Detailed Methodology

2014 Tompkins County

Community

Greenhouse Gas Emissions and Energy Use Inventory

September 2016

Table of Contents

1. ICLEI and ClearPath Software

This inventory is based upon the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version 1.1, July 2013. ClearPath version 2014, an online application for the calculation and tracking of greenhouse gas emissions at the government operations and community scales, was used to calculate 2014 emissions in June 2016. ClearPath is the most widely-used software tool for managing local climate mitigation efforts and is available to members of the International Council on Local Environmental Initiatives (ICLEI), including Tompkins County.

The Community Protocol requires that emissions be reported for the following 5 basic emissions generating activities:

- *Use of Electricity by the Community* – included in the 2014 inventory, including a further break-down to the Residential, Commercial and Industrial Sectors. This accounts for power plant emissions associated with generating electricity used within the jurisdictional boundary of the community, regardless of the location of the electricity generation facility.
- *Use of Fuel in Residential and Commercial Stationary Combustion Equipment* – included in the 2014 inventory, including a further break-down to the Industrial Sector. This accounts for combustion emissions associated with fuels used in residential and commercial stationary applications (e.g., natural gas used in boilers and furnaces) within the jurisdictional boundary of the community, excluding fuels used for production of electricity or district energy.
- *On-Road Passenger and Freight Motor Vehicle Travel* – included in the 2014 inventory. This accounts for emissions associated with transportation fuels used by on-road passenger and freight motor vehicles.
- *Use of Energy in Potable Water and Wastewater Treatment and Distribution* – partially included in the 2014 inventory. Only included emissions from the natural gas and electricity used to power treatment facilities, not emissions associated with byproducts and processes. This accounts for emissions associated with energy used in the treatment and delivery of potable water used in the community and in the collection and treatment of wastewater used in the community, regardless of the location of the water and wastewater infrastructure.
- *Generation of Solid Waste by the Community* – included in the 2014 inventory. This accounts for end-of-life emissions (i.e., projected future methane emissions) associated with disposal of waste generated by members of the community during the analysis year, regardless of disposal location or method.

The Community Protocol provides guidance on additional community GHG sources and activities. The ones that were included in this inventory are:

- *Agricultural Livestock Emission Activities and Sources – included in the 2014 inventory. This accounts for* emissions associated with livestock management activities.
- *Power Generation at Cornell's Central Energy Plant* – included in the 2014 inventory. This accounts for the emissions associated with Cornell's on-site use of natural gas and electricity generated at its central energy plant.
- *Village of Groton Electric* – included in the 2014 inventory. This accounts for the emissions associated with consumption of electricity within the Village of Groton.

- *Air Travel* – included in the 2014 inventory. This accounts for the emissions associated with jet and aviation fuel pumped into airplanes at the Ithaca-Tompkins Regional Airport.

In 2008, we began to track emissions from the regional power plant located in Tompkins County. These figures are included for tracking purposes, but not included in the GHG emissions inventory:

- *Power Generation at Cayuga Power Plant* – included in the 2014 inventory. This accounts for the emissions associated with the generation of electricity at this regional power plant located in Tompkins County.

In 2014, we began to track power generation from renewable energy resources in the residential, commercial and industrial sectors, as well as electric vehicle usage in the transportation sector.

A Note on "Scopes": The ICLEI U.S. Community Protocol says on page 13 that: "The sources and activities framework alleviates the need to utilize the "scopes" concept common in other types of organization-focused inventories, such as those developed using the Local Government Operations Protocol. This Protocol does not use scopes as a framework for categorizing emissions in community inventories because the organization-related definitions of scopes do not translate to the community scale in a manner that is clear and consistently applicable as an accounting framework."

2. General Inputs

What grid mix was used?

EPA eGRID 2012 (https://www.epa.gov/energy/egrid, eGRID 2012 Data File, Sheet 6 Sub-region Data), which is the latest emissions & generation resource database released in Oct. 2015.

Fuel Mix of Upstate New York	%
Gas	30.4
Hydro	29.2
Nuclear	28.9
Coal	5.5
Wind	3.6
Biomass	1.8
Other Fossil	0.4
Oil	0.2
Solar	0.0
Geothermal	0.0
Other Unknown/Purchased Fuel	0.0

Grid emission factors used in ICLEI ClearPath: CO_2 408.80 lbs/MWh, CH_4 15.59 lbs/GWh, and N_2O 3.83 lbs/GWh (also obtained from the EPA eGRID 2012 file Sheet 6 Sub-region Upstate New York).

Note that ICLEI guidance says that using NYSEG fuel mix and emissions factors, if attainable, is more accurate than the general Upstate New York ones for Tompkins County. However, we were not able to obtain from NYSEG the grid emission factors by greenhouse gas that is required to determine emissions.

Note also, that in order to determine the impact of the changes in fuels powering the electric grid between 2008 and 2014, the following calculations were made. The amount of NYSEG-reported electricity consumed in 2014 in the residential, commercial and industrial sectors, as well as the amount of kWh purchased by Cornell, were input in ClearPath applying the eGRID 2012 figures (used for the 2014 Inventory), and then again applying the eGRID 2005 figures (used for the 2008 Inventory) and a comparison was made to determine the amount of the GHG emissions reduction that was due to the change in grid generation (11% of the overall 21% reduction was determine to be attributable to this).

Conversion factors used throughout
1 kWh = 0.0034095106405145 MMBtu
1 therm = 0.10 MMBtu
1 barrel = 42 US gallon

What Global Warming Potential was used?
Global Warming Potential refers to multipliers that are applied to all non-CO_2 greenhouse gases in order to present them in a common term that indicates their relative strength of the greenhouse effect they have in the atmosphere. In the U.S., standard practice for a number of years now has been to maintain alignment with federal agencies, which are now using the 100 year GWP values published in the Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report. Therefore, this 2014 inventory uses IPCC 5th Assessment Report 100 year values and the 2008 inventory, which originally used the IPCC 2nd Assessment Report values, has been updated to the 5th Assessment 100 year values to allow direct comparison to the 2014 inventory.

The Role of Shale Gas in GHG Emissions Accounting
In addition to the GHG Emissions Inventory based on internationally recognized protocols and software tools, the GHG Emissions Inventory for 2014 for the first time includes a separate section and accounting that looks ahead at what may soon be modifications to those protocols to better understand the impacts to the climate of burning shale gas in the County. Between 2008 and 2014, there was a profound shift in how the natural gas consumed in the community was extracted from the ground, as well as new international recommendations on the time horizon and global warming potential (GWP) that should be used to calculate the GHG emissions for methane.

Methane Leakage Estimates from Shale Gas Extraction
By 2014, nearly all, if not all, of the natural gas consumed in the County came from the Marcellus Shale play in Pennsylvania. Recent studies estimate 5-19% leakage of unburned methane from production well to combustion in the home or business due to the techniques employed by the shale gas industry. As stated in a recent article in Energy and Emission Control Technologies, "The conclusion is that shale gas development during the 2009-2011 period, on a full life cycle basis including storage and delivery to consumers, may have on average emitted 12% of the methane produced."[1]

For these reasons, in a separate section of the GHG Inventory, we applied a leakage factor of 12%, with a range of 5-19%, to all methane emissions associated with natural gas.

In addition to the leakage of methane due to shale gas development and distribution, is the consideration of the appropriate timescale for GWP of methane. As the same article states, "Methane has a residence time in the atmosphere of only 12 years, while the influence of carbon dioxide emission persists in the atmosphere for many hundreds of years of longer. While both gases are in the atmosphere, the greenhouse warming effects of methane are >100-fold greater than for carbon dioxide on a mass-to-mass basis. When compared on a 100-year average time after emission, the emitted methane is largely absent from the

[1] Howarth R. Methane emissions and climatic warming risk from hydraulic fracturing and shale gas development: implications for policy. *Energy and Emission Control Technologies*. 2015:3 45-54.

atmosphere for almost 90% of that time, which greatly underplays the importance of methane while it is in the atmosphere."

"Given current emissions of greenhouse gases, the Earth is predicted to warm by 1.5° C above the preindustrial baseline within the next 15 years and by 2° C within the next 35 years. Not only will the damage caused by global warming increase markedly but also at these temperatures, the risk of fundamentally altering the climate system of the planet becomes much greater. Further reducing emissions of carbon dioxide will do little if anything to slow the rate of global warming over these decadal time periods. On the other hand, reducing emissions of methane has an immediate effect on slowing the rate of global warming."

For these reasons, in a separate section of the GHG Inventory, we applied a GWP estimate for the 20-year time period from the IPCC fifth assessment report of 86 to all methane emissions associated with natural gas.

3. Evaluation of the Data

Like all GHG emissions inventories, the quality of the data impacts the quality of the results and how easily emissions reductions or increases may be seen in the future. Below is a review of the quality of the data and considerations for future accounting. All data sets employed are considered the best available at the time, and ones that we hope will be consistently gathered for use in future GHG inventories.

Data for GHG emissions and energy use calculations:

Utility-delivered gas and electric

- *NYSEG Metered Residential, Commercial and Industrial Customers – Electricity*
- *NYSEG Metered Residential, Commercial and Industrial Customers – Natural Gas*

In general, these are high quality data for Tompkins County, because they are provided by professionals at NYSEG. There are, however, some limitations:

a) The electric and gas figures are based on billed consumption based on the calendar year in which the meter was billed. So, if a bill covered December 5, 2014 – January 5, 2015, it would show up as consumed in 2015 even though the bulk of the consumption was in 2014. There are 20 different meter reading cycles across the service area, spread out over each business day, so this variability can be significant.
b) In addition, many meters are estimated and read every other month at the most, so there is an error factor in that estimation process.
c) The way that NYSEG classifies its customers' meters can impact results, too. For example, if a multi-unit rental building has 1 meter per tenant, then it is considered residential and if there is one meter for the building then it is commercial. If, for example, there are 5 apartments in one house and each has their own electric meter, there could be 5 residential electric meters and 1 commercial gas meter. And, an agricultural enterprise that uses less than a certain load is considered a residential customer, not commercial.
d) The NYSEG electricity data is based on metered kWh sales. So, if a building or an institution has behind-the-meter generation (e.g., solar PV) where the building is at some point consuming its own electricity, the NYSEG figure does not capture that consumption.

e) The NYSEG electricity data figure provided by NYSEG for the community does not include all of the purchases/exports that Cornell makes through its own university-owned electric substation.

Fuel Oil and Propane

- *Residential, Commercial and Industrial Consumption of Fuel Oil and Propane*

  In general, these are poor quality data for Tompkins County, due to these limitations:

  a) Learned from Tompkins County Assessment that the data used to track this in the past is not an excellent database, is not updated regularly, and is not being tracked at all for the commercial and industrial sectors.
  b) Several attempts were made to gather data from the companies that sell and distribute these fuels in the County and resulted in very limited success.
  c) Using the current approach of scaling down from Statewide EIA data to Tompkins County based on the proportion of known NYSEG electricity and natural gas use by sector is a rough approximation of the amount used in the community.
  d) We will only see changes to the amount of those fuels used if NYS as a whole reduces or increases the amount of those fuels consumed.
  e) They are both highly emitting fuels, so their uncertainty has a larger impact on the GHG inventory than other fuels.

Cornell CEP

- *Cornell Central Energy Plant –Natural Gas, Fuel Oil, Electricity and Metered Steam Sales*

  In general, these are high quality data for Tompkins County, because they are provided by professionals at Cornell Facilities.

Transportation

- Annual vehicle miles travelled (VMT) by vehicle class

  In general, these are moderate quality data for Tompkins County, due to these limitations:

  a) VMT is based on output from modeling software, TransCAD, which reflects residential commutes based on trip generation. Models are based on many assumptions which may or may not prove true.
  b) VMT is then modified to include medium-duty and heavy-duty trucks, as well as motorcycles, with those estimates created by applying the percentage of each vehicle type found in overall class counts by NYSDOT to the residential VMT output by the TransCAD model and added to the VMT from the TransCAD model. These, therefore, are very much estimates, as it is unclear if percentages of residential commute numbers is an accurate way to capture truck and motorcycle VMT.
  c) In conjunction with average MPG from National Transportation Statistics and emission factors from the EPA, the data is complete.
  d) However, these data are not fine-grained enough for us to be able to see much change in emissions from conversion to electric vehicles, hybrids, or very fuel efficient vehicles, as data are based on overall MPG for vehicle classes, like "Passenger Vehicles" so we will not see much change until national numbers change the MPGs even though we may have a much higher percentage of passenger vehicles that are fuel efficient or electric.

Solid Waste

- Amount of waste disposed of in landfills
- Whether or not methane collection systems are in place at the landfills where the waste is disposed

- Composition of the disposed waste

  In general, these are high quality data for Tompkins County, because they are provided by professionals at Tompkins County Solid Waste. There are, however, some limitations:
  a) The waste streams identified in the 2014 Planning Unit Recycling Report are only broken-down into Municipal Solid Waste, C & D Debris, Non-Hazardous Industrial Waste, and Bio-solids and those categories do not match exactly with the waste streams offered as input items in ClearPath, so adjustments were made.

Agriculture
- Total number of methane-emitting livestock by type in the County
- CH4 emission factor of each type of ruminant animal

  In general, these are high quality data for Tompkins County, because they are provided at the County-level by the USDA for animal type and count, and by the EPA for emission factors. There are, however, some limitations:
  a) The USDA data is somewhat out of date, as the most recent data is for 2012.

Village of Groton Electric
- Fuel mix of the electricity that the Village of Groton purchased
- Amount of electricity consumed by the Village of Groton

  In general, these are high quality data for Tompkins County, because they are provided by professionals at the Village of Groton Electric Department.

Air Travel
- Amount of jet fuel pumped into airplanes in 2014
- Amount of avgas (aviation gasoline) pumped into airplanes in 2014

  In general, these are high quality data for Tompkins County, because they are provided by professionals at the Ithaca-Tompkins Regional Airport.

Cayuga Power Plant (formerly AES Cayuga)
- 2014 power generation: 306 MW
- 2014 GHG emissions: 940,998 MTCO2e

  In general, these are high quality data for Tompkins County, because they are provided by professionals at Cayuga Power Plant.

Data for energy use calculations only:

Electricity Used for Space Heating and Hot Water
- Percent of electricity used as thermal energy

  In general, these are poor quality data for Tompkins County, due to these limitations:
  a) The approach of applying the percent of electricity consumed for household space and water heating out of the total household electricity consumption for all purposes based on the average of Mid-Atlantic

and New England regional EIA data is a rough approximation of the actual percent consumed in Tompkins County.

b) We will only see changes to the amount of electricity consumed for household space and water heating if the New England and Mid-Atlantic regions reduce or increase the percentage of electricity consumed for those uses.

Solar

- Small-Scale Renewable Installations, Residential, Commercial and Industrial Sectors

In general, these are high quality data for Tompkins County, because they are provided by NYSERDA by County and as of 2014, most renewable energy projects in Tompkins County received some funding or incentives from NYSERDA so would be included in these data.

Large and Utility-Scale Renewables and CHP

- Renewable Installations Providing Electricity to the Residential, Commercial and Industrial Sectors

In general, these are high quality, but incomplete data for Tompkins County, because they are provided by NYSERDA by County and as of 2014, most renewable energy projects in Tompkins County received some funding or incentives from NYSERDA so would be included in these data. However, the NYSERDA website only includes renewable installations developed for the purpose of distributed generation. The renewable facilities that are grid-connected are not recorded in the database and are not currently tracked in an organized way. Additionally, the database only includes anaerobic digester gas systems, fuel cell systems, PV systems, and future main-tier RPS sites. Therefore, the Cornell hydro generator and any future utility-scale wind installations in the County are not/will not be tracked in the database.

Electric Vehicles

- Number of Electric Vehicles Registered in Tompkins County

In general, these are moderate quality data for Tompkins County, because while the number obtained from a consultant hired to write an electric vehicle charging infrastructure study in 2016 appears to be of high-quality, it is doubtful whether these data will be able to be reproduced in the future, and checks of other publicly-available websites tracking this information was variable.

4. Residential

This section consists of several parts:

For GHG emissions and energy use calculations:

- NYSEG Metered Residential Customers – Electricity
- NYSEG Metered Residential Customers – Natural Gas
- Residential Fuel Oil and Propane

For energy use calculations only:

- Small-Scale Renewable Installations Providing Electricity to the Residential Sector
- Percent of electricity used as thermal energy

Electricity Data – Residential

A) NYSEG Metered Residential Customers

SUMMARY
Input: 286,094,000 kWh for 2014

Output: 53,238 MTCO2e

Data provided on April 7, 2016 from Scott Bochenek with NYSEG.

Methods used by Scott to gather NYSEG data for 2008 and 2010-2015

- Compiled by "Tax jurisdiction code" (not by "county indicator")
- Used "Account Determination ID" type for processing (includes 4 main categories: Residential, Commercial, Industrial, Municipal). There are also ADID's for tax exempt within any of the larger categories, interdepartmental within NYSEG (D), municipal (M), sale of resale to ESCO's (Px), Streetlights (S), NYSEG use (U)

Explanation of data

- Data is held by NYSEG for 5-6 years plus the current year. Old data is purged
- "Public Authority" includes any account coded as municipal – state, federal, town, village, city, county, school districts, etc.
- The electric and gas figures are based on billed consumption based on the calendar year in which it was billed. So, if a bill covered December 5, 2014 – January 5, 2015, it would show up as consumed in 2015. Many meters are estimated and read every other month as the most. There are 20 different meter reading cycles across the service area, spread out over each business day.
- The vast majority of street lights and area lights are billed to municipal account.
- If a multi-unit rental building has 1 meter per tenant, then it is considered residential and if there is one meter for the building then it is commercial. If, for example, there are 5 apartments in one house and each has their own electric meter, there could be 5 residential electric meters and 1 commercial gas meter.
- Agriculture that uses less than a certain load is considered Residential (ADID)
- "Capacity Tag" is the contribution to peak energy use in NYS. The kWh contribution to peak demand of the system.

Sub-results for GHG Emissions
53,238 MTCO2e

B) Small-Scale Renewable Installations Providing Electricity to the Residential Sector

SUMMARY
Input: 2,084,141 kWh for 2014 (solar), no wind or micro-hydro

Output: N/A

Note that these results are only used for energy calculations, not GHG emissions calculations. And only small-scale renewable projects are included in the residential sector. Large- or utility-scale renewable projects are included in the commercial sector. Note that this approach may need to change as "community solar" becomes more common.

