Review of Greenhouse Gas Inventories: 2008, 2009, 2010
July 2011

Summary

Regular assessment of the environmental impact of campus operations and programs is necessary to guide our efforts to achieve climate neutrality. To that end, an annual greenhouse gas inventory is conducted. Inventories of activities and emissions for 2008, 2009, and 2010 are presented. Total emissions for these three years are 17,202 $mtCO_2e$, 15,716 $mtCO_2e$, and 16,049 $mtCO_2e$, respectively. These results indicate that campus emissions have not increased. This is particularly significant since both enrollment and occupied building space have increased over the period.

Background

Bi-annual reports on GHG emissions are required by ACUPCC and are released publicly on their website. Most institutions utilize a calculator designed by Clean Air/Cool Planet to prepare the inventory. Available as a free download, the calculator is an excel spreadsheet into which the user enters data on certain activities (for example, operation of campus maintenance vehicles). Emission factors are then applied, in this case converting the gallons of gas consumed into the amount of CO_2 or CO_2 equivalent. Emission factors are taken from the United Nations Intergovernmental Panel on Climate Change.

Activities listed in the CA/CP spreadsheet are divided into three scopes. Scope is defined in terms of the amount of control the institution has over the activity. For instance, the miles driven by campus maintenance fleet is under direct control and is therefore considered Scope 1. Though Centre can control the amount of electricity we consume, we cannot control the manner in which Kentucky Utilities generates this electricity, so purchased electricity is considered a Scope 2 activity. Between systems and institutions, the greatest differences of interpretation occur within Scope 3 activities, which include categories such as commuting, solid waste, and travel.

Carbon dioxide is the most important greenhouse gas emitted by human activities. However, other substances such as methane, nitrous oxide, and chlorofluorocarbons also influence the solar energy balance. Because each of these materials has a unique absorption spectra and residence time in the atmosphere, almost all studies use relative forcing factors to report relative climate impact in terms of carbon dioxide *equivalent*.

The CA/CP spreadsheet and all other similar systems must convert the units in which activities are measured into CO_2 equivalent. The methods used to generate electricity differ dramatically in the amount of emissions produced, both hydro or nuclear generation produce less CO_2 emissions than either coal or oil generation. Additionally, due to transmission and distribution losses, the amount of power produced at the generating station must be greater than the actual amount of power consumed at our location. The emission factors in CA/CP v6.6 attempt to control for that loss.

The ACUPCC extends to each institution the latitude to declare small emissions sources that collectively comprise less than 5% of the institution's total GHG emissions as *de minimis,* or materially insignificant, and to exclude them from the inventory. In the work reported here, we have attempted to include all categories even if they actually make only a small impact. At Centre, fertilizer use and student commuting are examples of activities that might be considered *de minimis.* However, we have used a more comprehensive approach because we think these small factors are important for evaluating future behavioral changes.

With respect to travel, the ACUPCC stipulates that travel paid for by the institution must be included in Scope 3 activities. This means that transportation of athletic teams and business travel of employees must be included, whereas GHG emissions for study abroad travel are *not* required to be reported because students purchase their own tickets. On our campus, the President's Advisory Committee had several discussions of this issue and decided that, since overseas study is such an integral part of our total educational program, and since the institution encourages and facilitates overseas study in a wide variety of fashions, these emissions should be included. Our inventory also includes paper use, another voluntarily reported activity.

The information used to prepare emission estimates for the past three years is presented in Table 1.

