tool has since been discontinued and users were transitioned to an online tool called SIMAP (Sustainability Indicator Management & Analysis Platform).* Therefore, in order to allow for accurate comparison from year to year, all previous data were imported into this online tool; all tables in this year's report reflect these updated results from SIMAP. Although overall total emissions for each fiscal year are effectively the same, it should be noted that the emissions from some categories do change slightly. This can primarily be attributed to slight changes in emissions factors that varied from one tool to the other; these specific instances will be highlighted throughout the report.

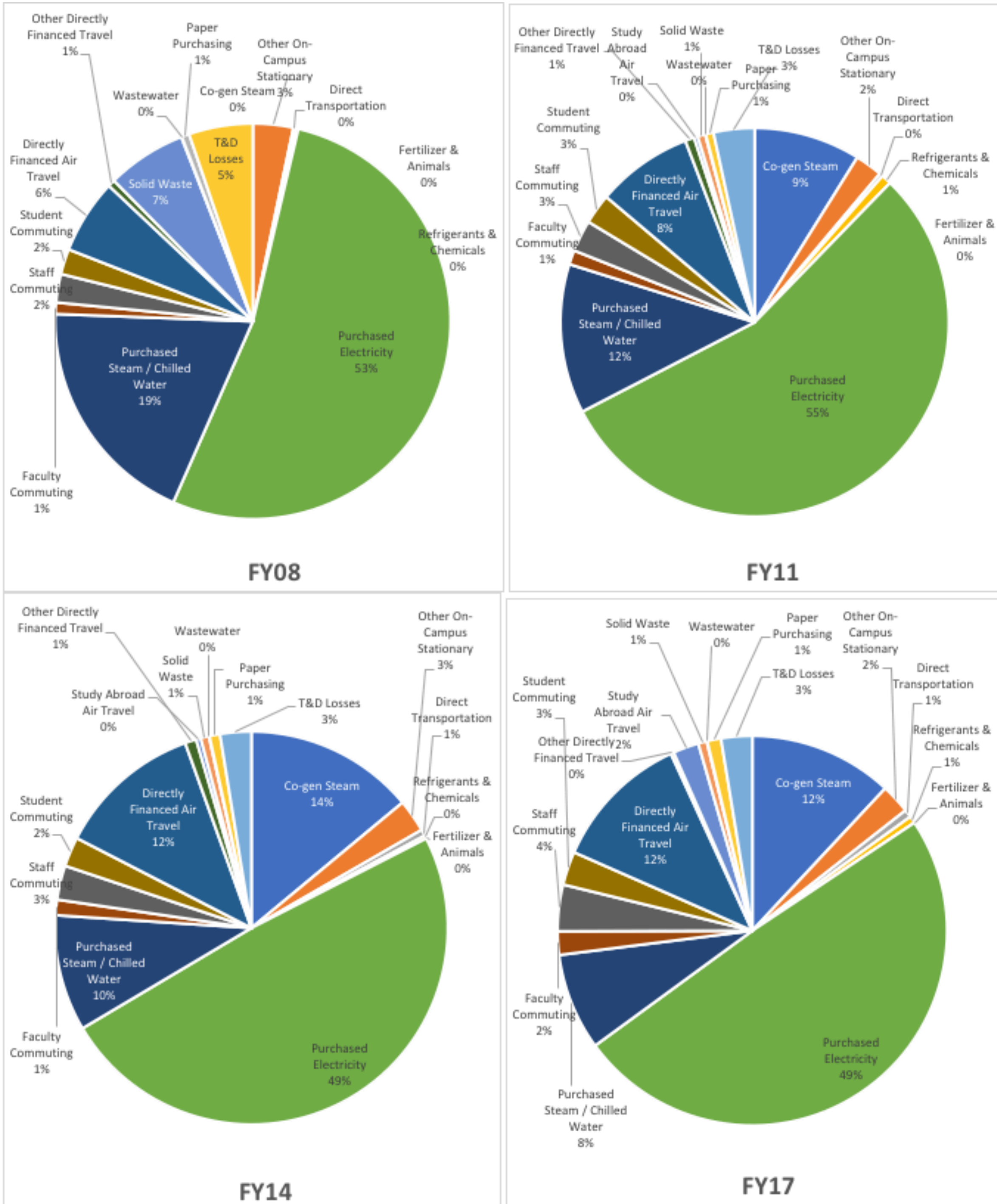


Figure 1 – GHG Emission Source Distributions for Fiscal Years 08, 11, 14, and 17

The biggest greenhouse gas emitting source for Pitt is again electricity generation which accounts for about half of all of the University's emissions. The total campus-wide electricity demand has remained relatively similar to FY14 level with only a 0.95% (2,000 MWh) increase, even though building changes resulted in a 0.2% (22 kSF) decrease in gross building area served. A change in electricity generation mix, significantly reducing the ratio of coal while increasing nuclear and natural gas-powered electricity, resulted in a 9% (10,000 metric tons CO2e) reduction in greenhouse gas emissions from electricity from FY14. Scope 2 transmission and distribution losses related to electricity demand also decreased over the years due to lowering of the regional emission factor and higher contribution from other sources.

Table 1 – Summary and Comparison of University of Pittsburgh GHG Emissions for Fiscal Years 08, 11, 14, and 17
(All emissions are reported in metric tons of carbon dioxide equivalent, MT CO_2e)

	Category	FY08	FY11	FY14	FY17
Scope 1	Co-generation Electricity	0	0	0	0
	Co-generation Steam	0	22,305	32,999	25,623
	Other On-Campus Stationary	9,212	5,723	6,390	5,245
	Direct Transportation	481	722	1,230	1,388
	Refrigerants & Chemicals	681	2,116	615	1,266
	Agriculture	0	1	2	1
Scope 2	Purchased Electricity	148,141	138,560	115,679	105,604
	Purchased Steam / Chilled Water	53,192	31,275	22,597	17,238
Scope 3	Faculty / Staff Commuting	9,128	9,583	9,634	12,433
	Student Commuting	5,801	6,333	5,753	5,962
	Directly Financed Air Travel	17,066	20,178	28,239	24,706
	Other Directly Financed Travel	1,636	1,910	2,186	548
	Study Abroad Air Travel	0	793	915	4,578
	Solid Waste	18,214	1,596	1,609	1,522
	Wastewater	120	106	121	104
	Paper	1,745	1,640	2,033	2,441
	Scope 2 T&D Losses	14,651	8,564	6,050	5,523
	Scope	**FY08**	**FY11**	**FY14**	**FY17**
Totals	Scope 1 (Direct Emissions)	10,374	30,867	41,236	33,523
	Scope 2 (Indirect Emissions)	201,333	169,835	138,276	122,842
	Scope 3 (All Other Emissions)	68,362	50,702	56,541	57,817
	Reporting Metric	**FY08**	**FY11**	**FY14**	**FY17**
Totals	Required (Scope 1 & 2)	211,707	200,702	179,511	156,364
	Scope 1 & 2, Air Travel, Solid Waste	246,987	223,268	210,275	187,170
	Scope 1 & 2, Transportation, Solid Waste	244,850	218,213	196,508	176,282
	All Accountable Emissions	280,069	251,404	236,052	214,181

The third largest contributor to GHG emissions, directly financed air travel, saw a slight decrease between FY14 and FY17. This can be attributed to an overall decrease in faculty and staff air travel, combined with increasing fuel efficiencies. Conversely, study abroad emissions increased by roughly a factor of five due to a significant growth in miles traveled by students. Pitt, similar to many other universities, is encouraging students to participate in international studies which, although beneficial to the students and the university for a multitude of reasons, does result in a substantial increase of emissions in this category.

Overall, the University of Pittsburgh saw a reduction in GHG emissions from previous years, particularly due to both an increase in natural gas use and shift in the regional electricity fuel mix away from coal. The use of Carrillo Street Steam Plant and improvements to Bellefield Boiler Plant had significant impact on lowering emissions from steam usage. This combined with an overall decrease in steam consumption campus-wide due to fewer heating degree days resulted in an overall decrease in the GHG emissions profile of the university.

1 INTRODUCTION

Universities have the knowledge that is necessary to create a sustainable environment on their campuses. Increasing numbers of student communities and increased enrollment in the sustainability field illustrate the increasing attention directed towards sustainability. Higher education institutions are often responsible for teaching and conducting research on environmental issues such as climate change. Educational institutions have the opportunity to lead society towards the solution of this global problem, which is a common threat for humans regardless of country and location.

This report stems from this understanding and aims to quantify and therefore facilitate strategies that will eventually reduce campus emissions. A GHG inventory is a first step towards effective reduction strategies since one main purpose of the inventory is to identify hotspots among different sources.

There are three stages to the GHG inventory process: data collection; GHG emissions calculation; and data analysis for climate action planning [7].

Step one: Data Collection – many items of raw data are required to conduct a GHG inventory, such as purchased electricity, transportation, solid waste, refrigerants, offsets, etc.

Step two: Emissions Calculations – collected data is then processed as input into a calculator tool. The American College and University Presidents' Climate Commitment (ACUPCC) recommends the use of Clean Air-Cool Planet Campus Carbon Calculator (CA-CP calculator), which since the last inventory (FY14) has been transitioned to an online tool called SIMAP (Sustainability Indicator Management & Analysis Platform). The CA-CP calculator was an Excel-based spreadsheet that used national inventories and methodologies of the Intergovernmental Panel on Climate Change (IPCC) and calculators of the Greenhouse Gas Protocol and was adapted for use with higher education institutions. All information used in the CA-CP calculator has been transitioned into SIMAP. This online tool covers all emission sources with the defined scopes of the ACUPCC.

