NEW YORK STATE | Department of Environmental Conservation

2021 Statewide GHG Emissions Report

SUMMARY REPORT

Kathleen C. Hochul, Governor | Basil Seggos, Commissioner

Acknowledgements

Many individuals provided the State with information, feedback, and expertise that has been incorporated into this report. This includes input on past greenhouse gas and related reporting initiatives and to support implementation of the recent Climate Leadership and Community Protection Act. Many of the concepts, data, and methods described here were informed by the comments received during the rulemaking for 6 NYCRR Part 496, “Statewide GHG Emission Limits”.

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- DEC’s Division of Materials Management
- DEC’s Division of Mineral Resources
- DEC’s Division of Lands and Forests
- Department of Agriculture and Markets
- Department of Public Service

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DEC’s GHG Inventory Team

Office of Climate Change: Suzanne Hagell, Greg Mumby, Caitlin Frame

Division of Air Resources: Nathan Putnam

Figures and Tables

Executive Summary

The New York State Statewide Greenhouse Gas Emissions Report is a foundational component of the State's strategy for addressing climate change. This emission inventory is designed to meet the requirements of the Climate Leadership and Community Protection Act (CLCPA),[1] measure progress at reducing greenhouse gas (GHG) emissions, and to make greenhouse gas information accessible to a broad audience. This report provides the most up-to-date estimation of annual emissions from 1990 through 2019. The structure and content of this report is aligned with guidelines from the Intergovernmental Panel on Climate Change (IPCC) for governmental greenhouse gas accounting as used in the U.S. national greenhouse gas emissions report (EPA 2021a). Any deviations from these guidelines reflect available datasets and the requirements of New York State law.

Format of This Report

This report includes five stand-alone documents: one summary report and four sectoral reports. This *Summary Report* provides general background and economy-wide trends. The *Sectoral Reports* each review the data, methods, and results of analysis for specific sectors. The default format used throughout this report meets the requirements of the CLCPA, but this Summary Report also presents results in a conventional format developed for national parties to the United National Framework Convention on Climate Change (UNFCCC). The conventional format is comparable to emission information issued by other governments and organizations and is provided for informational purposes. As outlined in Table ES.1, the differences between the CLCPA and conventional accounting relate to the scope of emissions, the use of gross as well as net emission totals, and Global Warming Potential (GWP).

Table ES.1: Comparison of GHG Emission Accounting Formats Used in This Report

	CLCPA Format	Conventional Format*
Emissions Scope	In-state sources, imported electricity and fossil fuels, exported waste	In-state sources only
Gross versus Net	Gross and Net totals*	Net totals are used, but gross emissions are also reported
Global Warming Potential	20-Year GWP from IPCC's Fifth Assessment Report (AR5)	100-Year GWP from IPCC's Fourth Assessment Report (AR4)

*The Statewide GHG Emission Limits established by ECL § 75–0107 and reflected in 6 NYCRR Part 496 are measured in gross emissions and the CLCPA's zero emission goal established by ECL § 75–0103(11) refers to net emissions.

Current New York State Greenhouse Gas Emissions

In 2019, statewide gross emissions were 379.43 million metric tons of carbon dioxide equivalent (mmt CO_2e) using CLCPA accounting (Table ES.2). Carbon dioxide (CO_2) and methane (CH_4) comprised the largest portion of emissions, or 58% and 35% respectively. Energy was the largest source of emissions (76%), primarily from fuel combustion and fugitive emissions from imported fossil fuels. When comparing economic sectors (Table ES.3), the largest sources are Buildings (32%) and Transportation (28%). Approximately 8% (29.11mmt CO_2e) of 2019 emissions were removed, primarily via carbon sequestration in forests, resulting in a net emission total of 338.53mmt CO_2e.

[1] Environmental Conservation Law (ECL) Article 75 and as adopted in 6 NYCRR Part 496

Table ES.2: 2019 New York State GHG Emissions, by IPCC Sector

CLCPA Format (mmtCO2e GWP20)	**CO_2***	**CH_4**	**N_2O**	**PFC**	**HFC**	**SF_6**	**NF_3**	**Total**	*% of Total*	UNFCCC Total**
Energy	216.07	72.46	0.92	-	-	0.13	-	289.58	*76%*	164.75
Fuel Combustion	168.67	2.02	0.76	-	-	-	-	171.45	*45%*	159.31
Electric Power	*22.03*	*0.04*	*0.05*	-	-	-	-	*22.12*	*6%*	*21.51*
Residential	*39.38*	*1.27*	*0.07*	-	-	-	-	*40.72*	*11%*	*36.18*
Commercial	*22.35*	*0.33*	*0.02*	-	-	-	-	*22.70*	*6%*	*21.94*
Industrial	*9.08*	*0.07*	*0.03*	-	-	-	-	*9.18*	*2%*	*7.38*
Transportation	*75.84*	*0.31*	*0.59*	-	-	-	-	*76.73*	*20%*	*72.29*
Fugitive Emissions	0.17	14.05	+	-	-	-	-	14.22	*4%*	4.35
Electricity T&D	-	-	-	-	-	0.13	-	0.13	*0%*	0.17
Other Use of Fuels	0.93	-	-	-	-	-	-	0.93	*0%*	0.93
Out of State Emissions	46.30	56.39	0.16	-	-	-	-	102.85	*27%*	-
Imported Electricity	*7.81*	*0.01*	*0.02*	-	-	-	-	*7.84*	*2%*	-
Imported Fossil Fuels	*38.49*	*56.37*	*0.15*	-	-	-	-	*95.01*	*25%*	-
Industrial Processes and Product Use	2.08	+	0.02	0.10	20.89	+	+	23.10	*6%*	11.59
Metals	0.37	+	-	0.02	-	-	-	0.40	*0%*	0.40
Minerals	1.71	-	-	-	-	-	-	1.71	*0%*	1.71
Electronics	-	-	0.02	0.08	+	+	+	0.12	*0%*	0.16
Product Use	-	-	+	-	20.89	-	-	20.89	*6%*	9.32
Agriculture, Forestry, and Other Land Use	0.15	19.20	1.86	-	-	-	-	21.21	*6%*	7.77
Livestock	-	19.20	0.36	-	-	-	-	19.55	*5%*	6.11
Soil Management	0.15	-	1.5	-	-	-	-	1.65	*0%*	1.65
Waste	3.59	41.41	0.54	-	-	-	-	45.54	*12%*	10.45
Solid Waste Management	0.52	19.44	-	-	-	-	-	19.96	*5%*	5.79
Waste Combustion	2.49	0.07	0.03	-	-	-	-	2.60	*1%*	2.18
Wastewater	-	6.43	0.50	-	-	-	-	6.93	*2%*	2.48
Exported Waste†	0.05	15.94	+	-	-	-	-	16.05	*4%*	-
Gross Total	**221.89**	**133.07**	**3.35**	**0.10**	**20.89**	**0.13**	**+**	**379.43**		**194.56**
% Gross Total	*58%*	*35%*	*1%*	+	*6%*	+	+			
Net Emission Removals	(29.11)							(29.11)		(29.11)
Net Total*	180.98	133.07	3.35	0.10	20.89	0.13	+	338.53		165.46
% Net Total	*53%*	*39%*	*1%*	+	*6%*	+	+			

NA Not Applicable. "+" less than 0.01mmt or less than 0.1%. Totals may not sum due to independent rounding.
*Gross CO_2 emissions include biogenic CO_2. The Net total and UNFCCC total omit 11.79mmt of biogenic CO_2.
**UNFCCC Total refers to conventional accounting used by other governments, applies a 100-year GWP (IPCC 2007), omits biogenic CO_2, and does not include emissions outside of New York State.
† Exported waste refers to emissions generated from waste sent to landfills and combustors outside of New York State.

Table ES.3: 2019 New York State GHG Emissions, by Economic Sector

CLCPA Format (mmtCO_2e GWP20)	**CO_2***	**CH_4**	**N_2O**	**PFC**	**HFC**	**SF_6**	**NF_3**	**Total**	% of Total	**UNFCCC Format****
Electricity	35.65	14.99	0.08			0.13		50.85	13%	21.68
Fuel Combustion	22.03	0.04	0.05	-	-	-	-	22.12	6%	21.51
Electricity T&D	-	-	-	-	-	0.13	-	0.13	0%	0.17
Imported Fuels	5.80	14.94	0.02	-	-	-	-	20.76	5%	NA
Imported Electricity	7.81	0.01	0.02	-	-	-	-	7.84	2%	NA
Transportation	91.14	11.40	0.66		3.71			106.92	28%	72.36
Fuel Combustion	74.46	0.31	0.59	-	-	-	-	75.36	20%	70.91
Product Use	-	-	-	-	3.71	-	-	3.71	1%	1.44
Imported Fuels	17.47	10.31	0.08	-	-	-	-	27.86	8%	NA
Buildings	74.70	28.22	0.14		17.18			120.25	32%	66.00
Residential Fuel Comb.	39.38	1.27	0.07	-	-	-	-	40.72	11%	36.18
Commercial Fuel Comb.	22.35	0.33	0.02	-	-	-	-	22.70	6%	21.94
Product Use	-	-	-	-	17.18	-	-	17.18	5%	7.88
Imported Fuels	12.99	26.62	0.04	-	-	-	-	39.65	10%	NA
Industry	16.64	17.85	0.06	0.10	+	+	+	34.67	9%	16.31
Industrial Processes†	2.08	+	0.02	0.10	+	+	+	2.21	1%	2.27
Oil and Gas Industry††	1.55	14.05	+	-	-	-	-	15.60	4%	5.73
Fuel Combustion	9.08	0.07	0.03	-	-	-	-	9.18	2%	7.38
Other Uses of Fuels	0.93	-	-	-	-	-	-	0.93	0%	0.93
Imported Fuels	2.13	2.41	+	-	-	-	-	6.75	2%	NA
Waste†	3.59	41.40	0.54	-	-	-	-	45.54	12%	10.45
Waste	3.02	25.94	0.53	-	-	-	-	29.49	8%	10.45
Exported Waste	0.58	15.47	+	-	-	-	-	16.05	4%	NA
Agriculture†	0.15	19.20	1.86	-	-	-	-	21.21	6%	7.77
Gross Total	**221.89**	**133.07**	**3.35**	**0.10**	**20.89**	**0.13**	**+**	**379.43**		**194.56**
% Gross	*58%*	*35%*	*1%*	+	*6%*	+	+			
Net Emission Removals	(29.11)							(29.11)		(29.11)
Net Total	180.98	133.07	3.35	0.10	20.89	0.13	+	338.53		165.46
% Net	*53%*	*39%*	*1%*	+	*6%*	+	+			

