2014 TOMPKINS COUNTY COMMUNITY

GREENHOUSE GAS EMISSIONS AND ENERGY USE INVENTORY

TOMPKINS COUNTY PLANNING DEPARTMENT

SEPTERMBER 2016

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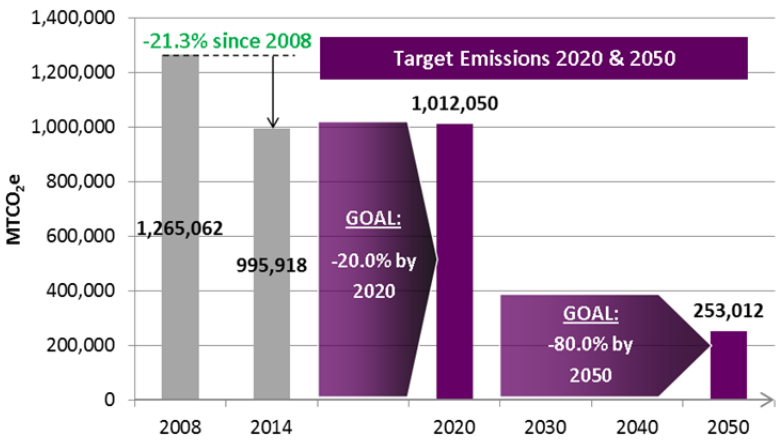
Detailed Methodology Updated 2008 Community Inventory

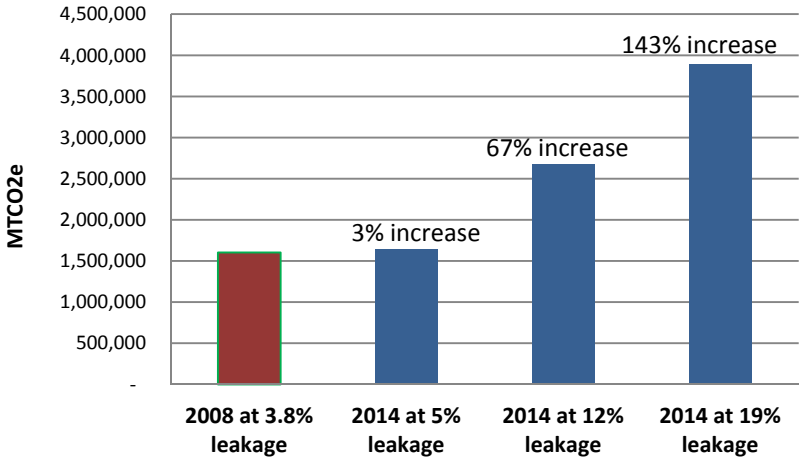
Executive Summary

2014 Tompkins County Community GHG Emissions and Energy Use Inventory



GHG Emissions Goals and Progress - Currently Accepted Accounting

The Tompkins County Community has reduced greenhouse gas (GHG) emissions 21% from 2008 levels by 2014. This is six years ahead of the target goal of a 20% reduction by 2020 and puts the community on a good path to achieve its goal of reducing emissions at least 80% from 2008 levels by 2050. While this is extremely positive news, it must be tempered by the fact that 11% of this reduction has been achieved through a major shift from coal to natural gas to power the electric grid, and there are growing concerns about the impact of natural gas extracted using high-volume hydrofracking techniques on total GHG emissions, including methane.



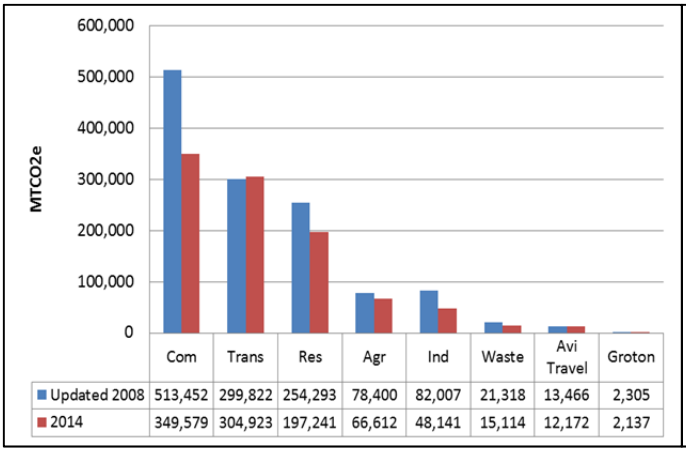
GHG Emissions – New Shale Gas Accounting

Between 2008 and 2014 the source of natural gas used in the community likely transitioned from wells drilled through conventional methods to fracked gas, primarily coming from the Marcellus Shale in Pennsylvania. Emissions associated with fracked shale gas are calculated extremely differently depending on whether one uses currently accepted GHG accounting, or if the findings of evolving climate science on methane are applied. **If the new science is applied, the community has not seen a remarkable 21% reduction in emissions, but instead seen a 67% *increase* in total GHG emissions** between 2008-2014 if the 20-year global warming potential and mid-range overall leakage rate of 12% are applied for methane emissions. Even at the lower-end estimate of 5% leakage, methane impacts would offset any other gains in reducing emissions and the higher leakage range of 19% would result in a 143% increase in emissions. While all recent local studies have pointed to the need to wean ourselves from natural gas regardless of accounting methods, the conclusion that emissions are sharply increasing due to reliance on fracked gas calls for making that transition to renewable energy much more quickly.

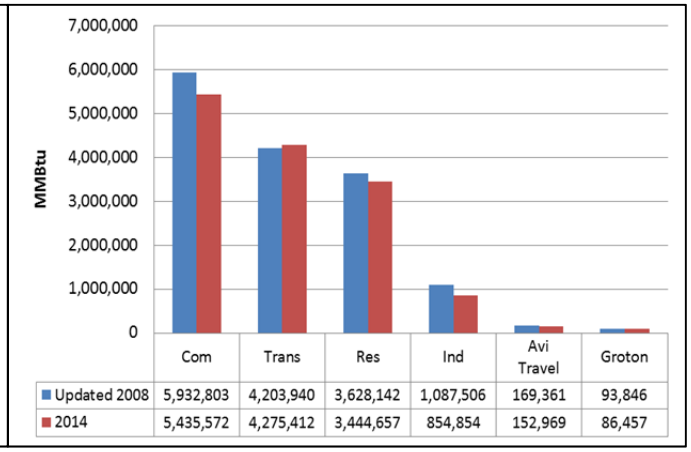
While this tension between two GHG accounting methods runs throughout this document, the main focus is on presenting the results using generally accepted GHG accounting methodologies and calling out differences with new climate science accounting in separate sections of the report. In order to be able to compare the new 2014 GHG Emissions and Energy Use Inventory, it was necessary to prepare a full Updated 2008 Inventory, which substantially revised the Original 2008 Inventory that was released in 2010.

Results: Comparison of Emissions and Energy Use 2008-2014

Energy consumption and GHG emissions were down in all sectors except for a slight rise in the transportation sector due to an increase in the numbers of vehicle miles traveled and a reduction in national on-road vehicle fuel efficiency.



GHG Emissions (MTCO2e)



Energy Use (MMBtu)

The commercial sector saw a significant reduction in emissions, largely due to Cornell's decision to stop using coal and begin using natural gas to produce its heat and electricity. It is notable that Cornell's Central Energy Plant used 27.4 million therms in 2014, accounting for 59% of all natural gas used in the commercial sector.

Emissions continue to remain closely correlated with energy use as energy used in the community is still largely supplied by fossil fuels. There was, however, substantial growth in development of local renewable energy generation between 2008 and 2014, with 3.3 MW of solar coming online and hydro power generation increasing at the Cornell hydro plant. The community saw an overall increase in renewable energy of 136%.

kWh	Updated 2008	2014	% Change
Solar	474,311	4,043,323	753%
Small-Scale	474,311	3,382,993	613%
Large- and Utility-Scale	0	660,330	NA
Hydro – Large-Scale	3,100,000	4,400,000	42%
Micro-hydro	0	0	NA
Wind	0	0	NA
Total Generation	**3,574,311**	**8,443,323**	**136%**

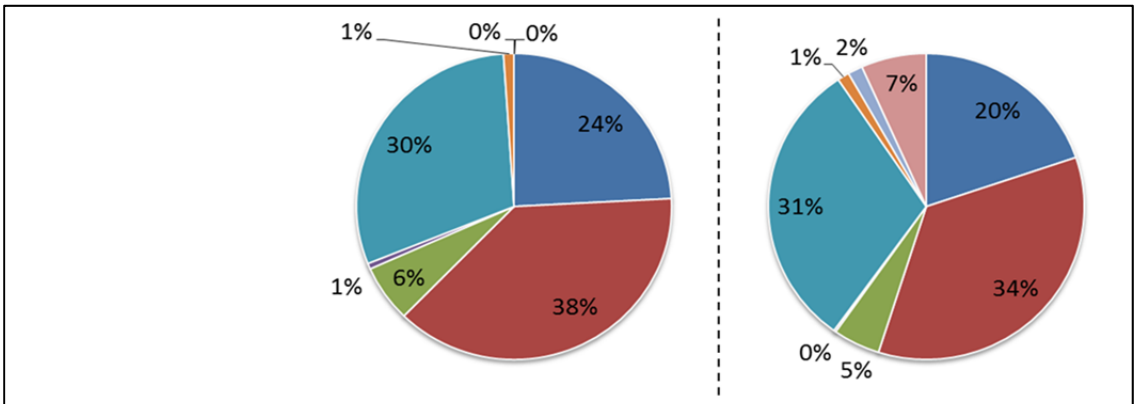
Local Renewable Energy Generation: 2008-2014

Although population has remained relatively flat, the community saw a decrease in energy consumption and emissions on a per person basis across the board, with a 24% reduction in GHG emissions per person between 2008 and 2014.

	Updated 2008	Updated 2008 Per capita	2014	2014 Per capita	% Change 2008-2014
Population (1-yr ACS estimates)	101,136	NA	104,691	NA	NA
Emissions (MTCO2e)	1,265,062	12.51	995,918	9.51	**-24%**
Electricity (kWh)	1,063,778,666	10,518,30	1,068,224,116	10,203.59	**-3%**
Thermal Energy (MMBtu)	7,252,136	71.71	6,313,608	60.31	**-16%**
Transportation (MMBtu)	4,203,940	41.57	4,275,412	40.84	**-2%**

Per Capita Energy and Emissions: 2008-2014

Results: 2014 Emissions and Energy Use



Sectors	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Residential	3,444,657	24%	197,241	20%
Commercial	5,435,572	38%	349,579	35%
Industrial	854,854	6%	48,141	5%
Groton Electric	86,457	1%	2,137	0%
Transportation	4,275,412	30%	304,923	31%
Air Travel	152,969	1%	12,172	1%
Solid Waste	0	0%	15,114	2%
Agricultural Livestock	0	0%	66,612	7%
TOTAL	**14,249,922**	**100%**	**995,918**	**100%**

Summary of 2014 GHG Emissions and Energy Consumption by Sector

Greenhouse Gas Emissions. The total GHG emissions in the county in 2014 were estimated to be 996,000 metric tons of carbon dioxide equivalent (MTCO2e[1]), with 92% of those emissions from fossil fuel consumption and the remainder from landfilled solid waste and agricultural livestock.

Electricity. The total electricity consumed in the community in 2014 was estimated to be 1,068,224,000 kWh[2]. Nearly 90% of that electricity was generated in nearly equal amounts using natural gas, hydro and nuclear power.

