Clarkson University Greenhouse Gas Inventory – 2017

Analysis through FY 17 (July 1, 2016-June 30, 2017)[1]

As part of our campus commitment to sustainability, President Tony Collins signed the ACUPCC Climate Commitment in April 2014. That was followed by his signing of a more comprehensive carbon and resilience Climate Commitment in October 2015. A critical aspect of planning for the low-carbon future associated with these commitments is understanding the relationship between specific campus activities and their greenhouse gas (GHG) emissions. Thus, the purpose of this inventory is to identify the most important sources of Clarkson's greenhouse gas emissions (GHG) and identify areas for improvement. The inventory for the Potsdam Campus was completed with standard practices following EPA GHG inventory procedures.

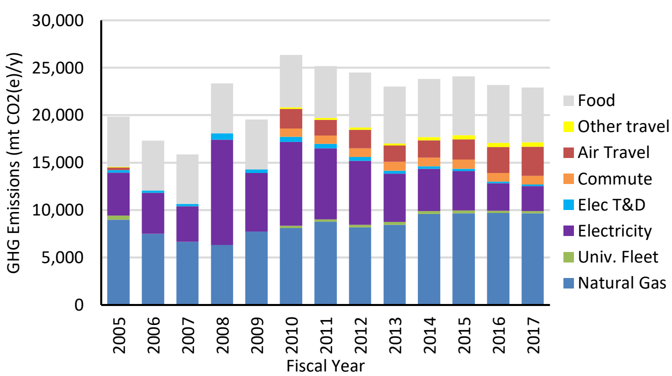
The greenhouse gas inventory is organized into three primary components:

- Scope 1: Emissions directly released from campus activities. Natural gas combustion for building and hot water heating comprises most of our scope 1 emissions
- Scope 2: Emissions that occur off site but that are associated with our electricity use
- Scope 3: Emissions that occur off site associated with other university business (including travel, commuting, paper use, solid waste management, food)

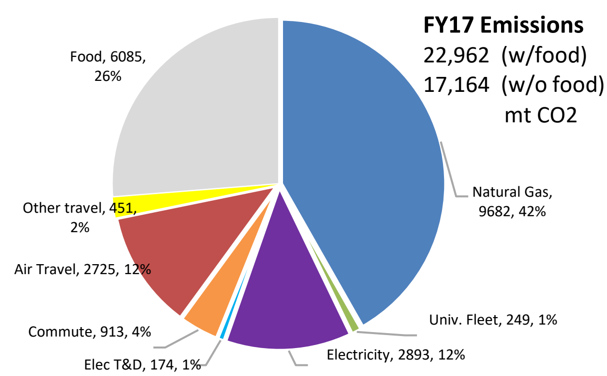
The methodology for assessing our greenhouse gas inventory is described in Attachment A. Data from natural gas and electricity bills provide a relatively high level of certainty for GHG emissions in scopes 1 and 2. However, methods to track data required for scope 3 emissions have varied over the years and have a much higher degree of uncertainty. Somewhat reliable scope 3 data are only available since 2010. Per the original AASHE STARS sustainability assessment completed in 2012, Fiscal Year 2005 is used as a baseline for comparison.

Figure 1 illustrates the greenhouse gas emissions since fiscal year 2004. Over the years, the largest contributors of campus emissions include natural gas consumption, electricity usage and travel. Food is included as a very rough estimate to illustrate its potential substantial contributions; further discussion is included below. Other factors, including paper use, solid waste disposal, and university fleet vehicles contribute negligible amounts of GHGs compared to our total.

Over time, our scope 1+2 emissions have dropped from our 2005 baseline. The change from 14,206 to 12,693 mt CO_2(eq) represents an 11% decrease in emissions. However, at the same time the campus community has grown substantially, including increases in full time students and employees (21%) and building area (9.3%). This suggests a substantial improvement in efficiency in operations and relative decrease in emissions per area or population.



a)



b)

Figure 1. Clarkson Greenhouse Gas inventory, a) Fiscal years 2004-2017; and b) percent distribution of primary sources in FY17

[1] GHG inventory and analysis prepared by Susan E. Powers, December 2017. This report supersedes all others previously prepared due to improvements in methodology, data and system boundary definition

Discussion

Building Energy:

Building energy use comprised 72% of non-food GHG emissions in FY17. Natural gas is used primarily for building heating, hot water and the microturbine for combined heating, cooling and electricity in the LEED Gold Technology Advancement building (TAC). Electricity is primarily purchased through a low-cost, third-party provider (Constellation), with some on-site and local renewable electricity generation.

Electricity consumption use remained remarkably constant over the decade from FY04 – FY14, with an average of 26.8 million kWh per year (91,600 MMBtu/y) and a standard deviation that is within 2% of this average value (Figure 2). Preliminary results from the new district cooling and ventilation project shows a total electricity use reduction of 4.2% over the summer months (FY17 compared to average of FY13-FY15). This impact is apparent from the decline in electricity consumption apparent in Fig.2.

