# Detailed Methodology

# Updated 2008 Tompkins County
# Community
# Greenhouse Gas Emissions and Energy Use Inventory

**September 2016**

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# 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 2008 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 updated 2008 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 updated 2008 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 updated 2008 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 updated 2008 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 updated 2008 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 updated 2008 inventory. This accounts for emissions associated with livestock management activities.
- *Power Generation at Cornell's Central Energy Plant* – included in the updated 2008 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 updated 2008 inventory. This accounts for the emissions associated with consumption of electricity within the Village of Groton.
- *Air Travel* – included in the updated 2008 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 AES Cayuga Power Plant* – included in the updated 2008 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 and updated the 2008 inventory with this information, as well. The energy resources were primarily small-scale solar and hydro in 2008.

**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 2005 (https://www.epa.gov/energy/egrid, eGRID Files (1996-2012), Year 2005 Sheet 7 Sub-region Data).

| Fuel Mix of Upstate New York | % |
|---|---|
| Nuclear | 27.0 |
| Hydro | 26.4 |
| Coal | 21.5 |
| Gas | 15.5 |
| Oil | 7.8 |
| Biomass | 1.2 |
| Other Fossil | 0.4 |
| Wind | 0.1 |
| Solar | 0.0 |
| Geothermal | 0.0 |
| Other Unknown/Purchased Fuel | 0.0 |

Grid emission factors used in ICLEI ClearPath: $CO_2$ 720.80 lbs/MWh, $CH_4$ 24.82 lbs/GWh, and $N_2O$ 11.19 lbs/GWh (also obtained from the EPA eGRID 2005 file Sheet 7 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.

**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 Updated 2008 inventory, which originally used the IPCC 2nd Assessment Report's 100 year GWP values, has been updated to the 5th Assessment 100 year values to allow direct comparison to the 2014 inventory.

*Methane Leakage Estimates from Traditional Gas Extraction and GWP*
In 2008, the natural gas consumed in the County likely came from traditionally drilled vertical wells. Dr. Robert Howarth advises that traditional extraction methods experience a 3.8% leakage rate. Therefore, in a separate section of the GHG Inventory, we applied a leakage factor of 3.8% 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. Because methane has a residence time in the atmosphere of only 12 years and the greenhouse warming effects of methane are >100-fold greater than for carbon dioxide on a mass-to-mass basis, 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, 2008 – January 5, 2009, it would show up as consumed in 2009 even though the bulk of the consumption was in 2008. 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.

**Fuel Oil and Propane**

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

In general, these are <u>poor quality data for Tompkins County</u>, 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 –Coal, Fuel Oil, Electricity and Metered Steam Sales*

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

**Transportation**

- Annual vehicle miles travelled (VMT) by vehicle class

In general, these are <u>moderate quality data for Tompkins County</u>, 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 2008 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 2007.

**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. There are, however, some limitations:

a) The 2008 fuel mix is not available. Therefore, data from 2014 was used as a proxy for 2008.

**Commercial Air Travel**

- Amount of jet fuel pumped into airplanes in 2008
- Amount of avgas (aviation gasoline) pumped into airplanes in 2008

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

**AES Cayuga Power Plant**

- 2008 power generation: 306 MW
- 2008 GHG emissions: 1,995,805 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 2008, most renewable energy projects in Tompkins County received some funding or incentives from NYSERDA so would be included in these data.

# 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: 293,371,081 kWh for 2008

Output: 96,405 MTCO2e

Data provided in the spring of 2010 from Kirk McAllister with NYSEG.

In 2016, Scott Bochenek of NYSEG confirmed that Kirk used the following methods to gather NYSEG data for 2008:

- 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*

- "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, 2007 – January 5, 2008, it would show up as consumed in 2008. 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**
96,405 MTCO2e

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

**SUMMARY**
Input: 444,343 kWh for 2008 (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**
444,343 kWh for 2008
421 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 Updated 2008 GHG inventory. Treat the NYSERDA categories Residential and Industrial as the sectors they are.

In the database, for the 2008 analysis the "Date Install" should be 12/31/2008 at the latest and "Project Status" should be "Complete" in order to filter for just the projects that started operating by the end of 2008. For systems that came online in 2008, their Expected kWh Annual Production need to be scaled down for the time they actually operated in 2008. For example, if a completed project's Date Install is 05/02/2008 and its expected annual production is 3,522 kWh, its actual annual production in 2008 is estimated as (365-122)*3,522/365 = 2,344 kWh. Note that May 2 is the 122$^{nd}$ day in 2008.

**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: 140,683 MMBtu for 2008

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)*(293,371,081 kWh) yields 41,071,951 kWh, or 140,683 MMBtu.

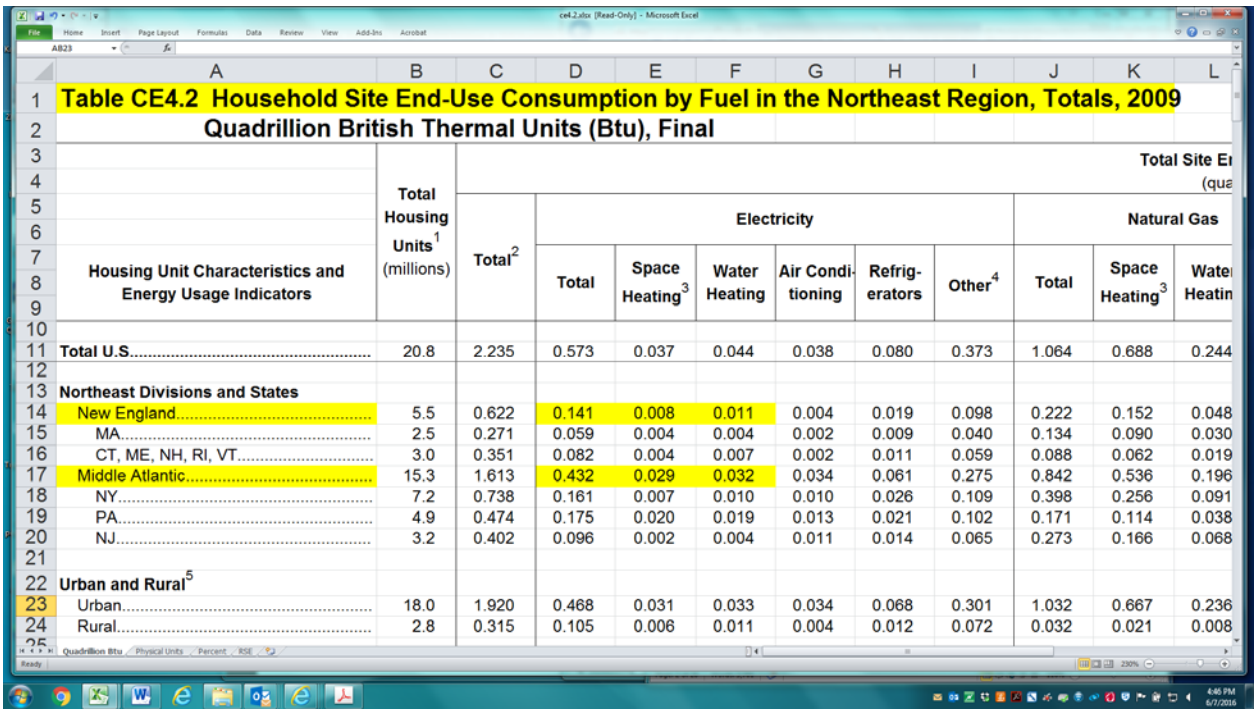


**Table CE4.2 Household Site End-Use Consumption by Fuel in the Northeast Region, Totals, 2009**
**Quadrillion British Thermal Units (Btu), Final**

| Housing Unit Characteristics and Energy Usage Indicators | Total Housing Units[1] (millions) | Total Site E (qua Total[2] | Electricity | | | | | | Natural Gas | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Total | Space Heating[3] | Water Heating | Air Condi-tioning | Refrig-erators | Other[4] | Total | Space Heating[3] | Wate 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: 17,018,828 therms for 2008

Output: 90,517 MTCO2e

Data provided in the spring of 2010 from Kirk McAllister with NYSEG. See above information in residential electricity on methods used to extract data.