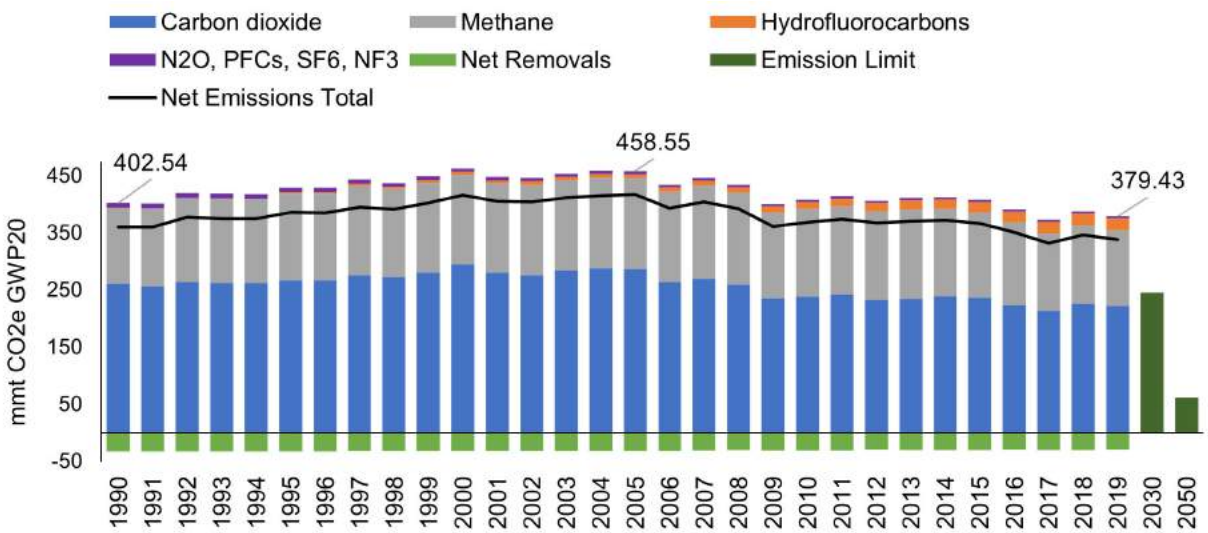
NA Not Applicable. "+" less than 0.01mmt or less than 0.1%. Totals may not sum due to independent rounding.
*Gross CO2 emissions include biogenic CO_2. The Net total and UNFCCC total omit 11.79mmt of biogenic CO_2.
**UNFCCC Total refers to conventional accounting used by other governments, applies a 100-year GWP (IPCC 2007), omits biogenic CO_2, and does not include emissions outside of New York State.
†See previous table for sources within these emission categories.
††Oil and Gas Industry includes fuel use in pipelines and fugitive emissions within New York.

Trends in Greenhouse Gas Emissions, 1990-2019

Total statewide gross emissions in 2019 were 6% below 1990 and 17% below 2005 levels, when assessed using CLCPA accounting. Figure ES.1 shows overall trends in statewide emissions by gas on an annual basis, including gross and net emission totals, as well as the emission limits for 2030 and 2050 pursuant to ECL § 75-0107 and 6 NYCRR Part 496.

Annual emissions of CO_2 declined 15%, or 39mmt CO_2e, from 1990 to 2019, but this was coupled with an increase in hydrofluorocarbon emissions of over 20mmt CO_2e. Methane emission rates were approximately the same in 1990 and 2019. Emission rates for remaining gases declined 58% since 1990, or 5.03mmt CO_2e, and remain at relatively low rates in terms of carbon dioxide equivalence. Annual, net emission removals of CO_2 declined 11% or from -32.69mmt to -29.11mmt.

Figure ES.1: NYS Statewide Greenhouse Gas Emissions by Gas, 1990-2019 (mmt CO_2e GWP20)



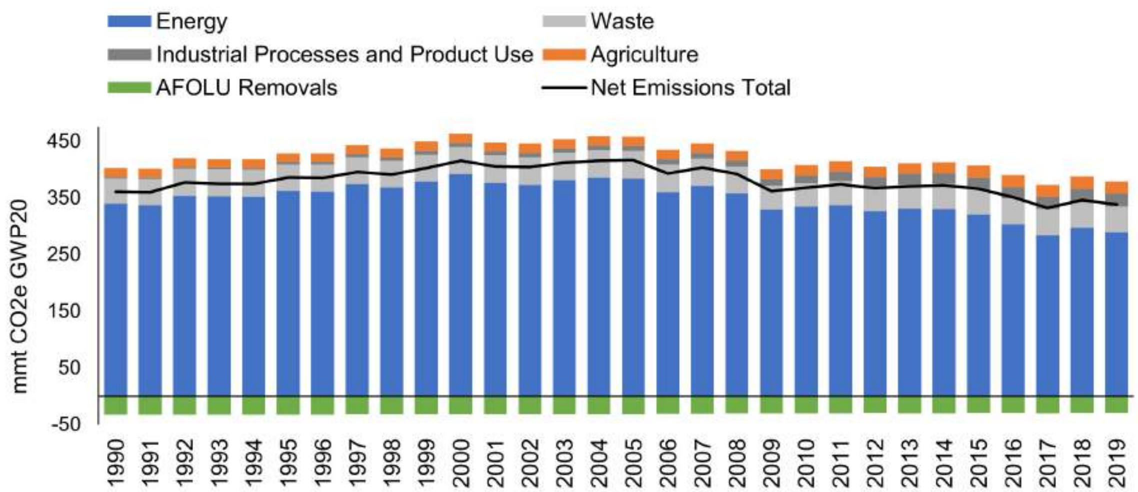
As a point of comparison, when applying the conventional, or UNFCCC, format for governmental accounting, emissions declined 21% percent from 1990 to 2019, or from a net emission rate of 210.43mmt to 165.46mmt CO_2e GWP100. This format does not meet CLCPA accounting requirements.

Trends in IPCC Emission Sectors, 1990-2019

In Figure ES.2, emissions are organized into the sectors described in IPCC guidelines (IPCC 2006). The Energy sector encompasses emissions associated with the energy system, including electricity, transportation, and building/industrial heating. The Industrial Process and Product Use (or IPPU) sector covers emissions associated with manufacturing and manufactured products. The Waste sector encompasses any activities to manage human wastes. Finally, the Agriculture, Forest, and Other Land Use (or AFOLU) sector encompasses emissions from the management of lands and livestock as well as net emission removals from land management and the long-term storage of carbon in durable goods.

The Energy sector represents the majority of emissions and energy emissions in 2019 were 15% lower than in 1990 (Figure ES.2). However, not all energy emissions were reduced over this time period. Additionally, the overall reduction in energy emissions was offset by increases in all other sectors and by a 11% decline in net emission removals. The largest increases occurred in IPPU due to the increasing use of hydrofluorocarbons (20mmt CO2e) and in AFOLU resulting from changes in agricultural practices (6mmt CO2e). Waste sector emissions increased slightly over 1mmt CO2e.

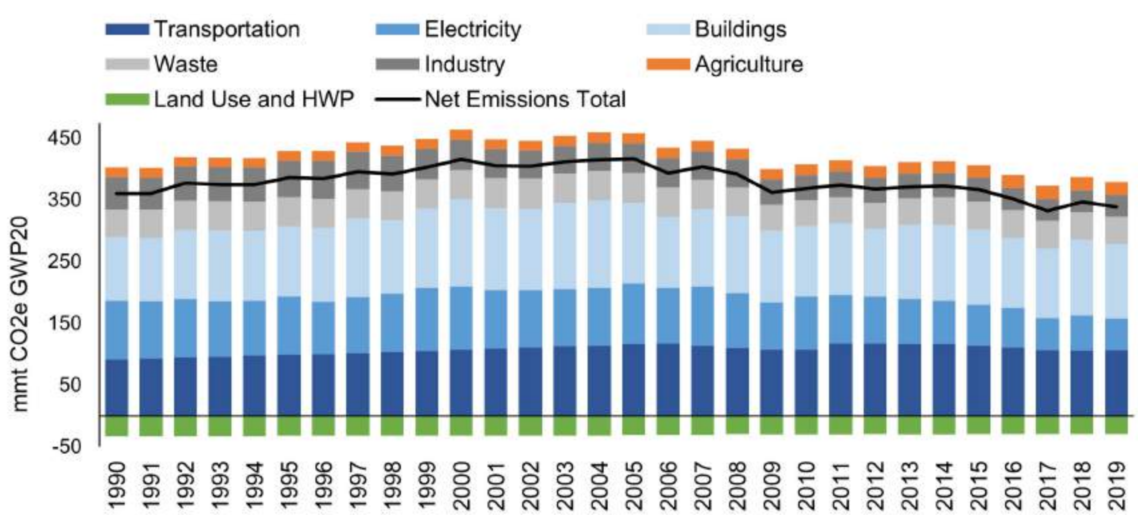
Figure ES.2: NYS Statewide Greenhouse Gas Emissions by Sector, 1990-2019 (mmt CO_2e GWP20)



Emission Trends by Economic Sectors and CLCPA Scoping Plan

Emissions can also be organized into sectors that reflect economic drivers and policy. Table ES.3 and Figure ES.3 organizes emissions according to the New York State Climate Action Council Draft Scoping Plan. For example, energy fuels were assigned to the sector where those fuels were used, such as in the transportation system or for electricity generation. Similarly, products that contain hydrofluorocarbons, such as air-conditioning equipment, were assigned to the transportation or buildings sectors. The most significant trends show a 46% decrease in electricity emissions and a 34% decrease in industrial emissions (15mmt and 18mmt CO_2e, respectively). These reductions were offset by a 16% increase in emissions from buildings and transportation (17mmt and 15mmt, respectively). Agricultural and waste emission increased by 6mmt and 1mmt CO_2e, respectively.

