



**Climate Smart
Communities**

New York Community and Regional GHG Inventory Guidance

METHODS AND DATA SOURCES FOR COMMUNITY-WIDE (GEOSPATIAL)
GHG EMISSIONS INVENTORIES

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Notice

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Introduction

Developing a greenhouse gas (GHG) emissions inventory is one of the first steps toward certification in the Climate Smart Communities (CSC) Program. Local governments rely on the GHG inventory to set emissions savings goals and to measure progress toward achieving those goals. Local governments should analyze their greenhouse gas emissions from both government operations and from the wider community as a whole to identify opportunities to reduce GHG emissions. This guide helps local governments and regional planning agencies create regional or community-wide GHG inventories.

The CSC Program recommends that inventories adhere, where feasible, to ICLEI's U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions ([U.S. Community Protocol](#)). This national standard advises communities to include a variety of direct and indirect sources they can control or influence with local and regional policy. The protocol is flexible and identifies a number of GHG sources and suggests strategies on how to calculate them. In many cases, however, it leaves final source selection and detailed methodology development to individual communities because data availability and technical capacity vary locally and state-to-state.

This guide is a collection of methods and data sources applicable for New York State created by the New York State GHG Working Group (GHG Working Group), a consortium of experts convened under Phase I of the Cleaner, Greener Communities Program. It can be considered a compendium guide to the U.S. Community Protocol but can also be used as a standalone guide. It does not cover all sources discussed in the U.S. Community Protocol but includes enough to complete a basic GHG inventory suitable for most regions or communities. Communities are always encouraged to explore quantification of additional emissions sources and development of new inventory methods, and may wish to monitor any developments with the U.S. Community Protocol for updates.

In some important cases, GHG Working Group recommendations *differ* from the U.S. Community Protocol. For example, Climate Smart Communities (CSCs) and applicants to various NYSDERDA programs are encouraged to use NYSDERDA's electricity emission factors instead of the U.S. Environmental Protection Agency's emission factors for electricity. Any differences are explained and highlighted throughout this guide. Where there are differences, communities should follow this guide.

Must a Community Use this Guide to Complete an Inventory?

It depends. This guide is a comprehensive technical manual with detailed methods to calculate GHG emissions, and is a great resource for those with the capacity and resources to develop a GHG inventory from the ground up. For non-expert community representatives and staff looking to take action on climate however, technical manuals like this can be a barrier. There are several resources available to them.

The CSC program, along with the U.S. EPA and organizations like ICLEI and Clean Air Cool Planet, have developed a variety of calculations tools to help people with basic technical skills make inventories without requiring a comprehensive GHG accounting background. Contact the CSC program for options available.

The simplest option for communities is to pull a ready-made community GHG inventory, if available, from the regional GHG inventories developed for the Cleaner Greener Communities Regional Sustainability Plans.

Those that overlapped the CSC Pilot regions already include breakouts for all cities, towns, and villages, while the rest all have county-level inventories. They cover all typical sectors and were developed with the methods in this guide. Although they are for base year 2010, they are more than adequate to identify priority sectors and are suitable to use a baseline in a community climate action plan. Using these products, communities can skip the GHG inventory step and move directly to planning.

The GHG Working Group

In 2012, New York State's Climate Smart Communities and Cleaner, Greener Communities (CGC) programs launched an effort to develop regional GHG inventories for all ten of the State's economic development regions as defined by the Department of Economic Development. The New York State Research and Development Authority (NYSDRDA) convened the New York GHG Working Group to review GHG protocols and design consensus methods applicable for New York State. The group included over 70 stakeholders representing CGC planning teams, academic institutions, CSC consultants, state agencies, and regional and municipal officials. Activities of the group included the following:

- Reviewing the U.S. EPA's Draft Regional GHG Inventory Guidance and ICLEI's U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions (ICLEI Community Protocol) to identify methods.
- Working with state agencies, MPOs, and utilities to identify and secure New York-specific data needed to complete the emission inventories.
- Developing standard GHG inventory reporting formats for regional and local community inventories.

This document, *New York State, Regional, and Community GHG Inventory Guidance*, is the compendium of methods and decisions made by the GHG Working Group. For the most part, regional GHG Inventories produced under CGC Phase I conformed, to these methods.

The purpose of this document is to provide guidance to local governments in New York State on the process, methodologies, and data sources for developing a community inventory. This is a technical guide, geared toward people with some basic understanding of GHG emissions reporting concepts. The guide provides both recommended and alternative methods for each of the data sources in step-by-step guidance. Some of the methods, however, are somewhat complicated and require gathering data from several sources.

To establish a baseline for managing GHG emissions, developing a GHG inventory is a significant amount of work which can take several months. Local governments seeking a robust GHG inventory, with the most up-to-date methods, should use this manual, along with other sources such as the U.S. Community Protocol. Some local governments may just seek an estimate of their community emissions, and are encouraged to use the regional or county-level GHG emissions inventories produced through the CSC program, and can downscale that data to produce an estimate of their local emissions. For the CSC pilot regions, the 2010 regional inventories are broken down by community and were completed through the pilot program for 2010. Communities can refer to the [Climate Smart Communities Regional Coordinator](#) webpages to access the 2010 regional inventories.

GHG Accounting Framework and Overview

As is described in greater detail in the U.S. Community Protocol, GHG accounting involves six key concepts:

- **GHG Sources.** What are GHGs and where do they come from?
- **Geospatial Boundary.** Is the inventory for a village, town, city, county or region, and how will this inventory relate to neighboring efforts?
- **GHG Source Boundary.** Are GHG emissions directly emitted inside the geospatial boundary, or are they emitted elsewhere but attributed to activities within the boundary?
- **Reporting Standards.** How should community and regional GHG inventories be reported, and what sources are included when representing an inventory as a single GHG emissions total?
- **Methods and Data Sources.** What methods and data sources are acceptable in New York for GHG inventories?

Overview of Greenhouse Gases (GHGs)

Communities must account for direct and indirect emissions of all major GHGs including carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and nitrogen trifluoride (NF₃). In New York, GHG emissions generally come from the following four basic activities.

- Fossil fuel combustion creates CO₂ and small amounts of CH₄ and N₂O. CO₂ represents 98-99% of a fuel's GHG footprint. Fossil fuels are the dominant source of GHG emissions in the region.
- Solid and sewage waste management, agriculture practices, and certain industrial processes release CO₂, CH₄, and N₂O. Some industries release PFCs.
- Common refrigerants (HFCs and SF₆) used in homes, businesses, vehicles and the utility industry are GHGs. They create footprints when they leak to the air. HFCs are also called ozone depleting substitutes (ODS) because they were created to replace chlorofluorocarbons (CFCs) that had been found to be degrading the ozone layer.
- Nitrogen trifluoride is an industrial gas primarily used in the manufacture of semiconductors and liquid crystal display (LCD) panels and in certain types of solar panels and chemical lasers.

Defining a GHG Inventory Geospatial Boundary

The boundaries of a GHG inventory define what should be included in the inventory, either from an organizational or geospatial perspective. Corporate or local government operations inventories take into account the GHG emissions from government facilities and services. Community or geospatial inventories take into account GHG emissions occurring within a defined geographic area such as:

- *Statewide GHG inventories*, such as those prepared by NYSERDA as part of the State Energy Plan.
- *Regional GHG inventories*, such as those prepared under the CGC Program for all state REDCs.
- *Community GHG inventories*, such as those prepared by CSCs at a village, city, town, or county scale.

The CSC Program recommends that if higher forms of government develop a community GHG inventory, it should always break out inventories for all incorporated communities that lie within it. A county should break out inventories for its cities, towns and villages. Towns should breakout inventories for villages. The idea is that if a higher form of government commits to reducing community-wide GHG emissions, it will not be successful unless it engages and supports its local governments since those local governments control land use, zoning, and code. This will promote economies of scale in GHG inventory development and provide a framework to share GHG management responsibility.

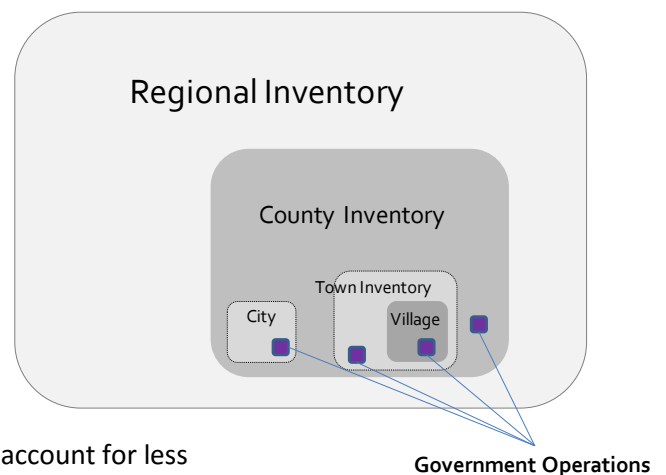
Communities and counties may also prepare their own distinct local government operations GHG inventories as shown in Figure 1. These are separate products based on a detailed analysis of energy bills and other sources of information. Communities should refer to the related [CSC GHG Inventory Guide for Local Government Operations](#), and to the [Local Government Operations Protocol](#) for more information (ICLEI, 2011).

Community inventories should include government operations since those operations are no different from those of any business operating in the community. All commercial sector data sources in this guide include government operations. Government operations typically account for less than three percent of a community's emissions.

Economies of Scale: Regional agencies leading the development of regional and community inventories

In many cases, individual community GHG inventories can effectively be developed at a regional level and managed by a regional planning agency because data sources and methods are often the same from community to community. For example, the 2010 Capital District Regional GHG Inventory prepared by the Capital District Regional Planning Commission includes GHG inventories for the Economic Development Region as a whole, for each of the eight counties, and subsequently for each of the region's 160 cities, towns and villages.

Figure 1: Regional to Local GHG Inventory Geography



Direct or Indirect Emissions Attribution

The U.S. Community Protocol recommends communities include all emissions that occur physically within the boundary and, to the extent possible, those that occur indirectly *regardless of location* because of community activity or consumption. Therefore, individual GHG sources are labeled as one of the following:

- Direct emissions that occur physically within a boundary such as those emitted by burning natural gas or fuel oil in homes and businesses; also called Scope 1.
- Indirect emissions at electricity power plants based on the amount of electricity consumed within the boundary, regardless of where the power plants are located; also called Scope 2.
- Other indirect, upstream, or lifecycle emissions attributed to community activity regardless of where they occur; also called Scope 3.

It is common that community GHG inventories will include line items for *both* direct and indirect emissions for what is essentially the same source. For example, a community with a landfill will have direct Scope 1 methane emissions resulting from actual waste in place regardless of where the waste came from. Concurrently, the community will also have a wholly separate Scope 3 waste GHG emissions attributed only to the amount of waste the community itself creates, regardless of whether it is disposed in the landfill or elsewhere. As discussed in the reporting guidance, for the Detailed GHG Inventory Report, it is not necessary to reconcile one scope against the other even if they appear to double count.

Another common example is electric power generation. Communities with electric power generation facilities will report direct Scope 1 emissions in the power-generation sector of the GHG reporting template. In addition, communities will report separately Scope 2 emissions related solely to the amount of electricity they consume, based on the GHG intensity of the regional grid. There is no need to reconcile an overlap except in a rare situation where a generation plant is known to directly feed a community, such as a microgrid.

GHG Sources and Sectors

Table 1, Geospatial GHG Accounting Framework, includes all GHG sources considered by the GHG Working Group. Communities should report all direct emissions, and at a minimum, indirect emissions from electricity consumption, solid waste generation, and air transportation demand. This guide includes reasonable New York specific methods for all of these sources. It also discusses conceptual approaches for adding more state-of-the-art indirect sources, such as attributing a share of regional vehicular emissions to a community based on its land-use patterns.

A variety of new approaches to attribute indirect emissions to land use, materials consumption, and other community activities are being developed and tested. As consensus indirect methods develop for New York they may be adopted in future editions of this guide over time.

Table 1: Geospatial GHG Accounting Framework

Sector / Source	Description of the Source	Scope
Built Environment		
Residential Energy	Direct emissions from natural gas, fuel oils, wood, and propane consumed within the boundary.	1
	Indirect emissions attributed to electricity consumption.	2
Commercial Energy	Direct emissions from natural gas, fuel oils, wood, and propane consumed within the boundary.	1
	Indirect emissions attributed to electricity consumption.	2
Industrial Energy	Direct emissions from natural gas, fuel oils, wood, propane, coal, residual fuel oils, petroleum coke, and others consumed within the boundary.	1
	Indirect emissions attributed to electricity consumption.	2
Power Generation	Direct emissions from grid-connected power generating facilities of capacity 1 MW or greater within the boundary.	1
Transmission Losses (T&D)	Direct fugitive emissions of natural gas that leaks from the gas transmission and distribution system within the boundary.	1
	Direct fugitive emissions from gas, oil, and coal production sites.	1
Industrial Processes and Product Use	Direct chemical process emissions (non-energy related) from the cement, paper, metals, and other industries.	1
	Direct emissions of PFC, HFCs (refrigerants), and NF ₃ used in vehicles, buildings, and industry.	1
	Direct fugitive emissions of SF ₆ , a specialized coolant used in the utility industry.	1
Materials Consumption	Indirect / lifecycle emissions related to consumption of raw materials, durable goods, and food in boundary.	3
Transportation		
On road	Direct emissions from on-road vehicles within the boundary.	1
	Indirect (community-induced) emissions caused by a community.	3
Off-road	Direct emissions from off-road equipment (construction, agricultural, lawn care, etc.) within the boundary.	1
Rail	Direct emissions from rail locomotives within the boundary.	1
	Indirect (community-induced) emissions caused by a community	3
Marine	Direct emissions from boats including private craft on lakes and rivers, and commercial shipping operating on rivers and around ports.	1
Air	Indirect emissions attributed to regional domestic and international air travel demand.	3
Waste		
Solid Waste	Direct emissions from regional landfills and waste incinerators. Grid-connected waste-to-energy (WTE) facilities are reported under Scope 1 in Power Generation.	1
	Indirect emissions attributed to communities based on the amount of solid waste they create within the boundary.	3
Sewage Waste	Direct emissions from waste water treatment plants and septic systems within the boundary.	1
Agriculture		
Livestock / Manure	Direct emissions from livestock operations (enteric fermentation and manure management) within the boundary.	1
Fertilizer and Soils	Direct emissions from cropland management and fertilizer application within the boundary.	1

Reporting

Standard Reporting Formats

To promote reporting consistency the GHG Working Group developed two standard reports for local and regional GHG inventories, the Detailed GHG Inventory Report and the Rollup GHG Inventory Report. Samples used to report GHG inventories prepared under CGC Phase I are shown in Table 2 and Table 3. Most community inventories will require some form of both of these reports. CSCs can modify these formats or refer to the U.S. Community Protocol for more options. These templates only include the recommended sources, and not any optional sources, such as lifecycle emissions. In the sample, cells shaded in green were required for CGC regional inventories.

Detailed GHG Inventory Report: Include all sources

This Detailed GHG Inventory Report is a complete line-item listing of GHG emissions to explain to stakeholders the sources that have been considered by the community. To prevent double counting, indirect and direct emissions are never added together, but are all included in the detailed inventory report. GHG emissions should be reported in metric tons of carbon dioxide equivalent (MTCDE) and energy consumption reported in MMBTUs (million British thermal units).

Rollup GHG Inventory Report: Avoid double counting

The Rollup GHG Inventory Report meets a community's need to report GHG emissions as a single number to support policymaking and reduction goal setting. To avoid double counting, the rollup should include either the direct or the indirect emissions if both are reported for the same source, such as in the case of a power plant or landfill within the community boundary in which there is both Scope 1, production emissions, and Scope 3, consumption emissions in the case of a community with local power generation. The U.S. Community Protocol recommends choosing the indirect source, as it typically better associates emissions with local consumption and land use patterns that can be managed by local policymaking.