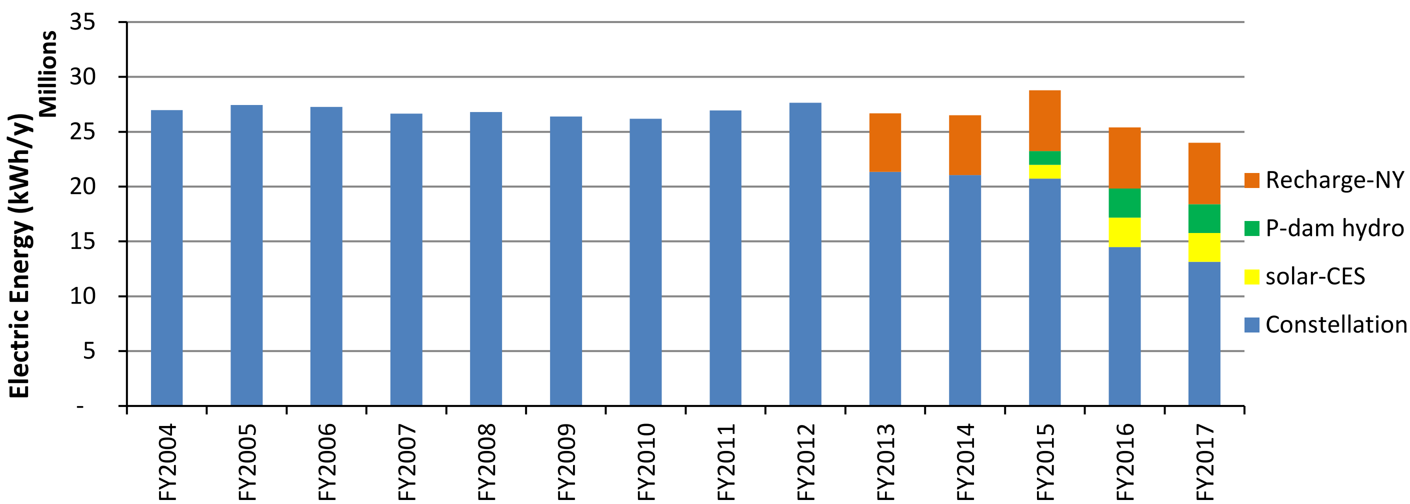


Fig. 2. Total electricity use and major sources

The much higher variability in electricity related GHG emissions (Figure 1, purple bars) compared to electric energy use (Figure 2) is associated with changes in the sources of electricity used over the years. Clarkson has purchased electricity commodity from National Grid (2004-2005), Suez/GDF Suez (2006-2012), and Constellation Energy (2013-current), with recent additions of remote net metering projects with Community Energy Solar (power purchase agreement for solar PV on campus, starting in FY15), the Village of Potsdam (starting in FY15), and credits for low-cost hydropower through Recharge NY (FY13-present). Renewable energy credits for the CES solar facility have been retired.

The overall mixture of electric power generation over the past decade is illustrated in Figure 3. The electricity supplied by National Grid in our baseline year of 2005 was primarily GHG-free nuclear and hydropower (74%). This changed to mostly fossil fuel sources (71%) in 2008 with the switch to Suez for purchase of our electricity commodity. More recently, reduced reliance on coal power and increase in nuclear power from Suez/Constellation have helped to greatly reduce the GHG emissions per unit of electricity purchased from these suppliers from 0.93 to 0.439 lb CO_2(eq)/kWh generated. These values are still considered high in New York. The most recent EPA data (2014) estimates the emission factor for the NY Upstate sub-grid to be 0.377.[2] This low value is consistent with the high amount of hydro (30.4%) and nuclear power (30.6%) production and very little coal power (5.5%) in this region. The emission factor for Clarkson's

[2] EPA Power Profiler, 2012 data, http://oaspub.epa.gov/powpro/ept_pack.charts

electricity from Constellation Energy is 8% higher than the NY UP region total due to substantially more gas and less hydro in the mix that they sell.