Figure ES.3: NYS Statewide Emissions by Economic Sector, 1990-2019 (mmt CO_2e GWP20)



2021 Statewide Greenhouse Gas Emissions Report

I. Introduction to the Report

This annual report on statewide greenhouse gas (GHG) emissions provides a summary of emissions for the years 1990-2019 and includes information on the relative contribution of each gas and emission source specified in the Climate Leadership and Community Protection Act.[2] This includes all anthropogenic greenhouse gas emissions from each sector of the economy for each year.

In producing this report, DEC used the guidelines provided by the International Panel on Climate Change (IPCC) Taskforce on National Inventories, referred to here as the "IPCC guidelines" (IPCC 2006, 2019). The IPCC guidelines are intended for use by national parties to the United Nations Framework Convention on Climate Change (UNFCCC) and represent a rigorous set of procedures for producing a full assessment of anthropogenic emission sources within a jurisdiction. The U.S. national greenhouse gas inventory applies these guidelines and is the primary model used for this state report (EPA 2021a).

The emission information provided in this report is intended to provide information in a way that is useful to the public and to policymakers. This includes summaries by gas, by IPCC sectors, and by the economic sectors used in the New York State Climate Action Council Draft Scoping Plan. DEC welcomes feedback on additional ways to present this information in future reports. DEC also intends to make the emission estimates available on Open Data NY so that users can produce their own summaries.

Organization of the Report

The annual report is provided in five stand-alone documents to enable users to locate the information most relevant to their needs. This *Summary Report* compares trends among all emission sectors and provides general information about the reporting process and the legal requirements of this report. The four *Sectoral Reports* provide more technical detail and a review of data, methods, and results for each of the IPCC sectors: Energy, Industrial Processes and Product Use (IPPU), Agriculture Forestry and Other Land Use (AFOLU), and Waste. The Sectoral Reports also provide information on subcategories of emission sources that are not described in the Summary Report. Finally, for informational purposes, the Summary Report provides emission results in a conventional format for ease of comparison to reports by other governments (see "Greenhouse Gas Accounting Used in This Report" below).

- Summary Report (this document)
- Sectoral Report #1: Energy
- Sectoral Report #2: Industrial Processes and Product Use
- Sectoral Report #3: Agriculture, Forestry, and Other Land Use
- Sectoral Report #4: Waste

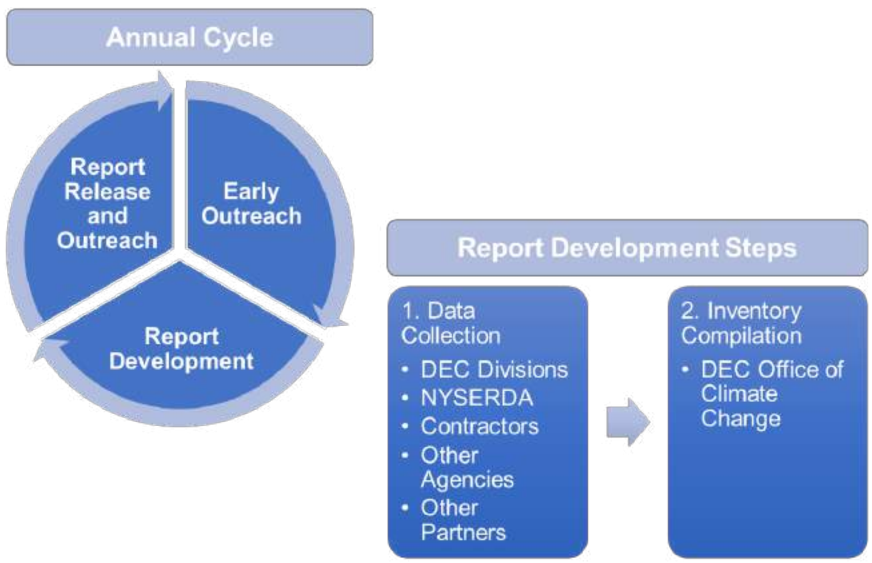
Annual Inventory Process

This report will be updated annually, as required by the CLCPA, following the release of the U.S. national greenhouse gas inventory and related datasets. DEC will update the emission estimation methodology as appropriate in order to incorporate the most recent data and best available methods. Wherever possible, the new methods will be applied to the full historical timeseries. DEC applied the following process for this

[2] ECL § 75-0105(1).

initial report, consistent with the requirements of the CLCPA (Figure 1). First, DEC invited early input on the scope of emissions to be covered in the report, the organization of the report, and the data and methods used to develop the emission estimates. As part of early outreach and as required by the CLCPA, DEC held three public hearings to seek input. For this report, DEC also consulted early with partners such as the U.S. EPA. Once this phase was completed and the relevant national datasets were made available, DEC developed the written report in collaboration with other State entities, contractors, and partners. Feedback received after the release of this report may be considered in the development of the following year's report. DEC will accept feedback on the annual reports on an ongoing basis in order to continually improve the data and methods.

Figure 1: New York State Greenhouse Gas Inventory Process Diagram



This report collates information from many sources including national datasets, published academic research, and analyses conducted by private and public entities on behalf of New York State. Certain sources are indicated below (Table 1); details on these and other sources are provided in the Sectoral Reports. While this report uses the best information available at the time of development, DEC will continue to seek improvements wherever possible as it develops future reports. DEC welcomes input on how best to integrate new data into this report as well as other State policies and programs.

Table 1: Example Resources Used in This Report

Energy	Industrial Processes and Product Use	Waste	Agriculture, Forests, and Other Land Use
USEIA State Energy Data System	EPA Greenhouse Gas Reporting Program	DEC Solid Waste Information Management System	USDA Forest Service Inventory and Analysis
Motor Vehicle Emission Simulator (MOVES)	USGS Minerals Information Center		USDA National Agricultural Statistics Service
NYSERDA Oil and Gas Methane Inventory	NYSERDA HFC Inventory		NOAA Coastal Change Analysis Program
USEPA US National Greenhouse Gas Inventory (EPA 2021a) and submissions to the UNFCCC			
USEPA State Inventory Tool (EPA 2020)			

Greenhouse Gas Accounting Used in This Report

This report uses metrics and an organizational scheme that balances the requirements of the CLCPA against other goals, including alignment with the accounting used by other governments, consistency with other State policies, and to provide a familiar format to the public and stakeholders.

Bottom-up versus Top-down Accounting

As with all governmental emission accounting, this inventory is largely based on "bottom-up" estimates of greenhouse gas emission sources and sinks. Bottom-up methods attempt to estimate emissions from the individual source level, whereas "top-down" methods measure total emissions from multiple potential sources. Governmental emission inventories must look at the individual source level in order to identify and address emission sources. Fortunately, bottom-up estimates can be refined by comparing them to top-down measurements (see the *Sectoral Report #1: Energy* for an example). As the IPCC (2021) describes it, bottom-up emission inventories use empirical upscaling of point measurements, emission inventories and dynamical model simulations and the summation across these to provide total emissions estimates for a region. In contrast, top-down estimates are those constrained by atmospheric measurements and chemistry-transport models in inversion systems. Intercomparison of top-down and bottom-up estimates is useful because discrepancies can point to emission sources that might be unidentified or as yet unaccounted for in bottom-up inventories. Top-down measurements can also provide a cross-check on how closely the scaling and models used in bottom-up estimates actually reflect the atmospheric reality. On the other hand, bottom-up estimate can help break down the total regional emissions provided by top-down measurements by providing local and sector-specific information about emitting activities and nearby facilities.

Emission Scope: In-state, Out-of-state, and Lifecycle Emissions

Governmental greenhouse gas emission inventories that follow the IPCC guidelines are intended to monitor activities that occurred within that government's jurisdictional boundaries. Unlike other governmental inventories, due to the requirements of the CLCPA, this report includes certain emission sources that are outside of New York State's borders. Specifically, this report follows the definition of "statewide greenhouse gas emissions" provided in the CLCPA and includes sources within the state plus emissions associated with imported electricity and fossil fuels. [3] It also includes emissions associated with wastes that have been exported outside of New York. In this report, these emissions may be referred to as imported, exported, or out-of-state. There are other types of accounting that go beyond jurisdictional boundaries, such as consumption and lifecycle accounting. As described in *Sectoral Report #1: Energy*, lifecycle models were used in the analysis of imported fuels. However, lifecycle accounting is not intended to produce annualized or historical inventories as is needed for this report.

Gross versus Net Greenhouse Gas Emissions

Governmental greenhouse gas inventories that follow the IPCC guidelines typically report emissions and emission removals (otherwise known as sources and sinks) that occurred within the government's jurisdictional borders over the course of a year. Removals refer to CO_2 taken out of the atmosphere, such as by plants that absorb and store carbon during growth. A net emission total refers to emissions minus removals. Gross emission totals refer to emissions only, with no consideration of carbon removal from the atmosphere. In other words, "gross" emissions are actual emissions and "net" emissions are a component of the IPCC guidelines that also considers emission removals.

