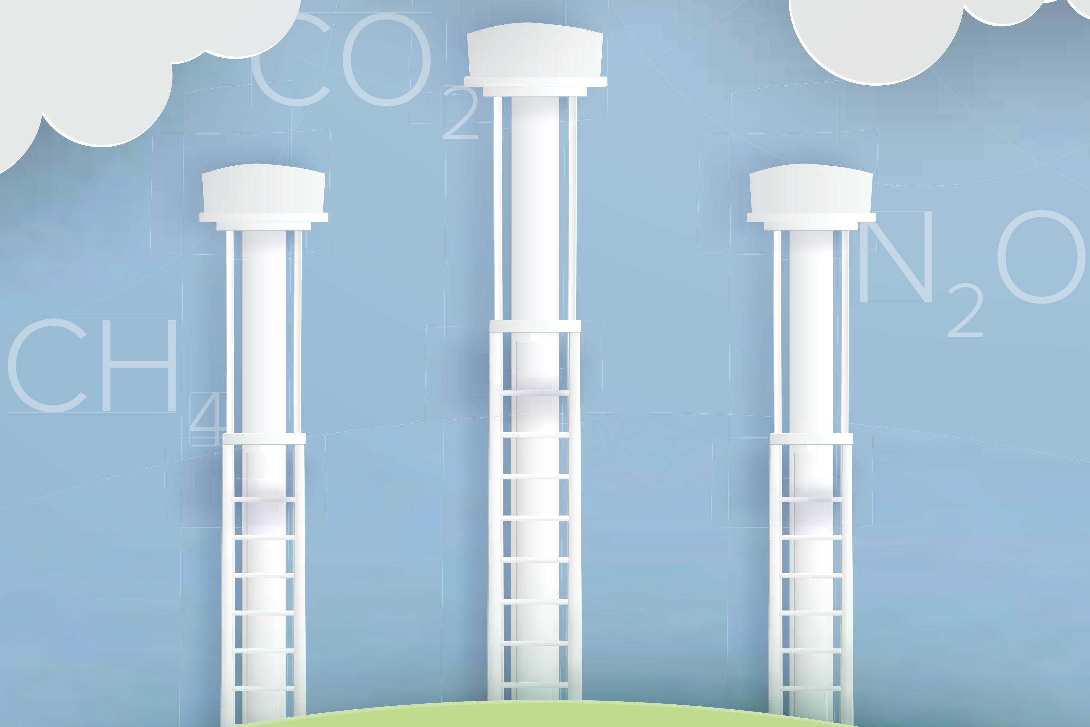
Louisiana 2021 Greenhouse Gas Inventory



Prepared on behalf of the
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David E. Dismukes, Ph.D.
LSU Center for Energy Studies

LSU | Center for Energy Studies

Louisiana 2021 Greenhouse Gas Inventory

Center for Energy Studies | 1077 Energy, Coast, and Environment Building | 93 S. Quad Drive
Louisiana State University | Baton Rouge, LA 70803 | dismukes@lsu.edu

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1 | Introduction

In February 2020, Governor John Bel Edwards announced the creation of a Climate Initiatives Task Force (CTF) to consider the important implications that climate change and greenhouse gas (GHG) emissions have for the Louisiana economy and environment. A key data tool that is needed by this task force will be an update of the Louisiana GHG inventory that has been conducted by the Louisiana State University (LSU) Center for Energy Studies (CES) several times in years past (1997, 2010). In January 2021, the Governor's Office of Coastal Activities (GOCA) contracted with CES to estimate and assess Louisiana GHG emissions from all major sources, activity types, and pollutant types.

A GHG inventory surveys and estimates GHG emissions by activity type and economic sector. A GHG inventory can be thought of as a "cross-sectional" analysis, or snapshot in time that identifies where each major Louisiana economic sector stands in terms of its GHG emissions. The GHG inventory estimation process can also be thought of as a "tops-down" analysis since it estimates emissions across broad economic sectors and activities. Over the course of this investigation, CES has worked with the governor's office, other stakeholders, and the CTF's Scientific Advisory Group (SAG) to identify and estimate carbon emission sources and sinks in Louisiana. This analysis not only estimates GHG emissions, by activity type, economic sector, and GHG pollutant type, but also estimates all three across a broad time period, 2000-2018.

GHG inventories are important tools that can be utilized in the formulation of state clean air and clean energy policy. The quantitative estimates that arise from the inventory estimation process are necessary, since many economic sectors are not required to report their GHG emissions. Thus, the inventory process itself estimates GHG emissions for each economic sector based on that sector's energy use and other factors, such as unique manufacturing processes, processing capabilities, and land area, all of which can impact and influence GHG emissions, as well as GHG sinks (i.e., resources that sequester GHG emissions).

This GHG inventory process has been guided by the oversight and direction of the CTF's SAG. The SAG was briefed at the onset of the project about methods and approaches, was debriefed once an initial set of empirical results were available, and were again consulted once the final results and inventory were available. The various presentations provided to the SAG are available online. Overall, the SAG has provided at least two rounds of comments on the inventory and written replies to the original. A more detailed set of comments is provided in Appendix 14. In addition, several SAG members have reached out directly and provided additional insights and support during the estimation process. The input of the SAG and its individual members is greatly appreciated.

This report is organized into nine sections, including this introduction. Section 2 provides a high-level overview of Louisiana's GHG emission trends as compared to overall U.S. totals and averages. Section 3 provides a general discussion of the methods used in estimating Louisiana's GHG inventory. Section 4 provides a high-level analysis of Louisiana's GHG emission trends by economic sector. Section 5 provides Louisiana's GHG inventory, for 2018, and for individual years back to 2000, on an economic sector basis, an activity type basis, and by GHG emissions type (CO_2, CH_4, N_2O, and fluorinated gases). Section 6 provides a more specific, "bottoms-up" analysis of individual industrial and power generation GHG sources. Section 7 utilizes air permitting data to project potential future industrial GHG emissions. Section 8 discusses the uncertainties associated with GHG estimation. Lastly, Section 9 provides the conclusions.

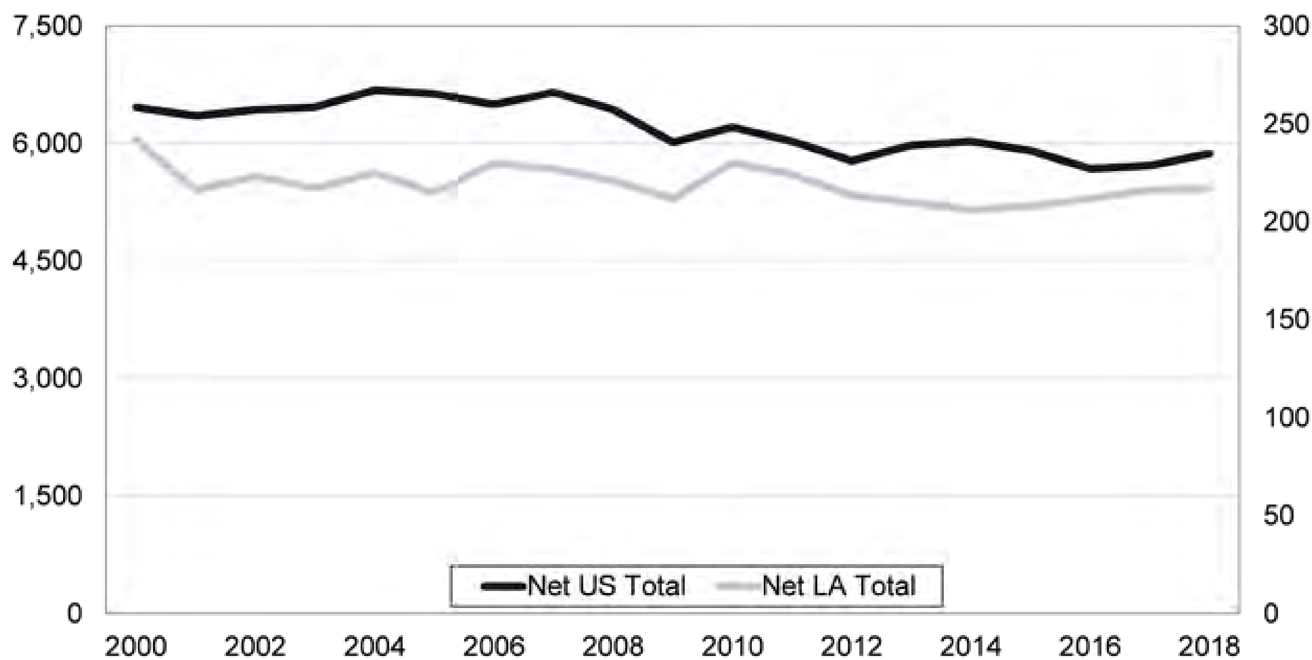
In addition, there are 15 appendices that are integral to the report and provide more detailed explanations about the GHG estimation process by major activity type. These appendices also provide considerably more detail examining GHG emission trends within various sub-sectors and activity types. This report also includes a “bottoms-up” plant-specific analysis of two large GHG emissions sectors: power generation and industry. This “bottoms-up” analysis is then compared to the “top down” analysis (i.e., the inventory itself) to assess the consistency of estimation outcomes and results between the two approaches. Two technical appendices (Appendix 12 and Appendix 13) provide more detailed analysis, at the plant level, regarding industrial and power generation GHG emissions that collectively account for 75 percent of all Louisiana GHG emissions. Lastly, the sources utilized in the estimation process and analysis are listed in Appendix 15.

2 | Louisiana aggregate GHG emission trends

U.S. and Louisiana total GHG emissions that arise from the combustion of fossil fuels have been decreasing since 2000. Figure 1 compares the GHG emission trends between the U.S. and Louisiana. In 2000, U.S. GHG emissions were reported at 6.5 billion metric tons, or gigatons (Gt), whereas Louisiana reported 242 million metric tons (“Mt”). Annual U.S. GHG emissions were relatively constant up to the 2008-2009 financial crisis and global recession. The recession slowed economic growth, and energy use, but also marked a period when a large degree of fuel switching, particularly in the power generation sector, stared to arise. Since the recession, U.S. GHG emissions have been decreasing and, as of 2018, are 12 percent lower than the pre-recession peak of 6.6 Gt.

Figure 1: Total U.S. versus Louisiana GHG emissions[1]

Source: Environmental Protection Agency



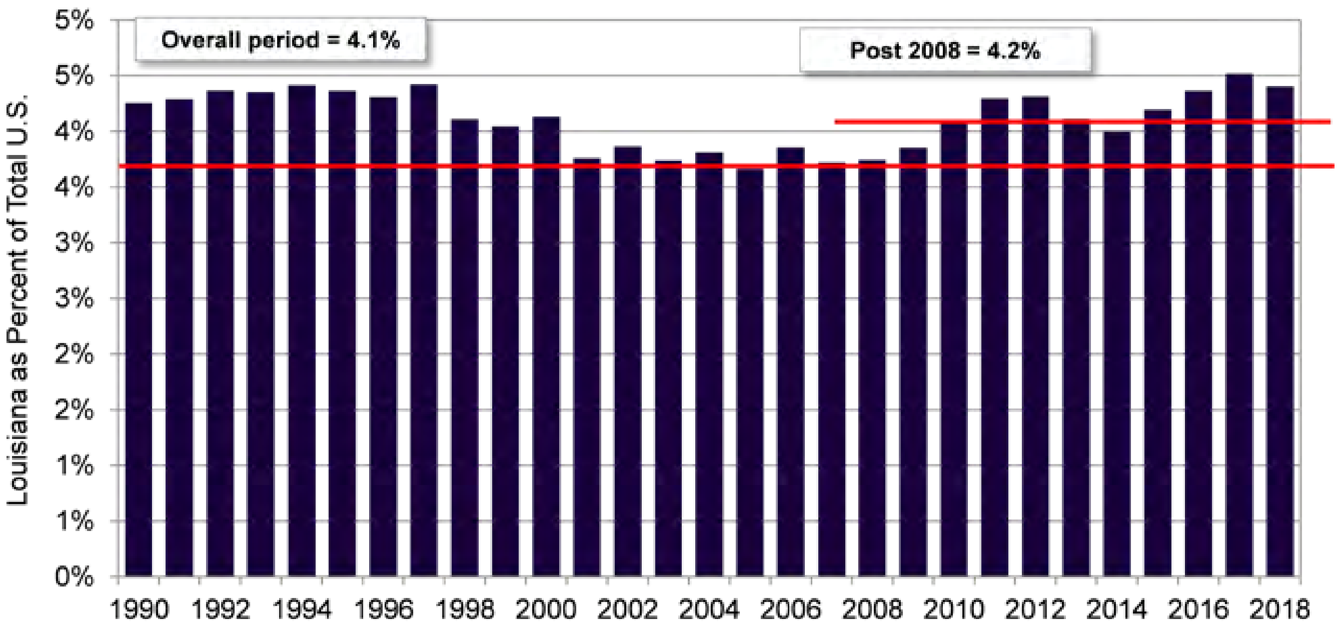
[1] Note that emissions are net of natural sinks at both the U.S. and Louisiana level.

Louisiana exhibits differing total GHG emission trends over the same time period. Louisiana's GHG emissions fell significantly between 2000 and 2002, likely due to decreased use of high-cost natural gas during this time period, and rebounded into the 225 to 229 Mt range, before peaking in 2010 at 230 Mt. As of 2018, Louisiana's total GHG emissions are down to 216 Mt, below the 20-year peak of 242 Gt, but at the same general place as in 2001.

Louisiana's share of total U.S. GHG emissions has also hovered around a constant rate of 4.1 percent to 4.2 percent of total, as seen in Figure 2. Throughout the 1990s, Louisiana's GHG emissions comprised a relatively higher share of the U.S. total, in large part due to relatively high in-state industrial output during this time period. The decade of the 2000s saw Louisiana's GHG emissions fall relative to U.S. totals, again, primarily due to a contraction of industrial activity that occurred as a result exceptionally high natural gas prices. Since 2000, Louisiana's share of total U.S. GHG emissions has been back on the rise, to about 4.2 percent of total, given the recent expansion of industrial activity in the state.

Figure 2: Louisiana share of total U.S. GHG

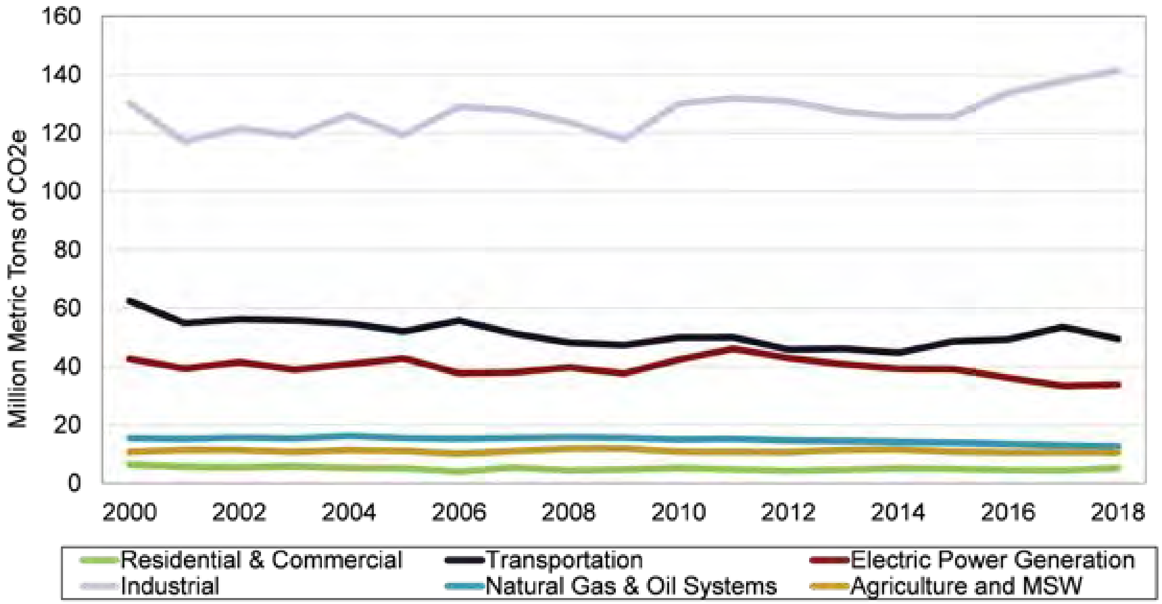
Source: Environmental Protection Agency



On a sector-specific basis, Louisiana's GHG emissions are highly concentrated in the industrial sector. Figure 3 shows the recent trends in Louisiana' sector-specific GHG emissions. The industrial sector has the largest emissions, increasing over the past several years to a near-term peak of around 141 Mt. The transportation sector follows, with recent years showing emission trends between 48 Mt to 52 Mt. Power generation, which includes utility and non-utility generation, ranks third at a recent level of 34 Mt. The other major sectors of the Louisiana economy, that include household and business, agriculture, and oil and gas production, account for the remaining GHG emissions in the state.

Figure 3: Louisiana GHG emission by sector

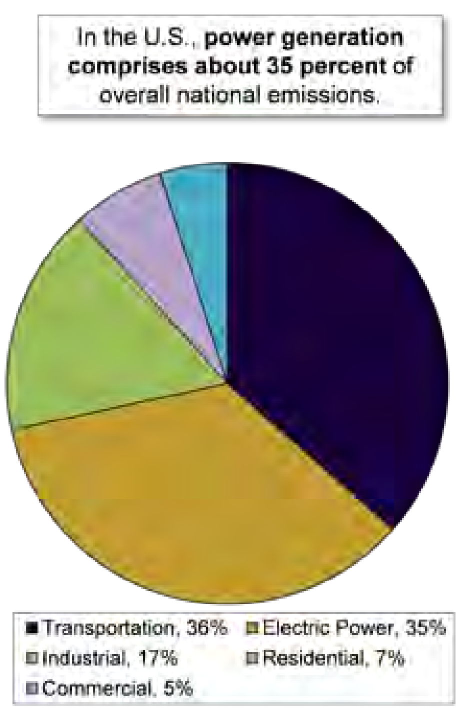
Source: Environmental Protection Agency



Louisiana's GHG emissions composition differs considerably from the national average. Figure 4 compares U.S. GHG emission shares by sector (left hand pie chart) to those in Louisiana (right-hand pie chart). The noticeable difference between the two charts is that U.S. GHG emissions shares are very highly dominated by power generation, not industrial activities. Louisiana's GHG emissions, on the other hand, are highly dominated by industrial activities.

Figure 4: U.S. and Louisiana GHG emission shares

Source: Environmental Protection Agency, Bureau of Economic Analysis.



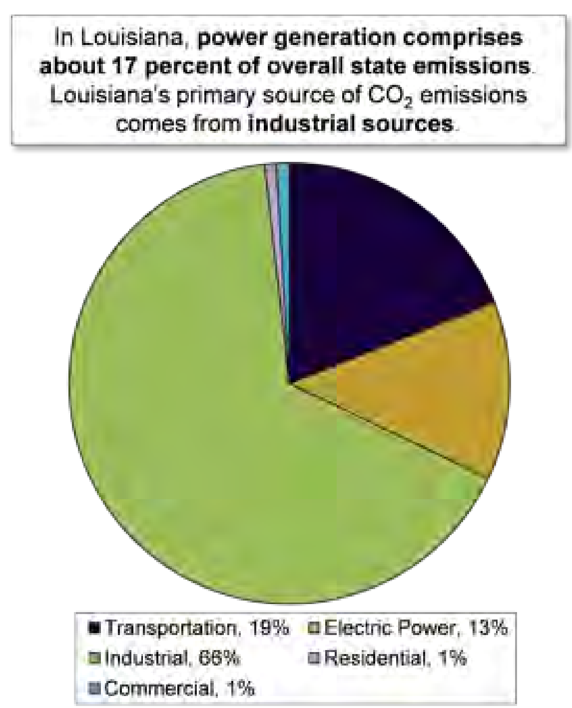


Figure 5: Louisiana and U.S. end use consumption comparison

Source: Environmental Protection Agency

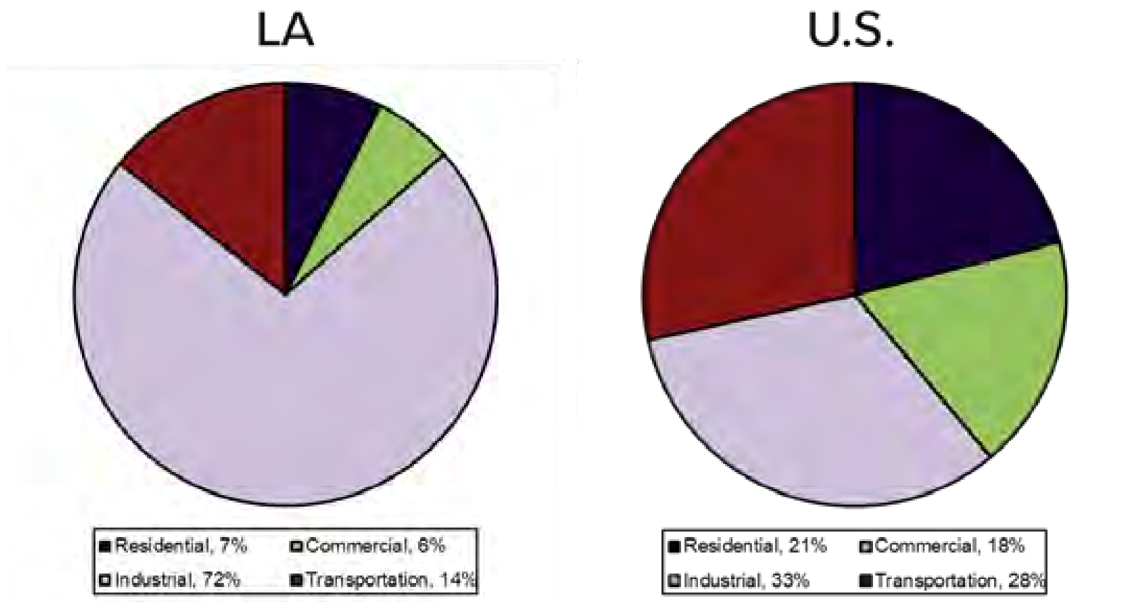
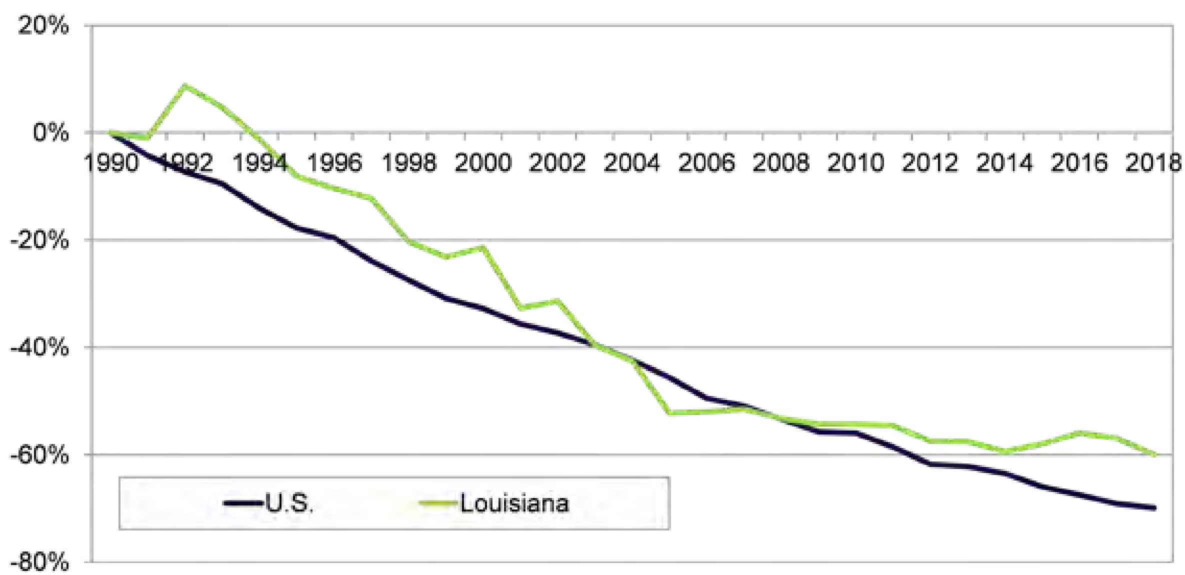


Figure 5 shows the important differences between Louisiana and U.S. average energy end uses, and their implications for GHG emissions. Industry comprises as much as 33 percent of all U.S. energy end uses. However, in Louisiana, industry comprises as much as 72 percent of all energy end uses.

Figure 6 examines trends in the level of GHG emissions per unit of economic output at both the state (Louisiana) and national levels. The chart shows that GHG emissions per unit of economic output have been falling at both the state and national level, although more so at the national level than in Louisiana.

Figure 6: Annual changes in U.S. and Louisiana GHG emissions per GDP

Source: Environmental Protection Agency, Bureau of Economic Analysis.



3 | State inventory estimation methods

The Intergovernmental Panel on Climate Change (IPCC) has published guidelines, starting in 1997, for GHG emissions inventory estimation. These guidelines have been adopted and incorporated into a tool developed by the Environmental Protection Agency (EPA) that in turn can be used to estimate state level GHG emissions across a wide range of sectors. This tool is referred to as the "State Inventory Tool" or "SIT." The SIT establishes a framework for estimating GHG emissions that span sectors, emission types, and processes. The SIT is composed of a variety of "modules" that estimate various GHG emission types by "activity" such as the combustion of fossil fuels, stationary processes, industrial processes, and land use activities, among others.

The basic "mathematics" of the SIT is relatively straightforward. An "emission factor" (expressed in terms of "emissions per activity") is provided by the tool and that factor is then multiplied by an "activity" to arrive at a total GHG emissions impact. This GHG emission is standardized to a CO_2 equivalent in order to arrive at a total impact across all modules and GHG emission types.

Figure 7 below provides just one example of how GHG emissions from the residential combustion of fossil fuels is estimated. The left column of the workpaper lists the various fossil fuel types combusted by the residential sector. The next column lists the volumes burned in any given year across all those fuel types (two years are provided in the example below, 2017 and 2018). The emissions factor is provided in pounds of carbon per units of heat input burned (by fossil fuel type). This is adjusted for an efficiency factor, which in turn is standardized in "short tons"[2] and then million metric tons of carbon equivalent (MMTCE), and million metric tons of CO_2 equivalent ($MMTCO_2E$).

Figure 7: Example, residential combustion of fossil fuel emission calculation

Source: EPA SIT, Louisiana.