The rollup developed for the CGC Phase I GHG inventories included the following:

- Indirect emissions from community electric consumption
- Indirect emissions from community solid waste generation
- Direct emissions from fuel consumption in the residential, commercial, industrial, and transportation sectors
- Direct emissions from industrial processes and product use

The rollup report did not include the following overlapping direct sources:

- Direct emissions from solid waste facilities (landfills and waste-to-energy (WTE) plants)
- Direct emissions from grid-connected power generation rated 1MW and greater

Table 2: Detailed GHG Inventory Report Template						
Community/Region GHG Emissions (year)						
	GHG Emissions (MTCDE)					Energy Use
Sector / Source	Scope 1	Scope 2	Scope 3	Biogenic	Include in Rollup report	(MMBTU)
Residential Energy Consumption						
Electricity / Steam					Yes	
Natural Gas					Yes	
Propane / LPG					Yes	
Distillate Fuel Oil (#1, #2, #4, Kerosene)					Yes	
Coal					Yes	
Wood					Yes	
Commercial Energy Consumption						
Electricity / Steam					Yes	
Natural Gas					Yes	
Propane / LPG					Yes	
Distillate Fuel Oil (#1, #2, #4, Kerosene)					Yes	
Residual Fuel Oil (#5 and #6)					Yes	
Coal					Yes	
Wood					Yes	
Industrial Energy Consumption						
Electricity / Steam					Yes	
Natural Gas					Yes	
Propane / LPG					Yes	
Distillate Fuel Oil (#1, #2, #4, Kerosene)					Yes	
Residual Fuel Oil (#5 and #6)					Yes	
Coal					Yes	
Petroleum Coke					Yes	
Motor Gasoline (E-10)					Yes	
Other Oils					Yes	
Wood					Yes	
Energy Generation and Supply						
Natural Gas					No	
Distillate Fuel Oil (#1, #2, #4, Kerosene)					No	
MSW					No	
Landfill Gas					No	
Electricity T&D Losses					Yes	
Natural Gas T&D Losses					Yes	
Industrial Processes						
Cement Production					Yes	
Pulp and Paper Manufacturing					Yes	
Product Use (HFC, ODS)						
Use of SF6 in the Utility Industry					Yes	
All Refrigerants except SF6					Yes	
Transport: On-Road						
Motor Gasoline (E-10)					Yes	
Diesel					Yes	
Ethanol (E-85)					No	
Biodiesel					No	
Transport: Rail, Marine, Off-Road, Air						
Motor Gasoline (E-10)					Yes	
Diesel					Yes	
Residual Fuel Oil (#5 and #6)					Yes	
Natural Gas					Yes	
Propane / LPG					Yes	
Jet Kerosene (Air)					Yes	
Waste Management						
Landfill Methane					Yes (S3)	
MSW Incineration					Yes (S3)	
Sewage Treatment					Yes	
Agriculture						
Enteric Fermentation / Manure					Yes	
Soils / Fertilizer					Yes	
Totals by Scope						

Table 3: Rollup GHG Inventory Report Template

Community/Region GHG Emissions (year)							
Sector / Source	GHG Emissions (MTCDE)						
	CO ₂ e	CO ₂	CH ₄	N ₂ O	PFC	HFC	SF ₆
Residential Energy Consumption							
Electricity / Steam							
Natural Gas							
Propane / LPG							
Distillate Fuel Oil (#1, #2, #4, Kerosene)							
Coal							
Wood							
Commercial Energy Consumption							
Electricity / Steam							
Natural Gas							
Propane / LPG							
Distillate Fuel Oil (#1, #2, #4, Kerosene)							
Residual Fuel Oil (#5 and #6)							
Coal							
Wood							
Industrial Energy Consumption							
Electricity / Steam							
Natural Gas							
Propane / LPG							
Distillate Fuel Oil (#1, #2, #4, Kerosene)							
Residual Fuel Oil (#5 and #6)							
Coal							
Petroleum Coke							
Motor Gasoline (E-10)							
Other Oils							
Wood							
Energy Generation and Supply							
Natural Gas							
Distillate Fuel Oil (#1, #2, #4, Kerosene)							
Use of SF ₆ in the Utility Industry							
Industrial Processes							
Cement Production							
Iron and Steel Production							
Aluminum Production							
Paper and Pulp							
Limestone Use							
Soda Ash Use							
Semi-Conductor Manufacturing							
Chemical Manufacturing							
Product Use (HFC, ODS)							
Use of SF ₆ in the Utility Industry							
All Refrigerants except SF ₆							
Transport: On-Road							
Motor Gasoline (E-10)							
Diesel							
Ethanol (E-85)							
Biodiesel							
Transport: Rail, Marine, Off-Road, Air							
Motor Gasoline (E-10)							
Diesel							
Residual Fuel Oil (#5 and #6)							
Natural Gas							
Propane / LPG							
Jet Kerosene (Air)							
Waste Management							
Landfill Methane							
MSW Incineration							
Sewage Treatment							
Agriculture							
Enteric Fermentation / Manure							
Soils / Fertilizer							
Totals by Scope							

Standard GHG Units and Global Warming Potentials (GWPs)

Communities should report all GHG emissions in units of MTCDE, the international standard unit for GHG emissions. One MTCDE is equivalent to the global warming potential (GWP) of 1000 kg of CO₂. Emissions of each gas can be converted to MTCDE by multiplying its mass in metrics tons (1000 kilograms) by its 100-year GWP published by the Intergovernmental Panel on Climate Change (IPCC). See Table 4.

The IPCC updates GWPs routinely through a series of “Assessment Reports.” The most current is the fifth assessment report (AR5). This New York State guidance differs from the U.S. Community Protocol in that the latter recommends using a combination of the second assessment report (SAR) and the fourth assessment report (AR4) GWPs. However, GWP choice is often made based on what assessment is current at the time protocol is written or updated. Therefore, the CSC Program recommends communities follow whatever GWP rules are in place for the U.S. EPA’s Mandatory Report Rule (MRR) at the time they develop the inventory. As of this report writing, MRR has adopted the AR4 GWPs. If and when MRR advances to AR5 or subsequent assessments, communities should follow suit.

If GHG inventories are being updated, changing the GWP tables might complicate progress tracking. Therefore, a community can continue to use its prior GWP set for consistency, or use the new set and explain the impact of the updated GWPs on the results. Prior emission inventories can be updated without redoing the inventory simply by multiplying MTCDE totals for each gas by the ratio of the new to old GWP for that gas.

Table 4: Greenhouse gases and 100-year net global warming potentials

		GWP		
		SAR ¹	TAR ²	AR4 ³
(1) Carbon Dioxide	CO ₂	1	1	1
(2) Methane	CH ₄	21	23	25
(3) Nitrous Oxide	N ₂ O	310	296	298
(4) Hydrofluorocarbons				
HFC-23 (trifluoromethane)	CHF ₃	11,700	12,000	14,800
HFC-32 (difluoromethane)	CH ₂ F ₂	650	550	675
HFC-41 (monofluoromethane)	CH ₃ F	150	97	92
HFC-125 (pentafluoroethane)	CHF ₂ CF ₃	2,800	3,400	3,500
HFC-134 (1,1,2,2-tetrafluoroethane)	CHF ₂ CHF ₂	1,000	1,100	1100
HFC-134a (1,1,1,2-tetrafluoroethane)	CH ₂ FCF ₃	1,300	1,300	1,430
HFC-143 (1,1,2-trifluoroethane)	CHF ₂ CH ₂ F	300	330	353
HFC-143a (1,1,1-trifluoroethane)	CF ₃ CH ₃	3,800	4,300	4,470
HFC-152 (1,2-difluoroethane)	CH ₂ FCH ₂ F	-	43	53
HFC-152a (1,1-difluoroethane)	CH ₃ CHF ₂	140	120	124
HFC-161 (ethyl fluoride)	CH ₃ CH ₂ F	-	12	12
HFC-227ea (heptafluoropropane)	CF ₃ CHFCF ₃	2,900	3,500	3,220
HFC-236cb (1,1,1,2,2,3-hexafluoropropane)	CH ₂ FCF ₂ CF ₃	-	1,300	1340
HFC-236ea (1,1,1,2,3,3-hexafluoropropane)	CHF ₂ CHFCF ₃	-	1,200	1370
HFC-236fa (1,1,1,3,3,3-hexafluoropropane)	CF ₃ CH ₂ CF ₃	6,300	9,400	9,810
HFC-245ca (1,1,2,2,3-pentafluoropropane)	CH ₂ FCF ₂ CHF ₂	560	640	693

		GWP		
		SAR ¹	TAR ²	AR ³
HFC-245fa (1,1,1,3,3-pentafluoropropane)	CHF ₂ CH ₂ CF ₃	-	950	1,030
HFC-365mfc (pentafluorobutane)	CF ₃ CH ₂ CF ₂ CH ₃	-	890	794
HFC-43-10mee (decafluoropentane)	CF ₃ CHFCHFCF ₂ CF ₃	1,300	1,500	1,640
(5) Perfluorocarbons				
Perfluoromethane	CF ₄	6,500	5,700	7,390
Perfluoroethane	C ₂ F ₆	9,200	11,900	12,200
Perfluoropropane	C ₃ F ₈	7,000	8,600	8,830
Perfluorobutane (FC 3-1-10)	C ₄ F ₁₀	7,000	8,600	8,860
Perfluorocyclobutane	c-C ₄ F ₈	8,700	10,000	10,300
Perfluoropentane	C ₅ F ₁₂	7,500	8,900	9,160
Perfluorohexane (FC 5-1-14)	C ₆ F ₁₄	7,400	9,000	9,300
(6) Sulfur Hexafluoride	SF ₆	23,900	22,200	22,800

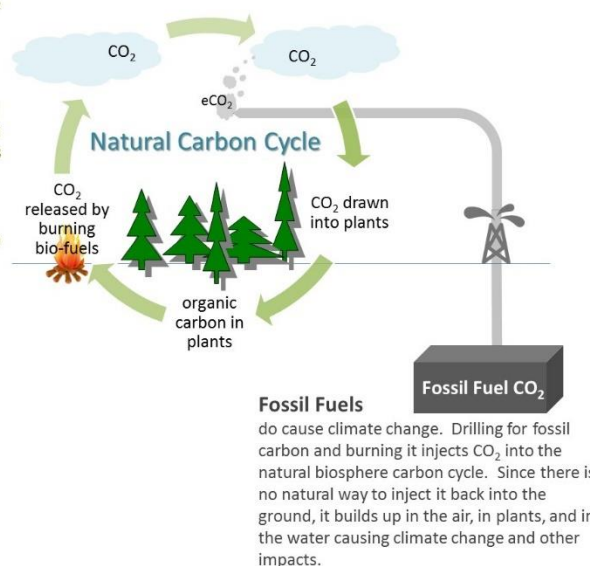
1. IPCC, 1995: Second Assessment Report
2. IPCC, 2001: Third Assessment Report
3. IPCC, 2007: Fourth Assessment Report

Biofuels and GHG Emissions Reporting

The GHG Working Group adopted the IPCC and WRI GHG Protocol convention that tailpipe biogenic CO₂ emissions are “carbon neutral” and therefore do not cause climate change. Communities can include lifecycle fossil fuel GHG emissions from the production and distribution of biofuels as discussed below, but they are not required to due to the lack of widely accepted accounting methods. Biomass tailpipe CO₂ is considered carbon neutral because biomass carbon released by burning was withdrawn from the atmosphere during growth, and simply returning it to the atmosphere does not contribute to a net build up.

Bio-Fuels

Tailpipe biofuel CO₂ emission do not cause climate change. Although it is the same CO₂ as emitted by fossil fuels, an equivalent amount of CO₂ was withdrawn from the air to grow the biomass grew creating a zero sum overall.



The GHG Working Group concluded that:

- Bio-fuel CO₂ emissions must be reported separately as “biogenic” on the Detailed GHG Inventory Report but will not be added to the roll-up GHG inventories.
- CH₄ and N₂O emissions from bio-fuel combustion must be included in Scope 1. This is because these emissions would not have occurred naturally if biomass decayed through natural decay processes.

- All conventional gasoline consumption in New York is assumed to be a 10-percent blend of ethanol, and emissions associated with ethanol must be reported as biogenic.
- Municipal solid waste (MSW) is a combination of bio-fuel and fossil-fuel based materials. If site specific composition data are not available, communities should assume that 44 percent of the resulting CO₂ emissions are fossil fuel based (Scope 1) and 56 percent are biogenic (U.S. EIA, 2007).

Lifecycle Emissions

Communities may elect to include lifecycle emissions in their GHG inventories, especially if they are considering policy to make major shifts to biofuels in the transport sector. While biofuel emissions are carbon-neutral at the tailpipe, they are not on a lifecycle “well-to-wheel” basis if fossil fuels or chemical fertilizers are used during production and distribution. For example, conventional corn ethanol is energy and fertilizer intensive and is thought to have a higher lifecycle GHG footprint than ethanol from easy-to-cultivate switch grass. Lifecycle emissions are the subject of ongoing research. Communities should refer to the U.S. National Renewable Fuels Standard program and reference therein for the latest research on biofuel lifecycle emissions (Schnepf, 2013).

To include biofuel lifecycle GHG emissions, communities should place lifecycle emissions in the indirect (Scope 3) column of the Detailed GHG Inventory Report alongside tailpipe biogenic CO₂ emissions. They can include lifecycle emissions in the Rollup GHG Inventory as long as they document that decision. If a community includes biofuel lifecycle emissions, it should consider including upstream emissions related to coal, petroleum and natural gas extraction as well. For well-to-wheel emission factors for fossil fuels, communities should refer to the U.S. Community Protocol section on Consumption-Based Emissions and Argonne National Laboratory’s Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model (Argonne, 2014) and references therein.

For further guidance on accounting for optional GHG emissions sources and alternative reporting approaches, such as through consumption-based inventories and supply-chain inventories, local governments should refer to the U.S. Community Protocol.

GHG Methods and Data

This guidance contains methods, data sources and discussion of all GHG sources listed in Table 1: Geospatial GHG Accounting Framework. There are methods for most sources.

Recommended Methods are based on high-quality local data and can be used to accurately track year-over-year changes in emissions. In some cases, these methods are an “ideal” but may not be practical.

Alternate Methods downscale state or regional data and provide a snapshot context for the magnitude of the GHG source relative to other sources. They are valuable for prioritization and goal setting, but are usually not accurate enough to track year-over-year local changes. Some alternative methods based on local census data may resolve changes over a three- to six-year timeframe.

Computing GHG Emissions from Fuel and Energy Use

Fossil fuel consumption in buildings and industry is usually the largest GHG source in a community or regional-scale GHG inventory. The vast majority of work in developing a GHG inventory is finding fuel consumption data and therefore all methods focus on identifying and acquiring suitable data. This guidance presumes the reader has a basic understanding of making emissions calculations, and understands the concept of emission factors and energy unit conversions. Communities can refer to the U.S. Community Protocol, or other GHG accounting resources for, for more information.

Emissions Factors

In general, burning fuel produces three GHGs: CO₂, CH₄ and N₂O. CO₂ typically represents 99 percent of the GHG footprint, with the latter two being trace gases of minimal impact. Each GHG has an emission factor unique to each fuel, and emissions in mass (e.g., kg) are calculated using the following formula:

$$GHG\ Emissions_{(Fuel,GHG)} = Emission\ Factor_{(Fuel,GHG)} \times Energy\ Consumption\ of\ the\ Fuel$$

Emissions across fuels and GHG types can be added and converted to a CO₂ equivalent using the AR4 global warming potentials in Table 4. The CSC Program recommends that local governments use the emission factor set published by the U.S. EPA as part of its MRR program, as shown in Table A- 1, with the exception of the electricity emission factors discussed in the next section. The emissions factors from the MMR program are also recommended by the U.S. Community Protocol and are commonly used for all types of GHG inventories. Table A- 1 presents a compressed emission factor for each fuel in MTCDE/MMBTU that represents the collective footprint of CO₂, CH₄ and N₂O. These can be used if a GHG inventory does not require a breakout by specific gas.

New York State Electricity Emission Factors

Communities create indirect (Scope 2) GHG emissions by consuming grid electricity. Actual emissions are based on the regional fossil carbon-intensity of the grid. The U.S. Community Protocol recommends that communities use emission factors developed by the U.S. U.S. EPA Emissions & Generation Resource Integrated Database (eGRID) (U.S. EPA, 2012). The CSC Program, however, recommends communities follow whatever guidance NYSDERDA currently has in place regarding emissions factors at the start of the inventory.

Table 5: NYSDERDA New York Average Grid Carbon Intensity

Year	lbs CO ₂ e /
2010	826
2011	826
2012	625
2013	625
2014	625
Source: NYSDERDA Energy and Environmental Analysis Team.	

NYSDERDA currently recommends using a statewide emission factor created by its Department of Energy and Environmental Analysis as shown in Table 5. They may differ from those produced by NYSDPS. NYSDERDA updates these annually. Contact NYSDERDA or the CSC Program for advice on the most current electricity emission factors to use. For jurisdictions updating GHG inventories that have used eGRID previously, they have the choice of continuing to use eGRID or updating prior baselines with NYSDERDA's emission factors.

Energy Service Companies and Community Choice Aggregation

Energy service companies (ESCOs) market specific energy mixes to help consumers meet sustainability goals. While consumers may purchase an ESCO energy mix, it is not possible to determine an ESCO- based energy mix for an entire community because consumers choose ESCOs on the open market. Under Community Choice Aggregation (CCA), an upcoming program in New York, communities can aggregate ESCO purchasing on behalf of residents and may intentionally try to influence its wider community energy mix. In this case, a community may create an electricity emission factor combining the NYSEERDA state average and the CCA energy mix weighted to participation rate or energy usage in the CCA program.

Getting Utility-Supplied Energy Data

Geospatially aggregated natural gas and electricity consumption provided by utilities is the best measure of energy use. It is responsive to year over year changes and is effective for tracking energy targets.

The CSC Program has been working with utilities to develop standard CSC Community Energy Reports (CERs) that include aggregated (non-private) energy consumption divided into residential, commercial, industrial, public authorities and street lighting sectors. The reports include annually aggregated data with line items for all communities in the utility's service territory. Table 6 shows a subset of National Grid's 2010 Community Energy Report supplied by National Grid with data for all 735 communities it serves.



Prior to contacting a utility directly, a community should always check with the CSC Program to find out if CER data are available for the years they seek. Availability of data varies and may be subject to limitations.

Table 6: Sample (partial) 2010 Community Energy Report for National Grid

			Electricity Consumption (MWh)				Natural Gas Consumption (MMBTU)			
Municipality	Type	County	Total	Res.	Com.	Ind.	Total	Res.	Com.	Ind.
Menands	Village	Albany	66,902	11,657	42,887	12,359	3,631,556	108,839	239,430	14,887
Colonie	Village	Albany	65,173	24,273	40,899	0	3,313,277	207,923	123,405	0
Voorheesville	Village	Albany	11,022	8,097	2,925	0	970,673	73,909	23,158	0
Bethlehem	Town	Albany	441,651	106,494	78,626	256,531	18,984,834	812,900	247,312	838,271
Colonie	Town	Albany	772,805	246,982	513,465	12,359	43,274,128	2,207,099	1,928,585	191,729
Altamont	Village	Albany	7,107	5,268	1,839	0	465,355	39,261	7,274	0
Cohoes	City	Albany	58,060	34,339	23,721	0	8,812,594	351,344	104,318	425,598
Source: National Grid, Capital Region Regional GHG Inventory, 2010.										