[3] ECL § 75-0101(13). See also ECL § 75-0105(3).

Unless stated otherwise, emission totals in this report are provided as gross emissions and include all sources of emissions except from the Land Use sector. The Land Use sector is reported in terms of net emission removals over the annual period. For example, total CO_2 associated with forests in a given year could include all of the CO_2 sequestered by trees as well as any gases emitted during forest fires. Consistent with the IPCC guidelines, biogenic CO_2 is a form of gross emissions, but it is treated as zero net emissions in net emission totals. This is a simplified assumption used in the IPCC guidelines that considers the balance of emissions (such as from plant-based fuels) with removals (from the growth of such fuel feedstocks on croplands or forest). Ultimately, this assumes that the annual, net amount of CO_2 in the atmosphere from biogenic sources will be reflected in the global accounting of the Land Use sector.[4] Put another way, this report follows IPCC guidelines and treats biogenic CO_2 as an anthropogenic emission source that is omitted from net emission totals to avoid double counting CO_2 sources across the Energy and Land Use sectors.

Global Warming Potentials

Greenhouse gases warm the atmosphere as a function of their atmospheric abundances, atmospheric lifetimes, specific warming power per molecule, and their influence on the physical and chemical dynamics of the atmosphere. The impact of a specific greenhouse gas emission on the current and future climate is dependent on this combination of factors as well as the response of the earth system to the emission. The IPCC developed the Global Warming Potential (GWP) metric as one method to compare the impact of a pulse emission of a particular greenhouse gas to a pulse emission of an equal amount of CO_2, integrated over a time horizon that is chosen based on the specific goals that policy makers are trying to achieve. The GWP is reported in units of carbon dioxide equivalence, or "CO_2e". National governments that report emissions to the UNFCCC apply a GWP integrated over a 100-year time horizon from IPCC's Fourth Assessment Report (IPCC 2007) and this has become the conventional approach.

The CLCPA requires that this report apply a GWP that is integrated over a 20-year time horizon. Shortening the time horizon over which the GWP is integrated increases the GWP of gases that are shorter-lived than CO_2, such as methane (CH_4; Table 2). In 2020, DEC adopted 20-year GWP values from the IPCC Fifth Assessment Report into the Part 496 regulation, which were the most up-to-date values at the time (IPCC 2013).[5] For the purposes of this report, greenhouse gas emissions are reported according to that regulation, unless otherwise noted. Newer GWP values are now available and may be adopted in future updates (IPCC 2021). Because different gases have different atmospheric lifetimes, and GWP is integrated over a finite time horizon, there is a range of possible temperature responses to apparently equivalent emissions as quantified by CO_2e (Tanaka and O'Neill 2018). The raw, unweighted tonnage of each emission estimate provided in this report can be determined by dividing by the GWP.

[4] E.g., IPCC Taskforce on National GHG Inventories (2021) Frequently Asked Questions #Q2-10, available at: https://www.ipcc-nggip.iges.or.jp/faq/faq.html (last visited November 4, 2021).
[5] 6 NYCCR Part 496.

Table 2: Global Warming Potential Values

Gas	**CLCPA** GWP20 (IPCC AR5)	**UNFCCC** GWP100 (IPCC AR4)
CO_2	1	1
CH_4	84	25
N_2O	264	298
HFC-23	10,800	14,800
HFC-32	2430	675
HFC-41	427	92
HFC-125	6090	3500
HFC-134a	3580	1430
HFC-143a	6940	4470
HFC-152a	506	124
HFC-227ea	5360	3220
HFC-236fa	6940	9810
HFC-43-10mee	4310	1640
HFC-245fa	2920	1030
HFC-365mfc	2660	794
PFC-14	4880	7390
PFC-116	8210	12,200
PFC-218	6640	8830
PFC-318	7110	10,300
PFC-3-1-10	6850	8860
PFC-5-1-14	5890	9300
SF_6	17,500	22,800
NF_3	12,800	17,200

Source: IPCC (2007, 2013)

Greenhouse Gases and Other Pollutants

Many of the references cited in this report provide additional information on the pollutants that are driving climate change, including the IPCC Assessment Report (IPCC 2021) and the U.S. national greenhouse gas inventory (EPA 2021a). This report provides information on seven types of well-mixed greenhouse gases subject to the CLCPA and that are commonly reported by governments. However, there are other types of pollutants that also affect climate change as well as pollutants that may be associated with greenhouse gas sources that are harmful for human health and the environment.

Carbon dioxide

Carbon dioxide (CO_2) is the major anthropogenic climate forcer. The current atmospheric abundance of CO_2 has risen to 413.2 +/- 0.2 ppm from a preindustrial abundance of 278 ppm (WMO 2021), mainly due to fossil fuel combustion. Carbon cycle processes redistribute the CO_2 that is emitted to the atmosphere to terrestrial ecosystems and ocean carbon reservoirs. These CO_2 sinks take up roughly half of anthropogenic CO_2 emissions annually. But these sinks are responsive to changes in the atmospheric abundance of CO_2, and any deliberate net removal of CO_2 in the future will be partially offset by outgassing of CO_2 from the ocean and land sinks (IPCC 2021). The processes that remove CO_2 from the atmosphere act over different timescales that range from decades (e.g., incorporation into forest biomass, afforestation and reforestation processes) to centuries (dissolution and circulation in the deep ocean) to millennia (uplift and weathering of silicate minerals). These timescales mean that CO_2 is a long-lived greenhouse gas, and its present-day emissions will impact the climate long into the future (IPCC 2018).

Methane

Like CO_2, the atmospheric abundance of methane (CH_4) has been driven upwards by anthropogenic emissions, from a preindustrial value of 722 ppb to over 1889 +/-2 ppb today (WMO 2020, 2021). For this reason, CH_4 is often grouped with CO_2 and other long-lived greenhouse gases, but its atmospheric lifetime is actually only 9 years (IPCC 2021). In contrast to CO_2, whose long atmospheric lifetime and high atmospheric abundance drive its climate impact, it is CH_4's radiative efficiency, or heat-trapping ability, that makes it an important climate forcer over the short term. CH_4 that is emitted now will cause warming that peaks and largely dissipates after about a decade, because atmospheric reactions remove it relatively quickly. As a consequence, the GWP20 of CH_4 is much higher than its GWP100 (Table 2). It also means that a steady ongoing release of CH_4, rather than a pulse emission, is most similar to a pulse CO_2 emission in terms of their respective long-term climate impacts.

Nitrous oxide

Nitrous oxide (N_2O) is long-lived like CO_2, and like CH_4, it is also particularly effective at trapping heat in the atmosphere. Its atmospheric lifetime is estimated to be 116 +/- 9 years (IPCC 2021) and the only major removal processes are stratospheric chemical reactions. N_2O takes centuries to achieve equilibrium between emissions and removals and therefore, like CO_2, N_2O emissions impact climate cumulatively (IPCC 2021). N_2O sources are natural (60%) and anthropogenic (40%). Like CH_4, N_2O is produced both biologically through the activity of microorganisms, and through combustion. Biological N_2O is produced by microbial action on certain nitrogen compounds in soil and water. Anthropogenic activity in the agricultural and waste management sectors enhance biological N_2O emission rates. Combustion sources of N_2O include motor vehicles and point sources. The global atmospheric abundance of N_2O has risen to 333.2+/-0.1 ppb from a preindustrial value of 270 ppb (WMO 2021). Even after global emissions of N_2O are stabilized, its long atmospheric lifetime means that it will take more than a century before atmospheric abundances stabilize. N_2O is also of concern because it is the most significant anthropogenic destroyer of stratospheric ozone (Ravishankara, Daniel, and Portmann 2009).

Fluorinated or High GWP Gases

In addition to the naturally occurring greenhouse gases above, certain human-made compounds also contribute to climate change. Following IPCC guidelines, the following types of gases should be included in greenhouse gas accounting. These gases all contain fluorine and are emitted at a lower rate globally than the other well-mixed greenhouse gases but have much higher global warming potentials.

Hydrofluorocarbons (HFCs) are a group of different compounds primarily manufactured as replacements for ozone-depleting substances in a variety of end-uses such as refrigeration and foam blowing. The growth of HFCs corresponds to the adoption of the Montreal Protocol in 1987, which called for the phase down in the production and trade of chlorofluorocarbons (CFCs) and other ozone-depleting substances. Use of HFCs had therefore just begun around 1990, the UNFCCC's baseline year for reporting GHG emissions. Over the past thirty years, HFC use grew to replace the ozone-depleting substances and to meet an accelerated, global demand for refrigeration equipment. For this reason, HFC emissions started very close to zero in 1990 but have continued to grow exponentially through today. For example, HFC-134a was introduced early in the 1990's, reached an atmospheric abundance of 57.5 ppt by 2010, and doubled to 107.6 ppt by 2019 (IPCC 2021, Annex III). Some, but not all, HFCs are relatively short-lived;

estimated atmospheric lifetimes are 14.0 +/- 2.8 years for HFC-134a, 5.4 +/- 1.1 years for rapidly increasing HFC-32, and 228 years for the high-GWP HFC-23 (IPCC 2021; Hodnebrog et al. 2020).

Perfluorocarbons (PFCs) are a group of compounds used in refrigerants, electronics manufacturing, and aluminum smelting that are chemically stable and long-lived in the atmosphere. For example, PFC-14 (perfluoromethane or CF_4) has an estimated atmospheric lifetime of 50,000 years. The atmospheric abundance of PFCs has risen steadily since the 1970s, though not at the accelerating rate seen among HFCs. Certain PFCs like CF_4 also have natural sources that contribute significantly to their atmospheric abundance (IPCC 2021).