Step three: Data Analysis – the calculator converts all emissions into CO_2 equivalent in order to compare GHG sources and identify 'hotspots' within the institution. These areas then form the greatest opportunities for emission reductions.

The report begins by introducing the SIMAP tool, the study boundaries, and scope. Results are presented under each category together with the various assumptions made during calculations. Discussion of results and comparison to previous GHG inventory results are presented, followed by recommendations for updating this report in the future. The last chapter of the report is the conclusion section.

2 SUSTAINABILITY INDICATOR MANAGEMENT AND ANALYSIS PLATFORM (SIMAP)

The University of New Hampshire (UNH) and the former non-profit CA-CP worked together to create a widely used tool to calculate GHG emissions, which is specifically designed for educational institutions. Currently, it has been used by 90% of the thousands of US colleges and universities that publically report their GHG emissions [8].

The CA-CP tool was an Excel-based spreadsheet designed to facilitate data collection and analysis. This first step forms the basis for institutional action on reducing greenhouse gas emissions. Although the primary purpose of the tool is to conduct a greenhouse gas inventory, the tool can be used to facilitate other tasks also. If data regarding carbon reduction projects are available, such as the amount of reduction expected for a certain commodity, the tool can be used to estimate future GHG emissions taking into account common emissions and reductions from potential projects; the tool can also be used to predict total Nitrogen emissions should that be valuable to the university. The calculator used standard methodologies and emission factors given by the GHG Protocol Initiative, and is a preferred tool by the ACUPCC [7].

The Sustainability Institute at the University of New Hampshire is the organization that developed this tool and is working to continuously improve it. As a result, they have shifted away from the Excel tool to an online portal and have ceased updating the calculator as of January 2018. They have now fully transitioned to an online tool called SIMAP (Sustainability Indicator Management and Analysis Platform). Therefore, this and all successive inventories will be performed using this online portal. This tool functions identically to the CA-CP calculator, even allowing for users to upload spreadsheets from previous, Excel-based version of the tool. All data from previous inventories were uploaded to SIMAP and all tables, analyses, and explanations reflect results from this updated tool.

3 BOUNDARIES OF THE INVENTORY

Three boundaries exist for calculating the campus GHG emissions: organizational, operational, and temporal.

3.1 ORGANIZATIONAL BOUNDARIES

Organizational boundaries are generally the highest level of the three boundaries, and therefore the first boundaries that are drawn during the creation of the GHG inventory. Organizational boundaries state whether GHG emissions are measured for one department, school, or the entire campus. Depending on this boundary, the facilities and operations that are to be included into the analysis are determined. For this study, Pitt's Oakland Campus was selected as the organizational boundary. Buildings managed and used by University of Pittsburgh Medical Center (UPMC) were excluded, as well as other regional campuses that belong to Pitt. Student housing facilities located on campus and managed by Pitt were included in the analysis; however, housing owned by Pitt but located outside of the campus boundary was not, since each tenant is billed individually and directly by utility companies.

Table 2 – List of Changes in Building Stock between FY14 and FY17

Building Name		Gross SF
Trees Field - Sports Dome	Constructed	16,988
Centre Plaza	Added (correction)	138,600
Halket Lot	Added	0*
Sennott Square Shops	Added	16,205
Joncaire Lot	Added	0*
Air Glow Observatory	Revoved from Inventory	1,472
Thomas Blvd	Removed from Inventory	192,000
	Total added:	**171,793**
	Total removed:	**193,472**

*Note: Surface lots do not contribute to the total building GSF

Within this organizational boundary, buildings owned and managed by Pitt at the Oakland Campus consisted of 96 buildings and had a gross building area of 10.2M ft^2, with a slight decrease of 21,000sf. Table 2 shows all the changes in the campus building stock since 2014, with the construction of a new sports dome, as well as the construction of two new surface parking lots. Additionally, shops in Sennott Square that had not been previously included were added as this area is operated by facilities and falls within the boundary of Pitt's campus. The Air Glow Observatory was removed as it was deemed outside of the boundary of campus and is not operated by Pitt's Facilities Management. Also, the square footage of Centre Plaza was absent in the FY14 inventory, so it was added here. Finally, the Thomas Blvd building was removed from the FY17 inventory as Facilities acquired it in FY18; it should therefore be included in the upcoming inventory. A full list of buildings included in this inventory can be seen in Appendix B.

LEED (Leadership in Energy and Environmental Design) is a building rating system that is becoming a standard for all new buildings. Created by the US Green Building Council, LEED certification is meant to distinguish high performance buildings that are designed to have lower energy and water consumption, in addition to a plethora of other sustainable features [9]. Over the last few years, Pitt has multiplied the number of LEED certified buildings on campus, with these facilities (pending or certified) totaling 1.8M square feet, or nearly 18% of the campus building stock. Table 3 shows a list of all completed or pending LEED projects on Pitt's campus.

Table 3 Campus Buildings with LEED Certification

Building Name	Certification	Year	Gross SF
McGowan Institute	LEED Gold	2005	45,000
MCSI	LEED Gold	2012	20,480
Benedum Hall	LEED Gold	2011	452,912
Chevron Sci. Center Annex	LEED Gold	2013	32,367
GSPH Addition	LEED Certified	2013	57,000
GSPH Renovation	LEED Gold - PENDING	TBD	227,908
Salk Hall Addition	LEED SIlver	2013	81,000
Mark A. Nordenberg	LEED Silver	2014	200,540
Clapp Hall Renovation	LEED Silver-PENDING	TBD	85,893
Mid-Campus Complex - NPL	LEED Gold	2014	20,000
BST 12th Floor	LEED Gold	2013	33,000
Hillman Library	LEED Silver- PENDING	TBD	252,778
Salk Hall Renovation	LEED Silver - PENDING	TBD	205,228
Crawford Hall Renovation	LEED Cerified- PENDING	TBD	87,637

During the study period, there were 26,240 full–time equivalent (FTE) students enrolled at Pitt. Part-time students are accounted for as a half of a full-time equivalent student, per SIMAP methodology, and are included in the FTE number above. Additionally, there were 2,944 faculty and post-doctoral associates and 5,341 staff. These numbers include all schools except for the school of medicine, which is considered a UPMC affiliate, and are compared to previous years in Table 4.

Table 4 – Population Numbers from FY08 to FY17

Community	FY08	FY11	FY14	FY17
Students (FTE)	24,755	26,740	25,917	26,240
Faculty	2,688	2,878	2,791	2,944
Staff	4,995	5,079	5,012	5,341
Total	**32,438**	**34,697**	**33,720**	**34,525**

3.2 OPERATIONAL BOUNDARIES

Operational boundaries identify GHG emitting sources to be included in the inventory. The GHG protocol uses a structure in which all emissions are categorized into three scopes [7]. Scope 1 includes direct emissions from sources that are owned and controlled by Pitt, such as on-campus electricity and steam generation, on-campus natural gas usage, transportation for campus operations, use of refrigerants and chemicals, and agricultural activities. Scope 2 emissions include indirect emissions from sources that are neither owned nor operated by Pitt, but whose products are linked to campus energy consumption, such as purchased electricity, steam, and chilled water. Scope 3 emissions are other sources that are neither owned nor operated by Pitt but are either directly financed (i.e. commercial air travel paid by Pitt, waste removal) or are otherwise linked to the campus via influence or encouragement (i.e. air travel for study abroad programs, daily faculty, staff, and student commuting). Emissions associated with paper consumption, solid waste disposal, wastewater treatment, and energy transmission and distribution losses are also included in Scope 3.

Emissions that fall under Scopes 1 and 2 are mandatory and must be included in the inventory by the GHG protocol. Although Scope 3 emissions are deemed optional by the GHG protocol, researchers are encouraged to include as many emission sources as possible to obtain a realistic inventory for the institution.

3.3 TEMPORAL BOUNDARIES

The final boundary is the temporal boundary. The calculator uses fiscal years instead of calendar years since most schools function on a fiscal year basis. Fiscal years at Pitt begin on July 1st and end on June 30th of the following calendar year. This study focused on evaluating fiscal year 2017, beginning on July 1st 2016 and ending on June 30th 2017. Previous inventories included fiscal years 2008, 2011, and 2014. One aim of this work is to understand the change in Pitt's carbon footprint since 2008.

4 EMISSIONS

The context of each emission source, results obtained, and assumptions made during calculations are detailed under each section below. Table 22 summarizes all of the information. However, individual data points input into SIMAP are also provided at the end of each subsection.

4.1 SCOPE 1 EMISSIONS

Scope 1 emissions cover sources that are fully owned and managed by the University of Pittsburgh.

4.1.1 STATIONARY COMBUSTION

Scope 1 stationary combustion emissions include any activities where fuel is burned or gasses are directly released into the atmosphere. This includes any on-campus electricity generation, steam generation, and gas usage. During Pitt's first GHG inventory in FY08, this area had a small impact because the university purchased all of its electricity and steam from outside vendors; however, in November 2009, Pitt began operation of its own Carrillo Street Steam Plant (CSSP), a natural gas powered, high-efficiency, low NOx emitting steam plant located on the upper campus of the University of Pittsburgh. It is jointly owned and operated by Pitt and the University of Pittsburgh Medical Center (UPMC), and is serving Pitt, UPMC, and some Carnegie Mellon University (CMU) buildings. It was first included in the FY11 inventory, but was not yet in full operation, supplying Pitt with 49% of its total steam demand. FY14 was the first inventoried year where CSSP was in full operation and supplied Pitt with 64% of its steam demand. The other 36% was then supplied by the Bellfield Boiler Plant (BBP) which is a steam plant not operated by Pitt which will therefore be covered in more detail in Scope 2.