Table 1: Activity Information, units vary

General	Fiscal Year	2008	2009	2010
	Operating Budget ($ 2005)	34,547,478.84	34,865,526.05	32,481,520.78
	Energy Budget ($ 2005)	1,281,161.83	1,342,259.01	1,441,298.45
	Students	1,186	1,196	1,216
	Faculty	108	106	103
	Staff	233	219	233
	Physical Size (ft^2)	942,109	1,090,941	1,136,810
Scope 1:	Natural Gas (MMBtu)	54,880	43,689	45,617
	Gasoline Fleet (gal)[1]	8,746	11,512	13,339
	Diesel Fleet (gal)	150	33	111
	Refrigerants & Chemicals (lbs)	525	225	210
	Fertilizer[2] (lbs nitrogen)	5,600	5,600	5,600
Scope 2:	Electricity (kWh)	13,390,000	12,861,568	13,873,327
Scope 3:	Faculty/Staff Commute (mi)	1,606,898	1,395,488	1,029,480
	Student Commute (mi)	118,410	42,099	18,366
	Faculty/Staff Air Travel (mi)	783,643	536,510	536,510[3]
	Student Air Travel (mi)	522,002	380,014	354,300
	Bus Travel (mi)[4]	- - -[5]	38,430	69,456
	Personal Mileage Reimbursement (mi)	783,643	132,033	132,033
	Study Abroad Travel (mi)	3,071,993	2,969,540	2,665,360
	Landfilled Solid Waste (tons)	367	455	412
	Paper- 25% Recycled (lbs)	- - -	31,747[6]	31,747

Notes to Table 1:

1. In cases where odometer readings were not reported, either the vehicle's previous mileage or the average mileage for the department was substituted.
2. Because the landscaping company was unable to supply the actual amount of fertilizer used, the approximate amount was calculated using lawn acreage and general fertilization recommendations from A.J. Powell. This amount was used for all three years
3. A faculty/staff travel survey was not conducted for 2010, so the data for the previous year was used as a replacement.
4. The CACP calculator draws no distinction between bus and van mileage, therefore all athletics ground miles were entered as bus travel.
5. Information for bus travel and paper are not available for FY 2008 because those fields were not required on the earlier version of CACP calculator.
6. Input information for FY 2010 is used for 2009, since the 2009 data was incomplete.

Data Sources

The data used were obtained from a variety of offices across campus. Below are the individuals and other sources from which we obtained our information.

- Operational Budget: Total Income, not including financial aid, from Scott Owens.
- Energy Budget: From SchoolDude "Building Total Cost" report
- Full Time Students: Registrars Report, "Fall FTE"
- Faculty/Staff: Reported by Meredith Sizemore
- Natural Gas: SchoolDude "Building Total Use" report, conversion factor: 1CF = 1030 Btu
- Fleet Mileage: each department is asked to report odometer readings of all assigned vehicles each July
- Refrigerants and Chemicals: Reported by Dawn Bailey
- Fertilizer: Pratt's Lawn Service does not disclose fertilization rates. This value was calculated using A.J. Powell's recommendation for lawns: 1 lb nitrogen per 1000 sq ft per year (www.ca.uky.edu/agc/pubs/agr/agr53.pdf). Number of acres of lawn reported by Ed Sullivan: 129.
- Purchased Electricity: From SchoolDude "Building Total Use" report
- Student Commuting: Calculated using Google Maps mileage from list of addresses for off-campus students (from Ann Young). We assumed 5 trips per week for 32 weeks.
- Staff/Faculty Commuting: Calculated using Google Maps mileage from home cities list (provided by Glenda Beaven). We assumed 5 trips per week for 50 weeks for staff, and 5 trips per week for 34 weeks and 2 trips per week for 18 weeks for faculty. No carpooling was assumed.
- Business Travel: Based on a fall survey of all employees asking destinations for previous year's business travel, including air travel and personal mileage reimbursement.
- Student Air Travel: Based on online team schedules and air mileage calculator from www.webflyer.com, using Louisville as the home airport
- Bus Travel: Based on online team schedules and Google Maps mileage
- Solid Waste: Reported by Scott Messer
- Paper: Reported by Dotti Rinehart

Limitations

Sound interpretation of statistical data includes an appreciation of the uncertainty of the information. The reliability of the Emission Results reported here depends on the calculator system used (in this case CA/CP v6.6) and also on the reliability of the information we have used (Table 1). Our first report (FY 2008) was calculated with CA/CP version 3, our second with v6.5, and the most recent with v6.6. Between these versions, some emission factors have been changed and new input categories have been added so, for this report, the original 2008 data have been recalculated with the newest version.