Sulfur hexafluoride (SF_6) is a synthetic fluorinated compound that is the most potent greenhouse gas currently known, with a GWP20 of 17,500 (Table 2). It is also an extremely stable, long-lived molecule, with an atmospheric lifetime estimated to be 1,000 years (IPCC 2021). It therefore has a cumulative impact on climate, like CO_2 and N_2O, and a relatively small amount of SF_6 can have a significant long-term impact. The atmospheric SF_6 abundance was estimated to be 10.0 ppt in 2019, up from 7.0 ppt in 2011 (IPCC 2021). SF_6 has been used in a variety of applications, including electronics manufacturing and in medical applications. Electric utilities rely on SF_6 in electric power systems for voltage electrical insulation, current interruption, and arc quenching in the transmission and distribution of electricity.

Nitrogen trifluoride (NF_3) is emitted during electronics manufacturing. Its atmospheric abundance is still low but steadily increasing, rising from 0.7 ppt in 2010 to 2.1 ppt in 2019 (IPCC 2021, Annex III). Its high GWP (Table ES1.2) is second only to that of SF_6, and its long atmospheric lifetime of 569 years (Hodnebrog et al. 2020) means that today's NF_3 emissions will have a long-lasting impact on climate.

Other Pollutants

The sources of greenhouse gas emissions are often also sources of co-pollutants that impact air quality and public health in ways that are highly variable in space and time. These co-pollutants tend to have short atmospheric lifetimes and highly heterogeneous sources and sinks. Examples include tropospheric ozone, carbon monoxide, particulate matter less than 2.5 microns in width (PM 2.5), and nitrogen oxides (or NOx) such as nitrogen dioxide. Both vehicles and stationary sources of greenhouse gases emit these co-pollutants. Under the Clean Air Act, states are required to meet national emission standards for co-pollutants. DEC collects information on emissions from sources that include power plants and vehicles, among others, and submits them to EPA be incorporated into the U.S. National Emissions Inventory (NEI), which is updated every three years (EPA 2021b). The CLCPA addresses greenhouse gases and co-pollutants to ensure reductions of both particularly in disadvantaged communities.

DEC seeks feedback on how to specifically integrate reporting on black carbon into this annual statewide greenhouse gas emissions report. Black carbon is a component of PM 2.5 and a type of carbonaceous aerosol, or soot that is mostly made of carbon. Although it is already monitored as part of air quality reporting, it is also an important climate pollutant that absorbs solar radiation and emits heat, contributing radiative forcing that warms the atmosphere. However, it is not a greenhouse gas and it has a very short atmospheric lifetime (an estimated 5.5 +/-2.0 days; IPCC 2021), so that it cannot be easily compared to the well-mixed greenhouse gases using a Global Warming Potential metric. The major sources of black carbon in New York State include diesel engine emissions and residential wood stoves.

Finally, other pollutants of concern are greenhouse gases that are ozone-depleting substances. Under the UNFCCC, emissions of stratospheric ozone-depleting substances are not reported in national greenhouse gas inventories because they are already controlled under the 1987 Montreal Protocol (IPCC 2006). For example, the production and trade in chlorofluorocarbons (CFCs) was phased down under this international agreement. As a result, estimated atmospheric abundances of CFC-12 and CFC-11 have declined from their respective peak concentrations of 542.3 ppt (c. 2000) and 259.3 ppt (c. 1995), to 2019 abundances of 503.1 ppt and 226.2 ppt, respectively (WMO 2020; IPCC 2021, Annex III). However, both chemicals have relatively long atmospheric lifetimes; 102 years for CFC-12 and 52 years for CFC-11. Although reported production of CFC-11 has stopped, emissions are still occurring (IPCC 2021).

II. Trends in New York State Greenhouse Gas Emissions, 1990-2019

In 2019, statewide gross emissions were 379.44 million metric tons of carbon dioxide equivalent emissions (mmtCO_2e GWP20), which is 6% lower than 1990 levels. The decrease in emissions reflects large-scale and long-term trends in population, economic factors including changes in the types of industries that are active in the state, and land-cover changes including those that affect forests. One key trend has been a reduction in CO_2 emissions associated with the electricity system. There is a national as well as strong New York-specific trend in the reduction of electricity emissions associated with various regulations, increased application of energy efficiency measures, and fuel switching. As the U.S. Environmental Protection Agency reports in the 2021 national inventory report (EPA 2021a):

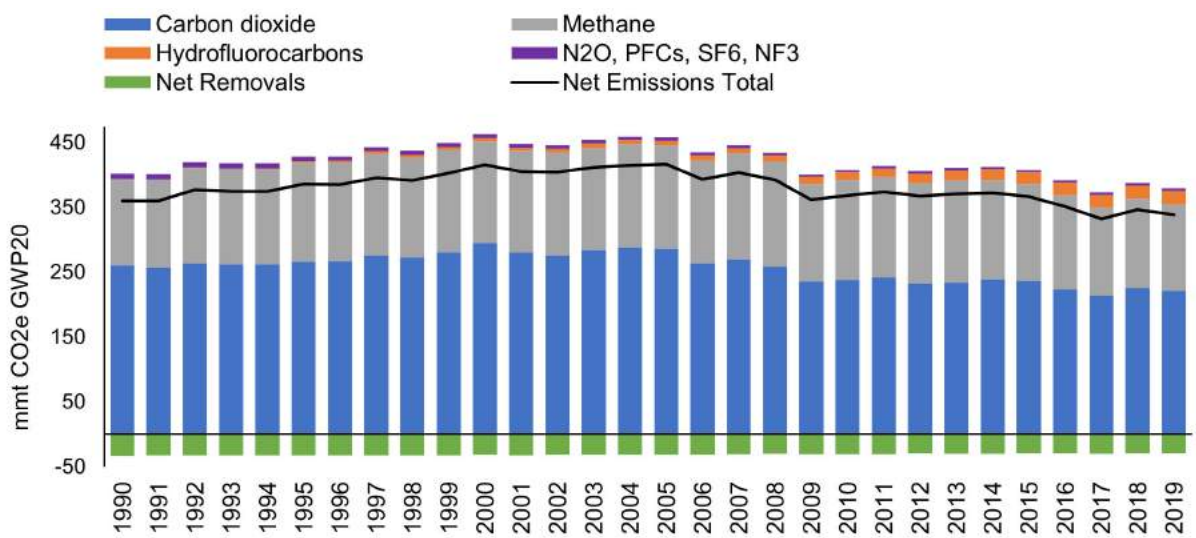
> *Between 2018 and 2019, the decrease in total greenhouse gas emissions was driven largely by a decrease in CO_2 emissions from fossil fuel combustion. The decrease in CO_2 emissions from fossil fuel combustion was a result of a 1 percent decrease in total energy use and reflects a continued shift from coal to less carbon intensive natural gas and renewables in the electric power sector.*

Figure 2 shows the relative contribution of each greenhouse gas to total statewide gross emissions and net removals over 1990-2019 in terms of carbon dioxide equivalence integrated over the 20-year timeframe. In New York State, CO_2 remains the primary greenhouse gas emitted by human activity (or 58% of emissions in 2019) and fossil fuel combustion is the primary source of CO_2. The land-use sector is an important CO_2 sink, removing roughly 8% of the State's total annual greenhouse gas emissions, primarily into forest biomass and soil organic carbon. Over time, there has been a significant reduction in CO_2 emissions, as discussed above, but also a reduction in CO_2 removals.

The second most important greenhouse gas in New York State, in terms of carbon dioxide equivalent emissions, is methane (35% of emissions; Figure 2). Major anthropogenic sources of CH_4 are fossil fuel infrastructure, waste, and agriculture. This includes CH_4 emissions from fuel infrastructure and waste management facilities outside of New York State. The majority of methane emissions are the result of leaks or other irregular releases from equipment or facilities, often referred to as fugitive emissions. Fugitive emissions often contain poorly understood release pathways which can make it difficult to estimate such emissions. One area of ongoing research is to reconcile bottom-up and top-down estimates of methane from the natural gas system, which may result in both a higher emission factor (Appendix A) and higher statewide emission estimate in future reports. For example, CH_4 emitted through incomplete natural gas combustion at the appliance level is an area of planned improvements discussed in *Sectoral Report #1: Energy*. Finally, DEC is evaluating data on CH_4 emissions from freshwater wetlands and other water bodies to better understand the carbon storage potential of these land use types and how they factor into net emission calculations. As with all aspects of net accounting, DEC seeks feedback on this approach (*Sectoral Report #3: AFOLU*).

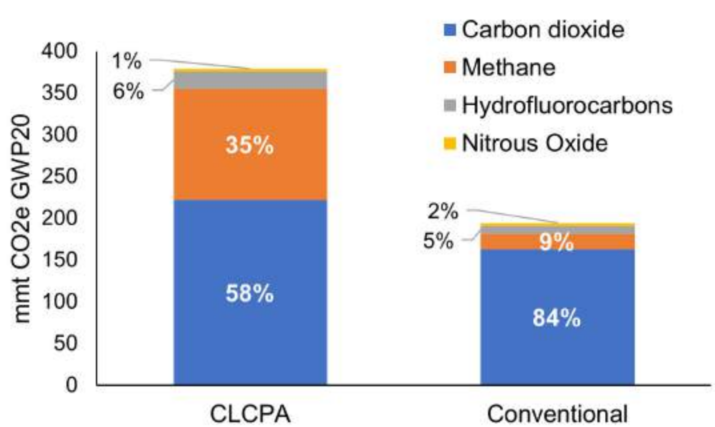
Almost all of the remaining statewide greenhouse gas emissions in 2019 are HFCs (6%), an emission source that was almost nonexistent in 1990. While the emissions of N_2O, PFCs, and SF_6 all declined as a result of technological and economic change in New York State, HFC emissions continue to grow. Importantly, all pollutants are more powerful than CO_2 per ton and most are much longer lived.

