

# Energy use and resulting greenhouse gas emissions from industry and agriculture in the Long Island 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.

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## 1 Introduction<sup>1</sup>

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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\***Current version:** March 02, 2022; **Corresponding author:** [eric@orebed-analytics.com](mailto:eric@orebed-analytics.com). This report is publicly released under the [Creative Commons Attribution 4.0 International license](#). The accompanying software (used to generate the report) is released under MIT license; see LICENSE.md.

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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)

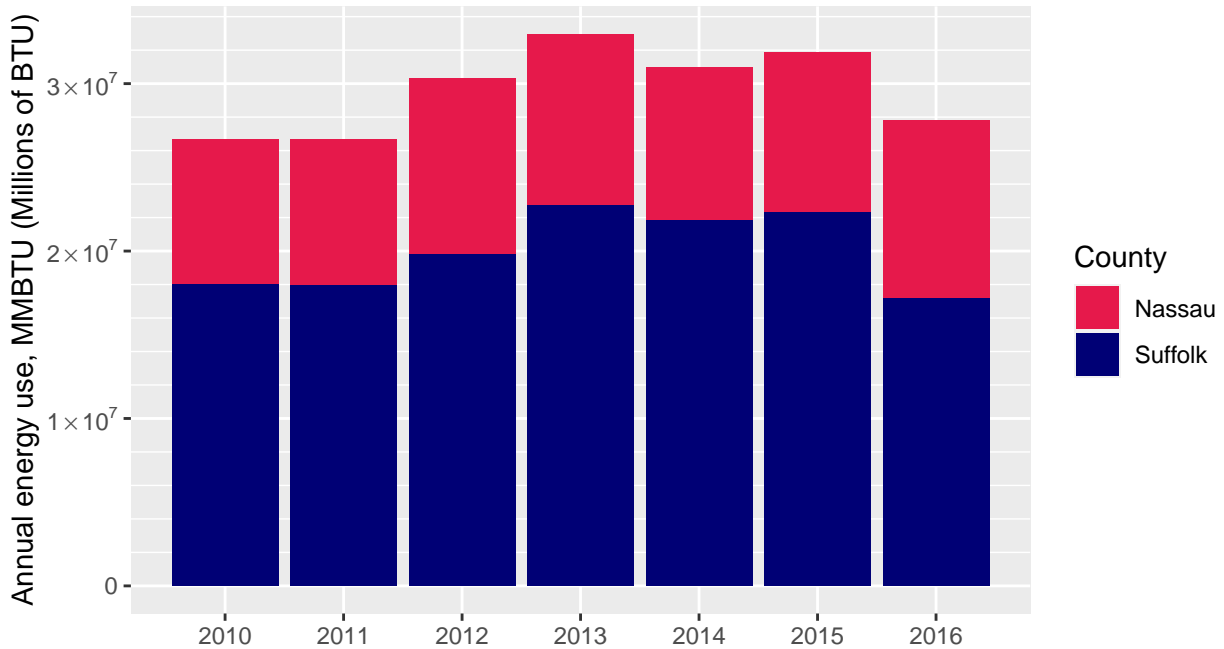
NYcountyEnergyEsts <- Updated_county_energy_estimates %>%
  filter(STATE == "NEW YORK") %>% # Keep only the NEW YORK rows
  left_join(County_FIPS_codes, by = "COUNTY_FIPS") %>% # Add county names
  # We have to do some finagling here. The NREL IEDB dataset contains some records in which
# the NAICS code 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

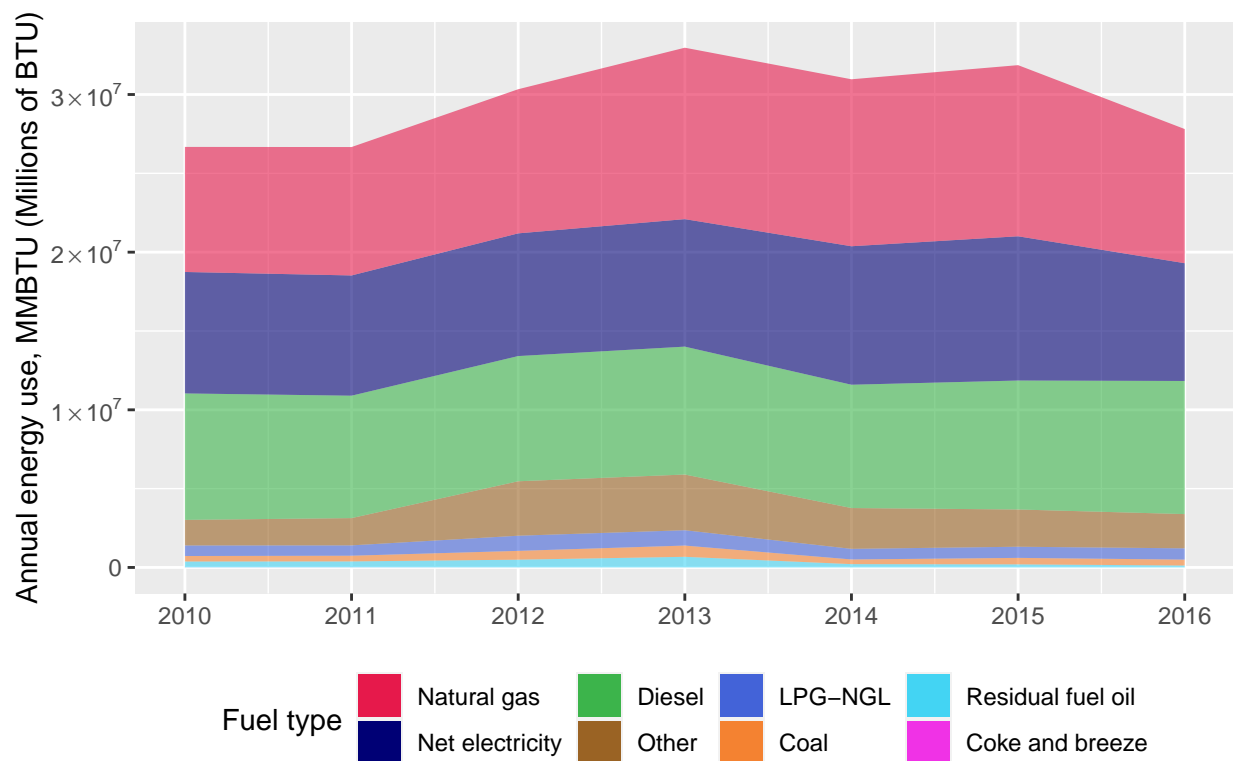
One of the benefits of using the NREL IEDB is the insight it provides into changes in energy use patterns that have occurred in recent years. Figure 4.1 illustrates how industrial and agricultural use changed in each county over the period from 2010 to 2016. Table 4.1 presents the same data in numerical 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
Nassau	8,659,527	8,709,506	10,552,414	10,245,941	9,156,352	9,524,669	10,621,695
Suffolk	18,016,949	17,957,206	19,781,974	22,721,323	21,809,632	22,336,877	17,187,427
Region	26,676,475	26,666,712	30,334,387	32,967,264	30,965,984	31,861,546	27,809,122



**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

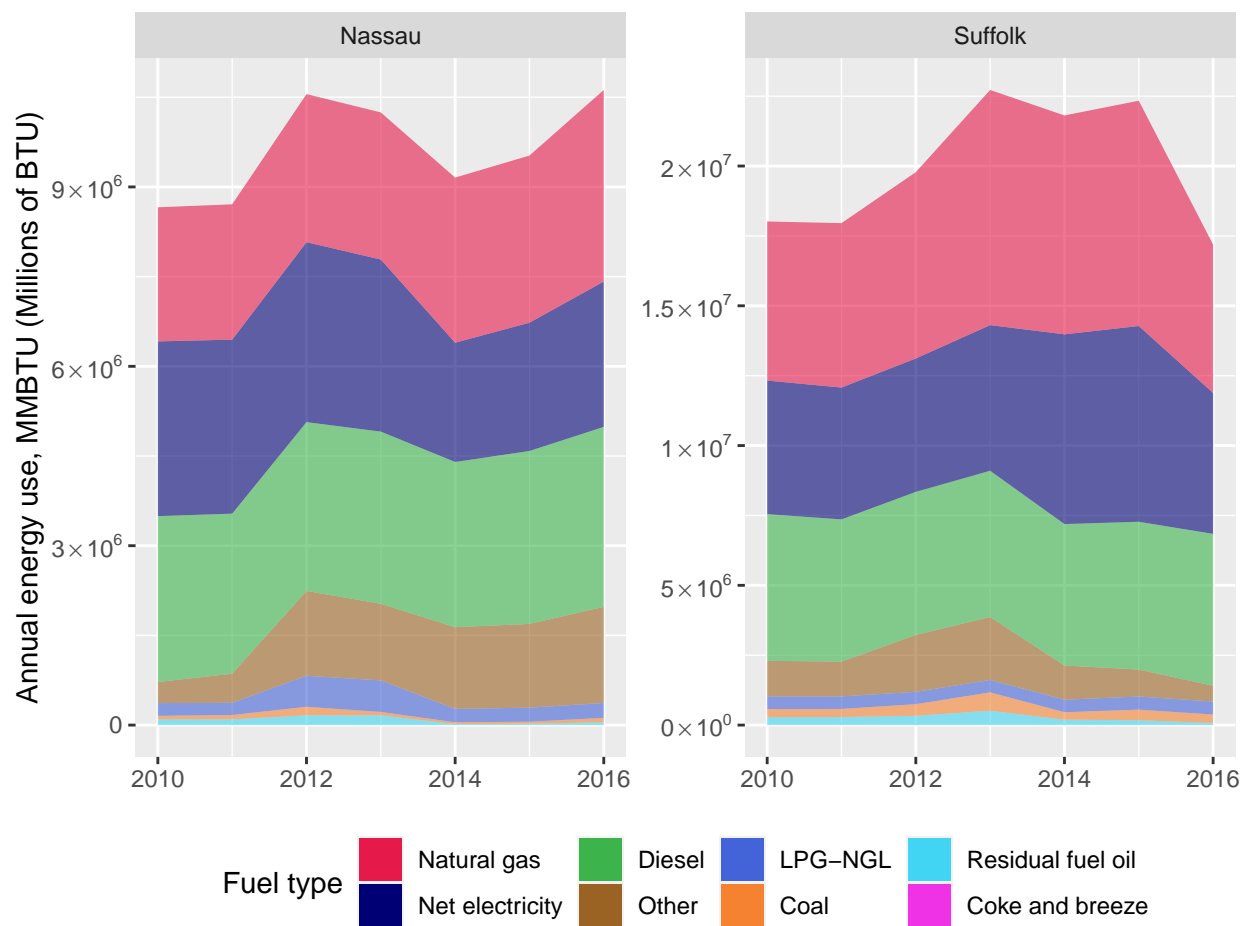
Year	Natural gas	Net electricity	Diesel	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze	Annual totals
2010	7,934,403	7,702,059	8,021,555	1,622,949	669,602	345,760	374,996	5,151	26,676,475
2011	8,144,553	7,626,789	7,762,918	1,731,935	655,011	361,091	379,140	5,276	26,666,712
2012	9,142,637	7,781,750	7,941,912	3,453,713	960,708	559,471	492,498	1,698	30,334,387
2013	10,872,273	8,087,816	8,112,301	3,532,220	973,527	713,510	674,209	1,409	32,967,264
2014	10,591,930	8,782,592	7,821,746	2,589,079	672,364	296,858	211,303	112	30,965,984
2015	10,854,904	9,148,148	8,180,557	2,363,409	706,088	411,930	196,402	107	31,861,546
2016	8,509,693	7,470,882	8,443,672	2,171,209	715,202	373,546	124,813	104	27,809,122
Totals	66,050,393	56,600,036	56,284,662	17,464,513	5,352,502	3,062,166	2,453,361	13,858	207,281,491