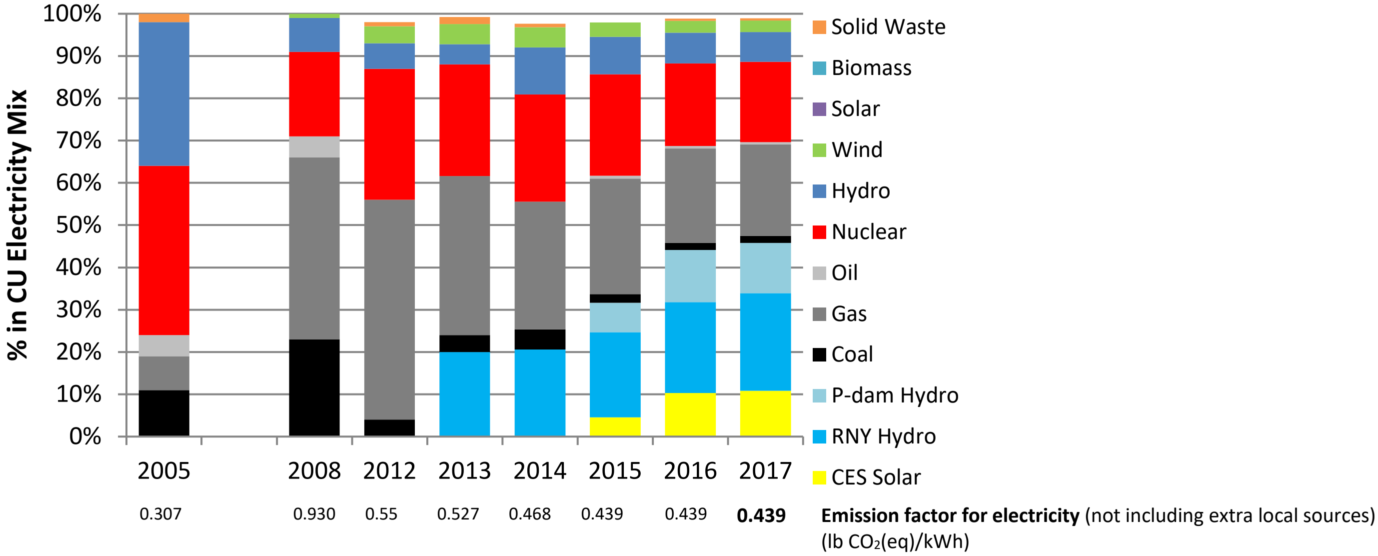


Figure 3. Electricity mix for Clarkson supplies. The emission factors are calculated for electricity from our primary supplier, they do not include extra solar and hydro sources. Data from the Public Service Commission for electricity mix is available only through 2015. Information for 2016 and 2017 Constellation supplier assumed to be the same as 2015. (Note – these values do not include electricity generated by TAC microturbine)

Natural gas use has varied much more than electricity over the same time period (Figure 3). The apparent increase in amount of natural gas used in 2009 is related to the commissioning of the microturbine in the TAC for combined heating, power and cooling and the colder year in 2009 compared to 2008.

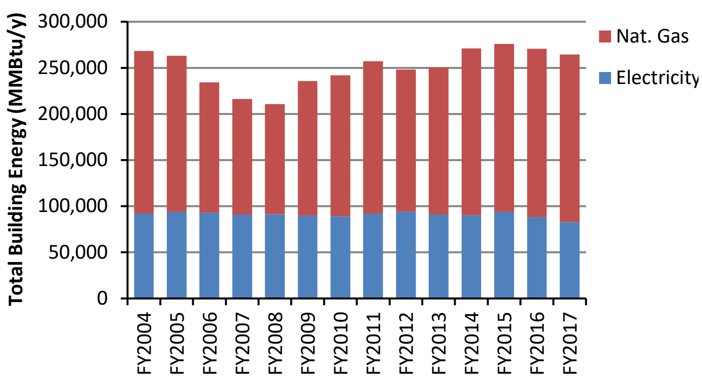


Figure 4. Building energy consumption

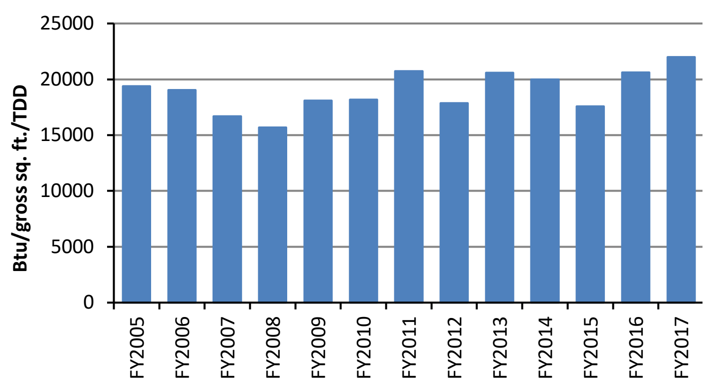


Figure 5. Normalized building energy consumption

Building energy use and GHG emissions across years can also be analyzed by normalizing consumption by the building area and total degree days (TDD) to account for variability due to weather (Figure 5). Our TDDs[3] average 8054 (65ºF basis) with a low in FY17 (6996) and a high value in FY15 (9258). The normalized energy consumption averages 19,000 Btu/sq. ft//TDD with a standard deviation of 9.5%. FY17 represented the highest normalized energy use (22,000 Btu/sq.ft./TDD) analyzed to date.

Building energy use data and scope 1+2 GHG emissions for many schools are published as part of the AASHE STARS sustainability assessment system. A comparison of our use and emission to others can help to benchmark our current status and potential for change. Schools used for comparison were chosen from among our peers in the region. The data

[3] Weather Data Depot, data for total degree days, http://www.weatherdatadepot.com/ (last accessed Feb. 2018)

presented in Figure 6 include both a building energy index and a CO_2 intensity, both of which are normalized by the gross building area. Energy index values range from 0.104 to 0.207 MMBtu/sq.ft., with an average value of 0.138. Cornell, which has the highest energy index also has the greatest amount of laboratory research space on campus (11%). Clarkson's energy index (0.154 for FY17) is higher than the average, but our climate is also colder than many of these other area schools. Clarkson's GHG emissions (FY17: 0.0074 mt CO_2(eq)/sq.ft.) are consistent with the average within this group (0.0086). The very low CO_2 intensity for Colgate (0.003) can be attributed to their use of wood for much of their heating needs. Overall, the information presented in Figure 6 provides some assurance of reasonable values for our analysis and consistency with regional values.