Thermal Energy. The total amount of energy consumed for space and water heating in the county in 2014 was estimated to be 6,314,000 million British Thermal Units (MMBtu[3]). In 2014, natural gas provided the overwhelming majority of thermal energy to the community, comprising roughly 79% of the fuel mix.

Transportation. In 2014, the community consumed an estimated 4,275,000 MMBtus of energy to fuel its transportation needs with an estimated 673,174,000 miles traveled over the course of the year. Gasoline accounted for roughly 86% of fuel used with 29 million gallons, and diesel accounted for 14%.

Next Steps. The results of this Inventory will be used to inform development of the update to the 2020 Energy Strategy, as well as future efforts to reduce GHG emissions and reduce consumption of energy in the community.

[1] MTCO2e – a measure of the combined ability of emitted GHGs to trap heat.
[2] kWh – kilowatt hour – a measure of electricity.
[3] MMBtu – a measure of the energy content in fuel; used as a basis for comparing the energy content of various fuels.

2014 Tompkins County Community GHG Emissions and Energy Use Inventory

Introduction

A greenhouse gas emissions inventory provides an accounting of the amount of greenhouse gases (GHG) emitted to the atmosphere during a specific period of time. A greenhouse gas inventory also provides information about the activities that cause emissions and the fuels used to power them. This information is then used to track emissions trends, develop strategies and policies, and assess progress.

The Intergovernmental Panel on Climate Change for the United Nations states that six greenhouse gases should be included in an inventory: Carbon Dioxide (CO2), Nitrous Oxide (N2O), Methane (CH4), Hydrofluorocarbons (HFCs), Perfluorocarbons (PFCs), and sulfur hexafluoride (SF6). For ease of analysis, all the emissions are converted into an equivalent amount of CO2 and reported as metric tons of carbon dioxide equivalent (MTCO2e).

This report quantifies emissions from the entire Tompkins County community including governments, higher education, residents, non-profits and business. Included in this report are results from two inventories of GHG emissions and energy use: 2014 and a significantly updated 2008. Both quantify GHG emissions released within Tompkins County's geographic boundary (plus some emissions that partially occur outside the boundary, such as those associated with air travel and waste disposal).

Since 1998, Tompkins County has tracked community-wide GHG emissions to measure progress towards meeting climate mitigation goals. In 2008, the County Legislature set a goal on behalf of the community to reduce greenhouse gas emissions by at least 20% below 2008 levels by 2020 and 80% below 2008 levels by 2050, setting 2008 as the baseline year. Due to changes in GHG accounting, the 2008 inventory was substantially updated in order to be able to be compared with this 2014 GHG emissions inventory.

The Inventories presented in this report are based upon the *U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version 1.1, July 2013*[4]. 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 emissions.

The Inventory uses Intergovernmental Panel on Climate Change (IPCC) 5th Assessment Report's 100-year Global Warming Potential (GWP) values. The Original 2008 Inventory used the IPCC 2nd Assessment Report's 100-year GWP values, and has been updated to the 5th Assessment 100-year values, as well. In addition, calculations using the latest climate science information on shale gas leakage and methane GWP were included as a separate analysis in this Inventory, to better inform actions to combat climate change.

Another addition to this Inventory is an extremely detailed methodology report for the 2014 Inventory and the Updated 2008 Inventory, which are included as appendices.

In preparing the inventory, three aspects of energy use and GHG emissions were quantified, with color themes carried through the document in order to make the distinctions clear.

[4] Developed in partnership and adopted by the California Air Resources Board, the California Climate Action Registry, ICLEI-Local Governments for Sustainability, and The Climate Registry.

Knowing the source of emissions helps in effectively planning and implementing emissions reduction actions. An emissions inventory creates a quantitative foundation for a community to take concrete actions to address climate change and sustainability.

Overview of Natural Gas Impacts

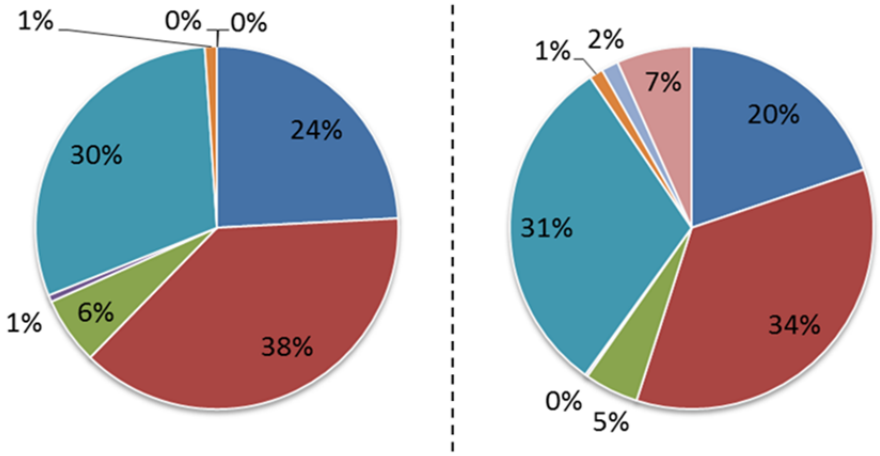
In conducting this analysis it has become clear that the biggest change in our energy system since 2008 has been the increased use of natural gas to generate electricity, largely replacing generation using coal and fuel oil, and the likely change in the source of that gas from wells drilled through conventional methods to fracked gas, primarily from the Marcellus Shale in Pennsylvania. Our methodology, using the protocols relied on by the International Coalition for Local Environmental Initiatives (ICLEI) in developing the ClearPath software tool, does not account for the impact of the change in the source of the natural gas or the increased focus internationally on the significance of methane as a greenhouse gas. Two factors are at play here: first, an international consensus is developing that methane should be accounted for at its 20-year warming impact (80 to 100 times that of carbon dioxide) rather than the 100-year impact (20 times CO2) reflected in the methodology that has been applied to date; and second, evidence suggests that more methane escapes to the atmosphere in the fracking process than from conventional natural gas production and this can have a profound impact on the effect of gas production on the climate. These factors fundamentally alter our understanding of the impacts of use of natural gas in Tompkins County and in drawing electricity from a more natural gas intensive grid.

We are thus faced with the dilemma of trying to use consistent methodology to measure change across time while recognizing that the science is rapidly evolving and methods of calculating emissions will likely change to reflect increasing concern regarding the impacts of methane as a greenhouse gas. So while the ICLEI methodology shows a 21% reduction in emissions from 2008 to 2014, a remarkable accomplishment that would put us ahead of schedule to reach our goal of a 20% reduction by 2020, the real impact on climate change may be a different story. We have tried to accurately portray both stories in this report, one that shows community progress toward our goal based on what we knew in 2008 and another that shows a significant increase in greenhouse gas emissions resulting from the transition to fracked gas. Going forward it is clear that we must rapidly build on our progress by adding more renewable electricity generation in the County and develop strategies to dramatically reduce reliance on natural gas.

2014 Community GHG Emissions and Energy Use Inventory

Summary: 2014 Inventory Results

In 2014, 38% of all energy consumed and 34% of all emissions were from the Commercial Sector. Another third of all energy consumed and emissions came from the Transportation Sector. The Residential Sector contributed 24% to the overall energy consumption and was responsible for 20% of all emissions. Solid Waste and Agricultural Livestock are two sectors which create GHG emissions but do not consume fossil fuel energy. Other sectors tracked in this Inventory include the Industrial Sector, the Village of Groton Electric, and Air Travel.



Sectors	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Residential	3,444,657	24%	197,241	20%
Commercial	5,435,572	38%	349,579	35%
Industrial	854,854	6%	48,141	5%
Groton Electric	86,457	1%	2,137	0%
Transportation	4,275,412	30%	304,923	31%
Air Travel	152,969	1%	12,172	1%
Solid Waste	0	0%	15,114	2%
Agricultural Livestock	0	0%	66,612	7%
TOTAL	**14,249,922**	**100%**	**995,918**	**100%**

Figure 1: Summary of 2014 GHG Emissions[5] and Energy Consumption[6] by Sector

[5] MTCO2e stands for one million metric tons of carbon dioxide equivalent, a measure of the combined ability of emitted GHGs to trap heat.

[6] MMBtu stands for one million British Thermal Units, a measure of the energy content in fuel. MMBtu is used as a basis for comparing the energy content of various fuels.

	Unit Measure	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Residential		**3,444,657**	**24%**	**197,241**	**20%**
Electricity (kWh)	288,178,141	983,541		53,238	
NYSEG Meters	286,094,000	976,430		53,238	
Renewables - Solar	2,084,141	7,111		0	
Natural Gas (therms)	17,774,330	1,777,400		94,535	
Fuel Oil (gallons)	4,113,382	567,647		42,265	
Propane (gallons)	1,275,479	116,069		7,203	
Commercial		**5,435,572**	**38%**	**349,579**	**35%**
Electricity (kWh)	633,443,980	2,161,760		134,661	
NYSEG Meters	396,366,000	1,352,800		73,759	
*Cornell Generation**	212,618,797	725,455		61,546	
Cornell Elect. Purch	56,900,000	194,198		10,588	
Cornell Elect. Export	-38,800,000	-132,391		-11,231	
Renewables - Hydro	4,400,000	15,013		0	
Renewables - Solar	1,959,183	6,685		0	
Natural Gas (therms)	46,441,632	2,897,598		185,461	
NYSEG Meters	19,070,642	1,907,100		101,430	
*Cornell Use**	27,370,990	990,498		84,031	
Fuel Oil (gallons)	2,527,232	338,534		27,118	
Commercial, non-Cornell	2,284,515	317,763		23,695	
Cornell Use	242,717	20,771		3,423	
Propane (gallons)	414,068	37,680		2,338	
Industrial		**854,854**	**6%**	**48,141**	**4.8%**
Electricity (kWh)	121,264,000	413,870		22,566	
Natural Gas (therms)	3,310,951	331,095		17,573	
Fuel Oil (gallons)	677,809	95,296		7,099	
Propane (gallons)	160,359	14,593		902	
Groton Electric (kWh)	**25,337,996**	**86,457**	**0.6%**	**2,137**	**0.2%**
Transportation		**4,275,412**	**30%**	**304,923**	**31%**
Gasoline (gallons)	29,034,150	3,631,500		257,272	
Diesel (gallons)	4,673,058	643,912		47,651	
VMT (miles)	673,173,683				
Passenger Vehicles	522,953,623				
Motorcycles	5,083,389				
Light Trucks (incl. Para-Transit Buses)	112,984,131				
Transit and School Bus	2,923,054				
Medium-Duty Trucks	20,460,640				
Heavy-Duty Trucks	8,768,846				
Air Travel		**152,969**	**1.1%**	**12,172**	**1.2%**
Jet Fuel (gallons)	1,241,929	149,031		11,898	
Aviation Gasoline (gallons)	32,820	3,938		274	
Solid Waste (Landfilled waste, tons)	**49,043**			**15,114**	**1.5%**
Agricultural Livestock (# Animals)	**25,401**			**66,612**	**7%**
TOTAL	**NA**	**14,249,922**	**100.0%**	**995,918**	**100.0%**

** Emissions associated with Cornell's use of natural gas to generate electricity appear in both electricity and natural gas use*

Table 1: Detailed Inventory of 2014 GHG Emissions and Energy Consumption

Analysis by Sector: 2014

Residential Sector

The Residential Sector accounted for 20% of all GHG emissions. Within this sector, natural gas use accounted for nearly half of all emissions and electricity made up 27% of emissions. Although fuel oil consumption accounted for 21% of emissions in this sector, these data are scaled down from State-level data, so may be less accurate than other fuels utilized at the County-level.