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

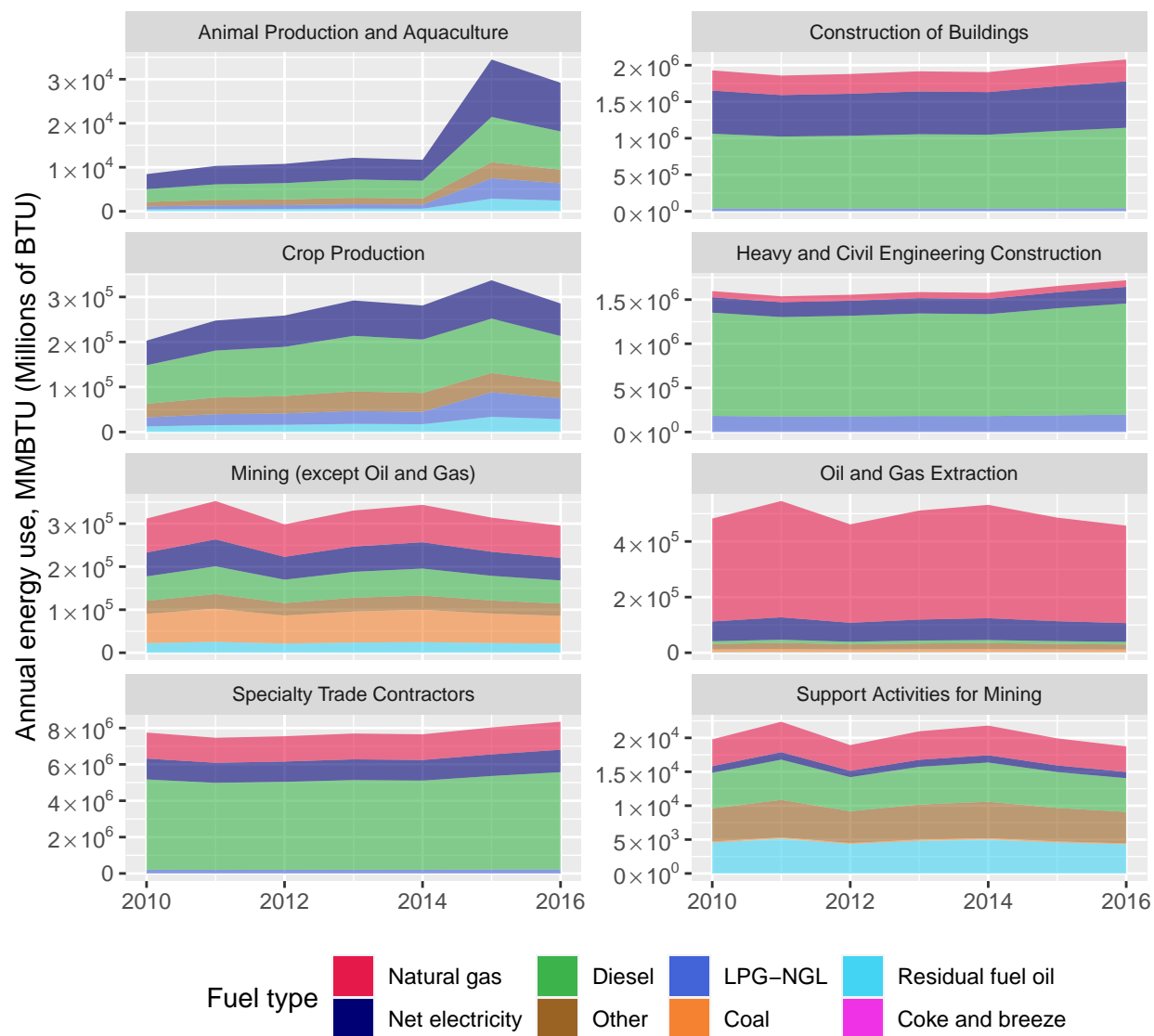
Fuel type	Definition
Coal	Coal: A readily combustible black or brownish-black rock whose composition, including inherent moisture, consists of more than 50 percent by weight and more than 70 percent by volume of carbonaceous material. It is formed from plant remains that have been compacted, hardened, 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



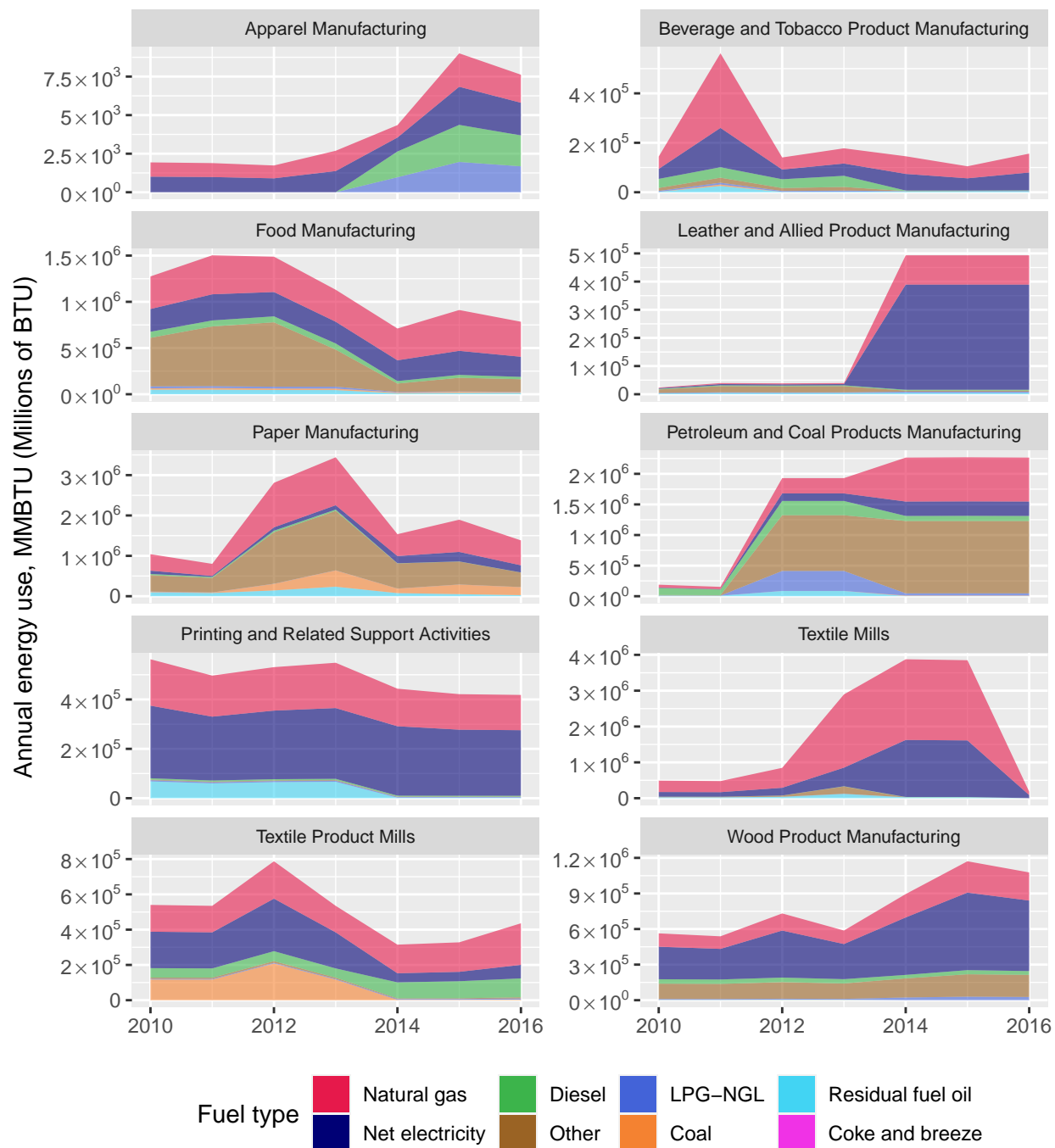


Figure 4.5: Annual energy use by *manufacturing* sector and fuel type, entire region

