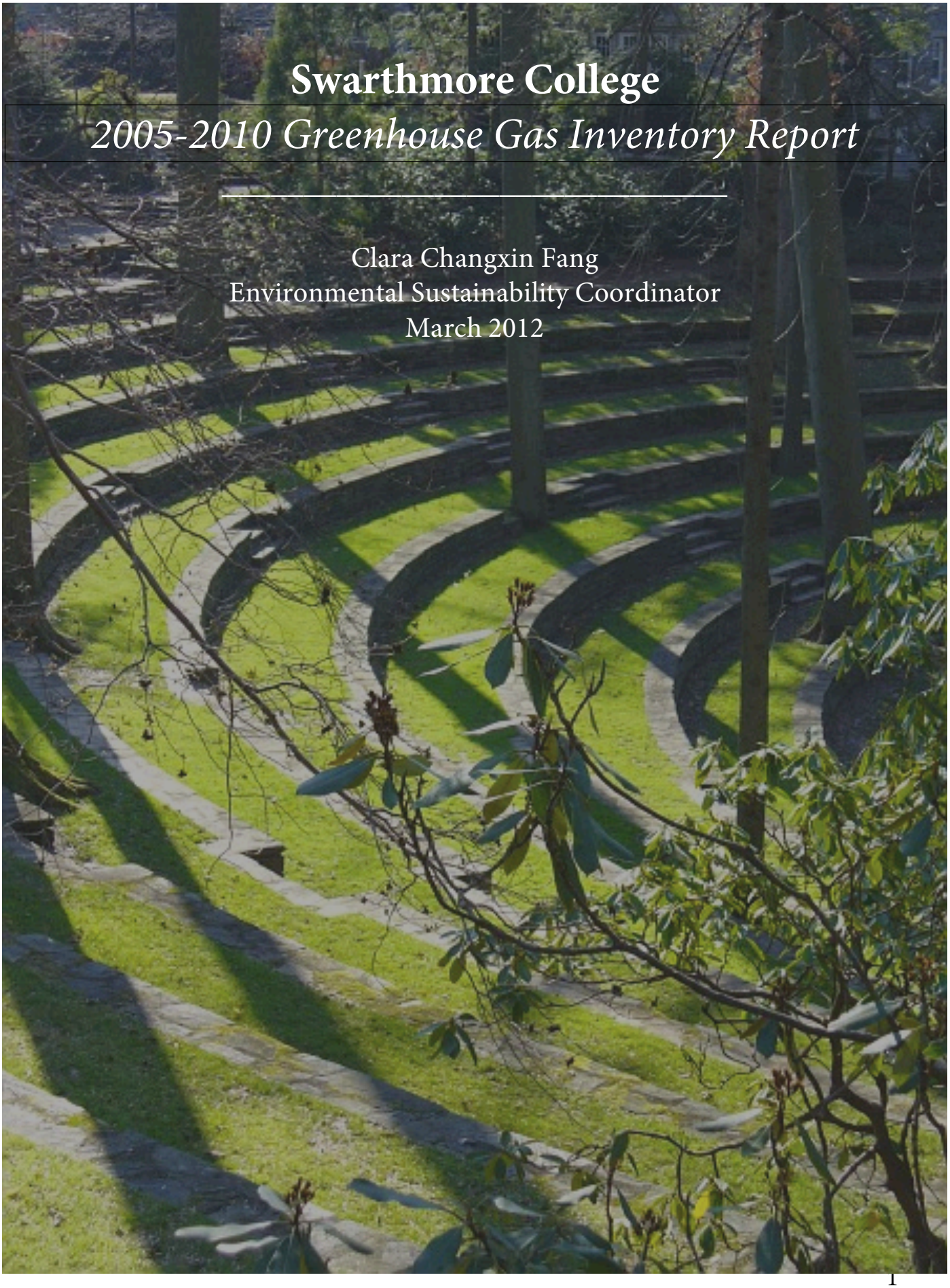

Swarthmore College

2005-2010 Greenhouse Gas Inventory Report

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March 2012

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Acknowledgements

This report couldn't have been produced without the help of the following individuals at Swarthmore who supplied data, technical expertise, guidance and support:

Ralph Thayer for providing information about energy use, buildings, fuels, vehicles, refrigerants, renewable energy credits, and for providing guidance on the final report and its presentation;
Rachel Merz for providing guidance on calculations of employee air travel emissions, and for guidance on the charts, the final report, and its presentation;
Maurice Eldridge and **Carr Everbach** for assistance with testing and administering the employee commute and air travel survey;
Andrew Reuther for help constructing the employee commute and air travel survey;
Patricia Martin for providing data on student study abroad;
Jim Boch and **Suzi Nam** for providing information on Admissions travel;
Jenny Gifford and the President's Office staff for providing information about the President's air travel;
Kimberly Freemont and the Human Resources Department for providing information on employee numbers;
Martin Warner for providing information on student enrollment;
Jeff Jabco and **Linda McDougall** for providing information about composting;
The following individuals for providing data on department vehicles: **Steven Green** (at Bryn Mawr College), **Chris Shea, Delores Robinson, Catherine Burnett, Matthew Powell, Eric Wagner, and Annette Newman**
The Sustainability interns **Brian Lee, Collin Smith,** and **Emily Zhang** for help compiling the data and assisting with sustainability tasks;
And thanks to **Joy Charlton, Carr Everbach**, **Nicole Selby**, the **Sustainability Committee** and the **Climate Action Planning Committee** for supporting this work.