Figure 2: NYS Statewide Greenhouse Gas Emissions by Gas, 1990-2019 (mmt CO_2e GWP20)



When considering emission sources only within New York State and using a GWP100, CO_2 is a much greater component of total emissions (Figure 3). The main difference is the CLCPA's focus on shorter-lived methane and HFCs, which appear much larger using the 20-year GWP, although the actual mass of these emissions has not changed. The other key difference between the accounting frameworks is out-of-state emissions. Over time, New York State has imported more natural gas and has exported more waste and methane is a major source of emissions for both the natural gas system and waste management.

Figure 3: Comparison of 2019 Emissions, CLCPA and Standard Format

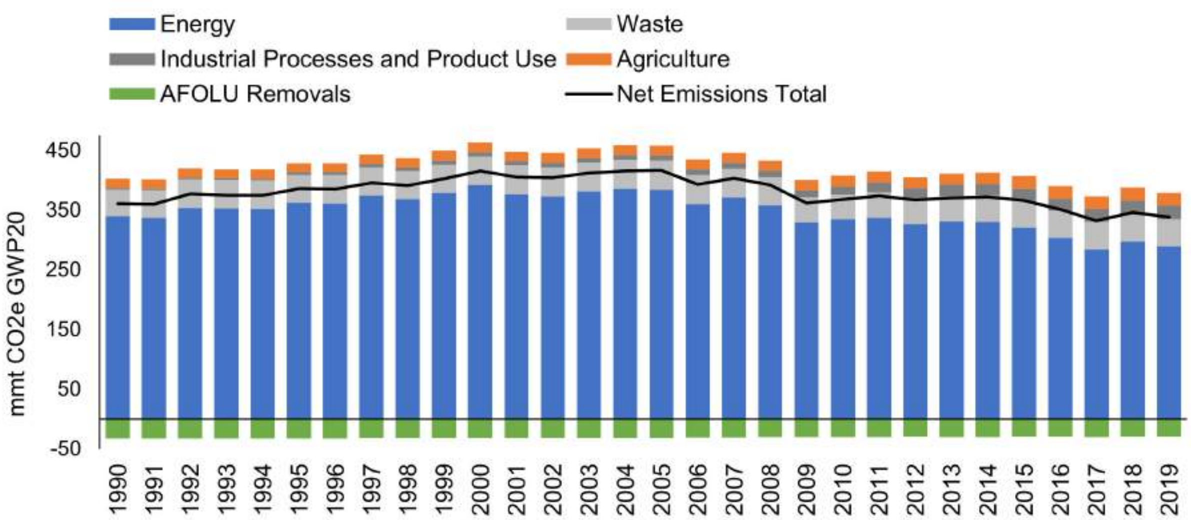


III. Trends in Greenhouse Gas Emission Sectors, 1990-2019

Figure 4 organizes emissions and removals into the sectors used by the IPCC and all national governments: "Energy," "Industrial Processes and Product Use," "Waste," and "Agriculture, Forestry, and

Other Land Use" (or AFOLU). A condensed explanation of each sector is provided below, and a detailed explanation of data sources, methods, and trends are provided in the sectoral reports.

Figure 4: NYS Statewide Greenhouse Gas Emissions by Sector, 1990-2019 (mmt CO_2e GWP20)



New York State's report makes slight changes to the IPCC guidelines as it is used in the national greenhouse gas inventory (EPA 2021). There are two additional sources of emissions associated with the Energy sector (imported electricity and imported fossil fuels) as well as new sources added to the Waste sector (for out-of-state or exported waste management). Waste combustion emissions have also been included in Waste sector emissions, rather than treated as a source of Energy sector emissions. Conversely, emissions associated with the electricity system and the oil and gas industry have been assigned to the Energy sector, rather than being assigned fully or partially to Industrial Process and Product Use. Finally, this report refers to the AFOLU sector, but the national inventory reports some emission removals as "Land Use, Land Use Change, and Forestry" (LULUCF).

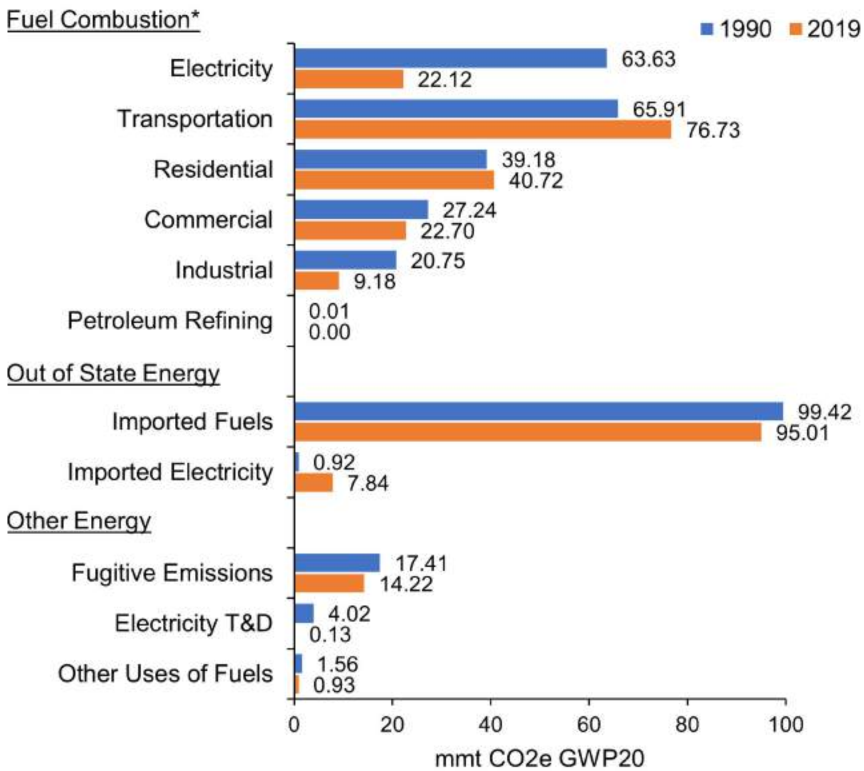
Energy

The Energy sector includes all emissions associated with the generation and use of energy, including for electricity, on-road transportation, non-road transportation (aviation, boating, and lawn and garden equipment), and on-site fuel use in buildings such as to heat buildings or for manufacturing. The Energy sector encompassed the largest portion of emissions every year from 1990 through 2019. These emissions are explained in detail in *Sectoral Report #1: Energy*.

The Energy sector is a major source of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and sulfur hexafluoride (SF_6) emissions. SF_6 in the Energy sector is exclusively associated with equipment used in electricity transmission. The remaining gases are associated with the production, transport, and combustion of fuels. For fossil fuels, this includes intentional and unintentional emissions at the point of extraction, during processing, in the transmission and distribution system, and during combustion.

Since 1990, there has been a substantial decrease in emissions associated with fuel combustion for electricity generation as well as a decrease in fuels combusted for industrial purposes (Figure 5). Emissions in all other energy sources saw minor declines and two sources saw minor increases (transportation and residential buildings). The largest source of emissions under CLCPA accounting is the imported fossil fuel system, or emissions associated with the extraction, processing, transmission, and distribution of the fossil fuels used in New York. If the overall decline in fuel combustion was the result of lower energy demand alone, then the emissions associated with imported fuels would have also declined. However, this would be offset by a transition to fuels with higher out-of-state emission rates.

Figure 5: Trends in Energy Sector Emissions



For plant and waste-based fuels, Energy emissions are associated only with the combustion of the fuels, and this includes biogenic CO_2. There may be additional emissions associated with these fuels, such as from the growing of fuel feedstocks in New York State (*Sectoral Report #3: AFOLU*).

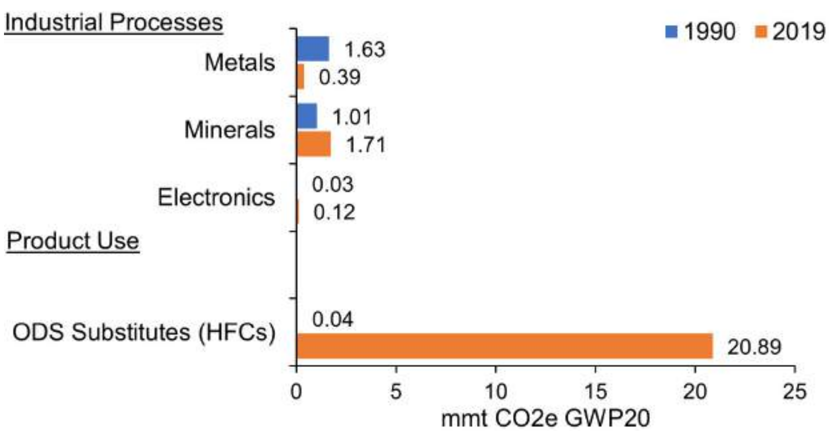
Industrial Processes and Product Use (IPPU)

The Industrial Processes and Product Use sector, or IPPU, encompasses emissions associated with manufacturing as well as the use of manufactured products. The majority of IPPU emissions in New York relate to the use of products rather than process emissions from industrial facilities. These emissions are explained in detail in the IPPU report (see *Sectoral Report #2: Industrial Processes and Product Use*).

Many industrial processes have the potential to produce greenhouse gases, and these are in addition to emissions associated with fuel use (fuel combustion is captured in the Energy sector). Industrial processes are a large source of emissions globally, but they are a relatively small portion of emissions in New York State. Industrial process emissions in New York are primarily CO_2 associated with the manufacturing of cement, metals such as iron and steel, or the various products made with limestone or dolomite (carbonates) such as glass. This report also includes sources associated with aluminum (PFCs) and electronics manufacturing (N_2O, PFCs, HFCs, and SF_6).

