Energy use and resulting greenhouse gas emissions from industry and agriculture in the Capital District Region *

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In support of the State of New York's Climate Leadership and Community Protection Act (CLCPA) and as part of the state's Climate Smart Communities program, regions, counties, and municipalities within the state are preparing climate action plans describing local and regional actions aimed at reducing the greenhouse gas emissions responsible for climate change. A key element of each such action plan is a Greenhouse Gas Inventory, which should provide rigorously-derived estimates of the area's current levels of greenhouse gas (GHG) emissions to serve as a basis for goal-setting and advancing the area's renewable energy transition. Two sectors in which greenhouse gas emissions have been difficult to measure or estimate are the industrial and agricultural sectors, which can be responsible for as much as 15 to 25% of an area's total greenhouse gas emissions. A dataset from the US National Renewable Energy Laboratory (NREL) provides detailed breakdowns of US energy use by county and industry sector, which are analyzed in this report to generate profiles of energy use in the industrial and agricultural sectors for the region, using the US Environmental Protection Agency 2018 emission factors for estimating greenhouse gas emissions from energy use; these are used to estimate and analyze greenhouse gas emissions from industry and agriculture across the region.

1 Introduction[1]

As the public comes to understand the gravity and urgency of the climate crisis, governments and related organizations are undertaking climate initiatives with the goal of reducing or eliminating the greenhouse gas emissions of a state, region, or community. A key first step in any such initiative is preparing a Greenhouse Gas Inventory [19][12] providing reliable estimates of annual anthropogenic (human-caused) greenhouse gas emissions for the region of interest. Such an inventory is needed in order to fill a number of key roles for the initiative:

- Providing a defined starting point or baseline: What are the region's current anthropogenic greenhouse gas emissions? What is their impact on the global climate crisis?
- Solution identification and prioritization: What economic sectors and activities are responsible for significant amounts of greenhouse gas emissions? What candidate solutions are potentially applicable and will have the greatest favorable impact?
- Target-setting: What reduced levels of net greenhouse gas emissions do we want to achieve, and over what time frame?
- Progress tracking (in due course): *n* years into the plan, what are the region's annual GHG emissions? How successful have actions under the plan been in reducing them? If other changes in GHG emissions have occurred, what were the causes? Does the plan need to be revised as a result?
- Public education and advocacy: What actions at an individual or community level have the greatest potential to reduce GHG emissions? How can individuals take action to further these reductions?

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These objectives can be more effectively realized to the extent that the prepared inventory has several important attributes: it needs to be

- credible, using sound methods based on authoritative research to measure and estimate emissions;
- transparent, using clearly-defined, surveyable algorithms and techniques to obtain emissions estimates;
- open, lending itself to being publicly reviewed, analyzed, and defended;
- fine-grained, permitting emissions sources to be unambiguously identified and made objects of targeted actions;
- versatile, facilitating the preparation of made-to-order analyses and visualizations in support of the diverse tasks and challenges of the transition to a sustainable economy;
- extendable, facilitating incorporation of new data as the effort proceeds.

The inventory presented in this document provides estimates for a clearly-defined subset of the region's greenhouse gas emissions: emissions resulting from energy use in the economic sectors of manufacturing, agriculture, construction, and mining, which may jointly constitute only around 10 to 15% of the total emissions across all economic sectors. At the same time, it is intended to illustrate effective methods for documenting and presenting the contents of an emissions inventory in order to inform and guide the activities through which emissions can be reduced or eliminated.

2 Data sources

The industrial and agricultural economic sectors have been recognized as being especially challenging to address in climate change mitigation activities due to the diversity of activities and processes involved [14]. Recognizing these challenges, a research group at the US National Renewable Energy Laboratory has sought to develop efficient and reliable techniques for estimating energy use in these sectors through the development of the NREL Industrial Emissions Tool (IET) [17]. In addition, they have used the IET to develop and publish a dataset of industrial and agricultural GHG energy use statistics broken down to the level of individual counties, NAICS activity codes [21], and fuel types used for energy generation for the entire United States, the NREL Industrial Energy Data Book (IEDB) [16], published through the NREL data catalogue. The analyses presented here use the IEDB in conjunction with publicly-available tables of County FIPS codes [18] and 2017 NAICS codes [21].

The energy use statistics in [16] are drawn from a variety of sources. Facilities with large amounts of greenhouse gas emissions are required to report their emissions under the US EPA's Greenhouse Gas Reporting Program (GHGRP) [25]. These reported quantities are used directly. To obtain emissions estimates for the far more numerous smaller emitters in the manufacturing, agricultural, mining, and construction sectors, data are combined from

- the EPA's Manufacturing Energy Consumption Survey (MECS) [8]
- the US Energy Information Administration's EIA Form-923 data on electricity use [5]
- the US Department of Agriculture's Agriculture Survey [28][29] and Census of Agriculture [27]
- the US Census Bureau's Economic Census [2] and County Business Patterns (CBP) dataset [26]

in order to first estimate the relationship between facility size and emissions for each economic sector; these estimates are combined with the numbers and sizes (employment, fuel and lubricant cost data, etc.) of emissions-generating facilities to obtain GHG emissions estimates [17].

Because of its reliance on census data available only after a time-lag of about three years, the NREL IEDB provides energy use data only through calendar year 2016. It is likely that any Greenhouse Gas Inventory would be similarly limited for similar reasons; for instance, New York State's Greenhouse Gas Inventory for years 1990-2016 [19] was not published until July 2019.

3 Tools and methods

The analyses and illustrations presented in this report were prepared using the R programming language [22] and the powerful associated collection of tools for data analysis and visualization [30][31]. The report itself is prepared using an R facility known as Rmarkdown [1], in which a single file or collection of files contains both the text of a document such as this one and the code (which needn't only be R code) used to generate the analysis it presents. Management of the document and code as a single unit permits the use of the rich, capable version control tools available to software developers and ensures that the document in its final form is reproducible. In use of Rmarkdown, the code used to generate elements such as figures and tables can be presented interleaved with the document text as desired, in the form of 'code chunks' such as the example below.

```
# I had been using countyNames.Rmd as a child document here, but ran into an Rstudio deficiency that
# makes debugging the document harder: the "Run All Chunks Above" and "Run Current Chunk" icons
# shown in the upper right corner of the chunk don't work when the chunk is a child document. This
# is a longstanding issue: see https://community.rstudio.com/t/making-child-code-chunks-execute-
# by-clicking-run-current-chunk/12907
# and https://stackoverflow.com/questions/48764918/rmarkdown-running-child-chunks-from-inside-
# rstudio/48777264.

# The NREL dataset identifies counties only by FIPS code. We get the corresponding county-names
# and add them to the dataset along with the NAICS sector names and descriptions. Then we filter
# to just the counties of the selected Region.

County_FIPS_codes <- read_delim("County FIPS codes.txt",
    "\t", escape_double = FALSE, col_names = FALSE,
    trim_ws = TRUE) %>%
  transmute(COUNTY_FIPS = X1, County = X2, State = X3)

NYcountyEnergyEsts <- Updated_county_energy_estimates %>%
  filter(STATE == "NEW YORK") %>%                       # Keep only the NEW YORK rows
  left_join(County_FIPS_codes, by = "COUNTY_FIPS") %>%  # Add county names
  # We have to do some finagling here. The NREL IEDB dataset contains some records in which
  # the NAICS code given is "11193 & 11194 & 11199" or "1125 & 1129". These result in NAs
  # when we convert them to numeric; we replace them with synthesized codes in fixNAICSgaps.R.
  mutate(across(NAICS, ~suppressWarnings(as.numeric(.)))) %>%
  left_join(NAICS_Descriptions_2017, by = "NAICS") %>%  # Add NAICS code names and
                                                        # descriptions
  mutate(across(County, ~str_replace(., "St Lawrence", "St. Lawrence")))

RegionEnergyEsts <- NYcountyEnergyEsts %>%
  filter(County %in% RegionCounties)

# The NREL dataset contains some rows with missing MMBTU_TOTAL values; these result in NAs.
# Replace the NAs with 0s.
RegionEnergyEsts[["MMBTU_TOTAL"]][
    which(is.na(RegionEnergyEsts[["MMBTU_TOTAL"]]))] <- 0
```

4 Energy use

One of the benefits of using the NREL IEDB is the insight it provides into changes in energy use patterns that have occurred in recent years. Figure 4.1 illustrates how industrial and agricultural use changed in each county over the period from 2010 to 2016. Table 4.1 presents the same data in numerical form.

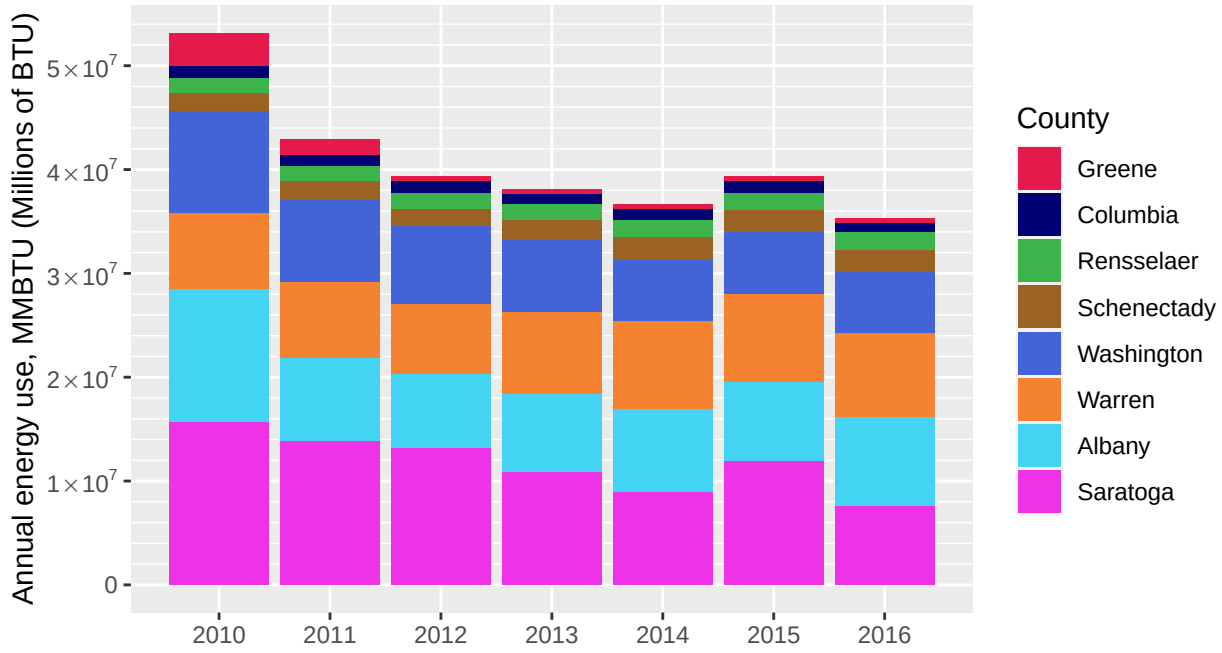

Figure 4.1: Energy use summary, industrial and agricultural

Table 4.1: Annual industrial and agricultural energy use (millions of BTU) by county

County	2010	2011	2012	2013	2014	2015	2016
Albany	12,900,574	8,047,105	7,160,941	7,505,268	8,035,015	7,681,018	8,665,138
Columbia	1,191,386	1,207,351	1,246,690	1,008,764	1,081,935	1,120,780	871,649
Greene	3,148,612	1,484,087	445,630	463,704	425,612	472,936	468,094
Rensselaer	1,495,351	1,450,751	1,451,386	1,564,599	1,582,838	1,628,976	1,743,117
Saratoga	15,605,936	13,782,163	13,161,861	10,882,163	8,897,522	11,885,253	7,515,853
Schenectady	1,678,964	1,739,215	1,657,107	1,905,830	2,200,957	2,166,684	2,092,955
Warren	7,355,821	7,410,537	6,740,942	7,876,383	8,530,112	8,434,136	8,082,176
Washington	9,778,740	7,837,254	7,487,679	6,916,468	5,853,859	5,947,099	5,871,524
Totals	53,155,386	42,958,462	39,352,237	38,123,179	36,607,849	39,336,882	35,310,506

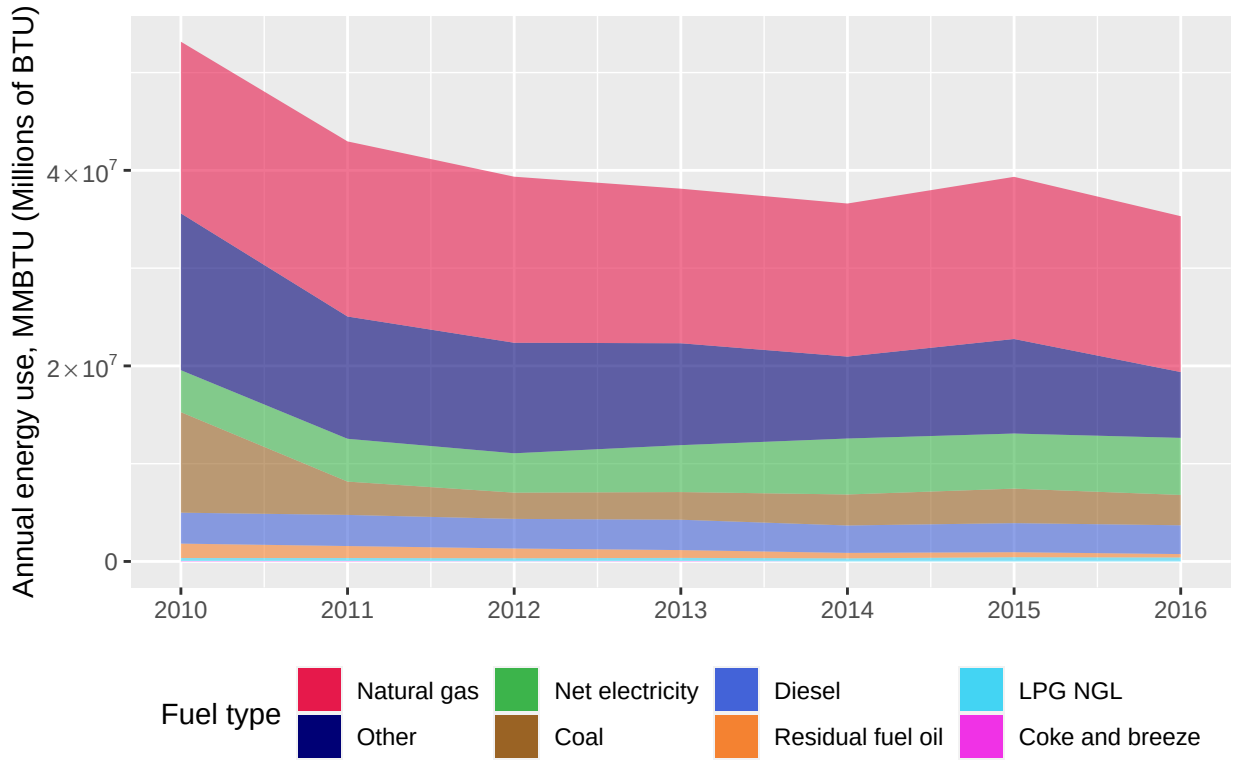

Figure 4.2: Energy use summary, industrial and agricultural by fuel type

Table 4.2: Annual industrial and agricultural energy use (millions of BTU) by fuel type

Year	Natural gas	Other	Net electricity	Coal	Diesel	Residual fuel oil	LPG NGL	Coke and breeze	Annual totals
2010	17,560,906	16,031,790	4,290,592	10,282,169	3,164,067	1,469,915	308,182	47,764	53,155,386
2011	17,906,299	12,505,253	4,378,315	3,408,975	3,182,374	1,220,290	309,285	47,671	42,958,462
2012	16,985,565	11,303,138	4,025,353	2,684,445	3,026,200	999,761	303,476	24,299	39,352,237
2013	15,806,648	10,422,524	4,796,257	2,828,663	3,105,450	797,433	318,439	47,764	38,123,179
2014	15,656,660	8,376,715	5,724,688	3,170,463	2,803,699	554,471	320,891	261	36,607,849
2015	16,584,494	9,667,012	5,635,736	3,530,103	2,972,554	512,931	433,795	256	39,336,882
2016	15,941,194	6,729,567	5,836,698	3,103,511	2,946,162	345,981	407,133	259	35,310,506
Totals	116,441,766	75,035,998	34,687,640	29,008,331	21,200,507	5,900,782	2,401,201	168,275	284,844,499

Figure 4.2 presents the same total energy use shown above, but this time broken down by fuel type.