2005-2010 Greenhouse Gas Inventory

Introduction

As an institution dedicated to academic excellence and social responsibility, Swarthmore College is committed to addressing global climate change by reducing its own impact and by improving education in sustainability. In 2010, President Rebecca Chopp signed the American Colleges and University President's Climate Commitment, a pledge that the college will develop a climate action plan to address climate change in its operations and its curriculum. The college also pledged to develop a greenhouse gas (GHG) inventory within one year of signing the commitment and update the inventory every year thereafter. Swarthmore's first inventory, which tracks emissions from 2005-2008, was developed by the Center for Sustainable Communities at Temple University. The inventory for 2010 completed in house updates and expands the greenhouse gas inventory developed by Temple University and serves as the baseline assessment for Swarthmore's Climate Action Plan. An annual GHG inventory also enables the College to track progress on its climate goals from year to year.

Overview

The 2005-2010 inventory tracks greenhouse gas emissions for each calendar year. Emissions were calculated using the Clean-Air Cool-Planet Campus Carbon Calculator version 6.7 (CACP) in accordance with the greenhouse gas protocol developed by the World Business Council for Sustainable Development and the World Resources Institute. The CACP calculator uses the most recent emissions factors from the EPA and is the most widely used tool in US higher education for tracking campus carbon footprints and modeling emissions reduction scenarios. Inputs to the CACP calculator came from data on energy, transportation and waste for Swarthmore collected from Facilities Management and various other departments at the college.

The inventory accounts for emissions that are under the college's operational control. This means that assets whose energy use the college has direct control over are included in the inventory. For example, heat and electricity in student housing is included because the college sets temperatures in student housing and directly controls the energy use in those buildings. The College decided not to include college-owned faculty housing in the inventory because the energy use is controlled by the occupants of those buildings. The inventory also does not include energy use by the college's contractors, or life cycle emissions of food and products purchased by the college. Carbon sequestered in the Crum Woods is also not counted because the college cannot take credit for existing carbon sinks. Establishing operational boundaries helps to verify that all applicable GHG emission sources are appropriately accounted for and to avoid double counting.

Emissions from sources in three scopes were included according to greenhouse gas accounting protocol:

Scope 1: Direct emissions from campus heat plant boilers, generators, chillers, vehicles, refrigerants
Scope 2: Indirect emissions attributed to purchased electricity
Scope 3: Indirect emissions including employee air travel, employee commute, study abroad air travel

The greenhouse gases emitted by the college in the scopes measured are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and hydrofluorocarbons (HFCs). Greenhouse gases have different impacts in the atmposhere. Global warming potential (GWP) describes the radiative forcing impact of a mass-burned unit of a given greenhouse gas relative to an equivalent unit of carbon dioxide over a given period of time. The GWP for CO_2 is by definition 1. GWPs for other greenhouse gases range from 21 to 23,900. GWPs for all recognized greenhouse gases are summarized below in Figure 1. The greenhouse gas emission quantities in the inventory were converted to carbon dioxide equivalents (CO_2e) by multiplying the quantity of each greenhouse gas by its corresponding GWP.

Figure 1: GHG Global Warming Potentials

GHG	GWP
Carbon Dioxide (CO_2)	1
Methane (CH_2)	21
Nitrous Oxide (N_2O)	310
Hydrofluorocarbons (HFCs)	Varies
Perfluorocarbons (PFCs)	6,500 – 9,200
Sulfur Hexafluoride (SF_6)	23,900

Because the quality and availability of data were varied for each source, about 83% of the inventory is highly accurate, and the remaining 17% is reasonably accurate. The data obtained on heat, electricity, refrigerants, and study abroad air travel are highly accurate. Meters at the college record the amount of heat and electricity used, and records are kept of refrigerants purchased. The Office of Off-Campus Study records data on all students who study abroad which makes it possible to obtain highly accurate mileages.

The data on employee commute and air travel were obtained through a survey. A survey was determined to be the best method for collecting this information because air travel information was not collected centrally by the college or by its departments. The Business Department only had records of reimbursements for the cost of travel and no records on the places traveled to or the mode of travel used. Employee commute data were also collected through a survey because no data were available on employee commute modes. 413 employees responded to the survey out of 923. We believe the data received from the survey respondents are representative of the entire employee body. In addition, we received records of all air travel conducted by the Admissions Office staff and the President's Office. Calculating emissions from these two groups separately increased the accuracy of our results for employee air travel.

The data on the vehicle fleet were highly variable. We were able to obtain accurate data on fuel use in Facilities vehicles, which constituted the majority of vehicle fuel used. We were able to obtain accurate records of fuel use or mileage on half of the vehicles used by Departments;

reasonable estimates were used for Departments that had no data. Not having completely accurate data on all vehicles in the fleet does not impact the accuracy of the inventory very much because emissions from the vehicle fleet constitute only 2% of total emissions.

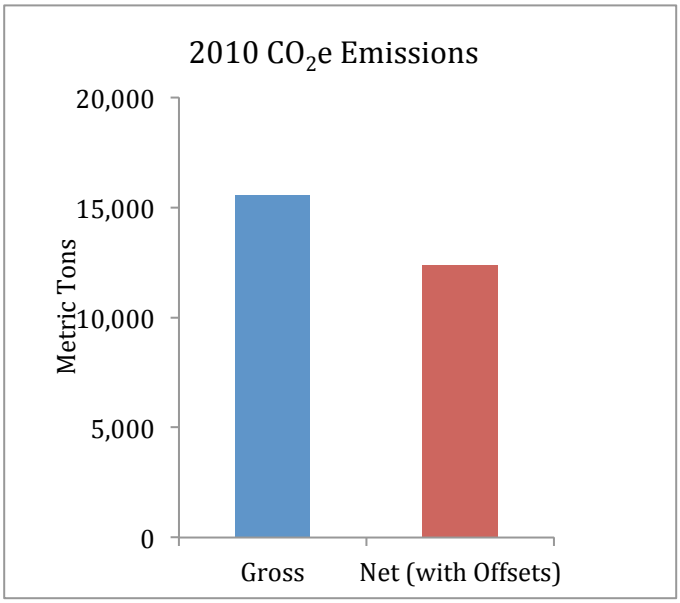
The summary of data collected and input into the CACP calculator is shown in Figure 2.