Pitt's total steam demand has increased by roughly 150,000klbs between each inventoried year, from 533,000klbs in FY08, to 699,000klbs in FY11, to 841,000klbs in FY14 before dropping back to 642,000klbs in FY17. In FY17, this translated into total steam related emissions being 42,861 MT CO2e, which accounted for 20% of the total GHG emissions. Since CSSP is the only Scope 1 steam source and supply's 64% of the total Pitt steam demand, the total Scope 1 co-generation emissions come to 25,623 MT CO_2e. A detailed breakdown and comparison of steam consumption and related emissions is shown in Figure 2. It is important to note that the plant efficiencies and emission factors vary between years, which is why the consumption to emission ratios are not constant year-to-year. Additionally, an overall decrease in heating degree days explains this significant drop in steam demand. Therefore, this decrease may not be sustained in upcoming inventories.

Figure 2 – Steam Consumption and Related Emissions for Fiscal Years 08, 11, 14, and 17

On-campus stationary sources at Pitt also include natural gas used in individual buildings. This natural gas is typically used for air heating, water heating, backup generators, or for laboratory purposes. The total natural gas usage in FY17 accounted for 98,595 MCF and translated into 5,245 MT CO_2e (2.45% of total emissions).

Conversion factors required to convert the amount of natural gas into energy units were obtained from EPA's EnergyStar website [10]. Emission factors associated with combustion of natural gas were provided by SIMAP.

Table 5 – Summary of Stationary Combustion Data
(CSSP = Carrillo Street Steam Plant, BBP = Bellefield Boiler Plant)

	FY08	FY11	FY14	FY17
CSSP steam (klbs)	n/a	342,405	535,812	409,236
BBP steam (klbs)	532,693	356,381	304,889	148,299
Total steam (klbs)	532,693	698,786	840,701	641,819
CSSP emissions (MT CO_2e)	0	22,305	32,999	25,623
BBP emissions (MT CO_2e)	53,192	31,275	22,597	17,238
Total emissions (MT CO_2e)	53,192	53,579	55,596	42,861
Natural gas[a] (MCF)	168,289	104,555	120,120	98,595
Total emissions (MT CO_2e)	9,212	5,723	6,390	5,245

a - On-campus natural gas usage for non-CSSP activities.

4.1.2 UNIVERSITY FLEET

Another source of Scope 1 emissions is the university fleet fuel use. This includes all of the fuel used and financed by the university for campus-wide transportation and select off-campus land transportation. This includes fuel used by the facilities management, food services, moving/receiving, property management, campus bus, athletics, chancellor and others, but does not include chartered bus service.

Pitt currently uses two tracking systems for its fleet fuel use. Guttman Oil tracking system is used for fuel purchased strictly on Pitt's Oakland campus, while Voyager tracking system includes all the rest of the University of Pittsburgh used fuel, including Oakland campus, regional and national campuses, and other uses. It is difficult to accurately extract Oakland related fuel purchases from the Voyager system because not all purchases have identification corresponding to a campus or a department. A combination of card numbers and fill up addresses was used to identify fuel purchases by Oakland campus personnel. The same records and analysis was performed in FY14 as FY17 but vary with those of FY08 and FY11.

Guttman Oil weekly fuel reports were available for the entire 2017 fiscal year, with minor adjustments needed to be performed as the weekly reports did not align precisely with the Fiscal Year calendar. Voyager reports are generated on a monthly basis and were available for all months.

Both Guttman and Voyager reported the purchased fuel to be either regular gasoline or diesel, which has been consistent between all inventories. Pitt uses blended biodiesel instead of pure petroleum-based diesel for appropriate vehicles. CO_2 emitted during biodiesel combustion is theoretically offset by the carbon sequestered during the life of the fuel source, such as soybean or vegetable matter from which the biodiesel was derived. Biodiesel can be mixed with petroleum diesel to create different blends suitable for different vehicle engines and performance. A mix of 5% biodiesel and 95% petroleum diesel is labeled as a B5 mix, whereas pure biodiesel is labeled as B100. Although different grades of biodiesel are currently available in the market, only two biodiesel mixtures exist in Pittsburgh, B5 or B100. B5 type of blend was assumed to be used for the University Fleet since higher grades of biodiesel might cause performance problems especially during winter months.

Based on data obtained from Pitt's Transportation Services, in FY17 Pitt's vehicle fleet consisted of 280 vehicles total, of which 228 were Oakland campus vehicles and 52 were regional campus vehicles. The estimated gallons of fuel reported from the Guttman Oil system were 35,239 and 871 of gasoline and biodiesel, respectively. The estimate from Voyager system was 93,925 gallons of gasoline, 22,179 gallons of biodiesel, and 1,487 gallons and other fuels. The total estimated fuel use was therefore 129,164 gallons of gasoline, 23,050 gallons of biodiesel, and 1,487 gallons of other fuels respectively, translating into total GHG emissions of 1,388 MT CO_2e (0.65% of total emissions). The difference from FY14 to FY17 for gasoline consumption was an increase of about 2,200 gallons, while biodiesel increased by about 11,000 gallons. The reason for the increase in fuel use can likely be attributed to the upgraded tracking system and more accurate records, as well as a slight increase in the size of the fleet.

Table 6 – Summary of University Fleet Data

	FY08	FY11	FY14	FY17
Number of Vehicles	203	193	218	228
Gasoline (gal)	42,300	71,800	126,973	129,164
Biodiesel (gal)	11,220	9,500	11,976	23,050
GHG Emissions (MT CO_2e)	481	722	1,230	1,388

4.1.3 REFRIGERANTS

Hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are greenhouse gases that are often used for refrigeration and are accounted under Scope 1 emissions. Under ideal conditions, these gases are used in a closed loop system and do not contribute to GHG emissions once they are input into the system. However, leaks in the system result in fugitive emissions and are included in the GHG inventory since some of these refrigerants have high global warming potentials (GWP). The amount of fugitive emissions was assumed to be equal to the amount of refrigerants needed to recharge the systems during maintenance activities.

Pitt used total of 1,595lbs of refrigerants in FY17, translating to GHG emissions of 1,266 MT CO_2e (0.6% of total emissions). This was similar to previous inventories; however, it is difficult to compare refrigerant use between GHG inventories due to the nature of refrigerant leakage, disposal, and replenishment. Most of the refrigerant use is associated with annual fluctuations in demand for refrigerant maintenance and cannot be attributed to any change in facilities or campus policies. Table 7 presents the type and amount of refrigerant used at Pitt together with the GWP of each refrigerant and the comparison between previous inventories. It should be noted that SIMAP uses IPCC Fifth Assessment Report (AR5) values, which can vary slightly from AR4, which was used in previous inventories. This results in some slight changes from CA-CP values to SIMAP values. Additionally, R-12 was input previously under NF3, which has a significantly higher GWP of 16,100 than that of CFC-12 of 10,200, which is used in SIMAP calculations.

As research on refrigerants becomes more robust, the GWP can be used to choose between various products. The university can use this report to start to shift away from products that have particularly high GWP, such as R-12 or R-22 when used in high volumes, to decrease the impact of refrigerants campus-wide. Although they make up a small percentage of overall GHG emissions, refrigerants pose significant threats to human health and should be minimized whenever possible.

Table 7 – Summary of Refrigerant Data
(GWP100 = global warming potential for a 100-year horizon) [11,12,13]

	Quantity Used (lbs)						
Type	FY08	FY11	FY14	FY17	GWP100 AR4	GWP100 AR5	Source
R-134a	41	840	400	6	1430	1300	EPA
R-12*	20	36	0	18	10900	10200	EPA
R-404a	1	1	0	171	3260	3922	EPA
R-22	637	754	453	897	1810	1760	EPA
R-123	400	200	200	400	77	79	IPCC
R-11	0	400	0	0	4750	4660	EPA
R-408a	0	4	0	0	5780	3152	EPA
R-410a	0	107	0	65	1980	1725	EPA
R-414	19	0	0	0	1450	1365	fy08
R-500	3	0	0	0	37	37	EPA
R-503	1	0	0	0	15000	15000	fy08
R-507	0	0	0	37	3985	3895	EPA
GHG Emissions (MT CO_2e)	680.77	2,116.48	614.95	1,266.09			

*This was previous input as NF3 which has a GWP of 16,100

4.1.4 AGRICULTURAL ACTIVITIES

Scope 1 agricultural sources of GHG emissions account for animal herding or fertilizer, pesticide, or herbicide use for crop growth and landscaping. Since there are no herding animals on the Pittsburgh Campus, there are no emissions associated with this source; however, Pitt does use herbicides for landscaping activities. Synthetic herbicides are labeled with their chemical makeup using three numbers to represent the percentages of nitrogen (N), phosphorus (P), and potassium (K). For example, Momentum, a pre-emergent crabgrass herbicide used on campus, is identified by the numbers 21-0-11 and consists of 21% nitrogen, 0% phosphorus, and 11% potassium. Fertilizers and herbicides contribute towards GHG emissions when a portion of their nitrogen content volatizes and forms the compound N_2O.

Different commercial fertilizers have different nitrogen percentages. Typically, a weighted average was calculated based on the amount of fertilizer used and its specific nitrogen content. Because there was only one type of fertilizer used, this calculation was not necessary. The total volume was 1,892lbs of fertilizer with a nitrogen content of 10.2%, down significantly from 20.3% in FY14. By using the emission factors present in SIMAP, a value of 0.72 MT CO_2-equivalents was obtained for GHG emissions from fertilizers.