Stationary Energy in the Built Environment

Residential Energy Consumption

(Natural Gas, Electricity, Fuel Oil, Propane and Wood)

Recommended Method: Use direct consumption data where feasible

While data may be difficult to find or not available, communities should use directly reported sales or surveyed consumption data within the community. For utility-supplied natural gas and electricity, the best data will come from a utility's Community Energy Report (CER) if available as discussed earlier. For delivered fuels like fuel oil and propane, communities can check with NYSERDA, local energy programs like [Energize New York](#), and/or with local universities to see if residential consumption surveys have been done. Usually good data are not available for tank fuels. Communities should also check for updates to the U.S. Energy Information Administration's (U.S. EIA) Residential Energy Consumption Survey (RECS) to see if that program has started releasing consumption rates by county, housing type, and fuel type.

Alternative Method: Allocate statewide consumption data

For fuels not covered by a reliable measured source, the GHG Working Group created an alternative method to estimate local residential consumption by downscaling statewide consumption reported by the U.S. EIA weighted based on the following parameters:

- **Home Heating Fuel Preference:** [The American Community Survey \(ACS\)](#) provides data on number of occupied housing units that heat with natural gas, propane, fuel oil, and wood.
- **Housing Unit Type:** Recent studies by the U.S. EPA show that multi-family units consume less energy than single family housing (U.S. EPA, 2011). The ACS provides housing unit count divided into single family and multi-family subset categories.
- **Heating Degree Days:** Heating degree days can drive fuel consumption patterns. The National Weather Service provides heating degree days (HDD) as a measure of heating demand and the ratio of local HDD to statewide HDD provides an additional layer of weighting.

Step 1: Estimate the number of state and local "effective housing units" (EHUs)

Because single family and multi-family housing units consume energy at different rates, straight housing unit counts reported by the ACS are inadequate for apportioning state consumption locally. The housing unit count must be normalized to "effective housing units," which is an effective count of the number of energy-equivalent single-family detached housing units within the community. To do this the U.S. EPA released a report suggesting standard differences in energy consumption rates by single-family detached (SFD), single-family attached (SFA), and multi-family (MF) units as shown in Table 7 (U.S. EPA, 2011).

Table 7: Energy Use by Housing Type (U.S. EPA, 2011)

Protocol Housing Unit Type	Related ACS Housing Type	MMBtu per Year	Energy Use Weighting
SFD	SFD	108	1
SFA	SFA	89	0.824
Multi Family	All Other Types (2+ Family)	54	0.5
<p><i>SFD</i> = Number of occupied single family detached community units <i>SFA</i> = Number of occupied single family attached community units <i>MF</i> = Number of occupied multi-family units Source: Location Efficiency and Housing Type: Boiling it Down to BTUs, U.S. EPA, Prepared by Jonathan Rose Companies, Revised March 2011.¹</p>			

From either a local assessor's database or from the 5-year average ACS² housing data available online, obtain the number of local and statewide occupied housing units and group them either as SFA, SFD, or MF. The ACS reports single family attached and single family detached separately, so count all other ACS housing types (2+ family and up) as MF. Alternatively, the New York Office of Real Property Tax Services now has online community profiles for all cities, towns and villages with complete parcel inventories divided into property tax codes.

Compute the number of EHUs for both the state and the local community as

$$EHU_{Local} = \frac{108}{108} \times SFD_{Local} + \frac{89}{108} \times SFA_{Local} + \frac{54}{108} \times MF_{Local}$$

$$EHU_{State} = \frac{108}{108} \times SFD_{State} + \frac{89}{108} \times SFA_{State} + \frac{54}{108} \times MF_{State}$$

Where:

EHU = "Effective" number of occupied housing units either locally or statewide
SFD = Number of occupied single family detached community units either locally or statewide
SFA = Number of occupied single family attached community units either locally or statewide
MF = Number of occupied multi-family units either locally or statewide

For example, Community A with 100 single family households would have an effective household count of 100, whereas Community B with 100 multi-family housing units would have an EHU of only 50 because the MF housing energy use weighting by 54/108, or 50%. This ensures that statewide energy is not over-allocated to communities with large MF housing stocks.

¹ The U.S. EPA 2011 study utilizes data from the 2005 EIA Residential Energy Consumption Survey (RECS). The weighting data could potentially be updated with more recent EIA RECS data.

² To access occupied housing unit data go to factfinder2.census.gov/ and search for the Selected Housing Characteristics Table (DP04) for your community and New York State.

Step 2: Divide the state and local EHU counts into their preference by fuel-use type and estimate local consumption.

From the ACS obtain the number of local and state housing units classified according to heating-fuel preference. Divide state and local EHUs from Step 1 into categories for fuel oil, propane, natural gas, and wood by multiplying EHU counts by the ratio of occupied housing units that heat with each fuel to the total number of housing units. Then, calculate actual local consumption of each fuel by multiplying the U.S. EIA-reported state residential consumption by the ratio of local to state EHUs that are presumed to prefer each fuel.

$$EHU_{State,Fuel} = EHU_{State} \times \frac{HU_{State,Fuel}}{HU_{State}}$$

$$EHU_{Local,Fuel} = EHU_{Local} \times \frac{HU_{Local,Fuel}}{HU_{Local}}$$

$$Consumption_{Local,Fuel} = Consumption_{State,Fuel} \times \frac{(EHU_{Local,Fuel\ Oil})}{\sum(EHU_{State,Fuel\ Oil})}$$

Where:

Fuel = Fuel Oil (#1, #2, #4, and Kerosene), Propane, Wood, Natural Gas

Local = Geographic boundary of the local or regional GHG inventory

State = All of New York State

$EHU_{(State,Fuel)}$ = Statewide number of effective occupied housing units that use the fuel to heat

$HU_{(State,Fuel)}$ = Statewide number of occupied housing units that heat with the fuel

$HU_{(State)}$ = Total statewide number of occupied housing units

$EHU_{(Local,Fuel)}$ = Local number of effective occupied housing units that use the fuel to heat

$HU_{(Local,Fuel)}$ = Local number of occupied housing units that heat with the fuel

$HU_{(Local)}$ = Total local number of occupied housing units

$Consumption_{(State,Fuel)}$ = Consumption of Residential fuel statewide (Reported by the U.S. EIA)

$Consumption_{(Local,Fuel)}$ = Consumption of Residential fuel locally (allocated portion of U.S. EIA total)

Residential Coal

Residential coal is not commonly used but is still present in some upstate regions. The methods above do not work for coal because the U.S. EIA reports that in New York residential usage has been zero for years. If a local jurisdiction has residential coal usage and the ACS data supports that, the Working Group decided to

use the following methodology to estimate coal usage³ assuming that coal houses use the same amount of energy as fuel oil homes:

$$Consumption_{Coal} = Consumption_{Fuel\ oil} \times \frac{EHU_{Local,Coal}}{EHU_{Local,Fuel\ Oil}}$$

Where:

Consumption_(Coal) = Community-wide residential consumption of coal in MMBTU

Consumption_(fuel Oil) = Community-wide residential consumption of fuel oil in MMBTU

EHU_(Local,Coal) = Effective Housing Units locally that use coal to heat

EHU_(Local,Fuel Oil) = Effective Housing Units locally that use fuel oil to heat

Step 3: [OPTIONAL] Correct for regional climate differences

Housing in colder climates consumes more heating fuels, and upstate New York State is significantly colder than downstate. The GHG Working Group decided that there should be a weighting factor when downscaling state energy consumption locally, but the group could not find a reliable correlation. As a placeholder, the GHG Working Group calculated HDD correction coefficients weighted to thirty-year average heating degree days (HDD) and EHU counts for each economic development region shown in Table 8. For rough weighting, these can be applied to heating fuel consumption estimates from step 2 to either increase or decrease the estimate based on the community's economic development region location.

$$HDD\ Coefficient_{REDC\ Region} = \frac{(EHU_{REDC\ Region} \times HDD_{REDC\ Region})}{\sum EHU_{REDC\ Region} \times HDD_{REDC\ Region}}$$

$$Corrected\ Local\ Fuel\ Use = Local\ Fuel\ Use \times HDD\ Correction\ Coefficient_{REDC}$$

³ This methodology was developed by the Working Group to estimate coal consumption in homes. Coal is used in a very small number of homes in New York State, and this methodology may overestimate coal energy use. Inventory preparers may elect to develop their own methodology for residential coal consumption, if appropriate.

Table 8: HDD Correction Coefficients by REDC Region

REDC	HDD	EHU	HDD Correction Coefficient
Western New York	6,609	572,929	1.13
Finger Lakes	6,570	472,542	1.13
Southern Tier	7,025	263,211	1.21
Central New York	6,618	306,081	1.14
Mohawk Valley	7,096	199,590	1.22
North Country	9,032	165,539	1.55
Capital Region	6,519	430,474	1.12
Mid-Hudson	5,936	810,003	1.02
New York City	4,776	3,047,249	0.82
Long Island	5,224	938,122	0.90
Source: 30 year average HDD data from National Weather Service. EHU and HDD Correction Coefficient for each REDC calculated by the Working Group. ⁴			

This simplistic HDD correction assumes that community energy use is proportional to the number of heating degree days. This was implemented to ensure that colder NY communities received a higher proportion of state fuel consumption compared to warmer communities when all else is equal. Actual relationship between climate and energy use is more complicated and so the above only applies roughly when apportioning state data downward. The GHG Working Group felt that since most communities may have access to real utility electricity and gas data, these alternative methods would to estimating consumption of tank heating fuels anyway. Communities can replace this method if a better approach is found to correct for regional climate differences.

Commercial/Institutional Energy Consumption

(Natural Gas, Electricity, Fuel Oils (#1, #2, #4, #6), Propane and Wood)

Recommended Method: Direct consumption data where possible

For natural gas and electricity, the best data come from a utility's CER as discussed earlier. For delivered tank fuels like fuel oil and propane, it is usually not possible to link consumption to sales data so alternative methods are nearly always used. Commercial consumption surveys may be performed by or through local institutions or universities. In the future, programs like the U.S. EIA's Commercial Buildings Energy Consumption Survey (CBECS) may release granular consumption data by state, county, facility type and fuel type. Always check that source for the latest available data sets.

⁴ NYSERDA uses NOAA Climate Prediction Center HDD data, which could also be used to develop a HDD correction coefficient for the REDCs.

Alternative Method: Allocate statewide consumption data

For energy and fuels not covered by a direct source, the GHG Working Group created an alternative method to estimate local consumption by downscaling statewide commercial consumption reported by the U.S. EIA weighted by the following parameters:

- **Commercial Floor Space:** The GHG Working Group felt that the local amount of conditioned commercial square footage would be a better weighting criterion than simple employment totals.
- **Home Heating Fuel Preference:** Although not a commercial metric, this will weight state commercial fuel allocation based on a community's access to or preference for specific fuels locally. For example, communities with many homes that heat with fuel oil will likely use more fuel oil in the commercial sector as well due to the implied lack of availability of natural gas.
- **Heating Degree Days:** New York's climate varies between upstate and downstate. The ratio of local HDD to statewide HDD provides an additional optional layer of weighting.

Step 1: Estimate employment and commercial floor space (sq. ft.)

Create a table with both statewide and local employment totals divided down by North American Industry Classification Code (NAICS) following the classifications in Table 9. In New York State data are available at county and local levels from the following sources:

- [New York State Department of Labor](#) produces and makes available online county level employment by NAICS code with annual updates.
- U.S. Census Transportation Planning Product (CTTP) estimates employment (and other metrics) at a highly granular resolution called Transportation Analysis Zones (TAZs). It is created every three years by the U.S. Census from the American Community Survey to support transportation planning by metropolitan planning organizations (MPOs). While raw data are available online, communities should check with their local MPOs (if they have one) to see if they have already processed the data in an easy-to-use format.
- U.S. Census Longitudinal Employment Household Dynamics (LODES) is a new product that contains similar employment and commuting data at the TAZ level. It may be more reliable than CTTP because it relies on actual business employment reporting to the state, as opposed to ground surveys of residents. LODES underestimates total employment by roughly 10% as it misses some small businesses and self-employment. It includes complete crosswalk files to help tabulate employment from TAZ levels to municipalities.

With local employment in hand, calculate state and local commercial square footage by multiplying employment by NAICS code by the average square footage per employee for that NAICS code found in the U.S. Department of Energy's [Commercial Building Energy Consumption Survey](#) (CBECS) program. The relevant NAICS codes and square footages from the most recent update completed in 2015 are provided in Table 9. Do not use NAICS codes for employment with a CBECS Principal Building Activity listed as N/A in the table.

Step 2: Divide floor space into its fuel preference and estimate local fuel consumption

Divide state and local commercial floor space into its likely “fuel preference” by multiplying total commercial floor space by the ratio of housing units that heat with each fuel to the total number of occupied housing units. Compute local consumption of fuel oil (#1, #2, #4, kerosene), propane, and wood by multiplying the U.S. EIA state commercial consumption by the ratio of local to state floor space that is presumed to prefer each fuel. For non-residential commercial fuels (e.g., fuel oil #6) it is acceptable to use only the ratio of local to state employment.

$$CSF_{Local,Fuel} = CSF_{Local} \times \frac{EHU_{Local,Fuel}}{EHU_{Local}}$$

$$CSF_{State,Fuel} = CSF_{State} \times \frac{EHU_{State,Fuel}}{EHU_{State}}$$

$$Consumption_{Local,Fuel} = Consumption_{State,Fuel} \times \frac{CSF_{Local,Fuel}}{CSF_{State,Fuel}}$$

Where:

Fuel = Fuel Oil (#1, #2, #4, and Kerosene), Propane, Wood, Natural Gas

Local = Geographic boundary of the local or regional GHG inventory

State = All of New York State

CSF_(Local,Fuel) = Local amount of commercial square footage that prefers the fuel

CSF_(Local) = Local amount of commercial square footage

EHU_(Local,Fuel) = Local number of effective housing units that heat with the fuel

EHU_(Local) = Local number of effective housing units

CSF_(State,Fuel) = Statewide amount of commercial square footage that prefers the fuel

CSF_(State) = Statewide amount of commercial square footage

EHU_(State,Fuel) = Statewide number of effective housing units that heat with fuel oil

EHU_(State) = Statewide number of effective housing units households

Consumption_(State,Fuel) = Consumption of fuel statewide (Reported by the U.S. EIA)

Consumption_(Local,Fuel) = Consumption of fuel locally (allocated portion of U.S. EIA total)

Step 3: (OPTIONAL) Correct for regional climate differences

Use the same correction table and method from Step 3 in the Residential Energy Consumption section.

Table 9: CBECS Average Square Footage per Worker

NYS DOL NAICS Industry	NAICS Code	CBECS Principal Building Activity	Average square footage per Worker
Total Commercial	NA	NA	977
Accommodation and Food Services	72	Lodging	2074
Administrative/Waste Services	56	Office	434
Agriculture, Forestry, Fishing Hunting	11	NA	NA
Arts, Entertainment, and Recreation	71	Public Assembly	1645
Construction	23	NA	NA
Educational Services	61	Education	791
Federal Government	951	Office	434
Finance and Insurance	52	Office	434
Health Care and Social Assistance	62	Health	501
Information	51	Office	434
Local Government	953	Public	809
Management of Companies	55	Office	434
Manufacturing	31	NA	NA
Mining	21	NA	NA
Other Services	81	Service	1105
Professional and Technical Services	54	Office	434
Real Estate and Rental and Leasing	53	Office	434
Retail Trade	44	Retail (Other Than Mall)	1246
State Government	952	Public Order and Safety	809
Transportation and Warehousing	48	Warehouse and Storage	2306
Unclassified	99	Other	956
Utilities	22	NA	NA
Wholesale Trade	42	Warehouse and Storage	2306
Source: USU.S. Department of Energy's Commercial Building Energy Consumption Survey (CBECS) program, 2015.			

Industrial Energy Consumption

(Natural Gas, Electricity, Fuel Oils (#1,#2,#4,#6), Coal, Petroleum Coke, Propane, Coal, Wood and Others)

Recommended Method: Direct consumption + statewide allocated data (Pie Slice Method)

(No alternate method was created)

Industrial energy use can be spread among small industries and/or concentrated in large point source industries. In some communities, a single industrial facility may dominate the entire community's GHG inventory; in others, there is no industry at all. Therefore, it is critical to find real data wherever possible because downscaling state data is less reliable for this sector than others. The GHG Working Group created a "pie slice" method to prioritize the use of reported public data first before allocating a share of statewide industrial fuel consumption presumed to be used by Unaccounted-For Industry (UFI) as is explained later.

Step 1: Identify and secure all measured and reported local industrial fuel consumption data

Large industry and some institutions may report energy consumption data to the state and federal government. These data should be identified and placed directly in a GHG inventory. For New York there are three primary sources of data:

Utility Community Energy Report: Determine if aggregate industrial electricity and natural gas consumption is available from the utility from a CER or from some other source. For electricity consumption, this is the only possible source of direct data besides asking the industries directly. Utility data may be reported as combined commercial and industrial in some cases.

New York State Department of Environmental Conservation (NYSDEC) Title 5 data: NYSDEC's air permitting program is required by the Clean Air Act and under New York State law and regulation, most notably 6 NYCRR Part 201. The program is administered by NYSDEC's Division of Air Resources (DAR). NYSDEC issues Title 5 Permits to the largest point sources and collects and publishes on its website each facility's fuel consumption, including coal, fuel oils, wood, natural gas and biomass. Data are available by address and location for each source. Pull data and sort for facilities with SIC or NAICS codes for Manufacturing, and Gas Production and Distribution (SIC: 20- to 39-, and 492-; NAICS: 31-, 32-, or 33-, and 486210). NYSDEC issues two additional classes of air emissions permits (State Registration and State Facility Permits) to smaller industry. These include community location but not fuel use. For GHG accounting, these industries are called Unaccounted for Industry (UFI). While actual energy consumption is not available, counting the number of these permits in a community can provide an understanding of how much small industry is active in the community.