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Electricity (kWh)	288,178,141	983,541	28.6%	53,238	27.0%
NYSEG Meters	286,094,000	976,430	28.3%	53,238	27.0%
Renewables - Solar	2,084,141	7,111	0.2%	0	0.0%
Natural Gas (therms)	17,774,330	1,777,400	51.6%	94,535	47.9%
Fuel Oil (gallons)	4,113,382	567,647	16.5%	42,265	21.4%
Propane (gallons)	1,275,479	116,069	3.4%	7,203	3.7%
SUBTOTAL	NA	3,444,657	100.0%	197,241	100.0%

Table 2: Residential Sector 2014 GHG Emissions and Energy Consumption

In addition to energy consumption from fossil fuels, this Inventory tracks consumption from renewable energy sources, which accounted for nearly 1% of total residential electricity consumption (and 0.2% of all residential energy consumption) in 2014. Small-scale solar PV (200 kW or less) provided all of the renewable power to the Residential Sector.

Residential Renewables

	Electricity (kWh)	Energy in MMBtu	Emissions MTCO2e
Small-Scale Solar	2,084,141	7,111	0
% of total sector electricity	0.7%	0.7%	0.0%

Table 3: Residential Sector 2014 Renewables

Commercial Sector

The Commercial Sector accounted for 35% of all GHG emissions. Within this sector, natural gas use accounted for over half of all emissions and electricity made up over a third of emissions.

Accounting for emissions and energy consumption in the Commercial Sector is complicated by the fact that Cornell University both generates and consumes large quantities of energy due to its 15.8 million sq. ft. of gross building space on the Ithaca campus in 2014 and its energy-intensive laboratory and other research needs. Cornell accounted for 17% of all Commercial Sector emissions from electricity and 24% from natural gas. Cornell also accounted for the vast majority of the renewable power generation in this sector, with 327,720 kWh produced in 2014 at its Snyder Road Solar Farm and 4,400,000 kWh produced at its Hydroelectric Plant.

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Electricity (kWh)	633,443,980	2,161,760	39.8%	134,661	38.5%
NYSEG Meters	396,366,000	1,352,800	24.9%	73,759	21.1%
Cornell Generation	212,618,797	725,455	13.3%	61,546	17.6%
Cornell Elect. Purch	56,900,000	194,198	3.6%	10,588	3.0%
Cornell Elect. Export	-38,800,000	-132,391	-2.4%	-11,231	-3.2%
Renewables - Hydro	4,400,000	15,013	0.3%	0	0.0%
Renewables - Solar	1,959,183	6,685	0.1%	0	0.0%
Natural Gas (therms)	46,441,632	2,897,598	53.3%	185,461	53.1%
NYSEG Meters	19,070,642	1,907,100	35.1%	101,430	29.0%
Cornell Use	27,370,990	990,498	18.2%	84,031	24.0%
Fuel Oil (gallons)	2,527,232	338,534	6.2%	27,118	7.8%
Commercial, non-Cornell	2,284,515	317,763	5.8%	23,695	6.8%
Cornell Use	242,717	20,771	0.4%	3,423	1.0%
Propane (gallons)	414,068	37,680	0.7%	2,338	0.7%
SUBTOTAL	**NA**	**5,435,572**	**100.0%**	**349,579**	**100.0%**

Table 4: Commercial Sector 2014 GHG Emissions and Energy Consumption

Renewable energy provided electricity for 1% of total commercial electricity consumption (and 0.4% of all commercial energy consumption) in 2014. In addition to Cornell's renewable installations, Kohl's Ithaca's 308 kW system rounded out the Commercial Sector renewables.

Commercial Renewables

	Electricity (kWh)	Energy in MMBtu	Emissions MTCO2e
Small-Scale Solar	1,298,853	4,432	0
Large- and Utility-Scale Solar	660,330	2,253	0
Hydro	4,400,000	15,013	0
TOTAL	**6,359,183**	**21,698**	**0**
% of total sector electricity	1.0%	1.0%	0.0%

Table 5: Commercial Sector 2014 Renewables

Industrial Sector

The Industrial Sector accounted for 5% of all GHG emissions. Within this sector, electricity accounted for nearly half of all emissions and natural gas made up over a third of emissions. There were no renewable energy sources directly attributed to the Industrial Sector.

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Electricity (kWh)	121,264,000	413,870	48.4%	22,566	46.9%
Natural Gas (therms)	3,310,951	331,095	38.7%	17,573	36.5%
Fuel Oil (gallons)	677,809	95,296	11.1%	7,099	14.7%
Propane (gallons)	160,359	14,593	1.7%	902	1.9%
SUBTOTAL	**NA**	**854,854**	**100.0%**	**48,141**	**100.0%**

Table 6: Industrial Sector 2014 GHG Emissions and Energy Consumption

Village of Groton Electric

The Village of Groton's municipal electric system supplies electricity within the Village's boundaries and accounted for 0.2% of all GHG emissions. The Village has a contract through 2025 to purchase 4,469 KW of hydro power from the New York Power Authority and purchases additional incremental power in cooperation with a group of 35 other municipal systems, called the New York Municipal Power Agency. Emissions calculated in this sector take into account the fact that 86% of this electricity is generated from non-emitting sources, including hydro, nuclear and other renewables.

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Electricity (kWh)	25,337,996	86,457	100.0%	2,137	100.0%

Table 7: Village of Groton Electric 2014 GHG Emissions and Energy Consumption

Transportation

Transportation accounted for 31% of all GHG emissions. The vast majority of those emissions were from gasoline with the remainder from diesel fuel. Vehicles drove approximately 673 million miles in 2014. Although emissions associated with electricity used to charge electric vehicles (EVs) are not separated out from electricity consumption and emissions in other sectors in this Inventory, there were 136 EVs registered in the County as of December 31, 2015, which represents 0.27% of all registered vehicles. Only two other counties had a higher percentage than Tompkins County (New York at 0.30% and Suffolk at 0.28%).[7]

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Gasoline (gallons)	29,034,150	3,631,500	84.9%	257,272	84.4%
Diesel (gallons)	4,673,058	643,912	15.1%	47,651	15.6%
VMT (miles)	673,173,683				
Passenger Vehicles	522,953,623				
Motorcycles	5,083,389				
Light Trucks (incl. Para-Transit Buses)	112,984,131				
Transit and School Bus	2,923,054				
Medium-Duty Trucks	20,460,640				
Heavy-Duty Trucks	8,768,846				
SUBTOTAL	NA	4,275,412	100.0%	304,923	100.0%

Table 8: Transportation 2014 GHG Emissions and Energy Consumption

Air Travel

Air Travel accounted for 1.2% of all GHG emissions. Nearly all of those emissions were due to burning jet fuel, which was the fuel used by all of the commercial carriers operating out of the Ithaca Tompkins Regional Airport.

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Jet Fuel (gallons)	1,241,929	149,031	97.4%	11,898	97.8%
Aviation Gasoline (gallons)	32,820	3,938	2.6%	274	2.2%
SUBTOTAL	NA	152,969	100.0%	12,172	100.0%

Table 9: Air Travel 2014 GHG Emissions and Energy Consumption

[7] Plug-in Electric Vehicle Infrastructure Plan in Tompkins County: Existing Conditions and Best Practices, August 2016, Energetics Incorporated; Clean Communities of Central New York; The Ithaca-Tompkins County Transportation Council

Solid Waste

Solid Waste accounted for 1.5% of all GHG emissions. All of these emissions were from the natural decay of solid waste that was generated in the community and disposed of in landfills outside of the county. All landfills used for disposal of municipal solid waste and bio-solids were equipped with methane collection systems, which reduces the GHG emissions associated with the natural decay of solid waste. In 2014, 67% of all waste was recycled.

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Landfilled Waste (tons)	49,043			15,114	100.0%

Table 10: Solid Waste 2014 GHG Emissions

Agricultural Livestock

Agricultural Livestock accounted for 7% of all GHG emissions. All of these emissions were from farm animals that had methane emissions factors available from the EPA.

	Unit Measure	Energy in MMBtu	% of Subtotal	Emissions MTCO2e	% of Subtotal
Number of Animals	25,401			66,612	100.0%

Table 11: Agricultural Livestock 2014 GHG Emissions

Power Generation at the Cayuga Power Plant (formerly AES Cayuga)

Although this source of emissions is not included in the emissions accounting protocol and therefore not included in the overall community emissions total, it is tracked as part of the Inventory since it is a significant energy facility in the community. In 2014, the Cayuga Power Plant produced 0.916 GWh of electricity and emitted 940,998 MTCO2e.

Analysis by Fuel Source: 2014

All Fuels

Natural gas provided 35% of all the energy needs in the community and a third of all emissions. Gasoline and electricity each provided 25% of the energy needs, however with the increasing penetration of renewables and reduction of the use of coal in electricity generation, electricity only accounted for 23% of the total emissions, while gasoline accounted for 28%. Renewables provided 0.2% of the energy needs of the community.

	Unit Measure	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Natural Gas (therms)	67,526,913	5,006,093	35.1%	297,569	32.5%
Gasoline (gallons)	29,034,150	3,631,500	25.5%	257,272	28.1%
Electricity (kWh) (not incl. hydro or solar)	1,059,780,793	3,616,820	25.4%	212,602	23.3%
Fuel Oil (gallons)	7,318,424	1,001,477	7.0%	76,482	8.4%
Diesel (gallons)	4,673,058	643,912	4.5%	47,651	5.2%
Jet Fuel (gallons)	1,241,929	149,031	1.0%	11,898	1.3%
Propane (gallons)	1,849,906	168,342	1.2%	10,444	1.1%
Aviation Gasoline (gallons)	32,820	3,938	0.0%	274	0.0%
Hydro (kWh)	4,400,000	15,013	0.1%	0	0.0%
Solar (kWh)	4,043,323	13,796	0.1%	0	0.0%
TOTAL	NA	**14,249,922**	**100.0%**	**914,192**	**100.0%**

Table 12: All Fuels 2014 GHG Emissions and Energy Consumption

Electricity

The Commercial Sector consumed 59% of the electricity in the community, with Cornell accounting for 22% of the total electricity consumption. The Residential Sector consumed 27% of the total electrical energy and the Industrial Sector accounted for 11%.

	kWh	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Residential	**288,178,141**	**983,541**	**27.0%**	**53,238**	**25.0%**
NYSEG Meters	286,094,000	976,430	26.8%	53,238	25.0%
Renewables - Solar	2,084,141	7,111	0.2%	0	0.0%
Commercial	**633,443,980**	**2,161,760**	**59.3%**	**134,661**	**63.3%**
NYSEG Meters	396,366,000	1,352,800	37.1%	73,759	34.7%
Cornell Generation	212,618,797	725,455	19.9%	61,546	28.9%
Cornell Elect. Purch	56,900,000	194,198	5.3%	10,588	5.0%
Cornell Elect. Export	-38,800,000	-132,391	-3.6%	-11,231	-5.3%
Renewables - Hydro	4,400,000	15,013	0.4%	0	0.0%
Renewables - Solar	1,959,183	6,685	0.2%	0	0.0%
Industrial	**121,264,000**	**413,870**	**11.4%**	**22,566**	**10.6%**
Groton	**25,337,996**	**86,457**	**2.4%**	**2,137**	**1.0%**
TOTAL	**1,068,224,117**	**3,645,629**	**100.0%**	**212,602**	**100.0%**

Table 13: Electricity: 2014 GHG Emissions and Energy Consumption

Thermal Energy

The Commercial Sector consumed 52% of the thermal energy required to heat spaces and provided hot water in the community, followed by the Residential Sector at 41%.