Figure 2 Energy Use Data

Scope	Source	Quantity	Unit
1	Natural Gas	96,874	Mcf (hundred cubic feet)
1	Fuel Oil #2	3,286	Gallons
1	Fuel Oil #6	586	Gallons
1	Vehicles - Diesel	5,446	Gallons
1	Vehicles - Gas	24,589	Gallons
1	Refrigerants	60	Pounds
2	Purchased Electricity	13,838,931	Kwh
3	Employee Commute	777	Metric tons CO_2e
3	Admissions Air Travel	151,793	Miles
3	President's Air Travel	36,258	Miles
3	Employee Air Travel	2,089,970	Miles
3	Study Abroad Air Travel	1,104,837	Miles
3	Total faculty and staff air travel	2,278,021	Miles
Offsets	Renewable Energy Certificates	6,417,000	Kwh
	Composting	183	Short tons

Emissions

In 2010, Swarthmore College emitted a total of 15,565 metric tons of CO_2e, an amount equivalent to emissions from powering 1,941 homes for a year.[1] CO_2e per person (employees and students) was 6.3 metric tons. With 1,476,860 square feet of building space, CO_2e emissions per square foot were 10.8 kg per year. In 2010 Swarthmore College also offset 3,172 metric tons of CO_2e through composting and the purchase of renewable energy credits. By subtracting offsets from total emissions, we obtain net emissions of 12,393 metric tons of CO_2e, or 5.2 metric



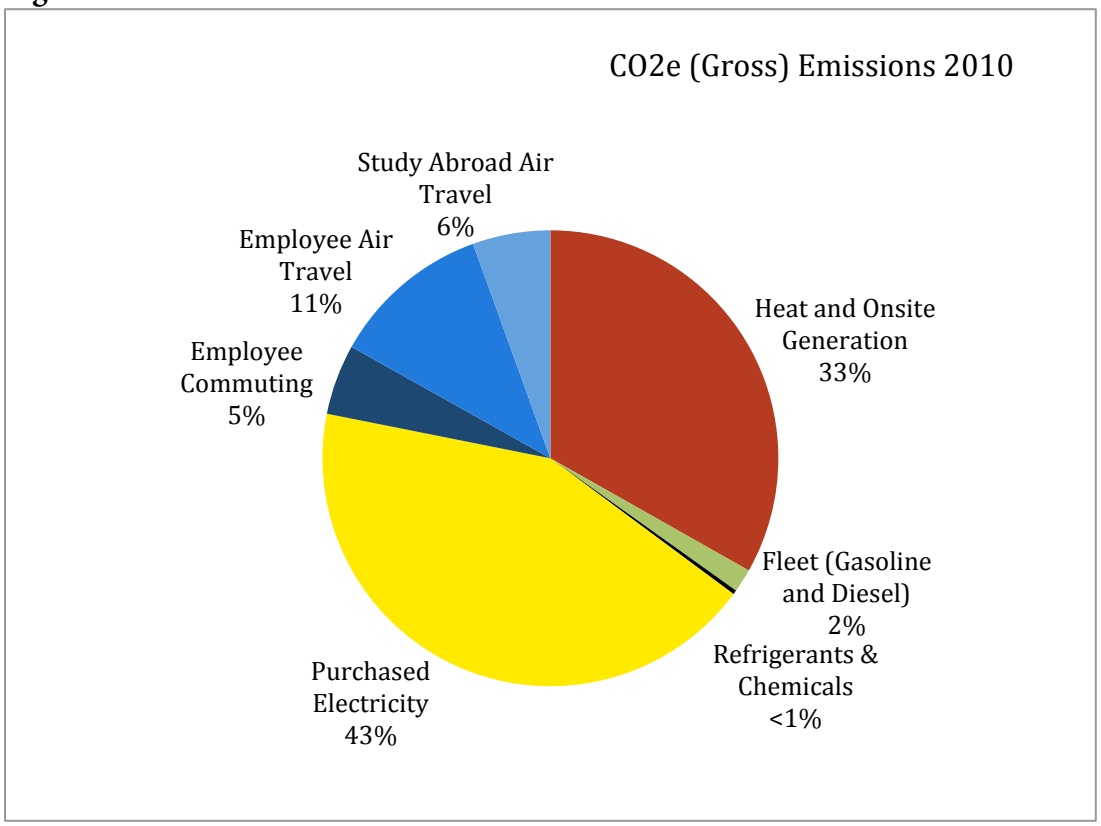
[1] Calculated using EPA Greenhouse Gas Equivalencies Calculator http://www.epa.gov/cleanenergy/energy-resources/calculator.html

tons per person. CO_2e emissions in 2010 are summarized in Figure 3. Figure 4 shows a percentage breakdown of Swarthmore's gross emissions.