A solar system's nameplate capacity is usually measured in direct current, so MWdc, not MWac. It is important to be consistent in using dc when citing solar capacity.

1) Solar PV – 200 kW or smaller
2,084,141 kWh for 2014
2,424 KW of total installed capacity

Methodology
Most renewable energy projects in Tompkins County receive some funding or incentives from NYSERDA. NYSERDA reports the installed capacity, daily/monthly/annual electricity generation, and other performance data of the projects that have received incentives since 2000. The data is publicly available online.

Assumption(s)
- The renewable energy projects funded and monitored by NYSERDA cover most projects of the kind in Tompkins County.
- Before 2000, the installed capacity of renewable energy projects was minimal and ignorable.

Data & Sources
Statewide 200kW or Less Residential/Non-residential Solar Photovoltaic Incentive Program: Beginning 2000
https://data.ny.gov/Energy-Environment/Statewide-200kW-or-Less-Residential-Non-Residentia/3x8r-34rs

Filter the database by County. Include the NYSERDA categories Non-Residential, Commercial, Government, and Non-Profit into sector "Commercial" in the Tompkins County 2014 GHG inventory. Treat the NYSERDA categories Residential and Industrial as the sectors they are.

In the database, for the 2014 analysis the "Date Install" should be 12/31/2014 at the latest and "Project Status" should be "Complete" in order to filter for just the projects that started operating by the end of 2014. For systems that came online in 2014, their Expected kWh Annual Production need to be scaled down for the time they actually operated in 2014. For example, if a completed project's Date Install is 05/02/2014 and its expected annual production is 3,522 kWh, its actual annual production in 2014 is estimated as (365-122)*3,522/365 = 2,344 kWh. Note that May 2 is the 122nd day in 2014.

2) Wind – 10 kW or smaller
The installed capacity or electricity generation of small-scale wind projects in the County is not tracked by NYSERDA or any other central database.

3) Hydro and Micro-hydro – 500 kW or smaller
The installed capacity or electricity generation of small-scale hydro projects in the County is not tracked by NYSERDA or any other central database.

C) Percent of electricity used as thermal energy

SUMMARY
Input: 138,131 MMBtu for 2014

Output: N/A

Note that these results are only used for energy calculations, not GHG emissions calculations.

Methodology

Estimate the percent of electricity consumed (in quadrillion Btu) for household space and water heating out of the total household electricity consumption for all purposes, including lighting and appliances, in Tompkins County. EIA data were used to assist in this process. It was assumed that the pattern of energy use in Tompkins County would be best represented by the entire Northeast, so an average was developed based on EIA data for New England and the Mid-Atlantic. The figure for New England region is 13.5% (5.7% for household space heating (0.008/0.141) plus 7.8% for water heating (0.011/0.141)) and the figure for Middle Atlantic region is 14.2% (6.7% for space heating and 7.4% for water heating). The average of the two is ~14.0%. Note that this percent break-down may change over time, as more heat pumps may be adopted for heating.

The next step was to apply the 14% to the total residential kWh as converted to MMBtu.
Therefore, (0.14)*(289,089,552 kWh) yields 40,472,537 kWh, or 138,131 MMBtu.

Table CE4.2 Household Site End-Use Consumption by Fuel in the Northeast Region, Totals, 2009
Quadrillion British Thermal Units (Btu), Final

			Total Site E… (qua…								
			Electricity						Natural Gas		
Housing Unit Characteristics and Energy Usage Indicators	Total Housing Units[1] (millions)	Total[2]	Total	Space Heating[3]	Water Heating	Air Conditioning	Refrigerators	Other[4]	Total	Space Heating[3]	Water Heatin…
Total U.S.	20.8	2.235	0.573	0.037	0.044	0.038	0.080	0.373	1.064	0.688	0.244
Northeast Divisions and States											
New England	5.5	0.622	0.141	0.008	0.011	0.004	0.019	0.098	0.222	0.152	0.048
MA	2.5	0.271	0.059	0.004	0.004	0.002	0.009	0.040	0.134	0.090	0.030
CT, ME, NH, RI, VT	3.0	0.351	0.082	0.004	0.007	0.002	0.011	0.059	0.088	0.062	0.019
Middle Atlantic	15.3	1.613	0.432	0.029	0.032	0.034	0.061	0.275	0.842	0.536	0.196
NY	7.2	0.738	0.161	0.007	0.010	0.010	0.026	0.109	0.398	0.256	0.091
PA	4.9	0.474	0.175	0.020	0.019	0.013	0.021	0.102	0.171	0.114	0.038
NJ	3.2	0.402	0.096	0.002	0.004	0.011	0.014	0.065	0.273	0.166	0.068
Urban and Rural[5]											
Urban	18.0	1.920	0.468	0.031	0.033	0.034	0.068	0.301	1.032	0.667	0.236
Rural	2.8	0.315	0.105	0.006	0.011	0.004	0.012	0.072	0.032	0.021	0.008

Assumption(s)

- The thermal energy extracted from electricity is used for both space and water heating.
- Northeast U.S. better represents the pattern of energy use in Tompkins County than New York State itself or the Middle Atlantic region because of the more rural nature of Tompkins County.

Data & Sources

Electricity consumed for space and water heating
EIA 2009 Residential Energy Consumption Survey, Table CE4.2 Household Site End-Use Consumption by Fuel Totals, Northeast homes
https://www.eia.gov/consumption/residential/data/2009/index.cfm?view=consumption

Natural Gas Data - Residential

NYSEG Metered Residential Customers

SUMMARY	
Input:	17,774,330 therms for 2014
Output:	94,535 MTCO2e

Data provided on April 7, 2016 from Scott Bochenek with NYSEG. See above information in residential electricity on methods used to extract data.

Sub-results for GHG Emissions
94,535 MTCO2e

Fuel Oil and Propane Data – Residential

SUMMARY	
Input:	4,113,382 gallons of fuel oil for 2014 1,275,479 gallons of propane for 2014
Output:	42,265 MTCO2e for fuel oil 7,203 MTCO2e for propane 49,468 MTCO2e in total for the two fuels

Sub-results for GHG Emissions
49,468 MTCO2e

Methodology (New)
Step 1: Estimate the average ratio of fuel used in Tompkins County compared to NYS.

1) Estimate the ratio of residential electricity use in Tompkins County for 2014 provided by NYSEG compared to EIA SEDS data for NYS residential electricity use in 2014. 286,094,000 kWh in Tompkins/49,975,000,000 kWh in NYS = 0.57%.

2) Estimate the ratio of residential electricity use in Tompkins County for 2008 provided by NYSEG, compared to EIA SEDS data for NYS residential electricity use in 2008. Therefore, 293,371,081 kWh in Tompkins/49,034,000,000 kWh in NYS = 0.60%.

3) Estimate the ratio of residential natural gas use in Tompkins County for 2014 provided by NYSEG, compared to EIA SEDS data for NYS residential natural gas use in 2014. First we needed to convert Tompkins data of 17,774,330 therms of natural gas to cubic feet using an online conversion calculator yields 1,777,008,709 cubic feet. Therefore, 1,777 million cubic feet in Tompkins/458,000 million cubic feet in NYS = 0.39%

4) Estimate the ratio of residential natural gas use in Tompkins County for 2008 provided by NYSEG compared to EIA SEDS data for NYS residential natural gas use in 2008. First we needed to convert

Tompkins data of 17,018,828 therms of natural gas to cubic feet using an online conversion calculator yields 1,701,476,543 cubic feet. Therefore, 1,701 million cubic feet in Tompkins/394,196 million cubic feet in NYS = 0.43%

These four numbers give you an average allocation factor of 0.50% [(0.57%+0.60%+0.39%+0.43%)/4 = 0.50%] to use in the next steps.

Residential Average Fuel Allocation Factor: Tompkins to NYS	0.50%

Step 2 (Fuel Oil): Next determine which fuel oils are used in the residential sector. We included only Distillate Fuel Oil, as according to an Environmental Defense Fund report, "residual fuels are very viscous and are generally only used in large boilers with heating capacity greater than 2.5 million Btu/hr." Therefore, we did not include Residual Fuel Oil for the residential sector.

Apply the allocation factor of 0.50% to the NYS Distillate Fuel Oil amount to get an estimate for the amount of distillate fuel oil consumed in Tompkins County in 2014. NYS residents consumed 19,682,000 barrels of distillate fuel oil". There are 42 US gallons in an oil barrel, so 19,682,000 barrels*42 = 826,644,000 gallons. Therefore, 0.0050*826,644,000 = 4,113,382 gallons of distillate fuel oil were consumed in Tompkins County.

Note that distillate fuel oil by default includes #1, #2, and #4 by the EIA. ClearPath only has the choice for distillate fuel oil #2, which gives the closest estimate.

Step 3 (Propane): Next apply the allocation factor of 0.50% to the NYS Propane (liquefied petroleum) amount to get an estimate for the amount of propane consumed in Tompkins County in 2014. NYS residents consumed 6,103,000 barrels of "Liquefied Petroleum Gases". There are 42 US gallons in a barrel of propane, so 6,103,000 barrels*42 = 256,326,000 gallons. Therefore, 0.0050*256,326,000 = 1,275,479 gallons of propane were consumed in Tompkins County.

Justification for a Change in Methodology from 2008: Changes were made because:

a. Good to use consistent methodology for residential as for commercial and industrial for fuel oil and propane consumption
b. The results between 2008 and 2014 intuitively make a lot more sense using the EIA scale-down approach rather than using the Assessment database
c. Removing the Assessment database makes it one less data source to obtain in the future, making it easier to conduct these inventories.
d. Learned from Jay Franklin that we likely used an incomplete dataset in 2008 and that the 2014 numbers are incomplete, too, as he described in a June 2016 email: "We didn't have the ability to distinguish in 2008 between propane and natural gas. Once we got the ability, we haven't gone in to update it on a mass level, simply as we review that parcel. I looked at the 2008 sheet – there is a tab called res heat (all). This only lists 16,384 entries. This was a common error that would creep in with older versions of excel. We should have ~22,000 entries here. If this tab was supposed to show all the entries, then this stops somewhere in the village of Lansing and does not include the Town of Lansing, Newfield, or Ulysses."

Assumption(s)

- Allocation percentage of electricity or natural gas = TC consumption / NYS consumption of the same year.

- Average the allocation percentages over energy sources and years within one sector.
- Assume that the sector average allocation % remains constant over years and can be applied to estimate the consumption of propane and fuel oil within the sector.

Data & Sources

a. State Energy Data System 2014
   http://www.eia.gov/state/seds/seds-data-fuel.cfm?sid=US#PetroleumandFuelEthanol
b. State Energy Data System 1960-2013, All Consumption Estimates in Physical Units
   http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US#Consumption
   - Electricity consumption
   - Natural gas consumption
   - Liquefied petroleum gases consumption (propane)
   - Distillate fuel oil consumption (#1, #2, and #4)

ClearPath Output

After entering the gallons of propane and fuel oil into ClearPath, the following MMBtu and MTCO2e were output.

Propane					
2014		Thousand Barrels	US Gallon	MMBtu	CO2e
Residential	NYS	6,103	256,326,000		
	TC	30	1,275,479	116,069	7,203

Fuel Oil					
Counted as Distillate Fuel Oil #2 in ClearPath					
2014		Thousand Barrels	US Gallon	MMBtu	CO2e
Residential	NYS	19,682	826,644,000		
	TC	98	4,113,382	567,647	42,265

5. Commercial

This section consists of several parts:

For GHG emissions and energy use calculations:

- NYSEG Metered Commercial Customers – Electricity
- Cornell Central Energy Plant – Electricity
- Cornell Metered Purchase from NYSEG/Grid – Electricity
- Cornell Metered Export to NYSEG/Grid - Electricity

- NYSEG Metered Commercial Customers – Natural Gas
- Cornell Central Energy Plant – Natural Gas

- Commercial Fuel Oil and Propane
- Cornell Central Energy Plant – Fuel Oil

- Coal Data

For energy use calculations only:

- Renewable Installations Providing Electricity to the Commercial Sector

Electricity Data – Commercial

A) NYSEG Metered Commercial Customers

SUMMARY
Input: 396,366,000 kWh for 2014

Output: 73,759 MTCO2e

Data provided on April 7, 2016 from Scott Bochenek with NYSEG. See above information in residential electricity on methods used to extract data.

Sub-results for GHG Emissions
73,759 MTCO2e

B) Cornell Central Energy Plant

SUMMARY
Input: 212,618,797 kWh generated for 2014

Output: 61,546 MTCO2e

For detailed information on how power generation from the Cornell CEP was calculated, please refer to the section below.

Sub-results for GHG Emissions
61,546 MTCO2e

C) Cornell Metered Purchase from NYSEG/Grid

SUMMARY
Input: 56,900,000 kWh purchased for 2014

Output: 10,588 MTCO2e

It was assumed that in 2014, the figure for the commercial sector provided by NYSEG did not include this Cornell electricity purchase, since the electricity purchased/exported by Cornell from NYSEG is fed through a university-owned electric substation.

Data provided by the FY 2014 Cornell University Energy Fast Facts (https://energyandsustainability.fs.cornell.edu/file/Final_FY_2014_CU_Energy_Fast_Facts.pdf)

Sub-results for GHG Emissions
10,588 MTCO2e

D) Cornell Metered Export to NYSEG/Grid

SUMMARY
Input: 38,800,000 kWh exported for 2014

Output: -11,231 MTCO2e

It was assumed that in 2014, the figure for the commercial sector provided by NYSEG did not include this Cornell electricity export, since the electricity purchased/exported by Cornell from NYSEG is fed through a university-owned electric substation.

Data provided by the FY 2014 Cornell University Energy Fast Facts (https://energyandsustainability.fs.cornell.edu/file/Final_FY_2014_CU_Energy_Fast_Facts.pdf)

Sub-results for GHG Emissions
-11,231 MTCO2e

Cornell Electricity Summary: Therefore, 212,618,797+56,900,000-38,800,000=230,718,797 kWh electricity was consumed on the Cornell campus (not including the electricity generated by Cornell hydro power or the Snyder Road Solar Farm) in 2014, and the total emission was 61,546+10,588-11,231=60,902 MTCO2e.

E) Renewable Installations Providing Electricity to the Commercial Sector

SUMMARY
Input: Solar (small-scale): 1,298,853 kWh for 2014
Solar (large-scale): 660,330 kWh for 2014 (332,610 + 327,720)
Total Solar: 1,959,183 kWh
Wind (small-scale): 0
Wind (large-scale): 0
Micro-hydro: 0
Hydro: 4,400,000 kWh Hydro
Other: 184,380,000 kWh Cornell CHP

Output: N/A

Note that these results are only used for energy calculations, not GHG emissions calculations. And a solar system's nameplate capacity is usually measured in direct current, MWdc instead of MWac. It is important to ensure consistency in reporting.

1) Small-scale

- **Solar PV – 200kW or smaller**

1,298,853 kWh for 2014
1,315 KW installed capacity

Methodology
Most renewable energy projects in Tompkins County receive some funding or incentives from NYSERDA. NYSERDA reports the installed capacity, daily/monthly/annual electricity generation, and other performance data of the projects that have received incentives since 2000. The data is publicly available online.

Assumption(s)

- The renewable energy projects funded and monitored by NYSERDA cover most projects of the kind in Tompkins County.
- Before 2000, the installed capacity of renewable energy projects was minimal and ignorable.

Data & Sources

Statewide 200kW or Less Residential/Non-residential Solar Photovoltaic Incentive Program: Beginning 2000
https://data.ny.gov/Energy-Environment/Statewide-200kW-or-Less-Residential-Non-Residentia/3x8r-34rs

Filter the database by County. Include the NYSERDA categories Non-Residential, Commercial, Government, and Non-Profit into sector "Commercial" in the Tompkins County 2014 GHG inventory. Treat the NYSERDA categories Residential and Industrial as the sectors they are.

In the database, for the 2014 analysis the "Date Install" should be 12/31/2014 at the latest and "Project Status" should be "Complete" in order to filter for just the projects that started operating by the end of 2014. For systems that came online in 2014, their Expected kWh Annual Production need to be scaled down for the time they actually operated in 2014. For example, if a completed project's Date Install is 05/02/2014 and its expected annual production is 3,522 kWh, its actual annual production in 2014 is estimated as (365-122)*3,522/365 = 2,344 kWh. Note that May 2 is the 122nd day in 2014.

- **Wind – 10 kW or smaller**

The installed capacity or electricity generation of small-scale wind projects in the County is not tracked by NYSERDA or any other central database.

- **Hydro and Micro-hydro – 500 kW or smaller**

The installed capacity or electricity generation of small-scale hydro projects in the County is not tracked by NYSERDA or any other central database.

2) Large- and Utility-Scale

NYSERDA Distributed Generation (DG) Integrated Data System reports on all DG and combined heat and power (CHP) renewable energy projects:
http://chp.nyserda.ny.gov/facilities/index.cfm?sort=MonitorDate&order=ASC

There are three projects that were in operation by the end of 2014: 1) Kohl's Ithaca Solar PV, 2) Cornell Snyder Road Solar Farm, and 3) Cornell University Combined Heat and Power. A monthly summary table of each project is available in the database. There annual electricity generation can therefore be obtained.