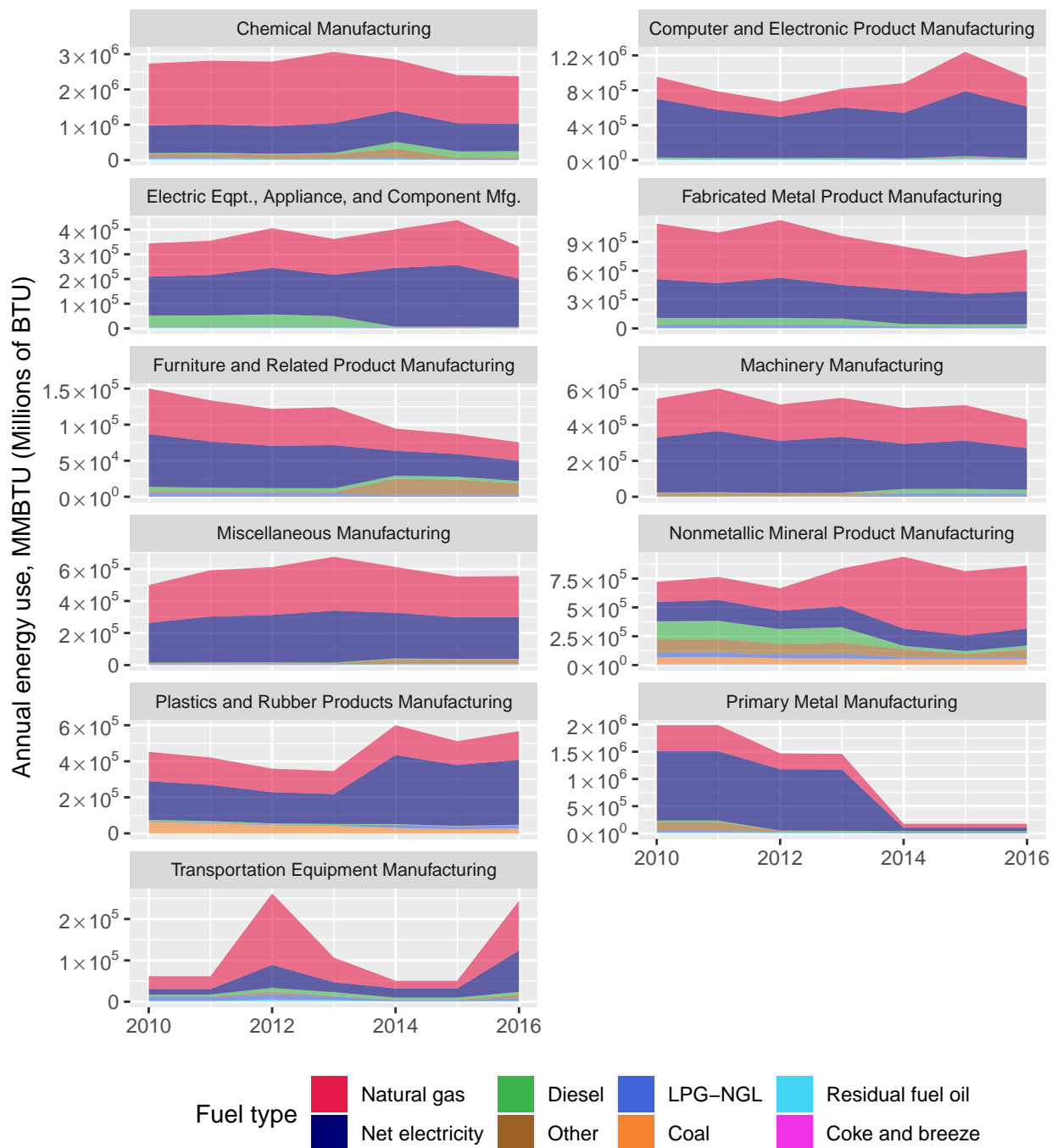


Figure 4.6: Annual energy use by *manufacturing* sector and fuel type, entire region (continued)

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

Sector (NAICS)	Fuel types								Sector totals
	Natural gas	Diesel	Net electricity	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze	
238. Specialty Trade Contractors	1,540,003	5,348,407	1,234,703	0	222,241	0	0	0	8,345,353
325. Chemical Manufacturing	1,336,655	179,094	785,300	53,647	17,636	0	1,326	0	2,373,658
324. Petroleum and Coal Products Manufacturing	718,239	82,495	235,409	1,182,382	36,783	8,147	1,799	0	2,265,253
236. Construction of Buildings	298,468	1,102,551	635,912	0	40,789	0	0	0	2,077,721
237. Heavy and Civil Engineering Construction	74,648	1,259,541	188,375	0	196,303	0	0	0	1,718,866
322. Paper Manufacturing	617,293	2,641	176,483	359,173	1,736	199,963	25,660	0	1,382,948
321. Wood Product Manufacturing	237,235	32,166	594,430	186,283	27,166	44	87	0	1,077,411
334. Computer and Electronic Product Manufacturing	329,503	5,513	591,955	5,201	5,926	0	5,035	0	943,133
327. Nonmetallic Mineral Product Manufacturing	543,802	27,992	148,052	74,180	15,822	50,802	806	38	861,495
332. Fabricated Metal Product Manufacturing	433,781	24,592	342,468	1,140	18,430	0	0	0	820,411
311. Food Manufacturing	378,916	25,367	217,338	137,100	3,315	8,532	13,589	0	784,157
326. Plastics and Rubber Products Manufacturing	157,990	2,392	361,126	804	17,197	27,911	0	0	567,421
339. Miscellaneous Manufacturing	255,143	4,113	261,553	27,087	2,845	0	4,906	0	555,647
316. Leather and Allied Product Manufacturing	104,036	3,036	373,363	3,738	4,071	0	5,031	0	493,275
211. Oil and Gas Extraction	350,142	9,364	67,529	18,331	0	9,855	1,559	0	456,779
314. Textile Product Mills	235,682	107,139	76,617	6,687	6,184	3,694	0	0	436,002
333. Machinery Manufacturing	159,032	21,049	230,955	1,095	17,509	0	0	0	429,640
323. Printing and Related Support Activities	142,820	3,471	265,672	1,537	2,744	0	2,071	0	418,316
335. Electrical Equipment, Appliance, and Component Manufacturing	129,439	2,881	195,538	956	2,103	0	0	54	330,971
212. Mining (except Oil and Gas)	74,713	53,840	52,485	28,578	0	64,447	21,202	0	295,264
111. Crop Production	0	102,335	72,183	36,127	46,275	0	28,515	0	285,435
336. Transportation Equipment Manufacturing	120,118	7,950	100,413	7,450	6,888	0	1,644	0	244,464
313. Textile Mills	94,486	974	86,320	15	528	0	234	0	182,557
331. Primary Metal Manufacturing	70,079	13,075	62,376	16,004	13,235	0	837	13	175,618
312. Beverage and Tobacco Product Manufacturing	76,329	2,301	72,125	344	1,340	0	3,777	0	156,216
337. Furniture and Related Product Manufacturing	25,566	3,704	28,118	15,648	2,515	0	0	0	75,551
112. Animal Production and Aquaculture	0	8,712	11,044	3,076	3,940	0	2,428	0	29,199
213. Support Activities for Mining	3,758	4,975	923	4,626	0	152	4,305	0	18,739

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

Sector (NAICS)	Fuel types								Sector totals
	Natural gas	Diesel	Net electricity	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze	
315. Apparel Manufacturing	1,819	2,004	2,116	0	1,682	0	0	0	7,621
Totals	8,509,693	8,443,672	7,470,882	2,171,209	715,202	373,546	124,813	104	27,809,122

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

Sector (NAICS)	County		Sector totals
	Suffolk	Nassau	
238. Specialty Trade Contractors	5,261,562	3,083,791	8,345,353
325. Chemical Manufacturing	2,153,225	220,433	2,373,658
324. Petroleum and Coal Products Manufacturing	29,223	2,236,030	2,265,253
236. Construction of Buildings	1,189,246	888,475	2,077,721
237. Heavy and Civil Engineering Construction	1,251,501	467,366	1,718,866
322. Paper Manufacturing	870,635	512,313	1,382,948
321. Wood Product Manufacturing	846,002	231,408	1,077,411
334. Computer and Electronic Product Manufacturing	633,841	309,292	943,133
327. Nonmetallic Mineral Product Manufacturing	849,109	12,386	861,495
332. Fabricated Metal Product Manufacturing	455,574	364,838	820,411
311. Food Manufacturing	164,155	620,002	784,157
326. Plastics and Rubber Products Manufacturing	395,043	172,378	567,421
339. Miscellaneous Manufacturing	493,606	62,041	555,647
316. Leather and Allied Product Manufacturing	483,905	9,370	493,275
211. Oil and Gas Extraction	108,628	348,151	456,779
314. Textile Product Mills	240,819	195,183	436,002
333. Machinery Manufacturing	280,061	149,578	429,640
323. Printing and Related Support Activities	296,617	121,699	418,316
335. Electrical Equipment, Appliance, and Component Manufacturing	237,530	93,441	330,971
212. Mining (except Oil and Gas)	276,355	18,909	295,264
111. Crop Production	268,061	17,375	285,435
336. Transportation Equipment Manufacturing	38,424	206,040	244,464
313. Textile Mills	65,199	117,358	182,557
331. Primary Metal Manufacturing	64,907	110,712	175,618
312. Beverage and Tobacco Product Manufacturing	136,928	19,288	156,216
337. Furniture and Related Product Manufacturing	50,720	24,831	75,551
112. Animal Production and Aquaculture	26,354	2,845	29,199
213. Support Activities for Mining	18,739	0	18,739
315. Apparel Manufacturing	1,458	6,163	7,621

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

Sector (NAICS)	County		Sector totals
	Suffolk	Nassau	
Totals	17,187,427	10,621,695	27,809,122

## 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<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O generated are provided per mmBTU for each fuel type, the calculations are quite straightforward, although the assumptions underlying them warrant a degree of scrutiny.<sup>2</sup>

- 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 hydroelectric 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

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<sup>2</sup>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 <sub>2</sub> , kg per mmBTU	CH <sub>4</sub> , g per mmBTU	N <sub>2</sub> O, g per mmBTU	CO <sub>2</sub> -equivalent emissions, kgCO <sub>2</sub> 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;<sup>3</sup> the emission factors used to compute each county’s emissions are those for the eGRID subregion in which the county is located.

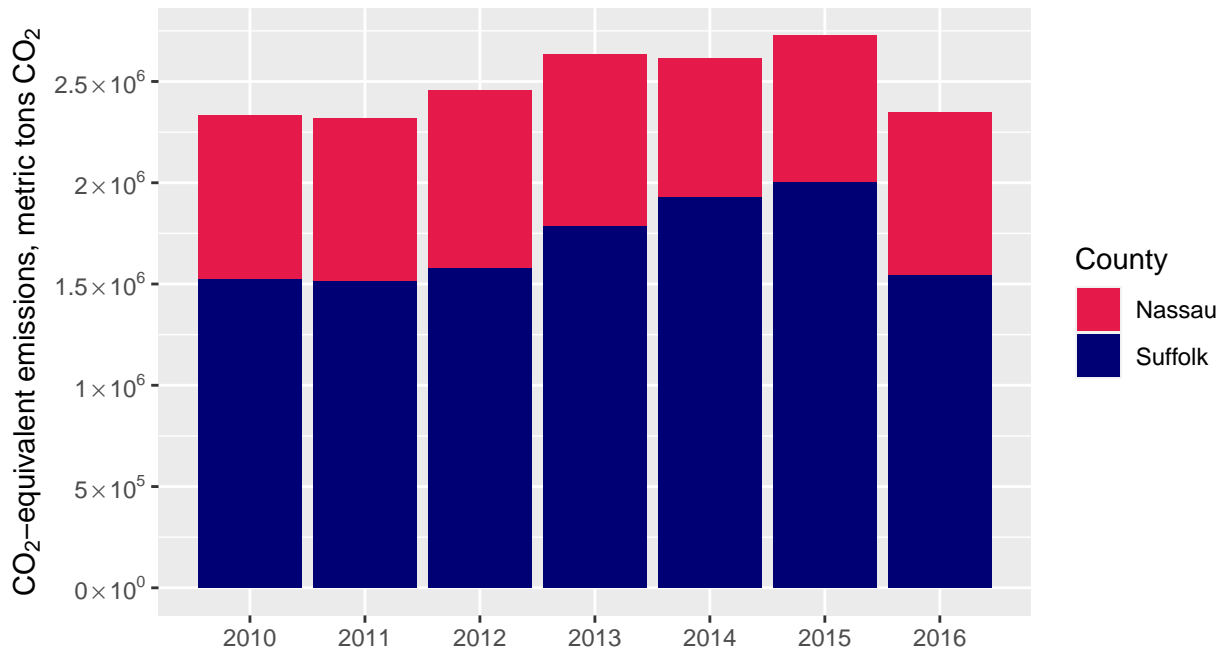
The greenhouse gas emission quantities in this report are presented in terms of “CO<sub>2</sub>-equivalent emissions,” weighting emissions of other greenhouse gases based on their marginal impact on radiative forcing compared to that of an equivalent incremental concentration of CO<sub>2</sub> [13]. 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<sub>2</sub> 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<sub>2</sub> itself accounts for about 99.5% of the CO<sub>2</sub>-equivalent agricultural and industrial greenhouse gas emissions of the Long Island Region; methane and nitrous oxide constitute an almost negligible fraction of these emissions.<sup>4</sup>

## 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 CO<sub>2</sub>-equivalent per person – across all sectors – with the largest fractions resulting from transportation (37%) and from commercial (18%) and residential

<sup>3</sup>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.