Figure 3 Emissions by Source

Scope	Source	Metric Tons CO_2e
1	Heat and Onsite Generation	5,166.4
1	Fleet (Gasoline and Diesel)	259.4
1	Refrigerants & Chemicals	46.3
2	Purchased Electricity	6,689.2
3	Employee Commuting	777.1
3	Employee Air Travel	1,768.6
3	Study Abroad Air Travel	857.8
	Total Emissions	15,564.8
	Composting	*-70.4*
	Renewable Energy Credits	*-3,101.7*
	Net Emissions (Total - Offsets)	12,392.7

Figure 4



Electricity

Electricity use generates the largest portion of the college's greenhouse gas emissions, or 43% of total emissions. In 2010, Swarthmore College used 13,838,931 kWh of electricity, resulting in 7,351 metric tons of CO_2e. Swarthmore College currently buys its electricity from Direct Energy with PECO acting as the local distributing company. The electricity is generated from a mixture of coal 56.4%, nuclear 34.2%, natural gas 5.9%, hydro 1.7%, oil 1.2%, renewable and other 0.7%.

Data on Swarthmore's electricity usage were provided by Ralph Thayer, Director of Maintenance, in the Facilities Department. The quantity and cost of electricity is supplied to the college in the form of energy bills from Direct Energy as the supplier and PECO as the local distribution company. Kilowatt hours of electricity were entered into the CACP calculator to obtain CO_2e for electricity. The e-grid subregion was set to Pennsylvania, RFCE, which determines the emissions factor used for calculating CO_2e.

Heating and Onsite Generation

Heating and onsite generation contributed 5,164 metric tons of CO_2e, or 33% of total emissions. Of that amount, 99% came from burning natural gas and less than 1% came from burning #2 and #6 fuel oil. Fuel oil has a much higher carbon content than natural gas and also releases more air pollutants when burned. A portion of fuel oil #2 is also used to generate emergency electricity, and a portion of natural gas is burned in an engine driven chiller for cooling.

Data on natural gas, fuel oil #6 and #2 were provided by Ralph Thayer, Director of Maintenance, in the Facilities Department. Swarthmore buys natural gas from PECO and fuel oil #6 and #2 from Hess Oil. The quantities were entered into the CACP calculator to obtain CO_2e for natural gas, fuel oil #6 and fuel oil #2.

Employee Air Travel

Employee air travel contributed 1768.6 metric tons of CO_2e, or 11% of total emissions. In 2010 Faculty and staff at Swarthmore traveled a total of 2,089,970 air miles. Ground travel was not included because no data were available.

Employee air travel was calculated based on information gathered through the Admissions Office, the President's Office, and a survey of Swarthmore faculty and staff.

Data on air travel by the Admissions staff were compiled by Suzi Nam in the Office of Admissions. Air miles were calculated using the Webflyer Mileage Calculator and then aggregated to arrive at a total.

The President's air travel was provided by Jenny Gifford in the President's Office. Air miles were calculated using the Webflyer Mileage Calculator and then aggregated to arrive at a total.

Data on faculty and staff air travel were collected through the "Employee Commute and Air Travel Survey" conducted in December 2011. 413 employees responded to the survey out of 913. Faculty and staff members reported in the survey the destinations they traveled to in 2010. Round trip air miles were then obtained by entering each person's origin and destination into the Webflyer Mileage Calculator. We grouped employees into the following categories:

a) No travel (Administrative Assistants, Dining Workers, Health Center Workers, etc.)
b) Low travel (Facilities Workers, Lecturers, Career Services, Communications, etc.)
c) Mid travel (Librarians, Dean's Office, Financial Aid, Arboretum, ITS, etc.)
d) High travel (Athletics, Development, Faculty, Registrar's Office, etc.)

We then divided the total number of miles in each group by the number of people who were in that category to obtain the following averages:

No travel = 0 mi/person
Low travel = 385 mi/person
Mid travel = 1,092 mi/person
High travel = 5,927 mi/person

Next, we separated the employees who did not respond to the survey into the same travel categories and then multiplied the number of employees in each category by the average miles in each category to obtain an estimate of the total miles of employees who did not respond to the survey. This number was added to the total miles traveled by employees who responded to the survey.

The sum of Admissions air travel, President's air travel, and employee air travel was entered into the CACP calculator to obtain CO_2e for employee air travel.

Study Abroad Air Travel

Students studying abroad as part of a semester or year-long program in 2009-2010 and the staff members that administer the program contributed 857.8 metric tons of CO_2e or 6% of total emissions. All together 116 students traveled 1,077,610 miles to 32 countries. Student travel for research, course work, or brief visits were not included. Also not included is student travel to Swarthmore from home at the beginning of the year or for vacations. Ground travel is also not included because data were not available.

Information on study abroad air travel was taken from the Off-Campus Study Annual Report 2009-2010 provided by Patricia Martin in the Office for Off-Campus Study. Air miles were calculated by entering the origin and destination of each trip into the Webflyer Mileage Calculator and then aggregated to arrive at a total. The sum was entered into the CACP calculator to obtain CO_2e for study abroad travel.

Employee Commute

Employee commute contributed 791 metric tons of CO_2e, or 5% of total emissions. In 2010, Swarthmore employed 932 faculty and staff members. Of those 695 were full time and 237 were part time. Only faculty and staff who were employed by the college at the time and commuting to campus were counted. Contractors, those on leave, and those working remotely were not included. All together, employees commuted approximately 2,526,380 miles in 2010. The average commute was 13 miles round trip per day. Approximately 75% of trips to and from campus were conducted by driving alone, 13% by walking, 4% by train, 4% by carpool, 3% by bicycle, and 1% by bus. Employees often mixed commute modes, such as driving alone some of the time and

carpooling at other times, or biking to the train station and then taking the train the rest of the way. Figure 5 shows the breakdown of commute modes used by employees.