Table 4.3 provides definitions of the fuel types used in the NREL IEDB and in this document, based on definitions provided by the US Energy Information Agency [6][10]. *Net electricity* in most cases refers to energy purchased from grid suppliers, but could refer increasingly to on-site renewable electricity generation in future years.

Figure ef{fig:countyAreaPlot} shows the trend in industrial/agricultural energy and fuel use over the period 2010-2016; note that vertical scales differ from one panel to another to allow detail to be shown legibly. Differences in fuel type composition from one county to another are very striking, probably resulting from the presence of diverse kinds of industrial and agricultural activity in the counties included in this report.

Figures 4.4, 4.5, and 4.6 show energy use by fuel type for each economic sector represented by a 3-digit

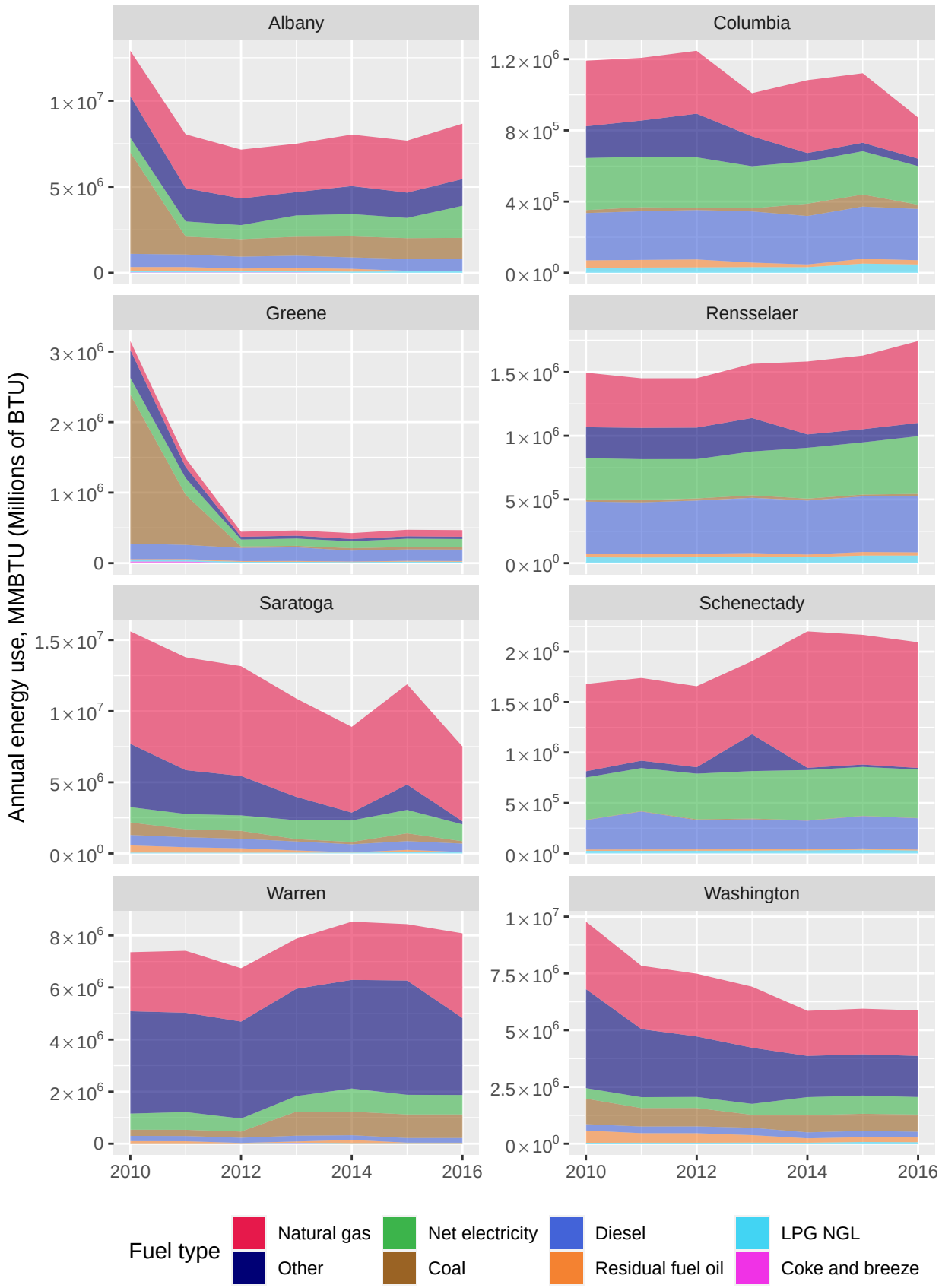

Figure 4.3: Annual industrial and agricultural energy use by county and fuel type

Table 4.3: Standard fuel types

Fuel type	Definition
Coal	Coal: A readily combustible black or brownish-black rock whose composition, including inherent moisture, consists of more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, chemically altered, and metamorphosed by heat and pressure over geologic time. Includes Anthracite, Bituminous, and Lignite varieties, which have different levels of heat content.
Coke and Breeze	Coal Coke: A hard, porous product made from baking bituminous coal in ovens at temperatures as high as 2,000 degrees Fahrenheit. It is used both as a fuel and as a reducing agent in smelting iron ore in a blast furnace. Breeze: The fine screenings from crushed coke. Usually breeze will pass through a $\frac{1}{2}$-inch or $\frac{3}{4}$-inch screen opening. It is most often used as a fuel source in the process of agglomerating iron ore.
Diesel	Diesel fuel: A fuel composed of distillates obtained in petroleum refining operation or blends of such distillates with residual oil used in motor vehicles. The boiling point and specific gravity are higher for diesel fuels than for gasoline.
LPG-NGL	Liquefied Petroleum Gases (LPG): Ethane, ethylene, propane, propylene, normal butane, butylene, ethane-propane mixtures, propane-butane mixtures, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate raw natural gas plant liquids. Natural Gas Liquids (NGL): Those portions of reservoir gas that are liquefied at the surface in field facility or gas processing plants. Some examples are ethane, propane, butanes, pentanes, natural gasoline, and condensate.
Natural gas	A mixture of hydrocarbon compounds and small quantities of various nonhydrocarbons existing in the gaseous phase or in solution with crude oil in natural underground reservoirs at reservoir conditions.
Net electricity	Net Electricity: Net electricity is estimated for each manufacturing establishment as the sum of purchased electricity, transfers in, and generation from noncombustible renewable resources minus the quantities of electricity sold and transferred offsite. Thus net electricity excludes the quantities of electricity generated or cogenerated onsite from combustible energy sources.
Other	Energy source not falling into any of the other categories. Includes wood-derived and other biomass fuels, but can also include miscellany such as used vehicle tires.
Residual fuel oil	A general classification for the heavier oils, known as No. 5 and No. 6 fuel oils, that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations. It conforms to ASTM Specifications D396 and D975 and Federal Specification VV-F-815C. No. 5, a residual fuel oil of medium viscosity, is also known as Navy Special and is defined in Military Specification MIL-F-859E, including Amendment 2 (NATO Symbol F-770). It is used in steam-powered vessels in government service and inshore powerplants. No. 6 fuel oil includes Bunker C fuel oil and is used for the production of electric power, space heating, vessel bunkering, and various industrial purposes.

Source: The EIA Glossary

NAICS code. (Here again, different panels have different vertical scales.) The contrasts in energy use from one economic sector to another are striking, suggesting that the challenges in making the transition to renewable energy will also be very diverse.

Table 4.4 provides numerical breakdowns of energy use by economic sector and fuel type, with the sectors having highest total energy use at the top and most-used fuels on the left. Table 4.5 provides the analogous breakdowns by sector and county. Comparing the two tables makes it a straightforward process to identify the sectors and approximate locations of the industrial and agricultural activities having the greatest energy use and likely greenhouse gas emissions, which should help focus climate

actions where they can have the greatest beneficial impact.

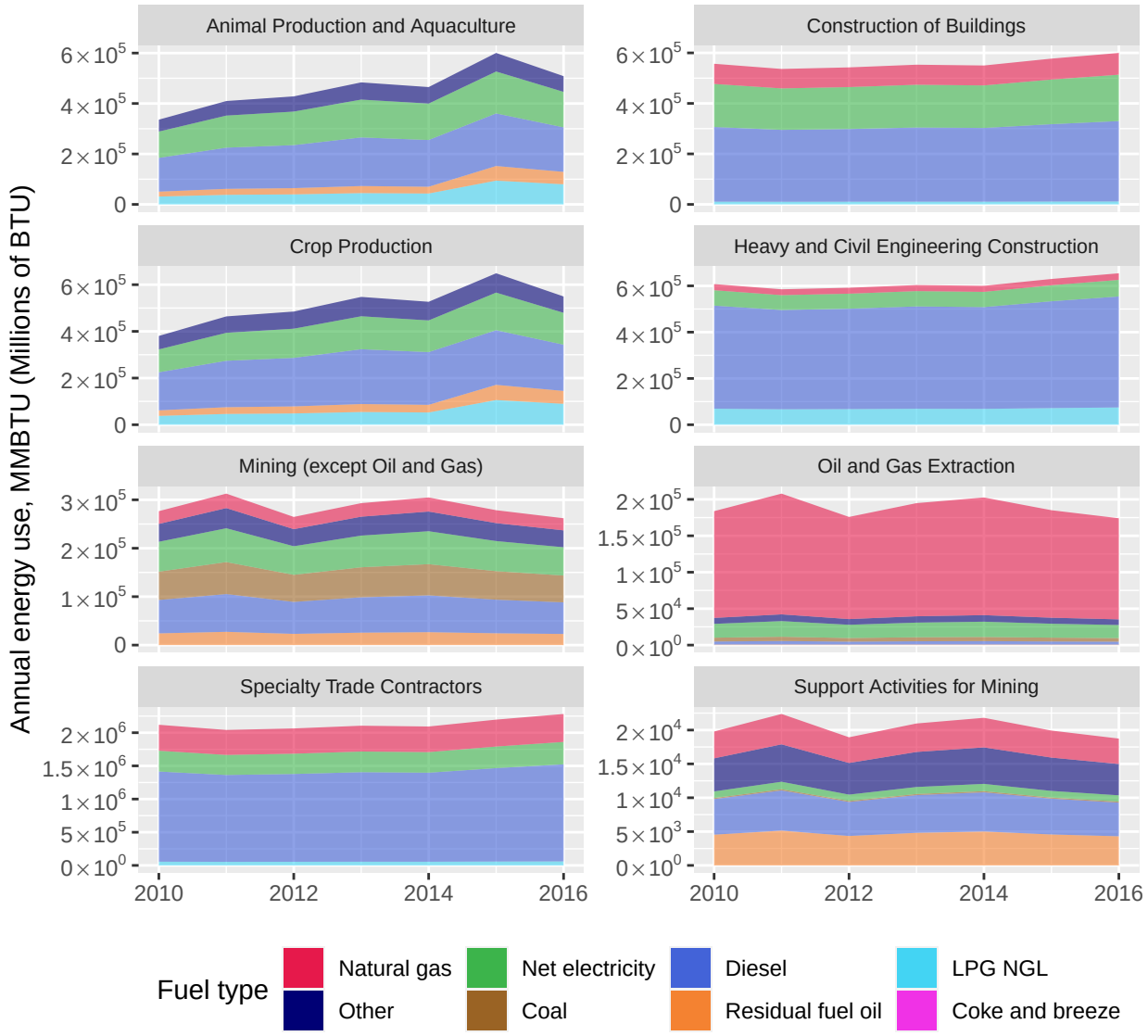

Figure 4.4: Annual energy use by *non-manufacturing* sector and fuel type, entire region

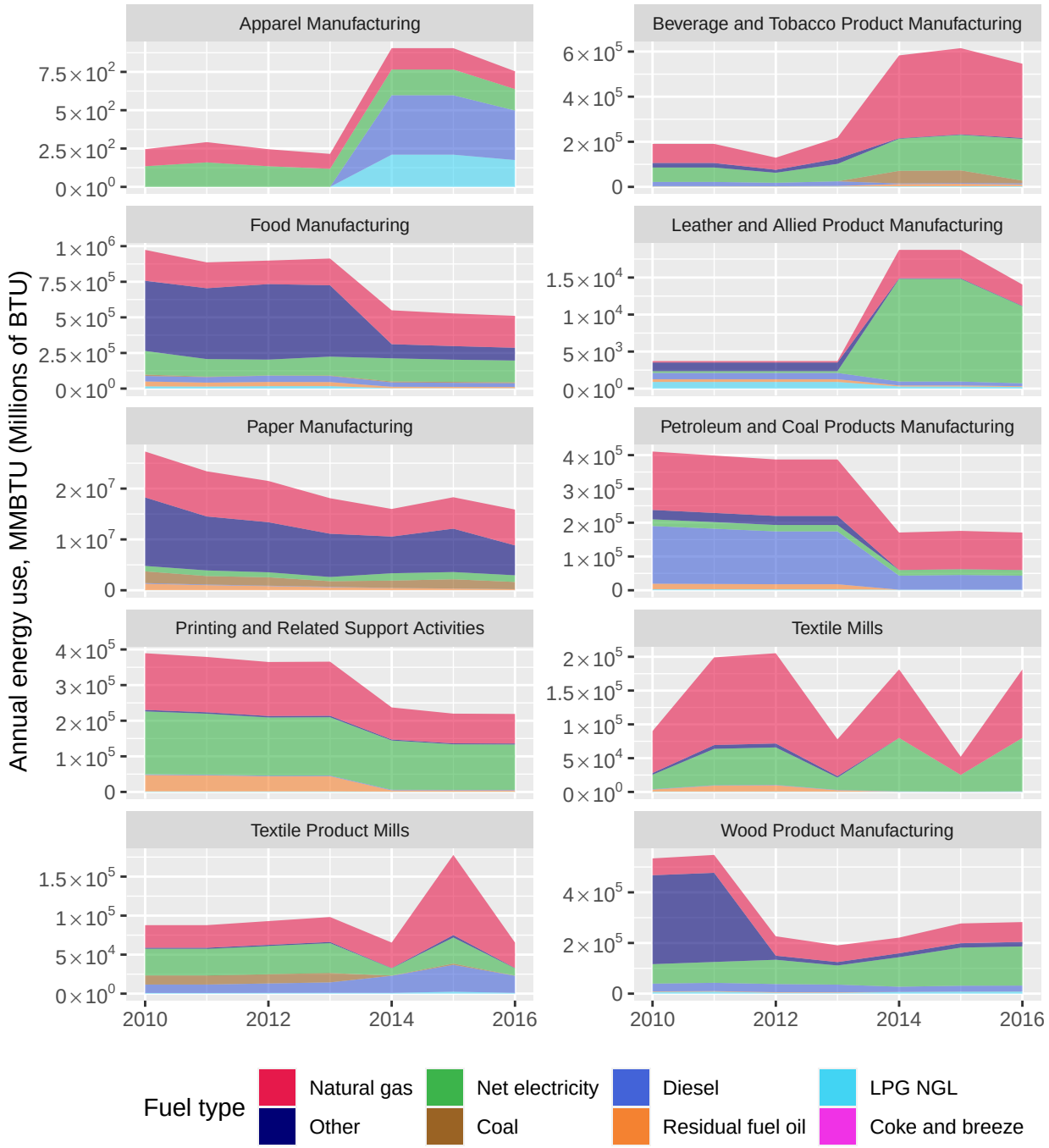

Figure 4.5: Annual energy use by *manufacturing* sector and fuel type, entire region