	Unit Measure	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Residential		**2,598,812**	**41.2%**	**151,456**	**38.6%**
Electricity (kWh)	40,344,940	137,696	2.2%	7,453	1.9%
Natural Gas (therms)	17,774,330	1,777,400	28.2%	94,535	24.1%
Fuel Oil (US gallon)	4,113,382	567,647	9.0%	42,265	10.8%
Propane (US gallon)	1,275,479	116,069	1.8%	7,203	1.8%
Commercial		**3,273,812**	**51.9%**	**214,917**	**54.8%**
Natural Gas (therms)	46,441,632	2,897,598	45.9%	185,461	47.3%
Sub-Category: NYSEG Meters	19,070,642	1,907,100	30.2%	101,430	25.9%
Sub-Category: Cornell Use	27,370,990	990,498	15.7%	84,031	21.4%
Fuel Oil (US gallon)	2,527,232	338,534	5.4%	27,118	6.9%
Sub-Category: Comm, non-Cornell	2,284,515	317,763	5.0%	23,695	6.0%
Sub-Category: Cornell Use	242,717	20,771	0.3%	3,423	0.9%
Propane (US gallon)	414,068	37,680	0.6%	2,338	0.6%
Industrial		**440,984**	**7.0%**	**25,575**	**6.5%**
Natural Gas (therms)	3,310,951	331,095	5.2%	17,573	4.5%
Fuel Oil (US gallon)	677,809	95,296	1.5%	7,099	1.8%
Propane (US gallon)	160,359	14,593	0.2%	902	0.2%
TOTAL	**NA**	**6,313,608**	**100.0%**	**391,948**	**100.0%**

Table 14: Thermal Energy: 2014 GHG Emissions and Energy Consumption

Transportation Fuels

Gasoline accounted for 82% of the transportation related energy consumption in 2014 and accounted for 81% of all emissions.

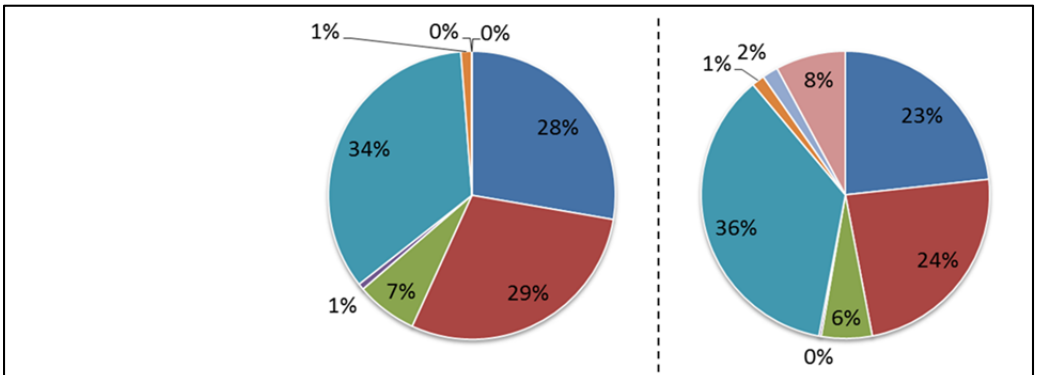
	US Gallon	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Gasoline	29,034,150	3,631,500	82.0%	257,272	81.1%
Diesel	4,673,058	643,912	14.5%	47,651	15.0%
Jet Fuel	1,241,929	149,031	3.4%	11,898	3.8%
Aviation Gasoline	32,820	3,938	0.1%	274	0.1%
TOTAL	34,981,957	4,428,381	100.0%	317,095	100.0%

Table 15: Transportation Fuels: 2014 GHG Emissions and Energy Consumption

Further Analysis to Inform the 2014 Inventory

Removing Cornell University Data

In order to better understand 2014 GHG emissions and energy consumption it is helpful to remove Cornell University from the data to determine whether a) the Commercial Sector remains the largest emitter and b) natural gas remains the largest contributor of GHG emissions. As can be seen in the three tables below, without the contribution of Cornell, transportation jumps to the number 1 spot for both emissions and energy consumption, with Commercial and Residential basically tied for second, and gasoline outpaces natural gas to become the largest contributor to emissions. This indicates that transportation is even more crucial to target for community actions to reduce emissions.



Sectors	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Residential	3,444,657	28%	197,241	23%
Commercial	3,620,910	29%	201,222	24%
Industrial	854,854	7%	48,141	6%
Groton Electric	86,457	1%	2,137	0%
Transportation	4,275,412	34%	304,923	36%
Air Travel	152,969	1%	12,172	1%
Solid Waste	0	0%	15,114	2%
Agricultural Livestock	0	0%	66,612	8%
TOTAL	12,435,260	100%	847,561	100%

Figure 2: Summary without Cornell of 2014 GHG Emissions and Energy Consumption

Commercial Sector without Cornell

	Unit Measure	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Electricity (kWh)	397,997,463	1,358,367	38%	73,759	36.7%
NYSEG Meters	396,366,000	1,352,800	37.4%	73,759	36.7%
Renewables - Solar	1,631,463	5,567	0.2%	0	0.0%
Natural Gas (therms)	19,070,642	1,907,100	52.7%	101,430	50.4%
Fuel Oil (gallons)	2,284,515	317,763	8.8%	23,695	11.8%
Propane (gallons)	414,068	37,680	1.0%	2,338	1.2%
TOTAL	NA	3,620,910	100.0%	201,222	100.0%

Table 16: Commercial Sector without Cornell 2014 GHG Emissions and Energy Consumption

All Fuels without Cornell

Even after removing Cornell's dedicated natural gas line from the equation, natural gas still provided nearly a third of all of the energy needs in the community, however, gasoline accounted for the most emissions of any of the fuel sources.

	Unit Measure	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Gasoline (gallons)	29,034,150	3,631,500	29.2%	257,272	33.6%
Natural Gas (therms)	40,155,923	4,015,595	32.3%	213,538	27.9%
Electricity (kWh) (not including solar)	829,061,996	2,829,557	22.8%	151,700	19.8%
Fuel Oil (gallons)	7,075,707	980,706	7.9%	73,059	9.5%
Diesel (gallons)	4,673,058	643,912	5.2%	47,651	6.2%
Jet Fuel (gallons)	1,241,929	149,031	1.2%	11,898	1.6%
Propane (gallons)	1,849,906	168,342	1.4%	10,444	1.4%
Aviation Gasoline (gallons)	32,820	3,938	0.0%	274	0.0%
Solar (kWh)	3,715,604	12,678	0.1%	0	0.0%
TOTAL	NA	12,435,260	100.0%	765,835	100.0%

Table 17: All Fuels without Cornell 2014 GHG Emissions and Energy Consumption

Applying Latest Climate Science on Shale Gas to Results: 2014

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

Studies conducted by local internationally-renowned experts, including Dr. Bob Howarth and Dr. Tony Ingraffea, have informed this section of the Inventory, with Dr. Howarth providing appropriate figures to include in these calculations. It is estimated that 5-19% of unburned methane leaks from the production well through transmission and distribution to where combustion occurs in the home, business, or electric generating plant, due in large part to the techniques employed by the shale gas industry. The analysis applies leakage rates of 5%, 12% and 19% to all natural gas consumed in the community, including the portion used to generate electricity.

In addition to the leakage of methane due to shale gas development, transmission and distribution, is the consideration of the appropriate timescale for GWP of methane. Methane is an extremely impactful GHG in the short-term, with a greenhouse warming effect of >100-fold more than carbon dioxide. Given the current state of the Earth's climate, the Earth is predicted to warm by 1.5° C above the preindustrial baseline within the next 15 years and by 2° C within the next 35 years[8] giving new urgency to the role of methane in the short-term. Standard GHG accounting principles applied elsewhere in this report call for the use of the 100-year GWP for greenhouse gases, which is appropriate for the other GHGs. However this special analysis applies the 20-year GWP for methane of 86 to all methane emissions in 2014.

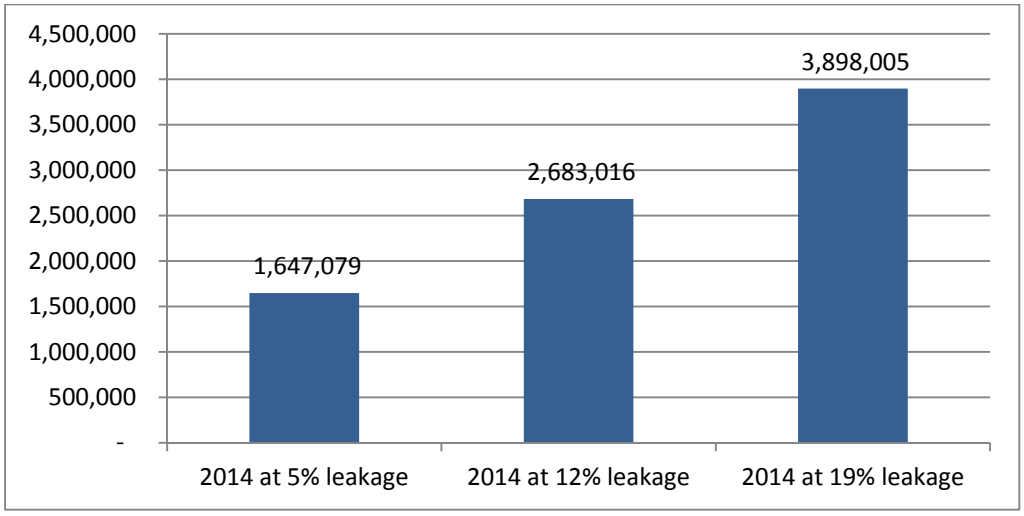


Figure 3: 2014 Emissions at 5%, 12% and 19% Methane Leakage and GWP of 86

	2014 with 100-yr GWP and without Leakage	2014 New Accounting 5th IPCC 20-yr GWP for Methane with 5% Leakage	2014 New Accounting 5th IPCC 20-yr GWP for Methane with 12% Leakage	2014 New Accounting 5th IPCC 20-yr GWP for Methane with 19% Leakage
MTCO2e from Leaked Methane	n/a	651,161	1,687,098	2,902,087
Total Community MTCO2e with Leakage	995,918 without	1,647,079	2,683,016	3,898,005

Table 18: 2014 Emissions at 5%, 12% and 19% Methane Leakage and GWP of 86

Weather Conditions in 2014

In 2014, there were 7,403 Heating Degree Days (HDD) where the average temperature was below 65° Fahrenheit, the temperature below which buildings are considered to need to be heated. There were 342 Cooling Degree Days (CDD) where the average temperature is above 65° Fahrenheit and people start to use air conditioning to cool their buildings. During the past 45 years (1970-2015), there were an average of 7,091 Heating Degree Days and 432 Cooling Degree Days. This indicates that 2014 was cooler in the summer and colder in the winter than past years. Therefore, one would expect that less electricity would be needed in 2014 compared to the past 45 years for air conditioning, and more natural gas and other thermal fuels for space heating.