U.S. EPA Mandatory Reporting Rule (MRR): The U.S. EPA has required facilities with GHG emissions of greater than 25,000 MTCDE/year to report emissions under the MRR since 2012. The dataset is available online at <http://ghgdata.epa.gov> and includes fossil fuel-based emissions by fuel type, as well as any process GHG emissions not reported to NYSDEC. Consider the same NAICS codes as above.

All of the three sources above will overlap to some degree. There is significant overlap between MRR and Title 5. The Title 5 dataset is preferred because it is quality controlled by NYSDEC. In theory, aggregate

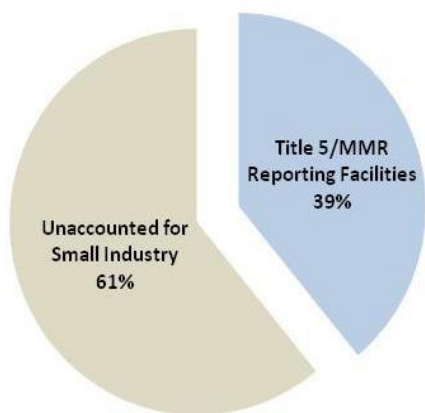
utility-supplied natural gas should include any usage reported independently to MRR or Title 5, but that is not always the case. If a utility's reported "total" industrial natural gas consumption is significantly lower than consumption by a single entity in the community reporting to MRR or Title 5, that usually means the industry is buying natural gas from a main line distributor and not from the retail utility.

Step 2: Add an Estimate of Consumption from Unaccounted-for Industry (UFI)

Communities will need to estimate consumption by smaller local industry that does not report fuel use to the programs listed in Step 1. Smaller communities should rely on local knowledge before proceeding however. If they are aware that they do not have small industry, then they should skip estimating UFI fuel consumption in the community.

The GHG Working Group compared 2010 GHG emissions from all New York Title 5 facilities to direct GHG emissions for the entire industrial sector (excluding electricity consumption) and found that 39 percent of industry emissions are represented by Title 5 reporters. The balance, 61%, is UFI.

Figure 2: Industrial "Pie Slice" Method



To estimate UFI fuel consumption locally, the simplest approach is to allocate a portion of 61% of each industrial fuel's U.S. EIA reported statewide consumption locally using one of following two approaches:

- Use a local to state ratio of manufacturing employment (SIC: 20- to 39-, and 492-; NAICS: 31-, 32-, or 33-, and 48)⁵ with employment data developed for and discussed in the commercial sector guidance.
- Use a local to state ratio of the *total* air emissions (across all three permit classes) issued by NYSDEC's air permitting program.

⁵It would be more accurate to estimate a UFI fraction of each fuel separately, but that was determined to be a diminishing return on the level of effort needed to do that.

Table 10 shows an example of UFI apportionment using 2010 data. Unless NYSDEC expands data collection to smaller entities, the Working Group decided that it is safe to assume that the rate of GHG emissions by UFI will remain at 61% in future years. Communities should update the U.S. EIA industrial sector fuel consumption totals to the current year.

Table 10: Energy Use In Unaccounted for Industry in 2010

Fraction of GHG Emissions by Unaccounted for Industry for 2010		
State Industrial GHG Emissions (MTCDE)	11,642,220	
Title 5 Facility GHG Emissions (MTCDE)	4,549,289	
Unaccounted for Industry (%)	61%	
Energy Use in Unaccounted for Industry (UFI) (MMBTU)		
Fuel Name	U.S. EIA State Total	UFI (61% of total)
Natural Gas	77,800,000	47,399,041
Coal	25,500,000	15,535,675
Fuel Oil (#1,#2,#4)	14,700,000	8,955,860
Fuel Oil #6	3,900,000	2,376,044
LPG	1,700,000	1,035,712
Motor Gasoline	10,100,000	6,153,346
Wood and Wood Residuals	15,000,000	9,138,633
Retail Electricity Sales	46,000,000	46,000,000
Other Petroleum Products	20,102,000	12,246,986
Source: State Industrial GHG Emissions and Title 5 Facility GHG Emissions provided by NYSERDA and NYSDEC, for 2010. Energy use by Fuel source from U.S. EIA, 2010. UFI energy use by fuel source calculated by Working Group.		

Electric and Heat Power Generation

(Coal, Fuel Oil, Natural Gas, MSW, Wood and Others)

Communities should include direct (Scope 1) GHG emissions from central power plants in the business of selling electricity to the wider grid. This will include microgrids and heating districts if they retail power to consumers through a local distribution grid. In general, emissions from power and heat generation dedicated to a specific industry, private institution or campus will be reported as either commercial or industrial consumption depending on the end user.

Recommended Method: Use GHG emissions reported to MRR and Title 5 programs

(No alternate method created)

There are three sources of power plant data: The U.S. EIA Form 923 Electric Power Reporting Program, the U.S. EPA MRR and the Title 5 program managed by NYSDEC. U.S. EIA Form 923 collects data on generators larger than 1 MW and is available online. The MRR and Title 5 datasets are discussed in the Industrial Sector of this guidance. Communities should download all three datasets and cross reference them, querying for

NAICS code 22 (power generation) in the MRR and Title 5 datasets. When there is overlap, communities should favor Title 5 data because NYSDEC quality controls this data. Each set includes address information so power plants can be easily placed directly in a community inventory.

Communities with retail heat energy districts (CHP) and microgrids have the option of reporting the same emissions as both direct and indirect. A community with a microgrid in an urban core can list total emissions as direct in the Electric and Heat Power Generation sector, and then divide those emissions as indirect (Scope 2) to the relevant end use sectors.

Transmission and Distribution (T&D) Losses

When natural gas consumption is metered by a utility, a portion, called lost and unaccounted for (LAUF), gas is lost during transmission. T&D loss can have a significant GHG footprint because LAUF gas is equivalent to direct fugitive emissions of unburned methane. The GHG Working Group decided that T&D losses should be included in community inventories as a line item as shown in Table 1: Geospatial GHG Accounting Framework. Electricity also suffers T&D losses. However, NYSERDA's electricity emission factors are created by dividing total grid-wide power plant emissions by end-use retail sales. Therefore, T&D is inherently included in indirect (Scope 2) emission calculations.

Recommended Method: Utility specific T&D loss rate

(No alternate method created)

Utilities estimate a T&D loss rate over their whole service territories as the difference between the natural gas they purchase and the natural gas they sell. Because the exact location of losses is not relevant for community planning, the GHG Working Group decided that T&D losses can be estimated by multiplying local consumption by the utility's service-territory wide reported LAUF gas rate disclosed in the utility's annual report to the New York State Public Service Commission (NYPSC). These reports are available at the NYPSC website. If a utility specific LAUF rate is not available, the GHG Working Group agreed that a state default of 1.8% can be used based on an informal survey of available loss rates in 2010.

Convert LAUF natural gas from therms or MMBTU to a mass basis, and then to MTCDE (metrics tons carbon dioxide equivalent) using the AR4 global warming potentials in Table 4. Exclude power station natural gas consumption because they usually tap huge quantities of gas directly from the main line distribution system. These lines are subject to lower loss rates.

Industrial Process and Product Use

Industrial Process Emissions

Recommended Method: Consult U.S. EPA's MMR program

Many industries such as the aluminum, cement, ferroalloy, iron and steel, semi-conductor, and pulp and paper industries may use GHGs or create them as chemical by-products of manufacturing. These emissions are distinct from fossil fuel emissions at the same facilities. Process emissions include CO₂, CH₄, N₂O, perfluorocarbons (PFCs) and NF₃. Communities should refer to Chapter 4 of the Inventory of U.S. GHG Emissions and Sinks: 2009-2011 for a detailed discussion of this source (U.S. EPA, 2013).

Historically, state and regional agencies roughly estimated emissions by counting local raw materials production and multiplying them by IPCC emissions. This does not work well locally. As of 2012, however, large facilities emitting GHGs greater than 25,000 MTCDE per year must measure and report industrial process emissions directly to the U.S. EPA under the Mandatory Reporting Rule (MRR). These data represent a significant improvement in accuracy and placement of sources and should be used. For smaller sources, the GHG Working Group agreed that communities can exclude them until there is a more reasonable way to estimate them.

Communities and regional planning agencies should consult their regional economic development councils and related groups to find out which, if any, process GHG relevant industries are active in the area.

Product Use: Ozone Depleting Substitutes (ODSs) and SF₆

Recommended Method: Develop and apply a U.S. average

Many refrigerants and other products are GHGs in themselves and create a GHG footprint when they leak into the atmosphere. Product use emissions are divided into two categories:

Hydrofluorocarbons (HFCs) are common refrigerants and fire retardants used ubiquitously in homes, buildings and vehicles, and in commercial facilities like ice rinks and supermarkets. They are also called ozone depleting substitutes (ODS) because they were created to replace chlorofluorocarbons (CFCs) banned by the Montreal Protocol.

Because ODS consumption cannot be measured in a community, the GHG Working Group developed a per capita emissions rate by dividing the total ODS emissions in the U.S. National GHG Inventory (U.S. EPA, 2013) by population as shown in the table below. This rate can be applied locally to the population in the community. For future inventories it would be preferable to update this rate using the latest U.S. GHG Inventory but it is also acceptable to use the 2010 rate in Table 11 since it is a small source.

Table 11: Ozone Depleting Substitutes (ODS) Emissions per Capita

Calculation of 2010 ODS GHG Emissions per Capita		
U.S. ODS Emissions	MTCDE	114,600,000
U.S. Population		308,745,538
ODS per Capita	MTCDE / Capita	0.371
Source: U.S. ODS Emissions from the U.S. National GHG Inventory (U.S. EPA, 2013). U.S. Population from U.S. Census, 2010. ODS per Capita calculated by the Working Group.		

Sulfur Hexafluoride (SF₆) is a specialized coolant used by the utility industry and is a very potent GHG. New York utilities run SF₆ use reduction and leak loss initiatives in partnership with the U.S. EPA. Since communities do not manage these emissions, the GHG Working Group agreed that communities can estimate SF₆ emissions as simply proportional to the amount of electricity they consume. Communities may be able to obtain an SF₆ use rate (as SF₆ use / KWh sold) from utilities, or they calculate a U.S. average rate by dividing total utility-related SF₆ emissions in the U.S. National GHG Inventory by total retail electricity sales (U.S. EPA, 2013). This emissions rate should be applied to total electricity consumption across all sectors in the community. Table 12 shows data for 2010. Since this is a small source and not under community control, this rate can be applied to future years for the sake of ease. Regional climate action plans that include utilities as partners, however, may want to target this source and account for it more accurately.

Table 12: SF₆ Emissions per MMBTU Electricity Consumed

Calculation of 2010 SF ₆ emissions rate		
U.S. SF ₆ Emissions	MTCDE	11,800,000
U.S. Electricity Consumption	MMBTU	12,810,300,000
SF ₆ / MMBTU consumed	MTCDE / MMBTU	0.000921134
Source: U.S. SF ₆ Emissions and electricity consumption from the U.S. National GHG Inventory (U.S. EPA, 2013). SF ₆ / MMBTU calculated by the Working Group.		

Transportation Energy Use

The transportation sector includes GHG emissions from fuels and energy used to power transport vehicles and related equipment. This sector is often 25-50% of a community's GHG inventory. In this guide, this sector does not include emissions from support operations such as electricity used in port operations. The U.S. Community Protocol divides emissions into five general categories:

- On-road mobile: motorcycles, cars, truck, buses and all other on-road vehicles.
- Off-road mobile: agricultural machinery, construction and maintenance vehicles, lawn and garden equipment, and other equipment that uses transportation fuels but do not operate on roads. *This category should not be confused with the common term "non-road," which refers to all transportation modes other than roads, including those below.*
- Rail: locomotives.
- Marine: commercial shipping, pleasure/private craft, ferries and all other ships.
- Aircraft emissions: all forms of aircraft.

Tailpipe GHG Emission Calculations

Transport fuel consumption creates CO₂, CH₄ and N₂O. CO₂ represents 98% of a fuel's GHG footprint and is the easiest to calculate by estimating fuel consumption by each mode and applying the fuel- specific CO₂ emission factors from the U.S. EPA's MRR Program. See Table 13.

$$CO_2 \text{ Emissions from Fuel} = CO_2 \text{ Emission Factor for Fuel} \times \text{Energy Consumption of Fuel}$$

Table 13: U.S. EPA MMR Transport Fuel Emission Factors

Fuel Type	kg CO ₂ per unit	Unit
Aviation Gasoline	8.31	gallon
Biodiesel (100%)	9.45	gallon
Compressed Natural Gas (CNG)	0.0545	scf
Diesel Fuel	10.21	gallon
Ethane	4.05	gallon
Ethanol (100%)	5.75	gallon
Jet Fuel (kerosene type)	9.75	gallon
Liquefied Natural Gas (LNG)	4.46	gallon
Liquefied Petroleum Gases (LPG)	5.68	gallon
Methanol	4.10	gallon
Motor Gasoline (100%)	8.78	gallon
Propane	5.72	gallon
Source: U.S. EPA Mandatory Reporting Rule Emissions Factors, April 2014.		

CH₄ and N₂O are more complicated because their emission factors depend upon vehicle technology and age, driving cycle, and climate conditions. Vehicle emission factors in the U.S. Community Protocol and in the U.S. EPA's MMR Program are expressed in grams / mile or grams / hour, and differ among types of vehicles and fuels. For community-scale GHG accounting, however, the GHG Working Group decided that there is a tremendous diminishing return on labor investment in accurately calculating CH₄ and N₂O. Not only are they more challenging to calculate, they represent less than 2% of a fuel's GHG footprint. Furthermore, communities only target fuel reduction and do not target specific transport GHGs.

Therefore, communities are free to use the full methods in the U.S. Community Protocol and the compendium full set of VMT-based emission factors in the MMR. However, the New York GHG Working Group determined that two simple methods are also acceptable:

- Where vehicle-miles-traveled (VMT) is available, it is acceptable to use national average fleet CH₄ and N₂O emission factors expressed in grams/mile as shown in Table 16.
- Where VMT is not available, it is acceptable to estimate CH₄ and N₂O emissions (as CO₂ equivalent) simply by multiplying CO₂ emissions by 0.1 percent and 1.8 percent respectively. These values were proposed in the U.S. EPA's Draft Regional GHG Inventory Guidance (U.S. EPA,2009) and confirmed by the GHG Working Group. This assumption can be applied to transport fuels consumed by any mode.

Reporting Biofuels

Communities should report biogenic CO₂ emissions separate from fossil fuel CO₂ as shown in the sample of the Detailed GHG Inventory Report shown in 3. This approach is consistent with international reporting guidance from the IPCC and WRI GHG Protocol. Associated CH₄ and N₂O emissions from biofuel combustion should be included as direct Scope 1 emissions.

Figure 3: Example of Biogenic CO₂ Reporting

Report petroleum gasoline emissions as Scope 1 and ethanol emissions as biogenic

Sector / Source	GHG Emissions (MTCDE)					(MMBT)
	Scope 1	Scope 2	Scope 3	Biogenic	Rolled up?	
Transport: On-Road						
Motor Gasoline (E-10)	2,300,000			214,000	Yes	
Diesel					Yes	
Ethanol (E-85)					No	
Biodiesel					No	
Transport: Rail, Marine, Off-Road, Air						
Motor Gasoline (E-10)	450,000			39,500	Yes	
Diesel					Yes	
Residual Fuel Oil (#5 and #6)					Yes	
Natural Gas					Yes	
Propane / LPG					Yes	
Jet Kerosene (Air)					Yes	

Nearly all motor gasoline in New York is a 10 percent blend of ethanol, or E-10, although some stations do offer a zero ethanol blend. For the purposes of the GHG inventory, inventory preparers can assume that all gasoline is E-10. Emissions from the petroleum portion should be reported as Scope 1 emissions and the ethanol component reported as biogenic.

On-Road Mobile (Direct and Indirect)

The U.S. Community Protocol recommends communities consider both direct GHG emissions by vehicles operating within the geographic boundary of the community, and indirect emissions induced by the community, regardless of whether the vehicles operate inside or outside the community boundary. Both approaches are discussed in this section, however most communities will elect to only include direct emissions as the methods for estimating indirect emissions are emerging and not widely in use around the country.

Direct Emissions: Conventional Gasoline and Diesel

Recommended Method: Use MOVES data (for jurisdictions that manage air quality)

U.S. EPA's Office of Transportation and Air Quality's [Motor Vehicle Emission Simulator \(MOVES\)](#) now has a robust module to report GHG emissions from cars, trucks and motorcycles. Communities should check with their local metropolitan planning organizations (MPO) to find out if MOVES is being used, and if data are available to them. This model will capture small changes in emissions that result from environmental and driving cycle differences across regions. MOVES can be expensive to implement and maintain, so this approach is recommended for regions that already use the MOVES model and can easily obtain GHG emissions from it.

If MOVES or a similar alternative model is used, communities should make sure to account for the fact that 10 percent of retail gasoline is ethanol and the associated GHG emissions should be reported as biogenic and not Scope 1. If straight GHG emission estimates from gasoline are available with no breakdown of Scope 1 and biogenic emissions, it is acceptable to simply allocate 6.78 percent of the GHG emissions as biogenic. This allocation takes into account the lower emissions factor for ethanol, as compared to 100% motor gasoline.

Alternative Method: Estimate VMT and fuel use

As an alternative, communities can estimate local vehicle-miles-traveled (VMT) and use average fuel economies to calculate total fuel consumption and GHG emissions.