Residential fuel types

Residential emissions factors

Residential GHG emissions

Residential Sector 2017

Fuel Type	Consumption (Billion Btu)		Emission Factor (lbs C/Million Btu)		Combustion Efficiency (%)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions ($MMTCO_2E$)
Coal	-	x	62.02	x	100.0%	=	-	=	0.000	=	0.000
Distillate Fuel	44	x	44.47	x	100.0%	=	978	=	0.001	=	0.003
Kerosene	2	x	44.01	x	100.0%	=	44	=	0.000	=	0.000
Hydrocarbon Gas Liquids	1,699	x	37.11	x	100.0%	=	31,525	=	0.029	=	0.105
Natural Gas	29,680	x	31.90	x	100.0%	=	473,396	=	0.429	=	1.575
Other	-	x		x		=	-	=	0.000	=	0.000

Residential Sector 2018

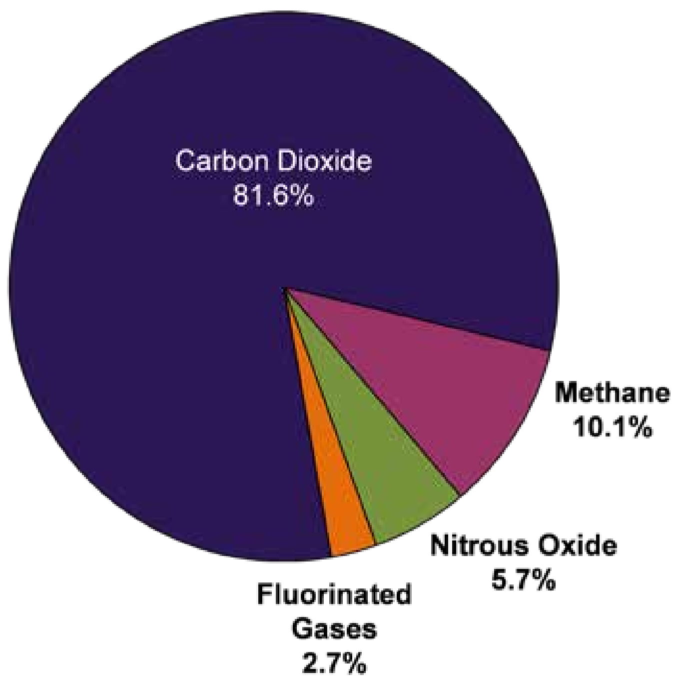
Fuel Type	Consumption (Billion Btu)		Emission Factor (lbs C/Million Btu)		Combustion Efficiency (%)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions ($MMTCO_2E$)
Coal	-	x	62.02	x	100.0%	=	-	=	0.000	=	0.000
Distillate Fuel	8	x	44.47	x	100.0%	=	178	=	0.000	=	0.001
Kerosene	4	x	44.01	x	100.0%	=	88	=	0.000	=	0.000
Hydrocarbon Gas Liquids	1,748	x	37.11	x	100.0%	=	32,434	=	0.029	=	0.108
Natural Gas	38,629	x	31.90	x	100.0%	=	616,133	=	0.559	=	2.049
Other	-	x		x		=	-	=	0.000	=	0.000

[2] "short ton" is equal to 2000 lbs.

All types of GHG emissions are considered in the SIT that include CO_2, N_2O, CH_4, and various fluorinated gases. CO_2 enters the atmosphere through the burning of fossil fuels, trees and wood products, solid wastes, and through other chemical reactions. Nitrous oxide is emitted during industrial process when organic fuels are burned at high temperatures and when air (including nitrogen) is used as the oxidant. These emissions can also arise in some agricultural emissions. Methane is emitted throughout the natural gas value chain (production, transportation, and distribution) as well as other refining and industrial activities. Methane can also be released through agriculture and livestock and the decay of organic material that can arise at landfills. Fluorinated gases (F-gases) are a family of gases that contribute fluorine. These F-gases are powerful and arise from the release of refrigerants, heat pumps, air conditioning, blowing agents for foam/solvent, and fire extinguishers. The decomposition and share of these GHG emissions, from a national perspective, are provided in Figure 8.

Figure 8: Total U.S. GHG emission shares (2018)

Source: EPA



The SIT is composed of 11 different "modules" that estimate various different GHG emissions across differing economic sectors and activities. These individual modules include:

- Agricultural Module
- Fossil Fuel Combustion Module
- Coal Module
- Electricity Consumption Module
- Industrial Process Module
- Land-use, Land-use Change, and Forestry Module
- Mobile Combustion Module
- Natural Gas and Oil Module
- Solid Waste Module
- Stationary Combustion Module
- Wastewater Module

While all of the modules listed above are important, the overwhelming share of all GHG emissions comes from the combustion of fossil fuels, so this module is very important in establishing the bulk of any state's GHG emissions. There are other modules that contribute to the estimation of CO_2 emissions, but several others such as the Industrial Process module, or the Natural Gas and Oil Module, focus on N_2O and/or CH_4 emissions exclusively.

As noted earlier, this report includes several appendices that discuss each of the modules above and provides specific GHG emissions estimates by a variety of detailed activity types. The main body of this report will focus on the higher-level, aggregate results across each major sector and module. The technical appendices offer greater level of granularity within each sector/module.

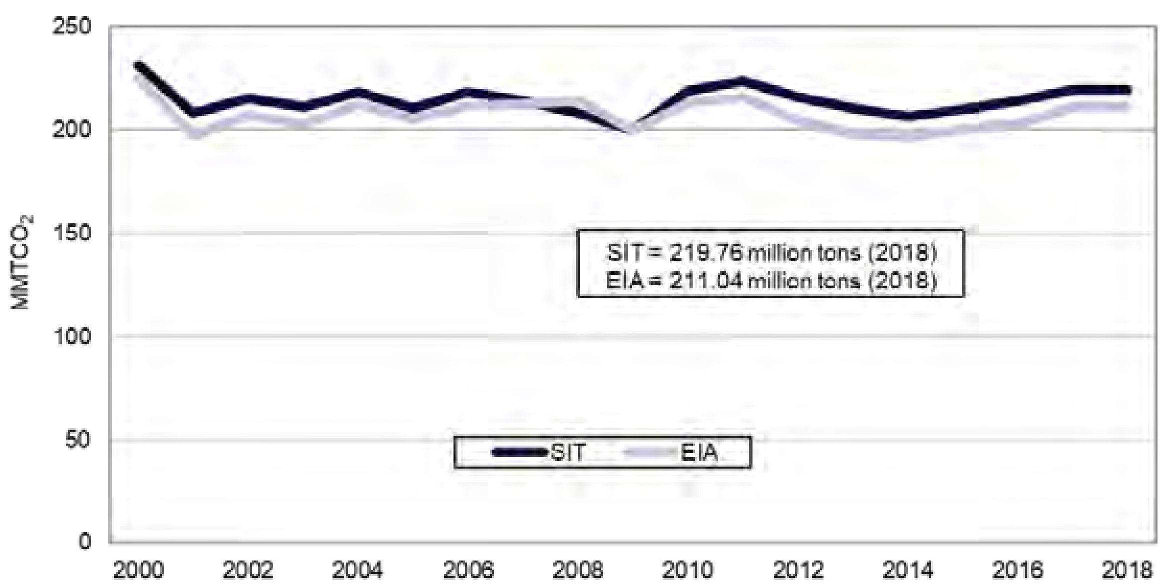
4 | Louisiana GHG emission trends

Figure 9 compares Louisiana's SIT-estimated GHG trends to those estimated and reported by the Energy Information Administration (EIA). Note that the comparison of GHG emission trends is for combustion related GHG emissions only, not total GHG emissions. The remaining GHG emissions are not included since EIA does not have consistent sector-specific detail at total emissions level basis (hence the purpose of the inventory). Later, in a subsequent section of this report, various tables are provided with the final GHG inventory that includes all GHG emissions, not only those associated with combustion activities.

Figure 9 shows relatively stable GHG emission trends for Louisiana dating back to 2000. While U.S. GHG emission trends have fallen, Louisiana GHG emission trends have been relatively flat. For 2018, the most recent year in which GHG emissions can be estimated, the SIT estimate for Louisiana is around 219 Mt (combustion only) whereas the independent estimate developed by the EIA for Louisiana is slightly lower at 211 Mt. Since 2010, the SIT based methods estimate consistently higher emission levels, although this bias is relatively small.

Figure 9: Louisiana GHG emission trends (combustion only)

Source: Author's estimates using EPA-SIT, EIA.



4.1 Residential and commercial GHG emission trends:

The trend in GHG emissions from the residential and commercial sectors of the Louisiana economy have been relatively consistent as seen in Figure 10. GHG emissions from the residential and commercial sector were close to 6 Mt in 2000, but have gradually fallen and flattened out to a level that hovers between 4.0 Mt to 5.0 Mt with 2018 emissions levels slightly up at 5.2 Mt. The up and down in the variation of the GHG emissions is likely a result of weather-related changes in fossil fuel demand, particularly retail natural gas demand.

Figure 10: Louisiana residential & commercial GHG emission trends (combustion only)

Source: Author's estimates using EPA-SIT, EIA.

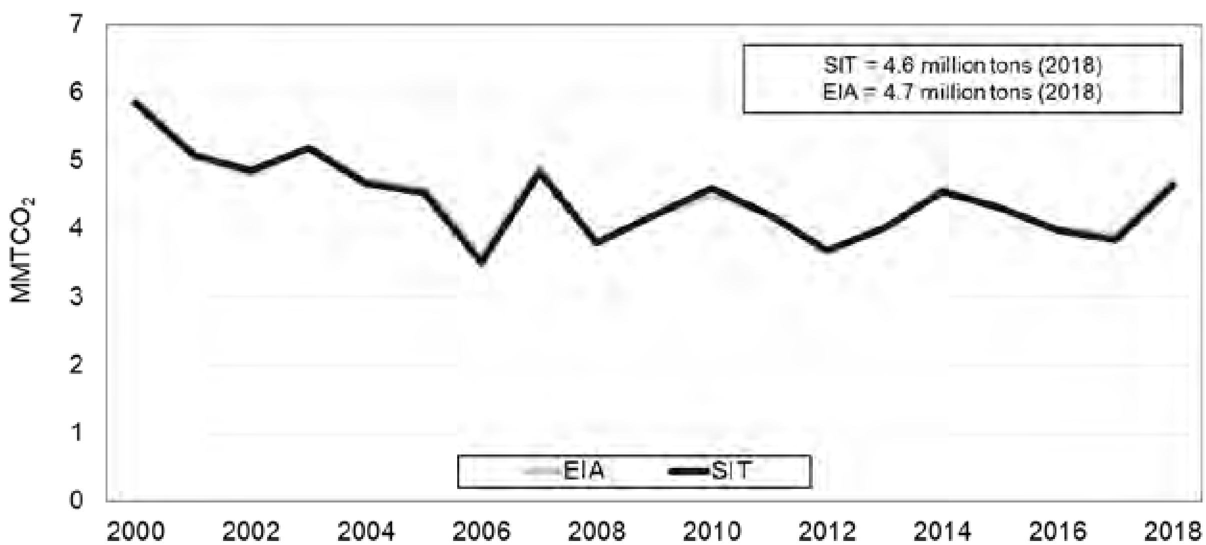


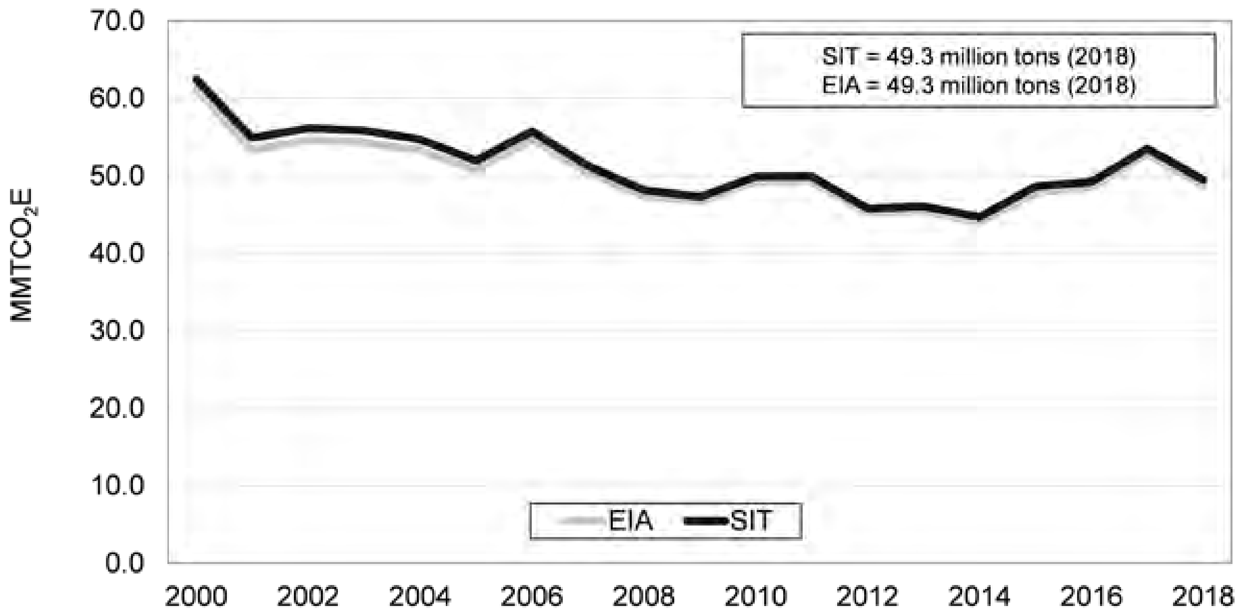
Figure 10 shows good comparability between EIA and the SIT-based GHG estimates for Louisiana. The SIT provides slightly more conservative estimates that tend to be consistently above the EIA estimates. Note that greater detail on the residential and commercial emissions can be found in Appendix 1: Combustion of Fossil Fuels. Almost all residential and commercial GHG emissions come from the combustion of fossil fuels.

4.2 Transportation GHG emission trends:

Figure 11 shows that Louisiana's transport related GHG emission trends have decreased from a 2000 level of around 60 Mt to a 2018 level at 49.1, close to a 10 Mt reduction. These decreases are likely due to greater vehicle fuel efficiencies that have arisen over the past decade as well as an increasing amount of fuel substitution to alternative fueled vehicle both for larger trucks and passenger vehicles.

Figure 11: Louisiana transportation GHG emission trends (combustion only)

Source: Author's estimates using EPA-SIT, EIA.



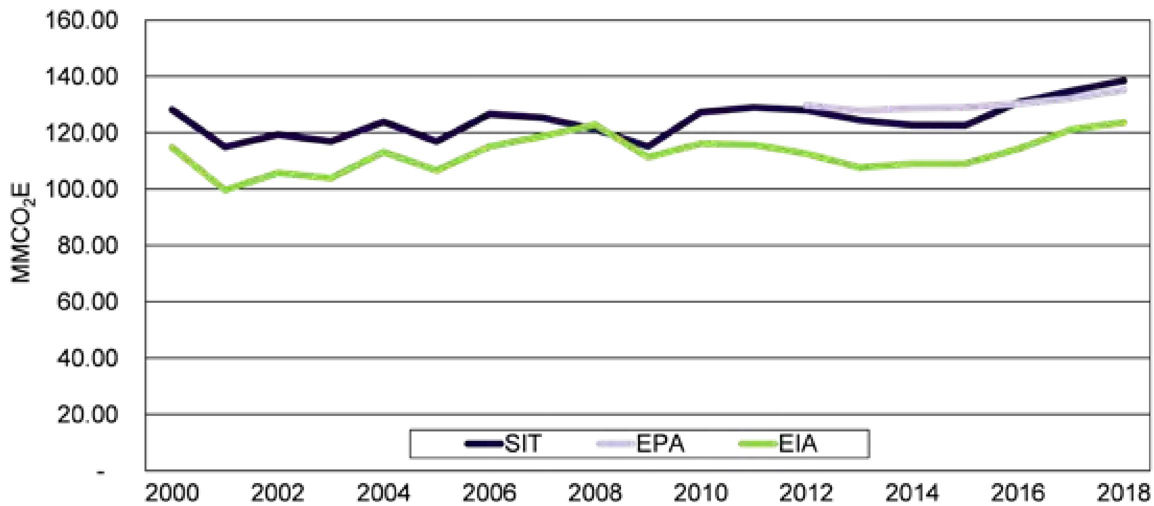
The comparability between the SIT-based estimates and those made by EIA for Louisiana's transportation sector are almost identical. This should come as no surprise since there are very few differences between how the EPA examines these emissions and the EIA. Greater detail on the transportation GHG emissions can be found in Appendix 1: Combustion of Fossil Fuels Module (CO_2 emissions only) and Appendix 5: Mobile Sources Module (CH_4 and N_2O only).The sum of these GHG emissions, on a CO_2E basis, will represent the entirety of Louisiana's transportation related GHG emissions. The chart provided above only examines the combustion related emissions to compare the accuracy of the SIT-estimates to other independent estimates provided by EIA.

4.3 Industrial GHG emission trends:

Louisiana's industrial GHG emission trends are provided in Figure 12. This is the largest GHG emitting sector in the analysis. Louisiana's industrial GHG emissions have increased since 2000 when there was an estimated 120 Mt for combustion related activities only. Industrial GHG emissions remained relatively constant around this level for the better part of a decade, and it was not until 2010, the year in which several large industrial plant expansions started to come on-line, that Louisiana's annual industrial GHG emissions started moving beyond the 120 Mt level. By 2018, Louisiana's industrial GHG emissions (combustion only) were up to around 140 Mt per year.

Figure 12: Louisiana industrial GHG emission trends (combustion only)

Source: Author's estimates using EPA-SIT, EIA, and EPA Flight database.



Three data series are compared within Figure 12: the SIT estimate and EIA estimates discussed earlier, as well as plant-level industrial emissions data that is made available by EPA after 2012 (EPA Flight). The chart shows a good reconciliation across all three series with the EIA data being the lower of the three. The EIA data is likely lower given that it does not include CO_2 emissions from feedstock use of fossil fuels like the SIT and the EPA-FLIGHT information.

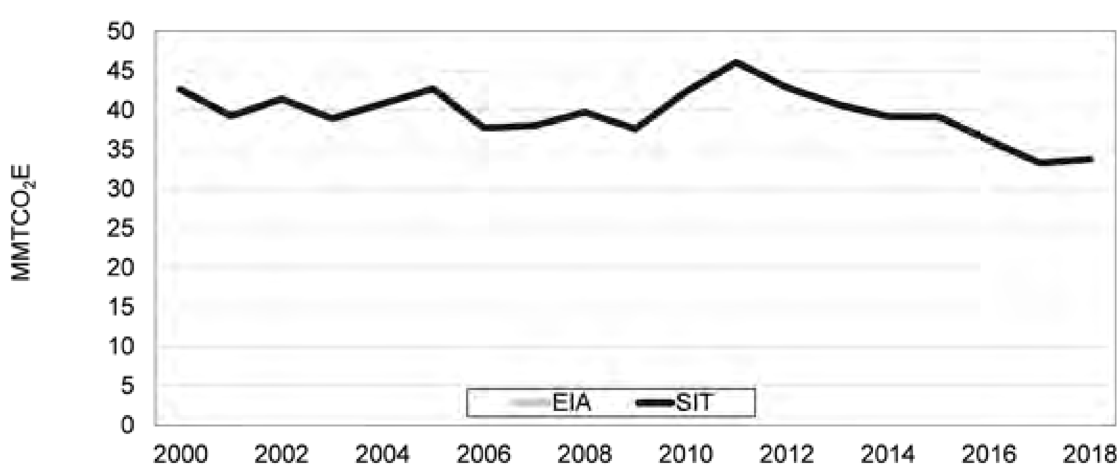
Detailed information on industrial GHG emissions can be found in several appendices and modules. Combustion related (including feedstock use) emissions can be found in Appendix 1: Combustion of Fossil Fuels Module. N_2O and CH_4 emissions are estimated in Appendix 2: Stationary Emissions Module, as well as Appendix 3: Industrial Process Module.

4.4 Power generation GHG emission trends:

Figure 13 examines the recent trends in Louisiana's power generation GHG emissions. The information provided on this chart is associated with all utility and industrial electric power generation facilities.

Figure 13: Louisiana power generation GHG emission trends

Source: Author's estimates using EPA-SIT, EIA.



The GHG emission trends from Louisiana's electric power generation have seen the most improvement of any sector, particularly after 2010. From 2000 to 2010, annual GHG emissions from the power generation sector hovered around 40 Mt. Since 2010, those annual GHG emissions have been on the decline, peaking at 45 Mt and dropping to below 35 Mt in 2018. A significant portion of this emissions reduction has come from increased thermal efficiencies at the state's natural gas fired generation facilities, and the closure of coal generation.

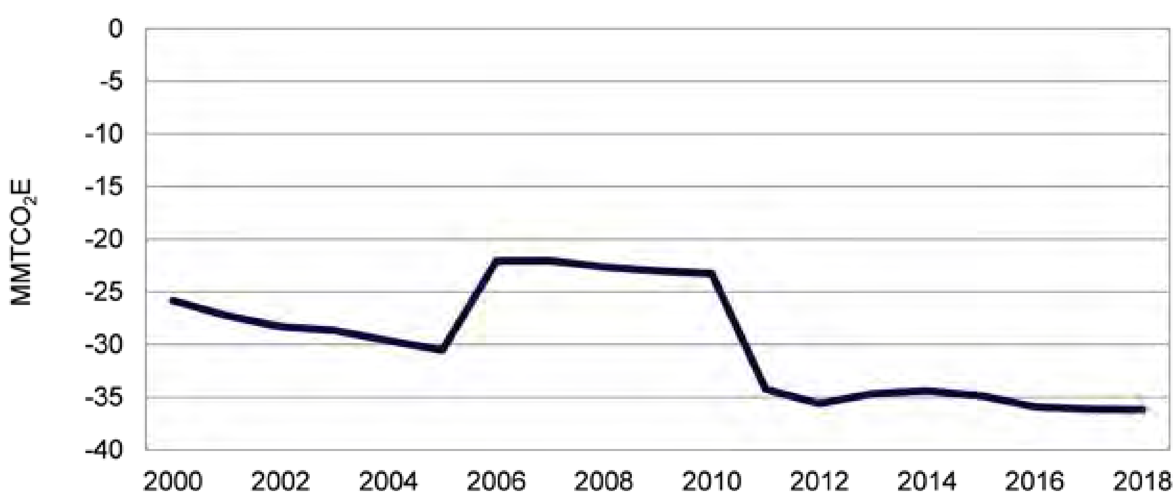
Additional detailed information can be found in Appendix 1: Combustion of Fossil Fuels; however, power generation represents a large sector with very large individual emission sources. This sector, along with Louisiana's industrial sector, has been selected for additional detailed analysis. Part of this analysis will be discussed later in this report; however, a very detailed analysis of the trends in Louisiana's power generation GHG emissions is provided in Appendix 13: Detailed Power Generation Analysis.

4.5 Land use and wetlands GHG emission trends:

Land use, particularly increasing forest area, can serve as a "sink" for sequestering Louisiana's carbon emissions. Louisiana's large forested lands, particularly in the northern part of the state, are a considerable carbon "sink," negative emission resources. This forestry land and other comparable sinks are included in the inventory as a negative number. This emission module reduces overall carbon emissions and does not increase those emission levels. Note that land use and wetlands do not include agricultural emissions. Figure 14 shows the trends in GHG emissions (or sink trends) since 2000.

Figure 14: Louisiana land use and wetlands GHG emission trends

Source: Author's estimates using EPA-SIT and data/preliminary modeling provided by EPA.



This version of the Louisiana GHG inventory, unlike prior estimates, includes the "sink" contribution made by wetlands as well as forests. Wetlands allow for large amounts of carbon sequestration and the restoration of wetlands can help combat greenhouse gas emissions. This addition was made possible by the EPA, which provided preliminary wetlands activity factors that were used in the national level inventory but are not available for the state level SIT modules at this time. The current sink estimates, therefore, are based upon national, not regional, or state-level emissions factors; however, despite this limitation, the inclusion of wetlands is an important first step for Louisiana's GHG inventory, particularly given the importance of wetlands and coastal restoration to our economy and ecosystem.

Figure 14 shows that historically, Louisiana's GHG sinks increased (in absolute value) from 2000 until the tropical season of 2005. Sinks were increasing in absolute annual value from over 25 Mt to over 30 Mt. But the dual hurricanes of 2005 led to massive land use changes and coastal destruction that converted some forest land to wetlands (lower sink value in absolute terms) and some wetlands to open water. Louisiana was not able to recover this sink capability until after 2010 when the negative trend in emissions began to progress again. Since 2012, all land uses have annually contributed to around a negative 35 Mt of emissions. To put this into perspective, all of Louisiana's land use creates a carbon sink comparable to cover all the emissions from the state's power generation sector.

More information and detail about the various components of these sink estimates can be found in Appendix 11: Land Use and Wetlands Module.

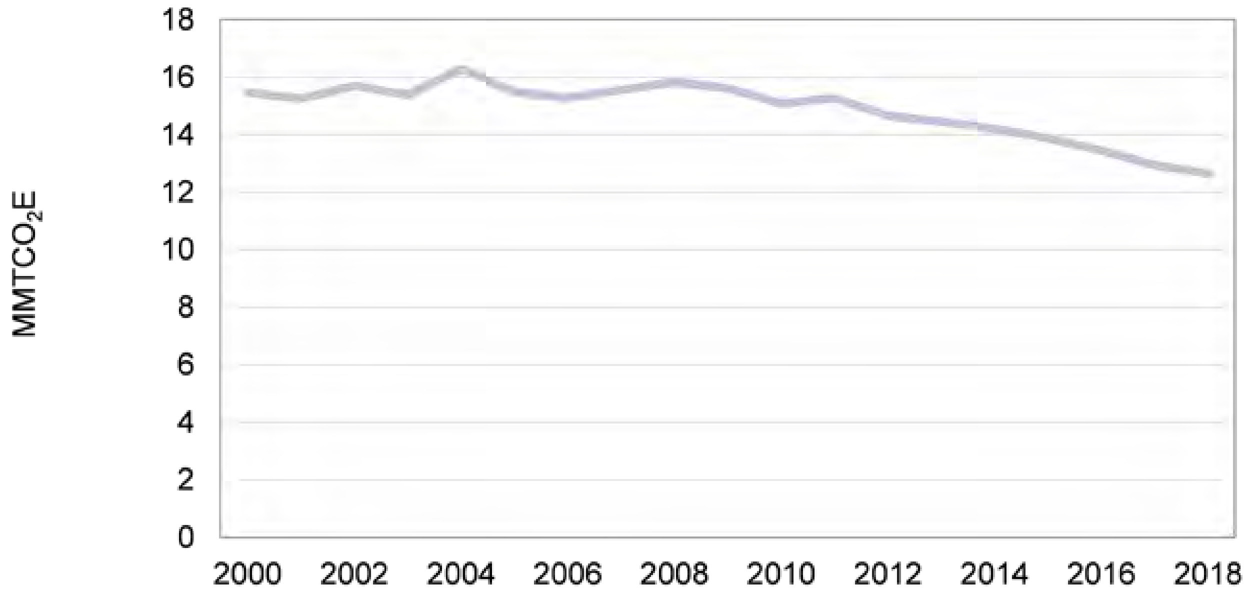
4.6 Natural gas and oil GHG trends:

Louisiana's oil and gas systems emit a variety of GHGs. The two largest GHG pollutants are CO_2 and methane (CH_4). The CO_2 emissions arise from combustion activities at production sites, compression stations, other transmission and distribution activities and refinery operations. The methane emissions arise from all industry sectors, particularly those at the wellhead level (wellhead releases, venting, flaring) and throughout the transmission and distribution pipeline system. Pipeline emissions are a function of the pipe diameter, the mileage of pipe, and pipe composition since some material types, particularly cast iron and bare steel, are more prone to leaks than others. The GHG estimates provided in Figure 15 are from methane emissions and not CO_2 emissions from combustion processes (although they are standardized in CO_2E terms).