Table 8 – Summary of Agricultural Data

	FY08	FY11	FY14	FY17
Total (lbs)	475	1,125	2,250	1,892
Nitrogen Content (%)	12.6%	18.1%	20.3%	10.2%
GHG Emissions (MT CO_2e)	0.23	0.76	1.68	0.72

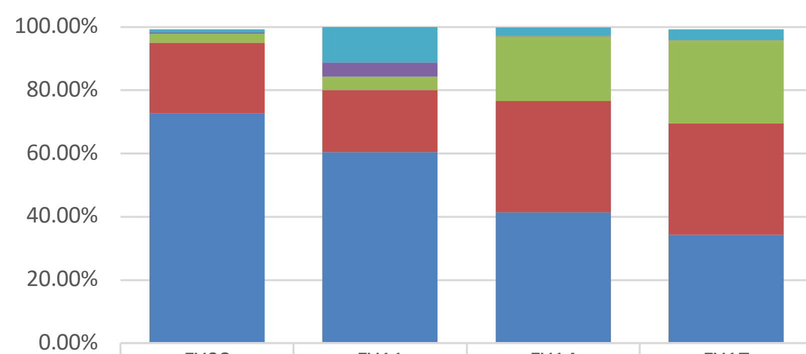
4.2 SCOPE 2 EMISSIONS

Scope 2 emission sources cover purchased electricity and steam that are vital for the activities of Pitt. These two items usually make up the majority of emissions for many institutions.

4.2.1 PURCHASED ELECTRICITY

Scope 2 purchased electricity category includes all electricity not generated on Pitt's campus and purchased from outside suppliers. This category has the most impact on the total GHG emissions, as it has accounted for about a half of all Pitt emissions in all inventoried years. These emissions are calculated based on the reported electricity usage and the electricity generation fuel mix reported by suppliers. The SIMAP tool uses either regional fuel mix information from the EPA's e-GRID program or a customized user input fuel mix for its calculation. Electricity generation fuels are organized into the following ten categories: coal, natural gas, distillate oil, residual oil, nuclear, waste-to-energy, hydroelectric, biomass, renewable (wind, solar), and other.

The FY08 inventory used the default fuel mix for the RFC West region, which was dominated by coal and nuclear power, 73% and 22% respectively. A custom fuel mix was used for the first time in the FY11 inventory. The fuel mix for that year was provided by First Energy and showed a significant increase in energy from oil and gas (8.6%) and renewables (11.3%). Coal and nuclear decreased that year to 60.5% and 19.6%. Custom fuel mix was also used for the FY14 inventory, provided by PJM Interconnection. This mix consisted of 41.1% coal, 35.2% nuclear, 20.4% natural gas, 2.7% renewables, and 0.2% oil. Finally, the mix for FY17 was provided by USource and consisted of 34.3% coal, 35.2% nuclear, 26.3% natural gas, 3.5% renewable, and 0.1% oil. A detailed comparison of fuel mixes is shown in Figure 3.



	FY08	FY11	FY14	FY17
Renewable	1.00%	11.34%	2.73%	3.35%
Oil	0.40%	4.29%	0.23%	0.08%
Natural Gas	2.70%	4.29%	20.38%	26.31%
Nuclear	22.30%	19.61%	35.24%	35.24%
Coal	72.80%	60.48%	41.39%	34.26%

Figure 3 – Fuel Mix Summary and Comparison

The total Pitt electricity consumption in FY17 increased by roughly 1% (2,000MWh) from FY14. Because the building stock decreased slightly, this increase is simply due to an increase in electricity demand. This rise in demand can almost certainly be attributed to an increase in cooling degree days from FY14, as seen in

Table 9, leading to an increase in energy consumption by building air conditioning systems campus-wide. *However, as a result of a continuous shift from coal to natural gas, combined with improved emissions factors, FY17 saw an overall decrease in GHG emissions from purchased electricity by about 10,000 MT CO_2e.*

Table 9 - Summary of Heating Degree Days for Fiscal Years 08,11,14, and 17

Category	FY08	FY11	FY14	FY17
Heating Degree Days	4,194	4,525	4,605	3,508
Cooling Degree Days	1,594	1,741	1,559	1,902

Table 10 – Summary of Electricity Data

	FY08	FY11	FY14	FY17
Electricity Usage (MWh)	198,040	211,101	211,614	213,622
GHG Emissions (MT CO_2e)	148141	138560	115679	105604

Because this custom fuel mix was used in SIMAP, the emissions factors are specific to the campus, as opposed to the eGrid emissions factors that represented geographic regions. As seen in Table 11, the emissions factors for the fuel mix of Pitt's campus are in general lower than the default eGrid factor. This means that the total emissions for the campus are site-specific and therefore more precisely reflect the impact of Pitt.

Table 11 eGrid and Custom Fuel Mix Emission Factors (measured. In kg CO_2/kWh)

Fiscal Year	eGrid Emission Factor	Custom Fuel Mix Emissions Factor
2008	0.703756000	0.742100
2011	0.681962521	0.651607
2014	0.626357935	0.539953
2017	0.568247400	0.487546

4.2.2 PURCHASED STEAM AND CHILLED WATER

Pitt does not purchase any chilled water, but it does purchase steam to offset the difference in demand not covered by the Pitt operated Carrillo Street Steam Plant (CSSP) mentioned in Scope 1. The purchased steam comes from the Bellefield Boiler Plant (BBP) which is operated by a third-party consortium of multiple owners and supplies steam to many other entities in Oakland. Since steam from the BBP is purchased, and the BBP is a non-Pitt plant, this steam generation falls under Scope 2 emissions.

Bellefield Boiler Plant was the only steam plant in Oakland until 2009 when Pitt built its own Carrillo plant. The BBP was powered by coal and natural gas until 2009 and was nicknamed the "The cloud factory". This nickname came from the coal burning related pollution that the plant released into the air, and also explains the higher greenhouse gas emissions from purchased steam in FY08. In 2009 this plant switched to 100% natural gas fuel and helped increase its efficiency and lower its emissions. This switch had an observable impact on the FY11 and FY14 emissions accounting for Pitt and continues to result in improvements of campus emissions.

As mentioned in section 4.1.1 for Scope 1 stationary combustion, Pitt consumed a total of 766,332klbs of steam in FY17, resulting in total emissions of 42,861 MT CO_2e. The Pitt CSSP plant supplied 64% (488,628klbs) of this demand and BBP supplied the remaining 36% (277,704klbs). With all natural gas fuel and estimated efficiency of 84%, the emissions associated with the BBP came to 17,238 MT CO_2e. This is a reduction of 5,000 MT CO_2e from FY14.

Table 12 – Summary of Purchased Steam
(CSSP = Carrillo Street Steam Plant, BBP = Bellefield Boiler Plant)

	FY08	FY11	FY14	FY17
CSSP steam (klbs)	n/a	342,405	535,812	488,628
BBP steam (klbs)	532,693	356,381	304,889	277,704
Total steam (klbs)	532,693	698,786	840,701	766,332
CSSP emissions (MT CO_2e)	-	22,305	32,999	25,623
BBP emissions (MT CO_2e)	53,192	31,275	22,597	17,238
Total emissions (MT CO_2e)	55,093	51,620	56,385	42,861

4.3 SCOPE 3 EMISSIONS

Sources that emit greenhouse gasses but are indirectly related to Pitt are account for under Scope 3. This includes any financially sponsored or outsourced activities such as travel, waste management, paper purchasing, etc.

4.3.1 DIRECTLY FINANCED OUTSOURCED TRAVEL

Pitt finances different modes of transportation for its faculty and staff, which include air travel, rental car, bus, train, and personal mileage reimbursement. Detailed information for such travel financing comes from different sources within the university, those being the business office, an air travel agent, and the athletics department.

The business office has records of travel reimbursements and P-card purchases. In FY08, the different modes of financed travel were recorded as a single entry into the reimbursement statement that also included items such as hotels, per diem, and meals. In FY11, departments within the university started switching to a new network-based system for recording reimbursements and P-card purchases, a system which provided more comprehensive expense data. In FY14 and FY17, this system also included descriptions of the nature of the expenses, allowing for more accurate disaggregation between air, bus, and train expenses. Since this was not a one-time university-wide switch, some departments still report their reimbursements in a paper form, in which case they are not accounted for in this system, or in the inventory. It is estimated that in FY11 about 30% of all reimbursements were filed using the new system, up to 70% in FY14 and 90% in FY17. These inconsistencies make it difficult to directly compare the emissions between FY08, FY11, FY14, and FY17.

Faculty, staff, and the athletics department may also book flights directly through a Pitt travel agent, in which case the expenses do not show in the reimbursement and P-card system. The travel agent provides a total dollar amount spent on airfares, which is then added to the expenses reported by the business office. The athletics department also books chartered busses for Pitt athletic teams and reports the total expenses separately.

Once all travel expense data was aggregated, it was separated into the following three modes: air travel, bus travel, and rail travel. To avoid the need of another conversion factor outside of SIMAP, the monetary values, which is what is provided by each department, were input directly into SIMAP which performs calculations using its own factors.

Using the monetary data, it was estimated that in FY17 Pitt financed about 40,000,000 air miles, and 281,000 land miles, resulting in total emissions of 25,254 MT CO_2e. Air mile estimates had previously increased each inventoried year by about 11 million miles, until this inventory saw a drop-off of 7 million miles. The increase from FY08 to FY14 is attributed to an increase in documentation, and the rapid decrease seems to be a result of less faculty and staff air travel. Land mile estimates have fluctuated rapidly from inventory to inventory mostly due to varying levels of detail in reported data, and varying conversion factors used to translate dollar values to miles previous to this inventory. The decrease in FY17 emissions is also a result of a change in fuel emission factors in SIMAP tool. This portal obtains its emission factors from the US Department of Transportation and the US Department of Energy and updates them each year [15,16].