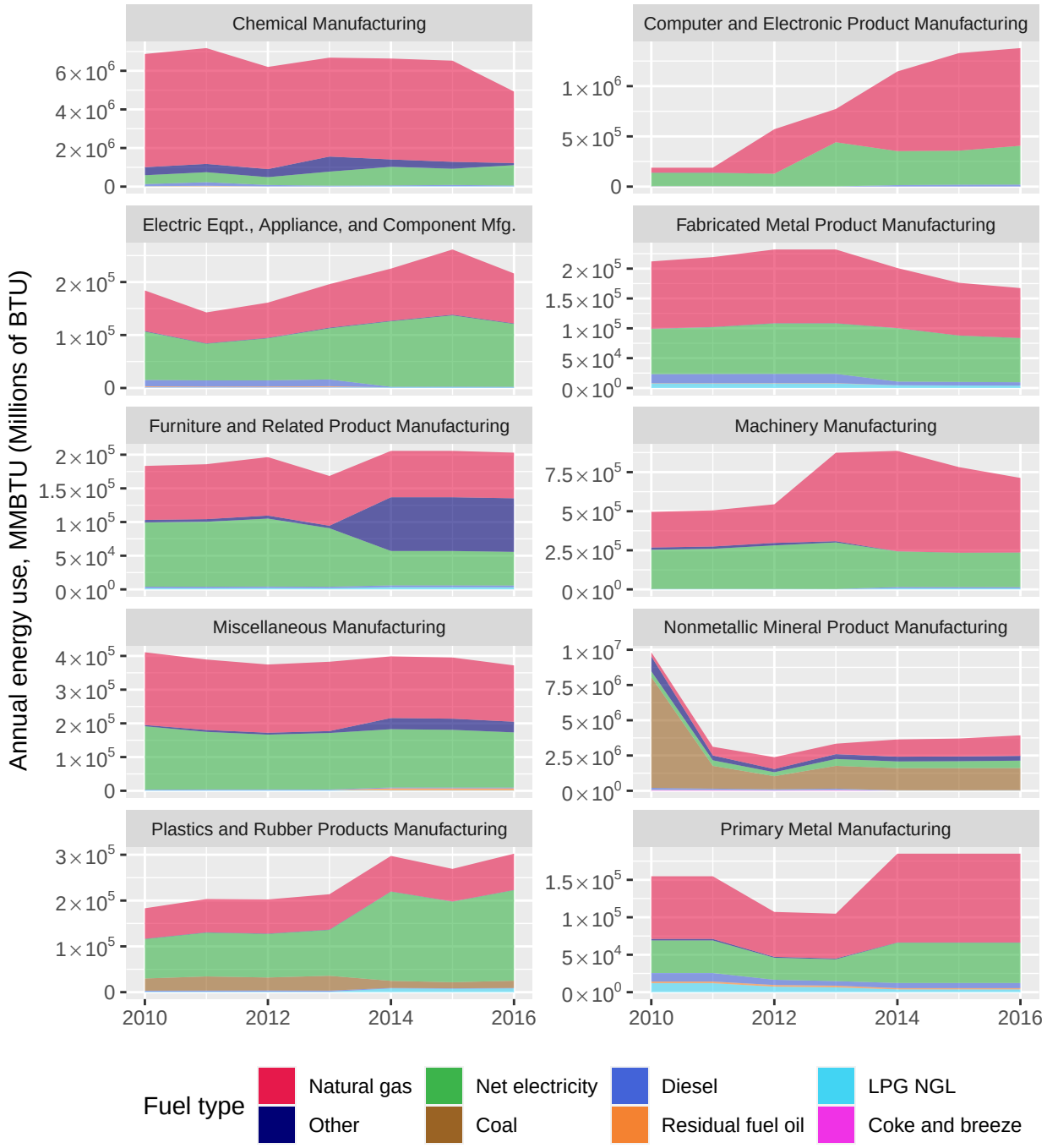

Figure 4.6: Annual energy use by *manufacturing* sector and fuel type, entire region (continued)

Table 4.4: 2016 energy use (millions of BTU) by industry sector and fuel type

Sector (NAICS)	Fuel types								Sector totals
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze	
322. Paper Manufacturing	7,051,779	5,877,750	1,306,634	1,435,537	17,875	11,796	175,458	0	15,876,829
325. Chemical Manufacturing	3,708,759	105,202	1,058,652	0	36,107	17,426	166	0	4,926,311
327. Nonmetallic Mineral Product Manufacturing	1,455,447	339,031	523,523	1,572,339	16,232	15,132	8,468	241	3,930,413
238. Specialty Trade Contractors	421,156	0	337,663	0	1,462,669	60,778	0	0	2,282,266
334. Computer and Electronic Product Manufacturing	972,090	173	386,237	0	19,169	787	137	0	1,378,592
333. Machinery Manufacturing	476,802	560	221,072	0	7,567	6,868	0	0	712,870
237. Heavy and Civil Engineering Construction	28,416	0	71,708	0	479,463	74,726	0	0	654,312
236. Construction of Buildings	86,153	0	183,557	0	318,252	11,774	0	0	599,736
111. Crop Production	0	69,960	136,504	0	198,169	89,611	55,220	0	549,463
312. Beverage and Tobacco Product Manufacturing	329,083	3,672	185,419	12,220	4,669	3,323	7,768	0	546,154
311. Food Manufacturing	224,070	89,513	152,724	6,743	26,333	2,165	8,975	0	510,524
112. Animal Production and Aquaculture	0	62,300	140,753	0	176,473	79,800	49,174	0	508,501
339. Miscellaneous Manufacturing	166,984	31,688	163,492	0	2,269	832	6,545	0	371,811
326. Plastics and Rubber Products Manufacturing	79,224	433	197,707	15,849	943	8,211	0	0	302,367
321. Wood Product Manufacturing	78,447	17,640	154,544	132	23,291	8,265	261	0	282,580
212. Mining (except Oil and Gas)	24,991	34,887	58,450	55,368	65,280	0	22,936	0	261,911
323. Printing and Related Support Activities	83,141	2,653	127,315	0	1,567	517	3,837	0	219,030
335. Electrical Equipment, Appliance, and Component Manufacturing	94,254	978	118,726	0	1,116	1,090	0	18	216,182
337. Furniture and Related Product Manufacturing	67,685	79,599	49,941	0	2,509	3,259	0	0	202,993
331. Primary Metal Manufacturing	118,576	311	53,823	0	6,869	3,726	1,653	0	184,958
313. Textile Mills	101,427	7	79,113	0	463	320	50	0	181,379
211. Oil and Gas Extraction	138,770	7,726	17,990	4,927	3,986	0	677	0	174,076
324. Petroleum and Coal Products Manufacturing	110,922	311	16,431	0	41,566	1,403	256	0	170,889
332. Fabricated Metal Product Manufacturing	83,611	179	73,904	0	5,627	4,043	0	0	167,364
314. Textile Product Mills	32,652	308	9,353	245	21,999	890	0	0	65,447
213. Support Activities for Mining	3,758	4,626	923	152	4,975	0	4,305	0	18,739
316. Leather and Allied Product Manufacturing	2,880	60	10,401	0	401	217	96	0	14,056
315. Apparel Manufacturing	116	0	140	0	323	175	0	0	754
Totals	15,941,194	6,729,567	5,836,698	3,103,511	2,946,162	407,133	345,981	259	35,310,506

Table 4.5: 2016 energy use (millions of BTU) by industry sector and county

Sector (NAICS)	County								Sector totals
	Albany	Warren	Saratoga	Washington	Schenectady	Rensselaer	Columbia	Greene	
322. Paper Manufacturing	2,539,812	5,669,602	2,278,661	5,022,085	0	366,669	0	0	15,876,829
325. Chemical Manufacturing	1,605,675	116,955	2,462,744	7,015	652,615	56,446	0	24,861	4,926,311
327. Nonmetallic Mineral Product Manufacturing	2,191,554	1,575,092	10,444	2,068	13,021	48,116	0	90,117	3,930,413
238. Specialty Trade Contractors	581,847	170,992	471,415	115,182	300,423	328,922	188,804	124,682	2,282,266
334. Computer and Electronic Product Manufacturing	90,198	0	1,275,156	0	13,237	0	0	0	1,378,592
333. Machinery Manufacturing	89,709	4,437	7,099	25,318	551,472	3,549	27,738	3,549	712,870
237. Heavy and Civil Engineering Construction	223,297	20,772	98,666	20,772	62,315	129,824	62,315	36,351	654,312
236. Construction of Buildings	145,573	44,514	137,151	31,882	68,576	84,817	54,740	32,483	599,736
111. Crop Production	65,531	18,483	105,839	94,549	26,068	74,401	127,332	37,261	549,463
312. Beverage and Tobacco Product Manufacturing	138,528	10,716	21,431	10,716	188,961	4,286	167,231	4,286	546,154
311. Food Manufacturing	123,838	0	73,805	32,500	33,853	172,213	57,389	16,927	510,524
112. Animal Production and Aquaculture	47,768	3,943	55,898	236,506	21,101	63,960	55,630	23,695	508,501
339. Miscellaneous Manufacturing	25,328	293,100	10,119	27,714	3,394	2,376	9,101	679	371,811
326. Plastics and Rubber Products Manufacturing	86,311	17,692	20,242	38,335	27,734	84,319	27,734	0	302,367
321. Wood Product Manufacturing	40,828	81,351	41,116	7,817	7,817	78,457	20,270	4,923	282,580
212. Mining (except Oil and Gas)	28,761	35,360	9,455	48,114	9,455	47,670	47,670	35,427	261,911
323. Printing and Related Support Activities	28,719	1,937	161,205	1,549	20,197	2,711	1,549	1,162	219,030
335. Electrical Equipment, Appliance, and Component Manufacturing	84,657	2,102	35,183	30,979	33,081	21,771	6,307	2,102	216,182
337. Furniture and Related Product Manufacturing	124,978	632	948	54,046	474	316	3,924	17,675	202,993
331. Primary Metal Manufacturing	0	0	29,846	1,864	0	153,248	0	0	184,958
313. Textile Mills	142,260	0	0	26,080	13,040	0	0	0	181,379
211. Oil and Gas Extraction	174,076	0	0	0	0	0	0	0	174,076
324. Petroleum and Coal Products Manufacturing	14,611	4,870	122,184	9,741	0	4,870	4,870	9,741	170,889
332. Fabricated Metal Product Manufacturing	54,750	5,229	47,778	17,662	29,743	7,554	4,648	0	167,364
314. Textile Product Mills	2,173	4,346	39,370	4,346	2,173	6,519	4,346	2,173	65,447
213. Support Activities for Mining	9,370	0	0	0	9,370	0	0	0	18,739
316. Leather and Allied Product Manufacturing	4,685	0	0	4,685	4,685	0	0	0	14,056
315. Apparel Manufacturing	302	50	101	0	151	101	50	0	754
Totals	8,665,138	8,082,176	7,515,853	5,871,524	2,092,955	1,743,117	871,649	468,094	35,310,506

5 Greenhouse gas emissions

5.1 Assumptions

With the energy use information in hand, it remains only to estimate greenhouse gas emissions using the conversion factors provided by the EPA, considering in turn the various fuel types and industry sectors. Since the energy use quantities are all provided in units of millions of BTU (mmBTU) and quantities of CO_2, CH_4, and N_2O generated are provided per mmBTU for each fuel type, the calculations are quite straightforward, although the assumptions underlying them warrant a degree of scrutiny.[2]

- Coal: The coal used in the US is of various types. For the year 2016, coal production by weight was 44.6% bituminous, 45.3% sub-bituminous, 9.8% lignite, and less than 0.3% anthracite by weight; or 55% bituminous, 38% sub-bituminous, 6.8% lignite, and less than 0.3% anthracite by heat content. The EPA emission factors include a set of emission values for a coal fuel type of "Mixed (Industrial Sector)" which are used below in computing GHG emissions from coal. This is clearly a weighted average of the emission values for the four coal types, based on the relative amounts of these coal grades used by the industrial sector [4].
- Coke and breeze: In addition to coke derived from coal, US petroleum refineries synthesize significant amounts of petroleum coke; however, nearly all of this 'petcoke' is exported rather than being used domestically [7]. The EPA emission factors provide values only for Coke (not Breeze), so these are used in the analysis below; breeze apparently differs from coke only in chunk size and not in composition to any significant degree.
- Diesel: Most diesel fuel used in the US is what is known as "Grade No.2-D diesel fuel", where the "No.2" refers to the fuel's level of density and viscosity. Grade No.2-D diesel fuel is very similar in composition to what the industry classifies as No.2 fuel oil [15]. The EPA emission factors don't specify values for diesel fuel specifically, so the values for No.2 fuel oil are used below.
- LPG and NGL: The fuel type "LPG-NGL" would appear from its name to apply to two categories of fuels: "Liquefied Petroleum Gases" and "Natural Gas Liquids". However, the EIA definitions don't seem to clearly distinguish the two categories; both are composed primarily of liquefied propane and butane [11]. Accordingly, the analysis below uses the EPA's emission factors for "Liquefied Petroleum Gases (LPG)" for this fuel type; EPA provides no separate factors for natural gas liquids.
- Natural gas: The natural gas fuel type is clearly delineated and has specified emission factors; these are used in the analysis below.
- Net electricity: For net electricity, the emission factors used are those provided by the EPA in [24] for the applicable eGRID subregion. Note that the EPA table gives emissions for all three of the principal GHGs in kg/MWh; these are converted to kg or g per mmBTU.
- Other: Other fuels for the region are almost entirely wood-based biomass fuels, based on statistics for New York State as a whole [9]. Modest quantities of wind and hydrolelectric power are also generated for on-site industrial use. Like the latter, biomass is considered for this analysis to have no greenhouse gas emissions, since emitted carbon was earlier absorbed from the atmosphere through photosynthesis (recognizing that this may be an oversimplification; see for instance Costanza et al [3]). Changes in carbon sequestration capacity due to the conversion from wild forest to harvested commercial forest should be accounted for under land use change.
- Residual fuel oil: The term "residual fuel oil" as defined applies to both of what are classified as No.5 and No.6 residual fuel oils. No.5 residual fuel oil is evidently used mostly as a fuel for naval

[2] The EPA tables give differing quantities of greenhouse gas emissions per unit fuel consumption (gallons) for gasoline-fueled vs. diesel-fueled agricultural equipment and for gasoline- vs. diesel-fueled construction equipment. However, the NREL dataset gives us no way to distinguish between gasoline-fueled and diesel-fueled equipment; the assumption appears to be that diesel fuel is used in most cases.

and commercial ships [11]. Accordingly, only the emission factors for No.6 residual fuel oil (which has a variety of onshore uses) are used in the analysis below.