Step 1: Estimate total VMT for all vehicle activity in the community

On-road VMT data are becoming more and more available, and communities are encouraged to search for the best data possible before they begin. Currently, there are several sources possible:

Local traffic counts and survey data: Some communities and local universities may have performed traffic counts and developed VMT estimates for traffic studies.

Metropolitan planning organizations (MPOs): Some communities are covered by an MPO that can produce VMT by community using a transportation demand model. MPOs run these models to support transportation planning and investment decisions. For example, the Capital District Transportation Committee (CDTC) develops VMT estimates for all communities within its service territory, as shown in the sample data for 2012 in Table 14 below:

Table 14: Sample 2010 VMT Data from the Capital District Transportation Committee

MCD NAME	TYPE of MCD	COUNTY NAME	Total VMT	Fuel Consumption (Gallons)		
				Gasoline	Ethanol	Diesel
Menands	Village	Albany	131,076,906	5,105,949	567,328	672,121
Colonie	Village	Albany	142,982,262	5,559,689	617,743	658,896
Voorheesville	Village	Albany	20,464,079	794,177	88,242	84,410
Bethlehem	Town	Albany	359,198,482	13,952,741	1,550,305	1,638,551
Colonie	Town	Albany	1,098,437,775	42,674,721	4,741,636	5,104,215
Altamont	Village	Albany	6,605,201	256,775	28,531	35,328
Cohoes	City	Albany	60,520,335	2,345,765	260,641	247,388
Guilderland	Town	Albany	465,561,729	18,090,213	2,010,024	2,052,958
Watervliet	City	Albany	111,067,234	4,324,953	480,550	563,806
Albany	City	Albany	1,041,725,983	40,542,803	4,504,756	5,132,858
Green Island	Village	Albany	17,866,323	695,426	77,270	85,947
Ravena	Village	Albany	25,278,922	983,622	109,291	138,578

Source: VMT data provided by the Capital District Planning Committee. Fuel Consumption calculated using the recommended method for jurisdictions that manage air quality.

New York State Department of Transportation (NYSDOT): NYSDOT maintains county-level VMT from its network of monitoring stations. It updates these data every three years to support NYSDEC's statewide air quality modeling efforts and to provide data to MPOs for planning purposes. The most recent dataset available from NYSDOT, for the year 2010, is in Table A- 2: 2010 NYSDOT Reported Vehicle Miles Traveled (VMT) by County. These data can be downscaled locally using a proportion of county-to-local road inventory, or by some other suitable metric. For areas with partial MPO coverage, communities should use the MPO data and backfill with NYSDOT data only where needed.

Step 2: Calculate consumption of gasoline and diesel

Divide total VMT into the vehicle and fuel categories shown in Table 16 and compute fuel consumption in gallons using each category's fuel economy. Choose the local vehicle mix based on the community's economic development region in Table 17. The GHG Working Group developed this table using data from the NYSDOT (NYSDOT, 2009). Sum consumption across vehicle/fuel categories:

$$Fuel\ Consumption_{Fuel} = \sum_{Vehicle\ Type} VMT \times FM_{type} \times \left(\frac{1}{FE_{type}} \right)$$

Where:

Fuel = Gasoline, diesel, etc.

Fuel Consumption_{Fuel} = Total amount of fuel used in gallons

Vehicle Type = Vehicle types, as listed in Table 16 or modified by a community
 VMT = Total community-wide VMT summed across all vehicle types
 $FM_{\text{Vehicle Type}}$ = Fraction of total on-road fleet made up by the specific vehicle type (%)
 FE_{type} = Fuel economy for the specific vehicle type expressed in miles/gallon

Step 3: Compute GHG Emissions (CO₂, CH₄, and N₂O)

Calculate CO₂ emissions using emission factors in Table 13. For CH₄ and N₂O use the emission factors in grams/mile listed in Table 16, or use the simplifying assumption discussed earlier that the carbon-equivalent footprint of CH₄ and N₂O from transport fuel combustion is equal to 0.1 and 1.8% of the fuel’s CO₂ emissions respectively.

As a double check, inventory preparers can use the county-level fuel sales data available from the NYS Department of Taxation and Finance, which is included in [NYSERDA’s Patterns and Trends Report](#). Although fuel sales are not directly linked to end-use consumption, this can be a reasonable estimate for a regional or county-level inventory, to make sure that the estimates developed using the alternative method are comparable to the fuel sales numbers.

Example: 2010 On-road Emissions from the Village of Colonie, NY

Fuel consumption for 2010 in the Village of Colonie is calculated in Table 16 using VMT data from the Capital District Transportation Committee (Table 14) and the Capital Region vehicle mix (Table 17). The Federal Highway Administration’s Highway Statistics Series reports on-road fleet average fuel economy and related emission factors (Table 15). This is updated annually (USDOT, Office of Highway Policy Information, 2012). Communities should seek data to match the year of the inventory since average fuel economy is improving, and this significantly changes community emissions.

Table 15: U.S. DOT 2010 fleet average fuel economies, and related GHG emission factors

Vehicle Type	Gas/Diesel	MPG	CO ₂ EF	CH ₄ EF	N ₂ O EF
Light Duty Vehicles Short WB	GASOLINE	23.50	8.78	0.028	0.029
	DIESEL	23.50	10.21	0.001	0.001
Light Duty Vehicles Long WB	GASOLINE	17.20	8.78	0.031	0.043
	DIESEL	17.20	10.21	0.001	0.001
Single-Unit Trucks	GASOLINE	7.30	8.78	0.0333	0.0134
	DIESEL	7.30	10.21	0.051	0.0048
Buses	GASOLINE	7.20	8.78	0.0333	0.0134
	DIESEL	7.20	10.21	0.051	0.0048
Combination Trucks	GASOLINE	5.90	8.78	0.0333	0.0134
	DIESEL	5.90	10.21	0.051	0.0048
Motorcycles	GASOLINE	43.20	8.78	0.028	0.029
Source: U.S. DOT, 2010.					

Table 16: Sample Fuel Consumption Calculation for the Village of Colonie, NY (Capital District Region)

Step 1	Step 2: Calculate Fuel Consumption (gallons)								Step 3: Calculate GHG Emissions in MTCDE				
County Total VMT	Vehicle Type	Fuel	Mix (%)	VMT (miles)	Fuel Economy	Gasoline	Ethanol	Diesel	CO2	CO2 (biogenic)	CH4	N2O	Total CO2
142,982,262	LDGV (Short WB)	Gasoline (E-10)	75.3%	107,665,643	23.5	4,123,365	458,152		36,203	2,634	63	968	37,234
	LDDV (Short WB)	Diesel	0.2%	285,965	23.5			12,169	124	0	0	0	124
	LDGV (Long WB)	Gasoline (E-10)	16.2%	23,163,126	17.2	1,212,024	134,669		10,642	774	15	309	10,965
	LDDV (Long WB)	Diesel	1.1%	1,572,805	17.2			91,442	934	0	0	0	934
	Single-Unit Trucks	Gasoline (E-10)	2.9%	4,146,486	7.3	511,211	56,801		4,488	327	3	17	4,509
	Single-Unit Trucks	Diesel	1.3%	1,858,769	7.3			254,626	2,600	0	2	3	2,604
	Buses	Gasoline (E-10)	0.1%	142,982	7.2	17,873	1,986		157	11	0	1	158
	Buses	Diesel	0.5%	714,911	7.2			99,293	1,014	0	1	1	1,016
	Combination Trucks	Gasoline (E-10)	0.0%	0	5.9	0	0		0	0	0	0	0
	Combination Trucks	Diesel	1.9%	2,716,663	5.9			460,451	4,701	0	3	4	4,708
	Motorcycles	Gasoline (E-10)	0.5%	714,911	43.2	14,894	1,655		131	10	0	6	138
Totals			100.0%	142,982,262		5,291,430	653,263	917,981	60,993	3,756	88	1,309	62,390
Source: Total VMT, Table 14. Vehicle Mix, Table 17. Fuel Economy, Table 15.													

Table 17: Default Vehicle Mix by Economic Development Region

LDGV (Short WB)			LDGV Long WB		Single-Unit Trucks		Buses		Combination Trucks		Motorcycles
REDC	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline
Capital Region	75.3%	0.2%	16.2%	1.1%	2.9%	1.3%	0.1%	0.5%	0.0%	1.9%	0.5%
Central NY	76.6%	0.2%	14.5%	1.0%	3.0%	1.4%	0.2%	0.7%	0.0%	1.9%	0.4%
Finger Lakes	78.2%	0.3%	13.2%	0.8%	2.9%	1.6%	0.2%	0.6%	0.0%	1.7%	0.4%
Long Island	75.9%	0.2%	15.8%	1.1%	2.5%	1.2%	0.2%	0.7%	0.0%	1.9%	0.6%
Mid-Hudson	79.2%	0.2%	12.4%	0.9%	3.3%	1.3%	0.1%	0.6%	0.0%	1.5%	0.5%
Mohawk Valley	78.3%	0.3%	13.3%	0.8%	2.9%	1.6%	0.2%	0.6%	0.0%	1.6%	0.4%
New York City	78.6%	0.3%	12.9%	0.8%	3.0%	1.8%	0.2%	0.6%	0.0%	1.6%	0.4%
North Country	79.9%	0.3%	12.3%	0.8%	2.5%	1.4%	0.2%	0.7%	0.0%	1.6%	0.4%
Southern Tier	75.9%	0.2%	15.0%	1.0%	3.2%	1.4%	0.2%	0.7%	0.0%	1.9%	0.5%
Western NY	85.0%	0.3%	8.8%	0.5%	1.5%	0.9%	0.1%	1.1%	0.0%	1.3%	0.3%
Source: Vehicle mix data from <i>Mobile 6.2 Emission factors for Micro-scale Project Analysis</i> (NYSDOT 2009) and reapportioned to the REDC regions.											

Incorporating Alternative Fuels (CNG, LPG, Biodiesel, E-85 and Electric Vehicles)

The default regional vehicles mixes in Table 17 assume that *all* vehicles use conventional gasoline (E-10) and diesel. This is still reasonable in most locations, and acceptable for an initial GHG emissions inventory baseline. For progress tracking, however, communities can create their own vehicle mix table by adding alternative fuels (e.g., E-85, natural gas and electricity) when there is enough data on market penetration.

Alternatively, communities can adjust gasoline and diesel estimates to shift some consumption to biodiesel and E-85 if there is significant local penetration of these fuels.

On-road Electric Vehicles (EVs)

Communities are investing in EV infrastructure to help electrify on-road transportation. This will significantly reduce GHG emissions in New York. NYSERDA is now tracking EV registration data by zip code, which inventory preparers can use to estimate emissions associated with electric vehicles. EV registration by zip code can be found at: <http://www.nyserda.ny.gov/Cleantech-and-Innovation/Electric-Vehicles/Tools/Electric-Vehicle-Registration-Map>. NYSERDA recommends using an average fuel economy of 4 miles/kWh and estimating the vehicle miles travelled using this fuel economy. Communities should report EV GHG emissions as Scope 2 emissions, using electricity emissions factors. In the future, EV penetration could inadvertently appear to slightly increase electricity consumption in the residential and commercial sectors while reducing direct gasoline and diesel use. If utilities cannot separate out electricity sales for EVs, communities may need to adjust utility-supplied residential and commercial sector totals to account for on-road electric vehicles, by deducting the actual or estimated emissions associated with EV usage.

Indirect Emissions from Induced Vehicle Miles Traveled (IVMT)

The U.S. Community Protocol recommends that, where feasible, communities calculate indirect GHG emissions based on the amount of regional VMT for which they are responsible. *This form of VMT is called a community's induced vehicle-miles-traveled, or its "IVMT."* This is a new concept to link regional transportation emissions to local land use planning policy, and is a more advanced optional method for communities seeking to do a more complex analysis of transportation emissions. As shown in Table 1, communities may substitute IVMT emissions for direct on-road emissions in the community's GHG Rollup Report, if the IVMT data is available. IVMT has yet to be used by a local government in New York state, and at the time of publication has only been used by several communities around the country.

In the IVMT paradigm, transportation demand is presumed to the sole responsibility of *origin and destination* communities only. A trip's actual physical VMT will be divided and counted toward each community's IVMT total and none is assigned to communities that are simply being passed through. All communities will have some IVMT, though maps of IVMT will correlate with population and business centers instead of road networks. A community's rate of IVMT per unit of housing, employment and other various economic indicators is a measure of the "transportation efficiency" of that community's land-use patterns. The most efficient communities create the least amount of regional VMT per household, per job, per commercial revenue dollar, etc.

IVMT highlights the regional nature of transportation planning. Suburban car-dependent commuter communities and distant job centers are jointly responsible for significant regional VMT, and hence they will be responsible for more IVMT than communities with mixed development and transit. Communities can diagnose the reason for high IVMT and achieve GHG reductions through land-use policy to co-locate housing, services, business and employment. Straight VMT is often a poor local planning tool by itself. In fact, any positive economic development, even mixed-use development, may increase local VMT and emissions, even though it can significantly reduce IVMT.

IVMT accounting is complex and will require communities to collaborate with an MPO or other expert group to design and run a transportation demand model (TDM) capable of generating IVMT. These models simulate origin-destination travel demand based on highly granular distribution of housing, employment, non-motorized connectivity, and other factors overlaid on the physical road network. In New York, most MPOs run TDMs for road planning and can produce VMT counts on roads. These models will need to be modified to tabulate IVMT at a community level.

Rail (Direct and Indirect)

Rail transportation creates GHG emissions. This mode is very energy efficient for moving freight and passengers compared to on-road vehicles. Railroads are classified as follows:

- Class I: Large long-distance freight.
- Class II/III: Local and regional freight.
- Line Haul Commuter: Regional passenger rail / subway operating in a metropolitan region.
- Line Haul (Amtrak): Long-distance passenger travel.

Rail locomotives throughout New York consume mostly diesel, although commuter rail and subway may be electric powered.

Direct Emissions

The source is from diesel and electricity consumed by rail locomotives operating in the community. All communities with rail infrastructure should attempt to include this source.

Recommended Method: Local commuter rail

Communities served by local commuter rail transit systems should contact operators, request system wide fuel and electricity use and, if necessary, try to apportion it by the amount of use that occurs in the community. For communities that have local rail simply passing through over short distances, this direct source can be excluded.

Alternative Method: All rail systems (diesel only)

NYSERDA surveyed the rail industry in 2002 and produced county-level estimates of diesel consumption across all types of rail transport (NYSERDA, 2005). These data are presented in Table A- 3: Diesel Consumption (Gallons) by Rail Mode by County. The GHG Working Group found no way to update the data and concluded it is still likely to be reasonably valid and can be used until it is updated. Communities can pull data directly from the table and apportion it locally based on the length of rail lines in boundary compared to the county.

Alternatively, NYSDEC reports that the National Emissions Inventory produced by the US EPA on a three-year cycle (2011 and 2014) has county-level GHG emissions data, and that they (NYSDEC) possesses this data. Communities should contact NYSDEC for this potentially improved source.

Direct emissions from freight and line-haul passenger (e.g., Amtrak and the Long Island Rail Road) are not usually under local policy control and smaller communities being passed through by rail can exclude this source. Regional planning agencies and communities with rail centers should include this source since they may implement infrastructure improvements to increase rail usage as a GHG reduction measure.

Indirect (Induced) Rail Emissions

Similar to on-road transportation, communities with significant rail ridership have the option of attempting to account for associated GHG emissions with passengers arriving and departing the community. A community would need to calculate (or obtain) a GHG emissions rate (or fuel use rate) per passenger track mile and multiply that by annual ridership and average trip length. Following the “IVMT” paradigm discussed for on-road indirect emissions, communities would count a share of each trip that arrives to and departs from the community. Communities would report this indirect source as Scope 3 and can substitute it for the direct emissions line item in the Rollup GHG Report. Including this source along with indirect on-road emissions would be a valuable tool to show the GHG benefits of expanding rail transportation. The GHG Working Group found no standard methods for this however since it is still a new concept. Communities can refer to the U.S. Community Protocol and references therein for more information.

Marine Vessels, Shipping and Boats (Direct)

Communities with waterways, lakes or ocean borders may have emissions from private and pleasure craft, commercial shipping, and passenger ferry operations. Methods in this guide are limited to emissions related to fuel consumed by boats and ships within the community boundary. Some communities may have significant emissions; others with boating limited to private crafts on small lakes and rivers will have a small source.

Recommended Method: Check for direct fuel sales and consumption records

Communities with major ports should always check if the port estimates local in-port fuel consumption for air quality reporting. Major ferry operators will supply data if they are publicly operated. Communities with major lakes or harbors may be able to estimate fuel consumption by contacting cooperating marinas for fuel sales data.

Alternative Method: NYSDEC NONROAD data and National Emissions Inventory (NEI) data

Direct sales and use data are usually not available. For pleasure and private craft, communities can use gasoline and diesel consumption produced by NYSDEC’s Division of Air Resources at a county level to support air quality modeling. NYSDEC runs U.S. EPA’s NONROAD model and estimates fuel consumption and GHG emissions for all types of non-road transport including pleasure and private craft. 2007 data used as a surrogate for 2010 are in Table A- 4: 2010 GHG Emissions by Off-road Vehicles and Pleasure Craft. NYSDEC updates these data every three to five years on an informal schedule. NYSDEC reports that the 2011 data are complete and communities can refer to NYSDEC for this data.