Table 13 – Summary of Directly Financed Outsourced Travel

	FY08	FY11	FY14	FY17
Air travel (miles)	25,417,945	36,094,326	47,063,237	40,470,287
Land travel (miles)	440,000	188,467	731,728	281,673
GHG Emissions (MT CO_2e)	18,702	22,087	30,425	25,254

4.3.2 STUDY ABROAD AIR TRAVEL

Like many universities, Pitt offers students the chance to complete one or two terms of academic studies in other countries, called the Study Abroad program. The calculator separates these miles from the Directly Financed Outsourced Travel section, but they carry the same weights, and are calculated the same way, using the same emission factors.

This category was not included in the FY08 inventory due to lack of data but was introduced in FY11. Just like in FY11 and FY14, the travel cost data of FY17 was obtained from the Study Abroad Office. The total expenses for study abroad in FY17 were $1.3M, which translated to 5.4M air miles traveled and total emissions of 4,578 MT CO_2e. This drastic increase is likely a result of a rise in the popularity of studying abroad. Although the only data provided in FY11 and FY14 was flight expenses, reported data in FY17 showed that 2,300 students studied abroad. Based on expenses from FY14, this would equate to only 470 students studying abroad in that fiscal year. Although this is a simplified estimation, it still demonstrates the significant increase in students who are taking advantage of this opportunity provided by Pitt. Although this increase subsequently results in higher GHG emissions, studying abroad has benefits for the students as well as the university.

Table 14 – Summary of Study Abroad Travel

	FY08	FY11	FY14	FY17
Expenses ($)	n/a	232,243	274,181	1,344,504
Conversion (cent/mi)	16.50	16.38	17.98	25.00
Distance (miles)	n/a	1,417,847	1,524,920	5,378,016
GHG Emissions (MT CO_2e)	n/a	793	915	4,578

4.3.3 COMMUTER TRAVEL

Commuting can be a significant contributor to greenhouse gas emissions as shown in previous inventories and other studies; however, it is difficult to assess without either a traffic data or a commuter survey data, none of which were available for this inventory. Generally, several important factors influence commuter habits, such as distance between destinations, road infrastructure, traffic patterns, public transportation access and reliability, parking availability, and others. At Pitt, there is access to public transportation, biking infrastructure, student housing, parking capacity, carpool and vanpool programs, and others.

In FY17, there were 4,381 parking spaces within Pitt parking lots and 118 metered parking spaces allocated for public use, totaling 4,499 parking spaces at Pitt Oakland campus. Pitt issued 2,797 parking permits to individuals and had 212 registered carpoolers and vanpoolers in FY17. There were also 182 bike racks with approximately 1,136 bike spaces. On-campus residence hall capacity in Oakland was approximately 7,928 students. In terms of public transportation, there is major bus transportation corridor through the campus, and all Pitt faculty, staff, and students can ride for free with their Pitt ID.

Table 15 – Summary of Commuting Facts

		FY08	FY11	FY14	FY17
Population	Faculty	2,154	2,487	2,791	2,944
	Staff	4,662	4,734	5,012	5,341
	Students	24,755	26,740	25,917	26,240
	Total	31,571	33,961	33,720	34,525
Student Housing	On-campus	7000	7000	7825	7928
	Off-campus (close)[a]	2,475	2,674	2,592	2,624
	Off-campus (far)	15,279	17,066	15,500	15,688
	Total	24,755	26,740	25,917	26,240
Carpool	Passengers	382	188	164	159
	Avg. Milage	11.87	11.27	11.73	11.28
Vanpool	Vans	10	9	9	7
	Passengers	65	57	67	53
	Avg. Milage	23.1	23.9	22.9	29.0
Permit	Number	3,058	3,153	2,756	2,797
	Avg. Milage	12.95	12.95	12.74	12.82
Total	Avg. Milage	12.86	12.88	12.72	12.77
Parking	Garage	4437[b]	2,563	2,299	2,597
	Lot	0	1,833	1,733	1,784
	Metered	165	147	119	118
Bike	Racks	0	181	178	182
	Spaces	1,000	1,670	1,600	1,136

a - This is based on an assumption that 10% of off-campus living students live within a walking distance to UPitt.

b - Garage and lot spaces were reported as a sum in FY08.

In order to calculate commuting related emissions, SIMAP calculator asks for faculty, staff, and student travel distributions by mode, the average distance traveled by each mode, number of one way trips each week, and the number of weeks in a fiscal year. The documented data from Table 15 therefore had to be supplemented with some general assumptions listed below:

1) There are 47 working weeks in a fiscal year for faculty and staff, and 30 regular (fall and spring semester) school weeks for students.
2) 10% of off-campus living students live in close proximity to Pitt and walk to school.
3) All students living on-campus walk to school.

4) All bike spaces fill up completely once a day proportionately by faculty, staff, and student ratios.
5) The same percentage of faculty and staff walks and bikes to campus.
6) Students hold 5% of all permits and fill up 4 times all metered spaces in a day.
7) Faculty holds 50% of all permits, and staff holds 45% of all permits.
8) Only staff carpools and vanpools.
9) The remaining portion of each population rides a bus to campus.

Although some of these assumptions may grossly generalize the different Pitt populations' commuting behaviors, they provide a relationship between some of the known numbers from Table 15 and estimated modal distributions in Table 16.

Table 16 – Summary of Calculated Commuting Distributions

		FY08	FY11	FY14	FY17
Students	Bike	3.2%	4.9%	4.7%	3.3%
	Walk	38.3%	36.2%	40.2%	40.2%
	Drive Alone	3.3%	2.8%	2.4%	2.3%
	Carpool	0.0%	0.0%	0.0%	0.0%
	Bus	55.3%	56.1%	52.7%	54.2%
Faculty	Bike	3.2%	4.9%	4.7%	3.3%
	Walk	3.2%	4.9%	4.7%	3.3%
	Drive Alone	71.0%	63.4%	49.4%	47.5%
	Carpool	0.0%	0.0%	0.0%	0.0%
	Bus	22.7%	26.8%	41.1%	45.9%
Staff	Bike	3.2%	4.9%	4.7%	3.3%
	Walk	3.2%	4.9%	4.7%	3.3%
	Drive Alone	29.5%	30.0%	24.7%	23.6%
	Carpool	9.6%	5.2%	4.6%	4.0%
	Bus	54.6%	55.0%	61.2%	65.9%

Attempt was made in holding the same assumptions as in the previous inventories; however, some of these assumptions have changed in an effort to incorporate all the known data shown in Table 15. Inventories for FY08 and FY11 were based primarily on assumptions and incorporated only a portion of the Pitt provided data shown in Table 15. This approach used in FY14 and FY17 is expected to give a more comprehensive evaluation of the different factors influencing Pitt's commuter choices and provides a firm and quantitative framework for the assessment. These results seen in Table 17 show an overall increase in miles, which can be attributed to an increase in total community members. Although the percentage of those who take the bus rose while personal driving fell, the overall increase in total community members offset this shift.

Table 17 – Summary of Commuting

	FY08	FY11	FY14	FY17
Automobile Commuting (miles)	26,843,062[a]	29,582,343[a]	9,310,993	9,509,977
Bus Commuting (miles)	31,347,922[a]	35,479,221[a]	37,617,623	45,677,433
GHG Emissions (MT CO_2e)	18,801[a]	20,225[a]	15,908	18,395

a - These are results reported in previous inventories and do not reflect the change in approach.

4.3.4 SOLID WASTE

Solid waste is managed by Republic Waste Services and is landfilled with a methane recovery system in place. Methane recovery is the process of trapping and storing methane before it is emitted to the atmosphere and then having it processed for use in electricity generation. The Republic Waste Services landfill utilized by Pitt captures methane but does not process it for electricity generation on site. The same system was used in FY14 and FY11, but not in FY08.

The solid waste stream data was reported by facilities management, housing services, food services, and property management. Pitt's solid waste stream increased by 392 short tons between FY14 and FY17 to a total of 6,790. The percentage of waste recycled has increased by over 2% between each inventory, climbing up to 35.4% in FY17, and accounting for 2,304 short tons of waste. The total emissions due to methane release from landfills accounted for 1,522 MT CO_2e.

Table 18 – Summary of Solid Waste

	FY08	FY11	FY14	FY17
Landfilled (tons)	5,246	4,596	4,634	4,384
Recycled (tons)	1,543	1,572	1,764	2,406
% of Waste Recycled	22.7%	25.5%	27.6%	35.4%
GHG Emissions (MT CO_2e)	5,688	1,404	1,437	1,522

4.3.5 WASTEWATER

Based on data from Pitt's Facilities Management, wastewater was assumed to be equal to the amount of water consumed in almost all campus buildings. It is not clear whether there is a possibility to measure the actual contribution of Pitt to the central treatment system, which was assumed to use aerobic treatment of wastewater. This problem has been stated by other researchers as well, but a solution to the problem could not be found. Even if the assumption made here is an overestimation of the actual situation, it results in 104 MT CO_2e from wastewater, which does not have a significant impact on the Pitt's total GHG emissions (0.05% of total emissions).