- **Solar PV –200kW – 1MW**

1) Kohl's Ithaca Solar PV

332,610 kWh for 2014
308.28 kW installed capacity

Kohl's #1203 Ithaca Summary Table					
Data Quality: Data Exists					
Date	DG Generator Output (kWh x 10^3)	DG Gas Input (cf x 10^3)	Useful Heat Recovery (MBtu x 10^3)	Electrical Efficiency HHV (%)	Total Efficiency HHV (%)
January 2014	8.56	-	-	-	-
February 2014	7.71	-	-	-	-
March 2014	25.84	-	-	-	-
April 2014	35.75	-	-	-	-
May 2014	45.32	-	-	-	-
June 2014	45.34	-	-	-	-
July 2014	46.22	-	-	-	-
August 2014	41.59	-	-	-	-
September 2014	35.38	-	-	-	-
October 2014	22.80	-	-	-	-
November 2014	12.00	-	-	-	-
December 2014	6.08	-	-	-	-
Total	332.61			-	-

- **Solar PV – greater than 1MW**

2) Cornell Snyder Road Solar Farm

327,720 kWh for 2014
2 MW installed capacity
Began operation in September 2014

Cornell Snyder Road Solar Farm Summary Table					
Data Quality: Data Exists					
Date	DG Generator Output (kWh x 10^3)	DG Gas Input (cf x 10^3)	Useful Heat Recovery (MBtu x 10^3)	Electrical Efficiency HHV (%)	Total Efficiency HHV (%)
September 2014	85.46	-	-	-	-
October 2014	126.74	-	-	-	-
November 2014	74.91	-	-	-	-
December 2014	40.62	-	-	-	-
Total	327.72			-	-

- **Combined Heat and Power (CHP)**

It should be noted that although CHP is tracked by the above NYSERDA database and therefore is explained below, it is not a source of renewable energy and is not carbon neutral. Therefore, it is not included in the renewable generation figures, but is fully explored in the section on Cornell energy generation and consumption.

3) Cornell University CHP

184,380 MWh for 2014
30 MW installed capacity

Cornell University Summary Table

Data Quality: Data Exists

Date	DG Generator Output (kWh x 10^6)	DG Gas Input (cf x 10^6)	Useful Heat Recovery (MBtu x 10^6)	Electrical Efficiency HHV (%)	Total Efficiency HHV (%)
January 2014	21.59	279.8	142.2	25.5	74.8
February 2014	19.93	257.4	129.7	25.6	74.4
March 2014	21.66	277.8	139.5	25.8	74.4
April 2014	17.81	211.2	96.0	27.9	71.9
May 2014	9.48	112.9	52.8	27.8	73.1
June 2014	10.60	117.1	47.4	29.9	69.2
July 2014	11.22	123.5	46.0	30.0	66.1
August 2014	10.72	120.2	48.6	29.5	68.7
September 2014	10.88	125.4	51.6	28.7	68.6
October 2014	10.42	129.2	66.8	26.7	76.8
November 2014	18.19	223.7	109.1	26.9	74.1
December 2014	21.87	275.0	135.0	26.3	73.9
Total	**184.38**	**2,253.2**	**1,064.7**	**27.1**	**72.8**

Note that Cornell uses co-generation in two ways:

1) Combustion turbine, generating heat and capturing what would be wasted energy to create steam to generate electricity electric

2) High pressure steam is used to power the two steam turbines, which produces additional electric for the campus

The NYSDERA DG website only addresses the first of those two: the combustion turbine output. Additional output of 212,618,797 – 184,380,000 = 28,238,797 kWh was produced by the second item, the high pressure steam turbines in 2014.

In addition to those large-scale renewable projects listed in NYSERDA's Distributed Generation (DG) Integrated Data System reports, the following project is in operation in Tompkins County.

- **Hydro and Micro-hydro – greater than 500 kW**

Cornell Hydropower
4,400,000 kWh for 2014
1.1 MW nameplate capacity

This accounts for all of the hydro-electricity production in Tompkins County in 2014: 4,400,000 kWh.

Data & Sources
Electricity output from a hydro power plant changes each year. Updates can be found from Cornell's official reports, such as the Energy Fast Facts
https://energyandsustainability.fs.cornell.edu/file/Final_FY_2014_CU_Energy_Fast_Facts.pdf

- **Wind**

The installed capacity or electricity generation of large-scale (10-100 kW) wind projects in the County is not tracked by NYSERDA or any other central database. And as of spring 2014, twenty utility-scale (greater than 1 MW) wind energy projects were operating with a rated capacity of 1,812 MW in New York State, but none are located in Tompkins County.
(http://www.dec.ny.gov/docs/permits_ej_operations_pdf/windstatuscty.pdf)

Natural Gas Data – Commercial

A) NYSEG Metered Commercial Customers

SUMMARY
Input: 19,070,642 therms for 2014

Output: 101,430 MTCO2e

Methodology
Data provided on April 7, 2016 from Scott Bochenek with NYSEG. See above information in residential electricity on methods used to extract data.

Sub-results for GHG Emissions
101,430 MTCO2e

B) Cornell Central Energy Plant

SUMMARY
Input: 27,370,990 therms for 2014

Output: 84,031 MTCO2e

For detailed information on how power generation from the Cornell CEP was calculated, please refer to the appropriate section below.

Sub-results for GHG Emissions
84,031 MTCO2e

Fuel Oil and Propane Data – Commercial

A) Commercial sector fuel oil and propane use

SUMMARY
Input: 2,527,232 gallons of fuel oil for 2014 (includes 242,717 gallons used at Cornell CEP)
414,068 gallons of propane for 2014

Output: 23,695 MTCO2e for fuel oil
2,338 MTCO2e for propane
26,033 MTCO2e in total for the two fuels

Methodology (New)
Step 1: Estimate the average ratio of fuel used in Tompkins County compared to NYS.

1) Estimate the ratio of commercial electricity use in Tompkins County for 2014 provided by NYSEG compared to EIA SEDS data for NYS commercial electricity use in 2014. 396,366,000 kWh in Tompkins/76,541,000,000 kWh in NYS = 0.52%.

2) Estimate the ratio of commercial electricity use in Tompkins County for 2008 provided by NYSEG compared to EIA SEDS data for NYS commercial electricity use in 2008. 384,138,000 kWh in Tompkins/77,416,000,000 kWh in NYS = 0.50%.

3) Estimate the ratio of commercial natural gas use in Tompkins County for 2014 provided by NYSEG compared to EIA SEDS data for NYS commercial natural gas use in 2014. First needed to convert Tompkins data of 19,070,642 therms of natural gas to cubic feet using an online conversion calculator yields 1,906,608,964 cubic feet. Therefore, 1,907 million cubic feet in Tompkins/320,000 million cubic feet in NYS = 0.60%.

4) Estimate the ratio of commercial natural gas use in Tompkins County for 2008 provided by NYSEG compared to EIA SEDS data for NYS commercial natural gas use in 2008. First needed to convert Tompkins data of 21,321,612 therms of natural gas to cubic feet using an online conversion calculator yields 2,131,652,231 cubic feet. Therefore, 2,132 million cubic feet in Tompkins/290,150 million cubic feet in NYS = 0.73%.

   These four numbers give you an average allocation factor of 0.59% [(0.52%+0.50%+0.60%+0.73%)/4 = 0.59%] to use in the next steps.

Commercial Average Fuel Allocation Factor: Tompkins to NYS	0.59%

Step 2 (Fuel Oil): Next determine which fuel oils are used in the commercial sector. We included Distillate Fuel Oil and Residual Fuel Oil in this analysis.

Apply the allocation factor of 0.59% to the NYS Distillate Fuel Oil amount to get an estimate for the amount of distillate fuel oil consumed in Tompkins County in 2014. NYS consumed 8,434,000 barrels of distillate fuel oil in the commercial sector. There are 42 US gallons in an oil barrel, so 8,434,000 barrels*42 = 354,228,000 gallons. 0.0059*354,228,000 = 2,076,250 gallons of distillate fuel oil in Tompkins County.

Apply the allocation factor of 0.59% to the NYS Residual Fuel Oil amount to get an estimate for the amount of residual fuel oil consumed in Tompkins County in 2014. NYS consumed 846,000 barrels of residual fuel oil in the commercial sector. There are 42 US gallons in an oil barrel, so 846,000 barrels*42 = 35,532,000 gallons. 0.0059*35,532,000 = 208,265 gallons of residual fuel oil in Tompkins County.

Therefore, the total fuel oil consumed by the commercial sector was 2,076,250+208,265 = 2,284,515 gallons.

Note that distillate fuel oil by default includes #1, #2, and #4 by the EIA. ClearPath only has the choice for distillate fuel oil #2, which gives the closest estimate.

Step 3 (Propane): Next apply the allocation factor of 0.59% to the NYS Propane (liquefied petroleum) amount to get an estimate for the amount of propane consumed in Tompkins County in 2014. NYS consumed 1,682,000 barrels of "Liquefied Petroleum Gases" in the commercial sector. There are 42 US gallons in a barrel of propane, so 1,682,000 barrels*42 = 70,644,000 gallons. Therefore, 0.0059*70,644,000 = 414,068 gallons in Tompkins County.

Justification for a Change in Methodology from 2008: Changes were made because:

a. Good to use consistent methodology for residential as for commercial and industrial for fuel oil and propane consumption
b. Removing the Assessment database makes it one less data source to obtain in the future, making it easier to conduct these inventories.
c. Learned from Jay Franklin that the data we used from the Assessment Department previously, showing the count of commercial and industrial buildings using fuel oil and propane for heating is no longer available in 2014.

Assumption(s)

- Allocation percentage of electricity or natural gas = TC consumption / NYS consumption of the same year.
- Average the allocation percentages over energy sources and years within one sector.
- Assume that the sector average allocation percent remains constant over years and can be applied to estimate the consumption of propane and fuel oil within the sector.

Data & Sources

a. State Energy Data System 2014
http://www.eia.gov/state/seds/seds-data-fuel.cfm?sid=US#PetroleumandFuelEthanol
b. State Energy Data System 1960-2013, All Consumption Estimates in Physical Units
http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US#Consumption
    - Electricity consumption
    - Natural gas consumption
    - Liquefied petroleum gases consumption (propane)
    - Distillate fuel oil consumption (#1, #2, and #4)
    - Residual fuel oil consumption (#5 and #6)

ClearPath Output

After entering the gallons of propane and fuel oil into ClearPath, the following MMBtu and MTCO2e were output.

Fuel Oil					
Counted as Distillate Fuel Oil #2 and Residuel Fuel Oil #6 in ClearPath					
a. Distillate Fuel Oil					
2014		**Thousand Barrels**	**US Gallon**	**MMBtu**	**CO2e**
Commercial	NYS	8,434	354,228,000		
	TC	49	2,076,250	286,523	21,333
Industrial	NYS	2,001	84,042,000		
	TC	13	531,256	73,313	5,442
b. Residual Fuel Oil					
2014		**Thousand Barrels**	**US Gallon**	**MMBtu**	**CO2e**
Commercial	NYS	846	35,532,000		
	TC	5	208,265	31,240	2,362
Industrial	NYS	552	23,184,000		
	TC	3	146,553	21,983	1,657
Total					
	US Gallon	**MMBtu**	**CO2e**		
Commercial	2,284,515	317,763	23,695		
Industrial	677,809	95,296	7,099		

Propane						
2014		Thousand Barrels	US Gallon	MMBtu	CO2e
Commercial	NYS	1,682	70,644,000		
	TC	10	414,068	37,680	2,338
Industrial	NYS	604	25,368,000		
	TC	4	160,359	14,593	902

B) Cornell Central Energy Plant

SUMMARY
Input: 242,717 gallons of fuel oil for 2014

Output: 3,423 MTCO2e

For detailed information on how power generation from the Cornell CEP was calculated, please refer to the appropriate section below.

Sub-results for GHG Emissions
3,423 MTCO2e

Coal Data – Commercial

SUMMARY
Input: 0 tons for 2014

Output: 0 MTCO2e

All coal used in 2008 was from Cornell CEP. This was switched to natural gas gradually from 2009 to March 2011, so there was no coal burned in the commercial sector in 2014.

Data & Sources
a. Cornell University Central Energy Plant (CEP) Fast Facts
https://energyandsustainability.fs.cornell.edu/em/fastfacts/default.cfm

6. Cornell Power Generation and Consumption

SUMMARY
Input: 27,370,990 therms of natural gas for 2014
242,717 gallons of fuel oil for 2014
212,618,797 kWh electricity generated in 2014
56,900,000 kWh electricity purchased in 2014
38,800,000 kWh electricity exported in 2014
Therefore, 230,718,797 kWh electricity was consumed on the Cornell campus (not including electricity generated by Cornell hydro and the Snyder Road Solar Farm)
981,814 klbs metered steam for 2014

Output: 148,357 total MTCO2e, with
84,031 MTCO2e from natural gas
3,423 MTCO2e from fuel oil
60,902 MTCO2e from electricity

Methodology, Data & Sources

GHG emissions were calculated based on these inputs (outside of ClearPath system):

1) Natural gas and fuel oil consumed at the CEP
2) Electricity generation and metered steam sales from the CEP
3) Electricity exported from the total generated on-site (not used on campus) to NYSEG/Grid
4) Electricity purchased from NYSEG
5) MTCO2e from Cornell's GHG Emissions Inventory

Input 1: Natural gas and fuel oil consumed at the CEP

27,370,990 therms natural gas
242,717 gallons of fuel oil
Obtained through personal correspondence from David Frostclapp from Cornell Facilities Services.

Input 2: Electricity generation and metered steam sales from the CEP.

212,618,797 kWh electricity – total generation from the co-gen steam turbine and the CCHPP gas turbine
Obtained through personal correspondence from David Frostclapp from Cornell Facilities Services.

981,814 klbs metered steam – a byproduct of the CHP system, please see Background on Cornell CEP, below.
Obtained through personal correspondence from David Frostclapp from Cornell Facilities Services.

Calculations:

In order to get the energy consumed based on the above inputs, standard conversion factors were applied:
1 therm = 0.1 MMBtu
1 gallon fuel oil = 0.1365 MMBtu
1 kWh = 0.003412 MMBtu
1 klbs = 1.03 MMBtu

Summary Table

Component	Quantity	Units		Energy	Units
Natural Gas - Central Energy Plant	27,370,990	therms		2,737,099	MMBtu
Fuel Oil - Central Energy Plant	242,717	gallons		33,131	MMBtu
Energy Input Totals				**2,770,230**	**MMBtu**
Electricity generation CEP (includes export)	212,618,797	kwh		725,455	MMBtu
Metered Steam Sales	981,814	klbs		1,011,268	MMBtu
Total Energy Output				**1,736,724**	**MMBtu**
Losses				**1,033,506**	**MMBtu**

Note: 212,618,797 kWh and 725,455 MMBtu electricity generation, and 242,717 gallons fuel oil, and 27,370,990 therms natural gas are used throughout analysis below.

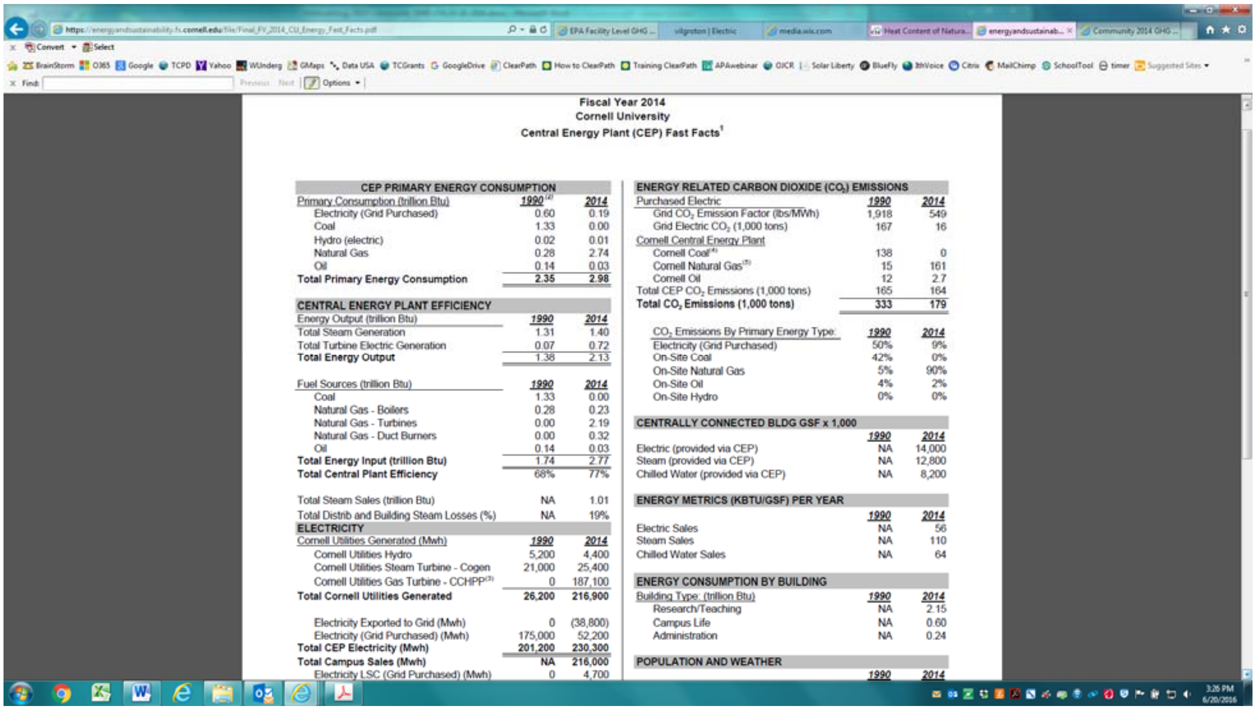
Background on Cornell CEP

Taken from Cornell's website (https://energyandsustainability.fs.cornell.edu/util/default.cfm) in July 2016: "The Utilities section of Energy and Sustainability operates the University energy infrastructure system on a 24 hour, 365 day per year basis. Production facilities include a combined heat and power facility which provides both the steam for heat and electricity for campus. All of the water for campus is provided by a university owned potable water filtration plant.

Electricity from the local utility is fed through a university owned electric substation. Utilities is also responsible for all of the distribution and collection systems located on campus including steam, chilled water, electricity, potable water and waste water. Utilities serves over 300 buildings and nearly 14 million square feet on central campus." And from (https://energyandsustainability.fs.cornell.edu/util/electricity/default.cfm) "The Cornell Ithaca campus has an annual electricity consumption of about 220 million kilowatt hours (that's the equivalent of about 20,000 homes).*(This is down from 250 million kilowatt hours just a few years ago, due to our campus wide energy conservation efforts!)*"

Also, in 2008, the gross Ithaca campus area was 13,944,000 sq.ft. In 2014, it increased to 15,800,000 sq.ft., an increase of 13.3%. Additional buildings include the Bill and Melinda Gates Hall that was constructed in 2014. Its gross area is 105,434 sq.ft. The Human Ecology Building was constructed in 2011 (86,797 sq.ft.), Milstein Hall was constructed in 2011 (56,025 sq.ft.), and the Physical Science Building was constructed in 2010 (204,029 sq.ft.), to name just a few.