For commercial vessels, the GHG Working Group did not identify a consensus alternative method using top-down data. Some of the CGC Regional Planning Teams used county-level carbon monoxide (CO) emissions

from the U.S. National Emissions Inventory⁶ as a proxy for CO₂ emissions. They converted CO into CO₂ emissions with a shipping CO/CO₂ combustion ratio developed from the revised IPCC 1996 Guidelines for emission inventories. In that guidance, on Table 1-47 for non-ocean going boats consuming residual fuel oil or diesel, the mass ratio of CO and CO₂ emission is $0.0065 \text{ MT CO} / \text{MT CO}_2$. Communities using this approach should add an additional 1.9 percent to the CO₂ equivalent estimate to account for emissions of CH₄ and N₂O as discussed earlier.

Aircraft (Direct and Indirect)

This sector includes emissions from all aircraft, including private and commercial airplanes and helicopters. This section considers both direct and indirect emissions.

Direct (Scope 1) Aircraft Emissions

Direct emissions are defined as emissions from all aircraft operating within the local or regional airspace. This includes local flights, helicopters, and the departing and arriving legs of long-haul flights. Some large airports model emissions from aircraft during departure and arrival stages for air quality purposes and may have fuel consumption estimates. This approach to accounting is not necessarily useful for local GHG policymaking and so the GHG Working Group decided it is not necessary to include this source unless the inventory is prepared at a regional level. No data were found to support this source. Communities should check with NYSDEC through the Climate Smart Communities or Division of Air Resources program to see if county-level data are now.

Indirect (Scope 3) Aircraft Emissions

A potentially more valuable policy tool for aircraft is to calculate an indirect (Scope 3) emissions footprint associated with all regional local and long distance air travel attributed to the community.

Similar to the IVMT framework discussed for on-road vehicles, the GHG Working Group developed a simplified approach to associate local and long-distance air travel to communities. The U.S. Federal Aviation Administration (USFAA) reports total departure and arrival miles, for all airports, segmented into domestic and international travel. The data are available online for download. The GHG Working Group took total U.S. aircraft GHG emissions from the 2008 national emissions inventory (215,300,000 MTCDE) and divided it by total U.S. flight miles (arrivals + departures) for all flights (9,040,532,232 miles) to arrive at an emission factor of 0.0238 MTCDE/flight-mile.

To apply this locally, it is necessary to attribute a total sum of *regional* arrival and departure flight miles to the community. A community should download the USFAA flight miles for all airports that serve the regional air travel watershed (not just the community) and calculate community indirect GHG emissions using the following equation:

⁶ Data and reports are available at the U.S. EPA website <http://www.epa.gov/ttn/chief/net/2008inventory.html>.

$$GHG\ Emissions_{Local} = Flight\ Miles_{Regional} \times \frac{Population_{Local}}{Population_{Regional}} \times Emission\ Factor_{Aircraft}$$

Where:

GHG Emissions_{Local} = Community indirect (Scope 3) aircraft emissions (MTCDE)

Flight Miles_{Regional} = Total arrival + departure flight miles from all regional airports

Population_{Local} = Total population in the community (or in boundary of the GHG inventory)

Population_{Regional} = Total population served by the regional air travel watershed

Emission Factor_{Aircraft} = 0.0238 MTCDE/flight-mile

Off-Road Mobile (Direct)

In New York, off-road mobile includes agricultural machinery, construction and maintenance vehicles, lawn and garden equipment, and other vehicles that use transportation fuels but do not operate on roads.

Communities should add these emissions and may be surprised to find they can account for five to ten percent of the community's total transportation GHG footprint.

Recommended Method: Direct emissions

It is not possible to count off-road transportation fuel use in a ground-up way. Therefore, communities should use NYSDEC's NONROAD county-level GHG data for off-road equipment discussed in the marine sector. The latest data available for 2010 is in Table A- 4: 2010 GHG Emissions by Off-road Vehicles and Pleasure Craft. DEC updates these data every three years. If no update is available communities can continue to use the 2010 data.

Solid Waste Management

Communities with landfills can reduce GHG emissions by capturing methane at the landfill. All communities can reduce emissions by reducing the amount of waste the community creates through recycling and composting. The GHG Working Group adopted methods to enable communities to report and then act upon emissions they can control:

Scope 1 is an accounting or estimate of *actual* GHG emissions in the year of the GHG inventory within the geography of the inventory. Only communities with landfills and certain incineration facilities will have this source. Following the U.S. Community Protocol, this guidance does not account for any possible fugitive emissions from composting facilities, because no widely accepted methods exist.

Scope 3 is an *estimated* GHG footprint attributed to a community's current annual waste generation regardless of where it is disposed and how long it takes to actually decay and create emissions in the future. Within this scope, community and regional planners can immediately report potential GHG benefits from waste reduction and recycling efforts.

All communities that report both Scope 1 and Scope 3 emissions are encouraged to choose the Scope 3 source for inclusion in GHG Rollup Inventory Report.

Landfill and WTE Plant Emissions (Direct)

Landfill Emissions (Scope 1)

Recommended Method: Use direct reported data from landfills

Communities should use any landfill emissions data reported to either the U.S. EPA MMR program or the NYSDEC.

U.S. EPA MRR Program: Large landfills with emissions greater than 25,000 MTCDE are required to report fugitive CH₄ emissions to U.S. EPA's MRR annually. Communities can include these data directly in the GHG inventory.

Reported Landfill Gas Collection to NYSDEC: NYSDEC's Division of Materials Management requires annual facility reports from all active landfills, waste-to-energy (WTE) plants and waste transfer stations. In section 10 of these reports, landfills report current waste-in-place totals, any landfill gas collection activity, and the fraction of the site covered by a landfill gas collection system. Fugitive CH₄ emissions can be inferred from the

GHG Emissions and Solid Waste Management (Landfills and Incineration)

The organic component of municipal solid waste (MSW) buried in one year decays and releases methane over many years. Modern landfills collect methane and flare it or use it to generate power which oxidizes the methane to CO₂, which has a lower global warming potential. Actual landfill GHG emissions are the "fugitive" portion of the CH₄ that escapes capture. Significant emissions are often linked to older or closed facilities with partial or no methane collection systems. Solid waste incineration creates GHGs because on average 44 percent of the carbon in municipal solid waste (MSW) is fossil fuel-based, and burning it is equivalent to burning a fossil fuel (U.S. EIA, 2007).

amount of CH₄ successfully collected if the landfill's collection efficiency is known or assumed. Collection efficiency is not reported in the annual facility report so the community should contact the landfill. If no data are available, assume a conservative estimate of 75 percent efficiency based on U.S. EPA's Landfill Methane Outreach Program guidance. For portions of the landfill not covered by collection, assume that 100 percent of the CH₄ generated escapes as fugitive emissions.

As noted the Industrial Energy Consumption section, if a Landfill exceeds the Emission Statement thresholds, they will report emissions directly to NYSDEC's DAR.

Alternative Method: Modeling landfill emissions

For active landfills and recently closed landfills that do not collect and/or report methane it is acceptable to estimate fugitive methane emissions using the first order decay (FOD) model developed by the U.S. EPA, called LandGEM (U.S. EPA, 2005). This simple Excel-based model simulates current emissions based on waste that has been disposed on site in the previous 100 years. There is also a user-friendly version of this model produced by the California Air Resources Board for the Local Government Operations Protocol (ICLEI, 2011). Refer to that model for detailed guidance on how to use it.

In general running an FOD model requires the user to input (1) historical municipal solid waste (MSW) receipt rates in tons/year for at least 50 years, (2) an average breakdown of waste by type (i.e., the waste stream profile), and (3) an estimate of the facility's methane capture rate. Historical year-by-year waste deposition can be estimated by dividing total current waste-in-place into years weighted to historical population. If waste-in-place data are not available, NYSDEC's study *Beyond Waste: A Sustainable Material Management Strategy* provides average per-capita MSW generation rates and a New York specific average waste profile (NYSDEC, 2010). Historical year-by-year MSW generation in tons may be estimated by applying the per capita rate to population figures.

Ideally, separate models are run for each landfill within the geospatial boundary. However, regional scale inventories can also apply the FOD model to estimate Scope 1 emissions at a macro level by modeling a "representative" landfill. This requires region-wide waste generation rates as well as a reasonable estimate of current effective methane capture rates for all facilities within the boundary.

What about landfill gas combustion emissions?

Burning landfill gas in flares or to generate power is an excellent way to destroy landfill methane and reduce a landfill's GHG emissions footprint. Burning landfill gas converts methane into "biogenic" CO₂ that is not counted as a Scope 1 emissions source. Burning landfill gas also produces small amounts of CH₄ and N₂O that, where practical, should be counted as a Scope 1 source. Communities can calculate CH₄ and N₂O emissions using the factors in Appendix A-1. However, as for most fuel combustion, non- CO₂ trace gases represent only about one percent of total GHG footprint. Therefore this source will be small for all but the largest landfills and can be excluded in most cases.

Waste Incineration Emissions (Scope 1)

Recommended Method: Use reported data

Refer to U.S. EPA's MRR or to NYSDEC's facility emissions data discussed in the Industrial Energy Use section to obtain the amount of MSW incinerated by WTE plants and then use the CO₂, CH₄ and N₂O emission factors for MSW in Appendix A-1 to compute emissions.

The U.S. EIA reports that on average, 56 percent of MSW carbon is organic and 44 percent is fossil fuel based, such as plastics (U.S. EIA, 2007). Therefore, the GHG Working Group concluded that unless there is better local data, 56 percent of the CO₂ should be reported as biogenic and the balance reported in Scope 1. All resulting CH₄ and N₂O emissions are reported in Scope 1.

NOTE: GHG emissions from WTE plants that are connected to the electricity grid are usually reported under power generation sector. Communities that wish to include WTE emission in its waste sector should take care to not double count this source.

Community Solid Waste Emissions (Indirect)

The U.S. Community Protocol recommends including GHG emissions related to the amount of waste a community creates regardless of where it is disposed. These are not physical emissions that happen during the inventory year but are estimated lifecycle future emissions created by waste produced today. This is a powerful approach to directly link waste reduction policy to GHG savings.

To calculate Scope 3 waste emissions, the U.S. Community Protocol recommends:

- Estimating MSW generated by the community sent to landfills and to WTE plants.
- Calculating landfill-related emissions using U.S. EPA's Waste Reduction Model (WARM).
- Multiplying waste incineration tonnages by appropriate emission factors.

Step 1: Estimated tonnage of MSW generated by the community and sent to landfills and WTE plants

As discussed above, NYSDEC collects annual facility reports from all landfills, transfer stations and WTE plants. These reports include a breakdown of incoming MSW received by county, and in some cases by community. Communities can pull reports for all local and statewide facilities known to receive local waste and count separate totals it sends to landfills and WTE plants. If community-level data are not available, communities can apportion county data locally using population.

Alternatively, communities may find average per-capita MSW generation rates from their local solid waste planning units, or they can use NYSDEC waste production estimates by counties in Table H-4 in the report *Beyond Waste: A Sustainable Material Management Strategy* (NYSDEC, 2010). Communities will still need to allocate MSW between landfilling and incineration.

Step 2: Calculate GHG emissions from landfilled MSW

For the MSW portion sent to landfills, use the method exactly as described in the U.S. Community Protocol. Communities will need to break landfilled MSW into waste components using a state or local waste profile, and then use the emission factors shown in Table 18. The emission factors estimate methane produced inside the landfill so totals need to be reduced first by an oxidation rate of 10%, and then by the prevailing average landfill gas capture rate employed in the region. For modern landfills, the minimum is 75%. Contact landfills to determine if the actual capture rates are higher.

Table 18: U.S. EPA Landfill Emission Factors (Table Reproduced from U.S. Community Protocol)

Table SW.5 CH ₄ Yield for Solid Waste Components		
Waste Component	Emissions Factor, EF _i (mt CH ₄ /wet short ton waste)	Source
Mixed MSW*	0.060	U.S. EPA AP-42
Newspaper	0.043	WARM
Office Paper	0.203	WARM
Corrugated Containers	0.120	WARM
Magazines/Third-Class Mail	0.049	WARM
Food Scraps	0.078	WARM
Grass	0.038	WARM
Leaves	0.030	WARM
Branches	0.062	WARM
Dimensional Lumber	0.062	WARM
* – Mixed MSW factor may be used for entire MSW waste stream if waste composition data is unavailable		
U.S. EPA AP-42 – U.S. EPA Emission Factor Database, Chapter 2.4 Municipal Solid Waste Landfills (1998)		
WARM—Exhibit 6 of http://epa.gov/epawaste/conserve/tools/warm/pdfs/Landfilling.pdf , February 2012.		

Step 3: Calculate GHG emission from incinerated MSW

Calculate CO₂, CH₄ and N₂O emissions using the amount MSW sent for incineration in step 1. Emission factors for MSW are found in Table A- 1. As discussed earlier, unless there are better data, report 56 percent of the CO₂ as biogenic and the balance in Scope 1. All resulting CH₄ and N₂O emissions are reported in Scope 1.

Wastewater Treatment

Central wastewater treatment plants (WWTPs) can emit fugitive CH₄ and N₂O at different stages in the treatment process. Septic systems also vent CH₄. Since local governments or regional authorities manage wastewater facilities, communities should refer to the Local Government Operations Protocol for complete methods based on treatment practices (ICLEI, 2011). Communities can count all emissions from facilities in boundary as direct (Scope 1) emissions, or attribute a portion of regional emissions from WWTPs to waste water it generates as indirect (Scope 3). There may also be some data available with NYSDEC. Similar to landfills if a municipal Wastewater Treatment Facility exceeds the Emission Statement thresholds, they will report emissions directly to NYSDEC's DAR.

In a region with many WWTP facilities, it is not practical to model each one separately. Regions can use U.S. EPA's State Inventory Tool (SIT)⁷ to estimate emissions based, for the most part, only on population. The model provides New York State-specific defaults that may need to be adjusted locally such the fraction of population on septic systems, etc. See the SIT tool for more details.

Agriculture

The U.S. Community Protocol identifies three community-scale GHG sources from agricultural activities:

Enteric Fermentation: Methane (CH₄) produced by livestock during digestion.

Manure Management: CH₄ and N₂O emissions created based on the way manure is managed. If these emissions are managed, it is typically using anaerobic digestion to capture methane and create energy.

Agricultural Soils: N₂O emissions resulting from the use of nitrogen fertilizer on crops.

For enteric fermentation and manure management, communities should follow the detailed methods provided in the U.S. Community Protocol with the following recommendations:

- For urban and suburban communities with modest agriculture, this sector can be deprioritized because the level of effort is relatively high compared to the source level.
- Communities can use and modify U.S. EPA's State Inventory Tool (SIT) since it is based on U.S. Community Protocol methods as long as default agricultural data loaded for New York is modified to reflect local conditions. This excel-based tool automates many of the calculations.

In general, the methods require a detailed breakdown of livestock populations available from the U.S. Department of Agriculture's National Agricultural Statistics Service (NASS).

The U.S. Community Protocol does not provide methods for N₂O emissions from fertilizer used on agricultural soils, citing uncertainty and lack of confidence in tools like the State Inventory Tool. However, N₂O emissions from fertilizer nationally are significant and agricultural New York communities with fertilizer-intensive cropping like corn are encouraged to explore adding it. The SIT tool may be improved if local or county-level fertilizer sales data become available from the New York State Department of Agriculture and Markets.

⁷ Available here: <http://www.epa.gov/statelocalclimate/resources/tool.html>

Bibliography

- Argonne National Laboratory. (2014) Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) model, <<https://greet.es.anl.gov/>>.
- ICLEI-Local Governments for Sustainability. (2011). The Local Government Operations Protocol. <<http://icleiusa.org/tools/ghg-protocols/>>.
- ICLEI-Local Governments for Sustainability. (2013). U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions. <<http://icleiusa.org/tools/ghg-protocols/>>.
- NOAA. (2012). *National Oceanographic and Atmospheric Administration Climate Prediction Center*. <<http://www.cpc.ncep.noaa.gov/>>.
- NYSDEC. (2010). *Beyond Solid Waste: a Sustainable Materials Strategy for New York State*. <<http://www.dec.ny.gov/chemical/41831.html>>.
- NYSDOT. (2009). *Mobile 6.2 Emission factors for Micro-scale Project Analysis*.
- NYSDERDA. (2007). *NYSDERDA Clean Diesel Technology: Development of the 2002 Locomotive Survey for New York State*.
- NYSDERDA. (2014). *Patterns and Trends - New York State Energy Profiles: 1998-2012*. <<http://www.nyserda.ny.gov/Cleantech-and-Innovation/EA-Reports-and-Studies/Patterns-and-Trends>>.
- Schnepf, R. (2013). *Renewable Fuel Standard (RFS): Overview and Issues*. Congressional Research Service. <<http://www.ifdaonline.org/IFDA/media/IFDA/GR/CRS-RFS-Overview-Issues.pdf>>.
- U.S. EIA. (2011). *U.S. Energy Information Administration State Energy Data System (SEDS)*. Accessed September, 2011. <<http://www.eia.gov/state/seds/>>.
- U.S. EPA. (2011). *eGRID 2007*. Accessed August 2011. <<http://www.epa.gov/cleanenergy/energy-resources/egrid/>>.
- USDOT, Office of Highway Policy Information. (2012). *Highway Statistics Series 2010, Annual Vehicle Distance Traveled in Miles and Related Data*. <<https://www.fhwa.dot.gov/policyinformation/statistics/2010/vm1.cfm>>.
- U.S. EIA. (2007). *Methodology for Allocating Municipal Solid Waste to Biogenic/Non-Biogenic Energy*. <<http://www.eia.gov/totalenergy/data/monthly/pdf/historical/msw.pdf>>.
- U.S. EPA. (2005). *Landfill Gas Emissions Model (LandGem) Version 3.02 User's Guide*. <<http://www.epa.gov/ttn/catc1/dir1/landgem-v302-guide.pdf>>.
- U.S. EPA. (2009). 2009 Draft Regional GHG Inventory Guidance.
- U.S. EPA. (2013). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2011*. <<http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2013-Main-Text.pdf>>.
- U.S. EPA, (2011) *Location Efficiency and Housing Type: Boiling it Down to BTUs*, Jonathan Rose Companies.