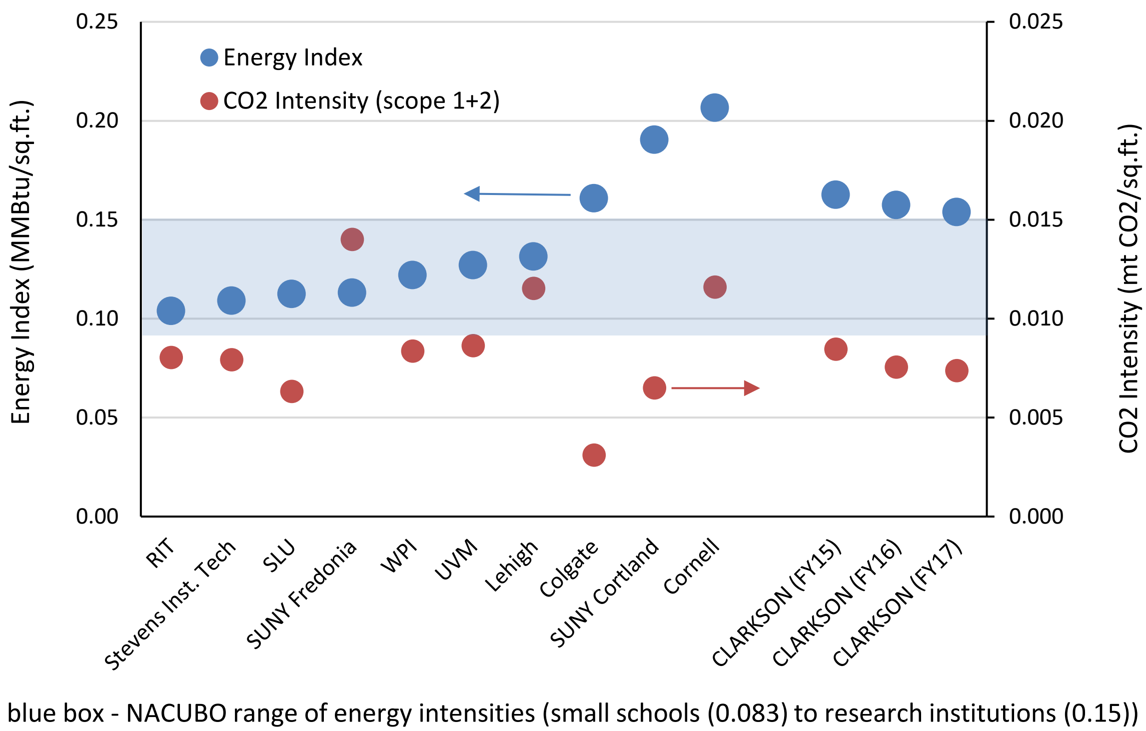


Figure 6. Normalized energy and CO_2 emission data (scope 1+2) compared to area institutions

Travel:

GHG emissions from travel include everyday commuting as well as trips for athletics, classes, research, administration and semester exchanges. Travel related GHG emissions were estimated from University credit card records, invoices for athletics travel bills, class itineraries and faculty/staff commuting surveys. Student travel from home to campus was not included, nor was daily student commuting. Most undergraduate students reside on campus resulting in primarily foot travel to attend classes.

Collectively, travel comprises 26% of our annual non-food GHG emissions (Figure 1). Commuting represents the 20% of the total travel related emissions (Fig. 7). Data for faculty and staff commuting were derived from two voluntary electronic surveys completed in November 2010 and January 2015. The results between the two surveys were remarkably similar (Table 1). On average, employees drive between 3,600-3,700 miles per year, most often as a single occupant of the vehicle. This average was taken over all employees completing the survey providing complete data, including those who typically walk, bike or carpool.

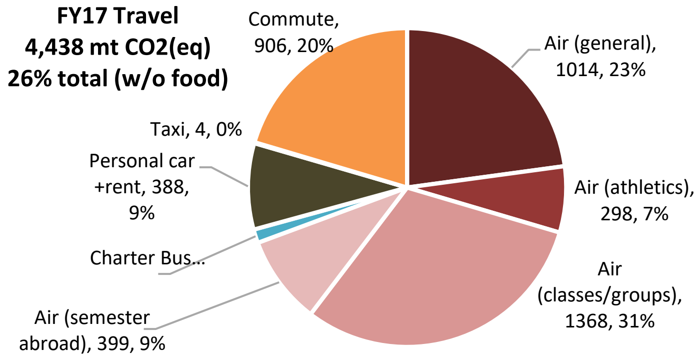


Figure 7: Breakdown of the travel and commuting that contribute to our overall GHG emissions. Commuting represents faculty and staff travel to campus.

Table 1. Results of faculty/staff commuting survey

Metric	2010	2015
# faculty/staff completing survey	259	220
Average annual values:		
Fuel Economy (MPG)	25.9	26.7
Commuting distance (miles)	3699	3618
Gasoline consumed (gal.)	154	139
% trips single driver	77%	92%
% miles single driver	92%	96%

Travel by air is a major contribution to travel-related GHG emissions. In FY2017, Clarkson faculty, staff and students travelled a total of over 5.6 million (up 27% from FY16 and 50% from FY15) air miles contributing to 3080 mt CO2(eq). An attempt was made to identify the nature of the trips made. Over 65% of the total miles include students travelling for classes (e.g., School of Business UNIV399 courses), athletics, spring break service trips and competitions. These trips were identified either directly with the organizing unit or through p-card records based on large numbers of travelers with the same itinerary (>5 used as basis). Miles associated with students who travel to conferences in smaller groups could not be identified. Regardless, the uncertainties in the analysis, it is clear that student travel is an important component of a Clarkson education.