Since the fall of 2009, Cornell has owned and operated its own natural gas supply lines independent of NYSEG services (http://www.news.cornell.edu/stories/2006/11/new-gas-line-cornells-combined-heat-and-power-project). So the natural gas use here to generate electricity is counted separately from the natural gas delivered by NYSEG to Cornell (included in the commercial sector).



Fiscal Year 2014
Cornell University
Central Energy Plant (CEP) Fast Facts[1]

CEP PRIMARY ENERGY CONSUMPTION		
Primary Consumption (trillion Btu)	1990[2]	2014
Electricity (Grid Purchased)	0.60	0.19
Coal	1.33	0.00
Hydro (electric)	0.02	0.01
Natural Gas	0.28	2.74
Oil	0.14	0.03
Total Primary Energy Consumption	2.35	2.98

CENTRAL ENERGY PLANT EFFICIENCY		
Energy Output (trillion Btu)	1990	2014
Total Steam Generation	1.31	1.40
Total Turbine Electric Generation	0.07	0.72
Total Energy Output	1.38	2.13
Fuel Sources (trillion Btu)	1990	2014
Coal	1.33	0.00
Natural Gas - Boilers	0.28	0.23
Natural Gas - Turbines	0.00	2.19
Natural Gas - Duct Burners	0.00	0.32
Oil	0.14	0.03
Total Energy Input (trillion Btu)	1.74	2.77
Total Central Plant Efficiency	68%	77%
Total Steam Sales (trillion Btu)	NA	1.01
Total Distrib and Building Steam Losses (%)	NA	19%

ELECTRICITY		
Cornell Utilities Generated (Mwh)	1990	2014
Cornell Utilities Hydro	5,200	4,400
Cornell Utilities Steam Turbine - Cogen	21,000	25,400
Cornell Utilities Gas Turbine - CCHPP[3]	0	187,100
Total Cornell Utilities Generated	**26,200**	**216,900**
Electricity Exported to Grid (Mwh)	0	(38,800)
Electricity (Grid Purchased) (Mwh)	175,000	52,200
Total CEP Electricity (Mwh)	**201,200**	**230,300**
Total Campus Sales (Mwh)	**NA**	**216,000**
Electricity LSC (Grid Purchased) (Mwh)	0	4,700

ENERGY RELATED CARBON DIOXIDE (CO_2) EMISSIONS		
Purchased Electric	1990	2014
Grid CO_2 Emission Factor (lbs/MWh)	1,918	549
Grid Electric CO_2 (1,000 tons)	167	16
Cornell Central Energy Plant		
Cornell Coal[4]	138	0
Cornell Natural Gas[5]	15	161
Cornell Oil	12	2.7
Total CEP CO_2 Emissions (1,000 tons)	165	164
Total CO_2 Emissions (1,000 tons)	333	179
CO_2 Emissions By Primary Energy Type:	1990	2014
Electricity (Grid Purchased)	50%	9%
On-Site Coal	42%	0%
On-Site Natural Gas	5%	90%
On-Site Oil	4%	2%
On-Site Hydro	0%	0%

CENTRALLY CONNECTED BLDG GSF x 1,000		
	1990	2014
Electric (provided via CEP)	NA	14,000
Steam (provided via CEP)	NA	12,800
Chilled Water (provided via CEP)	NA	8,200

ENERGY METRICS (KBTU/GSF) PER YEAR		
	1990	2014
Electric Sales	NA	56
Steam Sales	NA	110
Chilled Water Sales	NA	64

ENERGY CONSUMPTION BY BUILDING		
Building Type: (trillion Btu)	1990	2014
Research/Teaching	NA	2.15
Campus Life	NA	0.60
Administration	NA	0.24

POPULATION AND WEATHER		
	1990	2014

Steam sales, or consumption, at Cornell is metered and verified monthly by a sales-to-production report (https://energyandsustainability.fs.cornell.edu/em/metering.cfm). The steam is consumed in the form of condensate on campus.

Input 3: Electricity exported from the total generated on-site (not used on campus) to NYSEG/Grid
In 2014, 38,800,000 kWh of electricity generated from the CHP system at the Cornell Central Energy Plant was exported to the grid (obtained from the online publication Energy Fast Facts for 2014: https://energyandsustainability.fs.cornell.edu/em/fastfacts/default.cfm). 38,800,000 kWh equals 132,391 MMBtu given the conversion factor above.

Input 4: Electricity purchased from NYSEG
According to the 2014 Cornell Energy Plant Fast Facts, the CEP purchased 0.19 trillion Btus from the grid, which equals 56.9 million kWh given the conversion factor above.
(https://energyandsustainability.fs.cornell.edu/file/Final_FY_2014_CU_Energy_Fast_Facts.pdf)

Within the Commercial Sector, and using the “Emissions from Grid Electricity” calculator, the ClearPath software calculates 194,198 MMBtu and 10,588 MTCO2e emissions for the electricity purchased.

So total electricity consumed on the Cornell campus was 212,618,797-38,800,000+56,900,000=230,718,797 kWh or 725,455-132,391+194,198=787,262 MMBtu.

Input 5: $MTCO_2e$ from Cornell’s GHG Emissions Inventory
The 2014 Cornell University Greenhouse Gas Emissions Inventory includes the following table:
http://www.sustainablecampus.cornell.edu/initiatives/greenhouse-gas-emissions-inventory

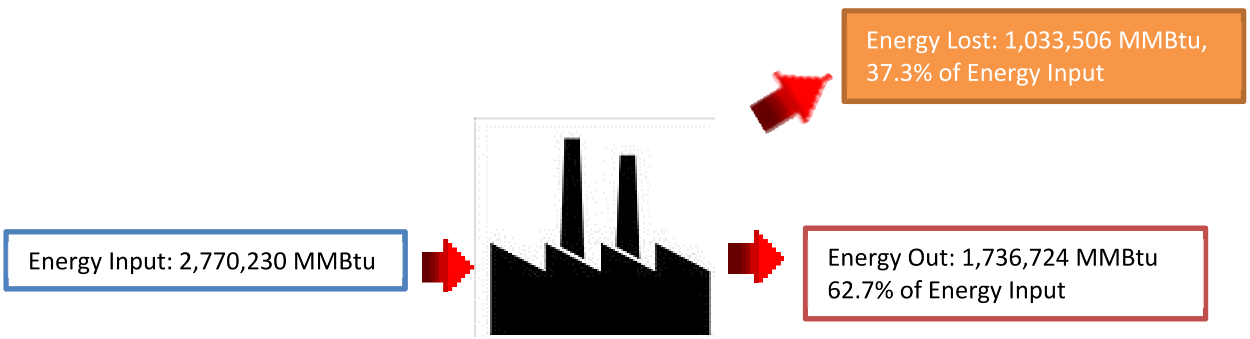
Ithaca Campus PCC GHG Inventory

Component(1)	2008 CO2-e Emissions (metric tons)	2014 CO2-e Emissions (metric tons)	Change CO2-e Emissions (metric tons)
On-Site Fossil Fuel Combustion(3)	176,000	149,000	(27,000)
Purchased Electricity	87,000	17,000	(70,000)
Commuting(2)	29,000	29,000	0
Air Travel	27,000	30,000	3,000
Totals	**319,000**	**225,000**	**(94,000) decrease**

Notes: (1) Cornell's fiscal year is from July 1 to June 30th of the following year (2) projected based on 2006 commuting mode survey and 2014 population (3) adjusted for exported electric

Calculations

First, need to determine how much of the total natural gas and fuel oil used to generate power is actually converted to energy to be utilized by Cornell for heat and electricity ("Energy Out" below).



Using the MMBtu from the Summary Table (pasted below again for ease of viewing) we assumed that: 1) the losses due to the process of converting natural gas and fuel oil to electricity and steam are both equal and 2) the losses for both fuels are proportional to the overall system loss of 37.3% (1,033,506/2,770,230 = 62.7%. 100%-62.7% = 37.3%).

Component	Quantity	Units		Energy	Units
Natural Gas - Central Energy Plant	27,370,990	therms		2,737,099	MMBtu
Fuel Oil - Central Energy Plant	242,717	gallons		33,131	MMBtu
Energy Input Totals				**2,770,230**	**MMBtu**
Electricity generation CEP (includes export)	212,618,797	kwh		725,455	MMBtu
Metered Steam Sales	981,814	klbs		1,011,268	MMBtu
Total Energy Output				**1,736,724**	**MMBtu**
Losses				**1,033,506**	**MMBtu**

These assumptions yield the table below, using the following calculations.

- Natural gas utilized = Energy input 2,737,099 MMBtu × 62.7% = 1,715,953 MMBtu

- Natural gas loss = Energy input 2,737,099 MMBtu – Energy utilized 1,715,953 MMBtu = 1,021,146 MMBtu
- Fuel oil utilized = Energy input 33,131 MMBtu × 62.7% = 20,771 MMBtu
- Fuel oil loss = Energy input 33,131 MMBtu – Energy utilized 20,771 MMBtu = 12,360 MMBtu

MMBtu	Total	Loss	Utilized MMBtu
Natural Gas	2,737,099	1,021,146	1,715,953
Fuel Oil	33,131	12,360	20,771
Sum	2,770,230	1,033,506	1,736,724

Second, need to allocate the amount of natural gas that was utilized to generate electricity and what portion went to burning for thermal demand.

Natural gas utilized for heating only: (Total natural gas utilized 1,715,953 MMBtu – amount of natural gas used to convert to energy in electricity 725,455 MMBtu) = 990,498 MMBtu

Third, need to convert kWh, gallons of fuel oil, and therms utilized by Cornell to GHG emissions. This was calculated as follows:

According to Cornell's 2014 GHG Emissions Inventory, total Cornell emission from on-site fossil fuel combustion was 149,000 $MTCO_2e$. When 27,370,990 therms of natural gas are entered into ClearPath, it calculates emissions of 145,577 MTCO2e. Therefore, the remaining 3,423 MTCO2e are from the combustion of fuel oil. Split the 145,577 MT CO_2e between natural gas and electricity by their utilized energy.

- Fuel oil emission = (total Cornell emissions from on-site fossil fuel combustion 149,000 MT – emissions from natural gas use 145,577 MT) = 3,423 MTCO2e
- Natural gas emissions from heating only = ((overall emissions from natural gas of 145,577 MTCO2e × natural gas utilized for heating only 990,498 MMBtu)/total natural gas utilized 1,715,953 MMBtu) = 84,031 MTCO2e
- Electricity emissions from natural gas used for electricity generation = ((overall emissions from natural gas of 145,577 MTCO2e × converted to energy in electricity 725,455 MMBtu)/total natural gas utilized 1,715,953 MMBtu) = 61,546 MTCO2e

Fourth, need to account for the export of electricity from the total generated at the CEP. This was calculated as follows:

38,800,000 kWh of electricity generated at Cornell CEP was exported to grid in 2014. Scale down the emissions from electricity by the amount actually consumed on-site:

61,546 MTCO2e x (212,618,797 kWh – 38,800,000 kWh)/212,618,797 kWh = 50,314 MTCO2e

So total emission from electricity consumed on the Cornell campus was 50,314+10,588=60,902 MTCO2e.

Summary Results:
CEP Generated Energy and Emissions Used On-Campus (figures used here are highlighted in yellow, above)

	MMBtu	Units Utilized On Campus		MTCO2e
Electricity (kWh)	787,262	230,718,797	Electricity – emissions from natural gas used to generate, and electricity purchased and exported	60,902
Fuel Oil (gallons)	20,771	242,717	Fuel Oil emissions	3,423
Natural Gas (therms)	990,498	27,370,990	Natural Gas - emissions from heating only	84,031
Total	1,798,531	NA	Total	148,357

7. Industrial

This section consists of several parts:

For GHG emissions and energy use calculations:

- NYSEG Metered Industrial Customers – Electricity
- NYSEG Metered Industrial Customers – Natural Gas
- Industrial Fuel Oil and Propane

For energy use calculations only:

- Renewable Installations Providing Electricity to the Industrial Sector

Electricity Data – Industrial

A) NYSEG Metered Industrial Customers

SUMMARY
Input: 121,264,000 kWh for 2014

Output: 22,566 MTCO2e

Data provided on April 7, 2016 from Scott Bochenek with NYSEG. See above information in residential electricity on methods used to extract data.

Sub-results for GHG Emissions
22,566 MTCO2e

B) Renewable Installations Providing Electricity to the Industrial Sector
While it is possible to determine whether small-scale non-residential renewable installations are attributed to the industrial sector, there were none in operation at this time.

The three projects that were reported as large- or utility-scale renewables were reviewed and determined that all are commercial projects.

The data will be reviewed in the future to ensure that we are not missing renewable installations that should be attributed to the industrial sector.

Natural Gas Data – Industrial

SUMMARY
Input: 3,310,951 therms for 2014

Output: 17,573 MTCO2e

Data provided on April 7, 2016 from Scott Bochenek with NYSEG. See above information in residential electricity on methods used to extract data.

Sub-results for GHG Emissions
17,573 MTCO2e

Fuel Oil and Propane Data – Industrial

SUMMARY
Input: 677,809 gallons of fuel oil for 2014
160,359 gallons of propane for 2014

Output: 7,099 MTCO2e for fuel oil
902 MTCO2e for propane
8,002 MTCO2e in total for the two fuels

Methodology (New)
Step 1: Estimate the average ratio of fuel used in Tompkins County compared to NYS.

1) Estimate the ratio of industrial electricity use in Tompkins County for 2014 provided by NYSEG compared to EIA SEDS data for NYS industrial electricity use in 2014. 121,264,000 kWh in Tompkins/18,003,000,000 kWh in NYS = 0.67%.

2) Estimate the ratio of industrial electricity use in Tompkins County for 2008 provided by NYSEG compared to EIA SEDS data for NYS industrial electricity use in 2008. 138,191,663 kWh in Tompkins/14,685,000,000 kWh in NYS = 0.94%.

3) Estimate the ratio of industrial natural gas use in Tompkins County for 2014 provided by NYSEG compared to EIA SEDS data for NYS industrial natural gas use in 2014. First needed to convert Tompkins data of 3,310,951 therms of natural gas to cubic feet using an online conversion calculator yields 331,016,064 cubic feet. Therefore, 331 million cubic feet in Tompkins/85,000 million cubic feet in NYS = 0.39%.

4) Estimate the ratio of industrial natural gas use in Tompkins County for 2008 provided by NYSEG compared to EIA SEDS data for NYS industrial natural gas use in 2008. First needed to convert Tompkins data of 4,231,084 therms of natural gas to cubic feet using an online conversion calculator yields 423,007,400 cubic feet. Therefore, 423 million cubic feet in Tompkins/80,653 million cubic feet in NYS = 0.52%.

These four numbers give you an average allocation factor of 0.63% [(0.67%+0.94%+0.39%+0.52%)/4 = 0.63%] to use in the next steps.

Industrial Average Fuel Allocation Factor: Tompkins to NYS	0.63%

Step 2 (Fuel Oil): Next determine which fuel oils are used in the industrial sector. We included Distillate Fuel Oil and Residual Fuel Oil in this analysis.

Apply the allocation factor of 0.63% to the NYS Distillate Fuel Oil amount to get an estimate for the amount of distillate fuel oil consumed in Tompkins County in 2014. NYS consumed 2,001,000 barrels of distillate fuel oil in the industrial sector. There are 42 US gallons in an oil barrel, so 2,001,000 barrels*42 = 84,042,000 gallons. 0.0063*84,042,000 = 531,256 gallons of distillate fuel oil in Tompkins County.

Apply the allocation factor of 0.63% to the NYS Residual Fuel Oil amount to get an estimate for the amount of residual fuel oil consumed in Tompkins County in 2014. NYS consumed 552,000 barrels of residual fuel oil in the industrial sector. There are 42 US gallons in an oil barrel, so 552,000 barrels*42 = 23,184,000 gallons. 0.0063*23,184,000 = 146,553 gallons of residual fuel oil in Tompkins County.

Therefore, the total fuel oil consumed by the industrial sector was 531,256+146,553=677,809 gallons.

Note that distillate fuel oil by default includes #1, #2, and #4 by the EIA. ClearPath only has the choice for distillate fuel oil #2, which gives the closest estimate.

Step 3 (Propane): Next apply the allocation factor of 0.63% to the NYS Propane (liquefied petroleum) amount to get an estimate for the amount of propane consumed in Tompkins County in 2014. NYS consumed 604,000 barrels of "Liquefied Petroleum Gases" in the industrial sector. There are 42 US gallons in a barrel of propane, so 604,000 barrels*42 = 25,368,000 gallons. Therefore, 0.0063*25,368,000 = 160,359 gallons in Tompkins County.

Justification for a Change in Methodology from 2008: Changes were made because:

a. Good to use consistent methodology for residential as for commercial and industrial for fuel oil and propane consumption
b. Removing the Assessment database makes it one less data source to obtain in the future, making it easier to conduct these inventories.
c. Learned from Jay Franklin that the data we used from the Assessment Department previously, showing the count of commercial and industrial buildings using fuel oil and propane for heating is no longer available in 2014.

Assumption(s)

- Allocation % of electricity or natural gas = TC consumption / NYS consumption of the same year.
- Average the allocation %s over energy sources and years within one sector.

- Assume that the sector average allocation % remains constant over years and can be applied to estimate the consumption of propane and fuel oil within the sector.

Data & Sources

a. State Energy Data System 2014
http://www.eia.gov/state/seds/seds-data-fuel.cfm?sid=US#PetroleumandFuelEthanol

b. State Energy Data System 1960-2013, All Consumption Estimates in Physical Units
http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US#Consumption
   - Electricity consumption
   - Natural gas consumption
   - Liquefied petroleum gases consumption (propane)
   - Distillate fuel oil consumption (#1, #2, and #4)
   - Residual fuel oil consumption (#5 and #6)

ClearPath Output

After entering the gallons of propane and fuel oil into ClearPath, the following MMBtu and MTCO2e were output.