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



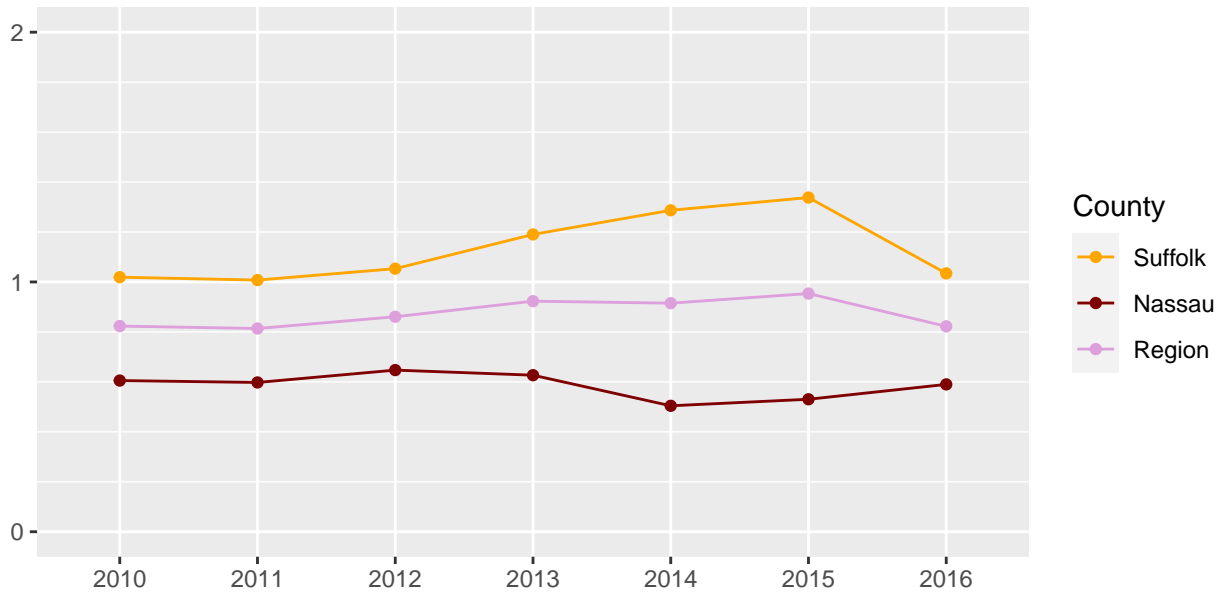
**Figure 5.1:** Annual CO<sub>2</sub>-equivalent agricultural/industrial emissions, metric tons

(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<sub>2</sub>-equivalent emissions (metric tons) by county

County	2010	2011	2012	2013	2014	2015	2016
Nassau	812,197	804,973	874,067	848,824	684,626	721,109	803,138
Suffolk	1,523,350	1,511,549	1,579,211	1,786,421	1,930,361	2,004,109	1,543,858
Region	2,335,547	2,316,522	2,453,278	2,635,245	2,614,986	2,725,218	2,346,995

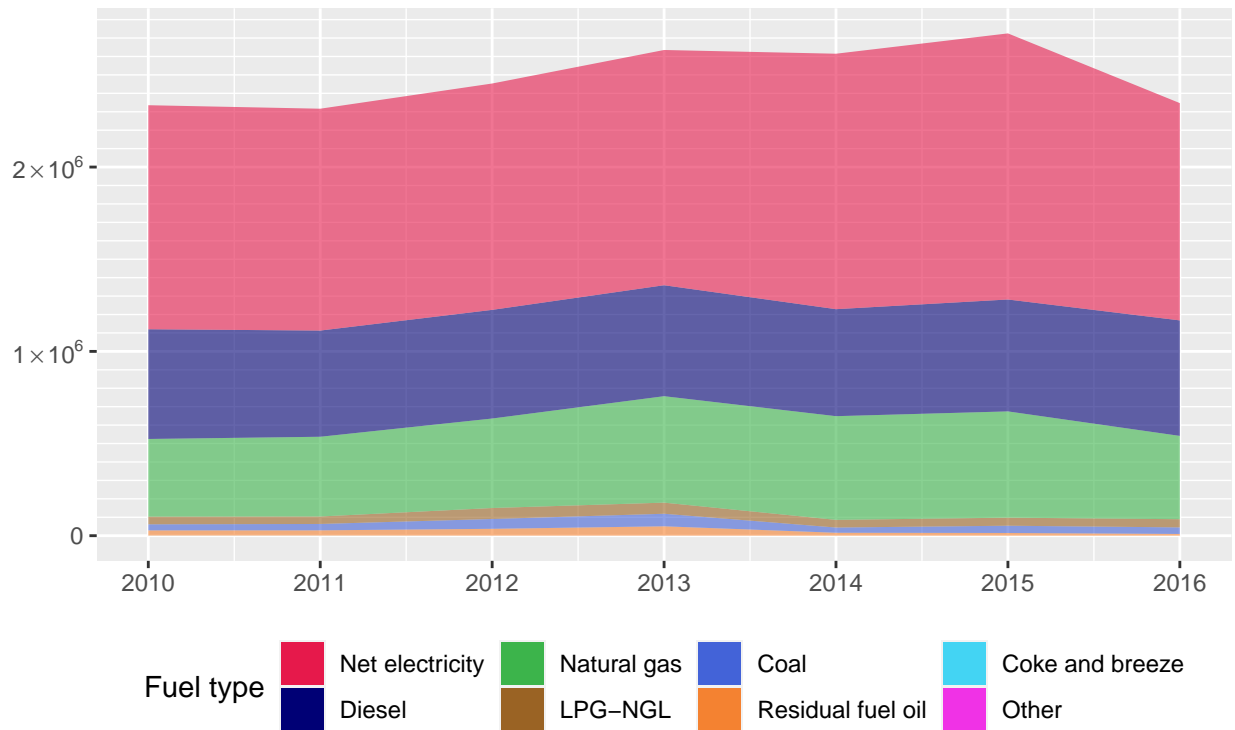




**Figure 5.2:** CO<sub>2</sub>-equivalent agricultural/industrial emissions per capita, metric tons

**Table 5.3:** CO<sub>2</sub>-equivalent agricultural/industrial GHG emissions per capita, metric tons

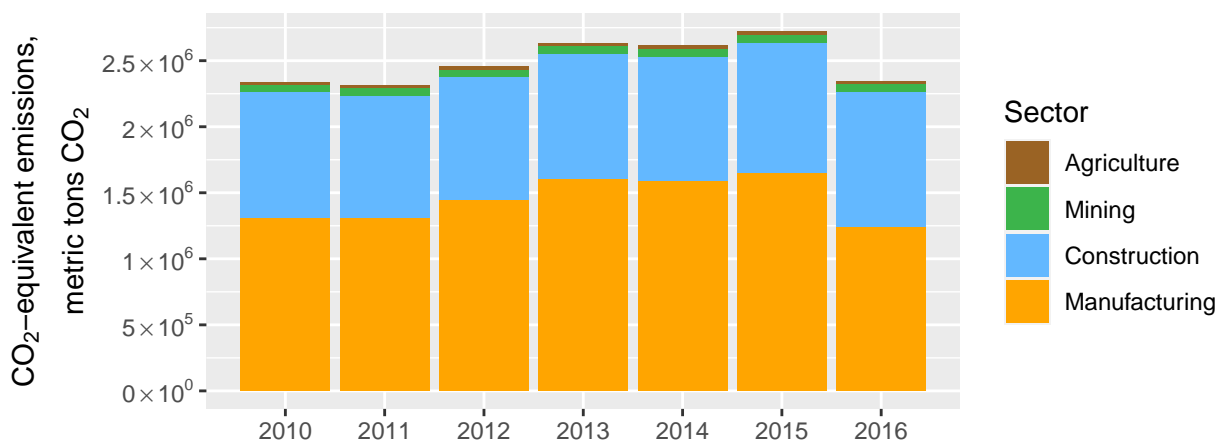
County	2010	2011	2012	2013	2014	2015	2016
Suffolk	1.02	1.01	1.05	1.19	1.29	1.34	1.03
Nassau	0.61	0.60	0.65	0.63	0.50	0.53	0.59
Region	0.82	0.81	0.86	0.92	0.92	0.95	0.82



**Figure 5.3:** CO<sub>2</sub>-equivalent agricultural/industrial emissions per fuel type, metric tons

As Figure 5.3 illustrates, emissions from coal were about 1% of the region's total industrial and agricultural greenhouse gas emissions in 2010, but about 2% by 2016.

### 5.3 Sector analysis







**Figure 5.4:** CO<sub>2</sub>-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.<sup>5</sup>

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

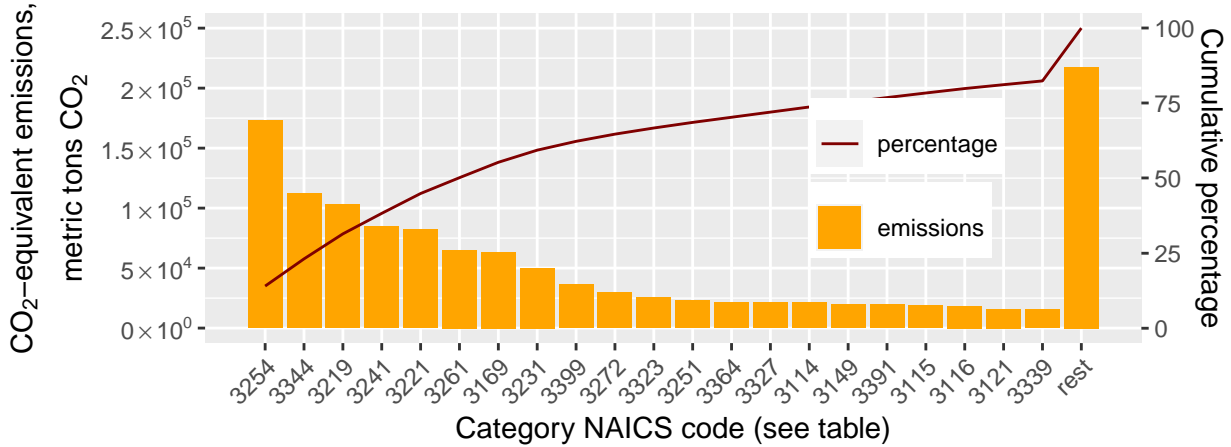
<sup>5</sup>The County distribution column employs a variant of the sparklines popularized by Edward Tufte [23] to graphically display the approximate geographic breakdown of emissions; the order of the bars corresponds to the order of the county columns to the right.