The margin of uncertainty for the information used in preparing this report varies for each category. Subjectively, we can consider two general types of data sources – utilities costs and all other activities. Approximately 70% of our GHG impact comes from purchased electricity and natural gas. Each year we obtain the actual utility bills for each meter and enter the data into the SchoolDude database. We can then use SchoolDude to access a variety of reports. The most likely source of error here is simple data entry error.

There are a wide range of other activities in the 30% portion – solid waste, commuting, and air travel reports. For some activities, such as study abroad travel, the uncertainty is very low. Probably the least reliable input data is for employee business travel (air and surface). Since there is no central information source for this data, the mileage has been estimated by a campus-wide survey conducted in fall 2008 and fall 2009, asking all employees to report the destinations for all business-related air and auto trips (recruiting, professional conferences, etc). In fall 2008 we had a 25% return, in fall 2009 we had a 30% return. It is difficult to estimate the uncertainty in this information. One might speculate the results are more likely to be incorrectly low than incorrectly high because a respondent is less likely to report a trip they didn't take than to forget to report a trip they did take.

Another clumsiness of the system is that, in several cases, multiple buildings are served by a common utility meter (either gas or electricity), making it impossible to distinguish individual performance for some buildings.

Results

The net emissions are presented by scope in Table 2 and by activity Table 3.

Table 2: Summary of Total Emissions by Scope, metric tons CO_2 equivalent

	2008	2009	2010
Scope 1 Total	3,355.0	2,612.1	2,703.3
Scope 2 Total	9,234.0	8,869.6	9,567.3
Scope 3 Total	4,613.1	4,234.4	3,778.0
Net Emissions	17,202.1	15,716.1	16,048.7

Table 3: Summary of Total Emissions by Activity, metric tons CO_2 equivalent

		2008	2009	2010
Scope 1:	Other On-Campus Stationary (Natural Gas)	2904.2	2312.0	2414.0
	Direct Transportation	79.6	103.1	120.2
	Refrigerants & Chemicals	347.7	173.5	145.6
	Agriculture (Fertilizer)	23.5	23.5	23.5
Scope 2:	Electricity	9234.0	8869.6	9567.3
Scope 3:	Faculty/Staff Commute	649.2	563.8	415.9
	Student Commute	47.8	17.0	7.4
	Air Travel	1013.7	711.6	691.6
	Other Directly Financed (Mileage Reimbursement)	84.9	63.1	71.0
	Study Abroad	2385.0	2305.5	2069.3
	Solid Waste	432.5	536.3	485.6
	Paper Purchasing		37.2	37.2

Transmission and Distribution Losses

There is disagreement in the field over whether or not to include transmission and distribution losses in an institutional GHG inventory. This component would be a voluntary report in Scope 3. The Clean Air/Cool Planet spreadsheet computes a value for T&D, but uses the same 9% factor for all regions and all locations. The computed values are 913.3 mtC02e for 2008, 877.2 mtCO2e for 2009, and 946.2 mtC02e for 2010. This report follows the practice of ACUPCC and does not include transmission and distribution loss.

Purchase of RECs

A renewable energy certificate is a product representing the environmental attributes of the power produced from renewable energy projects. There is no general consensus on whether, or how, RECs should be considered as an offset to other GHG emissions. The most common reservation is that RECs may in some cases not satisfy the additionality requirement. The current guidance document from ACUPCC suggests that ". . . institutions may determine for themselves how to calculate emissions reductions from REC purchases." A conservative approach is to consider the emission factor from the NERC eGRID region in which the RECs were generated (0.67807 kg CO_2 per kWh).