The types of industrial products that are emission sources are almost entirely imported into New York State and will release emissions while in use or after disposal. Globally and in New York, the majority of product use emissions are associated with hydrofluorocarbons (HFCs) used as a replacement for ozone-depleting substances in refrigeration equipment, aerosol products, and foam insulation. An insignificant amount of PFCs and SF_6 may also have been used in products historically but in too small of a quantity to be estimated. Finally, the IPPU sectoral report also reports on nitrous oxide product use, such as in medical applications, but it is also at too small of a quantity to be comparable to other emission sources.

Figure 6: Trends in Industrial Process and Product Use Sector Emissions

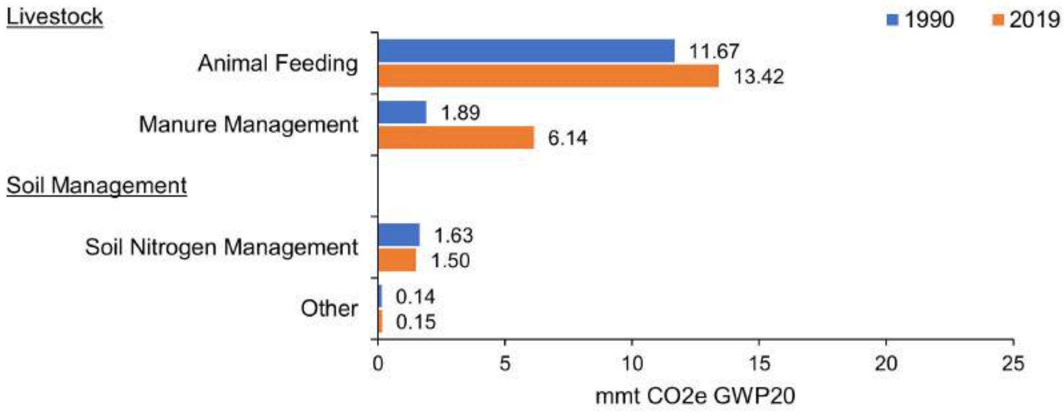


Agriculture, Forests, and Other Land Use (AFOLU)

The AFOLU sector captures emissions from agricultural operations as well as net emission removals, or carbon storage, in harvested wood products and from land management. The federal government considers all lands in the continental U.S. to be “managed” by humans and all emissions that result from the use of these lands as anthropogenic. This includes cropland and grasslands, forests, “wetlands” (which includes all modified water bodies), as well as emissions and removals associated with developed or “settlement” lands such as urban trees.

Agricultural livestock emissions are measured in much the same way as the sectors above and the largest source of emissions is methane (CH_4) from animal feeding (Figure 7). However, the largest growth in emissions is related to manure management (CH_4 and N_2O) as New York State policies regarding water quality went into effect and required certain livestock operations to store and manage manure in anaerobic, methane-generating systems. Finally, the use of different soil amendments is a consistent source of greenhouse gas emissions, particularly N_2O from nitrogen fertilizers.

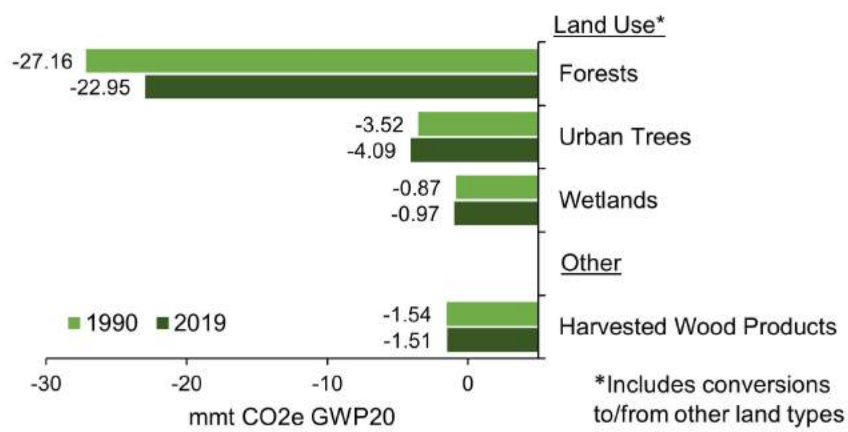
Figure 7: Trends in AFOLU Agriculture Sector Emissions



Unlike the rest of the emission sectors described in this report, the AFOLU sector also includes emission sinks, or net emission removals (Figure 8). One consistent source of emission removals for the past 30 years has been the long-term storage of carbon in Harvested Wood Products (under "Other" in Figure 8). However, the major source of net emission removals comes from New York's nearly 19 million acres of forest land.

Land Use accounting reflects both how much net CO_2e is taken up on a given type of land as well as how much of that land type may have been converted to or from another land type. For example, net emission removals from forests have declined in part because some portion of forest area has been converted to croplands or settlement lands. In addition, a large amount of forest is forested wetlands. As a result, the forest values shown in Figure 8 reflect changes in croplands, settlement lands, and wetlands.

Figure 8: Trends in AFOLU Net Emission Removals



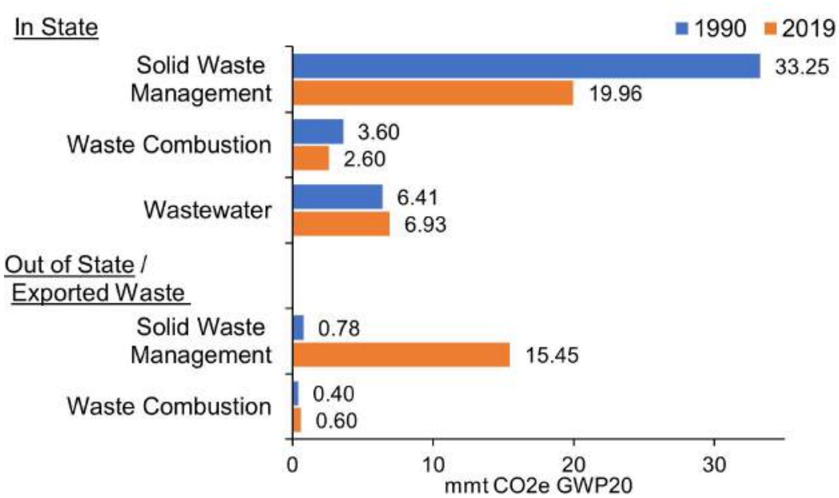
Waste

The IPCC's Waste sector specifically encompasses emissions associated with human-generated waste. The majority of waste emissions globally are associated with solid, organic wastes deposited in landfills (or "solid waste management", per the IPCC guidelines). Other sources of emissions include waste combustion, wastewater managed in septic systems or centralized systems, and the use of anaerobic digestion for either solid or liquid wastes.

The primary gas associated with the Waste Sector is methane (CH_4) because it is generated when organic materials decay in the type of anaerobic environment found in landfills.CO_2 is also a product of waste decay and the main component of waste combustion. Consistent with the Part 496 regulation, CO_2 emissions associated with composting or natural decay are not included in the State's greenhouse gas emissions reporting.[6]

From 1990 to 2019, emissions from solid waste facilities in New York declined while an increasing volume of waste was exported, which resulted in emissions from facilities in other states (Figure 9). Meanwhile, emissions from waste combustion declined at essentially the same level that emissions from wastewater increased. As a result, the total rate of emissions from the waste sector increased by roughly 1mmt CO_2e over this time period.

Figure 9: Trends in Waste Sector Emissions

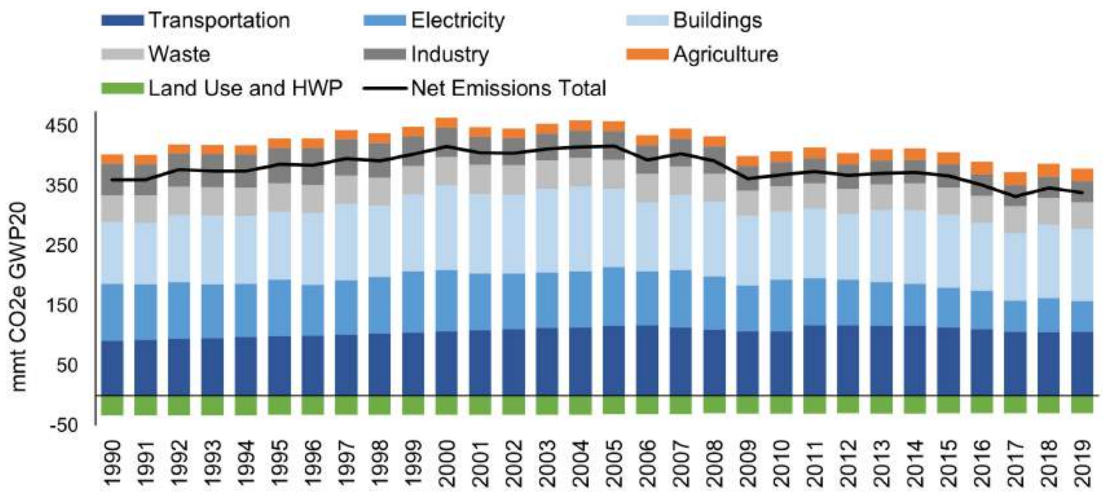


Emissions by Economic Sector and CLCPA Scoping Plan

Emissions can also be organized according to economic sectors and the U.S. national greenhouse gas inventory provides such a breakdown into residential, commercial, industry, transportation, electric power, and agriculture sectors (EPA 2021a). Figure 10 and Table ES.3 assigns emissions and removals to the economic sectors as organized in the New York State Climate Action Council Draft Scoping Plan. For example, HFC emissions from vehicle air-conditioning systems are assigned to the transportation sector as this is where the relevant equipment was used. Similarly, the emissions associated with imported fuels are also assigned based on the economic sector where these fuels where used. When using this organizational structure, the reduction in emissions from the electricity and industrial sectors in the state were offset by increasing emissions in buildings and transportation sectors, which are now the two largest emission sectors. The organization of agricultural and waste emission sources are the same as in the IPCC guidelines, these increased 6mmt and 1mmt respectively.