**Table 5.4:** 2016 CO<sub>2</sub>-equivalent GHG emissions per sector and county, metric tons CO<sub>2</sub>

Sector	County distribution	Nassau	Suffolk
Manufacturing		400,208	836,679
Construction		377,636	649,597
Mining		23,564	32,490
Agriculture		1,728	25,089

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

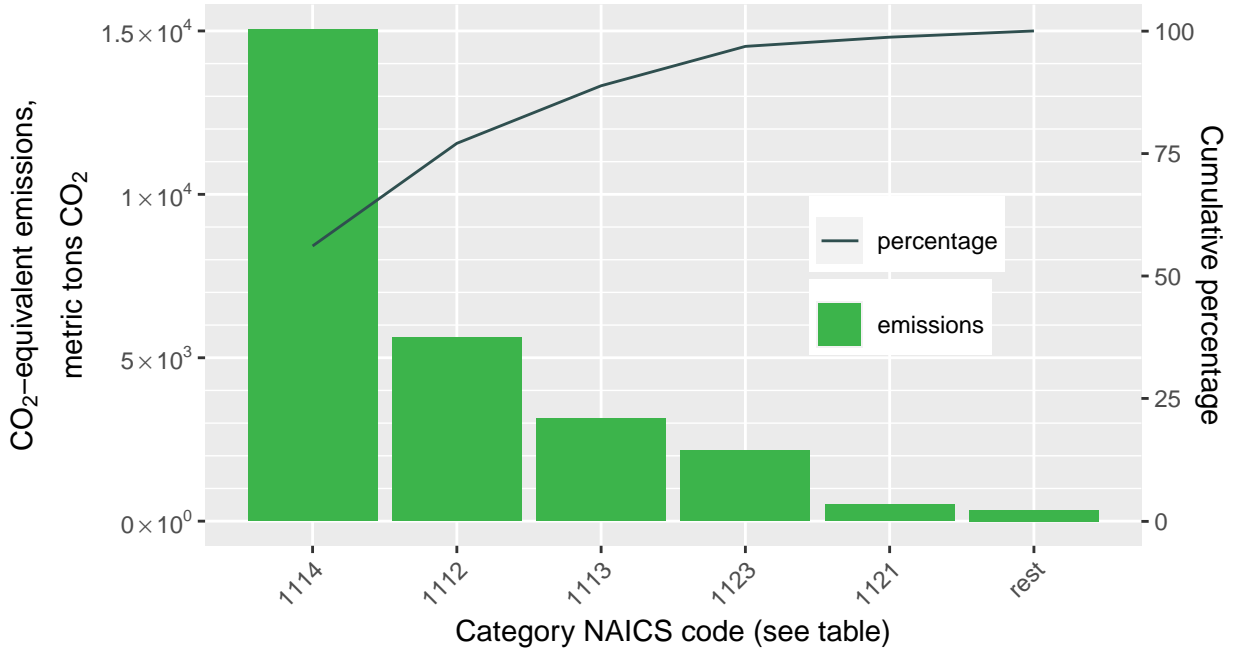


**Figure 5.5:** Manufacturing categories with highest CO<sub>2</sub>-equivalent GHG emissions

**Table 5.5:** Manufacturing categories with highest CO<sub>2</sub>-equivalent GHG emissions

NAICS	Manufacturing category	CO <sub>2</sub> -equivalent emissions, tonnes	County distribution	Principal counties
3254	Pharmaceutical and Medicine Manufacturing	173,285	-	Suffolk
3344	Semiconductor and Other Electronic Component Manufacturing	112,074	-	Suffolk, Nassau
3219	Other Wood Product Manufacturing	103,157	-	Suffolk, Nassau
3241	Petroleum and Coal Products Manufacturing	84,613	-	Nassau
3221	Pulp, Paper, and Paperboard Mills	81,956	-	Suffolk, Nassau
3261	Plastics Product Manufacturing	65,140	-	Suffolk, Nassau
3169	Other Leather and Allied Product Manufacturing	63,458	-	Suffolk
3231	Printing and Related Support Activities	50,095	-	Suffolk, Nassau
3399	Other Miscellaneous Manufacturing	36,323	-	Suffolk
3272	Glass and Glass Product Manufacturing	29,765	-	Suffolk
3323	Architectural and Structural Metals Manufacturing	25,203	-	Suffolk, Nassau
3251	Basic Chemical Manufacturing	23,088	-	Suffolk, Nassau
3364	Aerospace Product and Parts Manufacturing	21,312	-	Nassau, Suffolk
3327	Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	21,154	-	Suffolk, Nassau
3114	Fruit and Vegetable Preserving and Specialty Food Manufacturing	21,089	-	Nassau, Suffolk
3149	Other Textile Product Mills	19,534	-	Suffolk, Nassau
3391	Medical Equipment and Supplies Manufacturing	19,355	-	Suffolk, Nassau
3115	Dairy Product Manufacturing	18,911	-	Nassau, Suffolk
3116	Animal Slaughtering and Processing	18,349	-	Nassau, Suffolk
3121	Beverage Manufacturing	15,974	-	Suffolk, Nassau
3339	Other General Purpose Machinery Manufacturing	15,444	-	Suffolk, Nassau
0	Remaining manufacturing categories	217,596	-	Suffolk, Nassau

### 5.3.2 Agriculture

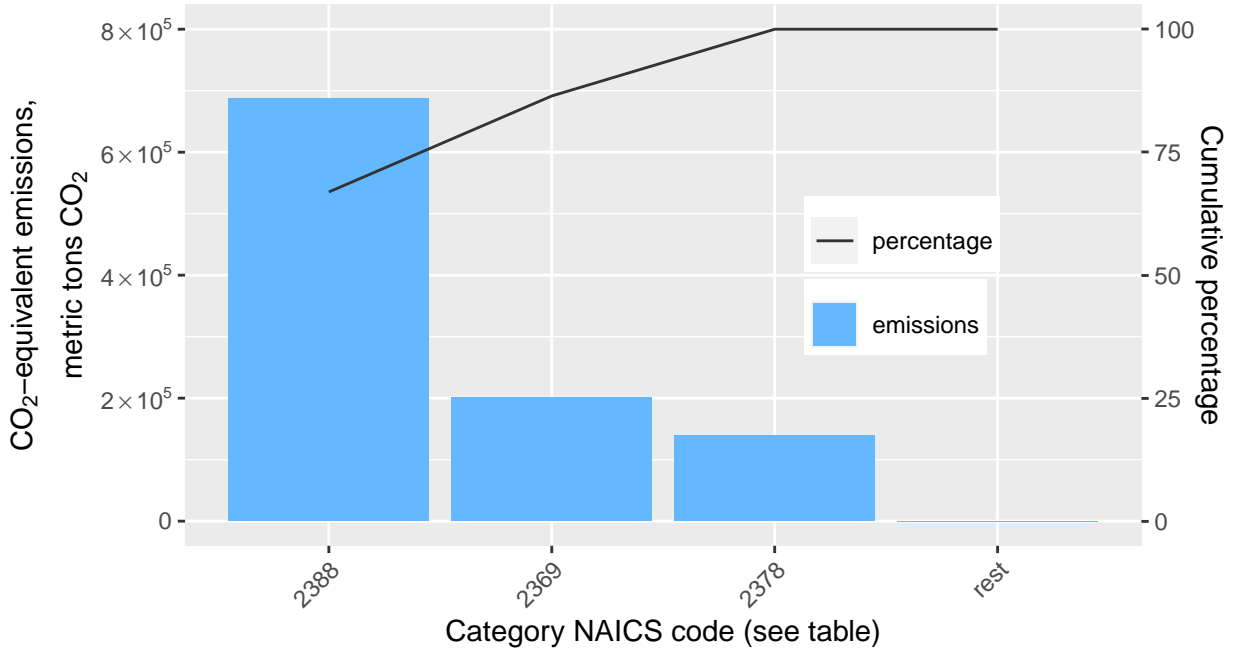


**Figure 5.6:** Agriculture categories with highest CO<sub>2</sub>-equivalent GHG emissions

**Table 5.6:** Agricultural categories with highest CO<sub>2</sub>-equivalent GHG emissions

NAICS	Agriculture category	CO <sub>2</sub> -equivalent emissions, tonnes	County distribution	Principal counties
1114	Greenhouse, Nursery, and Floriculture Production	15,052	■ - ■	Suffolk
1112	Vegetable and Melon Farming	5,617	■ - ■	Suffolk
1113	Fruit and Tree Nut Farming	3,149	■ - ■	Suffolk
1123	Poultry and Egg Production	2,154	■ - ■	Suffolk, Nassau
1121	Cattle Ranching and Farming	502	■ - ■	Suffolk
0	Remaining agriculture categories	341	■ - ■	Suffolk

### 5.3.3 Construction

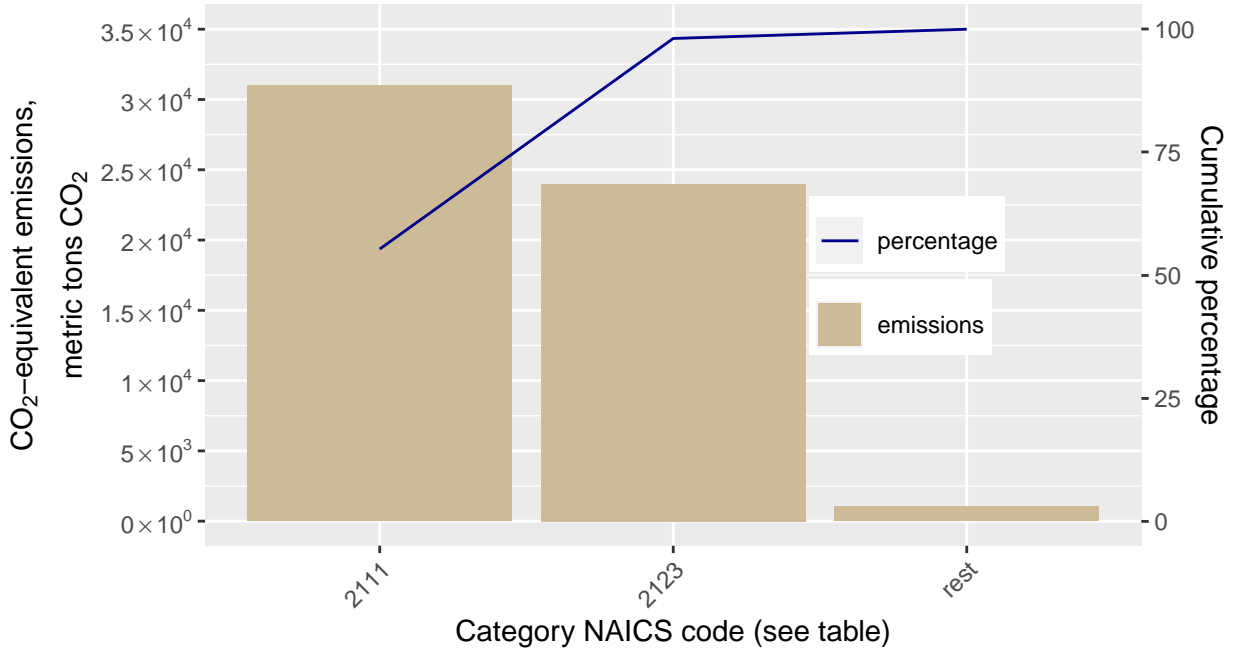


**Figure 5.7:** Construction categories with CO<sub>2</sub>-equivalent GHG emissions

**Table 5.7:** Construction categories with CO<sub>2</sub>-equivalent GHG emissions

NAICS	Construction category	CO <sub>2</sub> -equivalent emissions, tonnes	County distribution	Principal counties
2388	Specialty Trade Contractors (unclassified)	687,343	■ ■ ■	Suffolk, Nassau
2369	Building Construction (unclassified)	200,559	■ ■ ■	Suffolk, Nassau
2378	Heavy and Civil Engineering Construction (unclassified)	139,331	■ ■ ■	Suffolk, Nassau
0	Remaining construction categories	0		