**Sub-results for GHG Emissions**
90,517 MTCO2e

## Fuel Oil and Propane Data – Residential

**SUMMARY**
Input: 5,880,828 gallons of fuel oil for 2008
1,229,918 gallons of propane for 2008

Output: 60,425 MTCO2e for fuel oil
6,946 MTCO2e for propane
67,371 MTCO2e in total for the two fuels

**Sub-results for GHG Emissions**
67,371 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 2008. NYS residents consumed 28,139,000 barrels of distillate fuel oil". There are 42 US gallons in an oil barrel, so 28,139,000 barrels*42 = 1,181,838,000 gallons. Therefore, 0.0050*1,181,838,000 = 5,880,828 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 2008. NYS residents consumed 5,885,000 barrels of "Liquefied Petroleum Gases". There are 42 US gallons in a barrel of propane, so 5,885,000 barrels*42 = 247,170,000 gallons. Therefore, 0.0050*247,170,000 = 1,229,918 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, 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** | | | | | |
|---|---|---|---|---|---|
| **2008** | | **Thousand Barrels** | **US Gallon** | **MMBtu** | **CO2e** |
| Residential | NYS | 5,885 | 247,170,000 | | |
| | TC | 29 | 1,229,918 | 111,923 | 6,946 |
| | | | | | |
| **Fuel Oil** | | | | | |
| Counted as Distillate Fuel Oil #2 in ClearPath | | | | | |
| **2008** | | **Thousand Barrels** | **US Gallon** | **MMBtu** | **CO2e** |
| Residential | NYS | 28,139 | 1,181,838,000 | | |
| | TC | 140 | 5,880,828 | 811,554 | 60,425 |

# 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
- NYSEG Metered Commercial Customers – 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: 354,338,000 kWh for 2014

Output: 116,439 MTCO2e

Data provided in the spring of 2010 from Kirk McAllister with NYSEG. See above information in residential electricity on methods used to extract data.

**Sub-results for GHG Emissions**
116,439 MTCO2e

**B) Cornell Central Energy Plant**

**SUMMARY**
Input: 26,700,000 kWh generated for 2008
Output: 13,296 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**
13,296 MTCO2e

**C) Cornell Metered Purchase from NYSEG/Grid**

**SUMMARY**
Input: 220,100,000 kWh purchased for 2008

Output: 72,327 MTCO2e

It was assumed that in 2008, 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 2008 Cornell University Energy Fast Facts (https://energyandsustainability.fs.cornell.edu/file/CUEnergyFastFacts2008.pdf)

**Sub-results for GHG Emissions**
72,327 MTCO2e

**Cornell Electricity Summary:** Therefore, 26,700,000+220,100,000=246,800,000 kWh electricity was consumed on the Cornell campus (not including the electricity generated by Cornell hydro power) in 2008, and the total emission was 13,296+72,327=85,623 MTCO2e.

**D) Renewable Installations Providing Electricity to the Commercial Sector**

**SUMMARY**
Input: Solar (small-scale): 29,968 kWh for 2008
Wind (small-scale): 0
Wind (large-scale): 0
Micro-hydro: 0

| | |
|---|---|
| | Hydro: 3,100,000 kWh Hydro |
| Output: | N/A |

Note that these results are only used for energy calculations, not GHG emissions calculations. 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) Small-scale**

- **Solar PV – 200kW or smaller**

29,968 kWh for 2008
26 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 Updated 2008 GHG inventory. Treat the NYSERDA categories Residential and Industrial as the sectors they are.

In the database, for the 2008 analysis the "Date Install" should be 12/31/2008 at the latest and "Project Status" should be "Complete" in order to filter for just the projects that started operating by the end of 2008. For systems that came online in 2008, their Expected kWh Annual Production need to be scaled down for the time they actually operated in 2008. For example, if a completed project's Date Install is 05/02/2008 and its expected annual production is 3,522 kWh, its actual annual production in 2008 is estimated as (365-122)*3,522/365 = 2,344 kWh. Note that May 2 is the 122$^{nd}$ day in 2008.

- **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

No project was in operation by the end of 2008 as reported by the data system. In addition to it, the following project is known to be operating in Tompkins County then.

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

**Cornell Hydropower**
3,100,000 kWh for 2008
1.1 MW nameplate capacity

This accounts for all of the hydro-electricity production in Tompkins County in 2008: 3,100,000 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/CUEnergyFastFacts2008.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

**NYSEG Metered Commercial Customers**

**SUMMARY**
Input: 21,321,612 therms for 2008

Output: 113,402 MTCO2e

**Methodology**
Data provided in the spring of 2010 from Kirk McAllister with NYSEG. See above information in residential electricity on methods used to extract data.

**Sub-results for GHG Emissions**
113,402 MTCO2e

## Fuel Oil and Propane Data – Commercial

**A) Commercial sector fuel oil and propane use**

| **SUMMARY** | |
|---|---|
| Input: | 5,205,396 gallons of fuel oil for 2008 (includes 3,200 gallons used at Cornell CEP)<br>403,975 gallons of propane for 2008 |
| Output: | 55,466 MTCO2e for fuel oil<br>2,281 MTCO2e for propane<br>57,747 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 2008. NYS consumed 13,447,000 barrels of distillate fuel oil in the commercial sector. There are 42 US gallons in an oil barrel, so 13,447,000 barrels*42 = 564,774,000 gallons. 0.0059*564,774,000 = 3,310,332 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 2008. NYS consumed 7,685,000 barrels of residual fuel oil in the commercial sector. There are 42 US gallons in an oil barrel, so 7,685,000 barrels*42 = 322,770,000 gallons. 0.0059*322,770,000 = 1,891,864 gallons of residual fuel oil in Tompkins County.

Therefore, the total fuel oil consumed by the commercial sector was 3,310,332+1,891,864 = 5,202,196 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 2008. NYS consumed 1,641,000 barrels of "Liquefied Petroleum Gases" in the commercial sector. There are 42 US gallons in a barrel of propane, so 1,641,000 barrels*42 = 68,922,000 gallons. Therefore, 0.0059*68,922,000 = 403,975 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 2008.

**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

| 2008 | | Thousand Barrels | US Gallon | MMBtu | CO2e |
|---|---|---|---|---|---|
| Commercial | NYS | 13,447 | 564,774,000 | | |
| | TC | 79 | 3,310,332 | 456,826 | 34,014 |
| Industrial | NYS | 3,409 | 143,178,000 | | |
| | TC | 22 | 905,073 | 124,900 | 9,272 |

b. Residual Fuel Oil

| 2008 | | Thousand Barrels | US Gallon | MMBtu | CO2e |
|---|---|---|---|---|---|
| Commercial | NYS | 7,685 | 322,770,000 | | |
| | TC | 45 | 1,891,864 | 283,780 | 21,452 |
| Industrial | NYS | 1,247 | 52,374,000 | | |
| | TC | 8 | 331,072 | 49,661 | 3,743 |

Total

| | US Gallon | MMBtu | CO2e |
|---|---|---|---|
| Commercial | 5,202,196 | 740,606 | 55,466 |
| Industrial | 1,236,145 | 174,561 | 13,015 |

**Propane**

| 2008 | | Thousand Barrels | US Gallon | MMBtu | CO2e |
|---|---|---|---|---|---|
| Commercial | NYS | 1,641 | 68,922,000 | | |
| | TC | 10 | 403,975 | 36,762 | 2,281 |
| Industrial | NYS | 753 | 31,626,000 | | |
| | TC | 5 | 199,918 | 18,193 | 1,125 |