Table 5.1: Summary: emission factors for NREL fuel types

Fuel type	CO_2, kg per mmBTU	CH_4, g per mmBTU	N_2O, g per mmBTU	CO_2-equivalent emissions, kgCO_2 per mmBTU
Coal	94.67	11.00	1.60	95.42
Coke and breeze	113.67	11.00	1.60	114.42
Diesel	73.96	3.00	0.60	74.21
LPG-NGL	61.71	3.00	0.60	61.96
Natural gas	53.06	1.00	0.10	53.11
Other	0.00	0.00	0.00	0.00
Residual fuel oil	75.10	3.00	0.60	75.35
Net electricity (NYUP)	39.21	2.79	0.40	39.39
Net electricity (NYCW)	84.59	2.93	0.40	84.78
Net electricity (NYLI)	156.76	16.76	2.13	157.81

Table 5.1 summarizes the emission factors used for these fuel types. Since the electricity on different portions of the electric transmission grid can be generated using a different mix of energy sources, the EPA specifies a set of emission factors for each of what it calls *eGRID subregions*. Accordingly, the table shows one set of *Net electricity* emission factors for each of the three eGRID subregions in New York State;[3] the emission factors used to compute each county's emissions are those for the eGRID subregion in which the county is located.

The greenhouse gas emission quantities in this report are presented in terms of "CO_2-equivalent emissions," weighting emissions of other greenhouse gases based on their marginal impact on radiative forcing compared to that of an equivalent incremental concentration of CO_2 [13]. As can be seen in Table A.5, the global warming potentials of both methane and nitrous oxide are substantially larger than that of carbon dioxide; it is only because CO_2 is emitted in far greater quantities that it has a greater total impact on the global climate. Based on the NREL dataset and the EPA emission factors, CO_2 itself accounts for about 99.7% of the CO_2-equivalent agricultural and industrial greenhouse gas emissions of the Capital District Region; methane and nitrous oxide constitute an almost negligible fraction of these emissions.[4]

5.2 Results and analysis

Figure 5.1 and Table 5.2 provide summary views of estimated annual greenhouse gas emissions for the region, stratified by county. Figure 5.2 and Table 5.3 show *per capita* emissions from industrial and agriculture energy use for each county in the region. For comparison, 2016 emissions per capita for New York State as a whole were found to be about 10 metric tons CO2-equivalent per person – across all sectors – with the largest fractions resulting from transportation (37%) and from commercial (18%) and residential

[3] NYLI abbreviates "New York Long Island", i.e., Nassau and Suffolk counties; NYCW refers to the five boroughs of New York City together with Westchester County; and NYUP abbreviates "New York Upstate" and refers to the remainder of the state.

[4] This will not necessarily be true when use of nitrogen-based fertilizers and other agricultural chemicals is considered in a companion report.

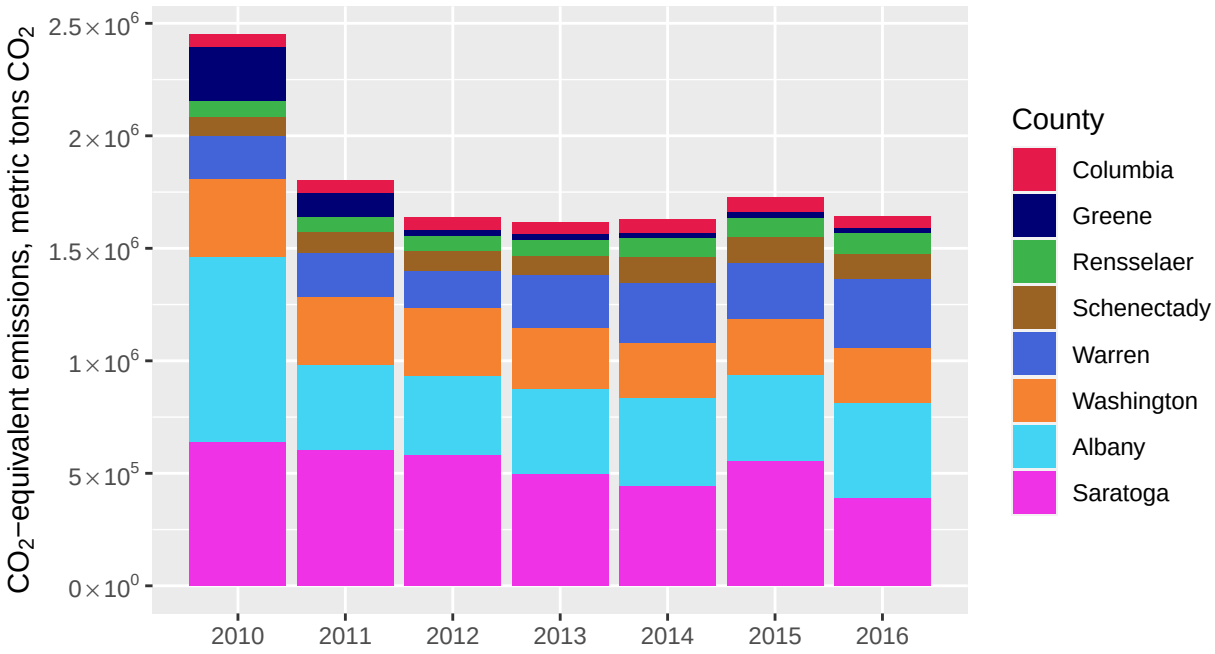

Figure 5.1: Annual CO_2-equivalent agricultural/industrial emissions, metric tons

(21%) combustion primarily for heating [19]. Natural gas is the largest remaining source of greenhouse gas emissions as of 2016, with diesel fuel and net electricity also being significant contributors.

Table 5.2: Annual agricultural/industrial CO_2-equivalent emissions (metric tons) by county

County	2010	2011	2012	2013	2014	2015	2016
Columbia	57,303	57,360	56,945	49,061	61,016	63,780	49,140
Greene	239,041	103,482	25,478	26,497	24,592	26,977	26,767
Rensselaer	72,433	69,899	70,250	75,528	83,467	86,376	91,954
Schenectady	86,974	91,285	85,439	82,578	115,627	114,722	110,851
Warren	189,774	197,925	168,033	237,750	264,370	247,166	304,714
Washington	347,343	300,623	299,842	268,102	245,823	251,483	247,762
Albany	817,777	379,511	350,302	377,595	392,268	380,792	419,522
Saratoga	642,412	601,526	582,135	497,074	442,260	554,619	392,057
Totals	2,453,057	1,801,612	1,638,424	1,614,185	1,629,423	1,725,915	1,642,766

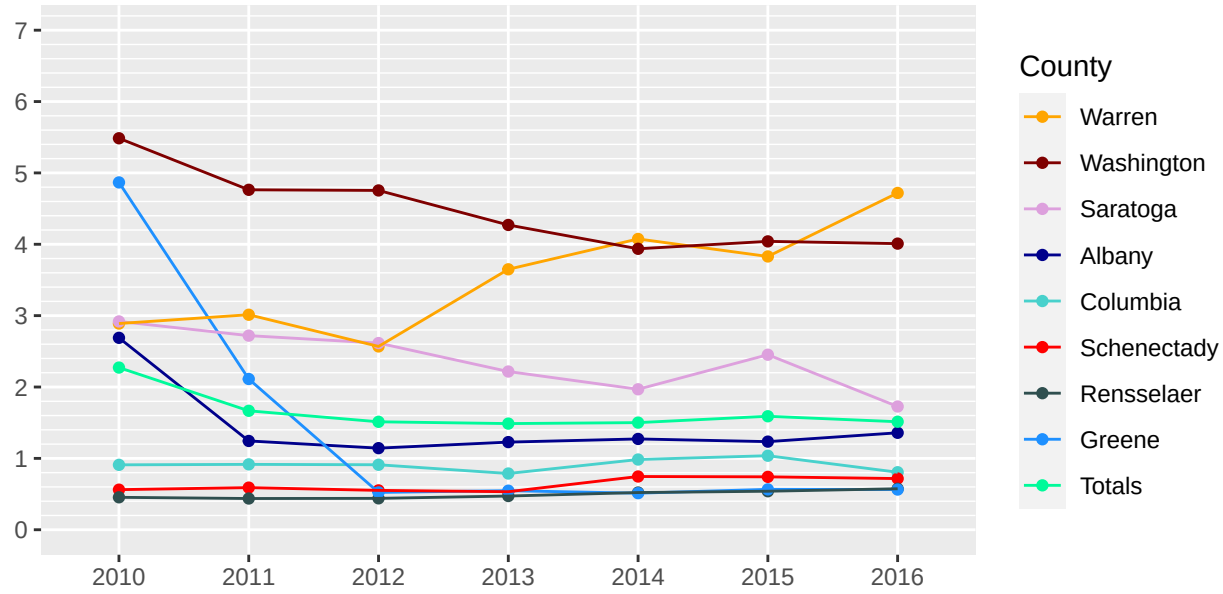

Figure 5.2: CO_2-equivalent agricultural/industrial emissions per capita, metric tons

Table 5.3: CO_2-equivalent agricultural/industrial GHG emissions per capita, metric tons

County	2010	2011	2012	2013	2014	2015	2016
Albany	2.69	1.24	1.14	1.23	1.27	1.23	1.36
Columbia	0.91	0.92	0.91	0.79	0.98	1.04	0.81
Greene	4.87	2.11	0.52	0.55	0.51	0.57	0.56
Rensselaer	0.45	0.44	0.44	0.47	0.52	0.54	0.57
Saratoga	2.92	2.72	2.62	2.22	1.97	2.45	1.73
Schenectady	0.56	0.59	0.55	0.53	0.75	0.74	0.72
Totals	2.27	1.67	1.51	1.49	1.50	1.59	1.51
Warren	2.89	3.01	2.57	3.65	4.07	3.83	4.72
Washington	5.49	4.76	4.75	4.27	3.94	4.04	4.01

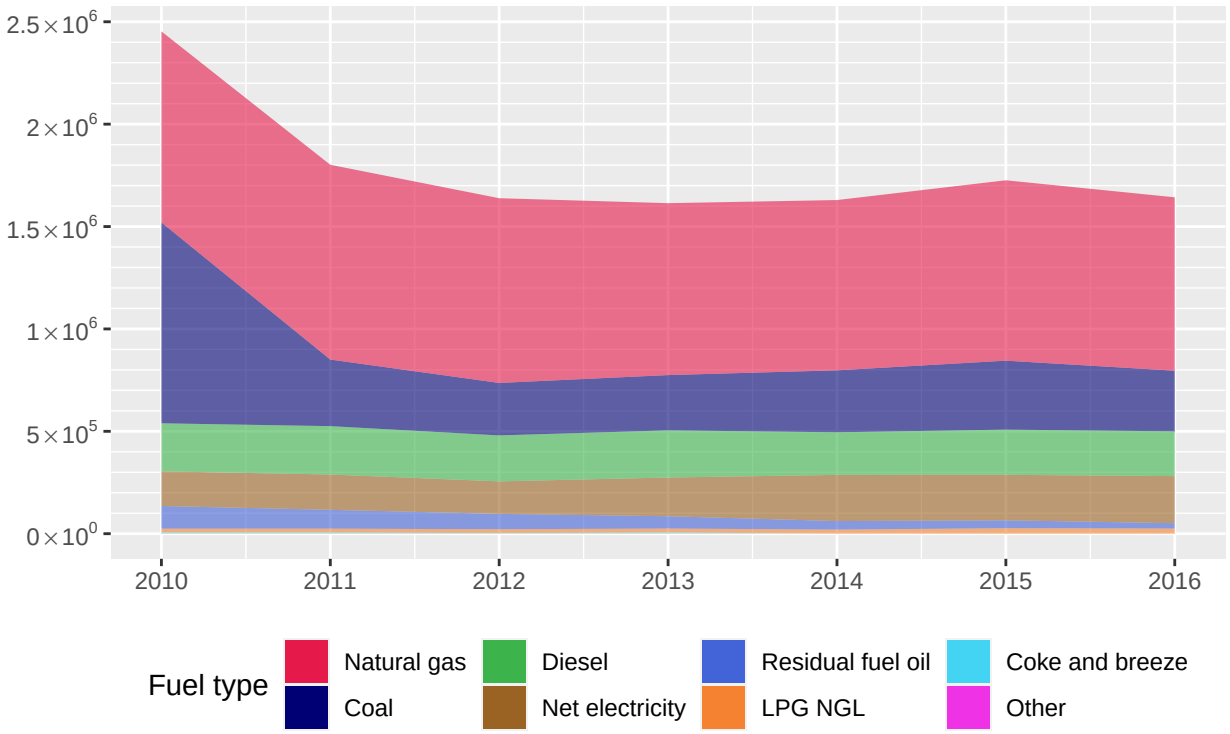

Figure 5.3: CO_2-equivalent agricultural/industrial emissions per fuel type, metric tons

As Figure 5.3 illustrates, emissions from coal were about 40% of the region's total industrial and agricultural greenhouse gas emissions in 2010, but about 18% by 2016.

5.3 Sector analysis

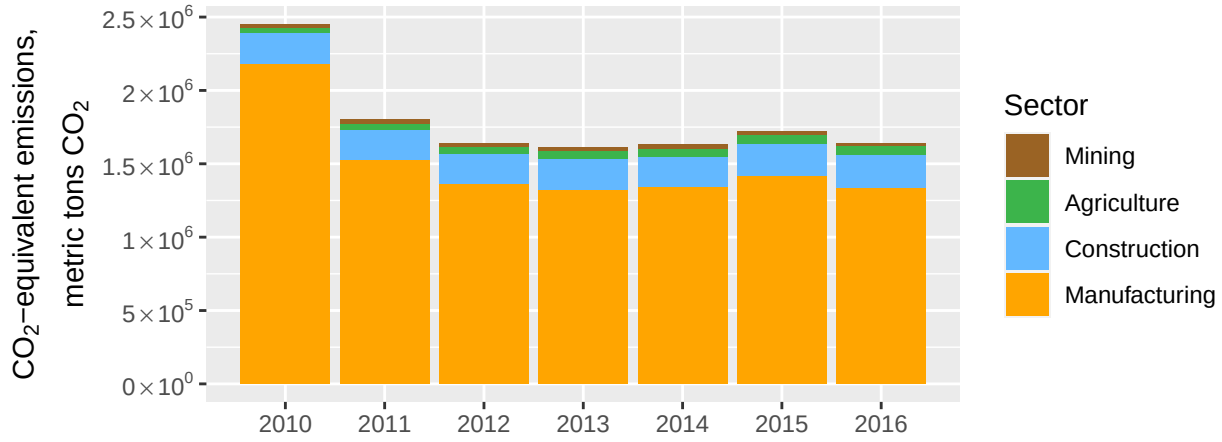

Figure 5.4: CO_2-equivalent agricultural/industrial emissions per sector, metric tons

Figure 5.4 provides an overview of GHG emissions by economic sector for the region. Table 5.4 breaks down each sector's 2016 emissions by county.[5]

The more detailed breakdowns by NAICS category in the following sub-sections yield greater insight

[5]The County distribution column employs a variant of the sparklines popularized by Edward Tufte [23] to graphically display the approximate geographic breakdown of emissions; the order of the bars corresponds to the order of the county columns to the right.

Table 5.4: 2016 CO_2-equivalent GHG emissions per sector and county, metric tons CO_2

Sector	County distribution	Albany	Columbia	Greene	Rensselaer	Saratoga	Schenectady	Warren	Washington
Manufacturing		340,565	16,696	8,757	46,439	337,256	79,473	286,189	216,281
Construction		61,707	19,785	12,517	35,280	45,553	27,856	15,185	10,804
Agriculture		6,112	9,879	3,290	7,455	8,742	2,543	1,208	17,858
Mining		11,137	2,778	2,201	2,778	504	976	2,131	2,816

into the sources of these emissions. For each of the four sectors, the following pages provide a plot showing the relative emissions quantities for sub-categories of each sector, and the distribution of these emissions across the region. The breakdown to this level of detail makes it possible in some cases to identify specific manufacturing operations responsible for large quantities of emissions. In many cases, these operations are easily identified because they appear in a *large energy users* dataset accompanying the *county energy estimates* dataset used primarily in this analysis [16]. Unfortunately, only a fraction of manufacturing operations in the region count as large energy users by the criteria of the EPA's Greenhouse Gas Reporting Program, so further research will be necessary to identify the next tier of significant GHG emitters. Fortunately, additional detail to the level of the entire NAICS six-digit classification can be available for analysis, although it is not presented in this report due to time and space limitations.