Table 19 – Summary of Wastewater

	FY08	FY11	FY14	FY17
Wastewater (million gallons)	278,350	246,450	280,055	240,165
GHG Emissions (MT CO_2e)	135	120	136	104

4.3.6 PAPER

Paper is vital for almost any type of business establishment. It is perhaps more important for educational facilities where printed material in great quantities is consumed daily. Therefore, capturing this potentially significant emission source was another objective of the study, although not mandatory based on ACUPCC guidelines. Information regarding the quantity of purchased regular and recycled paper was obtained through the Purchasing Department.

Pitt made great strides since 2008 to use higher grade post-consumer waste recycled paper and to raise recycling rates, and in FY11 and FY14 the reported data supported this claim; however, in FY17 the paper purchasing numbers rapidly increased again. This is due to a more comprehensive accounting in FY17 and may not necessarily indicate an increase in paper consumption. The total paper purchased during FY17 came to a total of about 1.8Mlbs of paper, and the overall recycled content came to 18.6%. The total associated GHG emissions from paper purchasing came to 2,441 MT CO_2e (1.1% of total emissions).

Because paper with recycled content is more readily available and economically sensible than ever, it is in the University's best interest to educate its departments and implement a campus-wide standard for recycled content of purchased paper. Doing so would have little to no impact on the quality of the paper yet would have a tremendous impact on the GHG impacts of the campus over time, especially if paper consumption continues to increase.

Table 20 – Summary of Paper Consumption and Emissions

	FY08	FY11	FY14	FY17
Total Paper (lbs)	1,113,740	730,725	1,488,165	1,787,020
Overall Recycled Content	4.2%	20.7%	9.4%	18.6%
GHG Emissions (MT CO_2e)	1,745	1,640	2,033	2,441

5 DISCUSSION OF RESULTS

GHG emissions of Pitt for fiscal year 2017 amounted to 214,181 MT CO_2e. The percentage result distribution is presented in Figure 4. The fiscal year 2008, 2011, and 2014 GHG inventory results tables can be found in Appendix B for comparison.

To put these results in context, Table 21 shows a comparison of Pitt's emissions for all inventories normalized to number of students, total number of community members, and gross building square feet. The total CO_2e value was used as the numerator for each calculation. Each inventory has seen a decrease in every category, supporting continuous monitoring and evaluation of campus emissions.

Table 21 - All Accountable Emissions per Student, Community Member, and Building GSF

All Accountable Emissions	FY08	FY11	FY14	FY17
Students, MT CO2e/FTE students	11.1	9.2	9.0	8.2
Community Members, MT CO2E/Person	8.5	7.1	6.9	6.2
Building Space, MT CO2e/1000sf	29.3	25.6	22.9	21.0

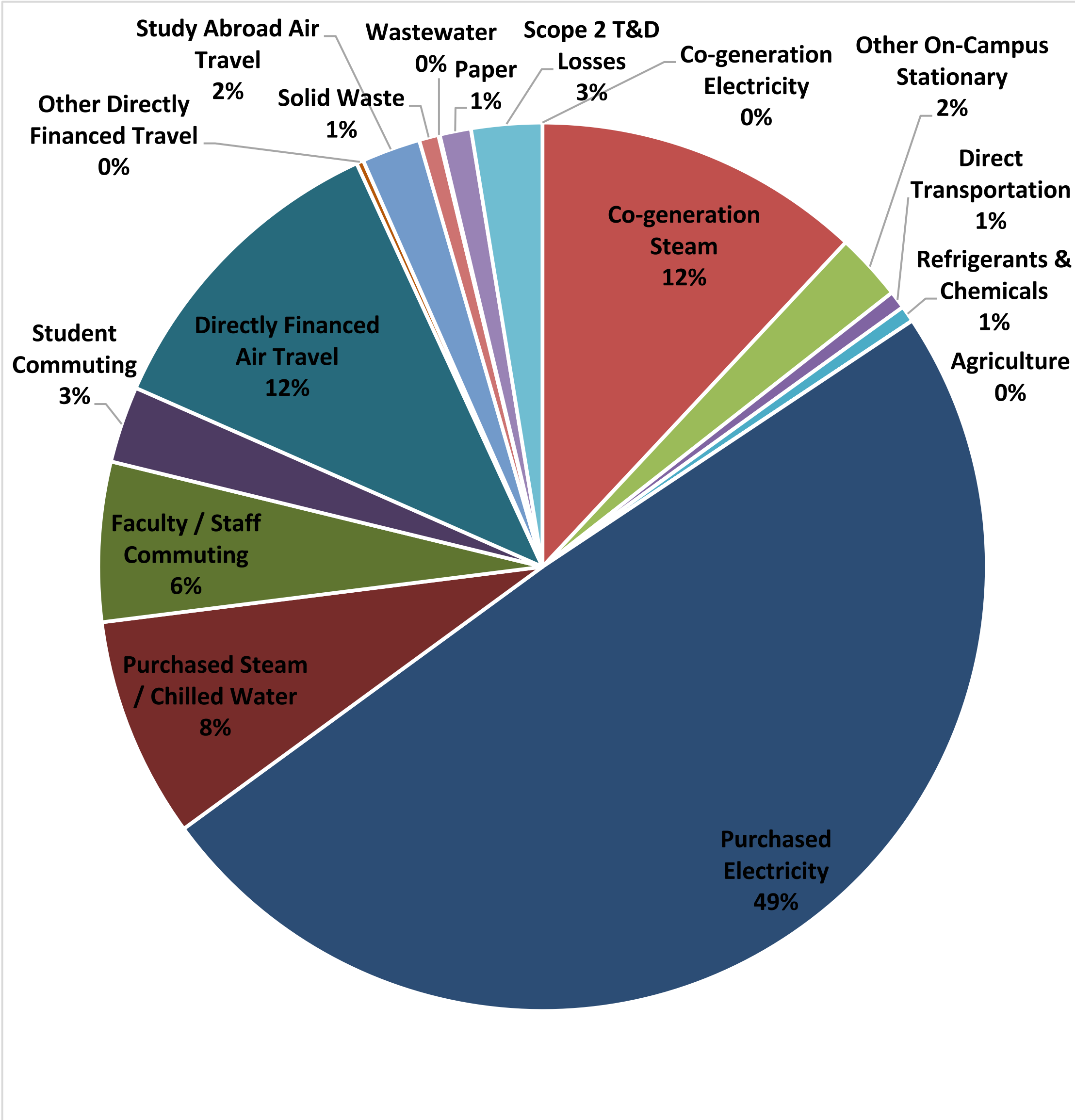


Figure 4 – Distribution of Pitt's FY17 GHG Results

Table 22 – Summary of Pitt's GHG Emissions for Fiscal Year 2017

		CO2	CH4	N2O	eCO2
		kg	kg	kg	Metric Tonnes
Scope 1	Co-gen Electricity	25,538,568	2,541	51	25,623.18
	Co-gen Steam	5,227,507	520	10	5,244.83
	Other On-Campus Stationary	1,357,785	254	87	1,387.82
	Direct Transportation	0	0	0	1,266.09
	Refrigerants & Chemicals	0	0	3	0.72
	Agriculture	104,150,501	11,049	4,317	105,603.97
Scope 2	Purchased Electricity	17,180,707	1,709	34	17,237.63
	Purchased Steam / Chilled Water	4,113,238	469	174	4,172.41
Scope 3	Faculty / Staff Commuting	8,169,149	688	274	8,260.89
	Student Commuting	5,906,664	393	167	5,962.00
	Directly Financed Air Travel	24,624,587	244	281	24,705.81
	Other Directly Financed Travel	462,219	581	263	548.26
	Study Abroad Air Travel	646,257	6	7	4577.67
	Solid Waste	0	54,362	0	1,522.12
	Wastewater	0	0	391	103.74
	Paper	0	0	0	2,441.06
	Scope 2 T&D Losses	5,446,996	578	226	5,523.01
Offsets	Additional				0
	Non-Additional				0
Totals	Scope 1	3,315	32,123,859	150	33,522.63
	Scope 2	12,758	121,331,208	4,352	122,841.60
	Scope 3	84,142	49,369,109	1,783	57,816.97
	All Scopes	100,215	202,824,176	6,285	214,181
	All Offsets				

Net Emissions: 214,181

The scoped approach, as defined previously, categorizes emission sources based on level of responsibility but does not dictate the boundaries to be used for emissions reporting. The final decision is left to the discretion of the institution. Nevertheless, some guidelines by the GHG Protocol Initiative and the ACUPCC exist to ensure that reported results are compatible with each other. Proposed boundaries are as follows:

- *All Scope 1 and Scope 2 emission sources*: Scope 1 and 2 are minimum levels for reporting emissions. The World Resources Institute (WRI) Corporate Accounting and Reporting Standard require reporting of all Scope 1 and Scope 2 emissions but consider Scope 3 emissions optional. ACUPCC on the other hand, additionally requires Scope 3 emissions for commuting and directly financed air travel, on top of Scope 1 and Scope 2 emissions.

- *All directly financed emissions*: This boundary includes Scope 1 and Scope 2 emissions as well as directly financed Scope 3 emissions, such as air travel and solid waste management.

- *All directly financed emissions and selected directly encouraged emissions*: In addition to the previous boundary, this boundary includes Scope 3 emissions that are encouraged, but not necessarily financed. A policy in effect that requires students to study abroad for a certain period of time would indirectly require them to use air transportation, although they might not be reimbursed for the trip. Another category to consider would be the daily commuting of students, faculty and staff, especially in locations with few public transportation options.

- *All directly financed or significantly encouraged emissions as well as selected upstream emissions:* This would be the largest boundary for reporting campus GHG emissions. In addition to the previous boundary, certain Scope 3 emissions are also included, mainly for allocating reductions to these sources. For example, if a policy to decrease paper consumption is in effect, then paper category could be included in the inventory to observe the impact of paper reduction policy.