[6] 6 NYCRR Part 496, as explained in the Regulatory Impact Statement.

Figure 10: NYS Greenhouse Gas Emissions by Economic Sector (mmt CO_2e GWP20)



IV. Additional Information

The following information is provided to aid stakeholders and to address questions that are frequently received by DEC. DEC seeks feedback on what other sources of information related to statewide greenhouse gas accounting under the CLCPA may be useful and could be added to future reports.

Comparison with 1990 Baseline in Part 496

Prior to this report, DEC and NYSERDA conducted an analysis of statewide emissions in 1990 to establish a baseline for the “Statewide GHG Emission Limits” established by ECL 75-0107 and reflected in 6 NYCRR Part 496. The data and methods used in the current report are an improvement over those used for 6 NYCRR Part 496 and DEC will continue to make improvements in future annual reports. The 6 NYCRR Part 496 regulation may be revised at a later date using updated information. The table below provides a comparison and explanation of the differences between the estimate of gross statewide emissions in 1990 from the 6 NYCRR Part 496 rulemaking and in this report.

Table 3: Comparison of 1990 Statewide Greenhouse Gas Emission Totals

Emission Sector	Part 496*	This Report	Example Improvement
Energy	337.04	340.05	Refinement of imported fuels and fugitive emissions methods.
Industrial Processes and Product Use (IPPU)	2.72	2.72	Inclusion of N_2O product use. Total change less than 0.01mmt CO_2e
Agriculture Forestry and Other Land Use (AFOLU)	17.13	15.32	Refinement of EPA SIT model inputs with NYS datasets
Waste	52.88	44.44	Use of historical waste data rather than EPA SIT model estimates of waste tonnage
Gross Total	**409.78**	**402.98**	

* As provided in the 6 NYCRR Part 496 Regulatory Impact Statement

CLCPA Informational Items

The CLCPA includes a list of informational items that are required to be included in this report.[7] These represent particular emission sources that are found in the IPCC guidelines and are commonly included in governmental greenhouse gas accounting, if relevant. The following table provides a list of these informational items along with the names of the corresponding IPCC sectoral category as it is found in this report. These sectoral categories largely match the organization of the IPCC guidelines and any deviations are explained in the text. For example, the IPCC guidelines place waste combustion emissions in the Energy sector, rather than in the Waste sector.

Table 8: Location of CLCPA Informational Items

Informational Item		**Sectoral Report:** Sections
a	The use of fossil fuels by sector, including for electricity generation, transportation, heating, and other combustion purposes	**SR1. Energy**: Fuel Combustion
b	Fugitive and vented emissions from systems associated with the production, processing, transport, distribution, storage, and consumption of fossil fuels, including natural gas	**SR1. Energy**: Fugitive Emissions, Imported Fossil Fuels
c	Emissions from non-fossil fuel sources, including but not limited to garbage incinerators, biomass combustion, landfills and landfill gas generators, and anaerobic digesters	**SR1. Energy**: Fuel Combustion **SR4. Waste**: All Sections
d	Emissions associated with manufacturing, chemical production, cement plants, and other processes that produce non-combustion emissions	**SR2. Industrial Processes and Product Use**: All Sections

[7] ECL § 75.0105(2).

Appendix A. Emission Factors for Use by State Agencies and Applicants

The following tables provide information on the greenhouse gas emissions associated with different types of fuels. This information can be used by any entity to estimate emissions that result from the use of fuels following the same CLCPA-compliant accounting used in this report and in the adoption of 6 NYCRR Part 496. These emission factors can be applied to generic (not source-specific) fossil fuels at the high heating content (see High Heating Values). The emission factors included in this document are derived from the same analyses described in the accompanying "*Sectoral Report #1: Energy"* for calculating Imported Fossil Fuels and Fugitive Emissions. The emission factors presented in this document are a work in progress, subject to future stakeholder comment, and will be subject to a continual improvement process as additional information becomes available. These factors do not include the direct emissions resulting from the combustion of the fuel.

Current Upstream and Out-of-State Emission Factors for Imported Fossil Fuels

Emission factors in Table A1 reflect greenhouse gas emissions associated with the extraction, production, and transmission of fossil fuels imported into New York State for the most recent year available, or 2019. This does not include extraction, production, or transmission of fuels within New York State (see below). Users may wish to adjust the specified emission factors for blended fuels. The gasoline emission factors represent 100% fossil fuel content gasoline, equivalent to gasoline blend stock, if evaluating blends with oxygenates (e.g., ethanol) these blends can be apportioned to the fraction of emissions associated with the energy fraction of the blend that is from fossil fuels (e.g., E85 is a blend of ethanol and gasoline estimated here to have the energy content of approximately 28% gasoline and 72% ethanol). Finally, units in grams can be converted to pounds by dividing by 453.6.

Table A1: 2019 Emission Rates for Upstream Out-of-State Sources (g/mmbtu)

Fuel Type	CO_2	CH_4	N_2O	Total CO_2e
Natural Gas	12,131	357	0.14	42,147
Diesel/ Distillate Fuel	15,164	121	0.26	25,375
Coal	3,300	364	0.10	33,891
Kerosene/Jet Fuel	10,071	109	0.17	19,270
Gasoline (E85)	5,097	33	0.08	7,905
Gasoline	19,604	128	0.33	30,405
LPG	17,295	121	0.27	27,553
Petroleum Coke	11,612	112	0.20	21,096
Residual Fuel	11,799	111	0.19	21,184

Note: Total CO2e conversion uses GWP20 per 6 NYCRR Part 496

Current Emission Factors for Non-Energy Fuel Use

Emission factors in Table A2 reflect the upstream out of state emissions associated with fossil fuel derived products that are not primary combustion fuels but have other consumption uses within the state.

Table A2: 2019 Emission Rates for Fossil Fuel Products (g/mmbtu)

Fuel Type	CO_2	CH_4	N_2O	Total CO_2e
Asphalt and Road Oil	8,487	105	0.13	17,325
Lubricants	20,190	116	0.37	30,009
Waxes	19,518	115	0.36	29,261
Miscellaneous Petroleum Products	10,691	109	0.17	19,904
Special Naphthas	14,313	117	0.26	24,193

Note: Total CO2e conversion uses GWP20 per 6 NYCRR Part 496

Current Downstream and In-State Emission Factors for Fossil Fuels

Emission factors in Table A3 reflect fugitive emissions within New York State associated with fuel throughput for the most recent year available, or 2019. Emission factors were generated by summing emissions from natural gas distribution, or downstream infrastructure and dividing by the instate consumption of natural gas in industry, commercial, residential, transportation sectors.

Table A3: 2019 Emission Rates for Downstream In-State Sources (g/mmbtu)

Fuel Type	CO_2	CH_4	N_2O	Total CO_2e
Natural Gas and Renewable Natural Gas (RNG/biogas)	2.0	68	n/a	5,714

Note: Total CO2e conversion uses GWP20 per 6 NYCRR Part 496

High Heating Value

The following table is reproduced from the Energy Information Administration (EIA) State Energy Data System (SEDS), with btu values divided by physical units. Renewable Natural Gas is assumed to be pipeline quality with equivalent energy content. Raw landfill gas has substantially different energy content per standard cubic foot. E85 is assumed to have the energy content of 28% gasoline and 72% ethanol.

Table A4: High Heating Value of Select Fuels (mmbtu)

Fuel Type	High Heating Value	Unit of volume or mass
Natural Gas/RNG	0.001033	Standard cubic foot
Diesel/Distillate Fuel	0.137	U.S. gallon
Coal	25.36	Short Ton
Kerosene/Jet Fuel	0.135	U.S. gallon
Gasoline E85	0.097	U.S. gallon
Gasoline	0.124	U.S. gallon
LPG	0.091	U.S. gallon
Petroleum Coke	0.136	U.S. gallon
Residual Fuel	0.150	U.S. gallon
Asphalt and Road Oil	0.158	U.S. gallon
Lubricants	0.144	U.S. gallon
Waxes	0.132	U.S. gallon
Misc. Petroleum Products	0.138	U.S. gallon
Special Naphthas	0.125	U.S. gallon

Appendix B: Abbreviations

AFOLU	Agriculture, Forestry, and Other Land Use
AR4	IPCC Fourth Assessment Report
AR5	IPCC Fifth Assessment Report
AR6	IPCC Sixth Assessment Report
btu	British thermal unit
CCAP	Coastal Change Analysis Program
CH_4	Methane
CLCPA	NYS Climate Leadership and Community Protection Act
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
DEC	NYS Department of Environmental Conservation
EIA	Energy Information Administration, U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
GWP	Global Warming Potential
GWP100	100-Year Global Warming Potential
GWP20	20-Year Global Warming Potential
HFC	Hydrofluorocarbon
HWP	Harvested Wood Products
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LPG	Liquefied petroleum gas
LULUCF	Land Use, Land-Use Change, and Forestry
mmt	Million metric tons
mmbtu	Metric million british thermal unit
N_2O	Nitrous oxide
NA	Not applicable
NE	Not estimated
NEI	National Emissions Inventory
NF_3	Nitrogen trifluoride
NOAA	National Oceanic and Atmospheric Administration
NOx	Nitrogen oxides
NYCRR	New York Codes, Rules and Regulations
NYSERDA	NYS Energy Research and Development Authority
ODS	Ozone depleting substances
PFC	Perfluorocarbon
ppm	Parts per million
ppb	Parts per billion
ppt	Parts per trillion
RNG	Renewable natural gas
SF_6	Sulfur hexafluoride
SIT	EPA State Inventory Tool
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WMO	World Meteorological Organization

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