Glossary

Unless otherwise noted, all definitions are taken from the U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions, (ICLEI, 2013).

Activity	Refers to a community use activity (or activities), which is defined as the use of energy, materials, and/or services by members of the community that result in the creation of GHG emissions either directly (e.g., use of household furnaces and vehicles with internal combustion engines) or indirectly (e.g., use of electricity created through combustion of fossil fuels at a power plant, consumption of goods and services whose production, transport and/or disposal resulted in creation of GHG emissions directly or indirectly).
Activity data	Data on the magnitude of a human activity resulting in emissions taking place during a given period of time. Data on energy use, fuel used, miles traveled, input material flow, and product output are all examples of activity data that might be used to compute GHG emissions.
Anthropogenic emissions	GHG emissions that are a direct result of human activities or are the result of natural processes that have been affected by human activities.
Analysis year	The single year timeframe for which GHG emissions are being quantified and reported. Typically, the analysis year refers to when the emissions occur, but in some cases it refers to when the activity occurs (e.g., future emissions resulting from disposal of waste in the analysis year).
Base year emissions	GHG emissions in chosen year against which a community's emissions are compared over time.
Biofuel	Fuel made from biomass, including wood and wood waste, sulphite lyes (black liquor), vegetal waste (straw, hay, grass, leaves, roots, bark, crops), animal materials/waste (fish and food meal, manure, sewage sludge, fat, oil and tallow), turpentine, charcoal, landfill gas, sludge gas, and other biogas, bioethanol, biomethanol, bioETBE, bioMTBE, biodiesel, biodimethylether, fischer tropesch, bio oil, and all other liquid biofuels which are added to, blended with, or used straight as transportation diesel fuel.
Biogenic emissions from combustion	CO ₂ emissions produced from combusting a variety of biofuels and biomass, such as biodiesel, ethanol, wood, wood waste and landfill gas.
Biomass	Non-fossilized organic material originating from plants, animals, and micro-organisms, including products, byproducts, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes, including gases and liquids

	recovered from the decomposition of non-fossilized and biodegradable organic material.
Boundaries	GHG emission accounting and reporting boundaries for a community have two dimensions, in-boundary and trans-boundary. In-boundary emissions are GHG emissions released within the jurisdictional boundary of a community. Examples include GHG emissions from natural gas combustion in household furnaces and gasoline combustion in motor vehicles driven on roads within the community's jurisdictional boundary. Trans-boundary emissions are GHG emissions occurring outside the jurisdictional boundary of a community as a result of activities occurring within the community boundary (see "Trans-boundary Emissions" for more details). Note: community boundaries are distinct from boundaries as defined in the Local Government Operations Protocol in which a boundary can have several dimensions, i.e., organizational, operational, and geographic. Those latter boundaries determine which emissions are accounted for and reported by the local governmental entity.
British thermal unit (Btu)	The quantity of heat required to raise the temperature of one pound of water by one degree Fahrenheit at about 39.2 degrees Fahrenheit.
Butane	A normally gaseous straight-chain or branch chain hydrocarbon extracted from natural gas or refinery fuel gas streams and is represented by the chemical formula C ₄ H ₁₀ . Butane includes normal butane and refinery-grade butane.
Carbon dioxide (CO ₂)	The most common of the six primary GHGs, consisting of a single carbon atom and two oxygen atoms, and providing the reference point for the GWP of other gases. (Thus, the GWP of CO ₂ is equal to 1.)
Carbon footprint	The total volume of GHG emissions caused by a community, organization, event, product, or person.
CO ₂ equivalent (CO ₂ e)	The universal unit for comparing emissions of different GHGs expressed in terms of the GWP of one unit of carbon dioxide.
Community	Community traditionally refers to residents, businesses, industries, and government co-located within a jurisdictionally defined area.
De minimis	Per the California Climate Action Registry's program-specific requirements, emissions reported for a source or sources that are estimated using alternate methodologies that do not meet CCAR's third-party verification requirements. De minimis emissions can be from one or more sources, for one or more gases which, when summed, equal less than 5% of an organization's total emissions.

Direct monitoring	Direct monitoring of exhaust stream contents in the form of continuous emissions monitoring (CEM) or periodic sampling.
Double counting	Two or more reporting entities taking ownership of the same emissions or reductions, or the same reporting entity counting the same emissions twice.
Emission factor	A unique value for determining an amount of a GHG emitted on a per unit activity basis (for example, metric tons of CO ₂ emitted per million Btus of coal combusted, or metric tons of CO ₂ emitted per kWh of electricity consumed).
Entity	Any business, corporation, institution, organization, government agency, etc., recognized under U.S. law and comprised of all the facilities and emission sources delimited by the organizational boundary developed by the entity, taken in their entirety.
Ethane	A normally gaseous straight-chained hydrocarbon that boils at a temperature of -127.48 degrees Fahrenheit with a chemical formula of C ₂ H ₆ .
Facility	Any property, plant, building, structure, stationary source, stationary equipment or grouping of stationary equipment or stationary sources located on one or more contiguous or adjacent properties, in actual physical contact or separated solely by a public roadway or other public right-of way, and under common operational or financial control, that emits or may emit any greenhouse gas.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Fugitive emissions	Emissions that are not physically controlled but result from the intentional or unintentional release of GHGs. They commonly arise from the production, processing, transmission, storage and use of fuels or other substances, often through joints, seals, packing, gaskets, etc. Examples include HFCs from refrigeration leaks, SF ₆ from electrical power distributors, and CH ₄ from solid waste landfills.
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one mass-based unit of a given GHG compared to one equivalent unit of carbon dioxide (CO ₂) over a given period of time.
Greenhouse gas emissions (GHGs)	Greenhouse gas emissions are gases that trap heat in the atmosphere. Some greenhouse gases such as carbon dioxide occur naturally and are emitted into the atmosphere through natural processes and human activities. Other greenhouse gases are created and emitted solely through human activities. The principal greenhouse gases that enter the atmosphere because of human activities are

	carbon dioxide (CO ₂), methane (CH ₄), nitrous oxide (N ₂ O), and fluorinated gases (hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).
GHG emission sources and associated activities	GHG emission sources are any physical process or activity that releases GHG emissions into the atmosphere. Examples of emission sources include: vehicle exhaust from combustion of gasoline, furnace exhaust from the combustion of natural gas, power plant exhaust from the combustion of coal for the production of electricity, fugitive emissions from leaking refrigerants, and methane emissions from a landfill. Activities associated with GHG emission sources are human activities that result in the production of GHG emissions. An example is electricity use, which requires the generation of electricity at a power plant that may produce a quantity of GHG emissions in the process of generating the electricity.
Greenhouse gas sink	Any physical unit or process that stores GHGs; usually refers to forests and underground/deep sea reservoirs of CO ₂ .
Greenhouse gas emission sources	Any physical process or activity that releases GHG emissions into the atmosphere (e.g., vehicle exhaust from combustion of gasoline, furnace exhaust from the combustion of natural gas, power plant exhaust from combustion of coal for the production of electricity).
Hydrofluorocarbons (HFCs)	One of the six primary GHGs, a group of manmade chemicals with various commercial uses (e.g., refrigerants) composed of one or two carbon atoms and varying numbers of hydrogen and fluorine atoms. Most HFCs are highly potent GHGs with 100-year GWPs in the thousands.
In-boundary emissions	GHG emissions released within the jurisdictional boundary of a community. Examples include GHG emissions from natural gas combustion in household furnaces and gasoline combustion in motor vehicles driven on roads within the community's jurisdictional boundary.
Inorganic	Being or composed of matter other than plant or animal.
Intergovernmental Panel on Climate Change (IPCC)	International body of climate change scientists. The role of the IPCC is to assess the scientific, technical and socio-economic information relevant to the understanding of the risk of human-induced climate change (www.ipcc.ch).
Inventory	A comprehensive, quantified list of a community's or organization's GHG emissions and sources.
Inventory boundary	An imaginary line that encompasses the GHG emissions included in the inventory. It results from the chosen organizational and operational boundaries.
Joule	A measure of energy, representing the energy needed to push with a force of one Newton for one meter.

Kerosene	A light distillate fuel that includes No. 1-K and No. 2-K as well as other grades of range or stove oil that has properties similar to those of No. 1 fuel oil.
Kilowatt hour (kWh)	The electrical energy unit of measure equal to one thousand watts of power supplied to, or taken from, an electric circuit steadily for one hour. (A Watt is the unit of electrical power equal to one ampere under a pressure of one volt, or 1/746 horsepower.)
Kyoto Protocol	A protocol to the United Nations Framework Convention on Climate Change (UNFCCC). Ratified in 2005, it requires countries listed in its Annex B (developed nations) to meet reduction targets of GHG emissions relative to their 1990 levels during the period of 2008–12.
Life cycle analysis	Assessment of the sum of a product's effects (e.g. GHG emissions) at each step in its life cycle, including resource extraction, production, use and waste disposal.
Life cycle emissions	GHG emission sources associated with all stages of the life cycle of materials, energy, and services. These could be materials, energy and services used in the community, consumed by the community, or produced in the community, depending on what kind of activity is being evaluated. ²² Life cycle emissions include the “upstream” supply chain (e.g., resource extraction, production, transport), use, and end-of-life management (including transportation and recycling). For example, the life cycle emissions of vehicle fuels include both combustion emissions (tailpipe emissions), as well as pre-combustion, or “well-to-pump” emissions. These pre-combustion emissions are the upstream emissions associated with extracting and growing fuel feedstocks (petroleum, corn, etc.), refining those feedstocks into fuels, and transporting the fuels to the point of sale. Two subsets of life cycle emissions are “embodied” emissions and “end-of-life” emissions.
Liquefied petroleum gas (LPG)	A group of hydrocarbon-based gases derived from crude oil refining or natural gas fractionation. They include propane, propylene, normal butane, butane, butylene, isobutene A-14 and isobutylene. For convenience of transportation, these gases are liquefied through pressurization.
Lower heating value (LHV)	Low or net heat content with the heat of vaporization excluded. The water is assumed to be in the gaseous state.
Methane (CH ₄)	One of the six primary GHGs, consisting of a single carbon atom and four hydrogen atoms, possessing a GWP of 21, and produced through the anaerobic decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion.

Metric ton (mt)	Common international measurement for the quantity of GHG emissions, equivalent to about 2,204.6 pounds or 1.1 short tons.
Mobile combustion	Emissions from the combustion of fuels in transportation sources (e.g., cars, trucks, buses, trains, airplanes, and marine vessels) and emissions from off-road equipment such as what is used in construction, agriculture, and forestry. A piece of equipment that cannot move under its own power, but that is transported from site to site (e.g., an emergency generator) is a stationary, not a mobile, combustion source.
Natural gas	A naturally occurring mixture of hydrocarbons (e.g., methane, ethane, or propane) produced in geological formations beneath the earth's surface that maintains a gaseous state at standard atmospheric temperature and pressure under ordinary conditions.
Nitrous oxide (N ₂ O)	One of the six primary GHGs, consisting of two nitrogen atoms and a single oxygen atom, possessing a GWP of 310, and typically generated as a result of soil cultivation practices, particularly the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.
Operational control	Full authority to introduce and implement operating policies at an operation.
Operator	The entity having operational control of a facility or other entity.
Organic	Of, relating to, or derived from living organisms.
Organizational boundaries	The boundaries that determine the operations owned or controlled by the reporting entity, depending on the consolidation approach taken.
Perfluorocarbons (PFCs)	One of the six primary GHGs, A group of man-made chemicals composed of one or two carbon atoms and four to six fluorine atoms, containing no chlorine. Originally introduced as alternatives to ozone depleting substances, PFCs have few commercial uses and are typically emitted as by-products of industrial and manufacturing processes. PFCs have very high GWPs and are very long-lived in the atmosphere.
Process emissions	Emissions from physical or chemical processing rather than from fuel combustion. Examples include emissions from manufacturing cement, aluminum, adipic acid, ammonia, etc.
Scope(s)	Scopes are used in the context of reporting on GHG emissions associated with individual organizational entities (e.g., the operations of a business or local government). In that context, the scopes framework can be used to categorize direct (scope 1) emissions (e.g., smoke stacks or tailpipes that release emissions

	within an organizational boundary), indirect energy-related (scope 2) emissions (e.g., the use of purchased or acquired electricity, heating, cooling, or steam regardless of where the energy is generated), and other indirect (scope 3) emissions not covered in scope 2 (e.g., upstream and downstream emissions from the extraction and production of purchased materials and fuels).
Short ton (ton)	Common measurement for a ton in the U.S. and equivalent to 2,000 pounds or about 0.907 metric tons.
Source(s)	Any physical process or activity that releases GHG emissions into the atmosphere (e.g., vehicle exhaust from combustion of gasoline, furnace exhaust from the combustion of natural gas, power plant exhaust from combustion of coal for the production of electricity).
Standard cubic foot (scf)	The amount of gas that would occupy a volume of one cubic foot if free of combined water at standard conditions.
Stationary	Neither portable nor self-propelled, and operated at a single facility.
Stationary combustion	Emissions from the combustion of fuels to produce electricity, steam, heat, or power using equipment (boilers, furnaces, etc.) in a fixed location.
Sulfur hexafluoride (SF6)	One of the six primary GHGs, consisting of a single sulfur atom and six fluoride atoms, possessing a very high GWP of 23,900, and primarily used in electrical transmission and distribution systems.
Therm	A measure of one hundred thousand (105) Btu.

Appendix A: Data Sets

Table A-1: U.S. EPA GHG Emissions Factors from the Mandatory Reporting Rule (MRR) Program, April 2014

Solid Fuels	Heating Value	CO ₂ Factor	CH ₄ Factor	N ₂ O Factor	CO ₂ Factor	CH ₄ Factor	N ₂ O Factor	eCO ₂
	MMBTU per short ton	kg CO ₂ per MMBTU	g CH ₄ per MMBTU	g N ₂ O per MMBTU	kg CO ₂ per short ton	g CH ₄ per short ton	g N ₂ O per short ton	MTCDE per MMBTU
Anthracite Coal	25.09	103.69	11.00	1.60	2601.58	276.00	40.00	104.44
Bituminous Coal	24.93	93.28	11.00	1.60	2325.47	274.00	40.00	94.03
Sub-bituminous Coal	17.25	97.17	11.00	1.60	1676.18	190.00	28.00	97.92
Lignite Coal	14.21	97.72	11.00	1.60	1388.60	156.00	23.00	98.47
Mixed (Commercial Sector)	21.39	94.27	11.00	1.60	2016.44	235.00	34.00	95.02
Mixed (Electric Power Sector)	19.73	95.52	11.00	1.60	1884.61	217.00	32.00	96.27
Mixed (Industrial Coking)	26.28	93.90	11.00	1.60	2467.69	289.00	42.00	94.65
Mixed (Industrial Sector)	22.35	94.67	11.00	1.60	2115.87	246.00	36.00	95.42
Coal Coke	24.80	113.67	11.00	1.60	2819.02	273.00	40.00	114.42
Municipal Solid Waste (fossil component)	9.95	90.70	32.00	4.20	902.00	318.00	42.00	92.75
Petroleum Coke (Solid)	30.00	102.41	32.00	4.20	3072.00	960.00	126.00	104.46
Plastics	38.00	75.00	32.00	4.20	2850.00	1216.00	160.00	77.05
Tires	28.00	85.97	32.00	4.20	2407.16	896.00	117.60	88.02
Agricultural Byproducts	8.25	118.17	32.00	4.20	975.00	264.00	35.00	120.22
Peat	8.00	111.84	32.00	4.20	895.00	256.00	34.00	113.89
Solid Byproducts	10.39	105.51	32.00	4.20	1096.25	332.48	43.64	107.56
Wood and Wood Residuals	17.48	93.80	7.20	3.60	1639.62	125.86	62.93	95.05
Gaseous Fuels	MMBTU per scf	kg CO ₂ per MMBTU	g CH ₄ per MMBTU	g N ₂ O per MMBTU	kg CO ₂ per scf	g CH ₄ per scf	g N ₂ O per scf	MTCDE per MMBTU
Natural Gas (per scf)	0.001026	53.06	1	0.1	0.0544	0.001026	0.0001026	53.11
Blast Furnace Gas	0.000092	274.32	0.022	0.1	0.0252	0.000002	0.000009	274.35
Coke Oven Gas	0.000599	46.85	0.48	0.1	0.0281	0.000288	0.00006	46.89
Fuel Gas	0.001388	59	3	0.6	0.0819	0.004164	0.0008328	59.25
Propane Gas	0.002516	61.46	0.022	0.1	0.1546	0.000055	0.000252	61.49
Landfill Gas	0.000485	52.07	3.2	0.63	0.0253	0.001552	0.00030555	52.34
Other Biomass Gases	0.000655	52.07	3.2	0.63	0.0341	0.002096	0.00041265	52.34
Liquid Fuels	MMBTU per gallon	kg CO ₂ per MMBTU	g CH ₄ per MMBTU	g N ₂ O per MMBTU	kg CO ₂ per gallon	g CH ₄ per gallon	g N ₂ O per gallon	MTCDE per MMBTU
Asphalt and Road Oil	0.158	75.36	3	0.6	11.91	0.47	0.09	75.61
Aviation Gasoline	0.12	69.25	3	0.6	8.31	0.36	0.07	69.50
Butane	0.103	64.77	3	0.6	6.67	0.309	0.0618	65.02
Butylene	0.105	68.72	3	0.6	7.22	0.315	0.063	68.97