Selection of a study boundary is vital for a GHG inventory study. Selection of a limited boundary would result in the exclusion of some important emission sources and result in an underestimation of the actual emissions from the institution. On the other hand, developing an inventory for all actual emissions requires significant amounts of time and resource; further, data is often not available. Emission results for Pitt increased by 27% from selecting the most limited reportable boundary to the most extended reportable boundary. Reporting emissions by any one of these defined boundaries is allowed. This fact should be recognized during comparison of results with respect to other institutions, since different studies use different boundaries, which directly affect end results.

For comparing results found here with other institutions of higher education, metrics were defined such as using Scope 1 and 2 sources only, including air travel and solid waste management in addition to Scopes 1 and 2, including all transportation activities and solid waste management in addition to Scopes 1 and 2, and finally all accountable emission sources. Comparing schools based on their net emissions only results in misleading conclusions since every school has different student enrollment numbers as well as different number of buildings to continue their educational and research activities. For a logical comparison, emission results are usually converted into one of the metrics given below. If institutional data such as student numbers and gross building area are input into the SIMAP tool, such conversions are done automatically and presented together with other results.

5.1 COMPARISON OF RESULTS WITH PEER INSTITUTIONS

Numerous sources and GHG Inventory reports published by other higher education institutions were reviewed in order to determine Pitt's performance when ranked according to greenhouse gas emissions. Table 23 below shows Pitt's performance among a group of peer institutions commonly used for benchmarking purposes. As was discussed previously, selection of an extended operational boundary for Pitt increases emissions by close to one third when compared to reporting only mandatory emission sources. Both results are provided in Table 23.

Table 23 - Comparative Results of Higher Education Institutions used for Peer Group Benchmarking, Sorted According to Net Emissions [17-19]

Institution	Year of Study	Net emissions MT CO2E	MT CO2E /FTE student	MT CO2E /1000 ft2
SUNY - Buffalo	2014	120,332	4.3	10.8
University of Delaware	2016	140,701	6.9	16.7
Univ. of Pittsburgh – mandatory sources only	**2017**	**156,364**	**6.0**	**15.4**
Temple University	2017	205,463	5.7	21.2
Univ. of Pittsburgh – all accountable sources	**2017**	**214,181**	**8.2**	**21.0**
University of Maryland - College Park	2016	240,650	5.3	16.2
Penn State - University Park	2017	278,660	13.0	17.6
The Ohio State University	2017	623,558	13.8	25.1

6 RECOMMENDATIONS FOR FUTURE GHG INVENTORY STUDIES

Some of the categories studied in this inventory would not be able to be completed without making some general assumptions. This means that some of the categories may lack precision and accuracy and may have resulted in under or over estimation of the associated emissions. These assumptions were made using external sources and best judgement of the investigator and are expected to roughly represent the true emission levels. This year's study had a good foundation in this aspect from the previous three inventories and attempted to improve or solidify some of the assumptions made. Future inventories should continue this effort and should either try to eliminate the need for assumptions, or should search for support from scientific sources, such as other studies, reports, and surveys.

The vehicles registered in the University Fleet and the fuel consumed is tracked under two separate programs. Obtaining data from the Guttman Oil system is simple, as it only includes Pitt Oakland campus fuel use. Obtaining Oakland campus data from the Voyager system is more challenging because it includes regional and other Pitt fuel use as well, and each transaction is not clearly identified with a particular campus. This year's study replicated the strategy used in FY14 to associate individual card numbers to a particular campus based on the location of majority of purchases with that card. Same approach can be used in future inventories to maintain consistency and shorten the time needed for investigating the fuel reports.

In 2008, the Carrillo Street Steam Plant was planned to become operational in the very near future, supporting the decision to create a benchmark study to analyze the impacts of switching to CSSP from the Bellefield Boiler Plant. As expected, steam related emissions decreased by ~6% between 2008 and 2011 even though total steam consumption increased due to the addition of new facilities. In 2014 steam demand further increased, and even though the CSSP was finally in full operation, it did not prevent from the steam related emissions from increasing as well. Even though overall steam demand decreased in this fiscal year, future studies should examine these demand patterns and perhaps draw direct correlations to a change in heating and cooling degree days now that the source of the steam is fully operational.

Purchased electricity has remained the largest source of emissions for Pitt, making up approximately half of the total emissions. Varying fuel mixes between the three inventories have shown the great differences in emissions associated with a variety of fuel sources. The Pittsburgh region has always been a coal dominated fuel mix region; however, federal emissions regulations have forced a shift away from coal, and in the case of Pittsburgh towards natural gas and nuclear power. It would be worth investigating the cost benefit of purchasing green power, since it could further reduce emissions from electricity. Some universities already employ this strategy and may be good resources in exploring this option for Pitt.

Recording of air travel improved since FY08 with the upgrading of network systems designed to simplify the travel reimbursement process for Pitt faculty and staff. The FY11 inventory first received data gathered through this system, and in FY14 majority of the Pitt departments were expected to use this system but participation was still not at 100%. FY17 saw full benefits of this system, but a completeness should be ensured moving forward. Also, because this was the first year detailed data was provided by athletics, the next inventory can take a closer look at consumption patterns of this department.

Since information on commuting preference of faculty and students was not available, assumptions were required to calculate emissions. Previous inventories suggested the use of campus-wide commuting survey; however, this was not feasible from a financial and time perspective. Instead, regional surveys administered by government or other organizations, such as the American Community Survey or the Make My Trip Count survey, that will be administered again in 2018, could be implemented in future inventories [20].

One potential emitter that should be considered moving forward is emissions from generators throughout campus. This data has yet to be collected but should be explored in the upcoming inventory as they could have substantial emissions that should be accounted for.

Although water consumption is not a focus of this inventory, it should be noted that water meters are being installed on Pitt's campus starting in 2018. Therefore, future inventories can take advantage of the increase in accurate data regarding campus water consumption. Because water prices are rising in Pittsburgh, it would be interesting to start addressing cost-benefit analyses of implementing more sustainable stormwater management practices on campus to help mitigate these city-wide issues while reducing the consumption of the campus.

The total number of study abroad miles increased significantly from the last inventory. This is a result of an increase in popularity of spending time during undergraduate years to study in a foreign country. Similar to Pitt, universities across the country are encouraging students to take advantage of these learning opportunities. Therefore, this is less a hotspot for this inventory and more a reflection of the study abroad department's growth.

Finally, facilities will continue to perform in-depth energy audits of campus buildings to identify the largest consumers of energy and water. Because the majority of the so-called "low hanging fruit" options have already been implemented (i.e. lighting retrofits), these detailed audits are crucial to identify other hotspot areas to help bring the energy demand of the campus down, reducing the footprint of the school as a whole.

7 CONCLUSIONS

The calculated emissions of Pitt in FY17 have shown an overall reduction in GHG emissions. Pitt emitted 181,578 MT CO_2e from mandatory sources (Scope 1 & 2) and 214,181 MT CO_2e from all accountable sources. A decrease in overall steam demand and a change in the electricity fuel mix had the largest impacts on these reductions. Electricity reduction strategies in Pitt's buildings appeared as a success as electricity use only increased slightly, which can be attributed to an increase in cooling degree days. Conversely, steam demand fell due to a decrease in heating degree days and should be monitored moving forward to discern if this drop could be attributed to other factors. Commuting and travel activities could also benefit from further tracking and consequential implementation of reduction strategies. Additionally, paper impacts could be reduced by implementing a campus-wide standard for recycled content of purchased paper. Similarly, staff members of Pitt should be educated on the GWP of all refrigerants so their impacts can help them make better decisions when a refrigerant is needed. In general, this overall decrease in GHG emissions is encouraging and should continue to propel the University of Pittsburgh into a more sustainable future.

Acronyms

AASHE – Association for the Advancement of Sustainability in Higher Education

ACUPCC – American College and University Presidents Climate Commitment,

AA – Airlines for America

BBP – Bellefield Boiler Plant

CA-CP calculator – Clean Air-Cool Planet Campus Carbon Calculator

CO_2 – Carbon dioxide

CSSP – Carrillo Street Steam Plant

FTE – Full Time Equivalent

GHG – Greenhouse Gas

GWP – Global Warming Potential

IPCC – Intergovernmental Panel on Climate Change

LEED – Leadership in Energy and Environmental Design

MMBtu – Million British thermal unit

MT CO_2e – Metric ton of carbon dioxide equivalent

SIMAP – Sustainability Indicator Management & Analysis Platform

Pitt – University of Pittsburgh, Oakland Campus

WRI – World Resources Institute

Appendix A

Meetings and communication with several Pitt staff were necessary in order to gather data for the SIMAP tool. Table 24 shows the list of contacts as well as data and information received from them.