5.3.1 *Manufacturing*

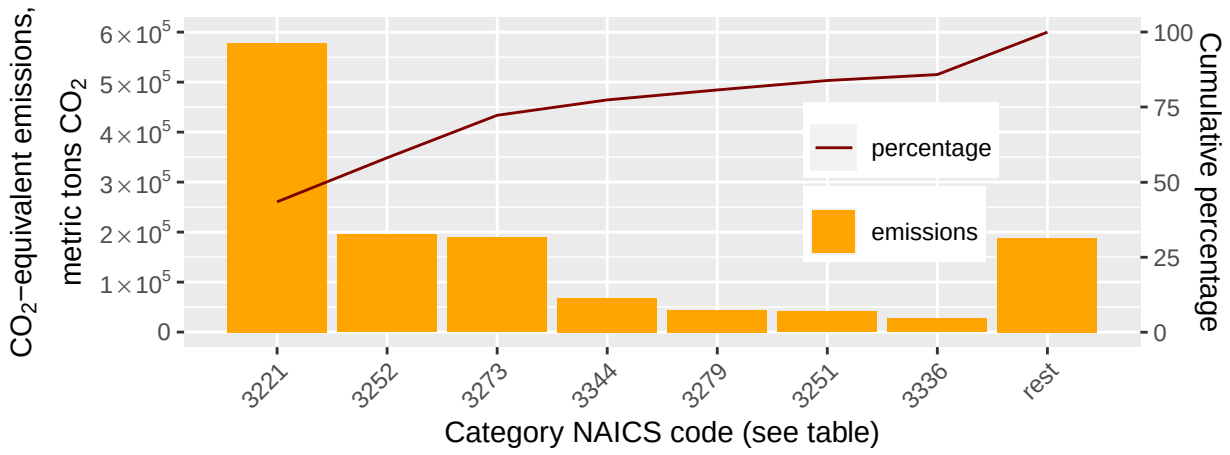

Figure 5.5: Manufacturing categories with highest CO_2-equivalent GHG emissions

Table 5.5: Manufacturing categories with highest CO_2-equivalent GHG emissions

NAICS	Manufacturing category	CO_2-equivalent emissions, tonnes	County distribution	Principal counties
3221	Pulp, Paper, and Paperboard Mills	578,288		Washington, Warren, Saratoga, Albany
3252	Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	195,577		Saratoga, Albany, Schenectady
3273	Cement and Concrete Product Manufacturing	188,646		Warren, Albany, Greene
3344	Semiconductor and Other Electronic Component Manufacturing	68,329		Saratoga, Albany, Schenectady
3279	Other Nonmetallic Mineral Product Manufacturing	44,133		Albany, Schenectady
3251	Basic Chemical Manufacturing	41,889		Albany, Warren, Saratoga, Greene
3336	Engine, Turbine, and Power Transmission Equipment Manufacturing	26,484		Schenectady, Albany, Saratoga
0	Remaining manufacturing categories	188,308		Albany, Saratoga, Rensselaer, Warren

5.3.2 *Agriculture*

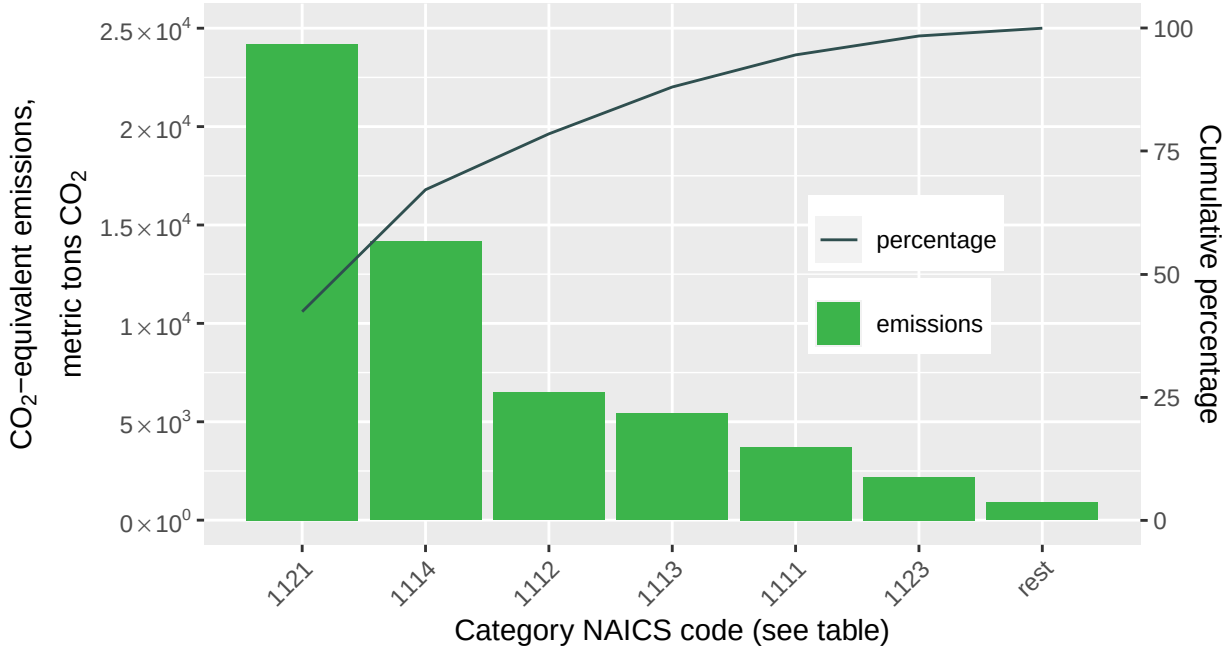

Figure 5.6: Agriculture categories with highest CO_2-equivalent GHG emissions

Table 5.6: Agricultural categories with highest CO_2-equivalent GHG emissions

NAICS	Agriculture category	CO_2-equivalent emissions, tonnes	County distribution	Principal counties
1121	Cattle Ranching and Farming	24,196		Washington, Rensselaer, Saratoga, Columbia
1114	Greenhouse, Nursery, and Floriculture Production	14,152		Saratoga, Columbia, Washington, Albany, Rensselaer
1112	Vegetable and Melon Farming	6,482		Columbia, Saratoga, Washington, Rensselaer
1113	Fruit and Tree Nut Farming	5,437		Columbia, Washington, Rensselaer, Saratoga, Albany
1111	Oilseed and Grain Farming	3,725		Columbia, Washington, Rensselaer, Saratoga
1123	Poultry and Egg Production	2,195		Rensselaer, Washington, Columbia, Albany, Saratoga
0	Remaining agriculture categories	899		Washington, Columbia, Albany

5.3.3 *Construction*

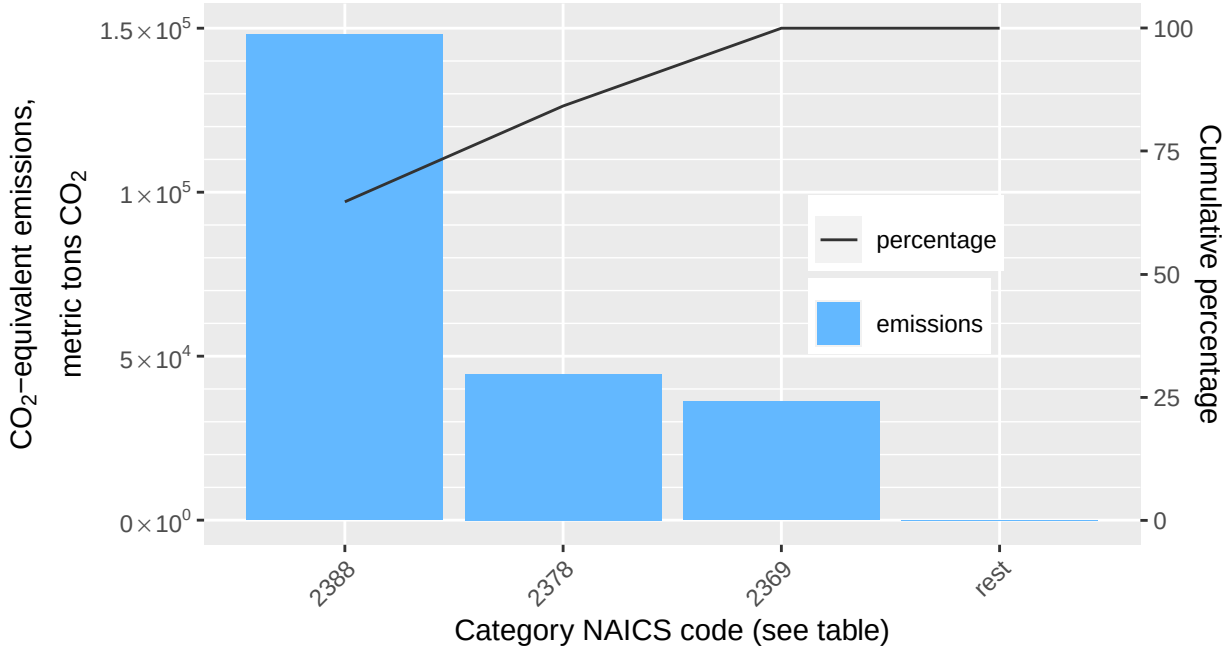

Figure 5.7: Construction categories with CO_2-equivalent GHG emissions

Table 5.7: Construction categories with CO_2-equivalent GHG emissions

NAICS	Construction category	CO_2-equivalent emissions, tonnes	County distribution	Principal counties
2388	Specialty Trade Contractors (unclassified)	147,988		Albany, Saratoga, Rensselaer, Schenectady
2378	Heavy and Civil Engineering Construction (unclassified)	44,547		Albany, Rensselaer, Saratoga
2369	Building Construction (unclassified)	36,155		Albany, Saratoga, Rensselaer, Schenectady
0	Remaining construction categories	0		

5.3.4 *Mining*

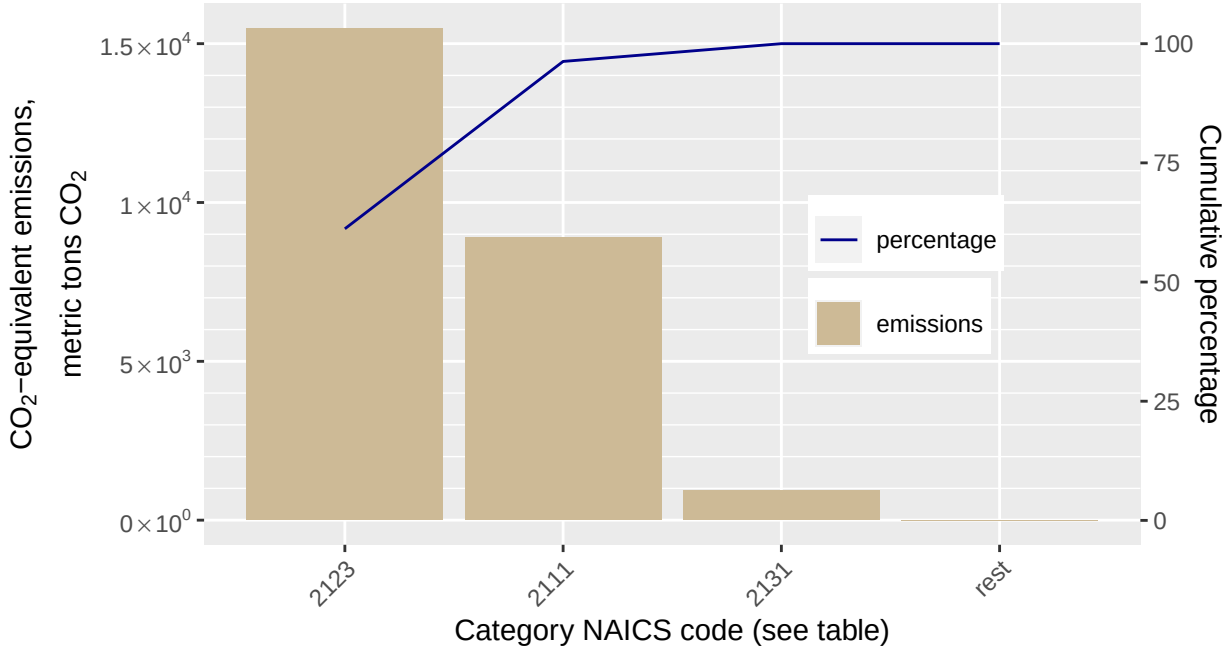

Figure 5.8: Mining categories with CO_2-equivalent GHG emissions

Table 5.8: Mining categories with CO_2-equivalent GHG emissions

NAICS	Mining category	CO_2-equivalent emissions, tonnes	County distribution	Principal counties
2123	Nonmetallic Mineral Mining and Quarrying	15,486		Washington, Columbia, Rensselaer, Greene, Warren, Albany
2111	Oil and Gas Extraction	8,896		Albany
2131	Support Activities for Mining	944		Albany, Schenectady
0	Remaining mining categories	0		

6 Limitations and caveats

1. The NREL dataset and the heuristic methods used to generate the estimates it contains deserve scrutiny – ideally, by comparison with independent sources of information. This may be difficult as the NREL dataset is apparently the most detailed data source available in the areas it covers.
2. The presentation of agricultural GHG emissions provided in this report is substantially incomplete as it includes no information about GHG emissions due to use (or overuse) of agricultural chemicals including nitrate fertilizers. This information can be obtained; it just requires more work.
3. The GHG emissions profiled in this report are those resulting from fuel combustion for generation of heat, kinetic energy, or electricity. Halocarbon emissions as a byproduct of industrial processes are potentially a significant contributor to global warming because of their very high global warming potentials. The EPA requires reporting of emissions of many of these chemicals as toxic pollutants rather than as greenhouse gases; the relevant reports may provide information useful in analyzing greenhouse gas emissions as well.
4. Unfortunately omitted from the NREL dataset is data on GHG emissions from waste management operations such as landfills. This information is also readily obtained and will be included in any full inventory of GHG emissions across the region.

7 Next steps

1. Investigate alternative methods and data sources that could be used to validate energy use and GHG emissions for industry and agriculture based on the NREL IEDB. Useful data sources for this purpose have already been identified, and include agricultural census information from the US Department of Agriculture [27][28], US Census Bureau information[26][2], and information from the New York State government including NYSERDA's *Patterns and Trends* report [20] and from the data.ny.gov portal.
2. Conduct and report similar analyses for other sources of greenhouse gas emissions: residential and commercial buildings, transportation, agricultural emissions unrelated to energy use, etc.

Appendices

A EPA emission factors

Source: [24]. The EPA publication includes additional tables; the ones shown here are those directly bearing on the agricultural and industrial sectors' greenhouse gas emissions.