Estimated Food Related Emissions

At this time, we do not have adequate food source and supply chain data to estimate GHG emissions with any certainty. It is known, however, that emissions related to agriculture, food processing, storage and preparation are significant. Food related emissions presented in Figure 1 are based on a generic per person average annual emissions. The Shrink That Footprint[4] blog posting identifies five types of American diets with average annual carbon footprints ranging from 1.5 (vegan) to 3.3 (meat lovers) mt CO_2(eq)/y. Their analysis was completed with data taken from USDA sources. The average 2.5 mt CO_2(eq)/y value was used for the GHG estimates included here. This value was multiplied by the number of residential students to provide a ballpark number for food emissions. These emissions could contribute to over a quarter of our total GHG emissions, thus confirming their significance. This value is consistent with the value of 19-29% (food related emissions/total emissions) that Vermeulen et al. (2012)[5] estimate as a global value.

Next Steps

The completion and basic assessment of our GHG emissions provides a basis for identifying priorities areas integrated into the campus Climate Action Plan. In addition, better estimates of some critical emissions need to continue to be refined. Most important food as a scope 3 emission and commuting emissions.

Efforts are also underway to evaluate and increase our use of carbon sequestration to offset some of these emissions. An analysis of annual carbon sequestered by trees on campus estimated that 1,200 mt CO_2 taken in by our trees. Although this represents a potentially important 8% of our scope 1+2 emissions, our current forest do not provide any additional

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[4] Shrink That Footprint, The Carbon Footprint of 5 Diets http://shrinkthatfootprint.com/food-carbon-footprint-diet (accessed 12/30/15)
[5] Vermeulen,S.J., B.M. Campbell, J.S.I. Ingram (2012) Climate Change and Food Systems, *Annual Review of Environment and Resources*. 37: 195-222.

carbon sequestration above what is happening naturally. Efforts to manage and protect this resource would have to be a component of efforts to use this as an offset. We also have another opportunity to offset some of our carbon emissions with an educational project and regional partnership in Uganda that is promoting agroforestry for many benefits, including sequestering carbon for Clarkson offsets. These projects can be developed further as we look forward to meeting our current Climate Commitments

Clarkson's Climate Action Plan

Clarkson approved a Climate Action Plan in April 2017 to meet the requirements of our Second Nature Climate Commitment. The ***Race to Zero*** plan sets an aspirational goal to achieve net zero GHG emissions by 2025. By setting a near term goal, we help to drive campus renovation projects to adopt energy efficiency standards that exceed ASHRAE standards (see the Sustainability Section of the Construction standards document). Decisions based on lifecycle costing and efficiency will help to achieve the GHG emission goals and provide long-term savings on utility costs. Given the aspirational nature of our current goals, a quantitative assessment of progress and expected projects in 2020 will be undertake to assess our progress.

The CAP has several high level goals (relative to average of FY14-FY15 average):

- Achieve net zero GHG emissions by 2025 (not including food)
- Reduce electric energy consumed by 35% by 2025
- Reduce natural gas by 40% by 2025
- Purchase 100% renewable electricity by 2020

Achieving these goals will substantially reduce emissions (Figure 8). Substantial carbon credits (~10,000 mt) will be required though to offset the remaining emissions. Current work to develop carbon sequestration through tree planting in Uganda and forest preservation in NNY are both aimed at meeting some of these offset requirements in a manner that is relatively low-cost and with substantial educational and ecosystem services co-benefits.