**B) Cornell Central Energy Plant**

**SUMMARY**
Input: 3,200 gallons of fuel oil for 2008

Output: 37 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**
37 MTCO2e

## Coal Data – Commercial

**SUMMARY**
Input: 65,420 tons for 2008

Output: 140,204 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 FY 2008
https://energyandsustainability.fs.cornell.edu/file/CUEnergyFastFacts2008.pdf

## 6. Cornell Power Generation and Consumption

**SUMMARY**

Input: 65,420 tons of coal for 2008
3,200 gallons of fuel oil for 2008
26,700,000 kWh electricity generated in 2008
220,100,000 kWh electricity purchased in 2008
Therefore, 246,800,000 kWh electricity was consumed on the Cornell campus (not including electricity generated by Cornell hydro)
1,008,000 klbs metered steam for 2008

Output: 225,864 total MTCO2e, with
140,204 MTCO2e from coal
37 MTCO2e from fuel oil
85,623 MTCO2e from electricity

**Methodology, Data & Sources**

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

1) Coal and fuel oil consumed at the CEP
2) Electricity generation and metered steam sales from the CEP
3) Electricity purchased from NYSEG
4) MTCO2e from Cornell's GHG Emissions Inventory

**Input 1: Coal and fuel oil consumed at the CEP.**

65,420 tons of coal
3,200 gallons of fuel oil
Obtained through personal correspondence from David Frostclapp from Cornell Facilities Services.

Cornell CEP also consumed 1,211,000 therms of natural gas in 2008. Before the fall of 2009, natural gas was supplied to Cornell via lines owned and operated by NYSEG (http://www.news.cornell.edu/stories/2006/11/new-gas-line-cornells-combined-heat-and-power-project). So the natural gas consumed here was included in the total amount of natural gas that NYSEG delivered to the commercial sector.

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

26,700,000 kWh electricity – total generation from the co-gen steam turbine
Obtained through personal correspondence from David Frostclapp from Cornell Facilities Services.

In 2008, 220,100,000 kWh of electricity was purchased from the grid (obtained from the online publication Energy Fast Facts for 2008: https://energyandsustainability.fs.cornell.edu/em/fastfacts/default.cfm). So the amount of electricity actually consumed by Cornell was 26,700,000+220,100,000=246,800,000 kWh (not including electricity generated by Cornell hydro).

1,008,000 klbs metered steam – a major product of the co-gen 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 ton of coal = 25.11 MMBtu
1 therm = 0.1 MMBtu
1 gallon fuel oil = 0.14 MMBtu
1 kWh = 0.003412 MMBtu
1 klbs = 1.03 MMBtu

Summary Table

| | Quantity | Units | | Energy | |
|---|---|---|---|---|---|
| Coal - Central Energy Plant | 65,420 | tons | | 1,642,414 | MMBtu |
| Natural Gas - Central Energy Plant | 1,211,000 | therms | | 120,618 | MMBtu |
| Fuel Oil - Central Energy Plant | 3,200 | gallons | | 448 | MMBtu |
| **Energy Input Totals** | | | | **1,763,480** | **MMBtu** |
| | | | | | |
| | | | | | |
| Electricity generation CEP | 26,700,000 | kwh | | 91,104 | MMBtu |
| Metered Steam Sales | 1,008,000 | klbs | | 1,038,240 | MMBtu |
| **Total Energy Output** | | | | **1,129,344** | **MMBtu** |
| **Losses** | | | | **634,136** | **MMBtu** |

Note: 26,700,000 kWh (91,104 MMBtu) electricity generation, 3,200 gallons fuel oil (448 MMBtu), and 65,420 tons of coal (1,642,414 MMBtu) are used throughout analysis below.

**Background on Cornell CEP**

**FY 2008**
**Cornell University**
**Energy Fast Facts[1]**

| PRIMARY ENERGY CONSUMPTION | | |
|---|---|---|
| Primary Consumption (trillion Btu) | 1990[2] | 2008 |
| Electricity (Grid Purchased) | 0.60 | 0.751 |
| Coal | 1.33 | 1.636 |
| Hydro | 0.02 | 0.011 |
| Natural Gas | 0.28 | 0.121 |
| Oil | 0.14 | 0.000 |
| **Total Primary Energy Consumption** | **2.35** | **2.519** |
| Primary Consumption (MMBtu) per sq. ft. | **0.20** | **0.18** |

| ENERGY CONSUMPTION BY BUILDING | | |
|---|---|---|
| Building Type: (trillion Btu) | 1990 | 2008 |
| Research/Teaching | NA | 2.14 |
| Campus Life | NA | 0.30 |
| Administration | NA | 0.08 |

| ELECTRICITY | | |
|---|---|---|
| Cornell Utilities Generated (Mwh) | 1990 | 2008 |
| Cornell Utilities Hydro | 5,200 | 3,100 |
| Cornell Utilities Steam Turbine - Cogen | 21,000 | 26,700 |
| Cornell Utilities Gas Turbine - CCHPP[3] | 0 | 0 |
| **Total Cornell Utilities Generated** | **26,200** | **29,800** |
| Electricity (Grid Purchased) (Mwh) | 174,500 | 220,100 |
| **Total Electricity (Mwh)** | **200,700** | **249,900** |

| *Electricity (Grid Purchased) Sources*[4,5] | 1990 | 2008 |
|---|---|---|
| Biomass | 0% | <1% |
| Coal | 74% | 16% |
| Natural Gas | 5% | 23% |
| Hydro | 14% | 19% |
| Nuclear | 5% | 30% |
| Oil | 2% | 11% |
| Solar | 0% | <1% |
| Solid Waste | 0% | 1% |
| Wind | 0% | <1% |

| ADDITIONAL STATISTICS | | |
|---|---|---|
| | 1990 | 2008 |
| Total Enrollment | 18,581 | 19,800 |
| Campus Area (1000 sq. ft.) | 11,800 | 13,944 |
| Square Feet per Student | 635 | 704 |
| Heating Degree Days (7182 Normal) | 6,919 | 6,748 |

| ENERGY RELATED CARBON DIOXIDE ($CO_2$) EMISSIONS | | |
|---|---|---|
| Energy Source | 1990 | 2008 |
| Electricity (Grid Purchased) | 167.4 | 90.8 |
| Cornell Utilities | 165.2 | 176.3 |
| **Total $CO_2$ Emissions (thousand tons)** | **332.6** | **267.1** |
| $CO_2$ Emissions By Primary Energy Type: | 1990 | 2008 |
| Coal | 42% | 63% |
| Electricity (Grid Purchased) | 50% | 34% |
| Hydro | 0% | 0% |
| Natural Gas | 5% | 3% |
| Oil | 4% | 0% |
| $CO_2$ Emissions By Utility Type: | 1990 | 2008 |
| Electricity to Campus (Grid Purchased) | 44.2% | 33.0% |
| Electricity (Cornell Generated) | 2.6% | 4.3% |
| Steam | 47.1% | 61.8% |
| Chilled Water | 6.1% | 0.9% |

| STEAM | | |
|---|---|---|
| | 1990 | 2008 |
| Total Steam Export (trillion Btu) | 1.31 | 1.32 |
| Steam Fuel Sources (trillion Btu) | | |
| Coal | 1.33 | 1.64 |
| Natural Gas | 0.28 | 0.12 |
| Oil | 0.14 | 0.00 |
| Total Energy Input (trillion Btu) | 1.74 | 1.76 |
| Thermal Efficiency | 69% | 69% |

| CHILLED WATER | | |
|---|---|---|
| | 1990 | 2008 |
| Total Chilled Water Production (trillion Btu) | 0.338 | 0.542 |
| Total Energy Input[2] (trillion Btu)[6] | 0.072 | 0.021 |
| System Coefficient of Performance | 4.7 | 25.8 |
| Chilled Water Sources | | |
| Mechanical Chillers | 83% | 1% |
| Lake/Free Cooling | 17% | 99% |

**GLOSSARY**
Btu: British thermal unit
Primary: Central Plant Usage
MMBtu: Million Btu
Mwh: mega watt-hour

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.