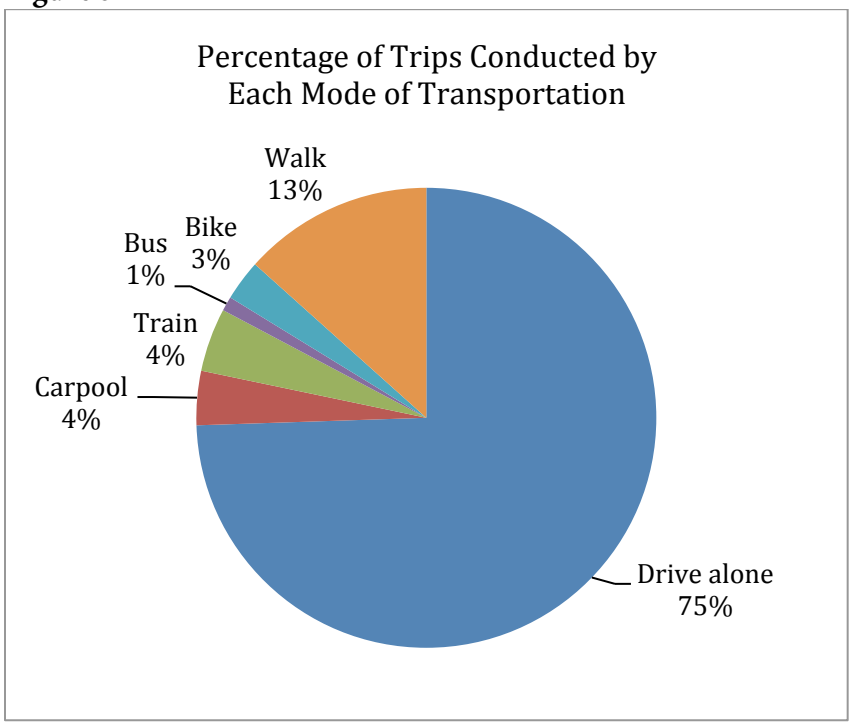
Information on employee commute was obtained through the "Faculty and Staff Commute and Air Travel Survey" conducted December 6-23 in 2011. 413 employees responded to the survey out of 913. Respondents reported the number of days they commuted to campus each week during 2010, miles commuted each day, the modes of commute used, percentage of time using each mode of commute, and fuel economy of their vehicle. Gallons of fuel used in driving alone and carpooling were obtained by dividing the miles commuted by fuel economy of vehicle. If the respondent did not provide the fuel economy of his/her vehicle, the average fuel economy of all respondents was used. CO_2 was obtained by multiplying gallons of gasoline by the CO_2 emissions factor for gasoline (8.7 kg CO_2/gallon). CO_2 was obtained for diesel by multiplying gallons of diesel by the CO_2 emissions factor for gasoline (9.9 kgCO2/gallon).

Emissions from N_2O and CH_4 were calculated by multiplying the miles driven alone and carpooled by the emissions factors for N_2O and CH_4. N_2O and CH_4 emissions were then multiplied by their respective global warming potentials to arrive at CO_2e emissions.

Commutes conducted by train, bus, biking and walking were assumed to have no emissions. Even though trains and buses do release emissions, those emissions could be attributed to the local transportation authority instead of Swarthmore College.

Finally, the total CO_2e obtained of all survey respondents was divided by the number of survey respondents and multiplied by the total number of employees.

Figure 5



Vehicle Fleet

Swarthmore's fleet contributed 245 metric tons of CO_2e, or 2% of total emissions. The vehicle fleet is composed of three sets of vehicles: Facilities vehicles, Department vehicles, and tri-co shuttles. The Facilities vehicles use both gasoline and diesel and quantities were obtained from Ralph Thayer in the Facilities Department. Vehicles include those used by Maintenance, Planning and Construction, Grounds, Security, Dining services, and Environmental Services. They range from skid steers, tractors, golf carts, vans, and box trucks.

The department vehicles were managed independently by each department and data had to be obtained from each department individually. Data requested from each department included the number of vehicles, type of fuel used, quantity of fuel used, cost of fuel, and miles driven in 2010. Many departments did not have all of the data that were requested. Figure 6 shows information that was obtained on the vehicle fleet.

Figure 6 Department Vehicles Fuel Use

Department	# of Vehicles	Fuel Used	Information Provided
Facilities	83	Gasoline Diesel	18,001 gallons 2,456 gallons
Chester Children's Chorus	1	Gasoline	No data
Biology	3	Gasoline	350 gallons
Engineering	1	Gasoline	No data
Library	1	Gasoline	$ 3,257
Lang Center	2	Gasoline	575 gallons
Student Council	4	Gasoline	35,000 estimated miles
Athletics	3	Gasoline	16,684 estimated miles
Tri-College Shuttle	3	Biodiesel 20	1,495 gallons

In the case where a department provided miles but not gallons, the number of miles driven was divided by an assumed fuel economy of 12 miles per gallon in order to arrive at gallons consumed. In the case where a department provided cost but not gallons, the cost of fuel was divided by an assumption of $2.90 per gallon in order to arrive at gallons consumed. In the case where no data were provided (Engineering and Chester Children's Chorus), it was assumed that Engineering's one vehicle used as much gas as one third of Biology's three vehicles. Chester Children's Chorus was also assumed to use one third of Biology.

Data on the tri-college shuttle were obtained from Steven Green, Transportation Manager at Bryn Mawr College. The three tri-co shuttles run on biodiesel that's 20% vegetable oil and 80% regular diesel. The amount of fuel used was divided by three in order to represent Swarthmore's share of the shuttle usage.