Louisiana's oil and gas systems GHG emissions, related to methane alone, were at one time as high as 16 Mt per year. As oil and gas activity has decreased so have these methane related emissions. The 2018 estimates are around 13 Mt. It is important to note that these estimates are based upon the methodologies and emission factors provided that are part of EPA's SIT. No attempt has been made to this baseline estimate to account for the findings of recent research that notes that oil and gas GHG emissions could be considerably higher than past estimates, particularly those arising from SIT methods. Further, some issues were raised in public comments by Healthy Gulf regarding the role that abandoned pipelines play in this sector's GHG emissions. These issues will be discussed in greater detail in a later section of this report addressing emissions uncertainties. Detailed information about this sector can be found in Appendix 7.

Figure 15: Louisiana natural gas and oil systems GHG emission trends

Source: Author's estimates using EPA-SIT.



5 | Annual inventory estimates by sector and module

Three sets of GHG inventories have been developed using the provided data. The first inventory decomposes statewide GHG emissions on the basis of economic sector. The second GHG inventory decomposes emissions by activity type or SIT “module” since GHG emissions are estimated in modules that are defined by activity. The third inventory decomposes GHG emissions by type.

5.1 Louisiana GHG inventory by economic sector:

Table 1 provided below inventories total GHG emissions, by economic sector for the period 2000 to 2018. These emissions follow the discussion and analysis provided in the prior sections of this report; however, the series provided here are for all GHG emissions, not just those associated with combustion activities alone. Thus, the numbers will be slightly higher than examined earlier.

Table 1: Louisiana GHG inventory by economic sector[3]

	Total emissions ($MMTCO_2E$)						
Year	**Residential & Commercial**	**Transportation**	**Electric Power Generation1**	**Industrial**	**Natural Gas Oil Sytems[2]**	**Other**	**Total**
2000	6.40	62.46	42.76	130.21	15.46	-15.15	**242.13**
2001	5.62	54.89	39.39	117.06	15.24	-15.84	**216.37**
2002	5.41	56.15	41.54	121.54	15.70	-16.95	**223.39**
2003	5.74	55.84	39.07	119.14	15.38	-17.92	**217.25**
2004	5.21	54.70	40.95	126.27	16.29	-18.32	**225.11**
2005	5.06	51.96	42.85	119.28	15.48	-19.47	**215.17**
2006	4.00	55.75	37.86	129.01	15.28	-11.97	**229.92**
2007	5.34	51.27	38.13	127.83	15.55	-11.02	**227.11**
2008	4.32	48.18	39.87	123.72	15.82	-10.79	**221.11**
2009	4.73	47.28	37.74	117.75	15.60	-11.09	**212.00**
2010	5.13	49.90	42.48	130.07	15.08	-12.52	**230.14**
2011	4.74	49.95	46.24	131.84	15.26	-23.56	**224.46**
2012	4.22	45.78	42.99	130.88	14.65	-25.01	**213.52**
2013	4.57	46.04	40.84	127.34	14.45	-23.25	**209.99**
2014	5.10	44.67	39.33	125.63	14.20	-22.81	**206.11**
2015	4.84	48.62	39.27	125.57	13.88	-24.08	**208.10**
2016	4.51	49.22	36.21	133.86	13.44	-25.33	**211.90**
2017	4.36	53.50	33.38	137.77	12.94	-25.51	**216.44**
2018	5.17	49.47	33.84	141.46	12.65	-25.63	**216.96**

[3]Electric power generation includes coal, natural gas oil systems data from 2001-2003 estimated due to incomplete data

5.2 Louisiana GHG inventory by SIT module:

Table 2 below provides Louisiana's GHG inventory, on annual basis from 2000 to 2018, on a per activity or SIT module basis. Note that the total GHG emission level matches the total provided in the prior table. This table shows that over 86 percent of all Louisiana GHG emissions are associated with the combustion of fossil fuels.

Table 2: Louisiana GHG inventory by SIT module

Year	Total emission ($MMTCO_2E$)										
	Agriculture	Coal	Combustion of Fossil Fuels	Industrial Process	Land and Land Use	Mobile Combustion	Municipal Solid Waste	Natural Gas Oil Systems	Stationary Combustion	Wastewater	Total
2000	7.74	0.04	231.58	7.64	-25.85	1.43	2.96	15.46	0.63	0.50	**242.13**
2001	8.20	0.04	207.92	6.58	-27.29	1.34	3.26	15.24	0.59	0.49	**216.37**
2002	8.16	0.05	215.21	7.01	-28.33	1.27	3.22	15.70	0.60	0.50	**223.39**
2003	7.82	0.05	211.02	6.40	-28.67	1.21	2.93	15.38	0.62	0.50	**217.25**
2004	8.35	0.05	218.05	6.68	-29.65	1.10	2.98	16.29	0.71	0.55	**225.11**
2005	8.14	0.05	210.79	6.17	-30.54	0.98	2.94	15.48	0.62	0.55	**215.17**
2006	7.08	0.05	218.48	6.06	-22.08	0.88	3.03	15.28	0.62	0.53	**229.92**
2007	7.83	0.04	214.17	6.45	-22.05	0.78	3.20	15.55	0.60	0.54	**227.11**
2008	8.43	0.05	208.03	6.28	-22.65	0.69	3.44	15.82	0.50	0.54	**221.11**
2009	8.40	0.04	199.75	6.10	-23.01	0.58	3.52	15.60	0.49	0.53	**212.00**
2010	7.87	0.05	219.13	6.77	-23.29	0.56	2.91	15.08	0.53	0.54	**230.14**
2011	7.86	0.04	223.75	7.36	-34.26	0.52	2.84	15.26	0.54	0.55	**224.46**
2012	7.79	0.05	215.81	6.47	-35.64	0.46	2.84	14.65	0.53	0.56	**213.52**
2013	8.37	0.03	210.65	6.56	-34.67	0.44	3.05	14.45	0.54	0.56	**209.99**
2014	8.66	0.03	206.50	6.67	-34.41	0.40	2.94	14.20	0.56	0.56	**206.11**
2015	7.87	0.04	210.00	6.80	-34.90	0.40	2.96	13.88	0.50	0.56	**208.10**
2016	7.53	0.03	214.37	7.89	-35.94	0.41	3.08	13.44	0.53	0.56	**211.90**
2017	7.55	0.03	219.35	8.14	-36.16	0.43	3.11	12.94	0.50	0.56	**216.44**
2018	7.83	0.02	219.76	8.74	-36.20	0.36	2.74	12.65	0.50	0.56	**216.96**

5.3 Louisiana GHG inventory by GHG emissions type:

Table 3 provides the Louisiana GHG inventory by GHG emissions type. The table shows that over 92 percent of all 2018 GHG emissions, on a CO_2E basis, are associated with CO_2 emissions. Methane emissions account for 4.3 percent of total GHG emissions and N_2O emission account for 2.13 percent of all Louisiana GHG emissions.

Table 3: Louisiana GHG inventory by GHG emissions type

Year	Total emissions ($MMTCO_2E$)				
	CO_2	N_2O	CH_4	HFC, PFC NF6, SF6	Total
2000	225.11	5.26	10.08	1.59	242.04
2001	198.67	5.36	10.60	1.65	216.28
2002	205.75	5.35	10.49	1.72	223.31
2003	200.26	5.37	9.77	1.76	217.16
2004	207.54	5.43	10.25	1.79	225.01
2005	198.06	5.10	10.08	1.83	215.06
2006	213.95	4.89	9.19	1.79	229.81
2007	210.11	5.31	9.66	1.92	227.00
2008	203.36	5.26	10.32	2.06	221.00
2009	194.11	5.13	10.46	2.20	211.90
2010	213.26	4.33	10.13	2.32	230.03
2011	207.62	4.96	9.39	2.37	224.34
2012	196.78	4.98	9.28	2.38	213.42
2013	192.48	5.47	9.55	2.39	209.90
2014	188.41	5.48	9.68	2.46	206.03
2015	191.21	4.85	9.46	2.50	208.02
2016	195.17	4.54	9.60	2.52	211.83
2017	199.71	4.68	9.48	2.50	216.37
2018	200.40	4.63	9.37	2.49	216.89

6 | Detailed large source GHG emitters analysis

GHG emission from industrial and power generation sites in Louisiana account for around 75 percent of all of the state's GHG emissions. Thus, any strategy to reduce overall GHG emissions will need to place a considerable amount of attention on these two sectors. Fortunately, both sectors provide relatively detailed GHG emissions information at the plant/generator level. This GHG inventory, unlike CES' prior work in 2000 and 2005, includes a site-specific analysis of these large source emitters. A summary of this analysis is discussed below. The reader should reference the detailed appendices for each analysis for additional information and analysis.

6.1 Power generation analysis:

This report includes a very detailed analysis of historic power generation GHG emissions. The analysis was conducted early in this research project and funded by the Nature Conservancy. This detailed power generation analysis is provided in Appendix 13.

Figure 16 shows that Louisiana's power generation sector is considerably different than the rest of the U.S. While the rest of the country has and continues to rely heavily on coal and natural gas fired generation, most of the electricity generated in Louisiana is produced from natural gas and nuclear, both represent low, or zero GHG emission sources. Over 71 percent of all Louisiana power generation comes from a natural gas fired prime mover.

Figure 16: Louisiana power generation fuel mix

Source: Energy Information Administration.

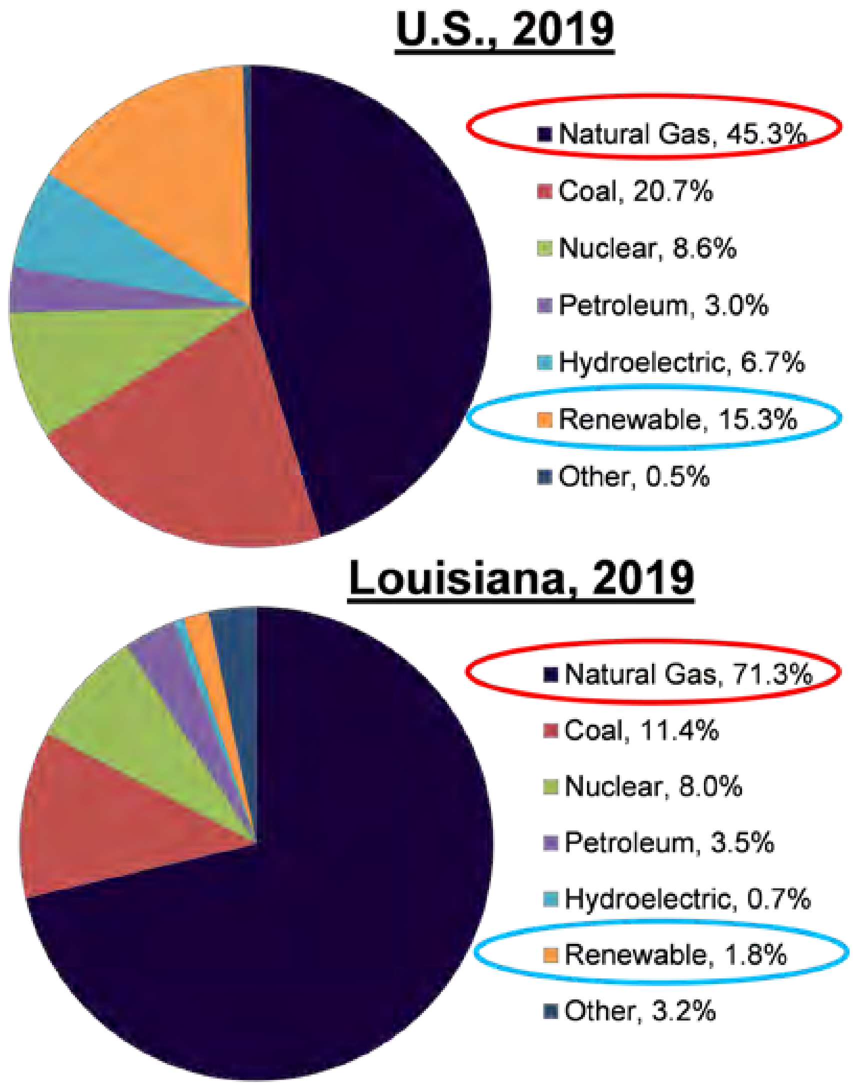


Figure 13, provided earlier, clearly shows that over the past decade, the GHG emissions from Louisiana's power generation facilities have improved dramatically. This improvement has been attributed, in large part, by the increase in thermal efficiencies at the active facilities in the state. While some units have been shut down over the past decade, the state continues to see overall capacity growth. This growth, and its increased generation, however, has not resulted in any new net GHG emissions. Overall, these GHG emission have fallen due to the improved heat rates, or thermal efficiencies, of the newer replacement generators (see Figure 17) that are all run on natural gas.

Figure 17: Louisiana power generation thermal efficiency trends

Source: Energy Information Administration and EPA eGrids.

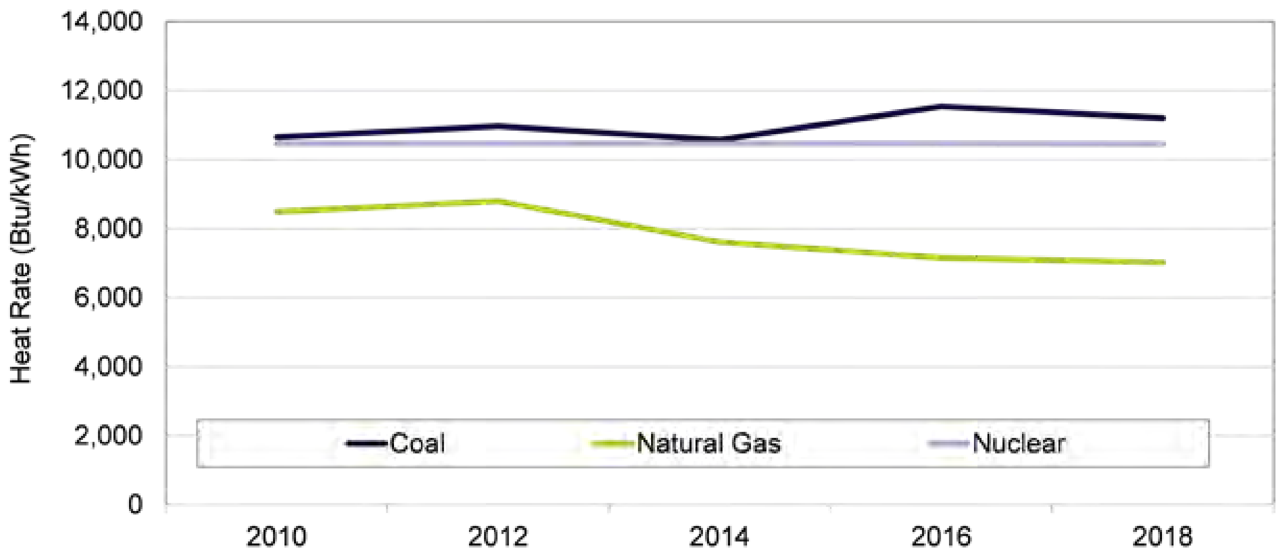


Table 4 below provides a listing of the top 10 GHG emission sources from Louisiana's power generators.

Table 4: Top 10 power generation GHG sources

Facility	Primary Fuel	CO_2 Emissions 2010	2012	2014	2016	2018
		(tons)				
Brame Energy Center	Coal	6,056,503	5,891,000	7,413,244	7,085,451	7,706,781
Big Cajun 2	Coal	13,707,365	11,034,921	11,710,895	6,491,832	5,222,001
Ninemile Point	Natural Gas	3,108,900	2,889,195	2,671,810	4,603,281	4,540,252
Nelson Industrial Steam Co.	Petroleum Coke	1,508,339	n.a.	2,046,282	2,204,305	2,147,748
Taft Cogeneration Facility	Natural Gas	2,400,920	2,232,926	2,446,573	2,390,342	2,117,677
Acadia Power Station	Natural Gas	1,350,490	2,060,818	1,973,816	2,878,268	1,953,255
Dolet Hills Power Station	Coal	5,424,155	5,678,438	3,244,987	3,750,931	1,674,703
Perryville Power Station	Natural Gas	847,109	1,138,930	1,425,702	1,373,639	1,637,373
Ouachita Plant	Natural Gas	499,904	673,382	1,458,381	1,562,408	1,627,090
Plaquemine Cogen Facility	Natural Gas	1,470,373	1,689,653	1,459,147	1,866,356	1,565,446
Total		**36,374,058**	**33,289,264**	**35,850,838**	**34,206,814**	**30,192,324**
Percent of Total Louisiana		**63%**	**56%**	**71%**	**73%**	**71%**

Lastly, Figure 18 provides a map that shows the location for each of the large power generation GHG emission sources in Louisiana. These resources are located throughout the state given the need to diversify resources to meet various in-state electrical loads.

Figure 18: Louisiana power generation GHG emission source locations

Source: Author's construct using EIA information.

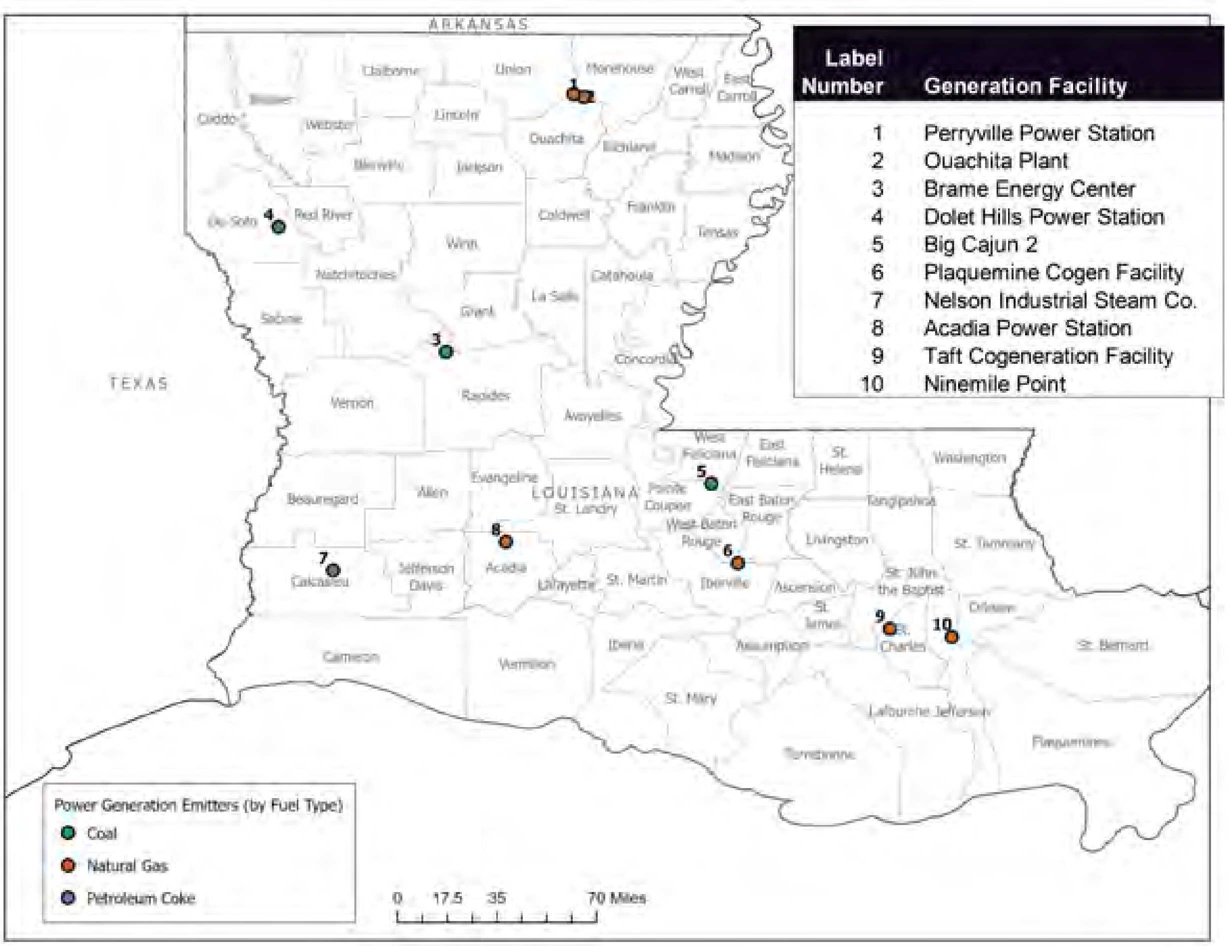


Table 5: GHG emissions from electricity consumption (2018)

Sector	2018 $MMTCO_2E$
Residential	12.78
Commercial	9.84
Industrial	14.92
Transporation	0.00
TOTAL	**37.55**

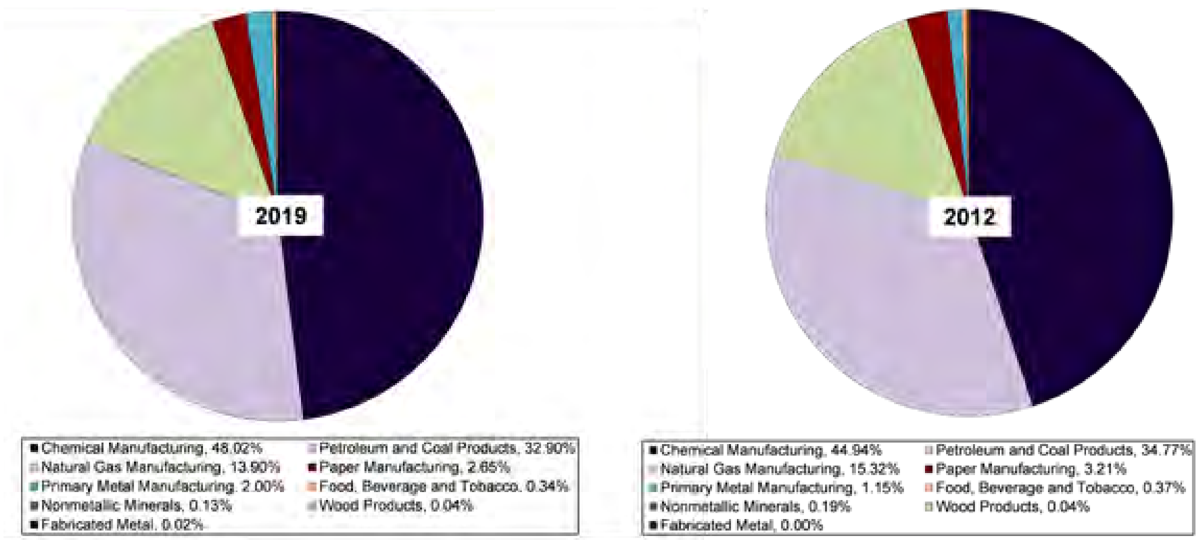
Table 5 provides estimates for GHG emissions from electricity end uses. The detail for these per sector electricity consumption-related GHG emissions estimates is provided in Appendix 4.

6.2 Industrial plant analysis:

A detailed GHG emissions analysis, using plant-specific information, for each industrial location has been provided in Appendix 12. This section summarizes some of the key findings of the analysis. Figure 19 shows that most of the state's industrial GHG emissions are concentrated in the chemical and refining sectors. These concentrations have only increased from 2012 to 2019, the years in which detailed, site-specific industrial GHG emissions information was made available.

Figure 19: Louisiana industrial GHG emission shares by sector (2012, 2019)

Source: EPA FLIGHT



Louisiana's industrial GHG emissions, which have been estimated via the SIT in this report, are very close to actuals, provided by EPA FLIGHT, as well as those estimated by EIA (see Figure 20). In addition, all three sources of information (FLIGHT, SIT, EIA) estimate or show that Louisiana's industrial emissions have been growing while the U.S. industrial average GHG emissions have been falling. Louisiana's 2018 industrial GHG emissions were between 8 to 12 percent higher (depending upon estimates/source) than 2012 levels. By comparison, U.S. industrial GHG emissions are down by over 10 percent since 2012.

Figure 20: U.S. and Louisiana industrial GHG emission trends

Source: EPA FLIGHT, SIT (author's estimates), EIA

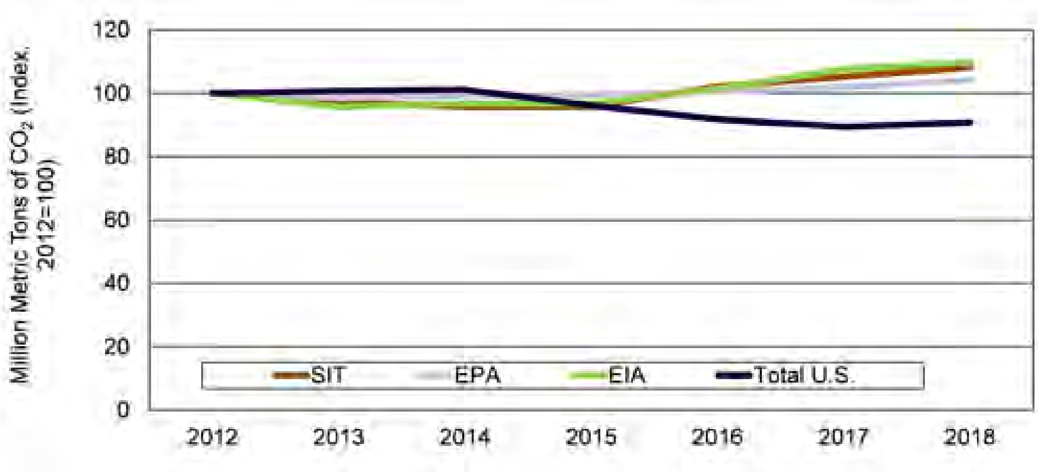


Table 6 lists the top 20 industrial GHG emission sources in Louisiana from the highest to the lowest based upon 2019 emission levels. This listing is strictly for industrial emitters and does not include large power generation facilities. These top 20 industrial facilities in Louisiana currently emit around 61 Mt per year. This is up considerably (29.6 percent) from the 47 Mt reported in 2012 for these top 20 industrial facilities; however, most of these large facilities are also those that have seen considerable capital investment and plant expansions over the past decade.