### 5.3.4 Mining



**Figure 5.8:** Mining categories with CO<sub>2</sub>-equivalent GHG emissions

**Table 5.8:** Mining categories with CO<sub>2</sub>-equivalent GHG emissions

NAICS Mining category		CO <sub>2</sub> -equivalent emissions, tonnes	County distribution	Principal counties
2111	Oil and Gas Extraction	31,007	■ ■ ■	Nassau, Suffolk
2123	Nonmetallic Mineral Mining and Quarrying	23,993	■ ■ ■	Suffolk
0	Remaining mining categories	1,053	■ ■ ■	Suffolk

## 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](https://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 <sub>2</sub> Factor, kg CO <sub>2</sub> per mmBtu	CH <sub>4</sub> Factor, g CH <sub>4</sub> per mmBtu	N <sub>2</sub> O Factor, g N <sub>2</sub> O per mmBtu	CO <sub>2</sub> Factor, kg CO <sub>2</sub> per gallon	CH <sub>4</sub> Factor, g CH <sub>4</sub> per gallon	N <sub>2</sub> O Factor, g N <sub>2</sub> O 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	0.125	71.02	3.0	0.60	8.88	0.38	0.08
Feedstocks							
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 <sub>2</sub> Factor, kg CO <sub>2</sub> per mmBtu	CH <sub>4</sub> Factor, g CH <sub>4</sub> per mmBtu	N <sub>2</sub> O Factor, g N <sub>2</sub> O per mmBtu	CO <sub>2</sub> Factor, kg CO <sub>2</sub> per short ton	CH <sub>4</sub> Factor, g CH <sub>4</sub> per short ton	N <sub>2</sub> O Factor, g N <sub>2</sub> O 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 <sub>2</sub> Factor, kg CO <sub>2</sub> per mmBtu	CH <sub>4</sub> Factor, g CH <sub>4</sub> per mmBtu	N <sub>2</sub> O Factor, g N <sub>2</sub> O per mmBtu	CO <sub>2</sub> Factor, kg CO <sub>2</sub> per scf	CH <sub>4</sub> Factor, g CH <sub>4</sub> per scf	N <sub>2</sub> O Factor, g N <sub>2</sub> O 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 <sub>2</sub> Factor, (kg / MWh)	CH <sub>4</sub> Factor, (g / MWh)	N <sub>2</sub> O Factor, (g / MWh)	CO <sub>2</sub> Factor, (kg / MWh)	CH <sub>4</sub> Factor, (g / MWh)	N <sub>2</sub> O 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 <sub>2</sub>	1	HFC-236ea	1370
CH <sub>4</sub>	25	HFC-236fa	9810
N <sub>2</sub> O	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 <sub>6</sub>	22800
HFC-134	1100	NF <sub>3</sub>	17200
HFC-134a	1430	CF <sub>4</sub>	7390
HFC-143	353	C <sub>2</sub> F <sub>6</sub>	12200
HFC-143a	4470	C <sub>3</sub> F <sub>8</sub>	8830
HFC-152	53	c-C <sub>4</sub> F <sub>8</sub>	10300
HFC-152a	124	C <sub>4</sub> F <sub>10</sub>	8860
HFC-161	12	C <sub>5</sub> F <sub>12</sub>	9160
HFC-227ea	3220	C <sub>6</sub> F <sub>14</sub>	9300
HFC-236cb	1340	C <sub>10</sub> F <sub>18</sub>	>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<sub>2</sub>-equivalent greenhouse gas emission by county and industry sector, metric tons CO<sub>2</sub>e

County / Sector (NAICS)	Fuel types							
	Natural gas	Diesel	Net electricity	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze
<b>Nassau</b>								
1112. Vegetable and Melon Farming	0.0	27.5	45.6	0.0	10.4	0.0	7.8	0.0
1113. Fruit and Tree Nut Farming	0.0	47.3	96.5	0.0	17.9	0.0	13.4	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	391.4	534.1	0.0	147.8	0.0	110.7	0.0
1121. Cattle Ranching and Farming	0.0	9.7	13.7	0.0	3.7	0.0	2.7	0.0
1123. Poultry and Egg Production	0.0	51.9	162.4	0.0	19.6	0.0	14.7	0.0
2111. Oil and Gas Extraction	14,741.4	591.6	5,678.2	0.0	0.0	940.4	102.0	0.0
2123. Nonmetallic Mineral Mining and Quarrying	85.9	458.9	667.6	0.0	0.0	194.5	103.7	0.0
2369. Building Construction (unclassified)	6,779.1	34,989.8	42,913.5	0.0	1,080.8	0.0	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	1,078.1	25,416.2	8,083.1	0.0	3,307.3	0.0	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	30,225.8	146,672.7	72,001.4	0.0	5,088.6	0.0	0.0	0.0
3114. Fruit and Vegetable Preserving and Specialty Food Manufacturing	7,725.0	75.9	8,820.3	0.0	61.0	188.9	8.8	0.0
3115. Dairy Product Manufacturing	5,494.9	503.9	9,767.2	0.0	51.7	0.0	746.4	0.0
3116. Animal Slaughtering and Processing	2,913.6	407.3	6,827.6	0.0	23.0	443.3	50.1	0.0
3121. Beverage Manufacturing	474.8	26.7	1,427.5	0.0	12.1	0.0	52.3	0.0
3132. Fabric Mills	1,433.9	20.6	3,892.1	0.0	9.3	0.0	5.0	0.0
3133. Textile and Fabric Finishing and Fabric Coating Mills	1,792.4	25.8	4,865.1	0.0	11.7	0.0	6.3	0.0
3141. Textile Furnishings Mills	5,067.7	1,858.5	4,888.9	0.0	131.7	165.9	0.0	0.0
3149. Other Textile Product Mills	736.5	1,308.8	715.0	0.0	37.0	6.4	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	83.9	99.2	288.4	0.0	81.8	0.0	0.0	0.0
3159. Apparel Accessories and Other Apparel Manufacturing	0.8	3.2	2.9	0.0	1.4	0.0	0.0	0.0
3161. Leather and Hide Tanning and Finishing	51.0	9.9	547.1	0.0	4.5	0.0	2.4	0.0
3169. Other Leather and Allied Product Manufacturing	51.0	9.9	547.1	0.0	4.5	0.0	2.4	0.0
3211. Sawmills and Wood Preservation	193.5	107.5	593.2	0.0	4.9	1.7	2.6	0.0
3219. Other Wood Product Manufacturing	2,574.5	465.2	20,934.5	0.0	381.4	0.0	0.0	0.0
3221. Pulp, Paper, and Paperboard Mills	9,599.1	113.1	9,363.7	0.0	51.2	3,533.5	1,933.6	0.0
3231. Printing and Related Support Activities	2,177.0	93.6	12,229.8	0.0	55.0	0.0	46.9	0.0
3241. Petroleum and Coal Products Manufacturing	37,374.6	5,262.0	36,754.4	0.0	2,259.7	777.4	125.0	0.0
3251. Basic Chemical Manufacturing	328.2	31.9	2,641.0	0.0	14.4	0.0	0.0	0.0
3252. Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	701.3	34.1	1,254.2	0.0	15.4	0.0	8.3	0.0
3253. Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	26.7	103.7	95.4	0.0	46.9	0.0	25.3	0.0

**Table B.1:** 2016 CO<sub>2</sub>-equivalent greenhouse gas emission by county and industry sector, metric tons CO<sub>2</sub>e (*continued*)

County / Sector (NAICS)	Fuel types							
	Natural gas	Diesel	Net electricity	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze
3254. Pharmaceutical and Medicine Manufacturing	4,359.0	1,512.9	7,697.5	0.0	44.0	0.0	0.0	0.0
3259. Other Chemical Product and Preparation Manufacturing	168.4	65.5	602.3	0.0	29.6	0.0	16.0	0.0
3261. Plastics Product Manufacturing	2,360.8	49.9	16,979.6	0.0	304.9	660.3	0.0	0.0
3262. Rubber Product Manufacturing	101.2	4.9	814.8	0.0	22.3	13.8	0.0	0.0
3272. Glass and Glass Product Manufacturing	407.0	38.6	603.6	0.0	17.5	1.8	0.0	0.0
3312. Steel Product Manufacturing from Purchased Steel	421.0	32.7	602.3	0.0	14.8	0.0	0.0	0.0
3313. Alumina and Aluminum Production and Processing	1,079.1	414.6	2,054.1	0.0	507.0	0.0	0.0	0.0
3314. Nonferrous Metal (except Aluminum) Production and Processing	31.2	121.3	1,116.5	0.0	55.0	0.0	0.0	0.0
3315. Foundries	575.4	133.7	1,697.5	0.0	122.0	0.0	12.4	1.5
3321. Forging and Stamping	71.2	13.8	201.1	0.0	6.3	0.0	0.0	0.0
3322. Cutlery and Handtool Manufacturing	3,232.1	67.1	4,894.8	0.0	77.8	0.0	0.0	0.0
3323. Architectural and Structural Metals Manufacturing	3,687.8	155.7	6,181.6	0.0	117.9	0.0	0.0	0.0
3324. Boiler, Tank, and Shipping Container Manufacturing	725.8	30.0	2,036.5	0.0	33.2	0.0	0.0	0.0
3325. Hardware Manufacturing	14.2	2.8	40.2	0.0	1.3	0.0	0.0	0.0
3326. Spring and Wire Product Manufacturing	28.5	5.5	80.4	0.0	2.5	0.0	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	1,153.0	113.0	3,242.9	0.0	70.9	0.0	0.0	0.0
3328. Coating, Engraving, Heat Treating, and Allied Activities	1,060.3	67.1	2,874.7	0.0	52.8	0.0	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	1,074.5	69.9	2,914.9	0.0	54.1	0.0	0.0	0.0
3331. Agriculture, Construction, and Mining Machinery Manufacturing	15.6	7.2	69.8	0.0	3.3	0.0	0.0	0.0
3332. Industrial Machinery Manufacturing	579.2	79.9	2,575.2	0.0	69.4	0.0	0.0	0.0
3333. Commercial and Service Industry Machinery Manufacturing	62.4	28.8	279.1	0.0	13.1	0.0	0.0	0.0
3334. Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	723.3	95.0	3,089.0	0.0	81.3	0.0	0.0	0.0
3335. Metalworking Machinery Manufacturing	109.3	50.4	488.5	0.0	22.8	0.0	0.0	0.0
3336. Engine, Turbine, and Power Transmission Equipment Manufacturing	548.0	65.5	2,435.6	0.0	62.8	0.0	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	929.8	139.0	3,881.9	0.0	106.3	0.0	0.0	0.0
3344. Semiconductor and Other Electronic Component Manufacturing	5,179.2	117.5	32,220.7	0.0	121.5	0.0	176.0	0.0
3351. Electric Lighting Equipment Manufacturing	594.5	24.8	2,571.0	0.0	12.6	0.0	0.0	0.6