Table A.1: Emission factors, liquid fuels

Fuel Type	Heat Content (HHV), mmBtu per gallon	CO_2 Factor, kg CO_2 per mmBtu	CH_4 Factor, g CH_4 per mmBtu	N_2O Factor, g N_2O per mmBtu	CO_2 Factor, kg CO_2 per gallon	CH_4 Factor, g CH_4 per gallon	N_2O Factor, g N_2O per gallon
Asphalt and Road Oil	0.158	75.36	3.0	0.60	11.91	0.47	0.09
Aviation Gasoline	0.120	69.25	3.0	0.60	8.31	0.36	0.07
Butane	0.103	64.77	3.0	0.60	6.67	0.31	0.06
Butylene	0.105	68.72	3.0	0.60	7.22	0.32	0.06
Crude Oil	0.138	74.54	3.0	0.60	10.29	0.41	0.08
Distillate Fuel Oil No. 1	0.139	73.25	3.0	0.60	10.18	0.42	0.08
Distillate Fuel Oil No. 2	0.138	73.96	3.0	0.60	10.21	0.41	0.08
Distillate Fuel Oil No. 4	0.146	75.04	3.0	0.60	10.96	0.44	0.09
Ethane	0.068	59.60	3.0	0.60	4.05	0.20	0.04
Ethylene	0.058	65.96	3.0	0.60	3.83	0.17	0.03
Heavy Gas Oils	0.148	74.92	3.0	0.60	11.09	0.44	0.09
Isobutane	0.099	64.94	3.0	0.60	6.43	0.30	0.06
Isobutylene	0.103	68.86	3.0	0.60	7.09	0.31	0.06
Kerosene	0.135	75.20	3.0	0.60	10.15	0.41	0.08
Kerosene-Type Jet Fuel	0.135	72.22	3.0	0.60	9.75	0.41	0.08
Liquefied Petroleum Gases (LPG)	0.092	61.71	3.0	0.60	5.68	0.28	0.06
Lubricants	0.144	74.27	3.0	0.60	10.69	0.43	0.09
Motor Gasoline	0.125	70.22	3.0	0.60	8.78	0.38	0.08
Naphtha (<401 deg F)	0.125	68.02	3.0	0.60	8.50	0.38	0.08
Natural Gasoline	0.110	66.88	3.0	0.60	7.36	0.33	0.07
Other Oil (>401 deg F)	0.139	76.22	3.0	0.60	10.59	0.42	0.08
Pentanes Plus	0.110	70.02	3.0	0.60	7.70	0.33	0.07
Petrochemical Feedstocks	0.125	71.02	3.0	0.60	8.88	0.38	0.08
Petroleum Coke	0.143	102.41	3.0	0.60	14.64	0.43	0.09
Propane	0.091	62.87	3.0	0.60	5.72	0.27	0.05
Propylene	0.091	67.77	3.0	0.60	6.17	0.27	0.05
Residual Fuel Oil No. 5	0.140	72.93	3.0	0.60	10.21	0.42	0.08
Residual Fuel Oil No. 6	0.150	75.10	3.0	0.60	11.27	0.45	0.09
Special Naphtha	0.125	72.34	3.0	0.60	9.04	0.38	0.08
Unfinished Oils	0.139	74.54	3.0	0.60	10.36	0.42	0.08
Used Oil	0.138	74.00	3.0	0.60	10.21	0.41	0.08
Biodiesel (100%)	0.128	73.84	1.1	0.11	9.45	0.14	0.01
Ethanol (100%)	0.084	68.44	1.1	0.11	5.75	0.09	0.01
Rendered Animal Fat	0.125	71.06	1.1	0.11	8.88	0.14	0.01
Vegetable Oil	0.120	81.55	1.1	0.11	9.79	0.13	0.01
North American Softwood	NA	94.40	1.9	0.42	NA	NA	NA
North American Hardwood	NA	93.70	1.9	0.42	NA	NA	NA
Bagasse	NA	95.50	1.9	0.42	NA	NA	NA
Bamboo	NA	93.70	1.9	0.42	NA	NA	NA
Straw	NA	95.10	1.9	0.42	NA	NA	NA

Table A.2: Emission factors, solid fuels

Fuel Type	Heat Content (HHV), mmBtu per short ton	CO_2 Factor, kg CO_2 per mmBtu	CH_4 Factor, g CH_4 per mmBtu	N_2O Factor, g N_2O per mmBtu	CO_2 Factor, kg CO_2 per short ton	CH_4 Factor, g CH_4 per short ton	N_2O Factor, g N_2O per short ton
Anthracite Coal	25.09	103.69	11.0	1.6	2602	276	40
Bituminous Coal	24.93	93.28	11.0	1.6	2325	274	40
Sub-bituminous Coal	17.25	97.17	11.0	1.6	1676	190	28
Lignite Coal	14.21	97.72	11.0	1.6	1389	156	23
Mixed (Commercial Sector)	21.39	94.27	11.0	1.6	2016	235	34
Mixed (Electric Power Sector)	19.73	95.52	11.0	1.6	1885	217	32
Mixed (Industrial Coking)	26.28	93.90	11.0	1.6	2468	289	42
Mixed (Industrial Sector)	22.35	94.67	11.0	1.6	2116	246	36
Coal Coke	24.80	113.67	11.0	1.6	2819	273	40
Municipal Solid Waste	9.95	90.70	32.0	4.2	902	318	42
Petroleum Coke (Solid)	30.00	102.41	32.0	4.2	3072	960	126
Plastics	38.00	75.00	32.0	4.2	2850	1216	160
Tires	28.00	85.97	32.0	4.2	2407	896	118
Agricultural Byproducts	8.25	118.17	32.0	4.2	975	264	35
Peat	8.00	111.84	32.0	4.2	895	256	34
Solid Byproducts	10.39	105.51	32.0	4.2	1096	332	44
Wood and Wood Residuals	17.48	93.80	7.2	3.6	1640	126	63

Table A.3: Emission factors, gaseous fuels

Fuel Type	Heat Content (HHV), mmBtu per scf	CO_2 Factor, kg CO_2 per mmBtu	CH_4 Factor, g CH_4 per mmBtu	N_2O Factor, g N_2O per mmBtu	CO_2 Factor, kg CO_2 per scf	CH_4 Factor, g CH_4 per scf	N_2O Factor, g N_2O per scf
Natural Gas	0.001026	53.06	1.000	0.10	0.054440	0.001030	0.000100
Blast Furnace Gas	0.000092	274.32	0.022	0.10	0.025240	0.000002	0.000009
Coke Oven Gas	0.000599	46.85	0.480	0.10	0.028060	0.000288	0.000060
Fuel Gas	0.001388	59.00	3.000	0.60	0.081890	0.004164	0.000833
Propane Gas	0.002516	61.46	3.000	0.60	0.154630	0.007548	0.001510
Landfill Gas	0.000485	52.07	3.200	0.63	0.025254	0.001552	0.000306
Other Biomass Gases	0.000655	52.07	3.200	0.63	0.034106	0.002096	0.000413

Table A.4: Emission factors, grid electricity

eGRID Subregion	Total Output			Non-Baseload		
	CO_2 Factor, (kg / MWh)	CH_4 Factor, (g / MWh)	N_2O Factor, (g / MWh)	CO_2 Factor, (kg / MWh)	CH_4 Factor, (g / MWh)	N_2O Factor, (g / MWh)
AKGD (ASCC Alaska Grid)	486.39	34.93	4.99	620.42	49.90	7.26
AKMS (ASCC Miscellaneous)	228.20	10.43	1.81	695.72	30.84	5.44
AZNM (WECC Southwest)	473.37	35.83	5.44	628.13	44.00	6.35
CAMX (WECC California)	239.45	14.97	1.81	427.69	20.41	2.72
ERCT (ERCOT All)	457.77	34.47	4.99	636.30	48.99	6.80
FRCC (FRCC All)	458.90	34.02	4.54	539.09	35.38	4.99
HIMS (HICC Miscellaneous)	522.54	43.09	6.80	694.00	66.68	10.43
HIOA (HICC Oahu)	754.28	82.10	12.70	742.76	69.40	10.89
MROE (MRO East)	756.68	70.76	11.79	789.30	70.76	11.34
MROW (MRO West)	561.91	52.16	9.07	826.45	69.85	13.15
NEWE (NPCC New England)	253.20	40.82	5.44	442.30	39.01	4.99
NWPP (WECC Northwest)	295.38	27.67	4.08	691.68	56.25	9.07
NYCW (NPCC NYC/Westchester)	288.39	9.98	1.36	481.58	9.98	0.91
NYLI (NPCC Long Island)	534.47	57.15	7.26	607.27	16.33	1.81
NYUP (NPCC Upstate NY)	133.67	9.53	1.36	461.85	27.67	3.63
RFCE (RFC East)	343.91	22.68	4.08	650.63	35.83	7.71
RFCM (RFC Michigan)	576.97	30.39	8.16	819.23	45.81	11.34
RFCW (RFC West)	564.00	48.99	8.62	877.43	78.02	13.15
RMPA (WECC Rockies)	620.42	62.14	9.07	765.80	66.68	9.53
SPNO (SPP North)	640.65	67.59	9.98	903.01	91.63	13.15
SPSO (SPP South)	566.22	43.09	6.80	754.10	54.88	8.62
SRMV (SERC Mississippi Valley)	380.52	22.68	3.18	537.96	32.21	4.54
SRMW (SERC Midwest)	731.46	37.19	11.79	886.86	38.10	14.06
SRSO (SERC South)	494.14	39.46	5.90	659.30	52.16	7.71
SRTV (SERC Tennessee Valley)	537.69	42.18	7.71	797.14	61.23	11.34
SRVC (SERC Virginia/Carolina)	365.28	30.39	4.99	645.10	50.35	8.62
US Average	452.87	36.29	5.90	680.84	50.35	8.16

Table A.5: Global warming potentials (IPCC AR4)

Gas	100-Year GWP	Gas	100-Year GWP
CO_2	1	HFC-236ea	1370
CH_4	25	HFC-236fa	9810
N_2O	298	HFC-245ca	693
HFC-23	14800	HFC-245fa	1030
HFC-32	675	HFC-365mfc	794
HFC-41	92	HFC-43-10mee	1640
HFC-125	3500	SF_6	22800
HFC-134	1100	NF_3	17200
HFC-134a	1430	CF_4	7390
HFC-143	353	C_2F_6	12200
HFC-143a	4470	C_3F_8	8830
HFC-152	53	c-C_4F_8	10300
HFC-152a	124	C_4F_{10}	8860
HFC-161	12	C_5F_{12}	9160
HFC-227ea	3220	C_6F_{14}	9300
HFC-236cb	1340	$C_{10}F_{18}$	>7,500

Table A.6: Global warming potentials for blended refrigerants (IPCC AR4)

ASHRAE #	100-year GWP	Blend Composition
R-401A	16	53% HCFC-22 , 34% HCFC-124 , 13% HFC-152a
R-401B	14	61% HCFC-22 , 28% HCFC-124 , 11% HFC-152a
R-401C	19	33% HCFC-22 , 52% HCFC-124 , 15% HFC-152a
R-402A	2100	38% HCFC-22 , 6% HFC-125 , 2% propane
R-402B	1330	6% HCFC-22 , 38% HFC-125 , 2% propane
R-403B	3444	56% HCFC-22 , 39% PFC-218 , 5% propane
R-404A	3922	44% HFC-125 , 4% HFC-134a , 52% HFC 143a
R-406A	0	55% HCFC-22 , 41% HCFC-142b , 4% isobutane
R-407A	2107	20% HFC-32 , 40% HFC-125 , 40% HFC-134a
R-407B	2804	10% HFC-32 , 70% HFC-125 , 20% HFC-134a
R-407C	1774	23% HFC-32 , 25% HFC-125 , 52% HFC-134a
R-407D	1627	15% HFC-32 , 15% HFC-125 , 70% HFC-134a
R-407E	1552	25% HFC-32 , 15% HFC-125 , 60% HFC-134a
R-408A	2301	47% HCFC-22 , 7% HFC-125 , 46% HFC 143a
R-409A	0	60% HCFC-22 , 25% HCFC-124 , 15% HCFC-142b
R-410A	2088	50% HFC-32 , 50% HFC-125
R-410B	2229	45% HFC-32 , 55% HFC-125
R-411A	14	87.5% HCFC-22 , 11 HFC-152a , 1.5% propylene
R-411B	4	94% HCFC-22 , 3% HFC-152a , 3% propylene
R-413A	2053	88% HFC-134a , 9% PFC-218 , 3% isobutane
R-414A	0	51% HCFC-22 , 28.5% HCFC-124 , 16.5% HCFC-142b
R-414B	0	5% HCFC-22 , 39% HCFC-124 , 9.5% HCFC-142b
R-417A	2346	46.6% HFC-125 , 5% HFC-134a , 3.4% butane
R-422A	3143	85.1% HFC-125 , 11.5% HFC-134a , 3.4% isobutane
R-422D	2729	65.1% HFC-125 , 31.5% HFC-134a , 3.4% isobutane
R-423A	2280	47.5% HFC-227ea , 52.5% HFC-134a ,
R-424A	2440	50.5% HFC-125, 47% HFC-134a, 2.5% butane/pentane
R-426A	1508	5.1% HFC-125, 93% HFC-134a, 1.9% butane/pentane
R-428A	3607	77.5% HFC-125 , 2% HFC-143a , 1.9% isobutane
R-434A	3245	63.2% HFC-125, 16% HFC-134a, 18% HFC-143a, 2.8% isobutane
R-500	32	73.8% CFC-12 , 26.2% HFC-152a , 48.8% HCFC-22
R-502	0	48.8% HCFC-22 , 51.2% CFC-115
R-504	325	48.2% HFC-32 , 51.8% CFC-115
R-507	3985	5% HFC-125 , 5% HFC143a
R-508A	13214	39% HFC-23 , 61% PFC-116
R-508B	13396	46% HFC-23 , 54% PFC-116