Note that the Combined Heat and Power Project had not yet begun operations in 2008, so there was no electric export in 2008.

**Input 3: Electricity purchased from NYSEG**
220,100,000 kWh of electricity was purchased from NYSEG in 2008. Within the Commercial Sector, and using the "Emissions from Grid Electricity" calculator, the ClearPath software calculates 751,195 MMBtu and 72,327 MTCO2e emissions for the electricity purchased.

So total electricity consumed on the Cornell campus was 26,700,000+220,100,000=246,800,000 kWh or 91,104+751,195=842,299 MMBtu.

**Input 4: $MTCO_2e$ from Cornell's GHG Emissions Inventory**
The 2012 Cornell University Greenhouse Gas Emissions Inventory includes the following table:

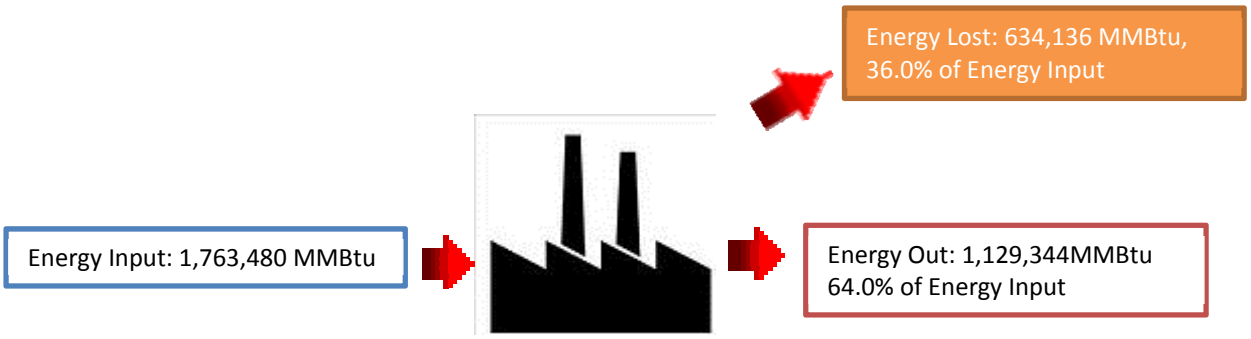
http://www.sustainablecampus.cornell.edu/initiatives/greenhouse-gas-emissions-inventory

*Table 3.2: On-Site Combustion Summary FY 2008*

| Fuel Type | Quantity Consumed | $CO_2$-e Emitted (metric tons) | % of On-Site Combustion |
|---|---|---|---|
| Coal - Central Energy Plant | 65,420 tons | 153,500 | 87% |
| Natural Gas - Central Energy Plant | 1,211,000 therms | 6,400 | 3.6% |
| Fuel Oil - Central Energy Plant | 3,200 gallons | 37 | <<1% |
| **Total Central Energy Plant** | | **159,937** | |

***Calculations***

**First, need to determine how much of the total coal, 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 coal, natural gas, and fuel oil to electricity and steam are both equal and 2) the losses for fuels are proportional to the overall system loss of 36.0% (1,129,344/1,763,480 = 64.0%. 100%-64.0% = 36.0%).

| | Quantity | Units | | Energy | |
|---|---|---|---|---|---|
| Coal - Central Energy Plant | 65,420 | tons | | 1,642,414 | MMBtu |
| Natural Gas - Central Energy Plant | 1,211,000 | therms | | 120,618 | MMBtu |
| Fuel Oil - Central Energy Plant | 3,200 | gallons | | 448 | MMBtu |
| **Energy Input Totals** | | | | **1,763,480** | **MMBtu** |
| | | | | | |
| | | | | | |
| Electricity generation CEP | 26,700,000 | kwh | | 91,104 | MMBtu |
| Metered Steam Sales | 1,008,000 | klbs | | 1,038,240 | MMBtu |
| **Total Energy Output** | | | | **1,129,344** | **MMBtu** |
| **Losses** | | | | **634,136** | **MMBtu** |

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

- Coal utilized = Energy input 1,642,414 MMBtu × 64.0% = 1,051,813 MMBtu
- Coal loss = Energy input 1,642,414 MMBtu – Energy utilized 1,051,813 MMBtu = 590,601 MMBtu

- Fuel oil utilized = Energy input 448 MMBtu × 64.0% = 287 MMBtu
- Fuel oil loss = Energy input 448 MMBtu – Energy utilized 287 MMBtu = 161 MMBtu

| MMBtu | Total | Loss | Utilized |
|---|---|---|---|
| Coal | 1,642,414 | 590,601 | 1,051,813 |
| Natural Gas | 120,618 | 43,374 | 77,245 |
| Fuel Oil | 448 | 161 | 287 |
| Sum | 1,763,480 | 634,136 | 1,129,344 |

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

Coal utilized for heating only: Coal utilized total 1,051,813 MMBtu – converted to energy in electricity 91,104 MMBtu = 960,709 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 2012 GHG Emissions Inventory, total Cornell emission from on-site coal combustion was 153,500 $MTCO_2e$. Split the 153,500 MT $CO_2e$ between coal and electricity by their utilized energy.

- Coal emission = emissions from coal use 153,500 MT × coal utilized for heating only 960,709 MMBtu/coal utilized total 1,051,813 MMBtu = 140,204 MTCO2e
- Electricity emission = emissions from coal use 153,500 MT × converted to energy in electricity 91,104 MMBtu/coal utilized total 1,051,813 MMBtu = 13,296 MTCO2e

So total emission from electricity consumed on the Cornell campus was 13,296+72,327=85,623 MTCO2e. And total emission from on-site fuel oil combustion was 37 MTCO2e.

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

| | MMBtu | Unit Utilized on Campus | | MTCO2e |
|---|---|---|---|---|
| Electricity (kWh) | 842,299 | 246,800,000 | Electricity – emissions from coal used to generate and electricity purchased | 85,623 |
| Fuel Oil (gallons) | 287 | 3,200 | Fuel Oil - emissions | 37 |
| Coal (tons) | 960,709 | 65,420 | Coal – emissions from heating only | 140,204 |
| Total | 1,803,295 | NA | Total | 225,864 |

# 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: 138,191,663 kWh for 2008

Output: 45,411 MTCO2e

Data provided in the spring of 2010 from Kirk McAllister with NYSEG. See above information in residential electricity on methods used to extract data.

**Sub-results for GHG Emissions**
45,411 MTCO2e

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

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: 4,231,084 therms for 2008

Output: 22,456 MTCO2e

Data provided in the spring of 2010 from Kirk McAllister with NYSEG. See above information in residential electricity on methods used to extract data.

**Sub-results for GHG Emissions**
22,456 MTCO2e

## Fuel Oil and Propane Data – Industrial

**SUMMARY**

Input: 1,236,145 gallons of fuel oil for 2008
199,918 gallons of propane for 2008

Output: 13,015 MTCO2e for fuel oil
1,125 MTCO2e for propane
14,140 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 2008. NYS consumed 3,409,000 barrels of distillate fuel oil in the industrial sector. There are 42 US gallons in an oil barrel, so 3,409,000 barrels*42 = 143,178,000 gallons. 0.0063*143,178,000 = 905,073 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 2008. NYS consumed 1,247,000 barrels of residual fuel oil in the industrial sector. There are 42 US gallons in an oil barrel, so 1,247,000 barrels*42 = 52,374,000 gallons. 0.0063*52,374,000 = 331,072 gallons of residual fuel oil in Tompkins County.