**Table B.1:** 2016 CO<sub>2</sub>-equivalent greenhouse gas emission by county and industry sector, metric tons CO<sub>2</sub>e (*continued*)

County / Sector (NAICS)	Fuel types							
	Natural gas	Diesel	Net electricity	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze
3353. Electrical Equipment Manufacturing	1,096.1	23.4	4,943.2	0.0	17.9	0.0	0.0	0.8
3359. Other Electrical Equipment and Component Manufacturing	249.6	16.2	1,190.3	0.0	7.3	0.0	0.0	0.3
3361. Motor Vehicle Manufacturing	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3364. Aerospace Product and Parts Manufacturing	5,887.8	398.7	12,031.4	0.0	340.2	0.0	77.1	0.0
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	189.9	56.7	637.7	0.0	27.4	0.0	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	224.7	35.9	679.4	0.0	21.3	0.0	0.0	0.0
3379. Other Furniture Related Product Manufacturing	70.7	10.4	211.7	0.0	6.4	0.0	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	726.9	38.3	2,473.1	0.0	18.2	0.0	8.4	0.0
3399. Other Miscellaneous Manufacturing	710.2	46.0	2,540.2	0.0	20.8	0.0	11.2	0.0
<b>Suffolk</b>								
1111. Oilseed and Grain Farming	0.0	74.2	59.3	0.0	28.0	0.0	21.0	0.0
1112. Vegetable and Melon Farming	0.0	1,666.0	2,759.4	0.0	629.0	0.0	471.4	0.0
1113. Fruit and Tree Nut Farming	0.0	803.7	1,640.2	0.0	303.5	0.0	227.4	0.0
1114. Greenhouse, Nursery, and Floriculture Production	0.0	4,584.5	6,256.2	0.0	1,730.9	0.0	1,297.1	0.0
1121. Cattle Ranching and Farming	0.0	144.8	232.7	0.0	54.7	0.0	41.0	0.0
1122. Hog and Pig Farming	0.0	15.5	28.8	0.0	5.9	0.0	4.4	0.0
1123. Poultry and Egg Production	0.0	397.8	1,245.0	0.0	150.2	0.0	112.5	0.0
1124. Sheep and Goat Farming	0.0	26.9	60.2	0.0	10.2	0.0	7.6	0.0
2111. Oil and Gas Extraction	3,856.3	103.3	4,978.6	0.0	0.0	0.0	15.5	0.0
2123. Nonmetallic Mineral Mining and Quarrying	3,882.4	3,536.7	7,615.1	0.0	0.0	5,955.1	1,494.0	0.0
2131. Support Activities for Mining	199.6	369.2	145.7	0.0	0.0	14.5	324.4	0.0
2369. Building Construction (unclassified)	9,074.0	46,834.7	57,440.7	0.0	1,446.7	0.0	0.0	0.0
2378. Heavy and Civil Engineering Construction (unclassified)	2,886.8	68,059.1	21,644.7	0.0	8,856.3	0.0	0.0	0.0
2388. Specialty Trade Contractors (unclassified)	51,571.2	250,252.9	122,848.7	0.0	8,682.2	0.0	0.0	0.0
3114. Fruit and Vegetable Preserving and Specialty Food Manufacturing	1,450.3	71.4	2,626.6	0.0	32.3	11.2	17.4	0.0
3115. Dairy Product Manufacturing	713.7	277.4	1,276.3	0.0	12.6	0.0	67.8	0.0
3116. Animal Slaughtering and Processing	1,828.4	546.7	4,980.3	0.0	24.8	170.8	133.6	0.0
3121. Beverage Manufacturing	3,579.4	144.0	9,954.7	0.0	70.9	0.0	232.3	0.0
3132. Fabric Mills	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3133. Textile and Fabric Finishing and Fabric Coating Mills	1,792.4	25.8	4,865.1	0.0	11.7	0.0	6.3	0.0
3141. Textile Furnishings Mills	433.2	769.9	420.6	0.0	21.8	3.8	0.0	0.0
3149. Other Textile Product Mills	6,280.8	4,014.1	6,066.5	0.0	192.7	176.4	0.0	0.0
3151. Apparel Knitting Mills	1.6	6.4	5.9	0.0	2.9	0.0	0.0	0.0
3152. Cut and Sew Apparel Manufacturing	9.5	36.7	33.8	0.0	16.6	0.0	0.0	0.0
3159. Apparel Accessories and Other Apparel Manufacturing	0.8	3.2	2.9	0.0	1.4	0.0	0.0	0.0
3161. Leather and Hide Tanning and Finishing	51.0	9.9	547.1	0.0	4.5	0.0	2.4	0.0

**Table B.1:** 2016 CO<sub>2</sub>-equivalent greenhouse gas emission by county and industry sector, metric tons CO<sub>2</sub>e (*continued*)

County / Sector (NAICS)	Fuel types							
	Natural gas	Diesel	Net electricity	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze
3162. Footwear Manufacturing	51.0	9.9	547.1	0.0	4.5	0.0	2.4	0.0
3169. Other Leather and Allied Product Manufacturing	5,321.9	185.7	56,732.3	0.0	234.3	0.0	369.5	0.0
3211. Sawmills and Wood Preservation	290.3	161.2	889.9	0.0	7.3	2.5	3.9	0.0
3212. Veneer, Plywood, and Engineered Wood Product Manufacturing	1,091.7	146.3	3,770.0	0.0	66.3	0.0	0.0	0.0
3219. Other Wood Product Manufacturing	8,450.8	1,506.9	67,620.2	0.0	1,223.5	0.0	0.0	0.0
3221. Pulp, Paper, and Paperboard Mills	23,188.3	82.9	18,487.3	0.0	56.3	15,547.3	0.0	0.0
3231. Printing and Related Support Activities	5,408.8	164.0	29,696.2	0.0	115.0	0.0	109.1	0.0
3241. Petroleum and Coal Products Manufacturing	774.6	860.3	395.8	0.0	19.5	0.0	10.5	0.0
3251. Basic Chemical Manufacturing	5,889.1	246.0	13,819.1	0.0	119.2	0.0	0.0	0.0
3252. Resin, Synthetic Rubber, and Artificial and Synthetic Fibers and Filaments Manufacturing	3,413.5	245.5	5,744.4	0.0	115.4	0.0	25.0	0.0
3253. Pesticide, Fertilizer, and Other Agricultural Chemical Manufacturing	26.7	103.7	95.4	0.0	46.9	0.0	25.3	0.0
3254. Pharmaceutical and Medicine Manufacturing	56,083.4	10,948.2	91,979.8	0.0	660.8	0.0	0.0	0.0
3261. Plastics Product Manufacturing	5,592.1	106.2	36,479.6	0.0	664.2	1,943.1	0.0	0.0
3262. Rubber Product Manufacturing	337.5	16.4	2,715.9	0.0	74.3	46.1	0.0	0.0
3271. Clay Product and Refractory Manufacturing	1,246.6	96.9	891.8	0.0	43.9	0.0	0.0	0.0
3272. Glass and Glass Product Manufacturing	15,039.2	762.9	12,328.6	0.0	385.1	181.7	0.0	0.0
3273. Cement and Concrete Product Manufacturing	1,919.8	248.8	6,866.7	0.0	112.7	4,664.2	60.8	4.4
3274. Lime and Gypsum Product Manufacturing	9,142.0	710.7	654.0	0.0	321.9	0.0	0.0	0.0
3279. Other Nonmetallic Mineral Product Manufacturing	1,129.3	219.5	2,019.6	0.0	99.4	0.0	0.0	0.0
3313. Alumina and Aluminum Production and Processing	1,599.8	207.3	3,814.8	0.0	93.9	0.0	50.6	0.0
3314. Nonferrous Metal (except Aluminum) Production and Processing	15.6	60.7	558.3	0.0	27.5	0.0	0.0	0.0
3321. Forging and Stamping	420.0	53.7	1,079.4	0.0	27.1	0.0	0.0	0.0
3322. Cutlery and Handtool Manufacturing	249.1	20.5	596.9	0.0	12.0	0.0	0.0	0.0
3323. Architectural and Structural Metals Manufacturing	4,056.7	398.1	10,377.8	0.0	227.5	0.0	0.0	0.0
3324. Boiler, Tank, and Shipping Container Manufacturing	57.0	11.1	160.9	0.0	5.0	0.0	0.0	0.0
3325. Hardware Manufacturing	263.3	23.2	637.1	0.0	13.3	0.0	0.0	0.0
3326. Spring and Wire Product Manufacturing	85.4	16.6	241.3	0.0	7.5	0.0	0.0	0.0
3327. Machine Shops; Turned Product; and Screw, Nut, and Bolt Manufacturing	4,285.1	554.2	11,448.6	0.0	287.2	0.0	0.0	0.0



**Table B.1:** 2016 CO<sub>2</sub>-equivalent greenhouse gas emission by county and industry sector, metric tons CO<sub>2</sub>e (*continued*)