Table 24 - List of Contacts and Information Received

Contact	Information Received
Rich Heller	Building list Purchased electricity and steam Electricity fuel mix Wastewater
Kevin Sheehy Jeff Yeaman Gena Gowins	Parking permits
Kathy Tosh Thuman Wingrove Art Ramicone	Budget
Renee Galloway	Paper and Computing
Will Mitchell Nick Goodfellow	Solid Waste
Keith Duval Jay Frerotte	Refrigerants & chemicals
Cindy Comer	University fleet
Vince Johns	Directly financed air travel
Heather Lego	Directly financed air travel reimbursements
Vanessa Sterling	Study abroad air travel
Ryan Varley	Chartered Bus Athletic Travel
Andy Moran	Landscaping
Dan Divito Steve Svoboda	Steam Plant

Appendix B

Table 25 - Total Building List for FY17

Building Name	Gross area
Units	SF
Auxiliary - Housing	
Amos Hall	68,000
Bouquet Gardens A-H	
Bouquet Gardens A-J	
Bouquet Gardens A	19,708
Bouquet Gardens B	19,708
Bouquet Gardens C	19,708
Bouquet Gardens D	19,708
Bouquet Gardens E	19,708
Bouquet Gardens F	14,781
Bouquet Gardens G	19,708
Bouquet Gardens H	19,708
Bouquet Gardens J	64,800
Brackenridge Hall	55,569
Bruce Hall	63,006
Centre Plaza	138,600
Forbes Pavilion	87,114
Forbes Pavilion (Added Offices+Graphics)	
Fraternity Housing Complex	73,600
Holland Hall	136,958
Edward H. Litchfield Towers	465,393
Lothrop Hall	241,770
Mark A. Nordenberg Hall	200,540
Mark A. Nordenberg Hall - Wellness Ctr	
Mark A. Nordenberg Hall - PNC Bank	
McCormick Hall	43,686
Panther Hall	161,542
Pennsylvania Hall	127,835
Ruskin Hall	120,000
Sutherland Hall	223,903
Auxiliary - Parking	
Craig Hall Garage	10,409
Wesley W. Posvar Hall Garage	203,746
GSPH Garage	56,941
Halket/Iroquois Lot	
Joncaire/Boundary Lot	
Langley Hall Garage	6,904
Information Sciences Garage	38,499
O'Hara Garage	140,000
OC Garage	106,629
Soldiers & Sailors Garage	344,626
Sennott Square Garage	See Sennott Sc
Educational and General & Health Sciences Facilities	
3343 Forbes	25,122
480 Melwood St.	44,562
Allegheny Observatory	30,017
Allen Hall	58,026
Alumni Hall	162,970
Athletic Fields Building	1,312
Bellefield Hall	107,545
Benedum Aud.	19,586
Benedum Hall	433,326
Benedum Hall - Food Services	
Benedum Hall - MCSI Addition	20,480
Center for Bioengineering	91,123

Cathedral of Learning	599,637
Cathedral of Learning - Chick Fil A	
Cathedral of Learning - Food Services	
Carrillo Street Steam Plant	23,500
718 Devonshire Ave.	16,000
Chevron Science Center	236,768
Chevron Science Center - Food Services	
Chevron Science Center Addition	32,367
Child Development Center	24,517
Clapp Hall	85,893
Computer Center (RIDC)	19,355
Charles L. Cost Sports Center	82,977
Craig Hall Building	55,115
Crawford Hall	87,637
David Lawrence Hall	57,956
Eberly Hall	56,051
Eberly Solvent Storage	380
Engineering Hall	67,859
Eureka Building	36,607
Falk School	28,213
Falk School Addition	38,000
Fitzgerald Field House	105,045
Fitzgerald Field House - Concession Stand	
Frick Fine Arts	73,088
Gardner Steel Conf. Ctr.	26,714
GSPH - Parran and Crabtree	227,908
GSPH Annex	57,000
Heinz Chapel	18,717
Hillman Library	252,778
Hillman Library - Food Services	
Iroquois (SHRS)	60,000
Langley Hall Building	90,592
Langley Hall - Food Services	
Barco Law Building	139,611
Barco Law Building - Food Services	
Life Sciences Annex	50,000
Log Cabin	400
LRDC	96,734
Mervis Hall	86,570
Mervis Hall - Food Services	
Music Building	21,275
O'Hara Student Center	40,000
Van de Graaff (Nuclear Physics)	36,691
Petersen Events Center	430,000
Upper Campus Chilled Water Plant	
Petersen Sports Complex	23,200
Wesley W. Posvar Hall Building	513,893
Wesley W. Posvar Hall - Einstein Bagels	
Wesley W. Posvar Hall - Food Prep	
Lower Campus Chilled Water Plant	
University Public Safety Building	23,200
Salk Hall Annex	128,767
Salk Hall Main	205,228
Salk Hall Addition	81,000
Sennott Square	248,000
Information Sciences Building	76,130
Space Rsrch Coordination Center	41,849
Stephen Foster Memorial	27,182
Thackeray Hall	99,147
Thaw Hall	51,379
Trees Field - Sports Dome	16,988
Trees Hall	244,412
University Club	85,000
Victoria Hall	128,759
Victoria Hall - Food Services	
William Pitt Union	178,726
William Pitt Union - Food Services	
School of Medicine Division/Health Sciences Buildings	
Biomedical Science Tower 3	326,000
McGowan Inst for Regen Medicine	45,000
Total	**10,187,967**

Appendix C

Table 26 - Summary of Pitt's GHG Emissions for Fiscal Year 2014

		CO2	CH4	N2O	eCO2
		kg	kg	kg	Metric Tonnes
Scope 1	Co-gen Electricity	32,890,427	3,272	65	32,999.39
	Co-gen Steam	6,368,762	634	13	6,389.86
	Other On-Campus Stationary	1,201,002	244	82	1,229.63
	Direct Transportation	0	0	0	614.95
	Refrigerants & Chemicals	0	0	6	1.68
	Agriculture	114,262,060	14,386	3,828	115,679.30
Scope 2	Purchased Electricity	22,521,931	2,241	45	22,596.55
	Purchased Steam / Chilled Water	2,943,193	400	144	2,992.45
Scope 3	Faculty / Staff Commuting	6,563,554	595	233	6,641.92
	Student Commuting	5,700,006	376	161	5,753.16
	Directly Financed Air Travel	28,146,410	279	321	28,239.25
	Other Directly Financed Travel	1,833,537	2,380	1,079	2,186.05
	Study Abroad Air Travel	911,986	9	10	914.99
	Solid Waste	0	57,462	0	1,608.92
	Wastewater	0	0	456	120.97
	Paper	0	0	0	2,033.36
	Scope 2 T&D Losses	5,975,823	752	200	6,049.94
Offsets	Additional				0
	Non-Additional				0
Totals	Scope 1	40,460,192	4,150	167	41,235.51
	Scope 2	136,783,991	16,627	3,873	138,275.85
	Scope 3	52,074,508	62,252	2,604	56,541.02
	All Scopes	229,318,691	83,029	6,644	236,052.39
	All Offsets				

Net Emissions: 236,052

Table 27 - Summary of Pitt's GHG Emissions for Fiscal Year 2011

		CO2	CH4	N2O	eCO2
		kg	kg	kg	Metric Tonnes
Scope 1	Co-gen Electricity	22,231,127	2,212	44	22,304.78
	Co-gen Steam	5,704,263	568	11	5,723.16
	Other On-Campus Stationary	705,096	139	47	721.52
	Direct Transportation	0	0	0	2,116.48
	Refrigerants & Chemicals	0	0	3	0.76
	Agriculture	137,555,193	15,358	2,170	138,560.20
Scope 2	Purchased Electricity	31,121,306	3,243	236	31,274.68
	Purchased Steam / Chilled Water	2,935,411	434	153	2,988.20
Scope 3	Faculty / Staff Commuting	6,512,906	628	242	6,594.61
	Student Commuting	6,272,156	439	184	6,333.30
	Directly Financed Air Travel	20,111,362	199	229	20,177.67
	Other Directly Financed Travel	1,598,834	2,100	952	1,909.82
	Study Abroad Air Travel	790,008	8	9	792.61
	Solid Waste	0	56,990	0	1,595.73
	Wastewater	0	0	402	106.45
	Paper	0	0	0	1,639.98
	Scope 2 T&D Losses	8,501,989	949	134	8,564.11
Offsets	Additional				
	Non-Additional				
Totals	Scope 1	28,640,485	28,640,485	106	30,866.70
	Scope 2	168,676,500	168,676,500	2,406	169,834.87
	Scope 3	46,722,664	46,722,664	2,305	50,702.48
	All Scopes	244,039,649	83,266	4,817	251,404.05
	All Offsets				0

Net Emissions: 251,404

Table 28 - Summary of Pitt's GHG Emissions for Fiscal Year 2008

		CO_2	CH_4	N_2O	eCO_2
		kg	kg	kg	Metric Tonnes
Scope 1	Co-gen Electricity	0	0	0	0
	Co-gen Steam	0	0	0	0
	Other On-Campus Stationary	9,181,420	913	18	9,211.84
	Direct Transportation	471,071	85	29	481.21
	Refrigerants & Chemicals	0	0	0	680.77
	Agriculture	0	0	1	0.23
Scope 2	Purchased Electricity	146,965,686	18,938	2,435	148,141.11
	Purchased Steam / Chilled Water	52,874,682	5,673	597	53,191.61
Scope 3	Faculty / Staff Commuting	2,567,191	405	141	2,615.98
	Student Commuting	6,430,133	633	243	6,512.18
	Directly Financed Air Travel	5,744,764	401	169	5,800.70
	Other Directly Financed Travel	17,009,837	169	194	17,065.89
	Study Abroad Air Travel	1,369,756	1,799	815	1,636.18
	Solid Waste	0	650,504	0	18,214.11
	Wastewater	0	0	454	120.23
	Paper	0	0	0	1,745.30
	Scope 2 T&D Losses	14,535,068	1,873	241	14,651.32
Offsets	Additional				
	Non-Additional				
Totals	Scope 1	9,652,491	999	48	10,374.05
	Scope 2	199,840,368	24,611	3,031	201,332.72
	Scope 3	47,656,748	655,783	2,256	68,361.89
	All Scopes	257,149,606	681,392	5,336	280,068.66
	All Offsets				0

Net Emissions: 280,069

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