The total gallons of gasoline used by Facilities and department vehicles was aggregated and entered into the CACP calculator to obtain CO_2e from gasoline used in vehicles. The gallons of diesel used by Facilities and the tri-co shuttles were aggregated and entered into the CACP calculator to obtain CO_2e from diesel used in vehicles. Biodiesel for the tri-college shuttles was combined with diesel for facilities vehicles in the calculations because the concentration of vegetable oil in the biodiesel was not high enough for it to be calculated as a separate fuel.

Refrigerants and Chemicals

Refrigerants and chemicals contributed 46 metric tons of CO_2e, or less than 1% of total emissions. In 2010 Swarthmore purchased 60 pounds of hydrofluorocarbons for use refrigeration in the dining hall and window air conditioning units. The quantity of refrigerants and chemicals used was provided by Ralph Thayer in the Facilities Department. Refrigerants were purchased from United Refrigeration Company.

Offsets

In addition to conserving energy and reducing greenhouse gas emissions from operations, carbon offsets are an important component of Swarthmore's climate action strategy. Swarthmore's carbon offsets include composting and the purchase of Renewable Energy Credits. These two sources reduced Swarthmore's greenhouse gas emissions by 3,172 metric tons of CO_2e or 19% of total emissions in 2010. The college does not have any onsite renewable energy systems though solar panels are being considered for the roof of the Lang Performing Arts Center.

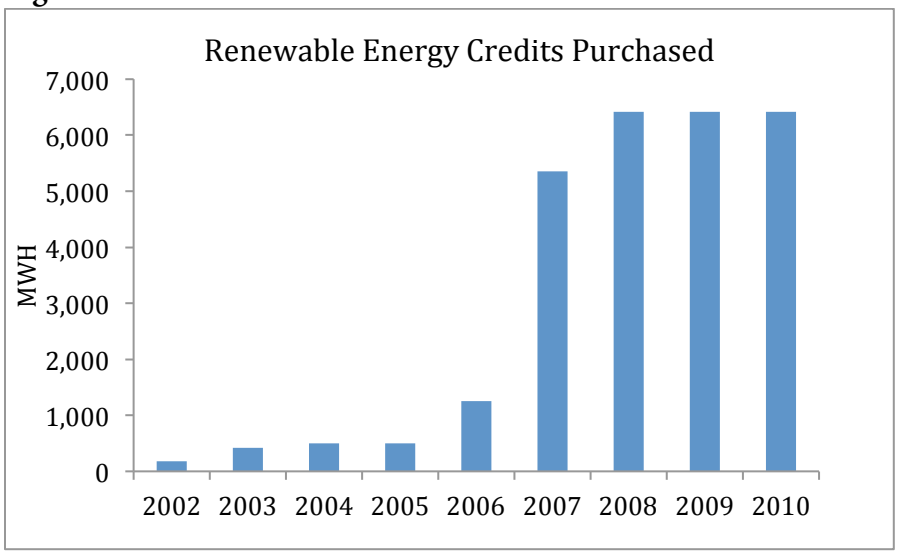
Composting

In 2010 Swarthmore composted 183 short tons of organic waste from dining operations and landscaping. Composting offset 70.4 metric tons of CO_2e. Even though Swarthmore composts its materials at the same facility as the Borough of Swarthmore, Swarthmore's quantity was estimated before it was combined with the Borough's. The quantity of food and yard waste composted was obtained from the EPA recycling report prepared by Jeff Jabco, Director of Grounds. The quantity in tons was entered into the CACP calculator to obtain CO_2e offset amount.

Renewable Energy Credits

In 2010 Swarthmore purchased 6,417 MWh of renewable energy credits (RECs) which offset 3,102 metric tons of CO_2e. The RECs were supplied by Renewable Choice, which supports renewable energy projects across the country. Swarthmore College began purchasing RECs in 2002 and the amount has increased each year. Together with Swarthmore Borough, the College and the municipality purchase enough RECs to be listed by the EPA as a Green Power Community. The quantity of RECs purchased was provided by Ralph Thayer in the Facilities Department. The KWh of RECs were entered into the CACP calculator to obtain CO_2e offset. Figure 7 shows the amount of RECs purchased by Swarthmore from 2005-2010.

Figure 7



Trends

Because the 2005-2008 emissions were compiled differently from 2009 and 2010 emissions, an exact comparison of total emissions cannot be made. However, information about building heat and electricity use was consistent from 2005-2010, which allows for an accurate comparison of energy use from 2005-2010. Figure 8 shows CO_2e emissions from all sources between 2005-2010. The energy totals and energy totals with offsets are aggregated at the bottom of the table.

Figure 8 CO2e Emissions by Source 2005-2010

	Metric Tons CO_2e					
	2005	2006	2007	2008	2009	2010
Natural Gas	2440.4	3155.3	4176.5	4849.4	4755.4	5111.2
Fuel oil #2	233.9	211.8	230.3	210.8	39.9	33
Fuel oil #6	5138.6	4225.1	3279.6	656.5	1015.7	6.9
Fleet - Gasoline	544.9	554.4	557.7	547.2	156.4	219.5
Fleet - Diesel	6.2	5.5	5.0	6.3	18.6	39.8
HFC R22	67.1	58.8		52.0	46.3	46.3
Electricity	9117.7	8491.4	82230.0	7940.8	6880.6	6689.2
Employee Air Travel						1768.6
Study Abroad Travel						857.8
Employee Commute						777.1
Offsets	320.1	800.9	2569.1	3168.9	3172.3	3172.2
Energy totals	16930.7	16083.7	15916.4	13657.5	12691.6	11840.3
Energy totals (with Offsets)	16610.6	15282.8	13347.3	10488.6	9519.3	8668.1
TOTAL	17548.9	16702.4	16479.1	14263.1	12912.9	15564.8