For FY 2010, 162 blocks of 1,000 kWh were purchased from Kentucky Utilities for each of ten months. The corresponding offset is 1,098 $mtCO_2e$, approximately 6.4% of the total emissions for FY 10. This offset is *not* subtracted from the total presented in Table 2.

Analysis

Examination of the total emissions for the period raises questions of how changes that have occurred at the college may have influenced the total emissions record. Among other factors, we can imagine that enrollment, total amount of building space, or weather changes may influence the total institutional GHG emissions.

Over this period, student enrollment has increased slightly. Table 4 shows that the ratio of emissions per student has decreased slightly.

Table 4: GHG Emissions Relative to Student Enrollment

Period	Enrollment	Total GHG Emissions, $mtCO_2e$	Emissions per Student, $mtCO_2e$/student
2008	1,186	17,202.1	14.5
2009	1,196	15,716.1	13.1
2010	1,216	16,048.7	13.2

Likewise, the past few years have seen several new buildings on our campus. Pearl Hall (55,916 sq ft) was first occupied in fall 2009 and the Campus Center (46,569 sq ft) in fall 2010. Both of these buildings were built to high standards for energy efficiency. In Table 5 presents the ratio of emissions to building area. One interpretation is that efficiency of newer buildings is leading to overall reduced utilities demand. For FY 2010 the overall energy costs for Pearl Hall of $\$1.05/ft^2$ ranks about mid-way among our major buildings. North Campus dorms used $\$0.75/ft^2$ and the Norton Center used $\$1.17/ft^2$ for the same period. We should also bear in mind that 670,000 ft^2 of building area were built before 2005 and have a wide range of utility efficiencies.

Table 5: GHG Emissions Relative to Total Building Space

Period	Building Area, ft^2	Total GHG Emission, $mtCO_2e$	$mtCO_2e$ per 1000 ft^2
2008	942,000	17,200	18.2
2009	1,091,000	15,716	14.4
2010	1,137,000	16,050	14.1

Everyone talks about the weather! But it is difficult to remember if this winter was really colder than last winter. The most common approach to adjust for annual changes in weather is the concept of heating degree days or cooling degree days. The HDD (CDD) is calculated from the difference between the average of the daily high and daily low and a reference temperature of 65^oF. As an example, a cold day in December with a high of 45 and a low of 25 would lead to calculation of 30 degree days. The total for the year is then the simple sum of the value for each day. In our work below, temperature data are taken from the Lexington airport. The ratios presented in Table 6 do not suggest a clear pattern. During this period, Bingham has been converted to all-electric and all-electric Pearl Hall has been added. Over the period,

emissions from purchased electricity have become a larger portion of total emissions: 54% in 2008, 56% in 2009, and 59% in 2010.

Table 6: GHG Emissions Relative to Annual Weather Variations

Period	HDD	CDD	Total	Electricity, kWh	Natural Gas, MMBtu	Electricity Use per Cooling Degree Days, kWh/CDD	Natural Gas Use per Heating Degree Days, MMBtu/HDD
FY 08							
	3,170	2,370	5,540	13,390,000	54,800	5,650	17.3
FY 09							
	3,583	2,062	5,645	12,861,000	43,689	6,237	12.2
FY 10							
	3,709	1,973	5,682	13,873,000	45,617	7,031	12.3

Note: Degree days are taken from www.weatherdatadepot.com and www.DegreeDays.net, accessed June 2011, and adjusted from annual calendar to fiscal year calendar.

The cost of utilities varies dramatically and Centre uses forward pricing for natural gas to minimize cost uncertainties. Table 7 presents expenditures for natural gas and electricity in both current and constant (2005) dollars. Conversion based on the deflator number used by CA/CP.