Fuel Oil					
Counted as Distillate Fuel Oil #2 and Residuel Fuel Oil #6 in ClearPath					
a. Distillate Fuel Oil					
2014		**Thousand Barrels**	**US Gallon**	**MMBtu**	**CO2e**
Commercial	NYS	8,434	354,228,000		
	TC	49	2,076,250	286,523	21,333
Industrial	NYS	2,001	84,042,000		
	TC	13	531,256	73,313	5,442
b. Residual Fuel Oil					
2014		**Thousand Barrels**	**US Gallon**	**MMBtu**	**CO2e**
Commercial	NYS	846	35,532,000		
	TC	5	208,265	31,240	2,362
Industrial	NYS	552	23,184,000		
	TC	3	146,553	21,983	1,657
Total					
	US Gallon	**MMBtu**	**CO2e**		
Commercial	2,284,515	317,763	23,695		
Industrial	677,809	95,296	7,099		

Propane					
2014		**Thousand Barrels**	**US Gallon**	**MMBtu**	**CO2e**
Commercial	NYS	1,682	70,644,000		
	TC	10	414,068	37,680	2,338
Industrial	NYS	604	25,368,000		
	TC	4	160,359	14,593	902

8. Village of Groton Electric

SUMMARY

Input: 25,337,996 kWh for 2014

Output: 2,137 MTCO2e

Village Electric System – From the Village of Groton's website: http://www.grotonny.org/#!electric/c51y. "The Village of Groton is one of 47 municipal electric systems in New York State. Being a public power system, the Village has complete utility responsibility within our boundaries. Under Federal license, 40% of the output of the New York Power Authority plant has to be distributed to publicly owned electric systems, which is among the lowest rates in the entire nation. The Village receives a hydro allotment of 4,469 KW. If we go over that amount (as we do in the winter), the Village purchases incremental power in cooperation with a group of 35 other municipal systems, called the New York Municipal Power Agency. The Village of Groton's contract for the hydro power with the New York Power Authority runs thru 2025."

Methodology, Data & Sources

GHG emissions were calculated by ClearPath based on the amount of energy input from fossil fuels used for electricity generation. To obtain that, we obtained the following data:

1) Fuel mix of the electricity that the Village of Groton purchased
2) Amount of electricity consumed by the Village of Groton

Note that Groton Electric is included as a record in the Industrial Sector in ClearPath. This is not because it is an industrial activity, but because the Industrial Sector includes a calculator titled "Emissions from Stationary Fuel Combustion at Energy Industries." Because the electricity that Groton Electric customers purchase is generated using a different fuel mix from that of the rest of community, it is not possible to use the calculators in the Residential or Commercial sectors; nor can the default grid emission factors be used. Using the above calculator allows for input of the electricity fuel breakdown to accurately reflect the fuel types that generate Groton's electricity (and its associated emissions).

Input 1: Fuel mix of the electricity that the Village of Groton purchased

The most recent data available is from 2013. Data obtained through personal communication with Chuck Rankin, Clerk-Treasurer/Administrator, the Village of Groton Electric Department. This information came from a NYS Department of Public Service fact sheet customized for the Village of Groton.

Fuel Sources (2013)	Percent
Hydro	76%
Natural Gas	13%
Nuclear	9%
Coal	1%
Other Renewables	1%
Total	100%

While the bulk (86%) of this electricity is from non-emitting sources (hydro, nuclear, and other renewables), there are emissions associated with the electricity generated by natural gas and coal. Emissions from them are calculated by ClearPath based on the portion of electricity each type of fuel generates out of the total. Emissions are counted at the source.

Input 2: Amount of electricity consumed by the Village of Groton

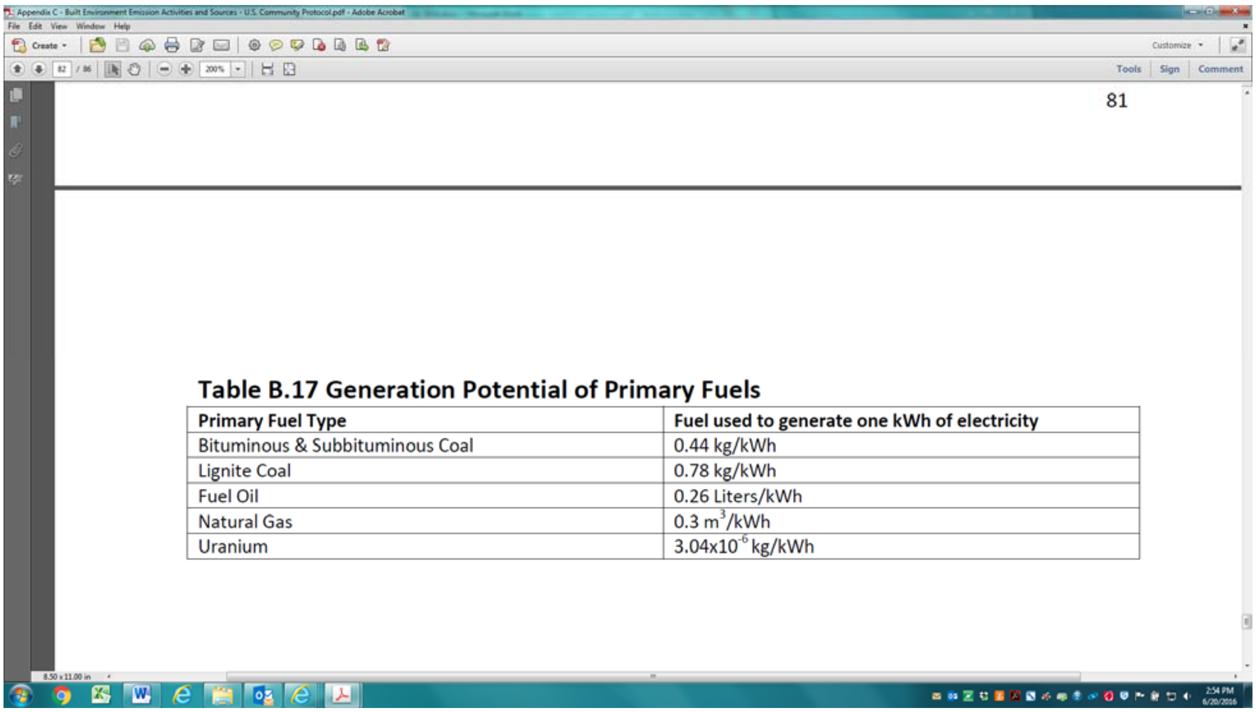
The Village of Groton consumed 25,337,996 kWh in 2014. Information provided by Chuck Rankin.

Calculations

Need to determine how much of each fuel was used to generate the electricity. Did this by applying the fuel mix percentages to the total amount of kWh consumed. For example, 13% of the fuel mix was from natural gas, so 25,337,996 kWh*0.13 = 3,293,939 kWh from natural gas.

Emissions Calculations – ClearPath Software

The ICLEI U.S. Community Protocol version 1.1, July 2013, (Appendix C, page 82, Table B.17) gives the generation potential of primary fuels. For bituminous & sub-bituminous coal, it's 0.44 kg/kWh. For natural gas, it's 0.3 m^3/kWh.



81

Table B.17 Generation Potential of Primary Fuels

Primary Fuel Type	Fuel used to generate one kWh of electricity
Bituminous & Subbituminous Coal	0.44 kg/kWh
Lignite Coal	0.78 kg/kWh
Fuel Oil	0.26 Liters/kWh
Natural Gas	0.3 m^3/kWh
Uranium	3.04×10^{-6} kg/kWh

- Assumed that the fuel mix didn't change from 2013 to 2014.
- Assumed a heat content of natural gas was 1,031 Btu/cubic foot for New York State in 2014.
  - From: https://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm

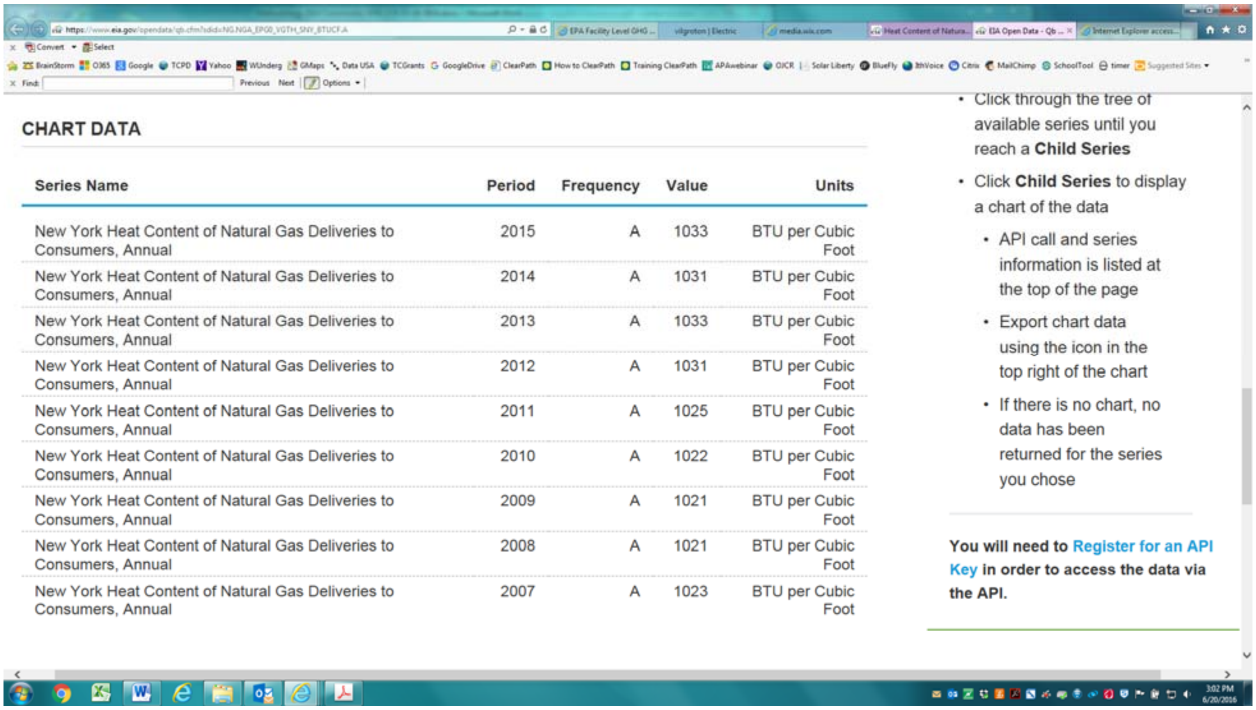


CHART DATA

Series Name	Period	Frequency	Value	Units
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2015	A	1033	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2014	A	1031	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2013	A	1033	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2012	A	1031	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2011	A	1025	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2010	A	1022	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2009	A	1021	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2008	A	1021	BTU per Cubic Foot
New York Heat Content of Natural Gas Deliveries to Consumers, Annual	2007	A	1023	BTU per Cubic Foot

- Click through the tree of available series until you reach a **Child Series**
- Click **Child Series** to display a chart of the data
  - API call and series information is listed at the top of the page
  - Export chart data using the icon in the top right of the chart
  - If there is no chart, no data has been returned for the series you chose

You will need to Register for an API Key in order to access the data via the API.

- Average heat content of coal consumed for the electric power industry was 9,710 Btu/lb in 2014.
  - From: http://www.eia.gov/electricity/annual/html/epa_07_03.html

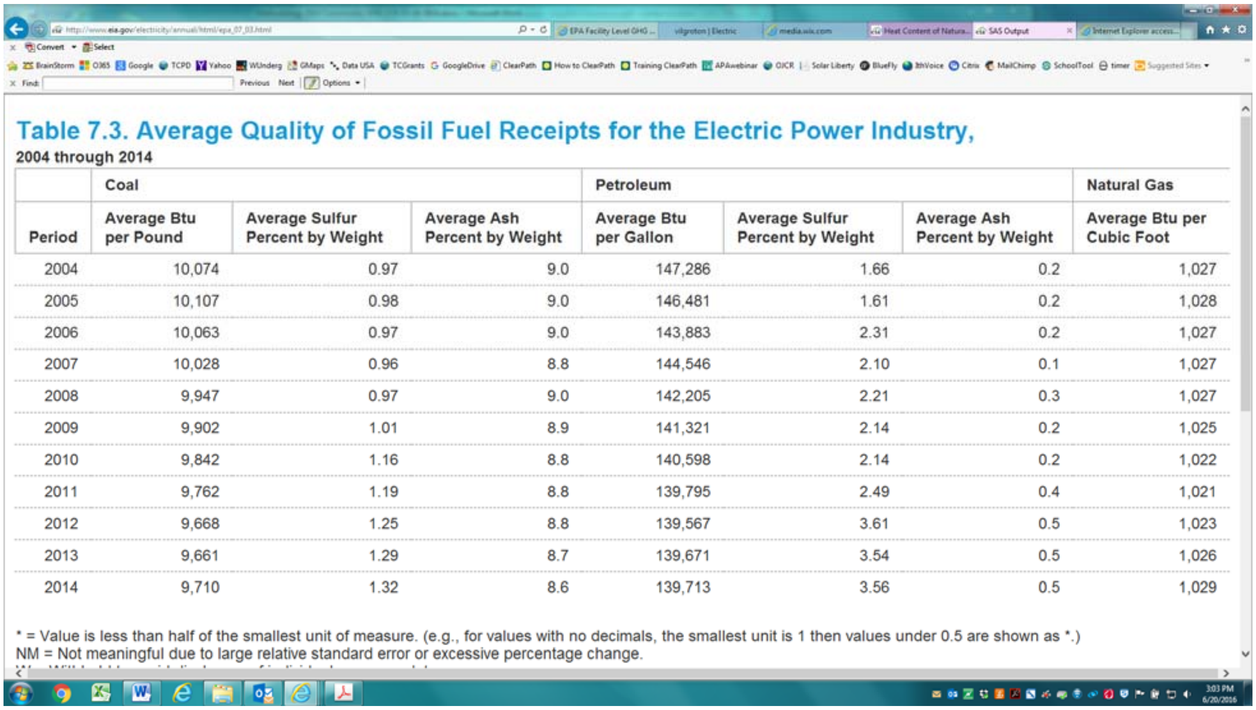


Table 7.3. Average Quality of Fossil Fuel Receipts for the Electric Power Industry,
2004 through 2014

	Coal			Petroleum			Natural Gas
Period	Average Btu per Pound	Average Sulfur Percent by Weight	Average Ash Percent by Weight	Average Btu per Gallon	Average Sulfur Percent by Weight	Average Ash Percent by Weight	Average Btu per Cubic Foot
2004	10,074	0.97	9.0	147,286	1.66	0.2	1,027
2005	10,107	0.98	9.0	146,481	1.61	0.2	1,028
2006	10,063	0.97	9.0	143,883	2.31	0.2	1,027
2007	10,028	0.96	8.8	144,546	2.10	0.1	1,027
2008	9,947	0.97	9.0	142,205	2.21	0.3	1,027
2009	9,902	1.01	8.9	141,321	2.14	0.2	1,025
2010	9,842	1.16	8.8	140,598	2.14	0.2	1,022
2011	9,762	1.19	8.8	139,795	2.49	0.4	1,021
2012	9,668	1.25	8.8	139,567	3.61	0.5	1,023
2013	9,661	1.29	8.7	139,671	3.54	0.5	1,026
2014	9,710	1.32	8.6	139,713	3.56	0.5	1,029

* = Value is less than half of the smallest unit of measure. (e.g., for values with no decimals, the smallest unit is 1 then values under 0.5 are shown as *.)
NM = Not meaningful due to large relative standard error or excessive percentage change.

Given the above factors and assumptions, calculations to get the energy input from natural gas and coal (MMBtu) for electricity generation are:

- Energy input from natural gas = 3,293,939 kWh*0.3 m^3/kWh*35.3147 cubic foot/m^3*1,031 Btu/cubit foot = 35,979 MMBtu
- Energy input from coal = 25,337,996 kWh*1%*0.44 kg/kWh*2.20462 lb/kg*9,710 Btu/lb = 2,387 MMBtu

ClearPath Output
After entering the energy input from natural gas and coal into ClearPath using the calculator "Emissions from Stationary Fuel Combustion at Energy Industries" under the Industrial section, the following MTCO2e were output.

Used the default emission factors of natural gas and coal.
Input Parameter: Energy End Use Type = Electricity Generation

Total 2014 Consumption	25,337,996	kWh	86,457	MMBtu
Fuel Sources (2013)			MMBtu Input*	CO2e (MT)
Hydro	76%	19,256,877		
Gas	13%	3,293,939	35,979	1,910
Nuclear	9%	2,280,420		
Coal	1%	253,380	2,387	227
Other Renewables	1%	253,380		
Total	100%	25,337,996		2,137

Additional Information from the Village of Groton's website: http://www.grotonny.org/#!electric/c51y.
"We are often asked what this charge is on your electric bill. The Village is billed each month for the kwh sold, demand, and wheeling and transmission charges (the cost of delivering power to the Village). The Village receives its power from two sources. The first source is hydroelectric power from the New York Power Authority's Niagara Project*, which is one of the lowest cost sources of power in the country. We have a maximum demand of 4,469 KW that we can receive from this source. If we exceed this demand, we have to purchase the balance (the second source, which we call incremental power) through a joint action agency that the Village participates with other municipal electric systems, the New York Municipal Power Agency. This source of power is three times more expensive than the hydropower. The Village usually exceeds the hydro demand during the months of November thru April.

Your base rate basically covers a portion of the cost of hydropower and all other costs that are needed to run the Dept., which is what we consider the base cost of power. Once we exceed this base cost, the remainder is billed through the PPA. This obviously is much greater during the months of November thru April, since we have to purchase power through the more expensive source.

In addition, the Village purchases special contracts, called TCC's, that mitigate excessive charges that the New York Independent System Operator can assess the Village when congestion in the grid occurs. These contracts are added as riders to the Purchase Power Adjustment."

9. Transportation

Conventional Gasoline and Diesel Vehicles

SUMMARY	
Input:	673,173,683 total vehicle miles traveled for 2014 641,021,143 miles (95% of total) attributable to passenger cars, motorcycles, and light trucks using gasoline 32,152,540 miles (5% of total) to medium-duty trucks, heavy-duty trucks, and transit and school buses using diesel
Output:	304,923 MTCO2e

Local governments may meet this requirement by reporting emissions associated with either: 1) Travel associated with origin and destination land uses in the community through a demand-based allocation of trips (preferred if available), or 2) Travel occurring within the jurisdictional boundary of the community. We chose to use input method 1.