Between 2005 to 2010 CO_2e emissions from energy use (electricity and heat) decreased by 4,429 metric tons or 26% of 2005 levels. Because the college increased its purchase of renewable energy credits during this time, the decrease in net emissions is even more dramatic. With offsets, the college decreased its CO_2e emissions from energy use by 49%. Much of this decline has been due to the drop in the use of #6 fuel oil, which has a much greater carbon intensity than natural gas. Emissions from electricity use have also declined 19% due to building retrofits and conservation measures. Figure 10 shows the trend in emissions from heat and electricity use between 2005 and 2010. Figure 11 compares the trend in gross and net energy emissions from 2005-2010.

Figure 9

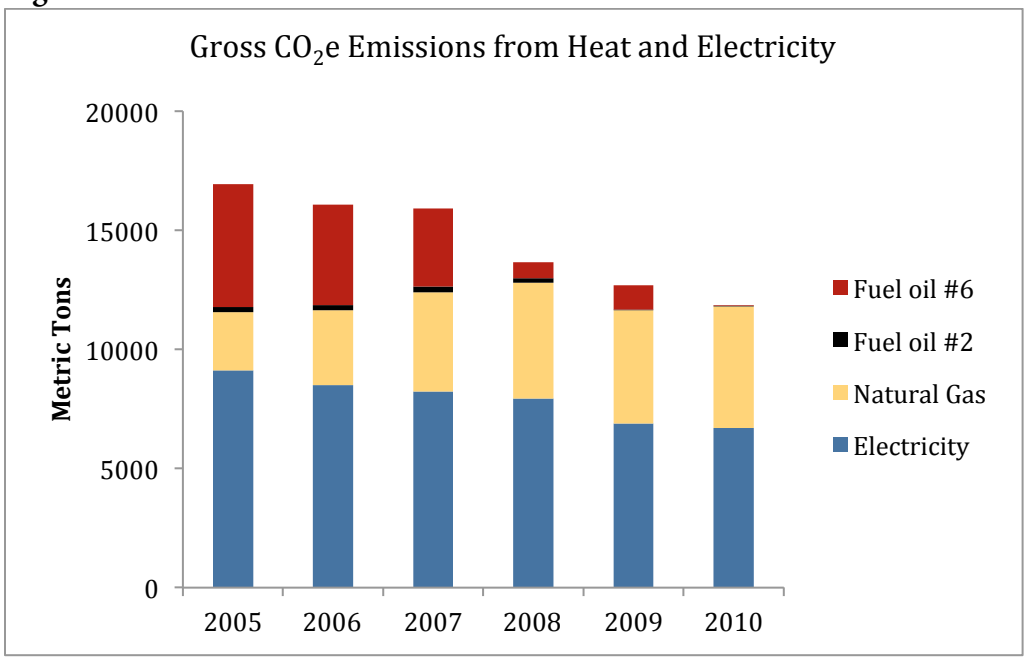
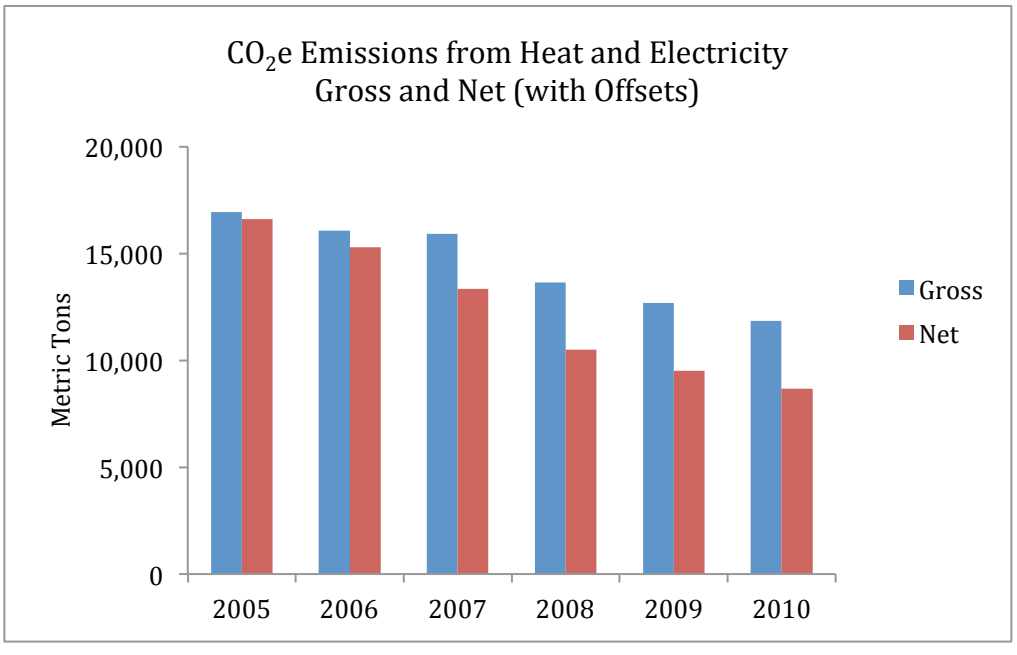