CF Industries, a large ammonia production facility in Louisiana, is the top GHG industrial emitter in the state. This facility, however, has seen considerable expansion over the past decade and is one of the largest of its type in the world. The increase in GHG emissions, from 2012 to current, mirrors the expansion of productive capacity at this plant.

The ExxonMobil Baton Rouge refinery is the second largest industrial GHG emission source in the state. Emissions for this facility have been relatively flat since 2012, despite seeing some mild productive capability expansions through normal efficiency gains and capacity creep. This refinery reported 2019 GHG emissions (6.3 Mt) that were slightly lower than those in 2012 (6.4 Mt).

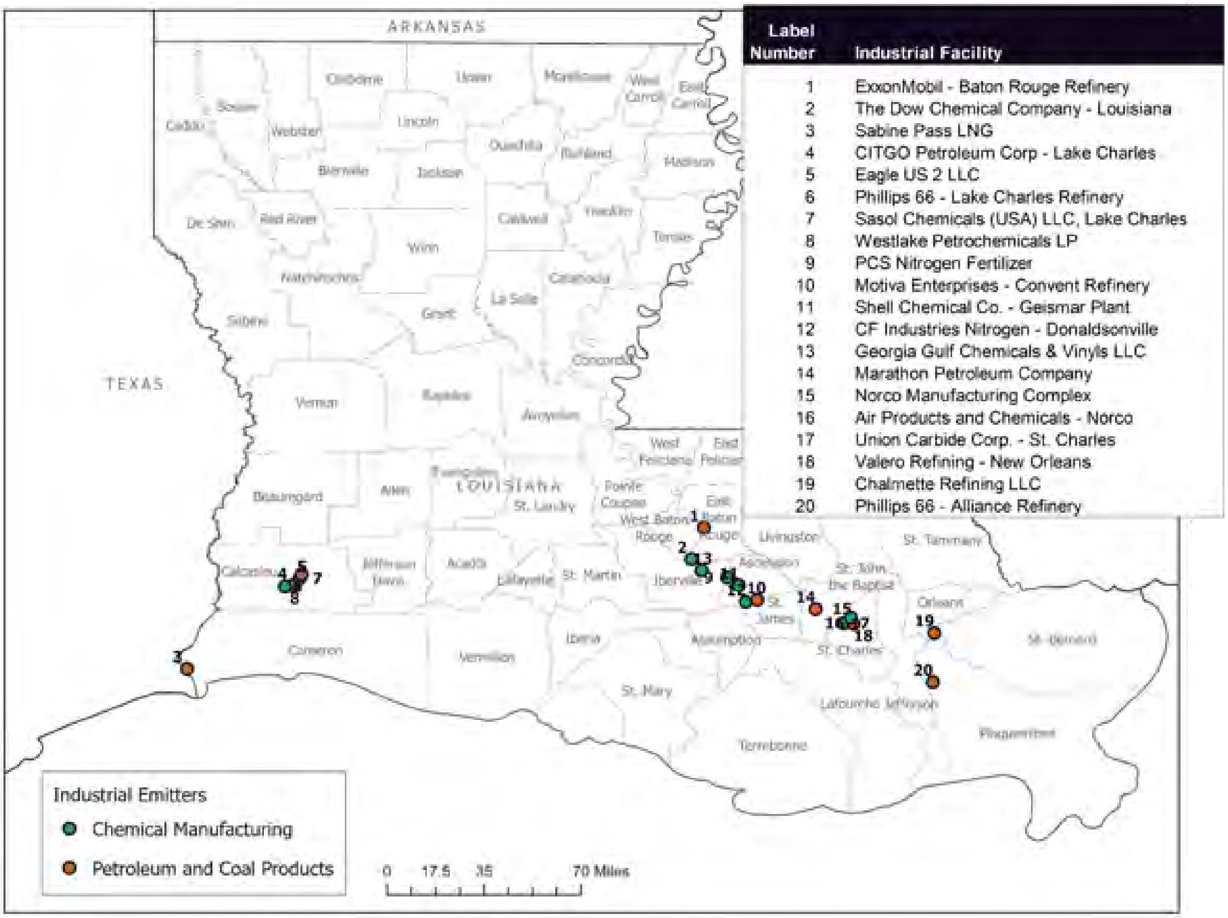
Table 6: Top 20 Louisiana industrial GHG emission sources

Facility Name	Facility Type	2012	2013	2014	2015	2016	2017	2018	2019
		(metric tons CO_2)							
CF Industries Nitrogen - Donaldsonville	Chemical Manufacturing	6,854,462	6,921,307	6,716,321	7,985,546	7,829,243	8,730,636	8,685,862	10,005,456
ExxonMobil - Baton Rouge Refinery	Petroleum and Coal Products	6,475,810	6,355,424	6,286,678	6,000,189	6,213,242	6,131,245	6,380,368	6,360,077
Sabine Pass LNG	Petroleum and Coal Products	62,003	59,472	173,625	181,518	1,259,324	3,383,744	4,197,628	5,093,801
CITGO Petroleum Corp-Lake Charles	Petroleum and Coal Products	4,370,519	4,587,270	4,792,825	4,723,531	4,652,445	4,681,829	4,895,572	4,703,535
Marathon Petroleum Company	Petroleum and Coal Products	3,958,139	3,946,970	3,956,022	3,978,498	3,806,019	4,040,303	4,103,370	3,967,921
Norco Manufacturing Complex	Petroleum and Coal Products	4,032,242	3,586,525	3,596,965	3,522,732	3,981,844	4,071,427	3,901,231	3,961,652
Eagle US 2 LLC	Chemical Manufacturing	2,991,200	3,053,842	2,843,695	2,787,825	2,673,863	2,894,510	2,962,654	3,307,323
Union Carbide Corp-St Charles	Chemical Manufacturing	2,089,716	2,830,069	2,905,740	2,868,338	2,881,109	2,957,077	3,053,784	2,970,876
Phillips 66 - Alliance Refinery	Petroleum and Coal Products	2,175,659	2,416,372	2,122,581	1,973,789	2,582,034	2,803,216	2,741,632	2,697,634
Valero Refining-New Orleans	Petroleum and Coal Products	2,395,982	2,764,110	2,606,177	2,529,869	2,800,860	2,535,694	2,528,290	2,312,540
Motiva Enterprises - Convent Refinery	Petroleum and Coal Products	2,044,250	1,985,611	2,089,138	2,271,203	2,371,145	2,370,044	2,165,013	2,301,471
Sasol Chemicals (USA) LLC, Lake Charles Chemical Complex	Chemical Manufacturing	724,244	743,325	808.304	781,522	771,955	780.782	818,956	1,798.680
The Dow Chemical Company — Louisiana Operations	Chemical Manufacturing	2,736,145	2,684,825	2,728,810	2,527,725	2,418,381	2,659,951	2,152,003	1,919,713
Phillips 66 - Lake Charles Refinery	Petroleum and Coal Products	1,624,822	1,682,175	1,584,268	1,739,973	1,730,893	1,779,721	1,896,562	1,730,933
Chalmette Refining LLC	Petroleum and Coal Products	1,582,620	1,473,867	1,533,904	1,601,253	1,614,862	1,604,410	1,653,272	1,601,075
Georgia Gulf Chemicals & Vinyls LLC	Chemical Manufacturing	1,377,625	1,349,492	1,291,403	1,271,561	1,137,967	1,168,226	1,215,427	1,149,415
Air Products and Chemicals - Norco	Chemical Manufacturing	———	———	844,232	1,139,730	1,156,879	1,169,458	1,073,525	1,072,351
Shell Chemical Co. - Geismar Plant	Chemical Manufacturing	918,606	907,640	939,534	933,213	898,534	917,053	980,823	1,064,539
PCS Nitrogen Fertilizer	Chemical Manufacturing	342,861	1,439,791	1,684,388	1,452,448	1,302,763	1,244,129	1,230,111	1,428,934
Westlake Petrochemicals LP	Chemical Manufacturing	1,055,582	1,157,973	2,102,927	901,198	785,374	896,666	740,227	1,034,631
Total		**47, 812, 487**	**49,946,058**	**51,607,536**	**51,171,663**	**52,868,737**	**56,820,121**	**57,376,309**	**60,482,558**
Average		**2,390,624**	**2,497,303**	**2,580,377**	**2,558,583**	**2,643,437**	**2,841,006**	**2,868,815**	**3,024,128**

Lastly, Figure 21 below provides a map that shows where all of the top 20 industrial GHG emission sources are located. Most of the large industrial GHG emission sources are located in the river corridor between Baton Rouge and New Orleans, and in the greater Lake Charles region.

Figure 21: Louisiana industrial GHG emission source locations

Source: Author's construct using EPA FLIGHT.



6.3 Total large emission sources compilation:

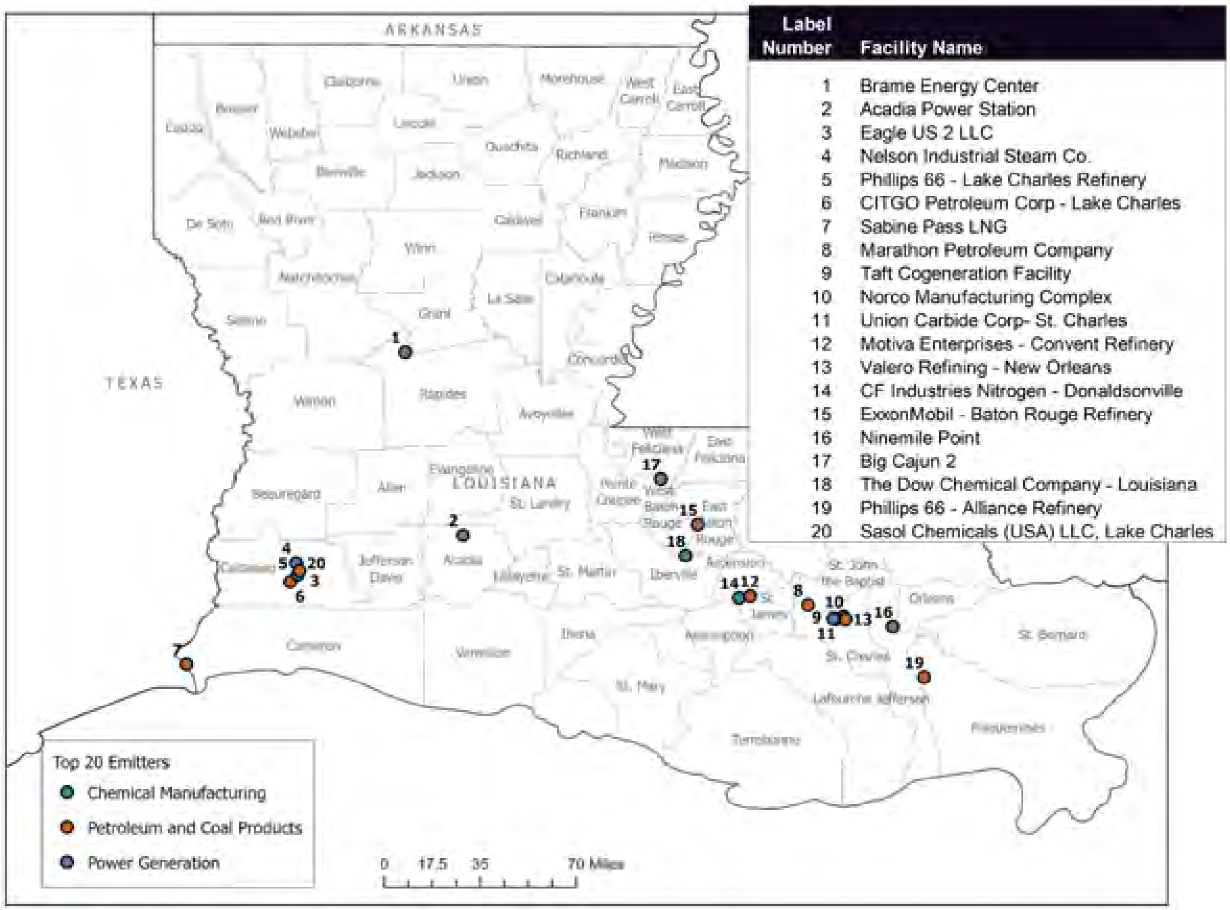
Table 7 combines the information provided in the prior two sub-sections to provide a composite table of the top 20 GHG locations in the state and their recent emission trends. Figure 22 maps those large GHG emission point sources.

Table 7: Louisiana's top 20 GHG emission sources

Facility Name	Facility Type	2012	2013	2014	2015	2016	2017	2018	2019
		(metric tons CO_2)							
CF Industries Nitrogen - Donaldsonville	Chemical Manufacturing	6,854,462	6,921,307	6,716,321	7,985,546	7,829,243	8,730,636	8,685,862	10,005,456
ExxonMobil - Baton Rouge Refinery	Petroleum and Coal Products	6,475,810	6,355,424	6,286,678	6,000,189	6,213,242	6,131,245	6,380,368	6,360,077
Brame Energy Center	Power Generation	5,359,464	7,645,036	6,736,624	6,187,695	6,439,245	6,122,036	7,017,058	5,409,289
Sabine Pass LNG	Petroleum and Coal Products	62,003	59,472	173,625	181,518	1,259,324	3,383,744	4,197,628	5,093,801
CITGO Petroleum Corp-Lake Charles	Petroleum and Coal Products	4,370,519	4,587,270	4,792,825	4,723,531	4,652,445	4,681,829	4,895,572	4,703,535
Ninemile Point	Power Generation	2,623,616	2,593,656	2,429,350	4,188,948	4,184,056	3,933,459	4,127,523	4,648,623
Marathon Petroleum Company	Petroleum and Coal Products	3,958,139	3,946,970	3,956,022	3,978,498	3,806,019	4,040,303	4,103,370	3,967,921
Norco Manufacturing Complex	Petroleum and Coal Products	4,032,242	3,586,525	3,596,965	3,522,732	3,981,844	4,071,427	3,901,231	3,961,652
Eagle US 2 LLC	Chemical Manufacturing	2,991,200	3,053,842	2,843,695	2,787,825	2,673,863	2,894,510	2,962,654	3,307,323
Union Carbide Corp- St. Charles	Chemical Manufacturing	2,089,716	2,830,069	2,905,740	2,868,338	2,881,109	2,957,077	3,053,784	2,970,876
Big Cajun 2	Power Generation	10,089,916	10,861,384	10,708,000	7,081,709	5,927,192	6,015,925	4,773,731	2,927,335
Phillips 66 - Alliance Refinery	Petroleum and Coal Products	2,175,659	2,416,372	2,122,581	1,973,789	2,582,034	2,803,216	2,741,632	2,697,634
Valero Refining-New Orleans	Petroleum and Coal Products	2,395,982	2,764,110	2,606,177	2,529,869	2,800,860	2,535,694	2,528,290	2,312,540
Motiva Enterprises - Convent Refinery	Petroleum and Coal Products	2,044,250	1,985,611	2,089,138	2,271,203	2,371,145	2,370,044	2,165,013	2,301,471
Taft Cogeneration Facility	Power Generation	2,190,413	2,171,509	2,285,092	2,081,806	2,441,617	2,325,817	2,239,733	2,399,413
Acadia Power Station	Power Generation	1,871,463	1,543,046	1,792,453	2,608,097	2,613,802	1,881,625	1,773,782	1,970,577
The Dow Chemical Company — Louisiana Operations	Chemical Manufacturing	2,736,145	2,684,825	2,728,810	2,527,725	2,418,381	2,659,951	2,152,003	1,919,713
Nelson Industrial Steam Co.	Power Generation	1,857,195	1,809,776	1,741,839	1,477,709	1,873,435	1,872,199	1,833,362	1,764,981
Sasol Chemicals (USA) LLC, Lake Charles Chemical Complex	Chemical Manufacturing	724,244	743,325	808,304	781,522	771,955	780,782	818,956	1,798,680
Phillips 66 - Lake Charles Refinery	Petroleum and Coal Products	1,624,822	1,682,175	1,584,268	1,739,973	1,730,893	1,779,721	1,896,562	1,730,933
Total		**66,527,259**	**70,241,702**	**68,904,508**	**67,498,222**	**69,451,705**	**71,971,241**	**72,248,114**	**72,251,830**
Average		**3,326,363**	**3,512,085**	**3,445,225**	**3,374,911**	**3,472,585**	**3,598,562**	**3,612,406**	**3,612,591**

Figure 22: Louisiana large GHG emission source locations

Source: Author's construct using EPA FLIGHT.



7 | Large industrial emissions projections

As noted earlier, most of Louisiana's GHG emissions come from large industrial facilities. There is a potential that these industrial emissions could grow as new industrial locations are developed. This is particularly true for LNG export facilities, an industrial sector that is (a) growing rapidly and (b) has large individual location GHG emissions profiles that are likely around the 5 Mt level per year or higher.

Several industrial project announcements, to date, have requested air permits from the Louisiana Department of Environmental Quality (DEQ) as part of their business development process. Information on these facilities permitting requests is available on-line within DEQ's Environmental Document Management System (EDMS). Furthermore, the Environmental Integrity Project (EIP), a non-profit environmental advocacy group, compiles this type of permitting information for Louisiana and other states in an easily-accessible database.[4] CES utilized the EIP database in order to ascertain permitting GHG emissions levels. CES spot-checked and compared several entries in the EIP database to the original DEQ/EDMS to assure accuracy.

[4] For information about EIP, see https://environmentalintegrity.org/. The data series collecting air permit information can be found at: https://environmentalintegrity.org/oil-gas-infrastructure-emissions/.

It is important to note that the use of air permits to estimate future GHG emissions is conservative since it is not uncommon to seek permits for the upper end of an individual facilities' emissions levels. Moreover, because a facility is authorized for a fixed level of emissions does not entail that it will emit at that level on a year-end and year-out basis. Further, the use of the permitted emissions levels does not consider future efficiency gains and opportunities in Louisiana's industrial sector. Thus, these industrial projections should be considered as the "outer boundary" or "book end" of future industrial GHG emissions given current project announcements. As project announcements increase, however this book end will also expand.

Figure 23 shows the incremental new GHG emission levels that have been permitted at DEQ as of September 2021. Information from 2019 forward is utilized to carry forward the earlier GHG industrial inventory estimates. A noticeable surge in emissions arises in the 2023-to-2026 time period which is primarily based on the approved permits for several very large LNG facilities.

Figure 23: Projected industrial GHG emissions

Source: Environmental Integrity Project, LDEQ

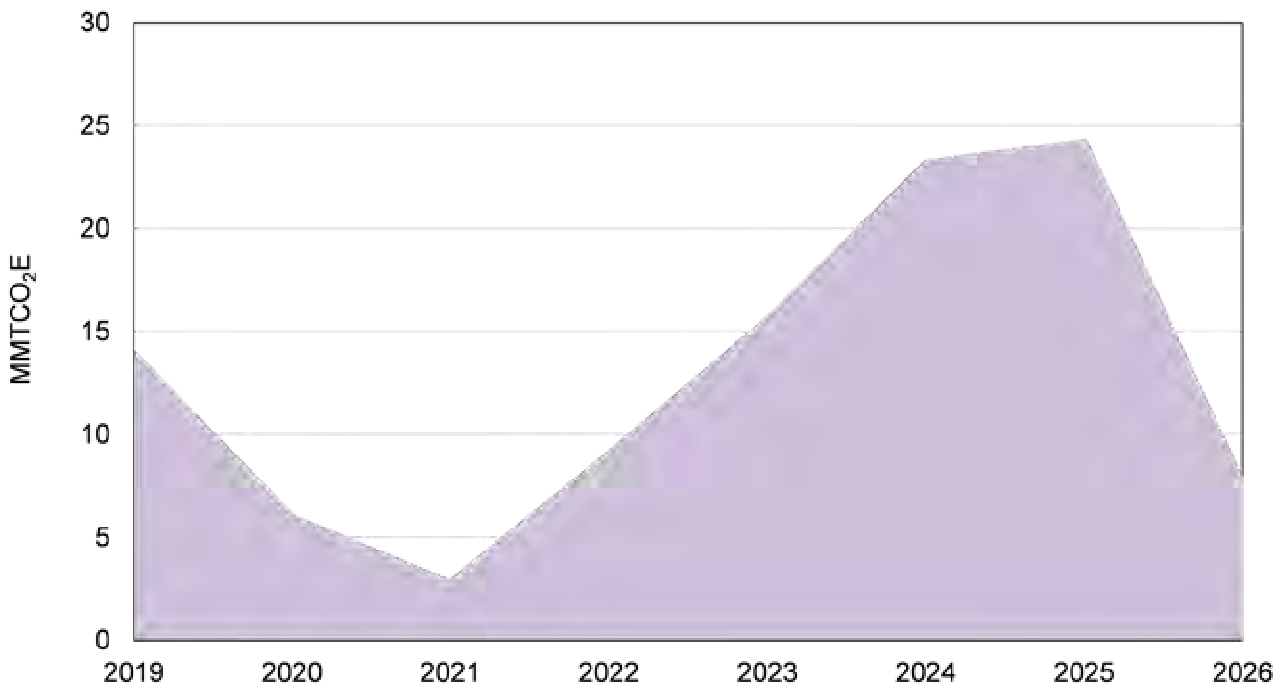


Figure 24 charts incremental industrial GHG emissions from 2019 to 2026. Again, the rapid growth post 2023 is attributable to LNG export facility development. Cumulative new industrial GHG emissions, based on announced project that have received air permits, is 120 Mt.

Figure 24: Cumulative industrial GHG emissions (proposed projects only)

Source: Environmental Integrity Project, LDEQ

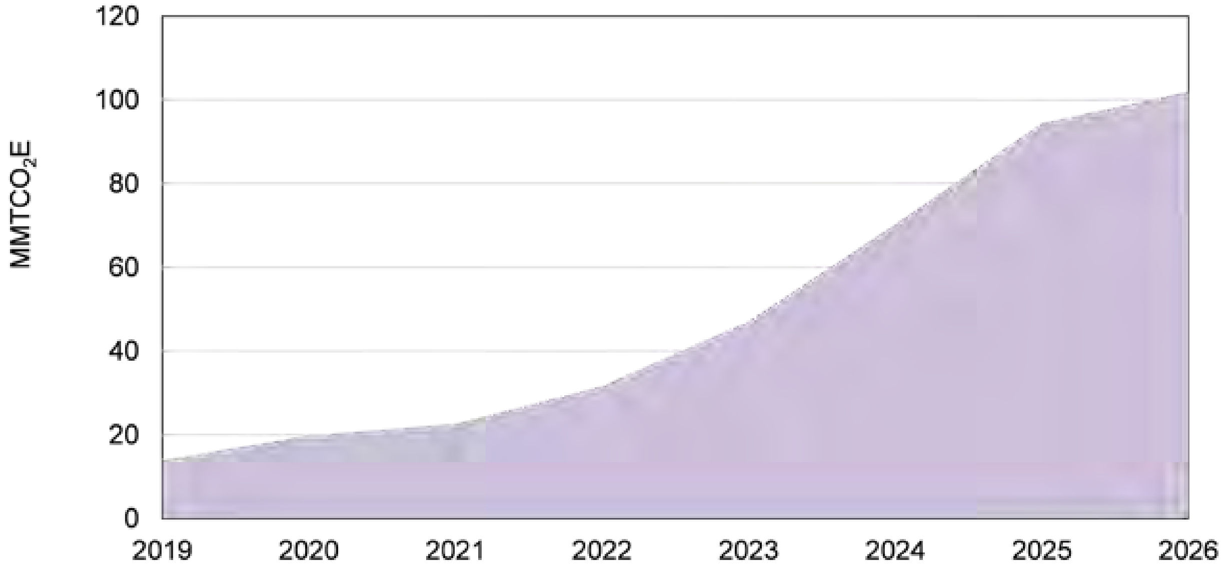


Figure 25 below brings together the industrial GHG inventory from 2000 and merges this data with the projections discussed above. As noted earlier, 2018 industrial GHG emissions are estimated at around 142 Mt. Adding this amount with the additional 101 Mt from the projected, permitted GHG emissions, results in a potential statewide total industrial emissions level of around 243 Mt. Again, this projection assumes (1) annual industrial GHG emissions that are exactly at permitted levels for each and every year those new facilities are in operation and (2) no change in GHG emissions from the existing industrial base present at the end of the GHG inventory (2018).