B Additional emissions tables

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
Albany								
1111. Oilseed and Grain Farming	0.0	0.0	34.5	0.0	173.1	65.4	49.0	0.0
1112. Vegetable and Melon Farming	0.0	0.0	125.2	0.0	302.9	114.4	85.7	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	138.5	0.0	271.9	102.6	76.9	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	342.8	0.0	1,006.4	380.0	284.7	0.0
1121. Cattle Ranching and Farming	0.0	0.0	411.7	0.0	1,051.5	397.0	297.5	0.0
1122. Hog and Pig Farming	0.0	0.0	2.9	0.0	6.2	2.3	1.8	0.0
1123. Poultry and Egg Production	0.0	0.0	94.6	0.0	121.1	45.7	34.3	0.0
1124. Sheep and Goat Farming	0.0	0.0	23.0	0.0	41.2	15.6	11.7	0.0
2111. Oil and Gas Extraction	7,370.7	0.0	708.7	470.2	295.8	0.0	51.0	0.0
2123. Nonmetallic Mineral Mining and Quarrying	116.2	0.0	264.4	753.8	456.5	0.0	178.2	0.0
2131. Support Activities for Mining	99.8	0.0	18.2	7.2	184.6	0.0	162.2	0.0
2369. Building Construction (unclassified)	1,110.7	0.0	1,755.2	0.0	5,732.9	177.1	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	515.1	0.0	964.1	0.0	12,143.3	1,580.2	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	5,703.0	0.0	3,391.3	0.0	27,674.1	960.1	0.0	0.0
3116. Animal Slaughtering and Processing	3,142.2	0.0	1,859.8	464.6	475.6	26.1	66.8	0.0
3121. Beverage Manufacturing	3,628.5	0.0	2,511.8	0.0	52.5	46.1	341.5	0.0
3132. Fabric Mills	4,311.9	0.0	2,387.9	0.0	18.8	12.8	0.0	0.0
3149. Other Textile Product Mills	43.3	0.0	10.5	0.4	77.0	2.2	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	1.2	0.0	1.1	0.0	4.8	2.2	0.0	0.0
3159. Apparel Accessories and Other Apparel Manufacturing	1.2	0.0	1.1	0.0	4.8	2.2	0.0	0.0
3162. Footwear Manufacturing	51.0	0.0	136.6	0.0	9.9	4.5	2.4	0.0
3211. Sawmills and Wood Preservation	290.3	0.0	222.1	2.5	161.2	7.3	3.9	0.0
3219. Other Wood Product Manufacturing	293.2	0.0	598.3	0.0	162.8	73.7	0.0	0.0
3221. Pulp, Paper, and Paperboard Mills	35,610.6	0.0	4,615.0	50,528.9	41.5	50.7	425.4	0.0
3231. Printing and Related Support Activities	554.0	0.0	696.4	0.0	23.4	12.5	3.6	0.0
3241. Petroleum and Coal Products Manufacturing	387.3	0.0	49.4	0.0	430.1	9.7	5.3	0.0
3251. Basic Chemical Manufacturing	679.0	0.0	31,792.5	0.0	334.9	339.4	0.0	0.0
3252. Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	34,643.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3254. Pharmaceutical and Medicine Manufacturing	643.2	0.0	344.6	0.0	500.0	22.6	0.0	0.0
3261. Plastics Product Manufacturing	1,180.5	0.0	2,152.0	412.0	18.8	138.1	0.0	0.0
3262. Rubber Product Manufacturing	33.7	0.0	67.8	4.6	1.6	7.4	0.0	0.0
3271. Clay Product and Refractory Manufacturing	10,874.8	0.0	1,929.0	0.0	138.2	187.8	0.0	0.0
3272. Glass and Glass Product Manufacturing	407.0	0.0	150.7	1.8	38.6	17.5	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3273. Cement and Concrete Product Manufacturing	6,849.1	0.0	5,787.1	62,189.4	138.2	189.5	303.8	7.3
3279. Other Nonmetallic Mineral Product Manufacturing	41,773.8	0.0	1,709.3	0.0	0.0	0.0	0.0	0.0
3323. Architectural and Structural Metals Manufacturing	113.9	0.0	80.3	0.0	22.1	10.0	0.0	0.0
3324. Boiler, Tank, and Shipping Container Manufacturing	28.5	0.0	20.1	0.0	5.5	2.5	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	569.3	0.0	348.2	0.0	54.8	30.3	0.0	0.0
3328. Coating, Engraving, Heat Treating, and Allied Activities	42.7	0.0	30.1	0.0	8.3	3.8	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	697.3	0.0	488.3	0.0	24.5	30.7	0.0	0.0
3332. Industrial Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3333. Commercial and Service Industry Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3334. Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3335. Metalworking Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3336. Engine, Turbine, and Power Transmission Equipment Manufacturing	175.3	0.0	163.1	0.0	29.6	18.5	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	1,980.0	0.0	1,442.3	0.0	117.8	137.9	0.0	0.0
3344. Semiconductor and Other Electronic Component Manufacturing	1,696.2	0.0	2,228.2	0.0	64.7	39.2	5.1	0.0
3351. Electric Lighting Equipment Manufacturing	41.6	0.0	49.5	0.0	2.7	1.2	0.0	0.0
3353. Electrical Equipment Manufacturing	83.2	0.0	99.0	0.0	5.4	2.4	0.0	0.1
3359. Other Electrical Equipment and Component Manufacturing	2,199.8	0.0	1,416.9	0.0	16.5	18.1	0.0	0.0
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	7.4	0.0	6.6	0.0	2.9	1.3	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	258.4	0.0	229.2	0.0	18.8	23.0	0.0	0.0
3379. Other Furniture Related Product Manufacturing	1,962.0	0.0	932.3	0.0	75.4	92.2	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	286.9	0.0	224.5	0.0	9.8	5.3	1.5	0.0
3399. Other Miscellaneous Manufacturing	341.0	0.0	272.7	0.0	13.3	6.9	2.3	0.0
Columbia								
1111. Oilseed and Grain Farming	0.0	0.0	118.4	0.0	593.5	224.1	167.9	0.0
1112. Vegetable and Melon Farming	0.0	0.0	404.2	0.0	977.6	369.1	276.6	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	295.0	0.0	579.2	218.7	163.9	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	428.5	0.0	1,257.9	474.9	355.9	0.0
1121. Cattle Ranching and Farming	0.0	0.0	452.7	0.0	1,163.1	439.1	329.1	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
1122. Hog and Pig Farming	0.0	0.0	7.2	0.0	15.5	5.9	4.4	0.0
1123. Poultry and Egg Production	0.0	0.0	135.1	0.0	172.9	65.3	48.9	0.0
1124. Sheep and Goat Farming	0.0	0.0	34.1	0.0	61.0	23.0	17.3	0.0
2123. Nonmetallic Mineral Mining and Quarrying	202.1	0.0	431.0	948.4	915.4	0.0	281.9	0.0
2369. Building Construction (unclassified)	417.7	0.0	660.0	0.0	2,155.8	66.6	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	143.7	0.0	269.0	0.0	3,388.8	441.0	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	1,850.6	0.0	1,100.4	0.0	8,980.0	311.5	0.0	0.0
3114. Fruit and Vegetable Preserving and Specialty Food Manufacturing	414.4	0.0	187.3	3.2	20.4	9.2	5.0	0.0
3115. Dairy Product Manufacturing	475.8	0.0	212.4	0.0	185.0	8.4	45.2	0.0
3116. Animal Slaughtering and Processing	457.1	0.0	310.8	42.7	136.7	6.2	33.4	0.0
3121. Beverage Manufacturing	422.0	0.0	316.8	0.0	23.8	10.8	46.5	0.0
3122. Tobacco Manufacturing	5,799.4	0.0	928.5	1,166.1	155.5	70.4	0.0	0.0
3149. Other Textile Product Mills	86.6	0.0	21.0	0.8	154.0	4.4	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	0.4	0.0	0.4	0.0	1.6	0.7	0.0	0.0
3211. Sawmills and Wood Preservation	193.5	0.0	148.1	1.7	107.5	4.9	2.6	0.0
3219. Other Wood Product Manufacturing	117.3	0.0	239.3	0.0	65.1	29.5	0.0	0.0
3231. Printing and Related Support Activities	27.1	0.0	38.8	0.0	2.1	1.0	0.5	0.0
3241. Petroleum and Coal Products Manufacturing	129.1	0.0	16.5	0.0	143.4	3.2	1.8	0.0
3261. Plastics Product Manufacturing	421.4	0.0	704.4	101.1	7.4	46.3	0.0	0.0
3322. Cutlery and Handtool Manufacturing	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3323. Architectural and Structural Metals Manufacturing	57.0	0.0	40.2	0.0	11.1	5.0	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	28.5	0.0	20.1	0.0	5.5	2.5	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3333. Commercial and Service Industry Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3334. Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	516.8	0.0	573.2	0.0	51.0	56.3	0.0	0.0
3335. Metalworking Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3353. Electrical Equipment Manufacturing	83.2	0.0	99.0	0.0	5.4	2.4	0.0	0.1
3359. Other Electrical Equipment and Component Manufacturing	41.6	0.0	49.5	0.0	2.7	1.2	0.0	0.0
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	75.7	0.0	57.3	0.0	12.3	7.3	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	5.0	0.0	4.4	0.0	1.9	0.9	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3391. Medical Equipment and Supplies Manufacturing	7.7	0.0	6.9	0.0	0.5	0.2	0.1	0.0
3399. Other Miscellaneous Manufacturing	225.2	0.0	169.4	0.0	5.8	3.5	0.5	0.0
Greene								
1111. Oilseed and Grain Farming	0.0	0.0	14.8	0.0	74.2	28.0	21.0	0.0
1112. Vegetable and Melon Farming	0.0	0.0	85.4	0.0	206.5	78.0	58.4	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	78.3	0.0	153.7	58.0	43.5	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	190.5	0.0	559.1	211.1	158.2	0.0
1121. Cattle Ranching and Farming	0.0	0.0	203.7	0.0	530.3	200.2	150.0	0.0
1122. Hog and Pig Farming	0.0	0.0	7.2	0.0	15.5	5.9	4.4	0.0
1123. Poultry and Egg Production	0.0	0.0	40.5	0.0	51.9	19.6	14.7	0.0
1124. Sheep and Goat Farming	0.0	0.0	7.0	0.0	12.6	4.7	3.6	0.0
2123. Nonmetallic Mineral Mining and Quarrying	422.0	0.0	224.7	833.2	512.8	0.0	209.0	0.0
2369. Building Construction (unclassified)	247.8	0.0	391.7	0.0	1,279.2	39.5	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	83.8	0.0	156.9	0.0	1,976.8	257.2	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	1,222.1	0.0	726.7	0.0	5,930.2	205.7	0.0	0.0
3114. Fruit and Vegetable Preserving and Specialty Food Manufacturing	207.2	0.0	93.7	1.6	10.2	4.6	2.5	0.0
3116. Animal Slaughtering and Processing	228.5	0.0	155.4	21.4	68.3	3.1	16.7	0.0
3121. Beverage Manufacturing	105.5	0.0	79.2	0.0	5.9	2.7	11.6	0.0
3149. Other Textile Product Mills	43.3	0.0	10.5	0.4	77.0	2.2	0.0	0.0
3211. Sawmills and Wood Preservation	96.8	0.0	74.0	0.8	53.7	2.4	1.3	0.0
3231. Printing and Related Support Activities	20.3	0.0	29.1	0.0	1.6	0.7	0.4	0.0
3241. Petroleum and Coal Products Manufacturing	258.2	0.0	32.9	0.0	286.8	6.5	3.5	0.0
3251. Basic Chemical Manufacturing	328.2	0.0	659.3	0.0	31.9	14.4	0.0	0.0
3272. Glass and Glass Product Manufacturing	347.8	0.0	124.2	0.0	27.0	12.2	0.0	0.0
3273. Cement and Concrete Product Manufacturing	959.9	0.0	857.1	2,332.1	124.4	56.3	30.4	2.2
3331. Agriculture, Construction, and Mining Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3332. Industrial Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3335. Metalworking Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3353. Electrical Equipment Manufacturing	41.6	0.0	49.5	0.0	2.7	1.2	0.0	0.0
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	5.0	0.0	4.4	0.0	1.9	0.9	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	2.5	0.0	2.2	0.0	1.0	0.4	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3379. Other Furniture Related Product Manufacturing	251.0	0.0	222.6	0.0	15.9	21.7	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	7.7	0.0	6.9	0.0	0.5	0.2	0.1	0.0
3399. Other Miscellaneous Manufacturing	7.7	0.0	6.9	0.0	0.5	0.2	0.1	0.0
Rensselaer								
1111. Oilseed and Grain Farming	0.0	0.0	64.1	0.0	321.5	121.4	91.0	0.0
1112. Vegetable and Melon Farming	0.0	0.0	176.5	0.0	426.8	161.2	120.8	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	204.7	0.0	401.9	151.7	113.7	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	285.7	0.0	838.6	316.6	237.3	0.0
1121. Cattle Ranching and Farming	0.0	0.0	550.4	0.0	1,401.0	529.0	396.4	0.0
1122. Hog and Pig Farming	0.0	0.0	2.9	0.0	6.2	2.3	1.8	0.0
1123. Poultry and Egg Production	0.0	0.0	148.6	0.0	190.2	71.8	53.8	0.0
1124. Sheep and Goat Farming	0.0	0.0	17.0	0.0	30.5	11.5	8.6	0.0
2123. Nonmetallic Mineral Mining and Quarrying	202.1	0.0	431.0	948.4	915.4	0.0	281.9	0.0
2369. Building Construction (unclassified)	647.2	0.0	1,022.7	0.0	3,340.3	103.2	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	299.5	0.0	560.5	0.0	7,060.1	918.7	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	3,223.9	0.0	1,917.1	0.0	15,644.3	542.8	0.0	0.0
3115. Dairy Product Manufacturing	2,985.3	0.0	1,325.3	0.0	344.4	30.0	395.8	0.0
3116. Animal Slaughtering and Processing	228.5	0.0	155.4	21.4	68.3	3.1	16.7	0.0
3121. Beverage Manufacturing	105.5	0.0	79.2	0.0	5.9	2.7	11.6	0.0
3149. Other Textile Product Mills	130.0	0.0	31.5	1.1	231.0	6.5	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	0.4	0.0	0.4	0.0	1.6	0.7	0.0	0.0
3159. Apparel Accessories and Other Apparel Manufacturing	0.4	0.0	0.4	0.0	1.6	0.7	0.0	0.0
3211. Sawmills and Wood Preservation	387.0	0.0	296.2	3.4	214.9	9.7	5.3	0.0
3219. Other Wood Product Manufacturing	844.7	0.0	1,441.7	0.0	176.4	108.8	0.0	0.0
3221. Pulp, Paper, and Paperboard Mills	13,598.7	0.0	3,571.2	0.0	311.0	140.8	76.0	0.0
3231. Printing and Related Support Activities	47.5	0.0	67.8	0.0	3.7	1.7	0.9	0.0
3241. Petroleum and Coal Products Manufacturing	129.1	0.0	16.5	0.0	143.4	3.2	1.8	0.0
3254. Pharmaceutical and Medicine Manufacturing	1,631.2	0.0	868.1	0.0	207.3	28.2	0.0	0.0
3261. Plastics Product Manufacturing	1,063.0	0.0	2,123.1	516.0	13.9	129.8	0.0	0.0
3262. Rubber Product Manufacturing	33.7	0.0	67.8	4.6	1.6	7.4	0.0	0.0
3274. Lime and Gypsum Product Manufacturing	2,285.5	0.0	40.8	0.0	177.7	80.5	0.0	0.0
3313. Alumina and Aluminum Production and Processing	5,485.2	0.0	1,632.5	0.0	355.4	160.9	86.8	0.0
3324. Boiler, Tank, and Shipping Container Manufacturing	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	113.9	0.0	80.3	0.0	22.1	10.0	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3328. Coating, Engraving, Heat Treating, and Allied Activities	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	42.7	0.0	30.1	0.0	8.3	3.8	0.0	0.0
3335. Metalworking Machinery Manufacturing	46.8	0.0	52.3	0.0	21.6	9.8	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3351. Electric Lighting Equipment Manufacturing	83.2	0.0	99.0	0.0	5.4	2.4	0.0	0.1
3353. Electrical Equipment Manufacturing	303.3	0.0	295.1	0.0	6.0	4.1	0.0	0.3
3359. Other Electrical Equipment and Component Manufacturing	83.2	0.0	99.0	0.0	5.4	2.4	0.0	0.1
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	5.0	0.0	4.4	0.0	1.9	0.9	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	30.9	0.0	27.6	0.0	2.0	0.9	0.5	0.0
3399. Other Miscellaneous Manufacturing	23.2	0.0	20.7	0.0	1.5	0.7	0.4	0.0
Saratoga								
1111. Oilseed and Grain Farming	0.0	0.0	64.1	0.0	321.5	121.4	91.0	0.0
1112. Vegetable and Melon Farming	0.0	0.0	216.3	0.0	523.2	197.5	148.0	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	204.7	0.0	401.9	151.7	113.7	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	542.8	0.0	1,593.4	601.6	450.8	0.0
1121. Cattle Ranching and Farming	0.0	0.0	498.2	0.0	1,279.0	482.9	361.9	0.0
1122. Hog and Pig Farming	0.0	0.0	2.9	0.0	6.2	2.3	1.8	0.0
1123. Poultry and Egg Production	0.0	0.0	94.6	0.0	121.1	45.7	34.3	0.0
1124. Sheep and Goat Farming	0.0	0.0	17.0	0.0	30.5	11.5	8.6	0.0
2123. Nonmetallic Mineral Mining and Quarrying	43.0	0.0	83.3	97.3	229.5	0.0	51.9	0.0
2369. Building Construction (unclassified)	1,046.5	0.0	1,653.7	0.0	5,401.3	166.8	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	227.6	0.0	426.0	0.0	5,365.7	698.2	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	4,620.6	0.0	2,747.6	0.0	22,421.7	777.9	0.0	0.0
3115. Dairy Product Manufacturing	2,195.9	0.0	801.2	0.0	259.1	17.6	0.0	0.0
3121. Beverage Manufacturing	527.5	0.0	395.9	0.0	29.7	13.5	58.1	0.0
3141. Textile Furnishings Mills	1,214.4	0.0	242.5	18.9	708.8	29.0	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	0.8	0.0	0.7	0.0	3.2	1.4	0.0	0.0
3211. Sawmills and Wood Preservation	193.5	0.0	148.1	1.7	107.5	4.9	2.6	0.0
3219. Other Wood Product Manufacturing	351.8	0.0	718.0	0.0	195.4	88.5	0.0	0.0
3221. Pulp, Paper, and Paperboard Mills	79,999.2	0.0	16,372.4	15,547.3	704.8	338.0	151.9	0.0
3231. Printing and Related Support Activities	3,301.3	0.0	3,613.1	0.0	69.1	6.7	281.8	0.0
3241. Petroleum and Coal Products Manufacturing	4,600.7	0.0	482.6	0.0	1,651.0	54.5	1.8	0.0
3251. Basic Chemical Manufacturing	1,622.4	0.0	916.1	0.0	87.8	39.8	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3252. Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	125,297.9	0.0	669.3	0.0	846.2	571.0	4.2	0.0
3254. Pharmaceutical and Medicine Manufacturing	160.8	0.0	86.1	0.0	125.0	5.7	0.0	0.0
3261. Plastics Product Manufacturing	295.1	0.0	521.7	62.1	7.8	41.7	0.0	0.0
3271. Clay Product and Refractory Manufacturing	415.5	0.0	74.2	0.0	32.3	14.6	0.0	0.0
3313. Alumina and Aluminum Production and Processing	799.9	0.0	476.2	0.0	103.7	46.9	25.3	0.0
3322. Cutlery and Handtool Manufacturing	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3323. Architectural and Structural Metals Manufacturing	277.6	0.0	169.1	0.0	26.0	14.5	0.0	0.0
3324. Boiler, Tank, and Shipping Container Manufacturing	683.0	0.0	478.3	0.0	21.7	29.5	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	85.4	0.0	60.2	0.0	16.6	7.5	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	220.6	0.0	128.9	0.0	14.9	9.5	0.0	0.0
3332. Industrial Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3333. Commercial and Service Industry Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3334. Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3335. Metalworking Machinery Manufacturing	31.2	0.0	34.8	0.0	14.4	6.5	0.0	0.0
3336. Engine, Turbine, and Power Transmission Equipment Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	31.2	0.0	34.8	0.0	14.4	6.5	0.0	0.0
3344. Semiconductor and Other Electronic Component Manufacturing	49,719.2	0.0	12,648.6	0.0	1,336.8	0.0	0.0	0.0
3351. Electric Lighting Equipment Manufacturing	41.6	0.0	49.5	0.0	2.7	1.2	0.0	0.0
3353. Electrical Equipment Manufacturing	41.6	0.0	49.5	0.0	2.7	1.2	0.0	0.0
3359. Other Electrical Equipment and Component Manufacturing	626.4	0.0	740.8	0.0	6.6	9.0	0.0	0.3
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	12.4	0.0	11.1	0.0	4.8	2.2	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	2.5	0.0	2.2	0.0	1.0	0.4	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	209.7	0.0	155.6	0.0	4.8	3.0	0.2	0.0
3399. Other Miscellaneous Manufacturing	46.3	0.0	41.4	0.0	3.0	1.4	0.7	0.0
Schenectady								
1111. Oilseed and Grain Farming	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
1112. Vegetable and Melon Farming	0.0	0.0	74.0	0.0	179.0	67.6	50.6	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	72.3	0.0	141.8	53.6	40.1	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	123.8	0.0	363.4	137.2	102.8	0.0
1121. Cattle Ranching and Farming	0.0	0.0	204.8	0.0	520.1	196.3	147.1	0.0
1122. Hog and Pig Farming	0.0	0.0	7.2	0.0	15.5	5.9	4.4	0.0
1124. Sheep and Goat Farming	0.0	0.0	9.0	0.0	16.1	6.1	4.6	0.0
2123. Nonmetallic Mineral Mining and Quarrying	43.0	0.0	83.3	97.3	229.5	0.0	51.9	0.0
2131. Support Activities for Mining	99.8	0.0	18.2	7.2	184.6	0.0	162.2	0.0
2369. Building Construction (unclassified)	523.2	0.0	826.8	0.0	2,700.6	83.4	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	143.7	0.0	269.0	0.0	3,388.8	441.0	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	2,944.6	0.0	1,751.0	0.0	14,288.9	495.7	0.0	0.0
3114. Fruit and Vegetable Preserving and Specialty Food Manufacturing	414.4	0.0	187.3	3.2	20.4	9.2	5.0	0.0
3116. Animal Slaughtering and Processing	457.1	0.0	310.8	42.7	136.7	6.2	33.4	0.0
3121. Beverage Manufacturing	6,363.1	0.0	2,597.2	0.0	43.5	46.3	57.9	0.0
3133. Textile and Fabric Finishing and Fabric Coating Mills	358.5	0.0	242.9	0.0	5.2	2.3	1.3	0.0
3149. Other Textile Product Mills	43.3	0.0	10.5	0.4	77.0	2.2	0.0	0.0
3151. Apparel Knitting Mills	0.4	0.0	0.4	0.0	1.6	0.7	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	0.8	0.0	0.7	0.0	3.2	1.4	0.0	0.0
3169. Other Leather and Allied Product Manufacturing	51.0	0.0	136.6	0.0	9.9	4.5	2.4	0.0
3219. Other Wood Product Manufacturing	87.9	0.0	179.5	0.0	48.8	22.1	0.0	0.0
3231. Printing and Related Support Activities	404.8	0.0	483.2	0.0	11.8	7.3	0.8	0.0
3252. Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	29,949.6	0.0	3,206.6	0.0	366.2	15.4	8.3	0.0
3261. Plastics Product Manufacturing	387.7	0.0	636.6	96.5	5.7	38.8	0.0	0.0
3262. Rubber Product Manufacturing	33.7	0.0	67.8	4.6	1.6	7.4	0.0	0.0
3279. Other Nonmetallic Mineral Product Manufacturing	376.4	0.0	168.1	0.0	73.2	33.1	0.0	0.0
3323. Architectural and Structural Metals Manufacturing	540.9	0.0	328.1	0.0	49.3	27.8	0.0	0.0
3324. Boiler, Tank, and Shipping Container Manufacturing	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	249.1	0.0	149.0	0.0	20.5	12.0	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3331. Agriculture, Construction, and Mining Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3334. Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3335. Metalworking Machinery Manufacturing	15.6	0.0	17.4	0.0	7.2	3.3	0.0	0.0
3336. Engine, Turbine, and Power Transmission Equipment Manufacturing	21,126.6	0.0	4,928.0	0.0	0.0	0.0	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	516.8	0.0	573.2	0.0	51.0	56.3	0.0	0.0
3344. Semiconductor and Other Electronic Component Manufacturing	216.9	0.0	339.0	0.0	21.1	9.5	5.1	0.0
3359. Other Electrical Equipment and Component Manufacturing	668.0	0.0	790.3	0.0	9.3	10.2	0.0	0.4
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	2.5	0.0	2.2	0.0	1.0	0.4	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	5.0	0.0	4.4	0.0	1.9	0.9	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	30.9	0.0	27.6	0.0	2.0	0.9	0.5	0.0
3399. Other Miscellaneous Manufacturing	46.3	0.0	41.4	0.0	3.0	1.4	0.7	0.0
Warren								
1111. Oilseed and Grain Farming	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1112. Vegetable and Melon Farming	0.0	0.0	28.5	0.0	68.8	26.0	19.5	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	18.1	0.0	35.5	13.4	10.0	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	133.3	0.0	391.4	147.8	110.7	0.0
1121. Cattle Ranching and Farming	0.0	0.0	10.3	0.0	29.1	11.0	8.2	0.0
1123. Poultry and Egg Production	0.0	0.0	40.5	0.0	51.9	19.6	14.7	0.0
1124. Sheep and Goat Farming	0.0	0.0	5.0	0.0	9.0	3.4	2.5	0.0
2123. Nonmetallic Mineral Mining and Quarrying	125.7	0.0	333.5	753.8	633.7	0.0	284.3	0.0
2369. Building Construction (unclassified)	339.6	0.0	536.7	0.0	1,753.0	54.1	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	47.9	0.0	89.7	0.0	1,129.6	147.0	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	1,676.0	0.0	996.6	0.0	8,132.8	282.2	0.0	0.0
3121. Beverage Manufacturing	263.8	0.0	198.0	0.0	14.9	6.7	29.0	0.0
3141. Textile Furnishings Mills	43.3	0.0	10.5	0.4	77.0	2.2	0.0	0.0
3149. Other Textile Product Mills	43.3	0.0	10.5	0.4	77.0	2.2	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	0.4	0.0	0.4	0.0	1.6	0.7	0.0	0.0
3211. Sawmills and Wood Preservation	290.3	0.0	222.1	2.5	161.2	7.3	3.9	0.0
3219. Other Wood Product Manufacturing	932.6	0.0	1,621.2	0.0	225.3	130.9	0.0	0.0
3221. Pulp, Paper, and Paperboard Mills	146,533.4	0.0	6,667.8	0.0	0.0	0.0	0.0	0.0
3231. Printing and Related Support Activities	33.9	0.0	48.4	0.0	2.6	1.2	0.6	0.0
3241. Petroleum and Coal Products Manufacturing	129.1	0.0	16.5	0.0	143.4	3.2	1.8	0.0
3251. Basic Chemical Manufacturing	1,873.8	0.0	3,076.7	0.0	55.3	37.6	0.0	0.0
3261. Plastics Product Manufacturing	261.3	0.0	453.9	57.5	6.1	34.3	0.0	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3272. Glass and Glass Product Manufacturing	347.8	0.0	124.2	0.0	27.0	12.2	0.0	0.0
3273. Cement and Concrete Product Manufacturing	12,608.9	0.0	9,633.0	85,510.4	416.5	328.6	303.8	18.1
3323. Architectural and Structural Metals Manufacturing	14.2	0.0	10.0	0.0	2.8	1.3	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	71.2	0.0	50.2	0.0	13.8	6.3	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	42.7	0.0	30.1	0.0	8.3	3.8	0.0	0.0
3332. Industrial Machinery Manufacturing	46.8	0.0	52.3	0.0	21.6	9.8	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	31.2	0.0	34.8	0.0	14.4	6.5	0.0	0.0
3359. Other Electrical Equipment and Component Manufacturing	41.6	0.0	49.5	0.0	2.7	1.2	0.0	0.0
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	7.4	0.0	6.6	0.0	2.9	1.3	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	2.5	0.0	2.2	0.0	1.0	0.4	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	6,940.1	0.0	4,848.6	0.0	111.6	16.5	470.4	0.0
3399. Other Miscellaneous Manufacturing	30.9	0.0	27.6	0.0	2.0	0.9	0.5	0.0
Washington								
1111. Oilseed and Grain Farming	0.0	0.0	103.6	0.0	519.3	196.1	146.9	0.0
1112. Vegetable and Melon Farming	0.0	0.0	182.2	0.0	440.6	166.4	124.7	0.0
1113. Fruit and Tree Nut Farming	0.0	0.0	264.9	0.0	520.1	196.4	147.1	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	0.0	361.9	0.0	1,062.3	401.1	300.5	0.0
1121. Cattle Ranching and Farming	0.0	0.0	2,290.6	0.0	5,814.1	2,195.1	1,645.0	0.0
1122. Hog and Pig Farming	0.0	0.0	11.5	0.0	24.8	9.4	7.0	0.0
1123. Poultry and Egg Production	0.0	0.0	148.6	0.0	190.2	71.8	53.8	0.0
1124. Sheep and Goat Farming	0.0	0.0	66.1	0.0	118.4	44.7	33.5	0.0
2123. Nonmetallic Mineral Mining and Quarrying	173.5	0.0	451.3	851.1	951.8	0.0	389.2	0.0
2369. Building Construction (unclassified)	243.3	0.0	384.4	0.0	1,255.6	38.8	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	47.9	0.0	89.7	0.0	1,129.6	147.0	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	1,129.0	0.0	671.3	0.0	5,478.3	190.1	0.0	0.0
3115. Dairy Product Manufacturing	237.9	0.0	106.2	0.0	92.5	4.2	22.6	0.0
3116. Animal Slaughtering and Processing	457.1	0.0	310.8	42.7	136.7	6.2	33.4	0.0
3121. Beverage Manufacturing	263.8	0.0	198.0	0.0	14.9	6.7	29.0	0.0
3131. Fiber, Yarn, and Thread Mills	716.9	0.0	485.8	0.0	10.3	4.7	2.5	0.0
3141. Textile Furnishings Mills	43.3	0.0	10.5	0.4	77.0	2.2	0.0	0.0
3149. Other Textile Product Mills	43.3	0.0	10.5	0.4	77.0	2.2	0.0	0.0
3161. Leather and Hide Tanning and Finishing	51.0	0.0	136.6	0.0	9.9	4.5	2.4	0.0
3219. Other Wood Product Manufacturing	87.9	0.0	179.5	0.0	48.8	22.1	0.0	0.0
3221. Pulp, Paper, and Paperboard Mills	98,812.0	0.0	20,248.3	70,905.3	269.3	201.4	12,568.2	0.0