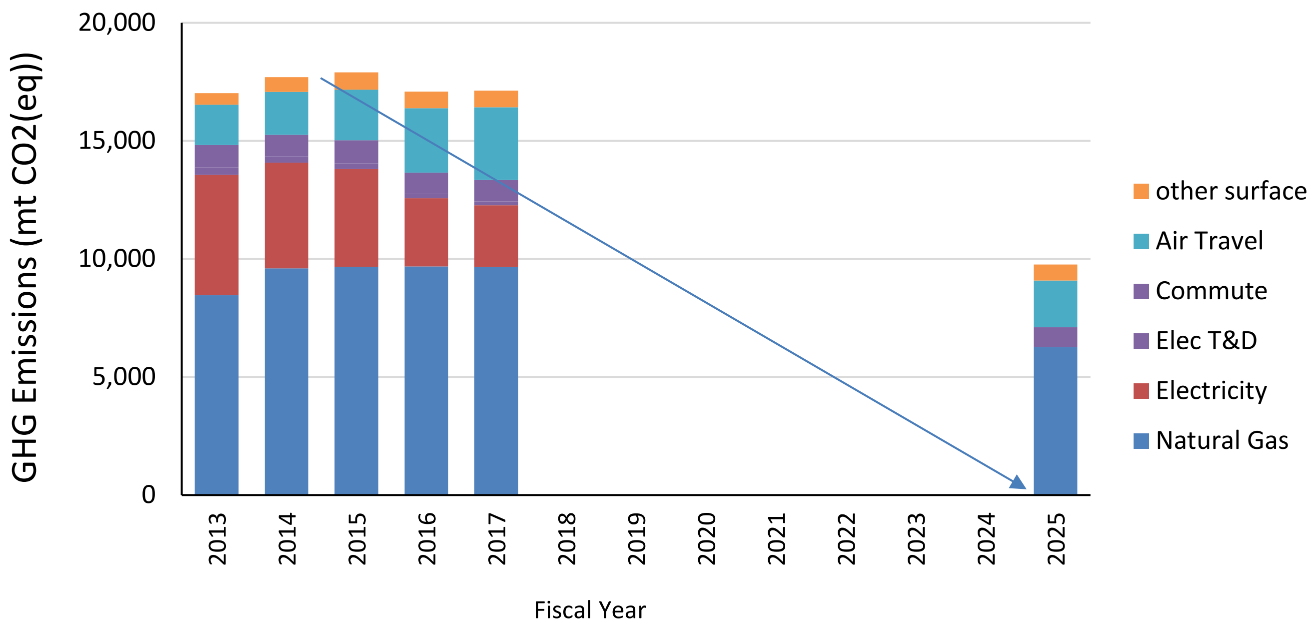

Fig. 8. Expected emissions in 2025 given current CAP goals. The2025 emissions will need to be balanced by nearly10,000 mt CO2(e) offsets in 2025 to meet a net of zero.

Attachment A: Methods

The current GHG emissions inventory was completed by Alex French, Sustainability Coordinator and Prof. Susan E. Powers, Assoc. Director of the ISE for Campus Sustainability. Data for the inventory have been collected from offices and sources from across campus for several years. The support from campus offices is greatly appreciated.

The data were initially organized for use with the Clean Air Cool Planet (CACP) spreadsheet or on-line calculator. The general approach for quantifying emissions requires two types of information:

- Activity data – Quantification of resources consumed, waste generated and miles travelled
- Emission factors (EF) – Constants that quantify the GHG emissions per unit of each activity

$$GHG\ Emissions = \sum_{activities} quantity\ of\ activity\ \ X\ emission\ factor\ for\ activity$$

Activity Data

The activity data required for CACP are identified in Table A-1. Significant effort to find data for the 2005 baseline year resulted in quantification of some scope 3 activities. However, compiling these data, especially for travel, required combing through paper invoices and travel expense reports. This approach was not feasible to continue for the following several years. Electronic resources became available starting in 2012. Current access to data is easier through queries to our institutional credit card system (p-cards). These queries identify purchases of fuel, reimbursement for travel (miles driven, taxis, trains) and flight itineraries with miles travelled automatically calculated.

Table A-1: Relevant activities available in the CACP carbon calculator that are included (√) in Clarkson's GHG inventory

Activities in CACP Inventory	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Scope 1													
Co-gen Electricity	N/A	N/A	N/A	N/A	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
Co-gen Steam	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Other On-Campus Stationary (2)	√	√	√	√	√	√	√	√	√	√	√	√	√
Direct Transportation (3)	√					√	√	√	√	√	√	√	√
Refrigerants & Chemicals	√						√	√					
Agriculture	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scope 2													
Purchased Electricity	√	√	√	√	√	√	√	√	√	√	√	√	√
Purchased Steam / Chilled Water	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Scope 2 electricity T&D Losses (4)	√	√	√	√	√	√	√	√	√	√	√	√	√
Scope 3													
Faculty / Staff Commuting (4)						√	√	√	√	√	√	√	√
Student Commuting													
Directly Financed Air Travel (5)	√					√	√	√	√	√	√	√	√
Other Directly Financed Travel (5)	√					√	√	√	√	√	√	√	√
Study Abroad Air Travel	√					√	√	√	√	√	√	√	√
Student Travel to/from Home													
Solid Waste	√					√	√	√	√	√	√	√	√
Wastewater													
Paper	√					√	√	√	√	√	√	√	√
Food												√	√

Offsets (6)

Notes:
1 co-Gen facilities and microturbine combined heat and power included as part of "other" on-campus stationary sources (since 2009)
2 On campus station sources are primarily natural gas for heating (and CHP) with a very small contribution from wood pellets. Totals determined from monthly utility bills.
3 Direct transportation includes gasoline and diesel purchased for fleet, safety and facilities vehicles. Gallons of fuel determined from purchasing records.
4 T&D losses assumed to be 6% of electricity consumed
4 Employee commuting habits determined from 2010 and 2015 commuting surveys. Results used to determine average number of miles driven and gallons of gasoline used per person per year. These results times the number of employees scaled used to quantify the commuting activity.
5 Travel miles determined from travel expense and P-card reports. Available data and tracking methods vary from year to year
6 We do not yet have any current and legitimate offsets. Carbon sequestration by our campus trees was estimated by Brittany Guarna as part of an ES&P capstone project (S12). The study showed that 324 mt carbon sequestered every year (1,200 mt CO_2/y). These values have not been included in our GHG inventory because they do not provide any additionality and they are not protected but policy to assure long-term benefits.

Data quantifying our activities were compiled in a spreadsheet and initially entered into the Clean Air Cool Plant campus carbon calculator. Both the on-line and MS Excel versions were used. The use of the calculator provides easy entry and a large database of emission factors for basic activities. However, the “black box” approach makes it difficult to complete basic quality control and to customize the inventory for our unique circumstances. For example, some overrides of the automatic calculations were required to include emission factors for the variable electricity generation mixes that are relevant for our campus in FY2008-FY2016.