Crude Oil	0.138	74.54	3	0.6	10.29	0.41	0.08	74.79
Liquid Fuels (Continued)	MMBTU per gallon	kg CO₂ per MMBTU	g CH₄ per MMBTU	g N₂O per MMBTU	kg CO₂ per gallon	g CH₄ per gallon	g N₂O per gallon	MTCDE per MMBTU
Distillate Fuel Oil No. 1	0.139	73.25	3	0.6	10.18	0.42	0.08	73.50
Distillate Fuel Oil No. 2	0.138	73.96	3	0.6	10.21	0.41	0.08	74.21
Distillate Fuel Oil No. 4	0.146	75.04	3	0.6	10.96	0.44	0.09	75.29
Ethane	0.068	59.6	3	0.6	4.05	0.204	0.0408	59.85
Ethylene	0.058	65.96	3	0.6	3.83	0.174	0.0348	66.21
Heavy Gas Oils	0.148	74.92	3	0.6	11.09	0.44	0.09	75.17
Isobutane	0.099	64.94	3	0.6	6.43	0.297	0.0594	65.19
Isobutylene	0.103	68.86	3	0.6	7.09	0.31	0.06	69.11
Kerosene	0.135	75.2	3	0.6	10.15	0.41	0.08	75.45
Kerosene-type Jet Fuel	0.135	72.22	3	0.6	9.75	0.41	0.08	72.47
Liquefied Petroleum Gases (LPG)	0.092	61.71	3	0.6	5.68	0.28	0.06	61.96
Lubricants	0.144	74.27	3	0.6	10.69	0.43	0.09	74.52
Motor Gasoline	0.125	70.22	3	0.6	8.78	0.38	0.08	70.47
Naphtha (<401 deg F)	0.125	68.02	3	0.6	8.50	0.38	0.08	68.27
Natural Gasoline	0.11	66.88	3	0.6	7.36	0.33	0.07	67.13
Other Oil (>401 deg F)	0.139	76.22	3	0.6	10.59	0.42	0.08	76.47
Pentanes Plus	0.11	70.02	3	0.6	7.70	0.33	0.07	70.27
Petrochemical Feedstocks	0.125	71.02	3	0.6	8.88	0.375	0.075	71.27
Petroleum Coke	0.143	102.41	3	0.6	14.64	0.43	0.09	102.66
Propane	0.091	62.87	3	0.6	5.72	0.27	0.05	63.12
Propylene	0.091	65.95	3	0.6	6.00	0.27	0.05	66.20
Residual Fuel Oil No. 5	0.14	72.93	3	0.6	10.21	0.42	0.08	73.18
Residual Fuel Oil No. 6	0.15	75.1	3	0.6	11.27	0.45	0.09	75.35
Special Naphtha	0.125	72.34	3	0.6	9.04	0.38	0.08	72.59
Still Gas	0.143	66.72	3	0.6	9.54	0.43	0.09	66.97
Unfinished Oils	0.139	74.54	3	0.6	10.36	0.42	0.08	74.79
Used Oil	0.138	74	3	0.6	10.21	0.414	0.0828	74.25
Biodiesel (100%)	0.128	73.84	1.1	0.11	9.45	0.14	0.01	73.90
Ethanol (100%)	0.084	68.44	1.1	0.11	5.75	0.09	0.01	68.50
Rendered Animal Fat	0.125	71.06	1.1	0.11	8.88	0.14	0.01	71.12
Vegetable Oil	0.12	81.55	1.1	0.11	9.79	0.13	0.01	81.61
Source: U.S. EPA Mandatory Reporting Rule, April 2014.								

Table A- 2: 2010 NYSDOT Reported Vehicle Miles Traveled (VMT) by County

County	Annual VMT by Road Class (thousands)			
	Highway (Classes 1, 11,12)	Arterial (Classes 2,6,14,16)	Collector/Local (Classes 7,8,9,17,19)	Total
Albany	1,609,181	1,136,536	1,073,756	3,819,474
Allegany	126,737	79,163	267,272	473,173
Bronx	1,782,683	868,547	888,524	3,539,753
Broome	859,824	568,704	717,433	2,145,960
Cattaraugus	245,297	202,447	383,884	831,629
Cayuga	94,103	261,521	376,718	732,342
Chautauqua	413,446	420,802	515,178	1,349,426
Chemung	136,145	325,148	374,250	835,543
Chenango	56,830	176,567	277,208	510,605
Clinton	219,624	255,949	389,597	865,170
Columbia	93,717	317,004	348,416	759,137
Cortland	191,750	119,306	304,720	615,776
Delaware	59,942	192,081	335,590	587,613
Dutchess	496,657	1,282,336	1,123,600	2,902,593
Erie	2,581,312	3,346,301	2,486,381	8,413,994
Essex	250,911	115,760	200,325	566,995
Franklin	0	180,875	266,643	447,518
Fulton	0	153,988	266,538	420,526
Genesee	300,453	393,630	403,116	1,097,199
Greene	214,317	152,150	395,647	762,115
Hamilton	0	76,136	21,098	97,234
Herkimer	200,326	210,564	323,569	734,459
Jefferson	288,927	365,574	491,556	1,146,056
Kings	1,398,532	3,009,554	900,865	5,308,951
Lewis	0	84,960	175,514	260,474
Livingston	231,984	223,937	330,337	786,258
Madison	140,761	221,102	426,675	788,538
Monroe	2,348,599	2,560,642	1,577,403	6,486,644
Montgomery	279,229	153,479	335,180	767,888
Nassau	4,352,772	4,748,728	2,659,771	11,761,272
New York	1,259,325	1,813,361	923,701	3,996,387
Niagara	261,022	765,650	562,328	1,589,000

Table A- 2: 2010 NYSDOT Reported Vehicle Miles Traveled (VMT) by County

County	Annual VMT by Road Class (thousands)			
	Highway (Classes 1, 11,12)	Arterial (Classes 2,6,14,16)	Collector/Local (Classes 7,8,9,17,19)	Total
Oneida	478,569	825,123	830,755	2,134,448
Onondaga	1,798,032	1,576,106	1,308,241	4,682,380
Ontario	348,933	492,767	582,649	1,424,349
Orange	1,722,119	1,475,777	1,291,412	4,489,307
Orleans	0	140,854	157,923	298,777
Oswego	249,209	375,131	520,939	1,145,278
Otsego	179,356	144,562	361,170	685,088
Putnam	554,204	708,499	813,796	2,076,498
Queens	3,904,183	3,173,179	1,561,703	8,639,065
Rensselaer	241,166	570,118	621,874	1,433,157
Richmond	800,163	806,691	563,250	2,170,104
Rockland	1,126,216	988,011	618,795	2,733,022
St Lawrence	0	384,318	466,901	851,219
Saratoga	791,961	937,626	1,152,074	2,881,660
Schenectady	625,611	447,060	349,190	1,421,861
Schoharie	147,652	167,126	305,688	620,467
Schuyler	0	59,789	156,675	216,464
Seneca	102,723	149,417	209,702	461,842
Steuben	423,714	198,835	625,369	1,247,918
Suffolk	4,245,172	5,424,846	3,756,989	13,427,007
Sullivan	98,749	217,153	546,590	862,493
Tioga	0	338,962	281,032	619,994
Tompkins	55,115	329,369	357,929	742,413
Ulster	587,018	759,215	873,117	2,219,350
Warren	340,079	290,880	255,682	886,641
Washington	0	212,879	358,773	571,653
Wayne	0	307,221	437,391	744,612
Westchester	4,095,160	1,877,804	1,871,124	7,844,088
Wyoming	0	103,386	255,616	359,002
Yates	0	70,354	128,184	198,538
Source: NYSDOT, 2010.				

Table A- 3: 2002 Diesel Consumption (Gallons) by Rail Mode by County

County	Class I RR	Class II/III RR	Switchyard	Amtrak	Metro-North Railroad	NJ Transit Rail	Long Island RR	Adirondack Scenic	TOTAL CONSUMPTION
Albany	2,609,348	0	164,980	0	0	0	0	0	2,774,328
Allegany	229,018	57,997	0	0	0	0	0	0	287,015
Bronx	288,167	0	0	84,195	0	0	0	0	372,362
Broome	941,847	179,456	0	0	0	0	0	0	1,121,303
Cattaraugus	379,992	60,997	0	0	0	0	0	0	440,989
Cayuga	753,616	50,000	0	97,663	0	0	0	0	901,279
Chautauqua	5,340,442	60,997	0	73,398	0	0	0	0	5,474,837
Chemung	525,303	0	0	0	0	0	0	0	525,303
Chenango	243,654	168,497	0	0	0	0	0	0	412,151
Clinton	593,866	0	0	67,752	0	0	0	0	661,618
Columbia	3,109,491	0	0	650,151	0	0	0	0	3,759,642
Cortland	0	168,497	8,364	0	0	0	0	0	176,861
Delaware	98,187	10,960	0	0	0	0	0	0	109,147
Dutchess	1,773,443	0	0	1,051,811	1,771,200	0	0	0	4,596,454
Erie	7,983,763	4,434	16,324	231,084	0	0	0	0	8,235,605
Essex	693,602	0	0	112,920	0	0	0	4,420	810,942
Franklin	319,634	0	0	0	0	0	0	0	319,634
Fulton	0	0	0	0	0	0	0	0	0
Genesee	2,457,430	4,434	0	202,838	0	0	0	0	2,664,702
Greene	799,912	0	0	0	0	0	0	0	799,912
Hamilton	0	0	0	0	0	0	0	0	0
Herkimer	1,670,549	0	0	187,813	0	0	0	2,720	1,861,082
Jefferson	2,143,200	42,948	0	0	0	0	0	0	2,186,148
Kings	0	100,362	0	0	0	0	0	0	100,362
Lewis	0	42,948	0	0	0	0	0	0	42,948
Livingston	193,807	834,365	0	75,125	0	0	0	0	1,103,297
Madison	919,016	168,497	0	105,175	0	0	0	0	1,192,688
Monroe	3,450,259	52,333	0	195,326	0	0	0	0	3,697,918
Montgomery	2,850,294	0	0	292,989	0	0	0	0	3,143,283
Nassau	0	102,013	0	0	0	0	874,053	0	976,066
New York	0	0	0	264,228	0	0	0	0	264,228
Niagara	1,820,673	309,320	0	78,827	0	0	0	0	2,208,820
Oneida	1,908,769	211,444	0	210,351	0	0	0	26,520	2,357,084
Onondaga	3,502,459	50,000	0	240,401	0	0	0	0	3,792,860
Ontario	9,028	220,246	0	0	0	0	0	0	229,274

Table A- 3: 2002 Diesel Consumption (Gallons) by Rail Mode by County

County	Class I RR	Class II/III RR	Switchyard	Amtrak	Metro-North Railroad	NJ Transit Rail	Long Island RR	Adirondack Scenic	TOTAL CONSUMPTION
Orange	998,256	12,895	0	0	0	1,663,963	0	0	2,675,114
Orleans	0	10,364	0	0	0	0	0	0	10,364
Oswego	2,685,226	0	0	0	0	0	0	0	2,685,226
Otsego	856,926	0	0	0	0	0	0	0	856,926
Putnam	0	0	0	224,190	1,785,999	0	0	0	2,010,189
Queens	265,640	102,013	70,884	0	0	0	0	0	438,537
Rensselaer	1,801,191	6,064	0	627,732	0	0	0	0	2,434,987
Richmond	0	0	0	0	0	0	0	0	0
Rockland	802,559	0	0	0	0	245,724	0	0	1,048,283
St Lawrence	2,931,363	48,276	0	0	0	0	0	0	2,979,639
Saratoga	1,176,972	0	0	124,722	0	0	0	0	1,301,694
Schenectady	2,121,460	0	0	131,632	0	0	0	0	2,253,092
Schoharie	340,570	0	0	0	0	0	0	0	340,570
Schuyler	29,473	50,000	0	0	0	0	0	0	79,473
Seneca	358	50,000	0	0	0	0	0	0	50,358
Steuben	1,065,587	136,173	0	0	0	0	0	0	1,201,760
Suffolk	0	102,013	0	0	0	0	6,027,328	0	6,129,341
Sullivan	50,229	10,960	0	0	0	0	0	0	61,189
Tioga	512,875	0	836	0	0	0	0	0	513,711
Tompkins	57,047	0	0	0	0	0	0	0	57,047
Ulster	1,339,084	0	0	0	0	0	0	0	1,339,084
Warren	34,713	0	0	0	0	0	0	0	34,713
Washington	718,723	25,111	0	132,189	0	0	0	0	876,023
Wayne	2,470,405	7,604	0	270,451	0	0	0	0	2,748,460
Westchester	0	1,651	0	697,036	1,221,206	0	0	0	1,919,893
Wyoming	581,975	0	0	0	0	0	0	0	581,975
Yates	42,096	50,000	0	0	0	0	0	0	92,096
TOTALS	68,491,497	3,513,863	261,388	6,429,999	4,778,405	1,909,687	6,901,381	33,660	92,319,880
Source: NYSDERDA, 2005.									

Table A- 4: 2010 GHG Emissions by Off-road Vehicles and Pleasure Craft

County	GHG Emissions (MTCDE) – NYSDEC Division of Air Resources					
	Off-Road Vehicles and Equipment (Land Based)				Pleasure Craft (Boats)	
	Gasoline (E-10)	Diesel	LPG	CNG	Gasoline (E-10)	Diesel
Albany	29,940	86,116	9,380	917	2,782	500
Allegany	10,693	13,513	2,384	157	1,224	220
Bronx	35,610	160,149	10,445	1,137	4,386	1,078
Broome	17,665	37,779	17,177	1,108	2,448	440
Cattaraugus	15,130	26,175	5,189	376	3,561	640
Cayuga	12,650	31,791	4,000	280	13,961	3,195
Chautauqua	20,249	44,744	11,855	800	14,068	5,239
Chemung	12,103	19,058	6,778	453	779	140
Chenango	11,018	15,366	2,753	184	1,224	220
Clinton	12,210	25,284	4,751	343	22,588	4,061
Columbia	15,937	19,519	1,998	166	3,561	640
Cortland	10,964	13,791	3,385	216	556	100
Delaware	14,778	22,370	4,218	262	6,231	1,120
Dutchess	32,672	60,893	18,445	1,222	6,899	1,240
Erie	95,661	213,884	54,711	4,186	10,603	4,738
Essex	18,481	14,802	1,098	67	34,493	6,201
Franklin	13,853	14,514	669	61	19,027	3,421
Fulton	11,154	7,176	1,989	164	10,571	1,900
Genesee	14,280	28,502	3,311	260	334	60
Greene	16,021	21,720	927	78	3,004	540
Hamilton	67,577	2,141	59	7	25,147	4,521
Herkimer	12,372	23,334	3,512	223	13,464	2,420
Jefferson	13,917	38,493	3,051	241	54,012	18,619
Kings	110,414	392,038	34,261	4,498	6,830	1,776
Lewis	17,593	17,190	1,104	81	4,117	740
Livingston	13,031	26,703	2,152	170	2,448	440
Madison	12,228	21,544	2,678	193	1,669	300
Monroe	96,869	187,164	58,923	4,052	9,143	4,140
Montgomery	13,314	32,231	3,459	231	1,558	280
Nassau	173,411	188,553	39,792	5,236	20,001	6,458
New York	227,342	575,863	79,295	13,012	1,902	479
Niagara	22,223	52,385	14,573	971	12,540	5,832
Oneida	22,194	64,722	12,379	845	12,796	2,300
Onondaga	52,216	115,340	27,463	2,214	7,344	1,320

Table A- 4: 2010 GHG Emissions by Off-road Vehicles and Pleasure Craft

County	GHG Emissions (MTCDE) – NYSDEC Division of Air Resources					
	Off-Road Vehicles and Equipment (Land Based)				Pleasure Craft (Boats)	
	Gasoline (E-10)	Diesel	LPG	CNG	Gasoline (E-10)	Diesel
Ontario	18,021	46,901	7,430	529	5,230	940
Orange	34,724	73,149	8,805	863	6,454	1,160
Orleans	11,327	16,200	1,501	99	5,048	2,567
Oswego	16,435	19,574	3,938	280	27,641	8,136
Otsego	11,165	19,398	1,329	112	3,561	640
Putnam	14,118	20,032	2,373	228	4,228	760
Queens	116,001	325,356	39,464	4,458	8,225	2,651
Rensselaer	14,183	38,550	3,623	298	3,338	600
Richmond	35,557	106,032	2,549	394	4,206	1,593
Rockland	36,390	53,748	11,100	1,126	7,232	1,300
St. Lawrence	12,008	37,586	4,035	282	39,167	7,041
Saratoga	22,839	74,469	6,672	550	9,235	1,660
Schenectady	11,373	26,146	5,858	413	1,001	180
Schoharie	13,906	12,391	363	36	1,224	220
Schuyler	19,088	5,623	567	41	5,007	900
Seneca	12,823	19,305	1,166	86	18,916	3,401
Steuben	13,234	38,832	7,393	459	3,338	600
Suffolk	234,832	311,273	64,899	6,274	140,141	50,145
Sullivan	26,159	21,082	774	102	7,789	1,400
Tioga	12,497	14,150	2,127	138	1,224	220
Tompkins	11,974	30,332	3,652	242	4,451	800
Ulster	22,858	34,677	5,384	426	9,903	1,780
Warren	24,779	33,254	4,553	315	17,914	3,221
Washington	10,321	23,301	3,521	230	3,004	540
Wayne	13,068	26,987	5,838	392	11,965	5,652
Westchester	131,548	197,758	20,994	2,660	14,085	2,897
Wyoming	15,712	23,496	1,960	147	1,001	180
Yates	16,708	11,220	668	56	9,680	1,740
Source: NYSDEC Division of Air Resources, 2010, NONROAD model.						