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

	HDD Higher number = colder winter	CDD Higher number = hotter summer
2008	6975	387
2009	7031	272
2010	6641	622
2011	6615	526
2012	6202	543
2013	7106	479
2014	7403	342
2015	6954	445
Average 1970-2015	7,091	432

Table 19: Historical Heating and Cooling Degree Days

Updated 2008 Community GHG Emissions and Energy Use Inventory

Summary of 1998-2008 Inventories Comparison

In 2010, the County Planning Department released the "Tompkins County Community Greenhouse Gas Emissions Report, 1998-2008" in which it presented the results of the 2008 GHG Emissions Inventory (the "Original 2008 Inventory"), as well as looked back to the initial 1998 GHG emissions inventory and compared results. While it is no longer possible to compare the 1998 Inventory with the Updated 2008 or 2014 Inventories due to substantial changes in methodology and accuracy, it is helpful to see that the community had achieved reductions of 6.9% in GHG emissions during that 10 year time period. That Original 2008 Inventory compared to the 1998 Inventory yielded the following results.

	1998	Original 2008	Original 2008 adjusted to compare to 1998
MTCO2e	1,109,892	1,172,918	1,033,072
Modifications to 2008 to Make Comparable to 1998			Subtracted 139,846 MTCO2e because Cornell Power Generation was not included in 1998
Percent Change	n/a	n/a	-6.9%

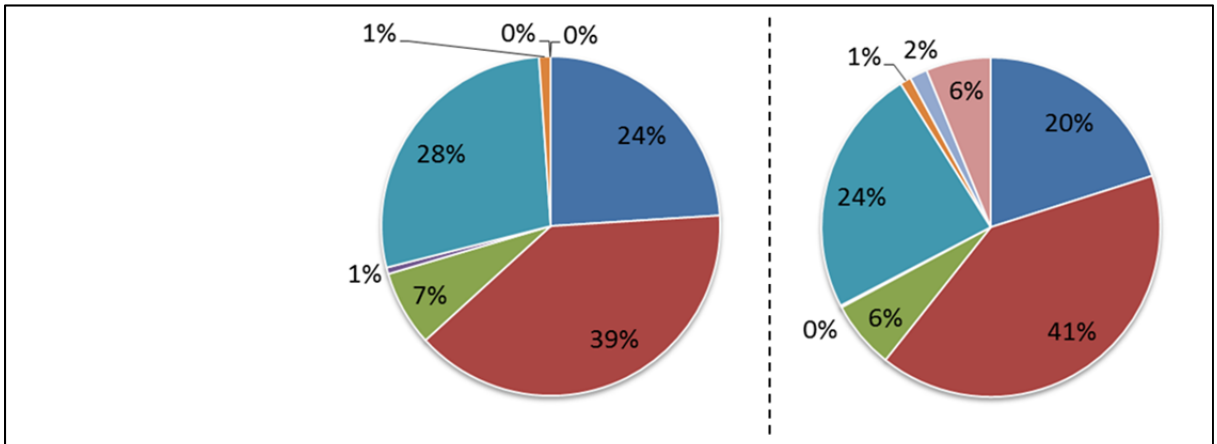
Table 20: Past GHG Emissions Totals – Not Comparable to 2014 or Updated 2008 Inventories

Since 2008 was selected as the baseline year for the County's GHG emission reduction goals, it was necessary to significantly update the 2008 Emissions Inventory to make it comparable to the 2014 Inventory and make it compliant with the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, Version 1.1, July 2013. The full list of changes made to the Original 2008 Inventory is presented in two appendices to this report: 1) the Updated 2008 Community Greenhouse Gas Emissions and Energy Use Inventory and 2) the Updated 2008 Community Detailed Methodology

Summary of Updated 2008 Community GHG and Energy Use Inventory

As can be seen in the summary figures below, in 2008, 39% of all energy consumed and 41% of all emissions were from the Commercial Sector. The second largest energy user and emitter was the Transportation Sector, followed closely by the Residential Sector. Solid Waste and Agricultural Livestock are two sectors which create

GHG emissions but do not consume fossil fuel energy. Other sectors tracked in the Updated 2008 Inventory include the Industrial Sector, the Village of Groton Electric, and Air Travel.



Sectors	Energy in MMBtu	% of Total	Emissions MTCO2e	% of Total
Residential	3,628,142	24%	254,293	20%
Commercial	5,932,803	39%	513,452	41%
Industrial	1,087,506	7%	82,007	6%
Groton Electric	93,846	1%	2,305	0%
Transportation	4,203,940	28%	299,822	24%
Air Travel	169,361	1%	13,466	1%
Solid Waste	0	0%	21,318	2%
Agricultural Livestock	0	0%	78,400	6%
TOTAL	**15,115,599**	**100%**	**1,265,062**	**100%**

Figure 4: Summary of Updated 2008 GHG Emissions and Energy Consumption by Sector

Since many community efforts have used the Original 2008 Inventory results to plan programs, below is a table comparing the Original 2008 Inventory with the Updated 2008 Inventory. Only the Updated Inventory should be used in the future, as it was significantly corrected and improved from the original.

MTCO2e	***Original 2008 Community Emissions***		***Updated 2008 Community Emissions***	
	Overall Total = 1,172,918 MTCO2e		Overall Total = 1,273,042 MTCO2e (including 13,466 MTCO2e from aviation travel but not listed below)	
	Total Emissions	**Percent of Total**	**Total Emissions**	**Percent of Total**
Residential	233,469	19.9	254,293	20.0
Commercial	232,081	19.8	287,588 (does not include Cornell CEP)	22.6
Industrial	74,265	6.3	82,007	6.4
Transportation	407,469	34.7	299,822	23.6
Waste	41,792	3.6	29,298	2.3

Agriculture	43,996	3.8	78,400	6.2
Local Power Generation (Cornell CEP and Groton Electric)	139,846	11.9	228,169	17.9
Energy Source				
Electricity	256,203	21.8	258,255 (does not include Cornell CEP or Groton Electric)	20.3
Natural Gas	226,427	19.3	226,375	17.8
Fuel Oil	22,837	1.9	128,906	10.1
Propane	34,348	2.9	10,352	0.8
Gasoline	337,866	28.8	253,715	19.9
Diesel	69,603	5.9	46,107	3.6
Methane (Ag +Waste)	85,788	7.3	107,698	8.5
Local Power Generation (Cornell CEP and Groton Electric)	**139,846**	**11.9**	**228,169**	17.9

Table 21: Comparison of Original 2008 and Updated 2008 GHG Emissions

Results: Emissions and Energy Use 2008 -2014

Summary

During the six years from 2008-2014, the Tompkins County community was able to reduce GHG emissions by 21.3%. This meets the goal of a 20% reduction by 2020 when using standard GHG emissions accounting principles. If, however, new accounting methods for shale gas are applied, the outlook is much less positive, as is explained in a separate section below.

Emissions for all sectors declined except for Transportation, which rose 1.7%. The largest decline in emissions was from the Industrial and Commercial Sectors.