Therefore, the total fuel oil consumed by the industrial sector was 905,073+331,072=1,236,145 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 2008. NYS consumed 753,000 barrels of "Liquefied Petroleum Gases" in the industrial sector. There are 42 US gallons in a barrel of propane, so 753,000 barrels*42 = 31,626,000 gallons. Therefore, 0.0063*31,626,000 = 199,918 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 2008.

**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

| 2008 | | Thousand Barrels | US Gallon | MMBtu | CO2e |
|---|---|---|---|---|---|
| Commercial | NYS | 13,447 | 564,774,000 | | |
| | TC | 79 | 3,310,332 | 456,826 | 34,014 |
| Industrial | NYS | 3,409 | 143,178,000 | | |
| | TC | 22 | 905,073 | 124,900 | 9,272 |

b. Residual Fuel Oil

| 2008 | | Thousand Barrels | US Gallon | MMBtu | CO2e |
|---|---|---|---|---|---|
| Commercial | NYS | 7,685 | 322,770,000 | | |
| | TC | 45 | 1,891,864 | 283,780 | 21,452 |
| Industrial | NYS | 1,247 | 52,374,000 | | |
| | TC | 8 | 331,072 | 49,661 | 3,743 |

Total

| | US Gallon | MMBtu | CO2e |
|---|---|---|---|
| Commercial | 5,202,196 | 740,606 | 55,466 |
| Industrial | 1,236,145 | 174,561 | 13,015 |

**Propane**

| 2008 | | Thousand Barrels | US Gallon | MMBtu | CO2e |
|---|---|---|---|---|---|
| Commercial | NYS | 1,641 | 68,922,000 | | |
| | TC | 10 | 403,975 | 36,762 | 2,281 |
| Industrial | NYS | 753 | 31,626,000 | | |
| | TC | 5 | 199,918 | 18,193 | 1,125 |

# 8. Village of Groton Electric

**SUMMARY**

Input: 27,503,611 kWh for 2008

Output: 2,305 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. It was assumed the fuel mix didn't change from 2008 to 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 27,503,611 kWh in 2008. Corrected information provided by Chuck Rankin in July 2016.

**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 27,503,611 kWh*0.13 = 3,575,469 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.

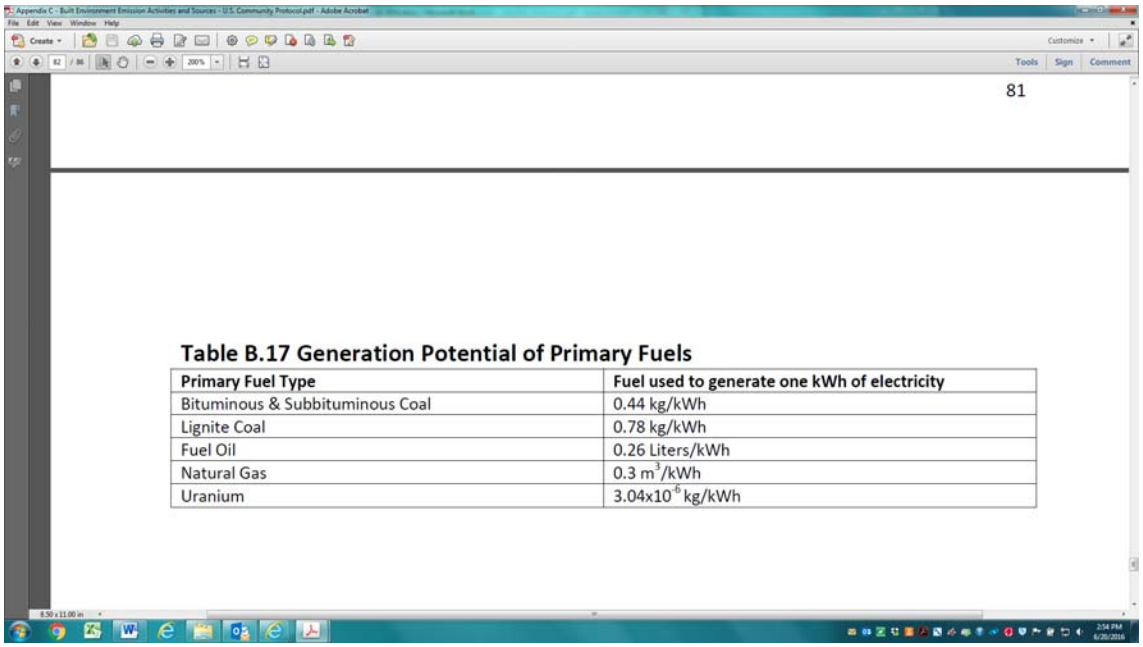


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**Table B.17 Generation Potential of Primary Fuels**

| 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 | 3.04x$10^{-6}$ kg/kWh |

- Assumed a heat content of natural gas was 1,021 Btu/cubic foot for New York State in 2008.
  - From: https://www.eia.gov/dnav/ng/ng_cons_heat_a_EPG0_VGTH_btucf_a.htm

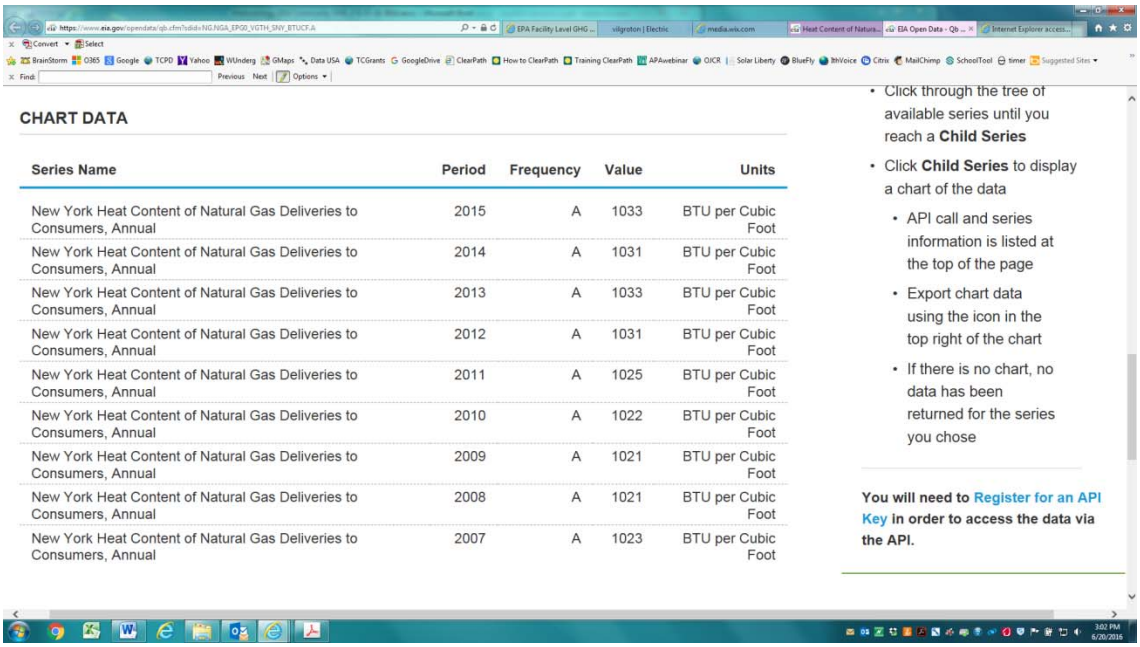


**CHART DATA**

| 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 9,947 Btu/lb in 2008.
  - From: http://www.eia.gov/electricity/annual/html/epa_07_03.html