Guidance from the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions
Appendix D: Transportation and Other Mobile Emission Activities and Sources, Version 1.1, July 2013: "The transportation sector comprises emissions associated with the movement of people and goods, as well as service vehicles. This movement may be by road, rail, air, or water. Combustion of fuel in vehicle engines produces CO2, N20, and CH4 emissions."

"Local government accounting for GHG emissions from passenger vehicles differs from state-level and national-level accounting because of the high proportion of cross-boundary travel, and the unique authority and influence local governments possess over transportation and land use. State and national methods are based on amount of fuel dispensed. This method does not serve local governments well as vehicles typically travel between multiple jurisdictions on a single tank of fuel and attributing emissions based on fueling locations would be both inaccurate and useless for local government emissions management purposes. "

"Likewise, methods based solely on the amount of vehicle travel within the community's geographic boundaries also produce inaccurate results. One reason is because of a high proportion of pass-through traffic in some communities, which occurs within the geographic boundaries, but the community cannot influence. An example is an interstate highway that passes through a small city. Another reason is that, for some communities a low proportion of vehicle miles from trips that terminate or originate in the community occur within the community's geographic boundaries."

"Local variations in vehicle fuel efficiency and fuel type may result in discrepancies between actual and estimated emissions for a community. Communities with a younger-than-average vehicle fleet may have a higher proportion of hybrid and high-mileage vehicles in their fleets than the regional, state, or national averages. These local variations should be accounted for in an integrated regional travel and emissions model, but this is not often the case. Adjustments based on known local data will improve the inventory's accuracy, but many communities do not have this data as state departments that manage the registration of motor vehicles do not produce it."

ClearPath Options and Choices
First a Factor Set was created titled “2014 Comm Transportation Factor Set”, described and shown below. This was applied to all of these entries below, except for aviation travel.

- *On Road Transportation*
  Available Calculation Methods: VMT and MPG; On-Road Factor; Fuel Use; and Direct Energy
  Two records were created using the VMT and MPG Calculation Method.
- *Emissions from Public Transit*
  One record was created for public transit.
- *Aviation Travel*
  Two records were created for aviation travel to reflect jet fuel and avgas. Methodology is described in the Commercial Air Travel section, below.
- *Rail Transportation*
  Freight rail travel was not included in this inventory because there is not good data on which to base the analysis.
- *Emissions from Off Road Vehicles*
  Off Road Vehicle travel was not included in this inventory because there is not good data on which to base the analysis. Options for equipment types are: ships and boats; locomotive; agricultural; construction; snowmobiles and recreational; small utility; large utility; and aircraft.
- *Water Transportation*
  Local sightseeing and recreational boating and ferry service was not included in this inventory because there is not good data on which to base the analysis.

Methodology and Data Sources
GHG emissions were calculated by ClearPath based on these inputs:
1) Type of fuel consumed by vehicle class
2) Annual vehicle miles travelled (VMT) by vehicle class
3) Average MPG and emission factors by vehicle class
4) Annual fuel consumption by vehicle class

1) Type of fuel consumed by vehicle class
It was assumed that the following vehicle classes used the fuel types shown. It was further assumed that alternative vehicles and fuels were not in widespread use in 2014. See below for more discussion of electric vehicles.

Vehicle Class	Fuel Type
Passenger Vehicles	Gasoline
Light Trucks	Gasoline
Motorcycles	Gasoline
Transit Buses	Diesel
Para-Transit Buses	Diesel
Medium Trucks	Diesel
Heavy Trucks	Diesel

Instead of considering individual vehicles, VMT was collected and an average fuel economy was assumed for each class of vehicle.

2) Annual VMT by vehicle class

The table below was provided by Tom Mank of the Ithaca-Tompkins Transportation Council (ITCTC) on June 21, 2016. The data are from the following sources:

a) **Estimated Passenger Vehicles and Light Trucks VMT** (note that these were really 2015 data, but were used as a proxy for 2014, since the figures were not updated for 2014): were derived by Tom running the TransCAD model (run in version 4.8, analyze in version 6.0). The "2014 Scenario" was used when running the model (i.e., 2014 "vehicles per household" and 2014 "employees" by Traffic Analysis Zone (TAZ)). The TransCAD model is PM Peak Hour (5-6PM) VMT for journey-to-work trips only (passenger vehicles and light trucks). The PM Peak hour VMT is extrapolated to a 24 Hour VMT, then to an annual VMT for passenger vehicles and light trucks only.

b) **Percent Passenger Vehicles and Percent Light Trucks:** The Estimated VMT for Passenger Vehicles and Light Trucks was then divided between the two by using NYSDOT Classification Count data, which included the percentage of vehicle classes based on periodic traffic counts conducted by the NYS DOT in Tompkins County. From an average of more than 200 Class Counts (2006-2014), 82.3% were determined to be "Autos" and 17.7% were determined to be "Pickups / Vans".

c) **Transit VMT:** Actual 2014 Transit bus (TCAT) VMT was provided to Tom by Matt Yarrow at TCAT on 6/18/2015.

d) **Para-Transit VMT:** Actual 2014 Para-Transit Bus (Gadabout) VMT was provided to Tom by Matt Yarrow at TCAT on 6/18/2015.

e) **School Bus VMT:** Actual School Bus VMT was provided to Tom by James Ellis at the Ithaca City School District in 2014.

f) **Medium and Heavy Truck VMT:** Medium and heavy truck VMT were manually added to the VMT total by Tom based on the NYSDOT Classification Count data, which included the percentage of vehicle classes based on periodic traffic counts conducted by the NYS DOT in Tompkins County (2006-2014 average).

   - Medium truck VMT was calculated to be 3.2% of total VMT by adding "Single-Unit 2-axle" (2.6%), "Single Unit 3-axle" (0.5%) and "Single-Unit 4-axle" (0.1%).
   - Heavy truck VMT was calculated to be 1.4% of total VMT by adding "Double-Unit 4 or less Axle" (0.5%), "Double-Unit 5-axle" (0.8%) and "Double Unit 6+-axle" (0.1%),"Multi-Unit 5 or less Axle" (0.0%), "Multi-Unit 6-axle" (0.0%) and "Multi-Unit 7+-axle" (0.0%).
   - The 3.2% Medium truck and the 1.3% Heavy Truck VMTs were added to the Estimated Passenger Vehicles and Light Trucks VMT calculated in (a) above by multiplying these percentages by the same Estimated Passenger Vehicles and Light Trucks VMT.

g) **Motorcycle VMT:** Motorcycle VMT was calculated by the Class Count data (i.e., 0.8% of the Estimated Passenger Vehicles and Light Trucks 2014 VMT) and manually added to the VMT total by Tom.

h) **Total VMT** from TransCAD Model: 522,953,623+(112,984,131-514,154) = 635,423,600

i) Inputs used for TransCAD: 1) Vehicles per Household (for origins) and 2) Employees (for destinations) for each TAZ are entered into TransCAD, which then generates an estimate of the number of trips and associated traffic volumes. (NOTE: The "Vehicles per Household" data comes from the US Census Bureau. The "Employees" data comes from the US Department of Labor). Those trips are then converted to annual VMT, which reflects residential commutes only. That is why medium-duty and heavy-duty trucks, as well as motorcycles, are added to the total VMT. Since the actual VMT of those 3 vehicle types is not known, they are estimated by applying the percentage of each vehicle type found in overall class counts by NYSDOT to the residential VMT output by the TransCAD model and added to the VMT estimates from the TransCAD model.

The class count percentages were applied to the total VMT to determine the VMT based on class count.

Fuel	Vehicle Class	Class Count, Percent of Total	2014 VMT based on class count
Gasoline	Passenger Vehicle	522,953,623	82.3% of TransCAD output
Gasoline	Motorcycle	5,083,389	0.8% of TransCAD output and then added to TransCAD output
Gasoline	Light Truck (incl Gadabout)	112,984,131	17.7% of TransCAD output + Actual Gadabout VMT (514,154)
	Subtotal	**641,021,143**	
Diesel	Transit and School Bus	2,923,054	Actual VMT
Diesel	Medium Truck	20,460,640	3.22% of TransCAD output and then added to TransCAD output
Diesel	Heavy Truck	8,768,846	1.38% of TransCAD output and then added to TransCAD output
	Subtotal	**32,152,540**	
	Total	**673,173,683**	

In the chart above, we assumed that Gadabout was not “transit” and put those miles into “light truck,” and that school buses were equivalent to Transit buses and put those miles into “transit”. In 2014, TCAT drove 1,698,819 miles, School Buses drove 1,224,235 miles and Gadabout drove 514,154 miles.

Caveats with these data: Tom said that it is not really valid to compare 2008 to 2014 VMT by class because class counts were not available in 2008. In the original 2008 GHG inventory, someone came up with a rough estimate on how many trucks were included in the total 2008 VMT and this resulted in far too many trucks being allocated in 2008. The 2014, this information is much more accurate because class counts are available. These class count percentages were applied to the Updated 2008 Inventory to make the inventories more comparable. Also, note that these are all really 2015 data, but are using them as a proxy for 2014 since the data was not updated in the interim. Also, in 2008 assumed that Gadabout mileage has stayed constant from 2008 to 2014, because Gadabout mileage was not included in the original 2008 VMT.

3) Average Fuel Economy (MPG) and emission factors by vehicle class

The Transportation Factor Set “2014 Comm Transportation Factor Set” from the ClearPath software was applied to the VMT by vehicle class figures. The factor set is shown below.

Name	2014 Comm Transportation Factor Set
Year	2014
Gas Passenger Vehicle Fuel Economy (MPG)	23.4
Gas Passenger Vehicle g CH4/mi	0.013
Gas PassengerVehicle g N2O/mi	0.012
Gas Light Truck Fuel Economy (MPG)	17.2
Gas Light Truck g CH4/mi	0.017
Gas Light Truck g N2O/mi	0.009
Gas Heavy Truck Fuel Economy (MPG)	6.8
Gas Heavy Truck g CH4/mi	0.004
Gas Heavy Truck g N2O/mi	0.005
Gas Transit Bus Fuel Economy (MPG)	7.2
Gas Transit Bus g CH4/mi	0.001
Gas Transit Bus g N2O/mi	0.002
Gas Para Transit Bus Fuel Economy (MPG)	7.2
Gas Para Transit Bus g CH4/mi	0.001
Gas Para Transit Bus g N2O/mi	0.002
Gas Motorcycle Fuel Economy (MPG)	43.5
Gas Motorcycle g CH4/mi	0.067
Gas Motorcycle g N2O/mi	0.007
Electric Vehicle Fuel Economy (MPGe)	0
Diesel Passenger Vehicle Fuel Economy (MPG)	23.4
Diesel Passenger Vehicle g CH4/mi	0.013
Diesel PassengerVehicle g N2O/mi	0.012
Diesel Light Truck Fuel Economy (MPG)	17.2
Diesel Light Truck g CH4/mi	0.017
Diesel Light Truck g N2O/mi	0.009
Diesel Heavy Truck Fuel Economy (MPG)	6.8
Diesel Heavy Truck g CH4/mi	0.004
Diesel Heavy Truck g N2O/mi	0.005
Diesel Transit Bus Fuel Economy (MPG)	7.2
Diesel Transit Bus g CH4/mi	0.001
Diesel Transit Bus g N2O/mi	0.002
Diesel Para Transit Bus Fuel Economy (MPG)	7.2
Diesel Para Transit Bus g CH4/mi	0.001
Diesel Para Transit Bus g N2O/mi	0.002
Diesel Motorcycle Fuel Economy (MPG)	43.5
Diesel Motorcycle g CH4/mi	0.067
Diesel Motorcycle g N2O/mi	0.007

In order to build the above Factor Set, the following was required.

a) The fuel economy data was obtained from the 2013 National Transportation Statistics - Average miles traveled per gallon (2013 statistics is the most recent data available)
http://www.rita.dot.gov/bts/publications

- Table 4-11 Light Duty Vehicle, Short Wheel Base and Motorcycle
- Table 4-12 Light Duty Vehicle, Long Wheel Base
- Table 4-13 Single-Unit 2-Axle 6-Tire or More Truck
- Table 4-14 Combination Truck
- Table 4-15 Bus

This information is shown below:

Table 4-11: Light Duty Vehicle, Short Wheel Base and Motorcycle Fuel Consumption and Travel						
	2008	2009	2010	2011	2012(R)	2013
Average miles traveled per gallon						
Light duty vehicles, short wheel base[a]	23.7	23.5	23.3	23.2	23.3	23.4
Motorcycles	42.5	43.2	43.4	43.5	43.5	43.5

Table 4-12: Light Duty Vehicle, Long Wheel Base Fuel Consumption and Travel						
	2008	2009	2010	2011	2012(R)	2013
Average miles traveled per gallon	17.3	17.3	17.2	17.1	17.1	17.2

Table 4-13: Single-Unit 2-Axle 6-Tire or More Truck Fuel Consumption and Travel[a]						
	2008	2009	2010	2011	(R) 2012	2013
Average miles traveled per gallon	7.4	7.4	7.3	7.3	7.3	7.3

Table 4-14: Combination Truck Fuel Consumption and Travel						
	2008	2009	2010	2011	2012(R)	2013
Average miles traveled per gallon	6.0	6.0	5.9	5.8	5.8	5.8

Table 4-15: Bus Fuel Consumption and Travel						
	2008	2009	2010	2011	2012(R)	2013
Average miles traveled per gallon	7.2	7.2	7.2	7.1	7.2	7.2

b) The emission factors for gCH4/mile and gN2O/mile were obtained from the most recent EPA publication available, titled, "Update of Methane and Nitrous Oxide Emission Factors for On-Highway Vehicles", November 2004 (Page 22, Table 28. "Recommended Emission Factors for On-Highway Vehicles" where values are given for Nitrous Oxide, N2O, and Methane, CH4, Emission Factors)
http://www3.epa.gov/otaq/models/ngm/420p04016.pdf

Factors were selected based on Low Emission Vehicles assuming the Federal Test Procedure (FTP). Low Emission Vehicles were selected because the factors were initially recommended in 2004 in the document and no updates have been released so far. It was assumed that vehicles today have reached this low emission level. And the FTP factors were selected instead of the IPCC ones because the former are more specific to the U.S. They were entered into ClearPath manually. No default values are available in ClearPath.

c) ClearPath does not have a classification of Medium Trucks, so data needed to be converted into the Heavy-duty truck category. This was done by creating a weighted average of Medium Trucks and Heavy Trucks, based on VMT data, to obtain average MPG of these two vehicle classes, as is shown below.
Weighted average MPG = 70.0% * 7.3 + 30.0% * 5.8 = 6.8

	MPG	VMT	% of the Total VMT
Medium Trucks	7.3	20,460,640	70.0%
Heavy Trucks	5.8	8,768,846	30.0%
Total	NA	29,229,486	100.0%

d) CH4 and N2O emission factors of Heavy Trucks were used for the combination of Medium and Heavy Trucks, because the EPA publication above does not give the emission factors for Medium Trucks.

In summary, the factor inputs are:

	Factor Set		
	MPG	g CH4/mile	g N2O/mile
Gasoline Passenger Vehicles	23.4	0.013	0.012
Gasoline Light Trucks (incl para-transit buses)	17.2	0.017	0.009
Gaoline Motorcycle	43.5	0.067	0.007
Subtotal			
Diesel Medium Truck**	6.8	0.004	0.005
Diesel Heavy Trucks			
Subtotal			
Diesel Transit Buses	7.2	0.001	0.002

4) Annual fuel consumption by vehicle class

In order to obtain the annual fuel consumption by vehicle class (in U.S. gallons), we divided the VMT for that class of vehicles by miles per gallon for that class of vehicles (i.e., fuel economy of the vehicle).

For example, for passenger vehicles, that calculation is: 522,953,623 VMT ÷ 23.4 miles/gallon = 22,348,445 gallons of gasoline consumed over 2014.

Emissions Calculations – ClearPath Software

The ClearPath calculator “Emissions from Public Transit” was used for diesel transit buses and “On Road Transportation” was used for the rest vehicle classes.

- **On Road Transportation**

  Calculation method “VMT & MPG” was used. The calculation should be made for gasoline and diesel vehicles separately. The VMT input is the total of all vehicle classes for both calculations, and the percentages are from the total VMT, including the additional VMT for motorcycles and medium-duty and heavy-duty trucks, as shown in the ClearPath Output table below. For example, 522,953,623 miles for Passenger Vehicles ÷ 673,173,683 total VMT = 77.7% of the overall total. All the percentages of total by vehicle class are shown in the ClearPath Output table below.

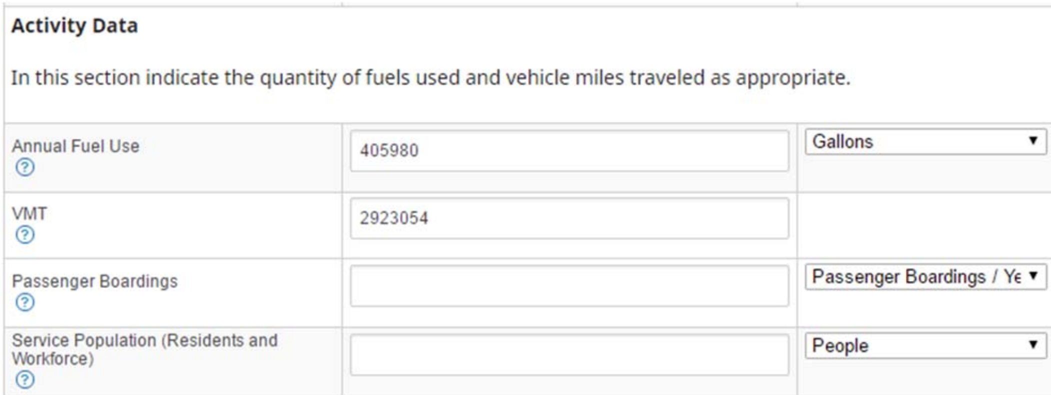
Input Data

Use the following fields to complete the record

VMT	673173683	Annual VMT
Percent Motorcycles	0.8	%
Percent Passenger Vehicles	77.7	%
Percent Light Trucks	16.8	%
Percent Heavy Tucks		%
Population		People

- **Emissions from Public Transit**

For this calculator, annual fuel use instead of vehicle class percentage is needed as input.



Activity Data

In this section indicate the quantity of fuels used and vehicle miles traveled as appropriate.