County / Sector (NAICS)	Fuel types							
	Natural gas	Diesel	Net electricity	Other	LPG-NGL	Coal	Residual fuel oil	Coke and breeze
3328. Coating, Engraving, Heat Treating, and Allied Activities	548.1	78.6	1,441.3	0.0	38.4	0.0	0.0	0.0
3329. Other Fabricated Metal Product Manufacturing	2,028.1	144.2	5,594.9	0.0	107.4	0.0	0.0	0.0
3331. Agriculture, Construction, and Mining Machinery Manufacturing	46.8	21.6	209.4	0.0	9.8	0.0	0.0	0.0
3332. Industrial Machinery Manufacturing	1,004.3	224.7	4,345.1	0.0	140.0	0.0	0.0	0.0
3333. Commercial and Service Industry Machinery Manufacturing	1,302.5	174.9	5,664.2	0.0	150.7	0.0	0.0	0.0
3334. Ventilation, Heating, Air-Conditioning, and Commercial Refrigeration Equipment Manufacturing	563.6	72.7	2,505.4	0.0	66.1	0.0	0.0	0.0
3335. Metalworking Machinery Manufacturing	627.9	238.5	2,677.1	0.0	113.1	0.0	0.0	0.0
3336. Engine, Turbine, and Power Transmission Equipment Manufacturing	62.4	28.8	279.1	0.0	13.1	0.0	0.0	0.0
3339. Other General Purpose Machinery Manufacturing	1,871.7	335.0	7,947.9	0.0	233.3	0.0	0.0	0.0
3344. Semiconductor and Other Electronic Component Manufacturing	12,322.3	291.6	61,196.6	0.0	245.7	0.0	203.4	0.0
3351. Electric Lighting Equipment Manufacturing	1,387.3	42.2	6,331.9	0.0	26.5	0.0	0.0	1.2
3352. Household Appliance Manufacturing	626.4	6.6	2,967.4	0.0	9.0	0.0	0.0	0.3
3353. Electrical Equipment Manufacturing	1,189.0	49.7	5,141.9	0.0	25.2	0.0	0.0	1.3
3359. Other Electrical Equipment and Component Manufacturing	1,732.2	50.9	7,712.5	0.0	31.8	0.0	0.0	1.5
3361. Motor Vehicle Manufacturing	0.0	0.0	2,054.1	0.0	0.0	0.0	0.0	0.0
3364. Aerospace Product and Parts Manufacturing	492.3	191.4	1,760.7	0.0	86.7	0.0	46.7	0.0
3371. Household and Institutional Furniture and Kitchen Cabinet Manufacturing	289.1	95.2	992.7	0.0	44.8	0.0	0.0	0.0
3372. Office Furniture (including Fixtures) Manufacturing	583.6	76.7	1,915.9	0.0	55.9	0.0	0.0	0.0
3391. Medical Equipment and Supplies Manufacturing	3,939.1	70.4	11,972.0	0.0	57.1	0.0	51.7	0.0
3399. Other Miscellaneous Manufacturing	8,175.6	150.5	24,290.7	0.0	80.1	0.0	298.3	0.0

## References

- [1] Allaire, JJ et al. *Rmarkdown: Dynamic Documents for R. R Package Version 2.0*. Version 2.0. R Studio, 2019. URL: <https://rmarkdown.rstudio.com/> (visited on 12/23/2019).
- [2] US Census Bureau. *Economic Census*. The United States Census Bureau. 2019. URL: <https://www.census.gov/EconomicCensus> (visited on 12/22/2019).
- [3] Jennifer K. Costanza et al. "Bioenergy Production and Forest Landscape Change in the Southeastern United States." In: *GCB Bioenergy* 9.5 (2017), pp. 924–939. ISSN: 1757-1707. DOI: [10.1111/gcbb.12386](https://doi.org/10.1111/gcbb.12386). URL: <https://onlinelibrary.wiley.com/doi/abs/10.1111/gcbb.12386> (visited on 01/02/2020).
- [4] EIA. *Annual Coal Report 2018*. US Energy Information Agency, Oct. 2019, p. 87. URL: <https://www.eia.gov/coal/annual/pdf/acr.pdf>.
- [5] EIA. *Form EIA-923 Detailed Data with Previous Form Data (EIA-906/920)*. US Energy Information Agency. 2018. URL: <https://www.eia.gov/electricity/data/eia923/> (visited on 12/22/2019).
- [6] EIA. *Glossary - U.S. Energy Information Administration (EIA)*. Glossary - U.S. Energy Information Administration (EIA). 2019. URL: [/tools/glossary/index.php](https://www.eia.gov/tools/glossary/index.php) (visited on 12/23/2019).
- [7] EIA. *International Energy Outlook 2016*. DOE/EIA-0484(2016). US Energy Information Administration, May 2016, p. 290. URL: <https://www.osti.gov/servlets/purl/1296780> (visited on 01/02/2020).
- [8] EIA. *Manufacturing Energy Consumption Survey (MECS) - U.S. Energy Information Administration (EIA)*. 2019. URL: <https://www.eia.gov/consumption/manufacturing/index.php> (visited on 12/22/2019).
- [9] EIA. *New York - State Energy Profile Analysis - U.S. Energy Information Administration (EIA)*. New York - State Energy Profile Analysis - U.S. Energy Information Administration (EIA). 2020. URL: <https://www.eia.gov/state/analysis.php?sid=NY> (visited on 01/02/2020).
- [10] EIA. *Petroleum & Other Liquids: Definitions, Sources, and Explanatory Notes*. URL: [https://www.eia.gov/dnav/pet/TblDefs/pet\\_cons\\_psup\\_tbldef2.asp](https://www.eia.gov/dnav/pet/TblDefs/pet_cons_psup_tbldef2.asp) (visited on 01/03/2020).
- [11] EIA. *PETROLEUM & OTHER LIQUIDS: Table Definitions, Sources, and Explanatory Notes*. PETROLEUM & OTHER LIQUIDS: Table Definitions, Sources, and Explanatory Notes. URL: [https://www.eia.gov/dnav/pet/TblDefs/pet\\_cons\\_psup\\_tbldef2.asp](https://www.eia.gov/dnav/pet/TblDefs/pet_cons_psup_tbldef2.asp) (visited on 01/01/2020).
- [12] EPA. *Inventory of U.S. Greenhouse Gas Emissions and Sinks*. Inventory of U.S. Greenhouse Gas Emissions and Sinks. Feb. 8, 2017. URL: <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks> (visited on 12/22/2019).
- [13] EPA. *State and Local Climate and Energy Program Glossary of Terms*. EPA Terminology Services Vocabulary Catalog. Oct. 5, 2012. URL: <https://bit.ly/3zTkW1r> (visited on 01/08/2020).
- [14] Birgit Fais, Nagore Sabio, and Neil Strachan. "The Critical Role of the Industrial Sector in Reaching Long-Term Emission Reduction, Energy Efficiency and Renewable Targets." In: *Applied Energy* 162.C (2016), pp. 699–712. URL: <https://ideas.repec.org/a/eee/appene/v162y2016icp699-712.html> (visited on 12/20/2019).
- [15] John Bacha et al. *Diesel Fuels Technical Review*. San Ramon, CA: Chevron Corporation, Global Marketing, 2007. URL: [www.chevron.com/products/prodserv/fuels/bulletin/diesel](http://www.chevron.com/products/prodserv/fuels/bulletin/diesel) (visited on 01/01/2020).
- [16] Colin McMillan and Vinayak Narwade. *NREL/Industry-Energy-Data-Book*. National Renewable Energy Laboratory, Nov. 12, 2019. URL: <https://github.com/NREL/Industry-energy-data-book> (visited on 12/22/2019).
- [17] Colin A. McMillan and Vinayak Narwade. *The Industry Energy Tool (IET): Documentation*. NREL/TP-6A20-71990, 1484348. Nov. 27, 2018, NREL/TP-6A20-71990, 1484348. DOI: [10.2172/1484348](https://doi.org/10.2172/1484348). URL: <http://www.osti.gov/servlets/purl/1484348> (visited on 12/12/2019).

- [18] USDA NRCS. *County FIPS Codes*. 2019. URL: [https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143\\_013697](https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/home/?cid=nrcs143_013697) (visited on 12/22/2019).
- [19] NYSERDA. *New York State Greenhouse Gas Inventory: 1990–2016*. Greenhouse Gas Inventory. Albany, NY: New York State Energy Research and Development Authority (NYSERDA), July 2019. URL: <https://www.nyserda.ny.gov/-/media/Files/EDPPP/Energy-Prices/Energy-Statistics/greenhouse-gas-inventory.pdf> (visited on 12/22/2019).
- [20] NYSERDA. *Patterns and Trends New York Energy Profiles: 2002–2016*. New York State Energy Research and Development Authority (NYSERDA), Jan. 2019. URL: <https://www.nyserda.ny.gov/-/media/Files/Publications/Energy-Analysis/2002-2016-Patterns-and-Trends.pdf> (visited on 12/22/2019).
- [21] OMB. *NORTH AMERICAN INDUSTRY CLASSIFICATION SYSTEM*. 2017. URL: [https://www.census.gov/eos/www/naics/2017NAICS/2017\\_NAICS\\_Manual.pdf](https://www.census.gov/eos/www/naics/2017NAICS/2017_NAICS_Manual.pdf) (visited on 12/22/2019).
- [22] R Core Team. *R: A Language and Environment for Statistical Computing*. Vienna, Austria: R Foundation for Statistical Computing, 2019. URL: <https://www.r-project.org/> (visited on 12/22/2019).
- [23] Edward Tufte. *Beautiful Evidence*. Cheshire, Conn: Graphics Press, 2006. ISBN: 0-9613921-7-7.
- [24] U.S. Environmental Protection Agency. *Emission Factors for Greenhouse Gas Inventories*, 2018. Washington, D.C.: U.S. Environmental Protection Agency, Mar. 2018. URL: [https://www.epa.gov/sites/production/files/2018-03/emission-factors\\_mar\\_2018\\_0.xlsx](https://www.epa.gov/sites/production/files/2018-03/emission-factors_mar_2018_0.xlsx).
- [25] U.S. Environmental Protection Agency. *Greenhouse Gas Reporting Program (GHGRP)*. US Environmental Protection Agency. June 10, 2014. URL: <https://www.epa.gov/ghgreporting> (visited on 12/22/2019).
- [26] US Census Bureau. *County Business Patterns (CBP)*. The United States Census Bureau. 2019. URL: <https://www.census.gov/programs-surveys/cbp.html> (visited on 12/22/2019).
- [27] USDA. *USDA - National Agricultural Statistics Service - Census of Agriculture*. 2019. URL: <https://www.nass.usda.gov/AgCensus/> (visited on 12/22/2019).
- [28] USDA. *USDA - National Agricultural Statistics Service - Surveys - Crops/Stocks (Agricultural Survey)*. 2019. URL: [https://www.nass.usda.gov/Surveys/Guide\\_to\\_NASS\\_Surveys/Crops\\_Stocks/index.php](https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Crops_Stocks/index.php) (visited on 12/22/2019).
- [29] USDA. *USDA/NASS QuickStats Ad-Hoc Query Tool*. USDA/NASS QuickStats Ad-hoc Query Tool. 2019. URL: <https://quickstats.nass.usda.gov/> (visited on 12/22/2019).
- [30] Hadley Wickham. *Ggplot2: Elegant Graphics for Data Analysis*. Springer-Verlag New York, 2016. ISBN: 978-3-319-24277-4. URL: <https://ggplot2.tidyverse.org/> (visited on 12/22/2019).
- [31] Hadley Wickham et al. “Welcome to the Tidyverse.” In: *Journal of Open Source Software* 4.43 (Nov. 21, 2019), p. 1686. ISSN: 2475-9066. DOI: [10.21105/joss.01686](https://doi.org/10.21105/joss.01686). URL: <https://joss.theoj.org/papers/10.21105/joss.01686> (visited on 12/22/2019).