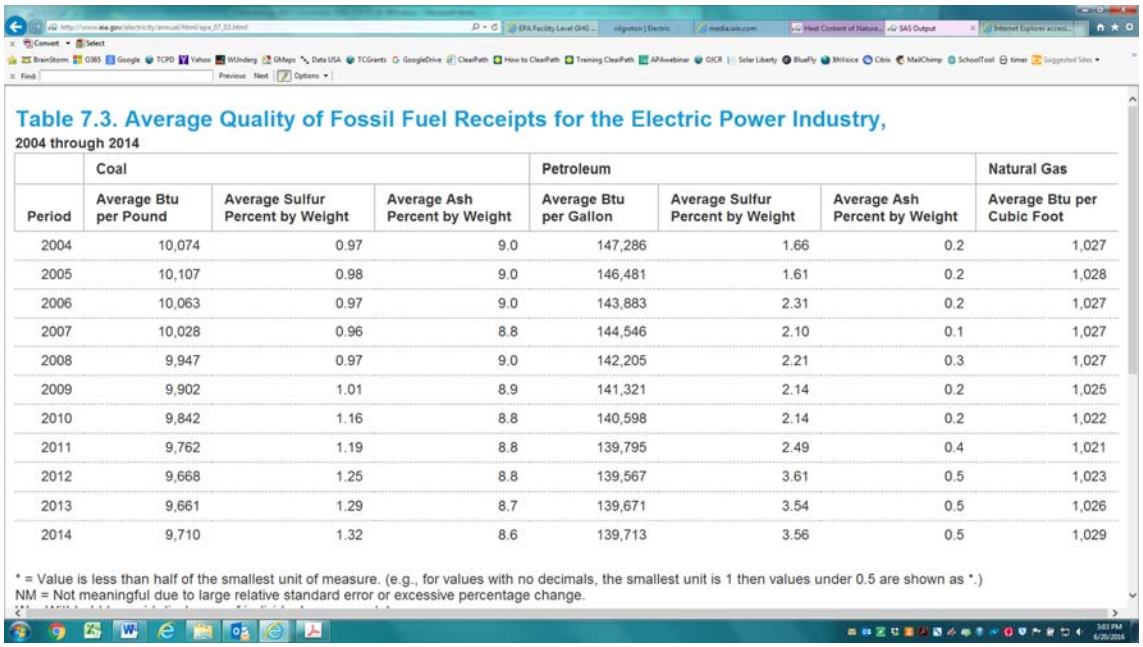


Table 7.3. Average Quality of Fossil Fuel Receipts for the Electric Power Industry, 2004 through 2014

| | 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 = 3,575,469 kWh*0.3 $m^3$/kWh*35.3147 cubic foot/$m^3$*1,021 Btu/cubit foot = 38,675.47 MMBtu
- Energy input from coal = 27,503,611 kWh*1%*0.44 kg/kWh*2.20462 lb/kg*9,947 Btu/lb = 2,653.80 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 2008 Consumption | | 27,503,611 | kWh | 93,846 | MMBtu |
| | | | | | |
| Fuel Sources (2008)* | | | MMBtu Input** | CO2e (MT) | |
| Hydro | 76% | 20,902,744 | | | |
| Gas | 13% | 3,575,469 | 38,675.47 | 2,052.70 | |
| Nuclear | 9% | 2,475,325 | | | |
| Coal | 1% | 275,036 | 2,653.80 | 252.33 | |
| Other Renewables | 1% | 275,036 | | | |
| Total | 100% | 27,503,611 | | 2,305.03 | |

**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: | 671,149,530 total vehicle miles traveled for 2008<br>639,445,494 miles (95% of total) attributable to passenger cars, motorcycles, and light trucks using gasoline<br>31,704,037 miles (5% of total) to medium-duty trucks, heavy-duty trucks, and transit and school buses using diesel |
| Output: | 299,822 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 "Updated 2008 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 2008.

| 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 2009 data, but were used as a proxy for 2008, since the figures were not updated for 2008): were derived by Tom running the TransCAD model (run in version 4.8, analyze in version 6.0). The "2008 Current Conditions Scenario" was used when running the model (i.e. 2008 "vehicles per household" and 2008 "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:** 2009 Transit Bus (TCAT) VMT was provided to Tom by Matt Yarrow at TCAT on 6/18/2015.

d) **Para-Transit VMT:** 2008 Para-Transit Bus VMT was assumed to be the same as its 2014 VMT provided by TCAT, because Gadabout mileage was not included in the original 2008 VMT. In 2014, Gadabout drove 514,154 miles.

e) **School Bus VMT:** 2009 School Bus VMT was provided to Tom by James Ellis at the Ithaca City School District in 2015.

f) **Medium and Heavy Truck VMT:** Medium and heavy truck VMT were manually added to the VMT total by Tom based on the 2014 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). Class counts were not available in 2008[1]. The 2014 information is much more accurate and is applied retroactively to be able to compare the VMT over years.

[1] In 2008, the ITCTC developed 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 the Original 2008 Inventory figures.

- 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 2008 VMT) and manually added to the VMT total by Tom.

h) **Total VMT** from TransCAD Model: 521,667,155+(112,707,455-514,154) = 633,860,456

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 | 521,667,155 | 82.3% of TransCAD output |
| Gasoline | Motorcycle | 5,070,884 | 0.8% of TransCAD output and then added to TransCAD output |
| Gasoline | Light Truck (incl Gadabout) | 112,707,455 | 17.7% of TransCAD output + Actual Gadabout VMT (514,154) |
| | Subtotal | **639,445,494** | |
| Diesel | Transit and School Bus | 2,800,000 | Actual VMT |
| Diesel | Medium Truck | 20,156,762 | 3.22% of TransCAD output and then added to TransCAD output |
| Diesel | Heavy Truck | 8,747,274 | 1.38% of TransCAD output and then added to TransCAD output |
| | Subtotal | **31,704,037** | |
| | Total | **671,149,530** | |

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 2008, it was assumed that Gadabout drove the same number of miles as it did in 2014, 514,154 miles.

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

The Transportation Factor Set “Updated 2008 Comm Transportation Factor Set” from the ClearPath software was applied to the VMT by vehicle class figures. The factor set is shown below.

| Name | Updated 2008 Comm Transportation Factor Set |
|---|---|
| Year | 2008 |
| Gas Passenger Vehicle Fuel Economy (MPG) | 23.7 |
| Gas Passenger Vehicle g CH4/mi | 0.013 |
| Gas PassengerVehicle g N2O/mi | 0.012 |
| Gas Light Truck Fuel Economy (MPG) | 17.3 |
| Gas Light Truck g CH4/mi | 0.017 |
| Gas Light Truck g N2O/mi | 0.009 |
| Gas Heavy Truck Fuel Economy (MPG) | 7.0 |
| 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) | 42.5 |
| 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) | 23.7 |
| Diesel Passenger Vehicle g CH4/mi | 0.013 |
| Diesel PassengerVehicle g N2O/mi | 0.012 |
| Diesel Light Truck Fuel Economy (MPG) | 17.3 |
| Diesel Light Truck g CH4/mi | 0.017 |
| Diesel Light Truck g N2O/mi | 0.009 |
| Diesel Heavy Truck Fuel Economy (MPG) | 7.0 |
| 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) | 42.5 |
| 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 2008 National Transportation Statistics - Average miles traveled per gallon 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 in 2008 had 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 = 69.7% * 7.4 + 30.3% * 6.0 = 7.0

| | MPG | VMT | % of the Total VMT |
|---|---|---|---|
| Medium Trucks | 7.4 | 20,156,762 | 69.7% |
| Heavy Trucks | 6.0 | 8,747,274 | 30.3% |
| Total | NA | 28,904,037 | 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 | 23.7 | 0.013 | 0.012 |
| Gasoline Light Trucks (incl para-transit buses) | 17.3 | 0.017 | 0.009 |
| Gaoline Motorcycle | 42.5 | 0.067 | 0.007 |
| ***Subtotal*** | | | |
| Diesel Medium Truck** | 7.0 | 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).