Annual Fuel Use	405980	Gallons
VMT	2923054	
Passenger Boardings		Passenger Boardings / Ye
Service Population (Residents and Workforce)		People

ClearPath Output

After entering VMT and Annual Fuel Consumption by Vehicle Class into ClearPath, the following MMBtu and MTCO2e were output.

Input parameters for ClearPath: VMT Location = In-Boundary; Travel Type = Assume it is Passenger for gasoline vehicles and transit buses, and Freight for diesel trucks.

	Input					Output	
	Travel Type ("P" for Passenger, "F" for Freight)	VMT	%	Diesel US Gal	Gasoline US Gal	MMBtu	CO2e tonnes
Gasoline Passenger Vehicles	P	522,953,623	77.7%	0	22,348,445		
Gasoline Light Trucks (incl para-transit buses)	P	112,984,131	16.8%	0	6,568,845		
Gaoline Motorcycle	P	5,083,389	0.8%	0	116,860		
Subtotal		**641,021,143**	**95.2%**	**0**	**29,034,150**	**3,631,500**	**257,272**
Diesel Medium Truck**	F	20,460,640	70.0%	2,986,955	0		
Diesel Heavy Trucks		8,768,846	30.0%	1,280,124	0		
Subtotal		**29,229,486**	**4.3%**	**4,267,078**	**0**	**587,848**	**43,504**
Diesel Transit Buses	P	2,923,054	0.4%	405,980	0	56,064	4,147
Totals	**NA**	**673,173,683**	**100.0%**	**4,673,058**	**29,034,150**	**4,275,412**	**304,923**

*Assume that all passenger vehicles are short wheel light duty and all light trucks are long wheel
http://www.randstatestats.org/stats/transportation/us_vehicles.php

** Medium trucks are counted as heavy trucks in ClearPath. An weighted average MPG of the two vehicle classes based on VMT is used and CH4/N2O emissions factors of heavy trucks are used.

Electric Vehicles

SUMMARY

Input: 136 registered EVs as of December 31, 2015

Output: N/A

Both plug-in hybrid electric vehicles (PHEVs) and battery electric vehicles (BEVs) displace petroleum fuel by charging their batteries from the electrical grid. BEVs typically have a larger battery pack for more electric miles (~60-200), but have no option when the battery is depleted. PHEVs have a less electric range (~10-50), but also have a small gasoline engine that can power the vehicle or generate electricity if needed. For the purposes of this report, BEVs and PHEVs are both considered EVs, except where necessary to differentiate.

While not included in the energy flow or GHG emissions at this point, however, we are beginning to track the number of plug-in hybrids and battery electric vehicles. Since this is a new item to track, several data sources are listed below, so that they may be compared over time to determine whether one source is better than another for ongoing tracking. As EVs grow in use, buses and vehicles powered by electricity should include an analysis of the indirect emissions from electricity generation.

Data & Sources

a. According to the Electric Vehicle Infrastructure Plan in Tompkins County: Existing Conditions and Best Practices, as of December 31, 2015, there were 136 Registered EVs in the County. EV ownership was determined through an analysis of NYS department of motor vehicles (DMV) data available at https://data.ny.gov/Transportation/Vehicle-Snowmobile-and-Boat-Registrations/w4pv-hbkt which lists all vehicle, snowmobile, and boat registrations. EV models must be identified by the first eight values in the vehicle identification number (VIN) which were obtained from existing lists compiled by the California Air Resources Board and other sources because the DMV data does not list a vehicle model and the fuel type designation is not accurate.

b. According to the New York Power Authority, as of December 31, 2015, there were 42 battery electric vehicles and 89 plug-in hybrid vehicles registered in Tompkins County, for a total of 131 EVs. http://www.nyserda.ny.gov/Cleantech-and-Innovation/Electric-Vehicles/Tools/Electric-Vehicle-Registration-Map

c. According to Data.ny.gov, as of August 1, 2106, the number of electric vehicles registered in Tompkins County is 72. https://data.ny.gov/Transportation/Electric-Vehicles-per-County/uu25-czyc#column-menu

10. Air Travel

SUMMARY

Input: 1,241,929 gallons of jet fuel pumped in 2014
32,820 gallons of avgas pumped in 2014

Output: 12,172 MTCO2e

Methodology, Data & Sources (New, updated in compliance with ICLEI protocol)

GHG emissions were calculated by ClearPath based on these inputs:

1) Amount of jet fuel pumped into airplanes in 2014
2) Amount of avgas (aviation gasoline) pumped into airplanes in 2014

Input 1: Amount of jet fuel pumped into airplanes in 2014

Total amount: 1,241,929 gallons

Input 2: Amount of avgas pumped into airplanes in 2014
Total amount: 32,820 gallons
Data from personal communication with Roxan Noble from the Ithaca Tompkins Regional Airport. She obtained the data from Erik Balcome, VP Fixed Base Operator at the Taughannock Aviation Corp. Taughannock Aviation Corp. manages fuel use of aircrafts at the Airport.

Note: Airline (scheduled carriers) fuel use in Ithaca is jet fuel only. JetA is the same as Jet Fuel. Basically, aircraft with turbine or fanjet engines use Jet Fuel. Avgas is used in piston (reciprocating engine) type aircraft. The rule is that one never puts avgas in a turbine engine and vice-versa. The term private vs. commercial has nothing to do with the type of fuel consumed; it is the model of aircraft which necessitates the choice of fuel product.

Emissions Calculations – ClearPath Software
ClearPath Output
After entering the above information into ClearPath, under the "Aviation Travel" section of the "Transportation and Mobile Sources" Sector, ClearPath calculated the following MMBtu and MTCO2e. Input was: Aviation Type = Between Jurisdictions; Flight Type = Domestic Passenger; Local Attribution = 100%

Fuel Type	Annual Consumption (U.S. Gallon)	MMBtu	CO2e (MT)
Jet Fuel	1,241,929	149,031	11,898
Aviation Gasoline	32,820	3,938	274
Total	**1,274,749**	**152,969**	**12,172**

11. Solid Waste

SUMMARY
Input: 39,534 short tons of Municipal Solid Waste (MSW) and Bio-solids were disposed of in landfills in 2014. 100% of those were sent to landfills that have methane collection.

Output: 15,114 MTCO2e

Guidance from the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions
Appendix E: Solid Waste Emission Activities and Sources, Version 1.1: "Greenhouse gas (GHG) emissions result from management of solid waste of all types and from the natural decay of solid waste with biologic constituents. GHG emissions from the management of solid wastes include those from combustion of fossil and/or biologic fuel in equipment used to transport and process the waste, and, in the case of incinerator and waste-to-energy (WTE) technologies, emissions from combusting the solid waste itself."

"This protocol is intended to cover emissions from the disposal of solid waste within a community, as well as emissions from waste that is generated by a community. This includes emissions from both landfills and waste combustion facilities. Depending on the location of facilities, there may be some overlap between emissions from community-generated waste and emissions from waste facilities within the community. Any given community might host or send waste to more than one facility or a mix of landfills and waste combustion facilities, so the applicable parts of the protocol will depend on the user."

"Because of the lack of widely accepted and standardized data and guidance, the Protocol does not include standardized methodologies to estimate fugitive emissions from composting."

ClearPath Options and Choices

Waste Generation

Two records were created for community-generated waste sent to landfills with methane collection, one factor set was developed to reflect that 100% municipal solid waste was disposed, and another was developed to reflect that bio-solid waste was disposed.

Emissions from In-Jurisdiction Landfills

There are two closed and capped landfills located at least partially within the jurisdiction of Tompkins County. The Hillview Road Landfill accepted municipal solid waste until 1992, however the bulk of the capped landfill, as well as the former transfer station, is located in Tioga County. The Caswell Road Landfill is wholly located in Tompkins County and was capped in 1985. At this time, there are no data collected on the amount of methane emitted from either landfill, which is the input necessary for ClearPath to compute CO_2e emissions from the in-jurisdiction landfill sources, and online methane estimators for capped landfills require data inputs that we do not have. Neither of the landfills had methane collection system in place by 2014 (http://www.dec.ny.gov/chemical/48873.html). Therefore, emissions from in –jurisdiction landfills are not included in the inventory.

Emissions from Collection and Transportation

These emissions were not included because they are already included in the heavy-duty truck figures in the transportation section.

Emissions from Processes Associated with Landfilling

Process emissions come from CO_2 emissions associated with powering the equipment necessary to manage the landfill (ICLEI U.S. Community Protocol). These emissions were not included because they are already included in the, electricity, natural gas, fuel oil and/or propane figures in the commercial section.

Emissions from Combustion of Solid Waste Generated by the Community

These emissions were not included because none of the community-generated wastes were sent to combustion facilities in 2014.

Emissions from Biologic Treatment of Solid Waste (Composting)

These emissions were not included because none of the community-generated wastes were sent to anaerobic digester gas facilities in 2014. Composting conducted by households, however, is possible but the quantity of waste composted was not tracked.

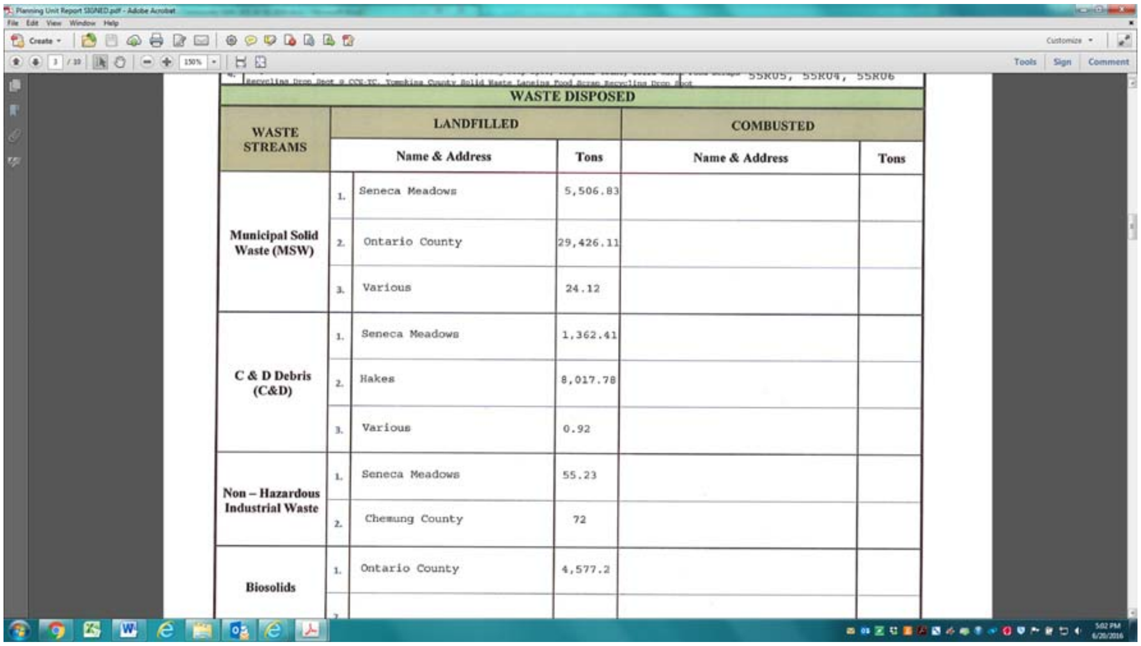
Methodology and Data Sources

GHG emissions were calculated by ClearPath based on these inputs:

1) Amount of waste disposed of in landfills
2) Whether or not methane collection systems are in place at the landfills where the waste is disposed
3) Composition of the disposed waste and a determination of whether those wastes would contribute much methane when landfilled

1) Amount of waste disposed of in landfills

The 2014 Planning Unit Recycling Report was provided by Barbara Eckstrom, Manager of the Solid Waste Division. The total amount may be summed from the following table from the report, or may be calculated by: Total waste generated within the County minus Recycled waste. 149,756-100,713 = 49,043 short tons.



WASTE DISPOSED					
WASTE STREAMS	LANDFILLED			COMBUSTED	
		Name & Address	Tons	Name & Address	Tons
Municipal Solid Waste (MSW)	1.	Seneca Meadows	5,506.83		
	2.	Ontario County	29,426.11		
	3.	Various	24.12		
C & D Debris (C&D)	1.	Seneca Meadows	1,362.41		
	2.	Hakes	8,017.78		
	3.	Various	0.92		
Non – Hazardous Industrial Waste	1.	Seneca Meadows	55.23		
	2.	Chemung County	72		
Biosolids	1.	Ontario County	4,577.2		
	2.				

	Short Tons
2014 Total Waste	149,756
2014 Recycled Waste	100,713
2014 Disposed of Waste in Landfills	49,043

2) Whether or not methane collection systems are in place at the landfills where the waste is disposed

The 2014 Planning Unit Recycling Report specifies four landfill destinations for disposed waste generated in the Tompkins County: Seneca Meadows, Ontario County, Hakes, and Chemung County.

The Seneca Meadows website states that landfill gas recovery to energy has been in place since 1995. http://www.senecameadows.com/facilities_energy.php

The Ontario County Landfill and Hakes Landfill are both managed by the Casella Waste Systems, Inc. The Casella Waste Systems Annual Report states that by 2014, six of their landfills have gas-to-energy facilities in place. The Ontario County Landfill is one of the six, but the Hakes Landfill is not. http://files.shareholder.com/downloads/CWST/0x0x777271/CDABB3A5-96D9-46BD-9DEE-0C624983C5F6/2014_Annual_Report.pdf

About 72 tons of non-hazardous industrial waste was sent to the Chemung County Landfill. Another 24.12 tons of municipal solid waste and 0.92 tons of C &D debris were sent to unspecified destinations. Whether these landfills have gas recovery systems is unknown. It was assumed that they did not have methane collection systems in place by 2014.

The table below summarizes that waste streams and the landfills they were sent to in 2014. Only the Ontario County Landfill and Seneca Meadows Landfill have methane collection systems.

	Chemung County	Hakes	Ontario County	Seneca Meadows	Various	Total
Bio-solids			4,577.20			**4,577.20**
C&D Debris (C&D)		*8,017.78*		*1,362.41*	*0.92*	*9,381.11*
Municipal Solid Waste (MSW)			29,426.11	5,506.83	24.12	**34,957.06**
Non-Hazardous Industrial Waste	*72.00*			*55.23*		*127.23*
Total	**72.00**	**8,017.78**	**34,003.31**	**6,924.47**	**25.04**	**49,042.60**

3) Composition of the disposed waste and a determination of whether those wastes would contribute much methane when landfilled

The waste streams identified in the 2014 Planning Unit Recycling Report, as may be seen above, are only broken-down into Municipal Solid Waste, C & D Debris, Non-Hazardous Industrial Waste, and Bio-solids. After discussion with ICLEI staff, it was determined that C&D Debris and Non-Hazardous Industrial Waste generally contribute little to methane produced at landfills, so may be ignored for this reporting. Almost all Bio-solids and MSW were sent to the Ontario County Landfill and Seneca Meadows Landfill, where there were methane collection systems in place.

Bio-solids are not offered as a category in ClearPath, so assumptions were made regarding the make-up of this category, as follows:

Report	ClearPath
Bio-solids	70% of tonnage assigned to "Food Scraps", 30% of tonnage assigned equally to "Grass", "Leaves", and "Branches"

In ClearPath, input the total amount of MSW waste sent to the Ontario County Landfill and Seneca Meadows Landfill (and also included the 24.12 tons sent to "various" since it was so small), so 29,426.11+5,506.83+24.12=34,957.06 tons. Then input the total amount of Bio-solids sent to the Ontario County Landfill (4,577.20 tons). All inputs are shown in the table below:

a.	Mixed Municipal Solid Waste (MSW)	34,957.06	**100.0%**
b.	Food Scraps	3,204.04	70.00%
	Grass	457.72	10.00%
	Leaves	457.72	10.00%
	Branches	457.72	10.00%
	Total	**4,577.20**	**100.0%**

And a screenshot from ClearPath Factor Sets:

Name	2014 Waste Estimation-With Methane Collection MSW
Year	2014
Percentage Mixed MSW	100
Percentage Newspaper	
Percentage Office Paper	
Percentage Corrugated Cardboard	
Percentage Magazines / Third Class Mail	
Percentage Food Scraps	
Percentage Grass	
Percentage Leaves	
Percentage Branches	
Percentage Dimensional Lumber	

Name	2014 Waste Estimation-With Methane Collection Biosolid
Year	2014
Percentage Mixed MSW	
Percentage Newspaper	
Percentage Office Paper	
Percentage Corrugated Cardboard	
Percentage Magazines / Third Class Mail	
Percentage Food Scraps	70
Percentage Grass	10
Percentage Leaves	10
Percentage Branches	10
Percentage Dimensional Lumber	

Emissions Calculations – ClearPath Software
Input parameters: Disposal Location = Outside the Jurisdiction

ClearPath calculates the $MTCO_2e$ emissions from the sector given the above information.

12. Agricultural Livestock

SUMMARY
Input: 19,797 cattle and calves; 1,904 sheep and lambs; 750 hogs and pigs; 520 goats; and 2,430 horses
2,379 CH4 emissions

Output: 66,612 MTCO2e

Guidance from the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions
Appendix G: Agricultural Livestock Emission Activities and Sources, Version 1.1: "Agricultural livestock activities can be a significant source of greenhouse gas emissions for some communities. Many different types of livestock activities can produce emissions. This Protocol addresses agricultural livestock emission sources for which there are well-established quantification methods and for which mitigation measures are available to reduce emissions. Quantification methods and emission factors were taken from the US EPA."

"This Protocol does not address the potential clean energy benefits of anaerobic digestion (e.g., combustion of captured biogas methane in a gas-to-energy facility). GHG inventories are intended to take stock of all emissions that are occurring, even if the process produces additional climate protection benefits in the form of non-fossil fuel energy production. For anaerobic digestion, emissions generation from biogas combustion takes the form of non-combusted methane. Emissions reductions associated with anaerobic digestion should be accounted for elsewhere, such as in your climate action plan or other GHG mitigation initiatives."

"Other agricultural processes that produce greenhouse gas emissions not covered here include N2O emissions related to soil management practices and CH4 emissions from the cultivation of rice in submerged fields. In addition to agricultural practices not covered in this Protocol, a number of other land-use related sources of emissions are also not covered. Emissions from land conversion, forestry and other similar processes again are not covered."