Figure 25: Total projected industrial GHG emissions (existing facilities and new project proposals)

Source: Environmental Integrity Project, LDEQ

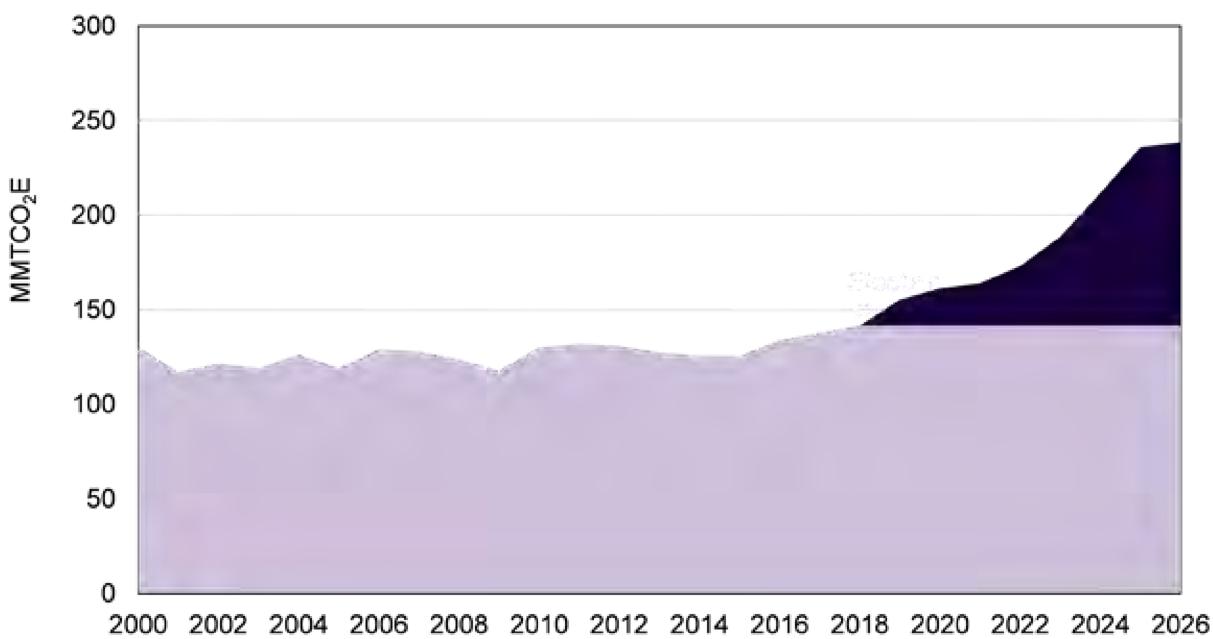


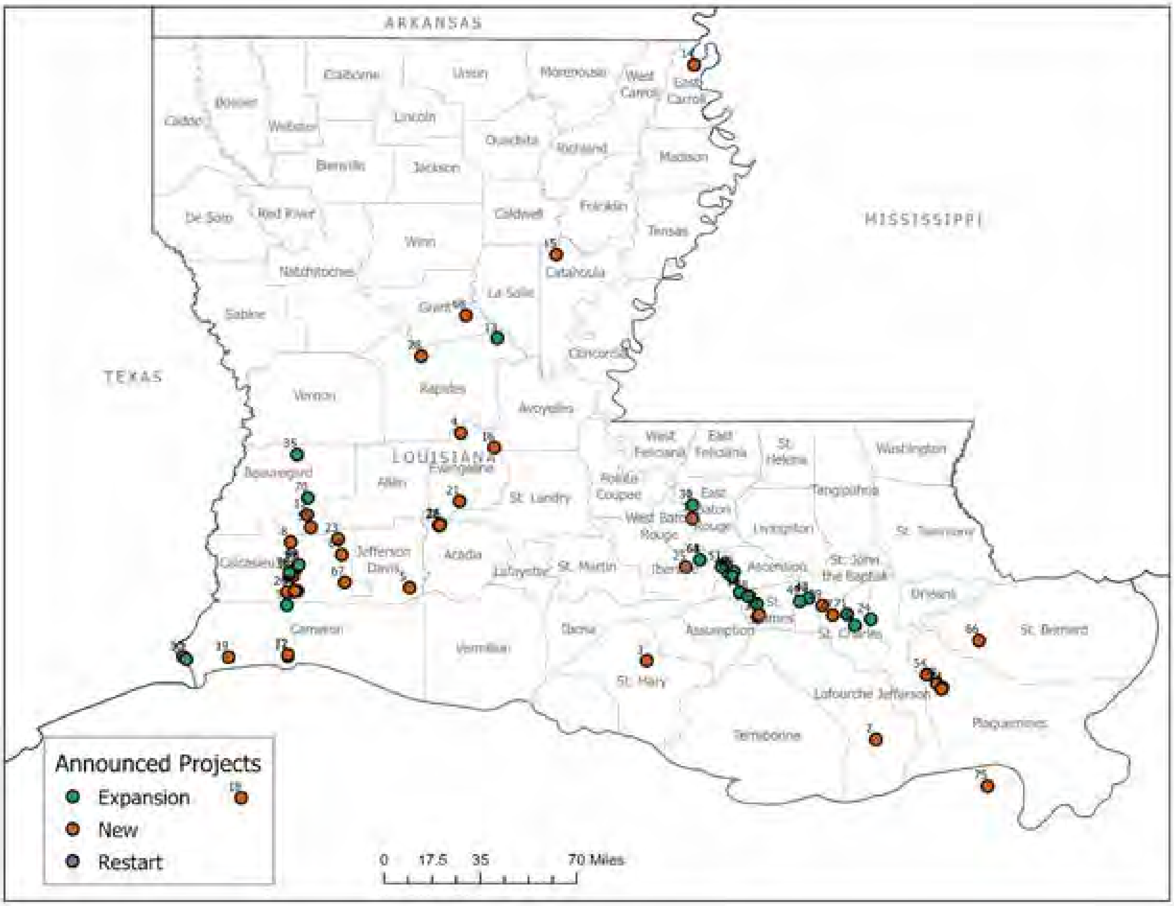
Table 8 provides additional information on potential future GHG emissions levels by sector over the entire period 2019-2026. Figure 26 provides a map of the location of these potential new industrial GHG emission sources.

Table 8: Projected additional industrial GHG emissions by sector in 2026

Category	$MMTCO_2E$
Natural Gas	3.14
LNG	54.94
Fertilizer and Pesticides	5.38
Plastics	0.01
Chemcial	35.57
Refining	2.94
Total	**101.99**

Figure 26: Location of announced industrial projects (based on approved/pending air permits)

Source: Environmental Integrity Project, LDEQ



Label Number	Facility Name
1	Air Liquide Large Industries U.S. LP
2	ANR Pipeline Company (dba TC Energy)
3	ANR Pipeline Company (dba TC Energy)
4	ANR Pipeline Company (dba TC Energy)
5	ANR Pipeline Company (dba TC Energy)
6	Bayer CropScience LP (Monsanto)
7	Big Lake Fuels, LLC (G2X Energy)
8	Cameron Interstate Pipeline, LLC
9	Cameron LNG, LLC (dba Sempra Energy)
10	CF Industries
11	CF Industries Nitrogen, LLC
12	Cheniere Creole Trail Pipeline LP (Cheniere Energy)
13	Columbia Gulf Transmission Co.
14	Columbia Gulf Transmission, LLC (dba TC Energy)
15	Columbia Gulf Transmission, LLC (dba TC Energy)
16	Columbia Gulf Transmission, LLC (dba TC Energy)
17	Commonwealth LNG LLC
18	Delfin LNG, LLC (dba Fairwood Peninsula Energy Corporation)
19	Delfin LNG, LLC (dba Fairwood Peninsula Energy Corporation)
20	Driftwood LNG, LLC (dba Tellurian)
21	Driftwood Pipeline LLC
22	Driftwood Pipeline LLC
23	Driftwood Pipeline LLC
24	Dyno Nobel Louisiana Ammonia
25	Enlink Processing Services, LLC
26	Enlink Processing Services, LLC
27	Enterprise Pelican Pipeline LP
28	Enterprise Products Operating LLC
29	Eurochem Louisiana, LLC
30	ExxonMobil
31	ExxonMobil Chemical Company
32	FG LA, LLC (Formosa Plastics)
33	IGP Methanol
34	Indorama Ventures Olefins LLC
35	Ingevity South Carolina LLC (Ingevity Corporation)
36	Kinder Morgan Louisiana Pipeline, LLC
37	LACC LLC (formerly Eagle US 2 LLC)
38	Lake Charles LNG LLC (dba Energy Transfer L.P.)
39	Lake Charles Methanol, LLC
40	Louisiana Integrated Polyethylene JV LLC
41	Magnolia LNG, LLC
42	Marathon Petroleum, LLC
43	Marathon Petroleum, LLC
44	Marathon Petroleum, LLC
45	MCC Methacrylates Americas Inc
46	Methanex USA
47	Methanex USA
48	Mosaic Fertilizer LLC
49	Mt. Airy Terminal LLC
50	Natural Gas Pipeline Company of America, LLC (dba Kinder Morgan)
51	NOVA Chemicals (formerly Williams Olefins)
52	Phillips 66
53	Phillips 66
54	Plaquemines Liquid Terminal, LLC
55	Port Arthur Pipeline LLC (dba Sempra Energy)
56	Praxair, Inc.
57	Sabine Pass LNG LP (dba Cheniere Energy)
58	Sasol North America, Inc.
59	Sasol North America, Inc.
60	Shell Chemical LP
61	Shintech Louisiana LLC
62	Shintech Louisiana, LLC
63	Shintech Louisiana, LLC
64	Shintech Louisiana, LLC
65	South Louisiana Methanol, LP
66	Tennessee Gas Pipeline Company, LLC
67	Texas Eastern Transmission LP
68	TopChem Pollock, LLC
69	Trunkline Gas Company (dba Energy Transfer L.P.)
70	Trunkline Gas Company (dba Energy Transfer L.P.)
71	Valero Refining- New Orleans, LLC
72	Venture Global Calcasieu Pass, LLC
73	Venture Global Delta LNG, LLC
74	Venture Global Plaquemines LNG, LLC
75	West Delta LNG, LLC (dba LNG21, LLC)
76	Westlake Polymers
77	YCI Methanol One, LLC (dba Koch Methanol Investments, LLC)

8 | GHG inventory estimate uncertainties

The GHG estimation process is similar to many other types of modeling exercises in that a large part of the empirical results are a function of the input, assumptions, and data used in the calculations. As noted earlier, the underlying methods for estimating activity and sector specific emissions is through the product of (1) an emissions activity factor as measured in pounds per activity level and (2) an activity level, as measured in MWhs generated, or MMBtus of fuel combusted. Thus, the uncertainties that arise in the estimation of GHG emissions, using the EPA's SIT, are primarily associated with measurement and assumption errors in either (1) the emissions activity factor itself or (2) the activity level data.

Of the two potential areas of uncertainty, the emission activity factor is likely the one that can yield more uncertainties than activity level data itself. A large amount of the activity level data used by the SIT in the estimation process is from information that is routinely collected by a wide range of state and federal government executive agencies. In fact, these are government data sources, and the transparency that comes with using this information makes the SIT such a useful tool for independent GHG emissions estimation. A large part of the data collected by federal executive agencies, like the EIA, the FERC, the Department of Agriculture, and others is based on required filings; while the data is often surveyed or "self-reported," there are often civil penalties associated with misrepresentation of information. Thus, for SIT purposes, the data is likely not as problematic as, in some instances, the activity emissions factors.

Uncertainties that arise with activity emission factors can be generalized into two categories: (1) that the factors themselves are not accurately estimated or are biased for various different reasons or (2) the factors are generally accurate but are averaged or aggregated in ways that may make state-specific application a challenge.

The first problem that can lead to estimation uncertainty is simply accuracy in the emissions factors themselves. The bias for this estimation can, in theory, go in either fashion (upwards or downwards in estimating GHG emissions). As an example, consider the oil and gas sector and the considerable uncertainties that can arise from their estimation. Over the past decade, increasing attention has been placed on oil and natural gas emissions, particularly natural gas. While natural gas has potential favorable environmental attributes relative to other fossil fuels like coal, methane (CH_4) can be released throughout the value chain. The increased drilling activity around various unconventional basins in the U.S., including in Louisiana, helped focus attention on these fugitive methane emissions.

Several studies have questioned whether emissions from natural gas production and natural gas pipelines are actually contributing more than believed to GHG emissions. These studies have used a variety of methods that include remote sensing, satellite imagery, and other technologies, such as mobile methane "sniffing" technologies to identify and measure methane releases. The results of these studies have shown that current methods used to estimate GHG emissions do not sync well with actual measurements. One such study, published in 2018 in ***Science***, notes that the SIT inventory methods may underestimate methane releases by as much as 60 percent since the methods fail to capture releases that can arise from abnormal operations. For purposes of this study, it is important to keep in mind that the releases from production sources in Louisiana are likely to have some degree of uncertainty. Thus, it would not be unreasonable to consider "grossed up" inventory estimates from the oil and gas sector in evaluating policies and strategies to address such uncertainties. The current estimates from this sector are at 12.65 Mt. A 60 percent gross up, for sensitivity purposes, would put those emissions at 20.24 Mt.

Aggregation and averaging can also serve as a source of uncertainty for the GHG estimates generated via the SIT. Many emission factors used in the tool are taken from national or regional averages and treat emissions as being relatively consistent across the country or broad geographic areas. In reality, however, these averages, while correct, may not adequately estimate more geographically specific emission characteristics.

Consider, as an example, Louisiana's wetlands. Recall from the earlier discussion that the emissions factor for wetlands is actually a negative number: wetlands are a net sink and actually sequester carbon rather than produce carbon. For purposes of this study, a national wetlands factor was used because, while EPA has utilized estimates for the national SIT, it has not worked these estimates down into the individual SITs for each state. This national emissions factor is based upon a national composite of all wetlands and wetland types across the country. However, Louisiana's wetlands can be quite unique and are formed from a variety of habitat types that vary in size and importance relative to the national average. Consider that the proportion of salt marshes in Louisiana alone is likely different than the share embedded into the national emissions factor estimate.

Thus, the estimates provided for wetlands sinks also represent an uncertainty for the GHG inventory, particularly given the size of the sink when wetlands are coupled with forestry related sinks. The inventory estimate for these sinks, collectively, is -36.2 Mt, a large amount and one slightly higher than the emissions from the entire power generation sector. Further, a comparison of the past CES SIT estimates for forestry alone show that the EPA has been revising these estimates in ways that have tended to increase, in absolute value, the positive impacts that natural systems can have in sequestering carbon.

The current wetlands share of the overall forestry and land use estimate is only around -1.0 Mt.; however, it is very likely that as the science in this area improves, those estimates, like the general land use and forestry estimates may increase. While EPA is continuing to revise its approach at estimating wetlands sinks, Louisiana is also independently working to improve its estimates as well. The Louisiana U.S. Geological Survey (USGS) and The Water Institute are working collectively at developing estimates across a series of studies that should provide better clarity on Louisiana-specific wetland carbon contributions by the end of 2021.

9 | Conclusions

Louisiana has a relatively high level of GHG emissions for its population size and GDP. Industrial sources explain the majority of the state's emissions, which varies greatly from the U.S. and other regional averages. While U.S. GHG emissions are heavily concentrated in power generation and transportation, Louisiana's are highly concentrated in industry, followed by transportation, and then power generation.

The purpose of this research has been to both (1) inform stakeholders about the trends in GHG emissions, across sectors, activities, and GHG emission types over the past two decades and (2) provide an inventory to the CTF and other stakeholders in their policy formation activities. The purpose of this report has not been to provide policy guidance but provide data that can be used to develop later policies to meet Louisiana's goal of net zero GHG emissions by 2050. However, after a review of this study, it is hard to walk away without reaching the conclusion that industrial decarbonization will have to be the predominate focus of attention for Louisiana policy makers in meeting our future GHG emission goals.

Appendices

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Louisiana 2021 GHG Inventory. Appendix 1: Combustion of fossil fuels emissions estimates.

Prepared on the behalf of the Governor's Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Fossil Fuels Combustion Emissions

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Fossil fuel consumption overview

- Most GHG emissions arise from the combustion of fossil fuels.
- Fossil fuel consumption is ubiquitous across over every major economic sector.
- The GHG state inventory tool estimates fossil fuel-related emissions across six sectors/areas: residential; commercial; transportation; electric power; bunker fuels; and industrial.
- Coal, petroleum, and natural gas are the main emitters of fossil fuels from combustion
- For Louisiana, the industrial sector is the largest GHG emitter followed by the transportation and electric power sectors.

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Mathematics of estimating fossil fuel emissions – general equation

The fossil fuel module estimates the carbon content of fossil fuels, in tons, converts to metric tons, and then standardizes to CO_2 equivalent. This is done for each fuel type and for each economic sector

Emissions ($MMTCO_2E$) =
Consumption (BBtu) × Emission Factor (lbs C/BBtu) × 0.0005 short ton/lbs × Combustion Efficiency (% as a decimal) × 0.9072 (Ratio of Short Tons to Metric Tons) ÷ 1,000,000 × (44/12) (to yield $MMTCO_2E$)

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Mathematics of estimating fossil fuel emissions – industrial equation

Primary difference is in non-energy consumption – or "feedstock" energy consumption

Emissions ($MMTCO_2E$) =
(Total Consumption (BBtu) – [Non-Energy Consumption (BBtu) × Storage Factor (%)]
× Emission Factor (lbs C/BBtu) × Combustion Efficiency (% as a decimal))
× 0.9072 (Ratio of Short Tons to Metric Tons) ÷ 1,000,000 × (44/12) (to yield $MMTCO_2E$)

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Combustion of Fossil Fuels - Residential

Residential fuel types

Residential Sector 2017

Fuel Type	Consumption (Billion Btu)		Emission Factor (lbs C/Million Btu)		Combustion Efficiency (%)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
Coal	-	x	62.02	x	100.0%	=	-	=	0.000	=	0.000
Distillate Fuel	44	x	44.47	x	100.0%	=	978	=	0.001	=	0.003
Kerosene	2	x	44.01	x	100.0%	=	44	=	0.000	=	0.000
Hydrocarbon Gas Liquids	1,699	x	37.11	x	100.0%	=	31,525	=	0.029	=	0.105
Natural Gas	29,680	x	31.90	x	100.0%	=	473,396	=	0.429	=	1.575
Other	-	x		x		=	-	=	0.000	=	0.000

Residential Sector 2018

Fuel Type	Consumption (Billion Btu)		Emission Factor (lbs C/Million Btu)		Combustion Efficiency (%)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
Coal	-	x	62.02	x	100.0%	=	-	=	0.000	=	0.000
Distillate Fuel	8	x	44.47	x	100.0%	=	178	=	0.000	=	0.001
Kerosene	4	x	44.01	x	100.0%	=	88	=	0.000	=	0.000
Hydrocarbon Gas Liquids	1,748	x	37.11	x	100.0%	=	32,434	=	0.029	=	0.108
Natural Gas	38,629	x	31.90	x	100.0%	=	616,133	=	0.559	=	2.049
Other	-	x		x		=	-	=	0.000	=	0.000

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Combustion of Fossil Fuels - Industrial

Feedstock uses.

Industrial Sector 2018

☑ Default Non-Energy Consumption Data

Fuel Type	Total Consumption (Billion Btu)	Non-Energy Consumption (Billion Btu)	Storage Factor (%)	Net combustible Consumption (Billion Btu)	Emission Factor (lbs C/Million Btu)	Combustion Efficiency (%)	Emissions (short tons carbon)	Emissions (MMTCE)	Emissions ($MMTCO_2E$)
Coking Coal	-	-	10%		0.00	100.0%	-	0.000	0.000
Other Coal	3,960	77	0%	3,960	55.85	100.0%	110,592	0.100	0.368
Asphalt and Road Oil	15,039	15,039	100%	66	45.31	100.0%	1,496	0.001	0.005
Aviation Gasoline Blending Components	(276)	-	0%	(276)	41.60	100.0%	(5,741)	-0.005	-0.019
Crude Oil	-	-	0%	-	44.77	100.0%	-	0.000	0.000
Distillate Fuel	31,937	170	50%	31,852	44.47	100.0%	708,230	0.642	2.356
Feedstocks, Naphtha less than 401 F	65,677	61,447	62%	27,288	40.90	100.0%	558,038	0.506	1.856
Feedstocks, Other Oils greater than 401 F	239,081	217,698	62%	103,074	44.47	100.0%	2,291,853	2.079	7.623
Kerosene	41	-	0%	41	44.01	100.0%	902	0.001	0.003
LPG	625,348	552,401	62%	280,236	37.07	100.0%	5,193,959	4.712	17.277
Lubricants	3,058	3,058	9%	2,783	44.53	100.0%	61,959	0.056	0.206
Motor Gasoline	3,675	-	0%	3,675	42.90	100.0%	78,830	0.072	0.262
Motor Gasoline Blending Components	-	-	0%	-	42.90	100.0%	-	0.000	0.000
Misc. Petro Products	29,248	29,248	0%	29,248	44.77	100.0%	654,770	0.594	2.178
Petroleum Coke	98,809	-	30%	98,809	61.39	100.0%	3,032,942	2.751	10.089
Pentanes Plus	32,988	15,402	62%	23,366	42.10	100.0%	491,844	0.446	1.636
Residual Fuel	3,812	-	50%	3,812	45.15	100.0%	86,056	0.078	0.286
Still Gas	286,652	29,673	65%	267,265	40.11	100.0%	5,359,996	4.862	17.829
Special Naphthas	1,308	1,229	0%	1,308	43.51	100.0%	28,456	0.026	0.095
Unfinished Oils	5,487	-	0%	5,487	44.77	100.0%	122,837	0.111	0.409
Waxes	147	147	58%	62	43.64	100.0%	1,347	0.001	0.004
Natural Gas	1,341,378	40,624	62%	1,315,998	31.90	100.0%	20,990,168	19.042	69.820
Other	-			-			-	0.000	0.000

Non-energy related emissions (feedstock uses)/shares

Feedstock shares based on national industry averages

National Non-Energy Consumption %'s	2	3	4	5	6	26	27	28	29	30
	1990	1991	1992	1993	1994	2014	2015	2016	2017	2018
Industrial Sector										
Coking Coal	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%
Other Coal	0%	1%	1%	1%	1%	1%	1%	2%	2%	2%
Natural Gas	4%	3%	3%	4%	4%	4%	4%	3%	3%	3%
Asphalt and Road Oil	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
LPG	73%	77%	73%	73%	76%	91%	88%	86%	87%	88%
Lubricants	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Pentanes Plus	47%	47%	47%	46%	47%	49%	49%	47%	47%	47%
Feedstocks, Naphtha less than 401 F	94%	93%	94%	93%	94%	98%	98%	94%	94%	94%
Feedstocks, Other Oils greater than 401 F	88%	90%	83%	79%	76%	96%	95%	92%	92%	91%
Still Gas	2%	3%	2%	3%	2%	11%	11%	10%	10%	10%
Petroleum Coke	4%	2%	9%	3%	6%	0%	0%	0%	0%	0%
Special Naphthas	94%	94%	94%	93%	95%	98%	98%	95%	95%	94%
Distillate Fuel	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%
Residual Fuel	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Waxes	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Misc. Petro Products	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Other Coal	0%	1%	1%	1%	1%	1%	1%	2%	2%	2%
Aviation Gasoline Blending Components	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Crude Oil	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Kerosene	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Motor Gasoline	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Motor Gasoline Blending Components	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Unfinished Oils	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Transportation	1990	1991	1992	1993	1994	2014	2015	2016	2017	2018
Lubricants	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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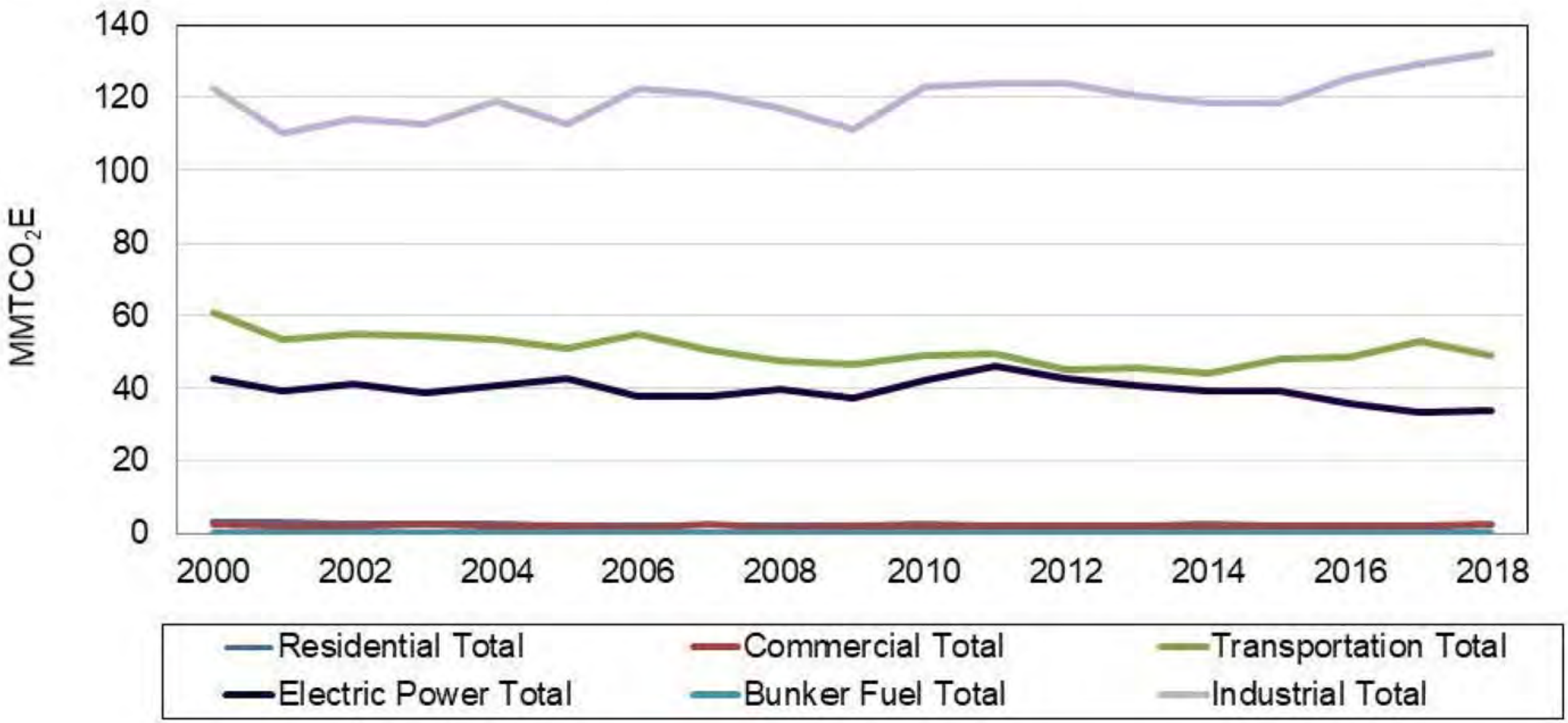
Estimated fossil fuel combustion trends

Louisiana sector-specific GHG emission trends

Industrial GHG emissions from fossil fuels account for 60 percent (around 160 million metric tons) of total GHG emissions across all sectors (fossil fuel based). Transportation sector accounts for the second largest sector with fossil-fueled GHG emissions (22 percent) followed by electric power (16 percent).