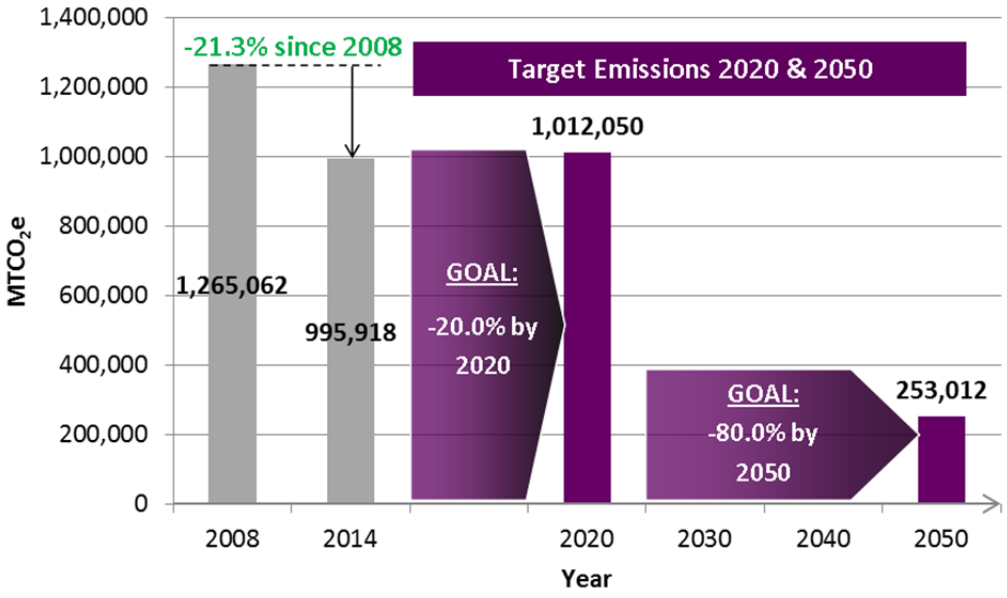


Figure 5: GHG Emissions Goals and Progress - Currently Accepted Accounting

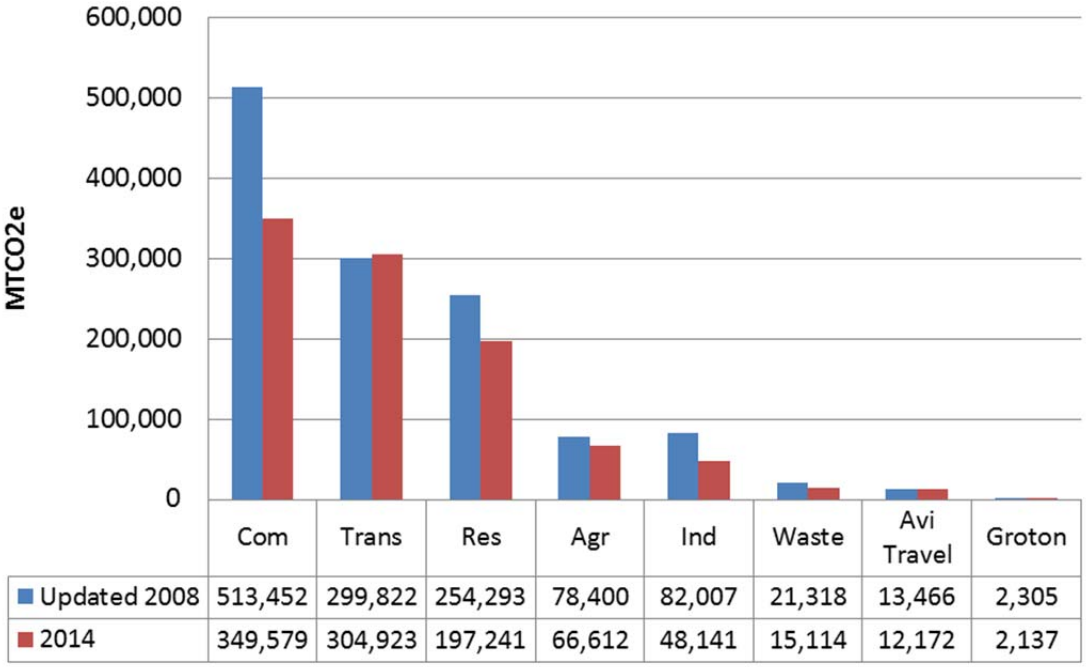


Figure 6: Summary of Emissions 2008-2014

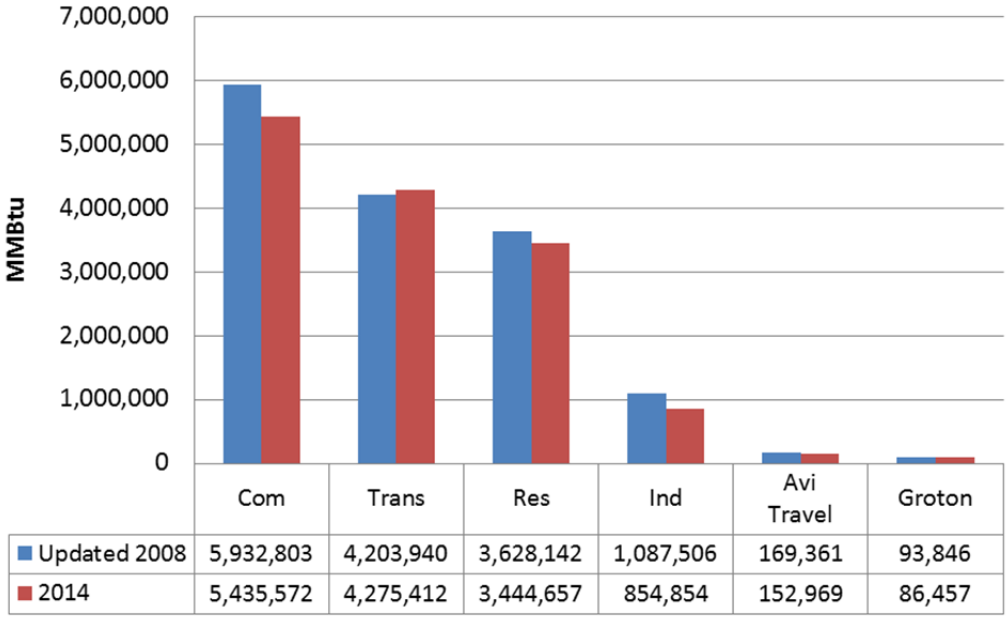


Figure 7: Summary of Energy Consumption 2008-2014

Community Energy Consumption and Emissions Caveats and Trends

Overarching Considerations

Weather Conditions in 2008 and 2014

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

2014 than 2008. In fact, the results were exactly opposite: electricity consumption increased 0.4% from 2008-2014 and thermal energy declined 13%. This shows that weather is only one factor in fuel consumption.

	2008	2014	Change	Percent Change
HDD (<65°need heat) Higher number = colder winter	6,975	7,403	428	6%
CDD (>65°need a.c.) Higher number = hotter summer	387	342	-45	-12%

Table 22: Heating and Cooling Degree Days 2008-2014

NYSEG Electric and Natural Gas Meters

While these data are provided directly from NYSEG, it is important to remember that electric and gas figures are based on billed consumption based on the calendar year in which the meter was billed (regardless of dates of consumption or whether or not it was an estimated bill or actual meter-read), which has inherent inconsistencies and make it difficult to accurately track changes from year to year.

Changes in the Electric Grid

There were large changes in the fuels used to generate electricity between 2008 and 2014, with wind, natural gas, biomass, hydro and nuclear growing as a percentage of the mix and oil and coal dropping substantially. This transition, primarily from coal to natural gas, resulted in an 11% reduction in GHG emissions between 2008 and 2014 using current GHG emissions accounting protocols. Therefore, over half of the 21% reduction was due to the changing grid fuel mix. If new climate science regarding leakage from shale gas extraction and distribution is applied to natural gas, the story is flipped and the changing grid goes from a help to a significant liability. A full discussion of the impact of shale gas is included in other sections of this Inventory.

Inventory Year Fuel Mix of Upstate NY in Percent	2008 (%) (EPA eGRID 2005)	2014 (%) (EPA eGRID 2012)	Percent Change
Natural Gas	15.5	30.4	96%
Hydro	26.4	29.2	11%
Nuclear	27.0	28.9	7%
Coal	21.5	5.5	-74%
Wind	0.1	3.6	3,500%
Biomass	1.2	1.8	50%
Other Fossil	0.4	0.4	0%
Oil	7.8	0.2	-97%
Solar	0.0	0.0	0%
Geothermal	0.0	0.0	0%
Other Unknown/Purchased Fuel	0.0	0.0	0%

Table 23: Electricity Generation: Fuel Mix of Upstate New York 2008-2014

Fuel Oil and Propane

Fuel oil and propane are distributed by many private companies in the area and are therefore very hard to quantify at the local level. The best available source for these fuels was State-wide information from the U.S. Energy Information Administration that was scaled down using comparisons of known consumption of electricity and natural gas in Tompkins County and those ratios applied to fuel oil and propane. While these are good proxies for the data and indicate statewide trends, they are not ground truthed for conditions in Tompkins County and must therefore be viewed with some skepticism.

Trends

Energy consumption and GHG emissions were down in all sectors except for a slight rise in the Transportation Sector due to an increase in the numbers of vehicle miles traveled and a reduction in national on-road vehicle fuel efficiency.

The Commercial Sector saw a significant reduction in emissions, largely due to Cornell's decision to stop using coal and begin using natural gas to produce its heat and electricity. It is notable that Cornell's Central Energy Plant used 27.4 million therms in 2014, accounting for 59% of all natural gas used in the commercial sector.

Emissions continue to remain closely correlated with energy use as renewable energy is still largely dependent on fossil fuels. There was, however, substantial growth in development of local renewable energy generation between 2008 and 2014, with 3.3 MW of solar coming online and hydro power generation increasing at the Cornell hydro plant. This resulted in a 136% increase in renewable energy generation during this time period.

kWh	Updated 2008	2014	% Change
Solar	474,311	4,043,323	752.5%
Small-Scale	474,311	3,382,993	613.2%
Large- and Utility-Scale	0	660,330	NA
Hydro – Large-Scale	3,100,000	4,400,000	41.9%
Micro-hydro	0	0	NA
Wind	0	0	NA
Total Generation	**3,574,311**	**8,443,323**	**136%**

Table 24: Local Renewable Energy Generation 2008-2014

Comparison by Sector: 2008-2014

Residential Sector

The Residential Sector experienced a decline of 22% in emissions from 2008 to 2014, however energy use in the sector only declined 5%. This was primarily due to significant reductions in the emissions from electricity and fuel oil. Consumption of electricity only declined 2%, so it seems that the reduction in emissions can be explained by a grid powered by more natural gas (using current accounting practices), more renewables and less coal as well as the exponential growth in solar PV in the community (up by 369% from 2008). Fuel oil consumption declined 30%, however, these data are scaled down from NYS data.

Unit Measure	Updated 2008	2014	% Change
Natural Gas (therms)	17,018,828	17,774,330	4.4%
Electricity (kWh)	293,815,424	288,178,141	-1.9%

NYSEG Res Figure *Solar*	293,371,081 444,343	286,094,000 2,084,141	-2.5% 369.0%
Fuel Oil (US gal)	5,880,828	4,113,382	-30.1%
Propane (US gal)	1,229,918	1,275,479	3.7%
MMBtu	**Updated 2008**	**2014**	**% Change**
Natural Gas	1,701,883	1,777,400	4.4%
Electricity	1,002,782	983,541	-1.9%
NYSEG Res Figure *Solar*	1,001,266 1,516	976,430 7,111	-2.5% 369.0%
Fuel Oil	811,554	567,647	-30.1%
Propane	111,923	116,069	3.7%
TOTAL	**3,628,142**	**3,444,657**	**-5.1%**
MTCO2e	**Updated 2008**	**2014**	**% Change**
Natural Gas	90,517	94,535	4.4%
Electricity	96,405	53,238	-44.8%
Fuel Oil	60,425	42,265	-30.1%
Propane	6,946	7,203	3.7%
TOTAL	**254,293**	**197,241**	**-22.4%**

Table 25: GHG Emissions and Energy Use in the Residential Sector, 2008-2014

Another way to look at the residential data is by household. Although the number of households has remained relatively flat, the community saw a decrease in energy consumption and emissions on a per household basis across the board, with a 24% reduction in GHG emissions per household between 2008 and 2014.

	Updated 2008	Updated 2008 Per HH	2014	2014 Per HH	% Change 2008-2014
Households (1-yr ACS estimates)	37,443	NA	38,120	NA	NA
Natural Gas (therms)	17,018,828	454.53	17,774,330	466.27	-2.6%
Electricity (kWh)	293,815,424	7,847.01	288,178,141	7,559.76	-3.7%
Emissions ($MTCO_2e$)	254,293	6.79	197,241	5.17	-23.8%

Table 26: GHG Emissions and Energy Use by Household, 2008-2014

Commercial Sector

The Commercial Sector includes businesses, municipal government, non-profits, higher education and most multi-unit residential buildings, depending on how NYSEG classifies the meters. This sector experienced a decline of 32% in emissions from 2008 to 2014, however energy use in the sector decreased only 8%. One significant change in during this time period was Cornell's decision to stop using coal at its Central Energy Plant in 2009 and switch to natural gas. This is reflected in the fact that use of natural gas in this sector rose 118% even though non-Cornell commercial operations reduced its use by 5%. Cornell used 27.3 million therms of natural gas in 2014, accounting for 59% of all natural gas used in the commercial sector.

Additionally, consumption of coal dropped to zero in 2014. Another change at Cornell that impacted this sector was that Cornell's Combined Heat and Power Project had not yet begun operations in 2008, so electricity generation at Cornell increased 696%, while the non-Cornell commercial electricity consumption went up 12%.

Another change of note was the7,485% increase in fuel oil used by Cornell's Central Energy Plant in 2014 compared to 2008. This was explained by the need to rent fuel oil-fired boilers in 2014 to provide back-up heat in the event of primary boiler or turbine failure while Cornell waited for the installation of new boilers. Since

2014, Cornell has installed new additional permanent back-up gas-fired boilers and no longer needs temporary boilers. In addition, in 2014 Cornell lost its natural gas supply for a day during the polar vortex and it was necessary to fire an unusual amount of fuel oil during that period.

In addition to Cornell's energy decisions, 2008-2014 was a time of substantial commercial growth in the community, including construction of 830 new multifamily units, several hotels and other retail and office space. This was somewhat balanced by a reduction in the industrial sector resulting in part from the 2009 shuttering of Emerson Power Transmission and it's 800,000 sq.ft. of manufacturing space.

Renewable energy saw huge growth from 2008-2014, with growth in solar PV of 6,438% and increased production at Cornell's hydro plant of 42% due to lack of ice impacting production in 2014, as well as a turbine re-build project between 2008 and 2014 that improved hydro plant operations.