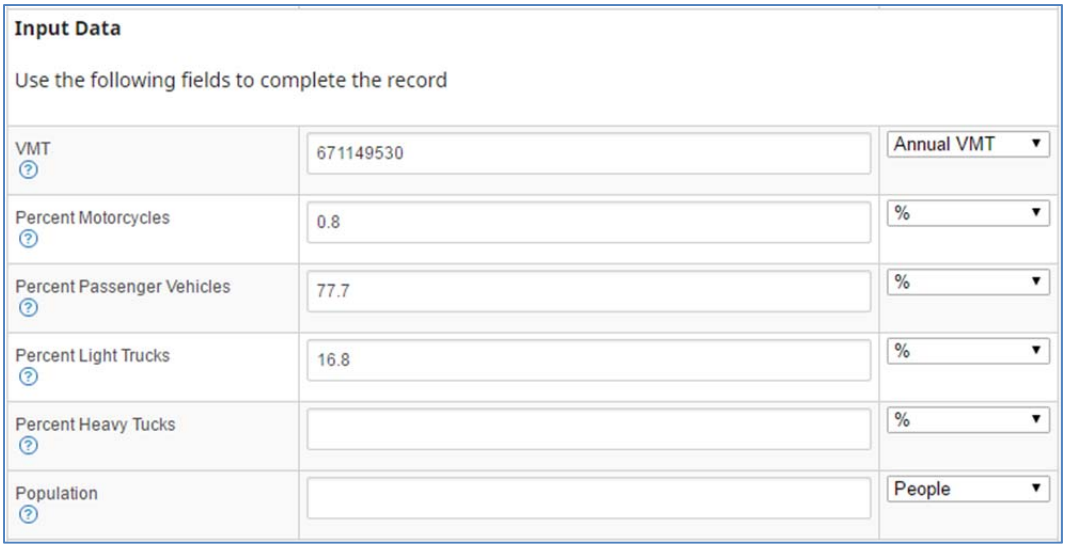
For example, for passenger vehicles, that calculation is: 521,667,155 VMT ÷ 23.7 miles/gallon = 22,011,272 gallons of gasoline consumed over 2008.

**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, 521,667,155 miles for Passenger Vehicles ÷ 671,149,530 total VMT = 77.7% of the overall total. All the percentages of total by vehicle class are shown in the ClearPath Output table below.



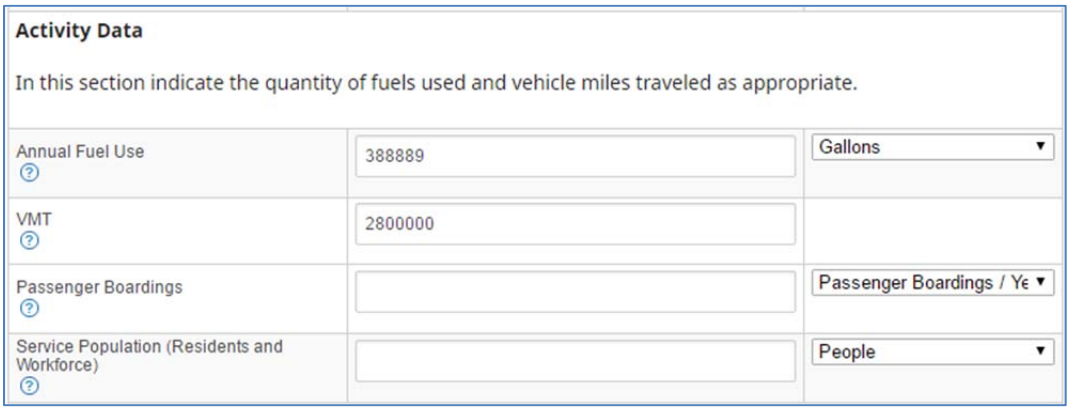
**Input Data**

Use the following fields to complete the record

| | | |
|---|---|---|
| VMT | 671149530 | 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 | 388889 | Gallons |
| VMT | 2800000 | |
| 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 | 521,667,155 | 77.7% | 0 | 22,011,272 | | |
| Gasoline Light Trucks (incl para-transit buses) | P | 112,707,455 | 16.8% | 0 | 6,514,882 | | |
| Gaoline Motorcycle | P | 5,070,884 | 0.8% | 0 | 119,315 | | |
| ***Subtotal*** | | **639,445,494** | **95.3%** | **0** | **28,645,469** | **3,580,900** | **253,715** |
| Diesel Medium Truck** | F | 20,156,762 | 69.7% | 2,889,313 | 0 | | |
| Diesel Heavy Trucks | | 8,747,274 | 30.3% | 1,253,853 | 0 | | |
| ***Subtotal*** | | **28,904,037** | **4.3%** | **4,143,166** | **0** | **569,336** | **42,135** |
| Diesel Transit Buses | P | 2,800,000 | 0.4% | 388,889 | 0 | 53,704 | 3,972 |
| **Totals** | **NA** | **671,149,530** | **100.0%** | **4,532,055** | **28,645,469** | **4,203,940** | **299,822** |
| | | | | | | | |
| *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. | | | | | | | |

# 10. Air Travel

**SUMMARY**

Input: 1,367,012 gallons of jet fuel pumped in 2008
44,334 gallons of avgas pumped in 2008

Output: 13,466 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 2008
2) Amount of avgas (aviation gasoline) pumped into airplanes in 2008

**Input 1: Amount of jet fuel pumped into airplanes in 2008**

Total amount: 1,367,012 gallons

**Input 2: Amount of avgas pumped into airplanes in 2008**

Total amount: 44,334 gallons

Data from personal communication with Roxann 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 | 1,367,012 | 164,041 | 13,096 |
| Aviation Gasoline | 44,334 | 5,320 | 370 |
| **Total** | **1,411,346** | **169,361** | **13,466** |

# 11. Solid Waste

**SUMMARY**

Input: 70,730 short tons of waste were disposed of in landfills in 2008. All of that were sent to a landfill that has methane collection.

Output: 21,318 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*

One record was created for community-generated waste sent to a landfill with methane collection. Need to create and apply Factor Sets to be used with input data as described below.

*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 CO2e 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 CO2 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 2008.

*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 2008. 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 2008 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. 185,724-114,994 = 70,730 short tons.

**WASTE DISPOSED**

If you include more than 10,000 tons of solid waste IMPORTED from another P. U., please specify on a separate sheet.
Do not report tons of ash that is disposed of or recovered from incineration, as such would constitute double counting

| | Landfilled | | Waste-to-Energy | | Out of State |
|---|---|---|---|---|---|
| | Within PU tons | Outside PU (exported tons) | Within PU tons | Outside PU (exported tons) | Outside PU (exported tons) |
| Municipal Solid Waste | 24,047 | 32,338 | | | |
| C & D (disposed) | | 12,786 | | | |
| Non-Haz. Industrial Waste | | 676 | | | |
| Sewage Sludge (wet/dry?) | | 872-dry<br>11-wet | | | |

Names of DISPOSAL FACILITIES that received your waste tons listed above (add additional sheets, if necessary):

Seneca Meadows Sanitary Landfill, Waterloo, New York- waste received by Tompkins County
Other unknown

| | Short Tons |
|---|---|
| 2008 Total Waste | 185,724 |
| 2008 Recycled Waste | 114,994 |
| 2008 Disposed of Waste in Landfills | 70,730 |

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

The 2008 Planning Unit Recycling Report specifies the Seneca Meadows Landfill as the destination for disposed waste generated in the Tompkins 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

**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 2008 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 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 Seneca Meadows Landfill, so 24,047+32,338=56,385 tons. Then input the total amount of Bio-solids sent to the landfill (872+11=883 tons). All inputs are shown in the table below:

| | | | |
|---|---|---|---|
| **a.** | Mixed Municipal Solid Waste (MSW) | **56,385** | **100.0%** |
| | | | |
| **b.** | Food Scraps | 618 | 70.0% |
| | Grass | 88 | 10.0% |
| | Leaves | 88 | 10.0% |
| | Branches | 88 | 10.0% |
| | **Total** | **883** | **100.0%** |