Source: US EIA state energy data system (SEDS)

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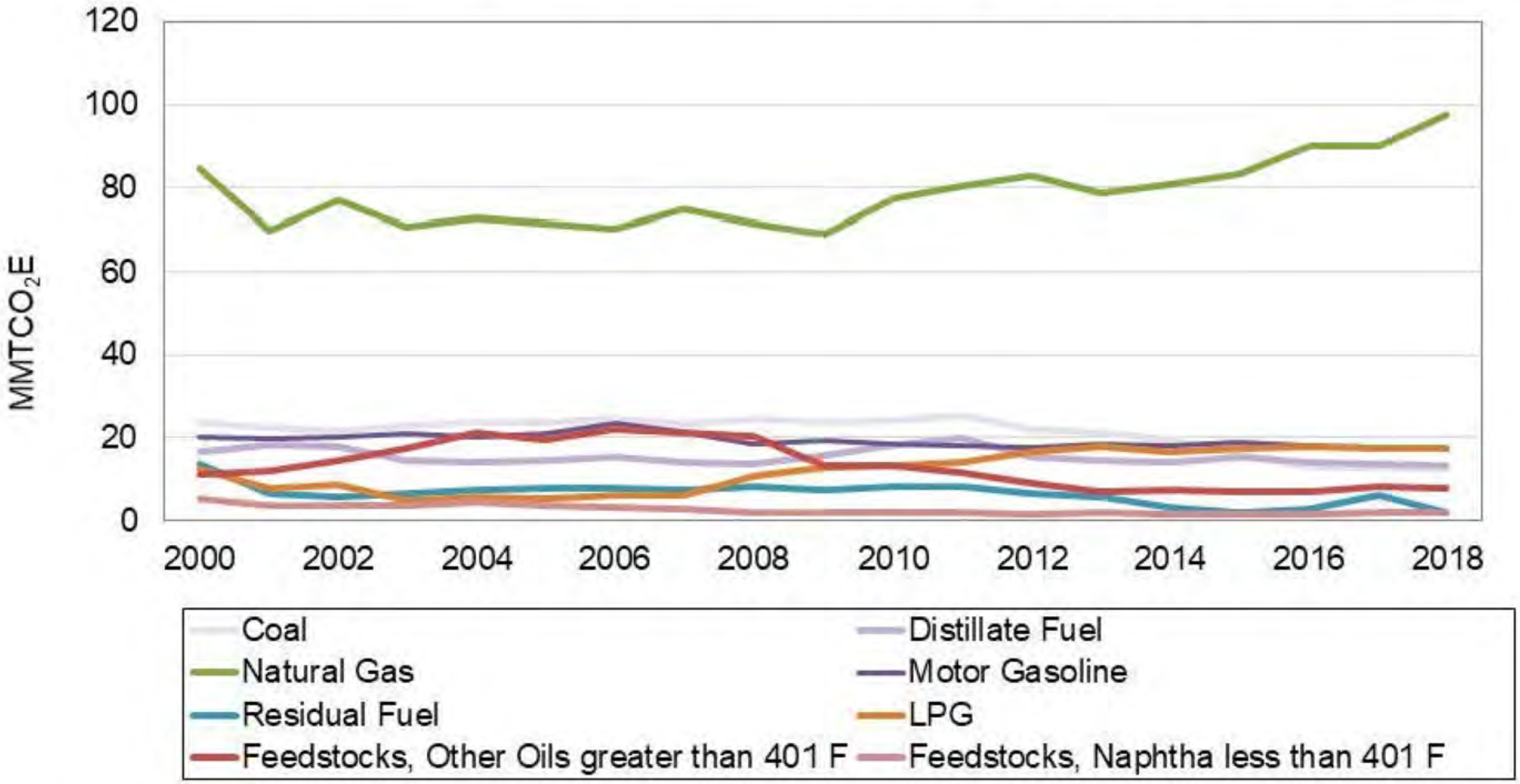
Louisiana, all sector fossil fuel combustion emission trends (by fuel type)

Most fossil fuel-based GHG emissions come from the combustion of natural gas (98 million metric tons). LPGs have recent risen to being the second largest fossil fuel-based source of GHG emissions. These LPGs are used as feedstocks for Louisiana's chemical industry.



Source: US EIA state energy data system (SEDS)

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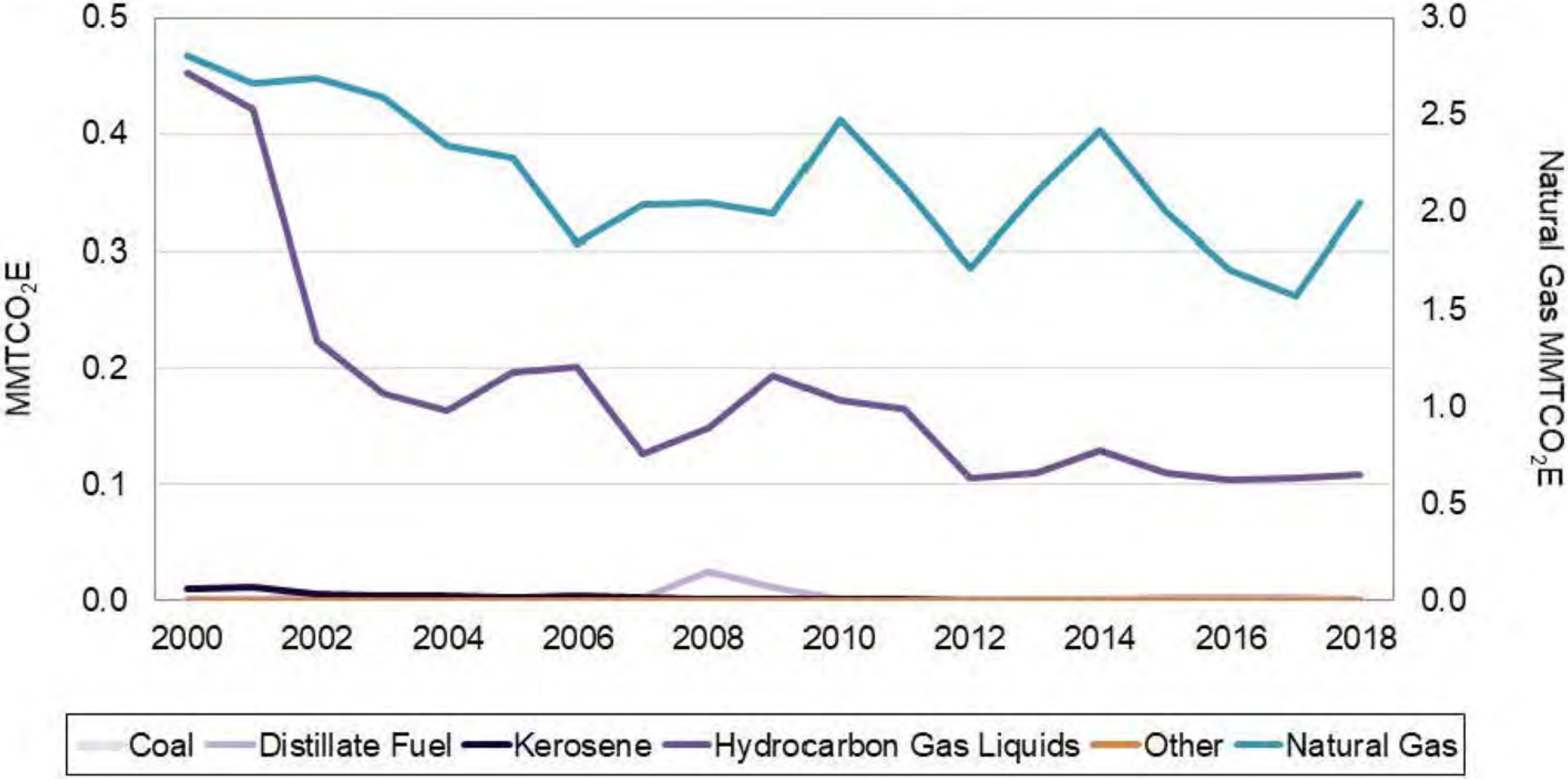
Louisiana residential fossil fuel combustion emission trends (by fuel type)

Natural gas consumption is the primary GHG emission for residential households in Louisiana. Those emissions have been trending down, due to end-use efficiency since 2000.



Source: US EIA state energy data system (SEDS)

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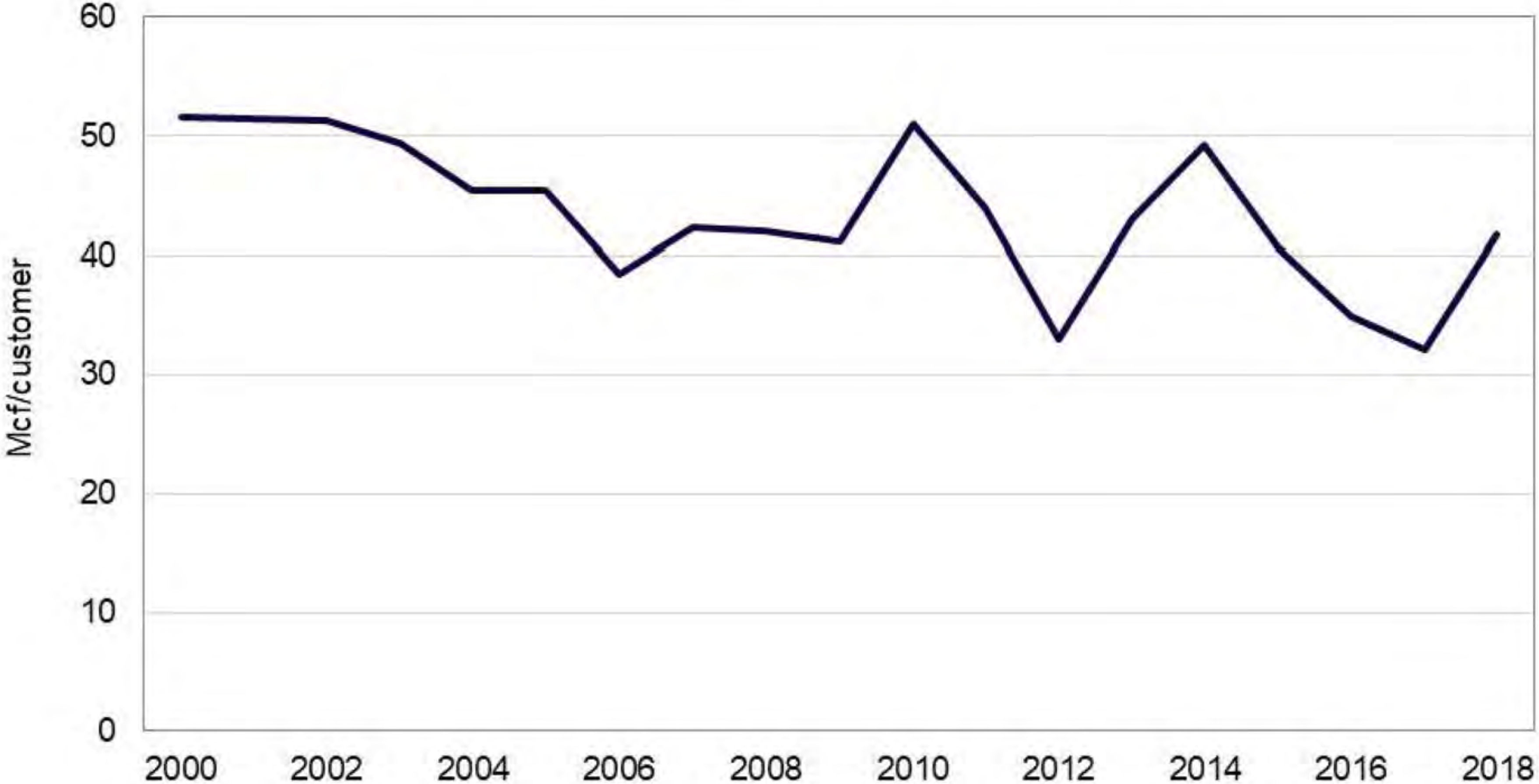
Louisiana residential natural gas use per customer

Residential natural gas end use efficiency, as measured by use per customer has been falling over the past two decades. This drives lower residential GHG emissions.



Source: EIA-176

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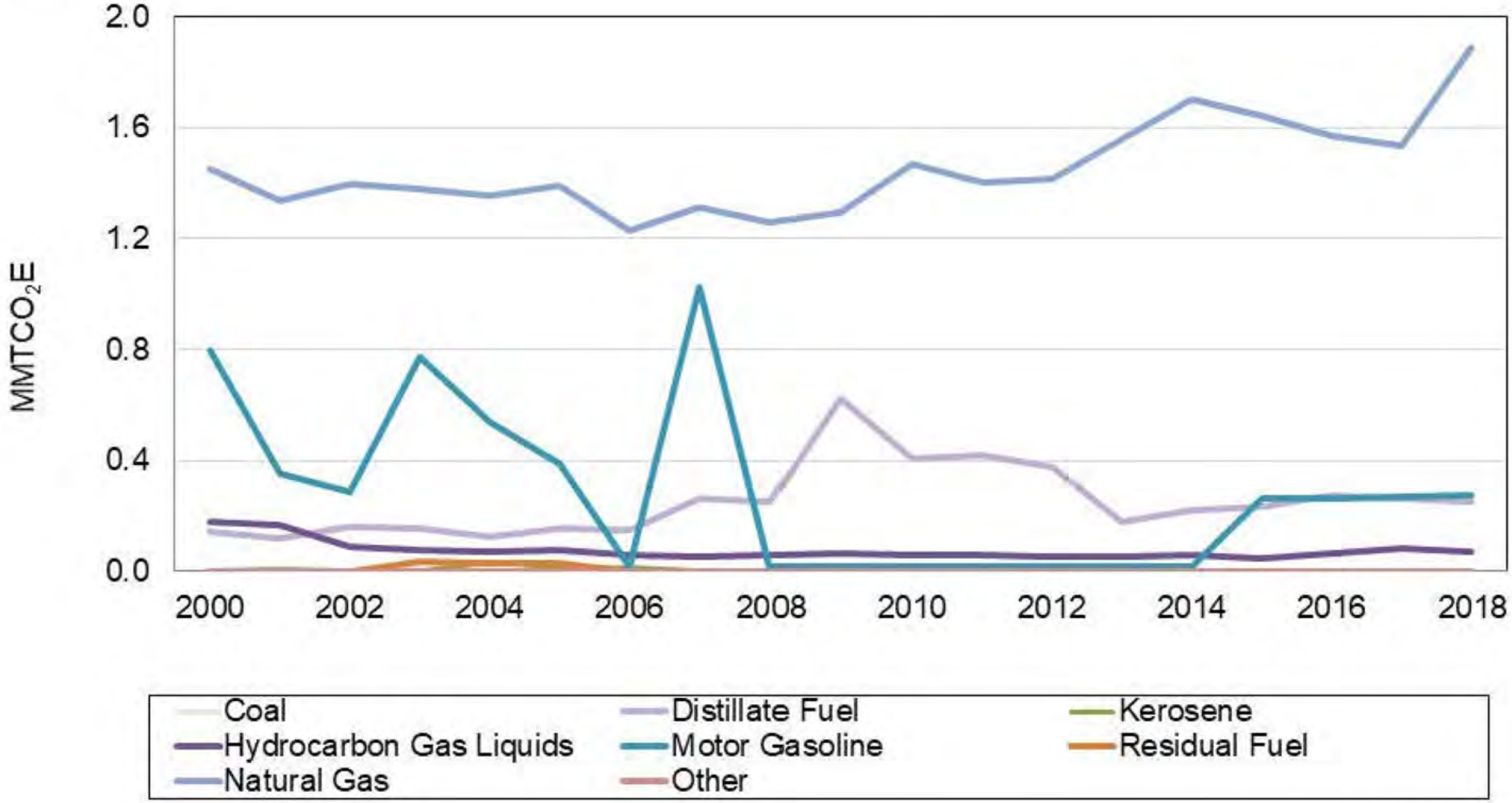
Louisiana commercial fossil fuel combustion emissions (by fuel type)

Natural gas based GHG emissions have been increasing since 2006 in the commercial sector.



Source: US EIA state energy data system (SEDS)

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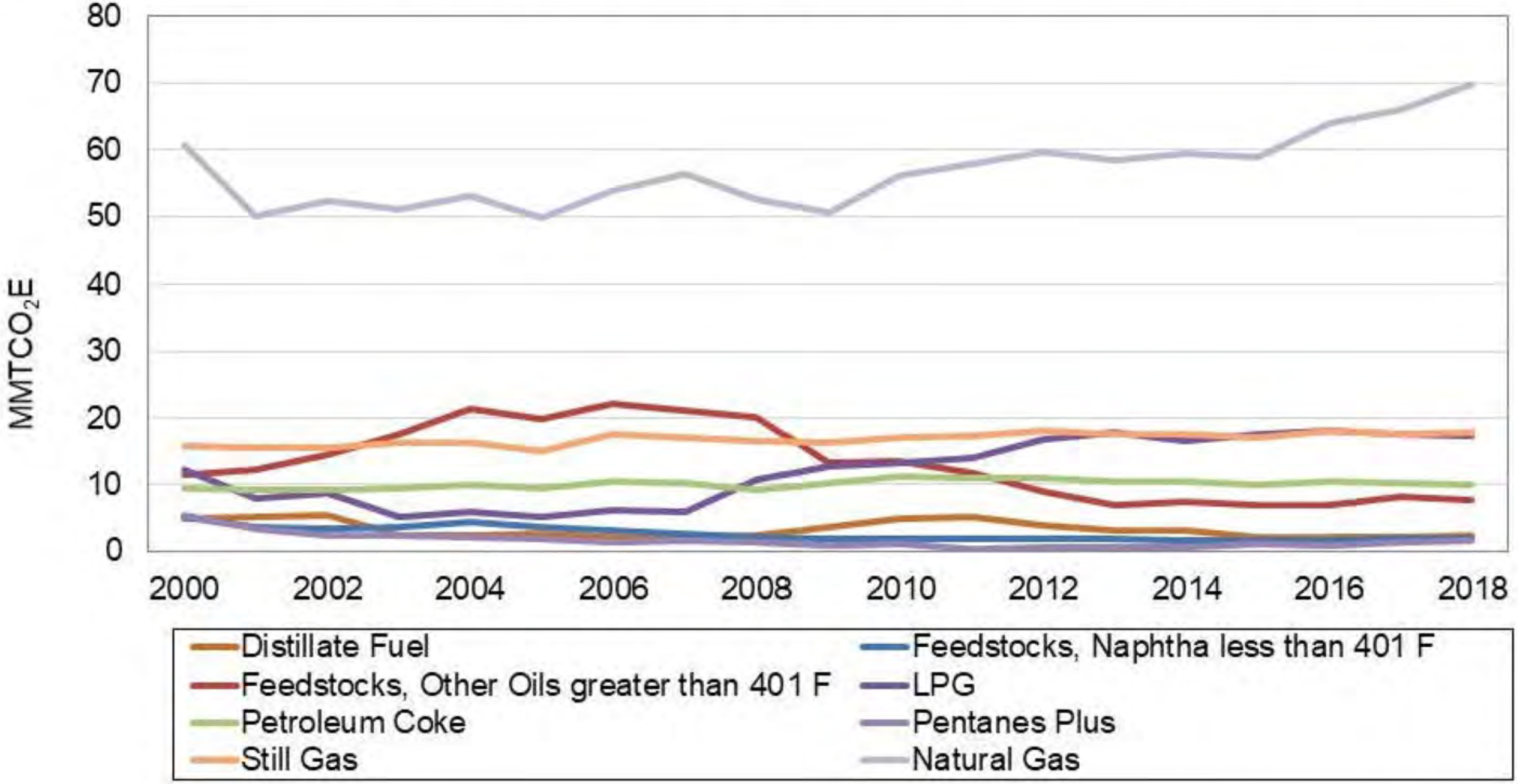
Louisiana industrial fossil fuel combustion emissions (by fuel type)

Industrial use of natural gas has increased GHG emissions in the state. This has increased relatively rapidly since 2008 and the industrial renaissance in Louisiana.



Source: US EIA state energy data system (SEDS)

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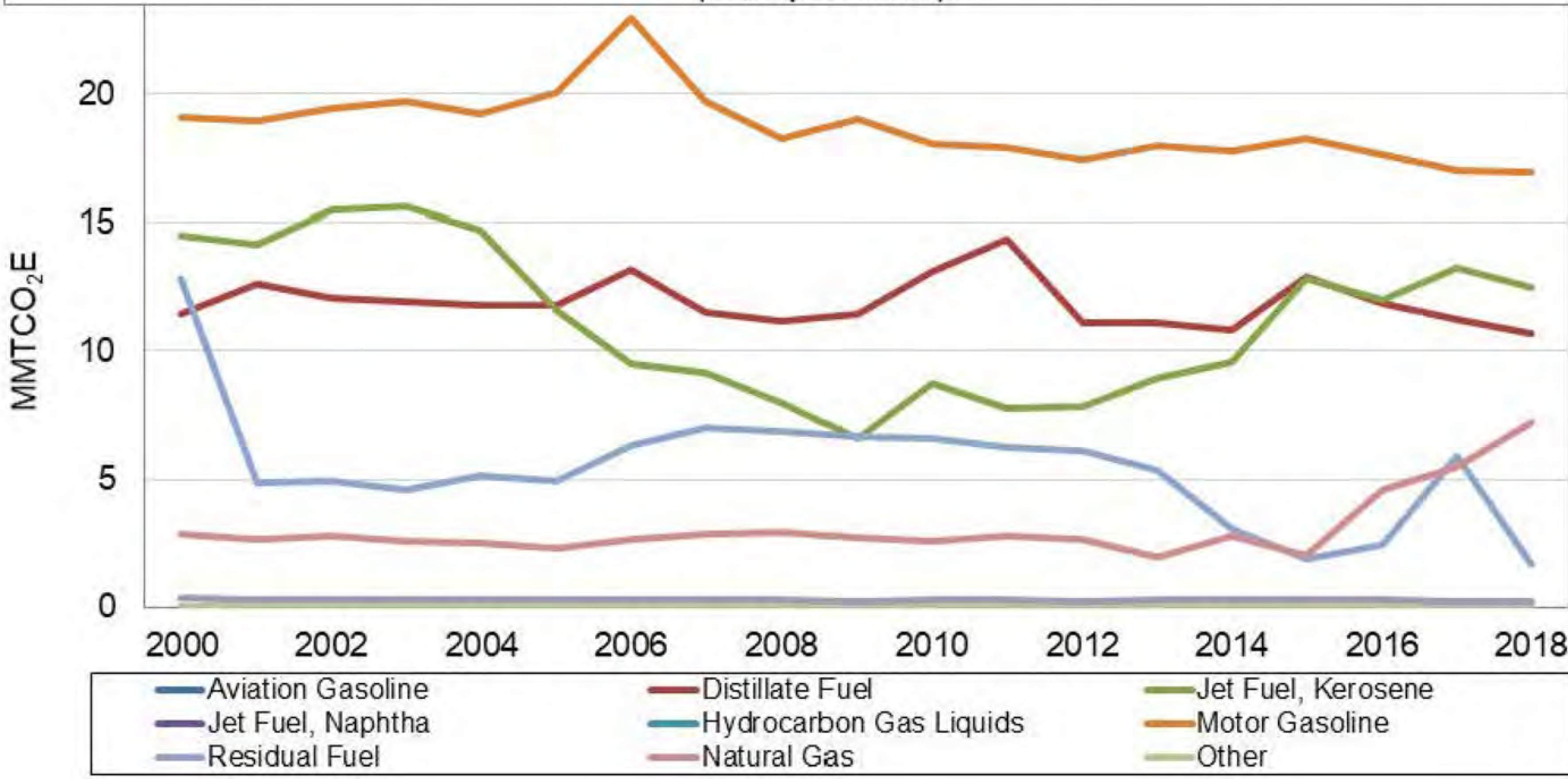
Louisiana transportation fossil fuel combustion emissions (by fuel type)

Gasoline (passenger vehicles) generated GHG emissions have been falling in Louisiana since 2006. Other transportation fuel-based GHG emissions are flat to down as well. However, jet fuel-related emissions are up over the past five years as are natural gas related emissions (transportation).



Source: US EIA state energy data system (SEDS)

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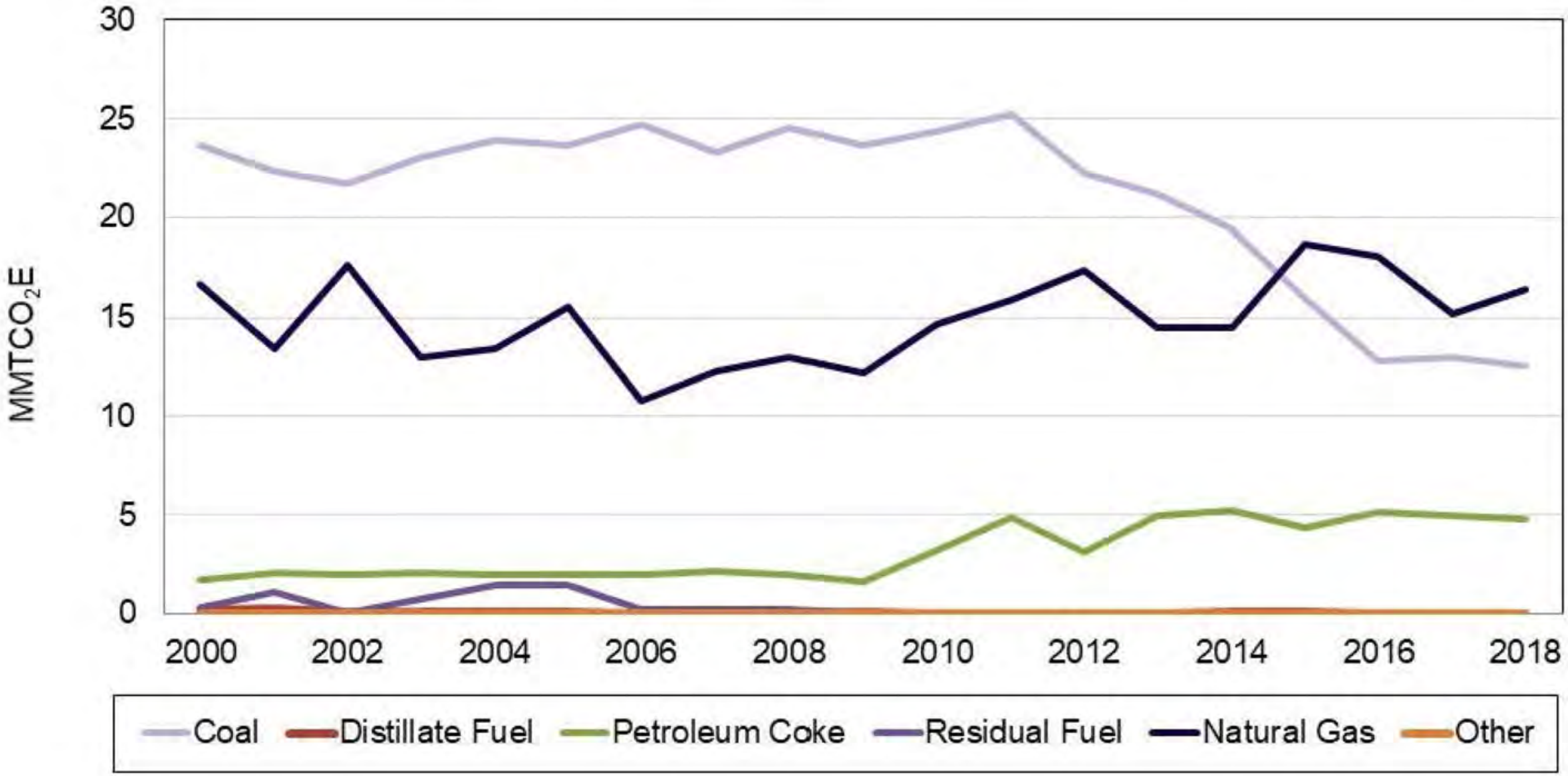
Louisiana electric generation fossil fuel combustion emissions trends (by fuel type)

Fossil fuel related emissions in the power generation sector have been falling since 2010 primarily due to reduced coal use.