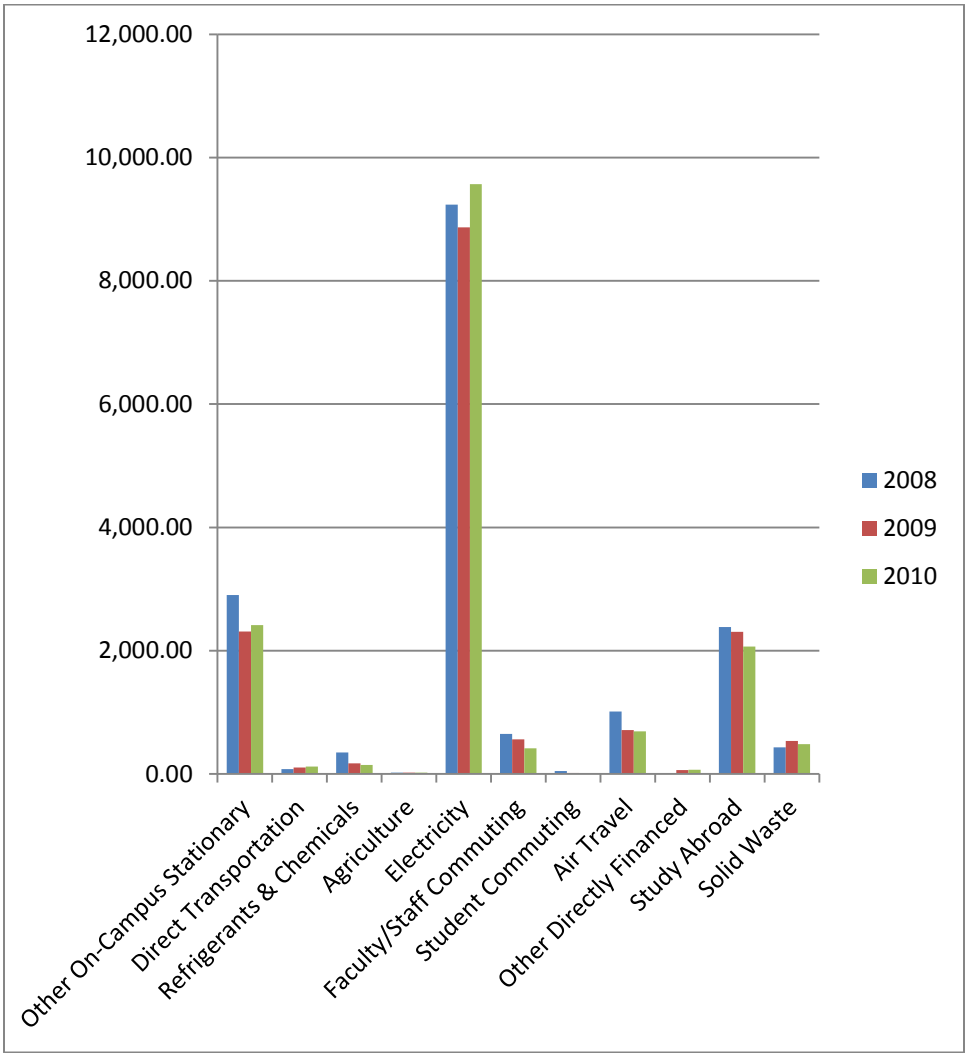
Table 7: Utility Cost per Year

	Gas		Electricity		Total	
	Actual Cost	2005 Dollars	Actual Cost	2005 Dollars	Actual Cost	2005 Dollars
2008	$583,572.89	$539,820.44	$841,758.64	$778,649.13	$1,425,331.53	$1,318,469.57
2009	$587,724.24	$534,018.05	$899,722.38	$817,505.82	$1,487,446.62	$1,351,523.86
2010	$415,491.14	$370,468.15	$949,734.67	$846,820.57	$1,365,225.81	$1,217,288.71

There does not appear to be any significant change in the type of activity leading to greatest GHG emissions. The operation of facilities is consistently the greatest single type of contributor to GHG emissions. The emissions from combustion of natural gas and from purchased electricity have been around 70% of total emissions for the period studied (2008, 70.5%; 2009, 71.1%; 2010, 74.6%).