Emission Factors

Estimating Emission Factors for Purchased Electricity

Emission factors for our commercial providers of electricity (National Grid, Suez, Constellation) were estimated based on the actual mix of electricity sources used each year. The overall emission factor (EF_{elect}) for these sources was calculated as weighted average of emission factors from all types of sources.

$$EF_{elec} = \sum_{i=sources} (frac_i * EF_i)$$

The % distribution of electricity sources ($frac_i$) was determined for our electricity commodity through data published by the New York State Public Service Commission Environmental Disclosure Label Program[6] (Table A-2)

Table A-2. Mixture of electricity generation for suppliers of Clarkson electricity

Source	Nat. Grid			Suez					Constellation (2)		
	FY05	FY06	FY07	Cal 08	Cal 09	Cal 10	Cal 11	Cal 12	Cal 13	Cal 14	Cal 15
Coal	11%	11%	10%	23%	11%	15%	10%	4%	5%	6%	3%
Gas	8%	8%	8%	43%	31%	47%	47%	52%	47%	38%	40%
Oil	5%	4%	2%	5%	2%	2%	<1%	<1%	<1%	1%	1%
Nuclear	40%	43%	53%	20%	32%	25%	28%	31%	33%	32%	35%
Hydro	34%	31%	24%	8%	21%	6%	9%	6%	6%	14%	13%
Wind	<1%	<1%	<1%	1%	1%	4%	4%	4%	6%	6%	5%
Solar	<1%	<1%	<1%	0%	<1%	0	<1%				
Biomass	<1%	<1%	1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%	<1%
Solid Waste	2%	2%	1%	<1%	<1%	<1%	<1%	1%	2%	1%	1%

(1) (name change to GDF Suez 2010 and beyond)
(2) Data for 2016 and 2017 not yet available through the PSC. Assume same as 2014

[6] http://www3.dps.ny.gov/e/energylabel.nsf/ , data are available through 2015; FY2016 and 2017 were assumed the same as 2015

Typical emission factors for each type of electricity sources (EF_i) were estimated as average values overall production in the NYUP electric grid area. Emission factors were calculated from eGRID[7] data for 2005, 2007, 2009, 2010 and 2012. For example, data extracted from the eGRID 9th edition year 2010 for NYUP are presented in Table A-3. The overall NYUP emission factor calculated by this method provided the same value as reported by eGRID for the region.

Table A-3. Emission factors for each type of electricity generation determined from eGRID data for NYUP (2010)

	Totals - NYUP		Emission Factors	
Source	Electricity generated (MWh)	CO_2(eq) emissions (short tons)	tons/MHw	lb/kWh
Coal	14,217,361	14,832,356	1.043	2.087
Gas	19,552,876	8,663,489	0.443	0.886
Oil	66,215	72,197	1.090	2.181
Nuclear	25,548,899	0	0.000	0.000
Hydro	24,936,130	0	0.000	0.000
Wind	2,357,389	0	0.000	0.000
Solar	0	0		0.000
Biomass	1,228,104	710,540	0.579	1.157
Solid Waste	641,574	0	0.000	0.000
TOTAL (NYUP)	88,548,547	24,278,582	0.274	**0.548**

Transmission and distribution losses were approximated as 6%.[8] The emissions associated with these losses are included as a separate item in the GHG inventory.

The resulting emission factors for Clarkson's electricity providers are presented in Figure A-1. The emission factors change by as much as a factor of 3 depending on electricity supplier and the sources of electricity they purchase. National Grid has emission factors that are quite low due to high dependence on nuclear and hydro power (74%) (2005-2007). Our current emission factor of 0.439 lb CO_2(eq)/kWh generated is 8% higher than the NYUP average of 0.474 lb CO_2(eq)/kWh generated, but is substantially lower than the national average of 1.137 lb CO_2(eq)/kWh generated.

These emission factors are applied only to the net electricity purchased from our primary provider. This is the total electricity consumed on campus minus the GHG free electricity purchased through Recharge NY, Community Energy Solar and the Village of Potsdam.

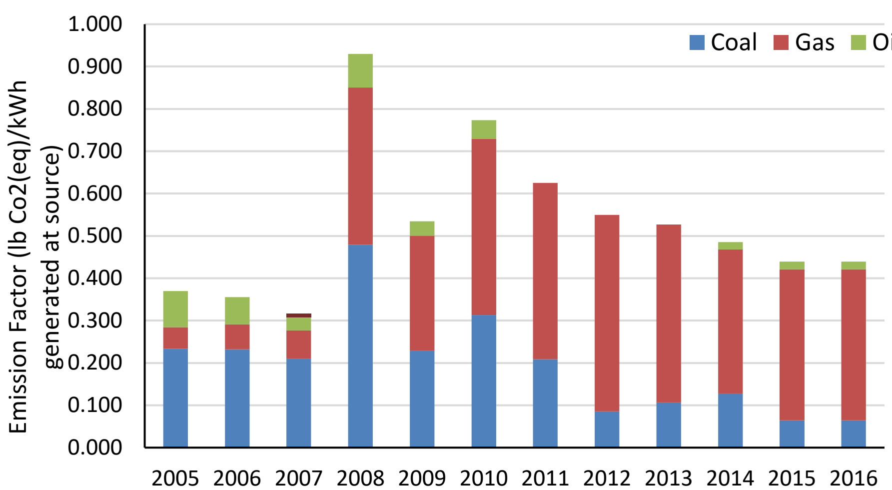

Figure A-1. Electricity emission factors for Clarkson primary electricity suppliers (does not include electricity from separate renewable resources). Due to insufficient current data for supplier electricity mixes, values for 2016and 2017 assumed the same as for 2015.