Source: US EIA state energy data system (SEDS)

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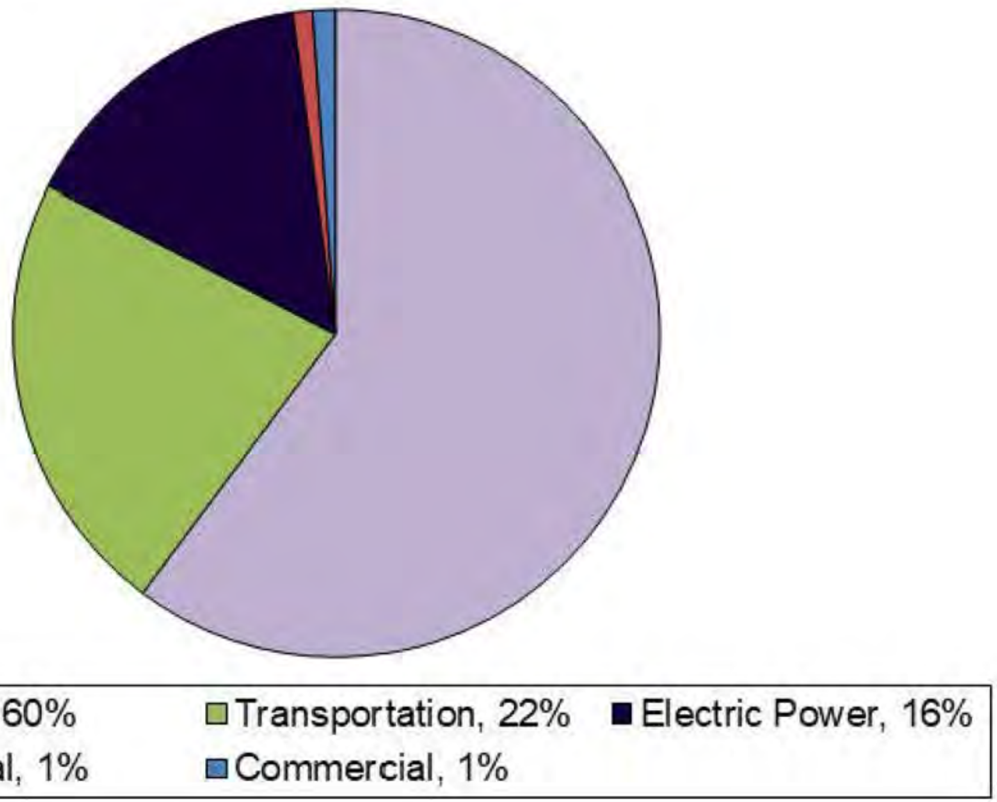
Estimated fossil fuel combustion shares

Louisiana fossil fuel combustion emission shares by sector (2018)

Most combustion-based GHG emissions in Louisiana come from the industrial sector (60 percent). Transportation is estimated by the SIT to rank second at 22 percent a share higher than the aggregate GHG emissions estimates developed by EIA.



Source: US EIA state energy data system (SEDS)

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2018 Summary Calculation: Fossil Fuel Combustion

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2018 Summary estimate

Sector	2018 $MMTCO_2E$
Residential	
Coal	0.00
Petroleum	0.11
Natural Gas	2.05
Other	0.00
Commercial	
Coal	0.00
Petroleum	0.59
Natural Gas	1.89
Other	0.00
Industrial	
Coal	0.37
Petroleum	62.10
Natural Gas	69.82
Other	0.00
Transportation	
Coal	0.00
Petroleum	41.87
Natural Gas	7.22
Other	0.00
Electric Power	
Coal	12.57
Petroleum	4.76
Natural Gas	16.39
Other	0.00
International Bunker Fuels	
Petroleum	0.02

Fossil fuel combustion dominates the 2018 Louisiana GHG inventory. Most of these emissions come from the industrial sector, followed by transportation.

Sector and Fuel Total	2018 $MMTCO_2E$
Residential	2.16
Commercial	2.48
Industrial	132.28
Transportation	49.09
Electric Power	33.73
International Bunker Fuels	0.02
Total	**219.77**
Coal	12.94
Petroleum	109.45
Natural Gas	97.37
Other	0.00
Total	**219.77**

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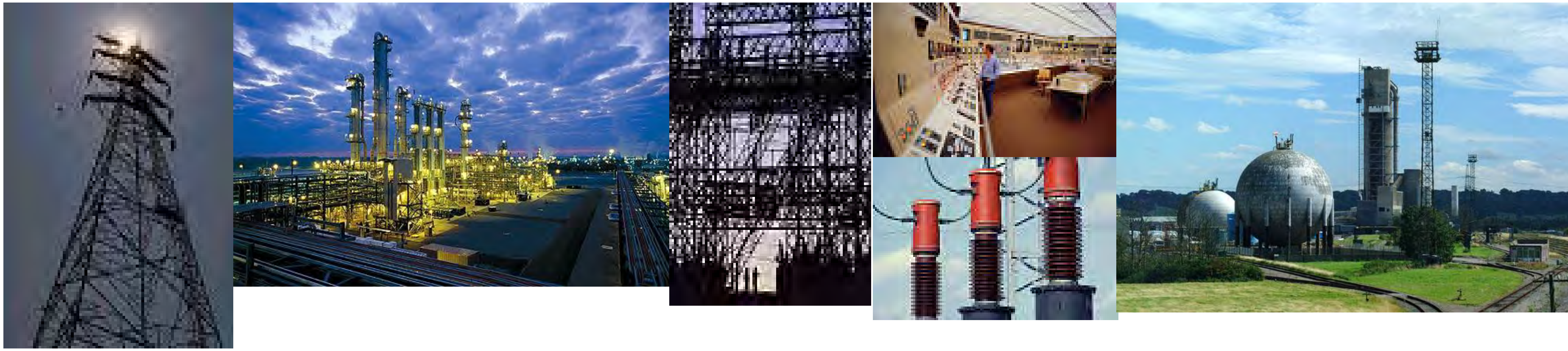

Louisiana 2021 GHG Inventory. Appendix 2: Stationary combustion emissions estimates.

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

GHG emissions: stationary sources

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Stationary combustion module: overview

- The stationary combustion module estimates methane (CH_4) and nitrous oxide (N_2O) emissions from the combustion of fossil fuels.
- This module is similar in structure to the combustion of fossil fuels module.
- The primary difference is that this module does not estimate direct CO_2 emissions; only the CO_2 equivalent of the methane and nitrous oxide emissions arises from the combustion of fossil fuels.

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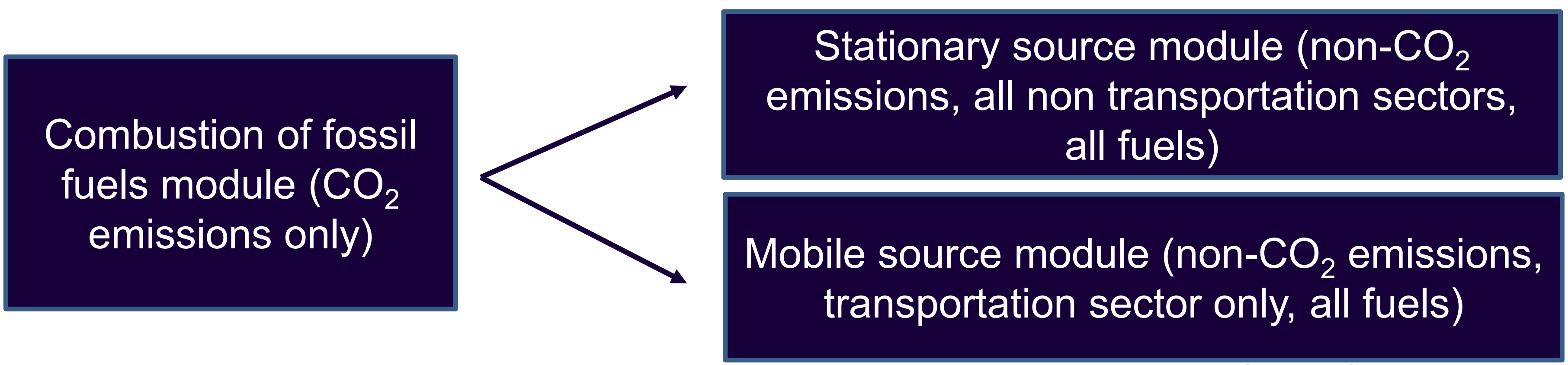
Stationary combustion module: sectors, fuels

- The stationary combustion module estimates non-CO_2 GHG emissions from residential, commercial, industrial, and electric power and examines all fossil fuel types.
- Note the mobile emissions module calculates transportation related methane and nitrous oxide emissions from transportation resources.
- So, it is also similar in nature to this module and the combustion of fossil fuel module.



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Residential stationary combustion calculation example (nitrous oxide)

2. Residential Consumption and N2O emissions in Louisiana

Click here to find possible data sources.

Click here for the bulk data worksheet.

N_2O emissions from stationary combustion in the residential sector are calculated using the IPCC Tier 1 approach. Consumption of each fuel is multiplied by a fuel-specific N_2O emission factor. The resulting fuel emission values, in metric tons N_2O, are then multiplied by the global warming potential, converted to million metric tons of carbon equivalent (MMTCE), then to million metric tons of carbon dioxide equivalent ($MMTCO_2E$), and summed. For further detail on this method, please refer to the Stationary Chapter in the User's Guide. Click on the orange "Click here for the bulk data worksheet." button to return to the energy consumption data entry worksheet.

Note that default emission factors are available through 2018. To facilitate emission calculations for later years, the tool utilizes 2018 emission factors as proxies for emission factors in subsequent years (2019 through 2020). Emission factors for 2019 and beyond will be updated as soon as new data become available. For further detail on this method, refer to the Stationary Combustion Chapter in the User's Guide

Return to the Control Sheet

Go to the Residential CH_4 Sheet

Residential Sector N2O 1990

Fuel Type	Consumption (Billion Btu)		Emission Factor (metric tons N2O/BBtu)		Emissions (metric tons N2O)		GWP		Emissions (MMTCE)		Emissions (MMTCO2E)
Coal	-	x	0.00150	=	-	x	298	=	0.0000	=	0.0000
Distillate Fuel	37	x	0.00060	=	0.022	x	298	=	0.0000	=	0.0000
Kerosene	73	x	0.00060	=	0.044	x	298	=	0.0000	=	0.0000
Hydrocarbon Gas Liquids	2,516	x	0.00060	=	1.510	x	298	=	0.0001	=	0.0004
Natural Gas	55,601	x	0.00009	=	5.004	x	298	=	0.0004	=	0.0015
Wood	5,421	x	0.00380	=	20.600	x	298	=	0.0017	=	0.0061
Other	-	x	0.00000	=	-	x	298	=	0.0000	=	0.0000
							Total	=	**0.002**	=	**0.0081**

Residential Sector N2O 1991

Fuel Type	Consumption (Billion Btu)		Emission Factor (metric tons N2O/BBtu)		Emissions (metric tons N2O)		GWP		Emissions (MMTCE)		Emissions (MMTCO2E)
Coal	-	x	0.00150	=	-	x	298	=	0.0000	=	0.0000
Distillate Fuel	8	x	0.00060	=	0.005	x	298	=	0.0000	=	0.0000
Kerosene	77	x	0.00060	=	0.046	x	298	=	0.0000	=	0.0000
Hydrocarbon Gas Liquids	2,680	x	0.00060	=	1.608	x	298	=	0.0001	=	0.0005
Natural Gas	57,228	x	0.00009	=	5.151	x	298	=	0.0004	=	0.0015
Wood	5,683	x	0.00380	=	21.595	x	298	=	0.0018	=	0.0064
Other	-	x	0.00000	=	-	x	298	=	0.0000	=	0.0000

Residential N2O | Residential CH4 | Commercial N2O | Commercial CH4 | Electric Power N2O | Electric Power CH4 | Ind ...

Residential stationary combustion calculation example (methane)

2. Residential Consumption and CH4 emissions in Louisiana

CH_4 emissions from stationary combustion in the residential sector are calculated using the IPCC Tier 1 approach. Consumption of each fuel is multiplied by a fuel-specific CH_4 emission factor. The resulting fuel emission values, in metric tons CH_4, are then multiplied by the global warming potential, converted to million metric tons of carbon equivalent (MMTCE), then to million metric tons of carbon dioxide equivalent ($MMTCO_2E$), and summed. For further detail on this method, please refer to the Stationary Chapter in the User's Guide.

Note that default emission factors are available through 2018. To facilitate emission calculations for later years, the tool utilizes 2018 emission factors as proxies for emission factors in subsequent years (2019 through 2020). Emission factors for 2019 and beyond will be updated as soon as new data become available. For further detail on this method, refer to the Stationary Combustion Chapter in the User's Guide.

Return to the Control Sheet

Return to the Residential N_2O Sheet

Residential Sector CH4 1990

Fuel Type	Consumption (Billion Btu)		Emission Factor (metric tons CH4 /BBtu)		Emissions (metric tons CH4)		GWP		Emissions (MMTCE)		Emissions (MMTCO2E)
Coal	-	x	0.30069	=	-	x	25	=	0.000	=	0.0000
Distillate Fuel	37	x	0.01002	=	0.371	x	25	=	0.000	=	0.0000
Kerosene	73	x	0.01002	=	0.731	x	25	=	0.000	=	0.0000
Hydrocarbon Gas Liquids	2,516	x	0.01002	=	25.210	x	25	=	0.000	=	0.0006
Natural Gas	55,601	x	0.00475	=	264.105	x	25	=	0.002	=	0.0066
Wood	5,421	x	0.28487	=	1,544.280	x	25	=	0.011	=	0.0386
Other	-	x	0.00000	=	-	x	25	=	0.000	=	0.0000
							Total	=	**0.013**		**0.0459**

Residential Sector CH4 1991

Fuel Type	Consumption (Billion Btu)		Emission Factor (metric tons CH4 /BBtu)		Emissions (metric tons CH4)		GWP		Emissions (MMTCE)		Emissions (MMTCO2E)
Coal	-	x	0.30069	=	-	x	25	=	0.000	=	0.0000
Distillate Fuel	8	x	0.01002	=	0.080	x	25	=	0.000	=	0.0000
Kerosene	77	x	0.01002	=	0.772	x	25	=	0.000	=	0.0000
Hydrocarbon Gas Liquids	2,680	x	0.01002	=	26.854	x	25	=	0.000	=	0.0007
Natural Gas	57,228	x	0.00475	=	271.833	x	25	=	0.002	=	0.0068
Wood	5,683	x	0.28487	=	1,618.916	x	25	=	0.011	=	0.0405
Other	-	x	0.00000	=	-	x	25	=	0.000	=	0.0000
							Total	=	**0.013**		**0.0480**

Residential N2O | Residential CH4 | Commercial N2O | Commercial CH4 | Electric Power N2O | Electric Power CH4 | Ind ...

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Stationary sources - industrial

Feedstock uses.

Industrial Sector N2O 1990

Fuel Type	Total Consumption (Billion Btu)		Non-Energy Consumption (Billion Btu)		Emission Factor (metric tons N2O/BBtu)		Emissions (metric tons N2O)		GWP		Emissions (MMTCE)		Emissions (MMTCO2E)
Coking Coal	-	-	-	x	0.00150	=	-	x	298	=	0.000	=	0.000
Other Coal	15,963	-	80	x	0.00150	=	23.825	x	298	=	0.002	=	0.007
Asphalt and Road Oil	11,094	-	11,094	x	0.00060	=	-	x	298	=	0.000	=	0.000
Aviation Gasoline Blending Components	36	-	-	x	0.00060	=	0.022	x	298	=	0.000	=	0.000
Crude Oil	-	-	-	x	0.00060	=	-	x	298	=	0.000	=	0.000
Distillate Fuel	53,258	-	101	x	0.00060	=	31.894	x	298	=	0.003	=	0.010
Feedstocks, Naphtha less than 401F	135,525	-	127,131	x	0.00060	=	5.036	x	298	=	0.000	=	0.002
Feedstocks, Other Oils greater than 401F	223,445	-	196,236	x	0.00060	=	16.325	x	298	=	0.001	=	0.005
Kerosene	265	-	-	x	0.00060	=	0.159	x	298	=	0.000	=	0.000
LPG	165,884	-	121,543	x	0.00060	=	26.605	x	298	=	0.002	=	0.008
Lubricants	7,938	-	7,938	x	0.00060	=	-	x	298	=	0.000	=	0.000
Motor Gasoline	1,767	-	-	x	0.00060	=	1.060	x	298	=	0.000	=	0.000
Motor Gasoline Blending Components	8,208	-	-	x	0.00060	=	4.925	x	298	=	0.000	=	0.001
Misc. Petro Products	22,237	-	22,237	x	0.00060	=	-	x	298	=	0.000	=	0.000
Petroleum Coke	69,221	-	2,632	x	0.00060	=	39.954	x	298	=	0.003	=	0.012
Pentanes Plus	97,919	-	45,835	x	0.00060	=	31.250	x	298	=	0.003	=	0.009
Residual Fuel	7,108	-	-	x	0.00060	=	4.265	x	298	=	0.000	=	0.001
Still Gas	225,206	-	5,614	x	0.00060	=	131.755	x	298	=	0.011	=	0.039
Special Naphthas	-	-	-	x	0.00060	=	-	x	298	=	0.000	=	0.000
Unfinished Oils	(56,402)	-	-	x	0.00060	=	(33.841)	x	298	=	-0.003	=	-0.010
Waxes	236	-	236	x	0.00060	=	-	x	298	=	0.000	=	0.000
Natural Gas	1,216,419	-	42,744	x	0.00009	=	105.631	x	298	=	0.009	=	0.031
Wood	105,996	-	NA	x	0.00380	=	402.785	x	298	=	0.033	=	0.120
Other	-	-		x	0.00000	=	-	x	298	=	0.000	=	0.000
									Total	=	**0.064**	=	**0.236**

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Non-energy related emissions (feedstock uses)/shares

Feedstock shares based on national industry averages

National Non-Energy Consumption %'s	2	3	4	5	6	26	27	28	29	30
	1990	1991	1992	1993	1994	2014	2015	2016	2017	2018
Industrial Sector										
Coking Coal	0%	0%	0%	100%	100%	100%	100%	100%	100%	100%
Other Coal	0%	1%	1%	1%	1%	1%	1%	2%	2%	2%
Natural Gas	4%	3%	3%	4%	4%	4%	4%	3%	3%	3%
Asphalt and Road Oil	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
LPG	73%	77%	73%	73%	76%	91%	88%	86%	87%	88%
Lubricants	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Pentanes Plus	47%	47%	47%	46%	47%	49%	49%	47%	47%	47%
Feedstocks, Naphtha less than 401 F	94%	93%	94%	93%	94%	98%	98%	94%	94%	94%
Feedstocks, Other Oils greater than 401 F	88%	90%	83%	79%	76%	96%	95%	92%	92%	91%
Still Gas	2%	3%	2%	3%	2%	11%	11%	10%	10%	10%
Petroleum Coke	4%	2%	9%	3%	6%	0%	0%	0%	0%	0%
Special Naphthas	94%	94%	94%	93%	95%	98%	98%	95%	95%	94%
Distillate Fuel	1%	1%	1%	1%	1%	0%	1%	1%	1%	1%
Residual Fuel	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Waxes	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Misc. Petro Products	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Other Coal	0%	1%	1%	1%	1%	1%	1%	2%	2%	2%
Aviation Gasoline Blending Components	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Crude Oil	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Kerosene	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Motor Gasoline	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Motor Gasoline Blending Components	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Unfinished Oils	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Transportation	**1990**	**1991**	**1992**	**1993**	**1994**	**2014**	**2015**	**2016**	**2017**	**2018**
Lubricants	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

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Stationary combustion emission trends

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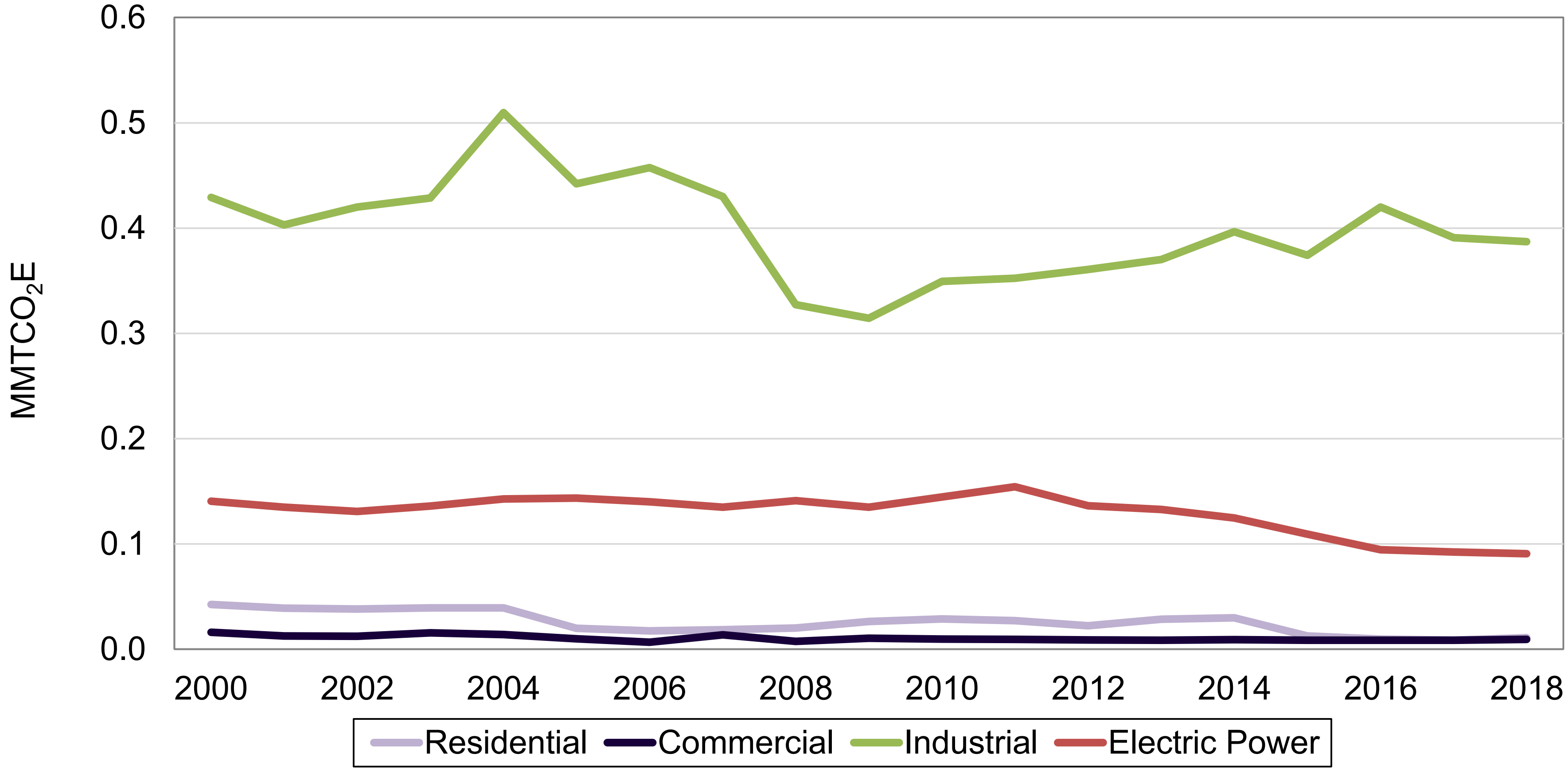
Louisiana stationary combustion trends, all sectors (CO_2 equivalent of CH_4 and N_2O)

Non-CO2 GHG emission trends, across all stationary combustion sectors, has been relatively flat over the past two decades. Industrial sector emissions dominate other sectors.