Unit Measure	Updated 2008	2014	% Change
Total Natural Gas (therms)	21,321,612	46,441,632	117.8%
NYSEG Commercial Figure	20,110,612	19,070,642	-5.2%
Cornell CEP Use	1,211,000	27,370,990	2160.2%
Total Electricity (kWh)	604,267,968	633,443,980	4.8%
NYSEG Commercial Figure	354,338,000	396,366,000	11.9%
Cornell CEP Generation	26,700,000	212,618,797	696.3%
Cornell Elec Purchase	220,100,000	56,900,000	-74.1%
Cornell Elec Export	0	-38,800,000	NA
Solar	29,968	1,959,183	6437.6%
Hydro	3,100,000	4,400,000	41.9%
Total Fuel Oil (US gal)	5,205,396	2,527,232	-51.4%
Commercial Figure	5,202,196	2,284,515	-56.1%
Cornell CEP Use	3,200	242,717	7484.9%
Propane (US gal)	403,975	414,068	2.5%
Coal (ton)	65,420	0	-100.0%
MMBtu	**Updated 2008**	**2014**	**% Change**
Total Natural Gas	2,132,161	2,897,598	35.9%
NYSEG Commercial Figure	2,011,061	1,907,100	-5.2%
Cornell CEP Use	121,100	990,498	717.9%
Total Electricity	2,062,279	2,161,760	4.8%
NYSEG Commercial Figure	1,209,300	1,352,800	11.9%
Cornell CEP Generation	91,104	725,455	696.3%
Cornell Elec Purchase	751,195	194,198	-74.1%
Cornell Elec Export	0	-132,391	NA
Solar	10,578	15,013	41.9%
Hydro	102	6,685	41.9%
Total Fuel Oil	740,893	338,534	-54.3%
Commercial Figure	740,606	317,763	-57.1%
Cornell CEP Use	287	20,771	7139.7%
Propane	36,762	37,680	2.5%
Coal	960,709	0	-100.0%
TOTAL	**5,932,804**	**5,435,572**	**-8.4%**
MTCO2e	**Updated 2008**	**2014**	**% Change**
Total Natural Gas	113,402	185,461	63.5%
NYSEG Commercial Figure	106,961	101,430	-5.2%
Cornell CEP Use	6,441	84,031	1204.7%
Total Electricity	202,062	134,661	-33.4%
NYSEG Commercial Figure	116,439	73,759	-36.7%

Cornell CEP Generation	13,296	61,546	362.9%
Cornell Elec Purchase	72,327	10,588	-85.4%
Cornell Elec Export	0	-11,231	NA
Solar	0	0	NA
Hydro	0	0	NA
Fuel Oil	55,503	27,118	-51.1%
Commercial Figure	55,466	23,695	-57.3%
Cornell CEP Use	37	3,423	9151.4%
Propane	2,281	2,338	2.5%
Coal	140,204	0	-100.0%
TOTAL	513,452	349,579	-31.9%

Table 27: GHG Emissions and Energy Use in the Commercial Sector, 2008-2014

Industrial Sector

The Industrial Sector saw a 41% reduction in emissions, however energy use in the sector only declined 21%. A lot of these reductions were from a 45% reduction in fuel oil consumption and 20% reduction in propane consumption. These data, however, are scaled down from NYS data and are not ground-truthed for conditions in Tompkins County so are less accurate than other data sources in this report.

Unit Measure	Updated 2008	2014	% Change
Electricity (kWh)	138,191,663	121,264,000	-12.2%
Natural Gas (therms)	4,231,084	3,310,951	-21.7%
Fuel Oil (US gal)	1,236,145	677,809	-45.2%
Propane (US gal)	199,918	160,359	-19.8%
MMBtu	**Updated 2008**	**2014**	**% Change**
Electricity	471,644	413,870	-12.2%
Natural Gas	423,108	331,095	-21.7%
Fuel Oil	174,561	95,296	-45.4%
Propane	18,193	14,593	-19.8%
TOTAL	1,087,506	854,854	-21.4%
MTCO2e	**Updated 2008**	**2014**	**% Change**
Electricity	45,411	22,566	-50.3%
Natural Gas	22,456	17,573	-21.7%
Fuel Oil	13,015	7,099	-45.5%
Propane	1,125	902	-19.8%
TOTAL	82,007	48,141	-41.3%

Table 28: GHG Emissions and Energy Use in the Industrial Sector, 2008-2014

Village of Groton Electric

The Village of Groton reduced the amount of electricity it purchased by 8% between 2008 and 2014, resulting in a 7% reduction in emissions.

kWh	Updated 2008	2014	% Change
Electricity	27,503,611	25,337,996	-7.9%
MMBtu	**Updated 2008**	**2014**	**% Change**
	93,846	86,457	-7.9%

MTCO2e	Updated 2008	2014	% Change
	2,305	2,137	-7.3%

Table 29: GHG Emissions and Energy Use in the Village of Groton, 2008-2014

Transportation

Vehicle miles traveled (VMT) stayed essentially flat between 2008 and 2014, however average miles per gallon for the various vehicle classes actually decreased during this time, which impacted energy use and emissions results. Emissions rose 2% from 2008-2014.

There are several caveats with these transportation data, however, that should be considered when comparing them from year to year. VMT is based on versions of modeling software that changes over time and reflects only residential journey-to-work trips with bus miles driven added to the total and truck and motorcycle miles driven also added based on estimates of percentage of those vehicles in local class counts. In 2008, these class counts were not available, so 2014 class counts were applied to the 2008 data.

The other concern is that the miles per gallon data by vehicle class (e.g., "passenger vehicles") from National Transportation Statistics are not fine-grained enough to be able to see much change in emissions from local conversion to electric vehicles, hybrids, or very fuel efficient vehicles. Even if the local mix becomes highly efficient or electrified, these numbers will not change until such changes are seen on the national level. This is why the number of electric vehicles registered in Tompkins County is now being tracked – going from 0 to 136 by the end of 2015.

US gal	Updated 2008	2014	% Change
Gasoline	28,645,469	29,034,150	1.4%
Diesel	4,532,055	4,673,058	3.1%
TOTAL	33,177,524	33,707,208	1.6%
MMBtu	Updated 2008	2014	% Change
Gasoline	3,580,900	3,631,500	1.4%
Diesel	623,040	643,912	3.4%
TOTAL	4,203,940	4,275,412	1.7%
MTCO2e	Updated 2008	2014	% Change
Gasoline	253,715	257,272	1.4%
Diesel	46,107	47,651	3.3%
TOTAL	299,822	304,923	1.7%

Table 30: GHG Emissions and Energy Use in the Transportation Sector, 2008-2014

Fuel	Vehicle	Annual VMT		
		Updated 2008	2014	% Change
Gasoline	Passenger Vehicle	521,667,155	522,953,623	0.2%
	Motorcycle	5,070,884	5,083,389	0.2%
	Light Truck (incl Gadabout)	112,707,455	112,984,131	0.2%
	Subtotal	**639,445,494**	**641,021,143**	0.2%
Diesel	Transit & School Bus	2,800,000	2,923,054	4.4%
	Medium Truck	20,156,762	20,460,640	1.5%
	Heavy Truck	8,747,274	8,768,846	0.2%

	Subtotal	**31,704,037**	**32,152,540**	1.4%
Total		**671,149,530**	**673,173,683**	**0.3%**

Table 31: Vehicle Miles Traveled by Vehicle Class, 2008-2014

Air Travel

The amount of fuel used to power aircraft flying out of the Ithaca Tompkins Regional Airport declined by 10% between 2008 and 2014, correlating to similar decreases in emissions and energy use.

US Gallon	Updated 2008	2014	% Change
Jet Fuel	1,367,012	1,241,929	-9.2%
Aviation Gasoline	44,334	32,820	-26.0%
TOTAL	1,411,346	1,274,749	-9.7%
MMBtu	**Updated 2008**	**2014**	**% Change**
Jet Fuel	164,041	149,031	-9.2%
Aviation Gasoline	5,320	3,938	-26.0%
TOTAL	169,361	152,969	-9.7%
MTCO2e	**Updated 2008**	**2014**	**% Change**
Jet Fuel	13,096	11,898	-9.1%
Aviation Gasoline	370	274	-26.0%
TOTAL	13,466	12,172	-9.6%

Table 32: GHG Emissions and Energy Use in Air Travel, 2008-2014

Solid Waste

In 2014, 67% of all waste was recycled and there was a 31% reduction in the amount of waste sent to landfills from 2008-2014. This correlated to a reduction in emissions from the sector of 29%.

Short Tons	Updated 2008	2014	% Change
Total Waste	185,724	149,756	-19.4%
Recycled Waste	114,994	100,713	-12.4%
Disposed of Waste in Landfills	70,730	49,043	-30.7%
MTCO2e	**Updated 2008**	**2014**	**% Change**
Waste	21,318	15,114	-29.1%

Table 33: GHG Emissions in the Solid Waste Sector, 2008-2014

Agricultural Livestock

There were 19% fewer cattle, sheep, hogs, goats and horses reported in 2014 than 2008. This reduction amounted to a 15% decrease in emissions from this sector.

Number	Updated 2008	2014	% Change
Cattle and calves	23,639	19,797	-16.3%
Sheep and lambs	3,355	1,904	-43.2%
Hogs and pigs	606	750	23.8%
Goats	962	520	-45.9%
Horses	2,718	2,430	-10.6%
TOTAL	31,280	25,401	-18.8%

MTCO2e	Updated 2008	2014	% Change
Agriculture	78,400	66,612	-15.0%

Table 34: GHG Emissions in the Agricultural Livestock Sector, 2008-2014

Power Generation at the Cayuga Power Plant (formerly AES Cayuga)

Cayuga Power Plant reduced generation and emissions significantly between 2008 and 2014 as the price for natural gas plummeted and made the coal-fired plant less economically competitive on the wholesale electricity market.

	2008	2014	Percent Change
Power Generation (GWh)	2.178	0.916	-41.1%
Emissions (MTCO2e)	1,995,806	940,997	-52.9%

Table 35: Power Generation and GHG Emissions at the Cayuga Power Plant, 2008-2014

Comparison by Fuel Source: 2008-2014

All Fuels

Between 2008 and 2014, there were major changes in the types of energy consumed and their resulting emissions. Major changes in use of coal, natural gas and fuel oil are explained to a large degree by the conversion from coal to natural gas by Cornell University and the unusual use of fuel oil required by Cornell in 2014, all explained in the Commercial Sector analysis. Electricity emissions declined by 39%, which is discussed in greater detail in the next section, below.

Unit Measure	Updated 2008	2014	% Change
Gasoline (US	28,645,469	29,034,150	1.4%
Diesel	4,532,055	4,673,058	3.1%
Natural Gas	42,571,524	67,526,913	58.6%
Electricity	1,063,778,666	1,068,224,116	0.4%
Fuel Oil	12,322,370	7,318,424	-40.6%
Propane	1,833,811	1,849,906	0.9%
Jet Fuel	1,367,012	1,241,929	-9.2%
Aviation Gasoline	44,334	32,820	-26.0%
Coal	65,420	0	-100.0%
TOTAL	NA	NA	NA
MMBtu	**Updated 2008**	**2014**	**% Change**
Gasoline	3,580,900	3,631,500	1.4%
Diesel	623,040	643,912	3.4%
Natural Gas	4,257,152	5,006,093	17.6%
Electricity	3,630,551	3,645,629	0.4%
Fuel Oil	1,727,008	1,001,477	-42.0%
Propane	166,878	168,342	0.9%
Jet Fuel	164,041	149,031	-9.2%
Aviation Gasoline	5,320	3,938	-26.0%
Coal	960,709	0	-100.0%
TOTAL	15,115,599	14,249,922	-5.7%

MTCO2e	Updated 2008	2014	% Change
Gasoline	253,715	257,272	1.4%
Diesel	46,107	47,651	3.3%
Natural Gas	226,375	297,569	31.4%
Electricity	346,183	212,602	-38.6%
Fuel Oil	128,943	76,482	-40.7%
Propane	10,352	10,444	0.9%
Jet Fuel	13,096	11,898	-9.1%
Aviation Gasoline	370	274	-26.0%
Coal	140,204	0	-100.0%
TOTAL	1,165,345	914,191	-21.6%

Table 36: All Fuels Use and Emissions, 2008-2014

Electricity

The community saw a 39% reduction in emissions from the electricity it consumed between 2008 and 2014, despite a slight increase in the amount of electricity used. This can be attributed to the transformation of the way electricity is being generated with more natural gas (with lower emission than coal using current accounting practices), more renewables and less coal as well as the explosive growth in solar PV in the community.