And a screenshot from ClearPath Factor Sets:

| Name: Updated 2008 Waste Estimation MSW | |
|---|---|
| Year | 2008 |
| 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: Updated 2008 Waste Estimation Biosolids | |
|---|---|
| Year | 2008 |
| Percentage Mixed MSW | |
| Percentage Newspaper | |
| Percentage Office Paper | |
| Percentage Corrugated Cardboard | |
| Percentage Magazines / Third Class Mail | |
| Percentage Food Scraps | 0.7 |
| Percentage Grass | 0.1 |
| Percentage Leaves | 0.1 |
| Percentage Branches | 0.1 |
| 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: 23,639 cattle and calves; 3,355 sheep and lambs; 606 hogs and pigs; 962 goats; and 2,718 horses
2,800 CH4 emissions

| Output: | 78,400 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 ruminant animals by type in the County**

Types and number of Livestock

a. USDA 2007 Census of Agriculture, County Level
Datahttps://www.agcensus.usda.gov/Publications/2007/Full_Report/Volume_1,_Chapter_2_County_Level/New_York/

| | | |
|---|---|---|
| Livestock and poultry: | | |
| Cattle and calves inventory | farms | 13,589 |
| | number | 1,443,297 |
| Beef cows | farms | 6,803 |
| | number | 103,620 |
| Milk cows | farms | 5,683 |
| | number | 626,455 |
| Cattle and calves sold | farms | 10,898 |
| | number | 583,468 |
| Hogs and pigs inventory | farms | 1,871 |
| | number | 85,741 |
| Hogs and pigs sold | farms | 1,817 |
| | number | 322,396 |

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 | Ul |
|---|---|---|---|
| **INVENTORY** | | | |
| Cattle and calves | farms, 2007 | 181 | |
| | 2002 | 209 | |
| | number, 2007 | 23,639 | |
| | 2002 | 20,867 | |

**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 2008 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 | 23,639 | 115 | 2,718 | |
| Sheep and lambs | 3,355 | 8 | 27 | |
| Hogs and pigs | 606 | 1.5 | 1 | |
| Goats | 962 | 5 | 5 | |
| Horses | 2,718 | 18 | 49 | CO2e Emissions (MT) |
| | | | 2,800 | 78,400 |

## 13. Power Generation at AES Cayuga Power Plant (later known as Cayuga Power)

**SUMMARY**
Input: 2.178 GWh electricity produced for 2008

Output: 1,995,806 MTCO2e

**Methodology, Data & Sources**
2008 power generation: 2.178 GWh
2008 GHG emissions: 1,995,806 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.

## 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 from Scott Bochenek at NYSEG the Heating and Cooling Degree Days. Shows that 2008 had a slightly warmer winter (6% fewer HDD: 6,975 days that required heating vs. 7,403) and a hotter summer (12% more CDD: 387 days that required cooling vs. 342). This indicates that more electricity would be needed in 2008 than 2014 for air conditioning, but less natural gas and other thermal fuels.

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 Methane 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 2008came from traditional vertical wells with a 3.8% methane leakage rate during the full life-cycle from well to delivery to consumers.

This analysis is based on 100g CO2 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 CO2 emitted to mass of methane, (100/44)*16 = 36.4 g CH4 (amount that is burned)

Given the 3.8% leakage rate, that means that 96.2% of total production is burned and 3.8% is leaked into the atmosphere. Therefore, to burn 36.4 g CH4, 37.8 g CH4 must be produced, with 4.9 g CH4 emitted unburned, as calculated below:

Methane Produced: (36.4/0.962) = 37.8g
Unburned Methane Leaked: (37.8-36.4) = 1.4g

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO2e: 1.4*86 = 124g CO2e

## Emissions from Natural Gas Consumed

**Step 1: Determine CO2 emissions from natural gas consumed in community**
Sum emissions figures from residential, commercial (including Cornell) and industrial NYSEG natural gas meters (90,517+113,402+22,456 = 226,375 MTCO2e).

**Step 2: Apply the Example Methodology above to these emissions from natural gas**
Convert 226,375 metric tons CO2 emitted to mass of methane, (226,375/44)*16 = 82,318 metric tons CH4 (amount that is burned)

Given the 3.8% leakage rate, that means that 96.2% of total production is burned and 3.8% is leaked into the atmosphere. Therefore, to burn 82,318 metric tons CH4, 85,570 metric tons CH4 must be produced, with 14,755 metric tons CH4 emitted unburned, as calculated below:

Methane Produced: (82,318/0.962) = 85,570 metric tons CH4

Unburned Methane Leaked: (85,570-82,318) = 3,252 metric tons CH4

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO2e: 3,252*86 = 279,642 metric tons CO2e

## 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 2008 is reported in the eGRID 2005 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 2008 was 3,433,405 MMBtu. (To calculate this figure, MMBtus for NYSEG residential, commercial and industrial electric meters and Cornell electric purchases were summed: 1,001,266+1,209,300+471,644+751,195=3,433,405). Contribution from each of the energy sources is broken down as shown in the table below. For example, apply 15.5% from natural gas to 3,433,405 MMBtu to yield 532,178 MMBtu contributed from natural gas.

| Fuel Mix of Upstate New York | % | MMBtu |
|---|---|---|
| Gas | 15.5 | 532,178 |
| Hydro | 26.4 | 906,419 |
| Nuclear | 27.0 | 927,019 |
| Coal | 21.5 | 738,182 |
| Wind | 0.1 | 3,433 |
| Biomass | 1.2 | 41,201 |
| Other Fossil | 0.4 | 13,734 |
| Oil | 7.8 | 267,806 |
| Solar | 0.0 | 0 |
| Geothermal | 0.0 | 0 |
| Other Unknown/Purchased Fuel | 0.0 | 0 |

Using CarbonSolutions online conversion calculator (http://www.carbonsolutions.com/calculator.html), 532,178 MMBtu of natural gas consumed yields 47,142 MTCO2e (which is really CO2 for the combustion of methane).

**Step 2: Apply the Example Methodology above to these emissions from natural gas**
Convert 47,142 metric tons CO2 emitted to mass of methane, (47,142/44)*16 = 17,143 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 17,143 metric tons CH4, 17,820 metric tons CH4 must be produced, with 2,338 metric tons CH4 emitted unburned, as calculated below:

Methane Produced: (17,143/0.962) = 17,820 metric tons CH4
Unburned Methane Leaked: (17,820-17,143) = 677 metric tons CH4

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO2e: 677*86 = 58,235 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 2008 was 93,846 MMBtu. Contribution from each of the energy sources is broken down as in the table below. Applying 13% to 93,846 yields 12,200 MMBtu.

| Fuel Mix | % |
|---|---|
| Hydro | 76% |
| Gas | 13% |
| Nuclear | 9% |
| Coal | 1% |
| Other Renewables | 1% |

Using CarbonSolutions.com online conversion calculator, 12,200 MMBtu yields 644 MTCO2e (which is really CO2 for the combustion of methane).

Note that this same calculation 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 644 metric tons CO2 emitted to mass of methane, (644/44)*16 = 234 metric tons CH4 (amount that is burned)

Given the 3.8% leakage rate, that means that 96.2% of total production is burned and 3.8% is leaked into the atmosphere. Therefore, to burn 234 metric tons CH4, 243 metric tons CH4 must be produced, with 9 metric tons CH4 emitted unburned, as calculated below:

Methane Produced: (234/0.962) = 243 metric tons CH4
Unburned Methane Leaked: (243-234) = 9 metric tons CH4

Using 20-yr GWP from IPCC (2013) of 86
Converting the unburned emitted methane to CO2e: 9*86 = 796 metric tons CO2e

## Total Emissions from Leaked Natural Gas

Sum all figures above highlighted in yellow. For a 3.8% leakage rate: 338,673MTCO2e.

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