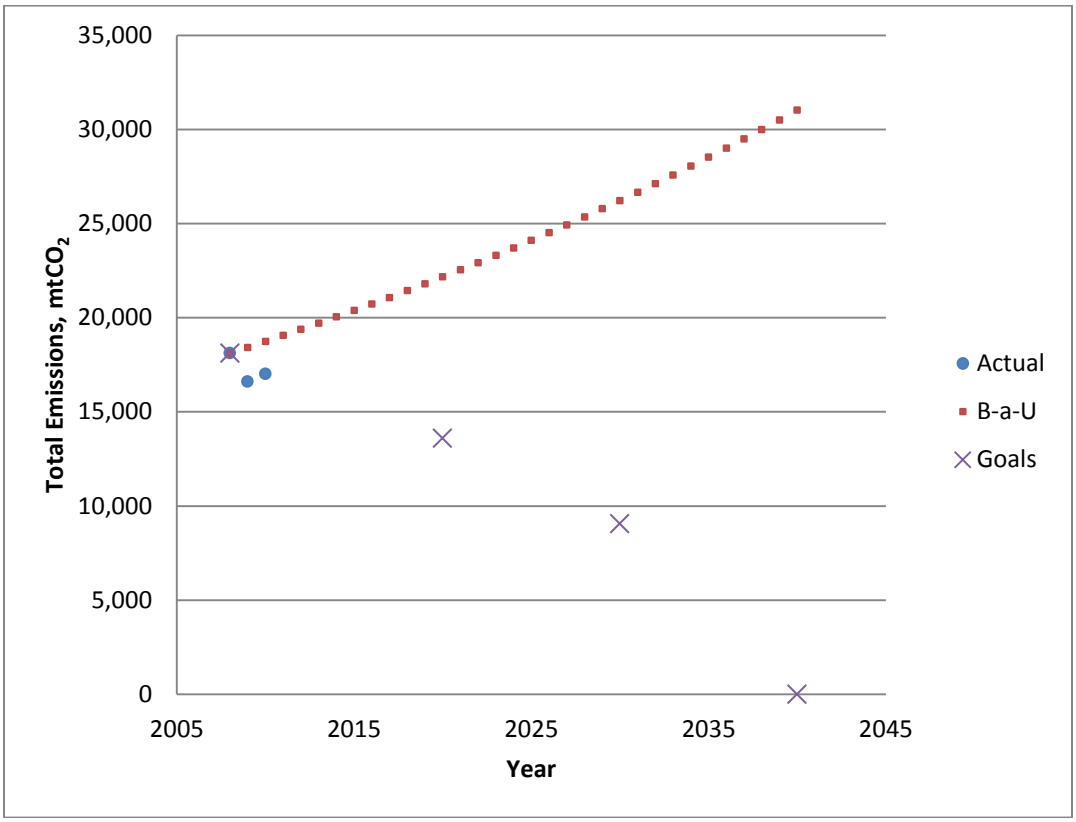
An alternative way to understand the changes in total emissions for this three year period is to look at the changes in each of the categories of emissions. Figure 1 presents the year-by-year emissions from 11 different categories.

Figure 1: Emissions by Category by Year



Finally, we must maintain a perspective between the results for the previous three year period and the bold goals that Centre has set for itself. Figure 2 presents the 2008, 2009, and 2010 results relative to business-as-usual trends and to our ACUPCC goals.

Figure 2: Comparison of Recent Results with Goals and Business as Usual Trend



Note: Goals are taken from Centre College Climate Action Plan, 2009. Business as Usual trend assumes student enrollment increases at the same rate as the average annual increase from 1989 to 2010 (1.69 %) and that total emissions are proportional to enrollment. Total GHG emissions are taken from Table 2.