ClearPath Options and Choices
Emissions from Agricultural Activities
Agricultural Process: Enteric Fermentation was used and input of CH4 Emissions from Agriculture was used to generate output. The method used to obtain that CH4 input is described below.

Emissions from Agricultural Activities
Agricultural Process: Fertilizer Application; Manure Treatment and Handling; Land Conversion; and Other were not used because the data is poor and there are limitations on methodology at this time.

Emissions from Stationary Fuel Combustion and *Emissions from Grid Electricity*
These emissions were not included here, but were included in the Commercial Sector.

Methodology and Data Sources
1) Total number of methane-emitting livestock by type in the County
2) CH4 emission factor of each type of ruminant animal

This inventory focused on "Emissions from agricultural activities", in the form of CH_4 emissions from enteric fermentation from livestock. Ruminating mammals include cattle, goats and sheep, which make up about 95% of the total population of domestic ruminants in the United States. The animals included in this analysis are all livestock that have CH4 emission factors from the EPA source below. Although pigs and horses are not ruminant animals, they also emit CH4. And although deer are ruminant animals, they are not a type of livestock, so the CH4 they emit are not included in this sector.

For each type of livestock, there is a generic CH_4 emission factor in kg CH_4/head/year. Given the count of this type of livestock, its annual CH_4 emission can be estimated. Total CH_4 emissions from enteric fermentation include the emissions from all types of livestock living within the County.

ClearPath converts the CH_4 emissions to CO_2e emissions.

1) Total number of methane-emitting livestock by type in the County
Types and number of Livestock
a. USDA 2012 (most recent data) Census of Agriculture, County Level Data
http://www.agcensus.usda.gov/Publications/2012/Full_Report/Volume_1,_Chapter_2_County_Level/New_York/

Other	number	276	159	53
Principal operator by days worked off farm:				
Any	number	348	261	75
200 days or more	number	206	147	42
Livestock and poultry:				
Cattle and calves inventory	farms	148	105	8
	number	19,797	4,213	136
Beef cows	farms	77	80	5
	number	1,133	1,350	(D)
Milk cows	farms	62	10	1
	number	9,085	399	(D)
Cattle and calves sold	farms	123	62	4
	number	7,733	940	13
Hogs and pigs inventory	farms	28	37	6
	number	750	342	17
Hogs and pigs sold	farms	18	33	4
	number	1,416	803	15
Sheep and lambs inventory	farms	40	42	8
	number	1,904	488	242
Layers inventory (see text)	farms	103	106	17
	number	2,846	5,623	1,556
Broilers and other meat-type chickens sold	farms	22	11	3
	number	1,737	1,716	620
Selected crops harvested:				
Corn for grain	farms	76	21	2
	acres	8,232	1,392	(D)

For Example: Cattle and Calves Inventory. Note this includes the inventory of beef cows and milk cows.

Table 11. **Cattle and Calves – Inventory and Sales:**

[For meaning of abbreviations and symbols, see introductory text.]

Item		Tompkins
INVENTORY		
Cattle and calves	farms, 2012	148
	2007	181
	number, 2012	19,797
	2007	23,639
Farms by inventory:		
1 to 9	farms, 2012	29
	2007	46
	number, 2012	120
	2007	227

The

2. CH4 Emission Factors for each type of ruminant animal

EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2014, Annex 3 Methodology Descriptions for Additional Source or Sink Categories Section 3.10. Table A-196 on page A-256 and Table A-198 on page A-257 http://www3.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2015-Annex-3-Additional-Source-or-Sink-Categories.pdf

Given the number of ruminant animals by type in the County and their CH4 emission factors, the total metric tons of CH4 emission within the County over 2014 can be computed outside of the ClearPath System.

The emission cannot be obtained by ClearPath directly because its major input is annual CH_4 emission from the Agriculture sector. ClearPath does not have the option for other inputs to calculate the CH_4 emissions first.

ClearPath Output
Input parameters: Agricultural Process = Enteric Fermentation

After entering the total MT of CH4 emission into ClearPath, the following MTCO2e were output.

Livestock	Number	CH4 Emission Factor (kg CH4/head/year)	MT of CH4	
Cattle and calves	19,797	117	2,316	
Sheep and lambs	1,904	8	15	
Hogs and pigs	750	1.5	1	
Goats	520	5	3	
Horses	2,430	18	44	CO2e Emissions (MT)
			2,379	66,612

13. Power Generation at Cayuga Power Plant (formerly AES Cayuga)

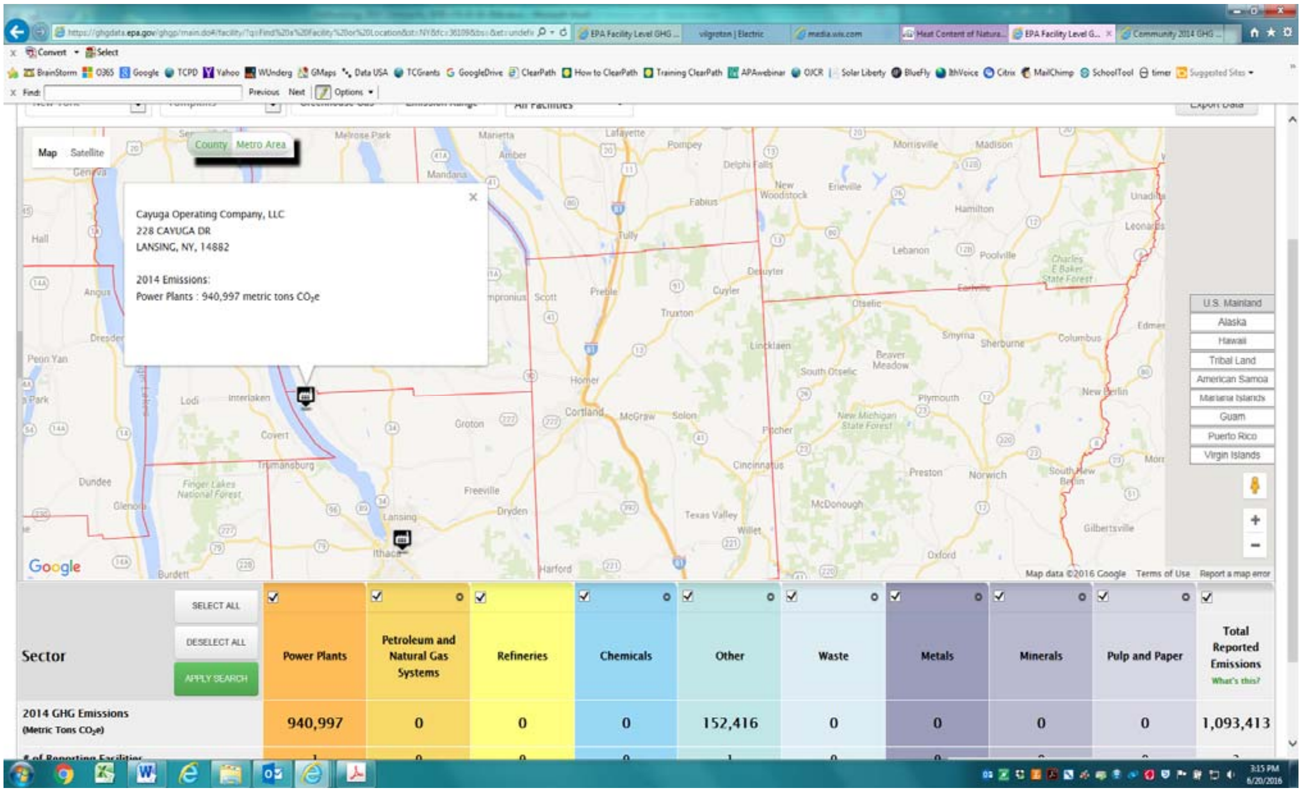
SUMMARY
Input: 0.916 GWh electricity produced for 2014

Output: 940,998 MTCO2e

Methodology, Data & Sources
2014 power generation: 0.916 GWh
2014 GHG emissions: 940,997 MTCO2e
Name Plate Rating**:** 306 MW

Above Input and Output were provided through personal communication from Jerry Goodenough on July 21, 2016. He also stated that the primary reason for less emissions is the plant is running less due to the very low pricing for natural gas. Natural gas generators usually set the market price for electricity and the whole sale market has cleared at historic lows the last few months and had been trending that way for a couple years.

CHECK: The information can also be obtained from EPA Greenhouse Gas Emissions from Large Facilities (https://ghgdata.epa.gov/ghgp/main.do). The CO_2e emission from Cayuga Power Plant in 2014 as recorded by the database is 940,997 MTCO2e, which is consistent with the number provided by Jerry Goodenough.



14. Potable Water and Wastewater Treatment and Distribution

SUMMARY

Input: Included in Commercial kWh and therms consumed.

Output: None

All of the water and wastewater treatment facilities serving the community are located within the community, and their energy use is included in totals for commercial energy. Emissions not included in this inventory are those associated with: 1) combustion of digester gas; 2) biosolids and sludges; 3) process emissions from wastewater treatment lagoons; and 4) fugitive emissions from septic systems. Aspects 1-3 are being tracked and addressed by the City and Town of Ithaca in their GHG emissions inventories and local action plans. At this time, there is not accurate enough information for aspect #4 to warrant including it for the first time in the community GHG emissions reporting.

From the 2015 Tompkins County Comprehensive Plan:

Drinking Water Supplies

There are seven municipal water supply and treatment facilities serving twelve municipalities. Six of these facilities are owned and operated by individual municipal entities. Of these six municipalities three supply water to users outside of their municipal boundaries. The sixth water supply and treatment facility is the Southern Cayuga Lake Intermunicipal Water Commission (Bolton Point), which is owned and operated by five member-municipalities. Groundwater is the source of drinking water for approximately 45 percent of county residents.

Wastewater Disposal
There are seven municipal wastewater treatment facilities that serve eleven municipalities. Six of these facilities are owned and operated by individual municipalities. Of these six municipalities three treat wastewater from users outside of their municipal boundaries. The seventh wastewater treatment facility is the Ithaca Area Wastewater Treatment Facility (IAWWTF), which is owned and operated by three municipalities. While many residences and businesses in Tompkins County are connected to sewer systems and large centralized wastewater treatment plants, a significant number are served by onsite wastewater treatment systems (septic systems).

15. Heating and Cooling Degree Days

Obtained the Heating and Cooling Degree Days from Scott Bochenek at NYSEG. Looking at Heating Degree Days (HDD) and Cooling Degree Days (CDD) for 2008 and 2014 shows that the winter was colder in 2014 than 2008, so the expectation would be more consumption of fuels to heat homes and businesses, and the summer was cooler, so would expect less electricity consumption for air conditioning in 2014 than 2008.

HDD is the number of degrees that a day's average temperature is below 65^{o}Fahrenheit (18^{o} Celsius), the temperature below which buildings need to be heated. CDD is the number of degrees that a day's average temperature is above 65^{o} Fahrenheit and people start to use air conditioning to cool their buildings.

	HDD	CDD
2008	6975	387
2009	7031	272
2010	6641	622
2011	6615	526
2012	6202	543
2013	7106	479
2014	7403	342
2015	6954	445

16. Applying Latest Climate Science on Shale Gas to Results

Obtained guidance in May 2016 from Dr. Robert Howarth, Cornell University, on the methodology to use in making these calculations, based on his most recent scholarly articles on the topic.

Example Using 100 g CO2 Emitted as Gas is Burned and Mid-range Overall Leakage Rate of 12% (Confidence Range 5-19%)

Assumed all natural gas burned for heating and electricity production in 2014 came from shale gas

Considered the methane leakage during the full life-cycle from well to delivery to consumers, and is based on analysis of recent satellite data.

This analysis is based on 100g CO_2 emitted as gas is burned.

The molar mass of methane is 16 g/mol.
The molar mass of carbon dioxide is 44 g/mol.

Convert 100g CO_2 emitted to mass of methane, (100/44)*16 = 36.4 g CH_4 (amount that is burned)

Given the 12% leakage rate, that means that 88% of total production is burned and 12% is leaked into the atmosphere. Therefore, to burn 36.4 g CH_4, 41.3 g CH_4 must be produced, with 4.9 g CH_4 emitted unburned, as calculated below:

Methane Produced: (36.4/0.88) = 41.3g
Unburned Methane Leaked: (41.3-36.4) = 4.9g

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO_2e: 4.9*86 = 421g CO_2e

Emissions from Natural Gas Consumed

Step 1: Determine CO_2 emissions from natural gas consumed in community
Sum emissions figures from residential, commercial and industrial NYSEG natural gas meters, as well as the amount of natural gas used by Cornell at its CEP plant (94,535+101,430+17,573+84,031 = 297,569 MTCO2e).

Step 2: Apply the Example Methodology above to these emissions from natural gas
Convert 297,569 metric tons CO_2 emitted to mass of methane, (297,569/44)*16 = 108,207 metric tons CH_4 (amount that is burned)

Given the 12% leakage rate, that means that 88% of total production is burned and 12% is leaked into the atmosphere. Therefore, to burn 108,207 metric tons CH_4, 122,962 metric tons CH_4 must be produced, with 14,755 metric tons CH_4 emitted unburned, as calculated below:

Methane Produced: (108,207/0.88) = 122,962 metric tons CH_4
Unburned Methane Leaked: (122,962-108,207) = 14,755 metric tons CH_4

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO_2e: 14,755*86 = 1,268,972 metric tons CO_2e

Emissions from Electricity Consumed: Portion from Natural Gas Generation

A. Grid Electricity

Step 1: Estimate the amount of natural gas that is used to generate electricity from the grid

Grid electricity includes the power that Cornell purchases. The fuel mix that generated grid electricity in 2014 is reported in the eGRID 2012 Upstate New York.

To determine the amount of natural gas used to generate electricity, it is first necessary to calculate the energy embodied in the fuel mix of Upstate NY and allocate that based on the percentage of each fuel source.

As may be seen in Table 1 of the GHG Inventory, total energy in grid electricity in 2014 was 2,937,298 MMBtu. (To calculate this figure, MMBtus for NYSEG residential, commercial and industrial electric meters and Cornell electric purchases were summed). Contribution from each of the energy sources is broken down as shown in the table below. For example, apply 30.4% from natural gas to 2,937,298 MMBtu to yield 892,939 MMBtu contributed from natural gas.

Fuel Mix of Upstate New York eGRID 2012	**%**	**MMBtu**
Gas	30.4	892,939
Hydro	29.2	857,691
Nuclear	28.9	848,879
Coal	5.5	161,551
Wind	3.6	105,743
Biomass	1.8	52,871
Other Fossil	0.4	11,749
Oil	0.2	5,875
Solar	0	0
Geothermal	0	0
Other Unknown/Purchased Fuel	0	0

Using CarbonSolutions online conversion calculator (http://www.carbonsolutions.com/calculator.html), 892,939 MMBtu of natural gas consumed yields 47,142 MTCO2e (which is really CO_2 for the combustion of methane).

Note that these same calculations could be done for coal, oil and other fossil fuels, but they are a relatively small part of the electricity generation mix.

Step 2: Apply the Example Methodology above to these emissions from natural gas
Convert 47,142 metric tons CO_2 emitted to mass of methane, (47,142/44)*16 = 17,143 metric tons CH_4 (amount that is burned)

Given the 12% leakage rate, that means that 88% of total production is burned and 12% is leaked into the atmosphere. Therefore, to burn 17,143 metric tons CH_4, 19,480 metric tons CH_4 must be produced, with 2,338 metric tons CH_4 emitted unburned, as calculated below:

Methane Produced: (17,143/0.88) = 19,480 metric tons CH_4
Unburned Methane Leaked: (19,480-17,143) = 2,338 metric tons CH_4

Using 20-yr GWP from IPCC (2013) of 86

Converting the unburned emitted methane to CO2e: 2,338*86 = 201,035 metric tons CO2e

B. Electricity Purchased by the Village of Groton

Step 1: Estimate the amount of natural gas that is used to generate electricity for Groton

Energy in Groton electricity in 2014 was 86,457 MMBtu. Contribution from each of the energy sources is broken down as in the table below.

Fuel Mix	%	MMBtu
Hydro	76%	65,707
Gas	13%	11,239
Nuclear	9%	7,781
Coal	1%	865
Other Renewables	1%	865

Using CarbonSolutions.com online conversion calculator, 11,239 MMBtu yields 593 MTCO2e (which is really CO2 for the combustion of methane).

Note that these same calculations could be done for coal, but it is a relatively small part of the electricity generation mix.

Step 2: Apply the Example Methodology above to these emissions from natural gas
Convert 411 metric tons CO2 emitted to mass of methane, (593/44)*16 = 216 metric tons CH4 (amount that is burned)

Given the 12% leakage rate, that means that 88% of total production is burned and 12% is leaked into the atmosphere. Therefore, to burn 216 metric tons CH4, 245 metric tons CH4 must be produced, with 29 metric tons CH4 emitted unburned, as calculated below:

Methane Produced: (216/0.88) = 245metric tons CH4
Unburned Methane Leaked: (245-216) = 29 metric tons CH4

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO2e: 29*86 = 2,529 metric tons CO2e

C. Electricity generated by Cornell CEP

Step 1: Estimate the amount of natural gas that is used to generate electricity for Cornell
Cornell uses natural gas to generate electricity. Emission from the electricity generated by Cornell CEP (including power export) is 50,314 MTCO2e.

TO DO
Step 2: Apply the Example Methodology above to these emissions from natural gas
Convert 50,314 metric tons CO2 emitted to mass of methane, (50,314/44)*16 = 18,296 metric tons CH4 (amount that is burned)

Given the 12% leakage rate, that means that 88% of total production is burned and 12% is leaked into the atmosphere. Therefore, to burn 18,296 metric tons CH4, 20,791 metric tons CH4 must be produced, with 963 metric tons CH4 emitted unburned, as calculated below:

Methane Produced: (18,296/0.88) = 20,791metric tons CH4
Unburned Methane Leaked: (20,791-18,296)=2,495 metric tons CH4

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO2e: 2495*86 = 214,562 metric tons CO2e

Total Emissions from Leaked Natural Gas

Sum all figures above highlighted in yellow. For a 12% leakage rate: 1,687,098 MTCO2e.

---END---