Figure 10

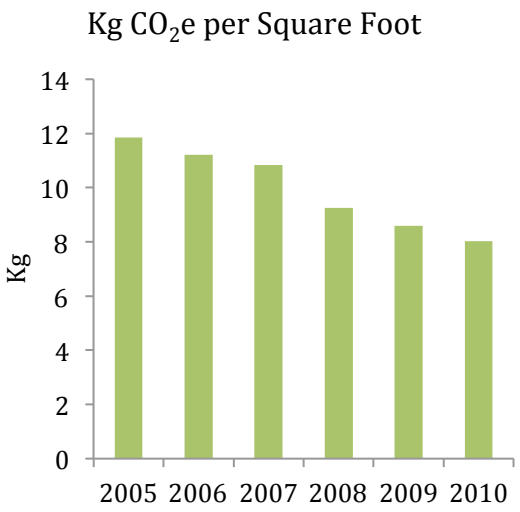


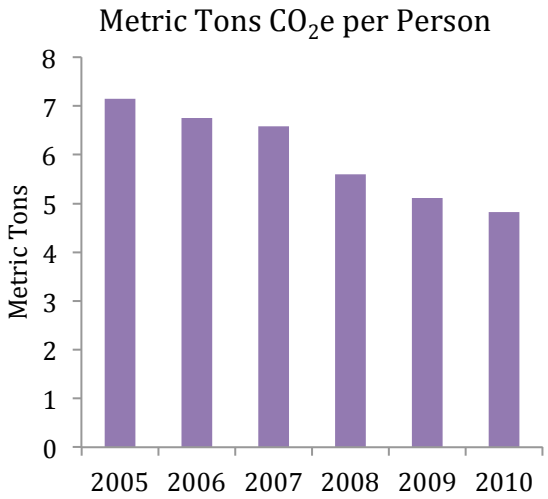
Between 2005-2010 the number of students increased 3%, the number of employees (faculty and staff) increased 5%, and the college added 48,392 square feet of building space. If we compare each year using only emissions from heat and electricity, gross emissions per person (employees plus students) declined 28% and emissions per square foot declined 28%. This indicates a gain in energy efficiency on campus. Figures 12, 13 and 14 show the change in emissions from energy use per person and per square foot.

Figure 11 Per Capita Emissions

Year	Employees	Students	Building Sq. Ft	Gross CO_2e from energy use	MT CO_2e per person	Kg per sq. ft.
2005	891	1479	1,428,468	16,930.7	7.1	11.8
2006	899	1484	1,435,510	16,083.7	6.7	11.2
2007	927	1491	1,468,360	15,916.4	6.6	10.8
2008	949	1490	1,476,860	13,657.5	5.6	9.2
2009	959	1525	1,476,860	12,691.6	5.4	9.1
2010	932	1524	1,476,860	11,840.3	5.1	8.5

Figure 12 and 13





Conclusion

Swarthmore College's greenhouse gas profile from 2005-2010 reflects improvements that the College has made to become more energy efficient. Overall gross emissions from energy use decreased 26% despite a 5% increase in the college population and a 3% increase in buildings over this time period. As the college enters its next phase of expansion and development it will be increasingly difficult to remain on this laudatory trajectory. Because heat and electricity use in buildings comprise 76% of the College's emissions, targeting conservation efforts in this realm is critical. In addition, it will be important to make sure that new construction and renovations to existing buildings and facilities incorporate technologies and construction methods that minimize future carbon emissions. Transportation, representing 24% of total emissions, is an essential part of college operations but it is also the most difficult to limit. An effective mode of tracking transportation would help in the formulation of specific recommendations to reduce or compensate these emissions.

Regardless of increased efficiencies and new technologies the College clearly cannot reach the goal of carbon neutrality without renewable energy certificates and/or carbon offsets. Indeed the purchase of renewable energy certificates is currently an important part of the College's mitigation strategy. Renewable energy and carbon offset options offer complex and interesting opportunities that need to be discussed in a broader context within the College community. The Climate Action Planning Committee, convened in October of 2011, is currently working to address all these challenges in the development of the College's Climate Action Plan. Continuing to monitor our energy consumption and carbon emissions will be crucial in helping the college refine strategies, track progress, motivate change, and celebrate successes in the process of minimizing our carbon footprint.

Supporting Documents

All of the supporting documents are available from the Swarthmore Sustainability Committee Swatfiles.

Clean Air Cool Planet Campus Carbon Calculator
CACP Working Calculator 2010.xlsx
The Calculator was to used turn data about Swarthmore energy use into CO_2e emissions. Emissions factors used for this inventory are contained in one of the spreadsheets. Employee commute calculations were conducted independently in the Greenhouse Gas Inventory Consolidated Spreadsheets. The calculator is available for download from http://www.cleanair-coolplanet.org/toolkit/inv-calculator.php.

Greenhouse Gas Inventory Journal
GHG Inventory Journal 2010.docx
Clara Fang kept a journal between September 2011 and March 2012 of all correspondence related to the greenhouse gas inventory. The journal provides sources for data, explains gaps, reveals obstacles, and explains the methodology for completing this report.

Greenhouse Gas Inventory Consolidated Datasheets
GHG Inventory Consolidated 2010.xlsx
The data and calculations for each section of the greenhouse gas inventory are consolidated in this spreadsheet. This spreadsheet also contains the source for the charts in this report.

Employee Commute and Air Travel Survey
Employee survey 2010.pdf
This document contains the text of the Employee Commute and Air Travel Survey administered in December 2011

Employee Commute and Air Travel Survey Results
Employee survey results 2010.xlsx
The results of the survey were imported into the Greenhouse Gas Inventory Consolidated Datasheets where commute and air travel were separated into two spreadsheets and additional columns were created to perform calculations.