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[7] EPA Energy and the Environment, eGRID. http://www.epa.gov/energy/egrid (accessed through 12/30/15)

[8] US DOE, Energy Information Administration, How much electricity is lost in transmission and distribution in the United States? http://www.eia.gov/tools/faqs/faq.cfm?id=105&t=3 (accessed Aug. 2015)

The analysis of our electricity supplies also included an estimation of the primary energy required for electricity supplied to campus. The source to site ratio, which defines the amount of primary energy required to generate and transmit electricity to our site, was calculated with eGRID data according to the general procedure described in the Energy Star Portfolio Manager Technical Reference.[9] The current national average of 3.14 implies that over three times more energy used to generate electricity than is available to the consumer. For coal, oil and natural gas, the electricity generated and source fuel were available for all generating facilities in NYUP (Table . A further 6% loss was assumed for T&D. The T&D loss were the only source to site losses appropriate for renewable resources (source:site = 1.06).

Table A-4. Source:site ratios for fossil fuel electricity generation in NYUP

Electricity Source	source energy (MMBtu)(1)	electricity generated (MMBtu) (1)	electricity delivered (MMBtu) (2)	Source:site (3)
Coal	142,769,132	48,474,092	45,565,647	3.13
Gas	145,407,744	66,665,529	62,665,597	2.32
Oil	894,403	225,760	212,214	4.21

(1) eGRID 2010 data for NYUP
(2) assumes 6% T&D losses
(3) source energy consumed / electricity delivered

With these source specific ratios, our current source to site ratio (including all of our electricity sources) is 1.574 and 2.06 for our electricity from Constellation. These values are significantly lower than the national average of 3.14 due to the much lower use of coal for electricity generation in this region.

Other Emission Factors

Values for other emission factors were critically reviewed as part of the quality control analysis of the CACP GHG inventory results. This review was precipitated by what seemed to be unreasonably high emissions associated with travel activities. Emission factors from CACP were compared to EPA values that are used for all US GHG inventory activities and a few on-line carbon calculators. Results of this comparison are included in Table A-5. The CACP EFs did seem to be unreasonably high for airplane and bus travel. The air travel miles are high because they include radiative forcing impacts in addition to direct GHG emissions.[10] Following this review, the use of the CACP calculator and worksheet were abandoned and emission factors identified as bold font in Table A-5 used directly in spreadsheet calculations to generate the inventory results presented in this report.

[9] Energy Star Portfolio Manager Technical Reference – Source Energy. (2013) https://portfoliomanager.energystar.gov/pdf/reference/Source%20Energy.pdf (accessed 12/3/15)

[10] ACUPCC, Guidance on Scope 3 Emissions, pt 2: Air Travel, http://www.aashe.org/blog/guidance-scope-3-emissions-pt-2-air-travel (accessed 1/4/16)

Table A-5. Emission factors for relevant campus activities (bold designates EFs used in the analysis presented here, underlined values are inconsistent with other sources)

	Units mt CO_2(eq) per	**CACP**	**EPA**	**EPA Calculator**	**Carbon Footprint**	**Terrapass**
Natural Gas	(/MMBtu)	5.32E-02	**5.31E-02**	5.31E-02	5.41E-02	*5.22E+00*
Gasoline	(/gallon)	9.10E-03	**8.78E-03**	8.90E-03	8.30E-03	8.86E-03
Diesel	(/gallon)	1.03E-02	**1.02E-02**		9.80E-03	
Electricity	(/kWh)	*5.62E-04*	1.86E-04	*2.99E-03*	3.90E-04	2.78E-04
Automobile	(/mile)	3.76E-04	**3.72E-04**	3.34E-04	3.10E-04	
Bus	(/passenger mile)	*3.24E-04*	**5.81E-05**		4.70E-05	1.07E-04
Light rail	(/passenger mile)	2.11E-04	**1.75E-04**		7.20E-05	
Train	(/passenger mile)	1.50E-04	**1.45E-04**		*1.90E-05*	1.64E-04
Charter Bus (1)	(/mile)		**1.72E-03**			
Air plane	(/passenger mile)	**4.82E-04**	2.11E-04		1.63E-04	1.86E-04
Landfill waste (w/flare)	(/short ton)	**3.10E-01**				
Landfill waste (w/LFGTE)	(/short ton)	**-3.00E-02**				
Paper, 0% recycled	(/lb)	**1.37E-03**				
Paper, 75% recycled	(/lb)	**9.19E-04**				
Paper, 100% recycled	(/lb)	**7.70E-04**				

(1) EFs for charter bus miles based on the EPA diesel EF and average 6 MPG estimate for bus fuel economy

Sources (accessed 12/29/15):

CACP (spreadsheet reviewed for EFs) http://www.sustainableunh.unh.edu/calculator

EPA, "Emission Factors for Greenhouse Gas Inventories" (updated 11/19/15) http://www.epa.gov/sites/production/files/2015-12/documents/emission-factors_nov_2015.pdf

EPA Calculator http://www3.epa.gov/carbon-footprint-calculator/

Carbon Footprint http://www.carbonfootprint.com/calculator.aspx

Terrapass http://www.terrapass.com/carbon-footprint-calculator/