kWh	Updated 2008	2014	% Change
Commercial	604,267,968	633,443,980	4.8%
NYSEG Com Figure	354,338,000	396,366,000	11.9%
Cornell CEP Generation	26,700,000	212,618,797	696.3%
Cornell Elec Purchase	220,100,000	56,900,000	-74.1%
Cornell Elec Export	0	-38,800,000	NA
Solar	29,968	1,959,183	6437.6%
Hydro	3,100,000	4,400,000	41.9%
Residential	293,815,424	288,178,141	-1.9%
NYSEG Res Figure	293,371,081	286,094,000	-2.5%
Solar	444,343	2,084,141	369.0%
Industrial	138,191,663	121,264,000	-12.2%
Groton	27,503,611	25,337,996	-7.9%
TOTAL	1,063,778,666	1,068,224,117	0.4%
MMBtu	Updated 2008	2014	% Change
Commercial	2,062,279	2,161,760	4.8%
NYSEG Com Figure	1,209,300	1,352,800	11.9%
Cornell CEP Generation	91,104	725,455	696.3%
Cornell Elec Purchase	751,195	194,198	-74.1%
Cornell Elec Export	0	-132,391	NA
Solar	102	6,685	6437.5%
Hydro	10,578	15,013	41.9%
Residential	1,002,782	983,541	-1.9%
NYSEG Res Figure	1,001,266	976,430	-2.5%
Solar	1,516	7,111	369.0%
Industrial	471,644	413,870	-12.2%
Groton	93,846	86,457	-7.9%
TOTAL	3,630,551	3,645,629	0.4%
MTCO2e	Updated 2008	2014	% Change
Commercial	202,062	134,661	-33.4%
NYSEG Commercial Figure	116,439	73,759	-36.7%

Cornell CEP Generation	13,296	61,546	362.9%
Cornell Elec Purchase	72,327	10,588	-85.4%
Cornell Elec Export	0	-11,231	NA
Solar	0	0	NA
Hydro	0	0	NA
Residential	**96,405**	**53,238**	**-44.8%**
NYSEG Res Figure	96,405	53,238	-44.8%
Solar	0	0	NA
Industrial	**45,411**	**22,566**	**-50.3%**
Groton	**2,305**	**2,137**	**-7.3%**
TOTAL	**346,183**	**212,602**	**-38.6%**

Table 37: Electricity Use and Emissions, 2008-2014

Thermal Energy

Consumption of energy used to heat water and buildings decreased in most sectors and fuels between 2008-2014, with the notable exception of natural gas consumption in the Commercial Sector, which can largely be explained by Cornell's decision to convert from coal to natural gas. Overall, consumption of thermal energy declined from approximately 7,252,000 to 6,314,000 MMBtu – a 13% reduction in use.

Unit Measure	Updated 2008	2014	% Change
Residential			
Electricity (kWh)	41,134,159	40,344,940	-1.9%
Natural Gas (therms)	17,018,828	17,774,330	4.4%
Fuel Oil (US gallon)	5,880,828	4,113,382	-30.1%
Propane (US gallon)	1,229,918	1,275,479	3.7%
Commercial			
Natural Gas (therms)	21,321,612	46,441,632	117.8%
Sub-category: NYSEG Meters	20,110,612	19,070,642	-5.2%
Sub-category: Cornell Use	1,211,000	27,370,990	2160.2%
Fuel Oil (US gallon)	5,205,396	2,527,232	-51.4%
Sub-category: Commercial, non-Cornell	5,202,196	2,284,515	-56.1%
Sub-category: Cornell Use	3,200	242,717	7484.9%
Propane (US gallon)	403,975	414,068	2.5%
Coal (tons)	65,420	0	-100.0%
Industrial			
Natural Gas (therms)	4,231,084	3,310,951	-21.7%
Fuel Oil (US gallon)	1,236,145	677,809	-45.2%
Propane (US gallon)	199,918	160,359	-19.8%
MMBtu	**Updated 2008**	**2014**	**% Change**
Residential	**2,765,750**	**2,598,812**	**-6.0%**

Electricity	140,390	137,696	-1.9%
Natural Gas	1,701,883	1,777,400	4.4%
Fuel Oil	811,554	567,647	-30.1%
Propane	111,923	116,069	3.7%
Commercial	**3,870,525**	**3,273,812**	**-15.4%**
Natural Gas	2,132,161	2,897,598	35.9%
Sub-category: NYSEG Meters	2,011,061	1,907,100	-5.2%
Sub-category: Cornell Use	121,100	990,498	717.9%
Fuel Oil	740,893	338,534	-54.3%
Sub-category: Commercial, non-Cornell	740,606	317,763	-57.1%
Sub-category: Cornell Use	287	20,771	7139.7%
Propane	36,762	37,680	2.5%
Coal	960,709	0	-100.0%
Industrial	**615,862**	**440,984**	**-28.4%**
Natural Gas	423,108	331,095	-21.7%
Fuel Oil	174,561	95,296	-45.4%
Propane	18,193	14,593	-19.8%
TOTAL	**7,252,136**	**6,313,608**	**-12.9%**
MTCO2e	**Updated 2008**	**2014**	**% Change**
Residential	**171,385**	**151,456**	**-11.6%**
Electricity	13,497	7,453	-44.8%
Natural Gas	90,517	94,535	4.4%
Fuel Oil	60,425	42,265	-30.1%
Propane	6,946	7,203	3.7%
Commercial	**311,391**	**214,917**	**-31.0%**
Natural Gas	113,402	185,461	63.5%
Sub-category: NYSEG Meters	106,961	101,430	-5.2%
Sub-category: Cornell Use	6,441	84,031	NA
Fuel Oil	55,503	27,118	-51.1%
Sub-category: Commercial, non-Cornell	55,466	23,695	-57.3%
Sub-category: Cornell Use	37	3,423	9151.4%
Propane	2,281	2,338	2.5%
Coal	140,204	0	-100.0%
Industrial	**36,596**	**25,575**	**-30.1%**
Natural Gas	22,456	17,573	-21.7%

Fuel Oil	13,015	7,099	-45.5%
Propane	1,125	902	-19.8%
TOTAL	519,371	391,948	-24.5%

Table 38: Thermal Energy Use and Emissions, 2008-2014

Transportation Fuels

As was shown in the Transportation Sector, there was little change in the amount of gasoline and diesel used to fuel the Transportation Sector between 2008 and 2014.

US gal	Updated 2008	2014	% Change
Gasoline	28,645,469	29,034,150	1.4%
Diesel	4,532,055	4,673,058	3.1%
TOTAL	33,177,524	33,707,208	1.6%

Table 39: Transportation Fuels Use, 2008-2014

Further Analysis to Inform the 2008-2014 Comparison

Removing Cornell Data

In order to better understand 2008-2014 GHG emissions and energy consumption it is helpful to see the progress the community is making toward its climate goals without the impact of Cornell on emissions figures. In other words, is the community making progress even without the significant investments made by Cornell between 2008 and 2014? The answer is yes, but it is slightly less: even without the contributions of Cornell, the community has reduced its GHG emissions 18.4% between 2008 and 2014.

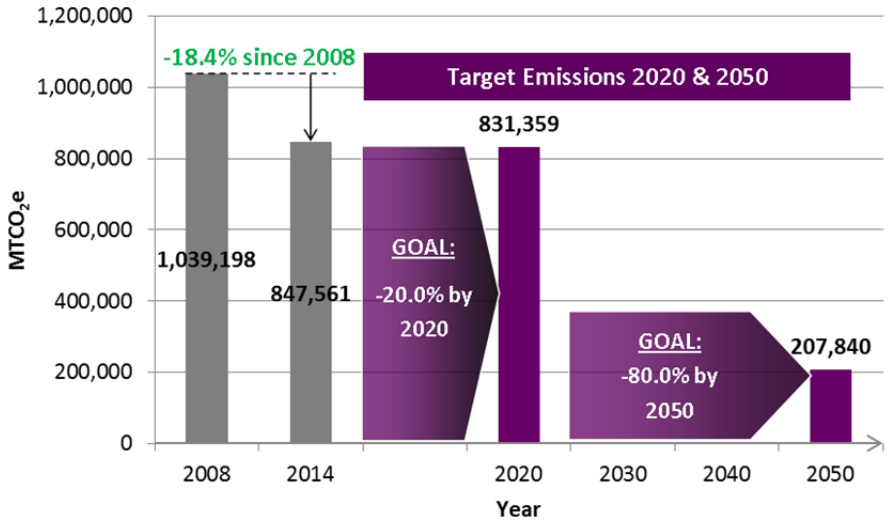


Figure 8: Removing Cornell Data, GHG Emissions Goals and Progress – Currently Accepted Accounting

Applying Latest Climate Science on Shale Gas to Results: 2008-2014

Between 2008 and 2014, there was likely a profound shift in how the natural gas consumed in the County was extracted from the ground, as well as new international recommendations on the time horizon and global warming potential (GWP) that should be used to calculate the GHG emissions for methane. While the results presented above are calculated using widely-accepted international protocols, it is important to look ahead at what may soon be modifications to those protocols to better understand the impacts to the climate of burning shale gas in the County and better inform near-term actions.

Studies conducted by local internationally-renowned experts, including Dr. Bob Howarth and Dr. Tony Ingraffea, have informed this section of the Inventory, with Dr. Howarth providing appropriate figures to include in these calculations. It is estimated that 5-19% of unburned methane leaks from the production well through transmission and distribution to where combustion occurs in the home, business or electric generating plant, due to the techniques employed by the shale gas industry. The analysis below applies an average leakage factor of 12% to all natural gas consumed in the community, including the portion used to generate electricity. In 2008, the natural gas consumed in the County came from traditionally drilled vertical wells. Dr. Howarth advises that traditional extraction methods experience a 3.8% leakage rate. Therefore, a leakage factor of 3.8% was applied to methane consumed in 2008, as well.

In addition to the leakage of methane due to shale gas development, transmission and distribution, is the consideration of the appropriate timescale for GWP of methane. Methane is an extremely impactful GHG in the short-term, with a greenhouse warming effect of >100-fold more than carbon dioxide. Given the current state of the Earth's climate, the Earth is predicted to warm by 1.5° C above the preindustrial baseline within the next 15 years and by 2° C within the next 35 years[9] giving new urgency to the role of methane in the short-term. Standard GHG accounting principles used elsewhere in this report call for the use of the 100-year GWP for greenhouse gases, which is appropriate for the other GHGs. However this special analysis applies the 20-year GWP for methane of 86 to all methane emissions in both 2008 and 2014.

Using the results below, the community has actually seen a 67% increase in GHG emissions since 2008 if the mid-range overall leakage rate of 12% is applied. Applying this conclusion to the Inventory calls for substantial and significant actions to reduce the community's use of natural gas coming from hydro-fracked shale formations.

	2008 New Accounting 5th IPCC 20-yr GWP for Methane with 3.8% Leakage	2014 New Accounting 5th IPCC 20-yr GWP for Methane with 5% Leakage	2014 New Accounting 5th IPCC 20-yr GWP for Methane with 12% Leakage	2014 New Accounting 5th IPCC 20-yr GWP for Methane with 19% Leakage
MTCO2e from Leaked Methane	338,673	651,161	1,687,098	2,902,087
Total Community MTCO2e w/o Leakage	1,265,062	995,918	995,918	995,918
Total Community MTCO2e with Leakage	1,603,735	1,647,079	2,683,016	3,898,005
Percent Change from 2008 at 3.8% Leakage	n/a	3%	67%	143%

Table 40: Comparison of Emissions, Shale Gas Leakage 3.8% and 5-19% & 20-Year GWP for Methane 86

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

Next Steps

The results of this Inventory will be used to inform development of the update to the 2020 Energy Strategy, as well as future efforts to reduce GHG emissions and reduce consumption of energy in the community.