Table B.1: 2016 CO_2-equivalent greenhouse gas emission by county and industry sector, metric tons CO_2e *(continued)*

County / Sector (NAICS)	Fuel types							
	Natural gas	Other	Net electricity	Coal	Diesel	LPG NGL	Residual fuel oil	Coke and breeze
3231. Printing and Related Support Activities	27.1	0.0	38.8	0.0	2.1	1.0	0.5	0.0
3241. Petroleum and Coal Products Manufacturing	258.2	0.0	32.9	0.0	286.8	6.5	3.5	0.0
3254. Pharmaceutical and Medicine Manufacturing	160.8	0.0	86.1	0.0	125.0	5.7	0.0	0.0
3261. Plastics Product Manufacturing	497.7	0.0	993.7	253.4	5.3	57.5	0.0	0.0
3272. Glass and Glass Product Manufacturing	59.3	0.0	26.5	1.8	11.5	5.2	0.0	0.0
3315. Foundries	13.1	0.0	11.7	0.0	50.8	23.0	12.4	0.0
3323. Architectural and Structural Metals Manufacturing	57.0	0.0	40.2	0.0	11.1	5.0	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	363.0	0.0	229.3	0.0	42.6	22.1	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	42.7	0.0	30.1	0.0	8.3	3.8	0.0	0.0
3331. Agriculture, Construction, and Mining Machinery Manufacturing	159.7	0.0	145.7	0.0	22.4	15.2	0.0	0.0
3332. Industrial Machinery Manufacturing	190.9	0.0	180.5	0.0	36.8	21.7	0.0	0.0
3333. Commercial and Service Industry Machinery Manufacturing	159.7	0.0	145.7	0.0	22.4	15.2	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	31.2	0.0	34.8	0.0	14.4	6.5	0.0	0.0
3359. Other Electrical Equipment and Component Manufacturing	626.4	0.0	740.8	0.0	6.6	9.0	0.0	0.3
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	988.5	0.0	472.8	0.0	40.6	47.4	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	2.5	0.0	2.2	0.0	1.0	0.4	0.0	0.0
3399. Other Miscellaneous Manufacturing	634.9	0.0	563.2	0.0	8.0	9.5	14.6	0.0

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