Source: EIA SEDS

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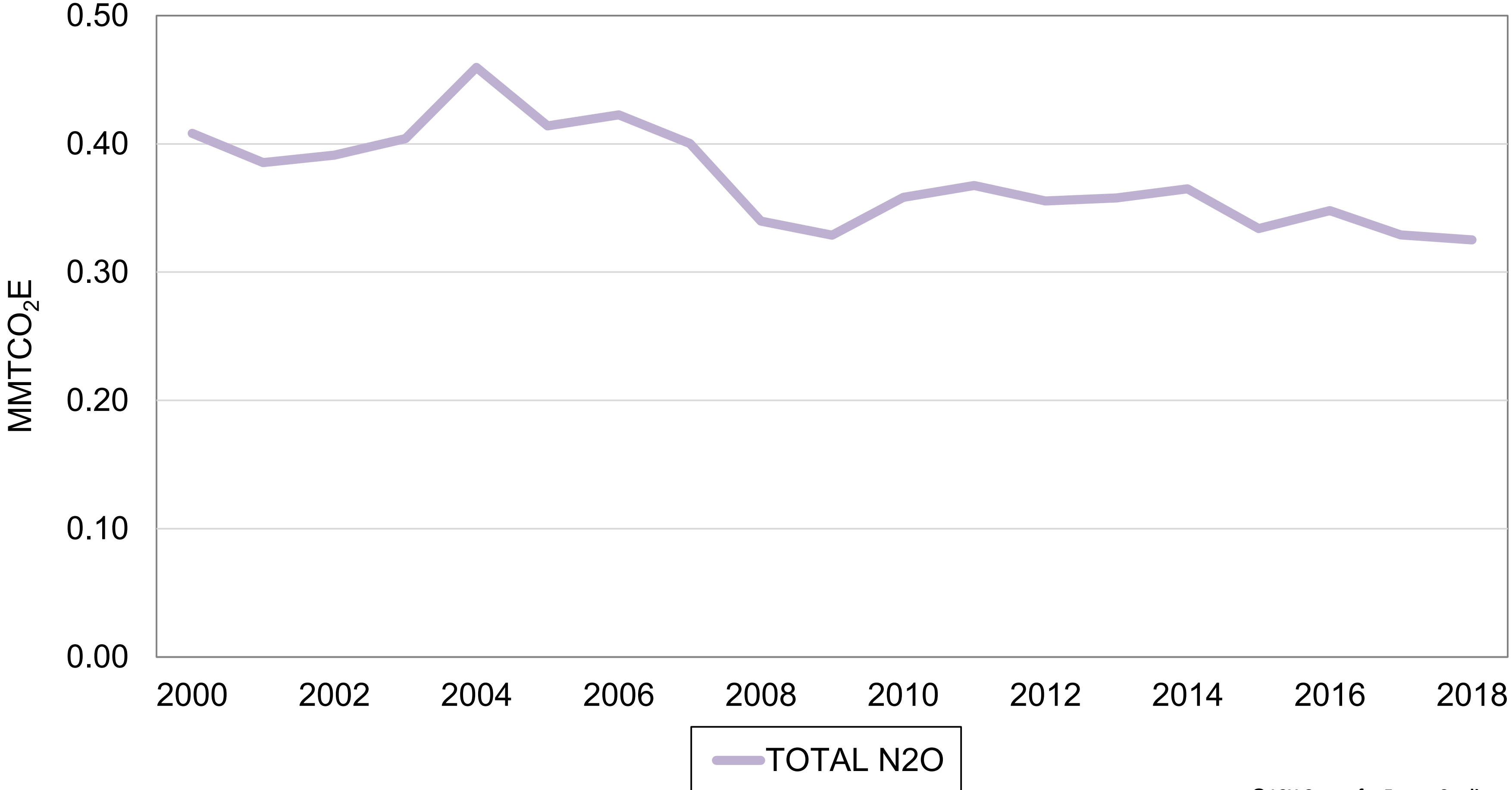
Louisiana nitrous oxide emissions, all sectors

Nitrous oxide emission trends are also flat. These emission are larger in total than methane releases across all other stationary sources. Overall, N_2O emissions have been trending down since 2004.



Source: EIA SEDS

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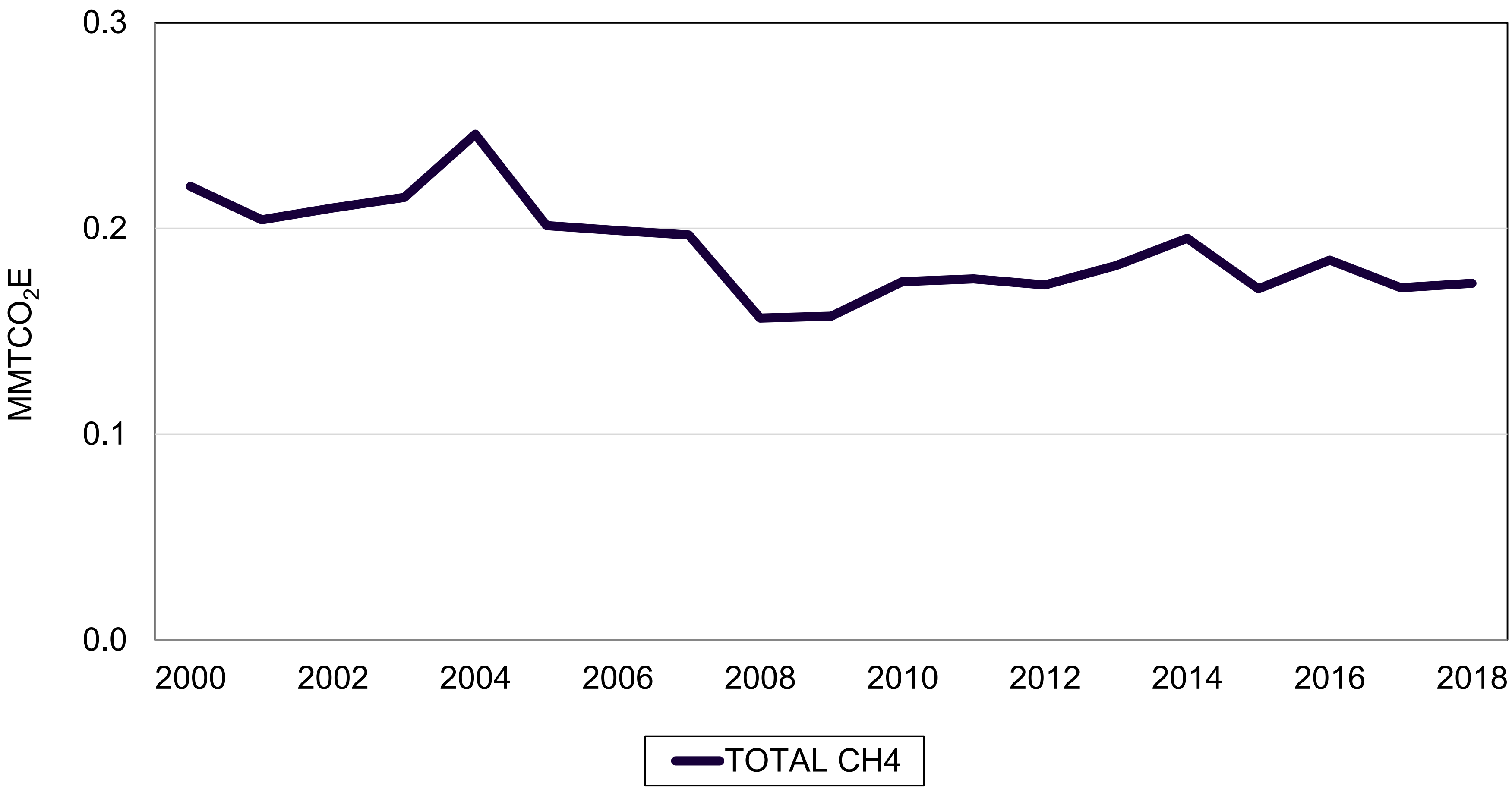
Louisiana methane emission trends, all sectors

Methane emission trends have been flat and are lower, in absolute value, than N_2O releases. Overall, methane emissions have been trending down since 2004.



Source: EIA SEDS

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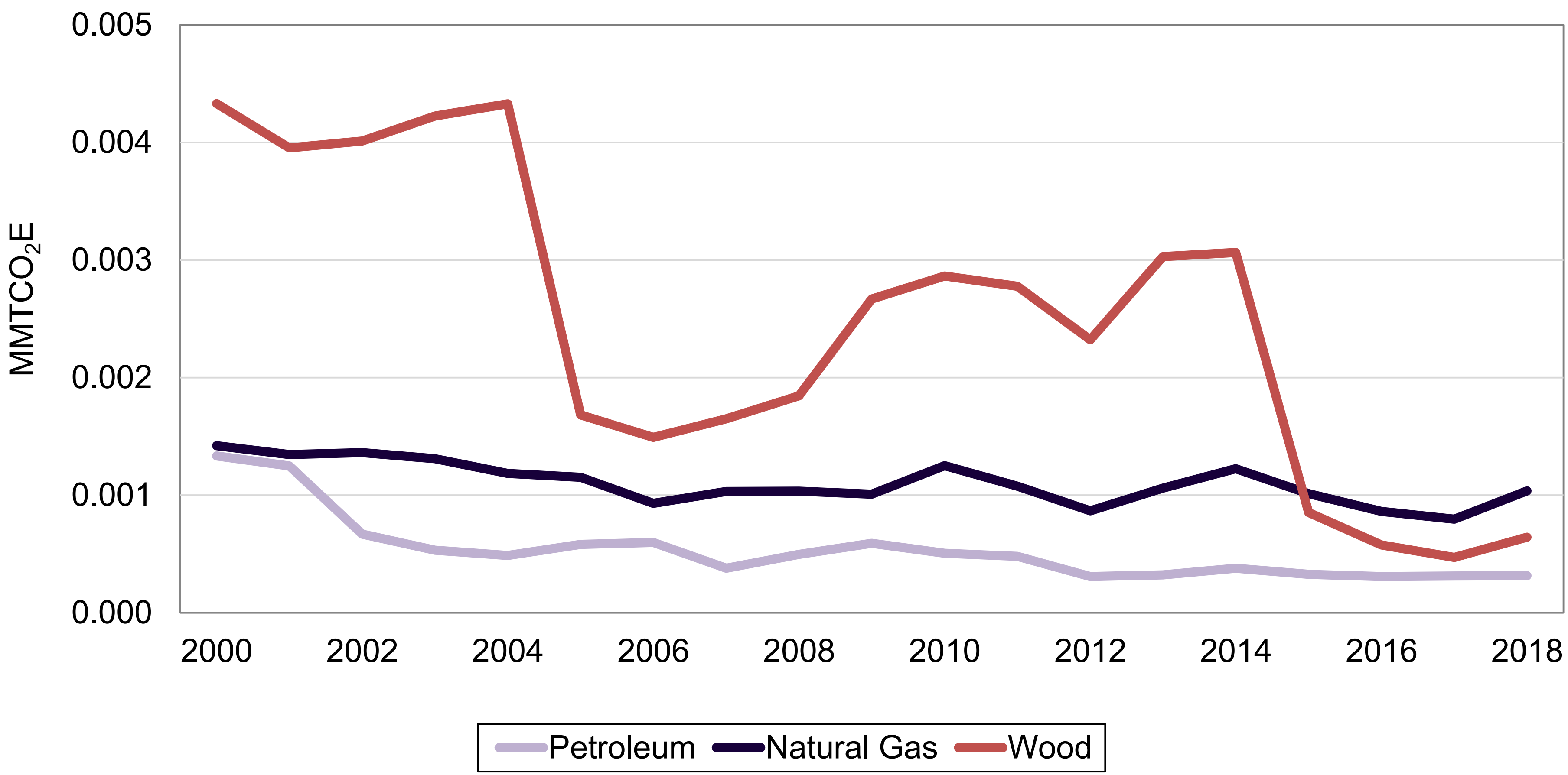
Louisiana residential nitrous oxide emissions (all fuels)

Most residential nitrous oxide emissions are either flat or down relative to historic trends. Wood related emissions are particularly lower. Overall, these emissions are very low relative to other GHG emissions.



Source: EIA SEDS

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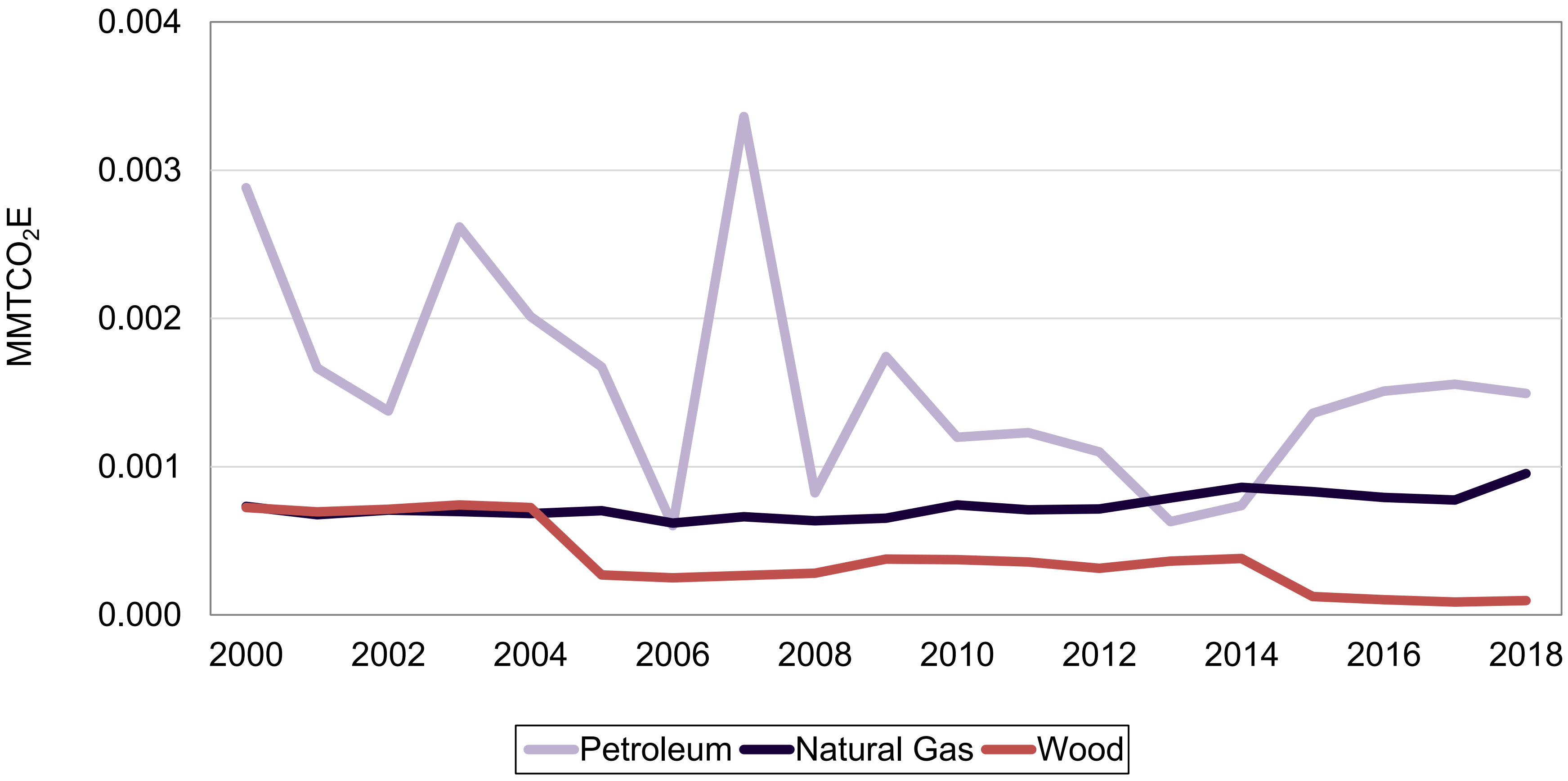
Louisiana commercial nitrous oxide emissions (all fuels)

Commercial nitrous oxide emissions are either flat or down relative to historic trends. The largest decreases have come from the reduced use of liquid fossil fuels from 2007 forward. Overall, these emissions are very low relative to other GHG emissions.



Source: EIA SEDS

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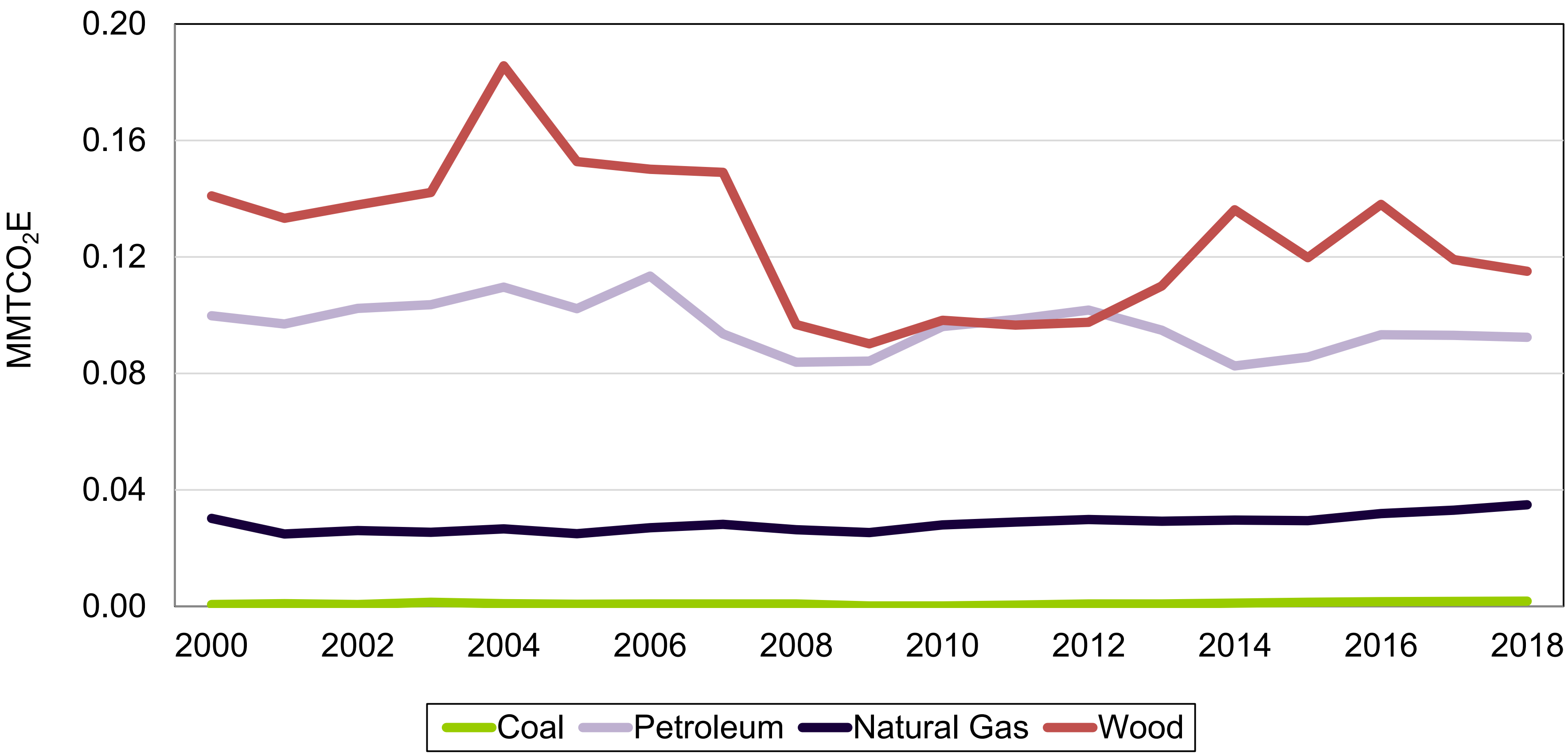
Louisiana industrial nitrous oxide emissions (all fuels)

Industrial nitrous oxide emissions are mostly flat. Emissions from natural gas are up starting in 2008 due to the increased natural gas usage associated with the industrial renaissance.



Source: EIA SEDS

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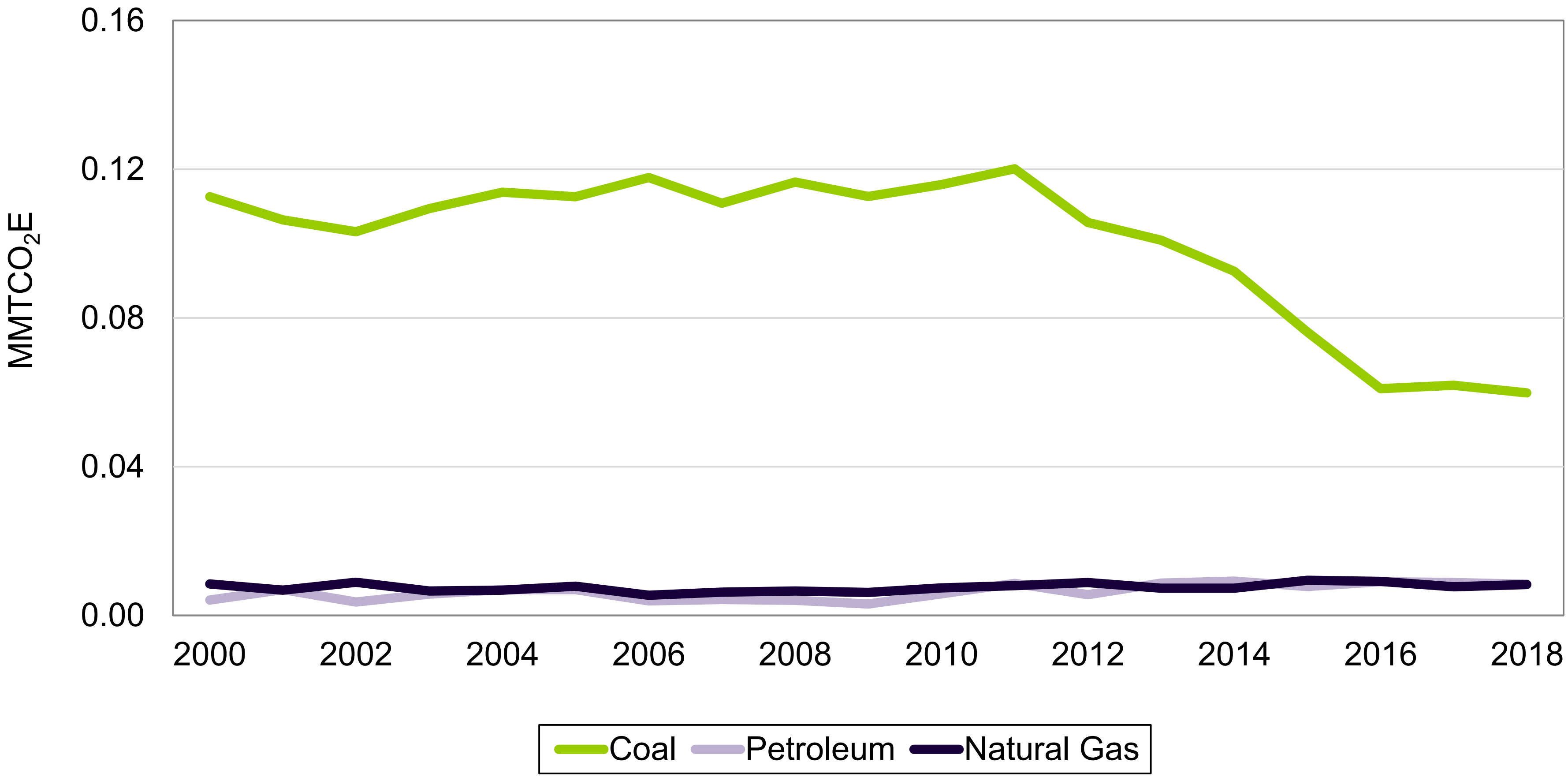
Louisiana power generation nitrous oxide emissions (all fuels)

Power plant nitrous oxide emissions fell considerably starting in 2011 with the decrease in coal use in the state.



Source: EIA SEDS

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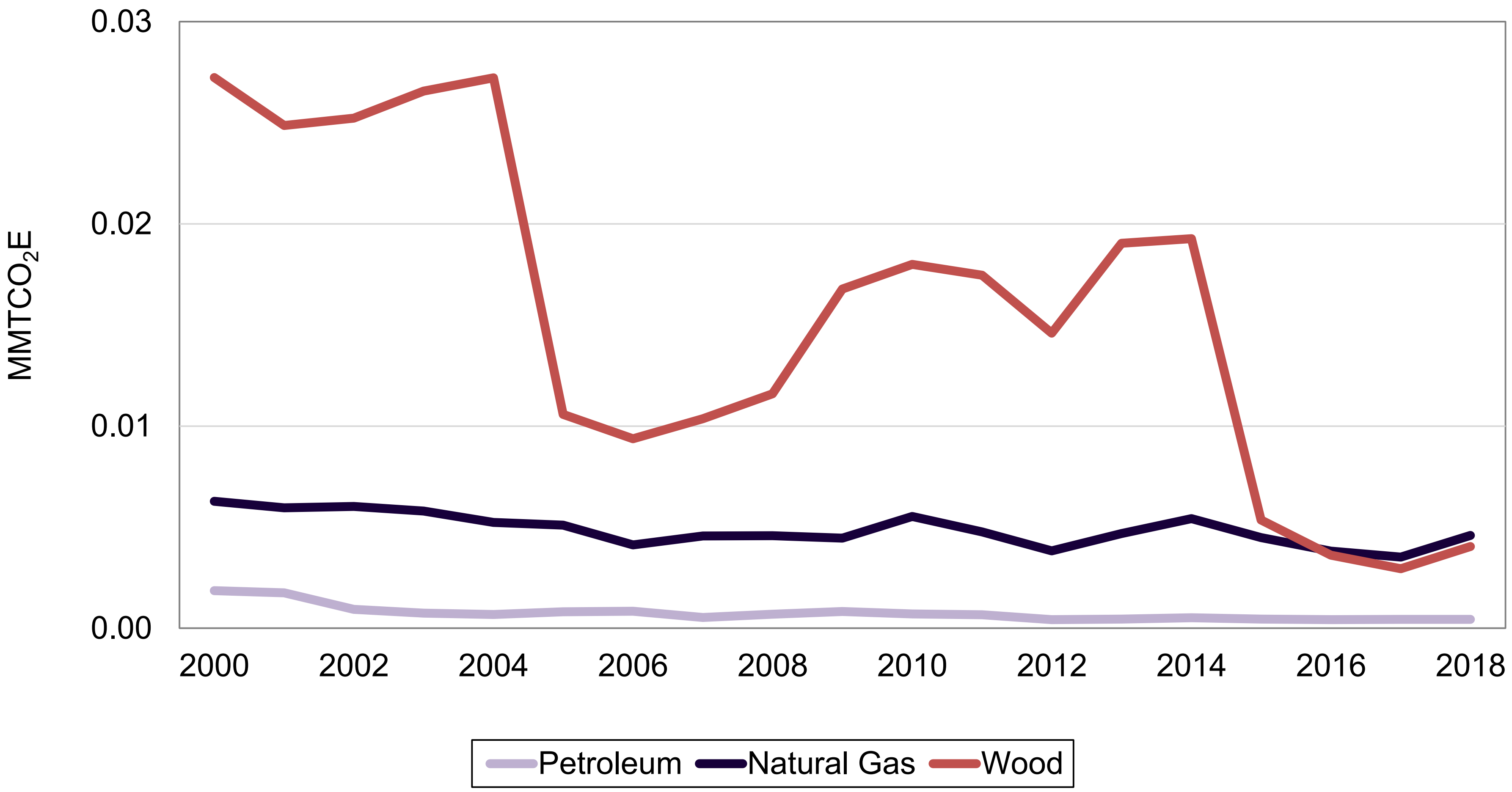
Louisiana residential methane emissions (all fuels)

Residential methane emissions are very small relative to other sectors. Overall emissions are down considerable since 2004.



Source: EIA SEDS

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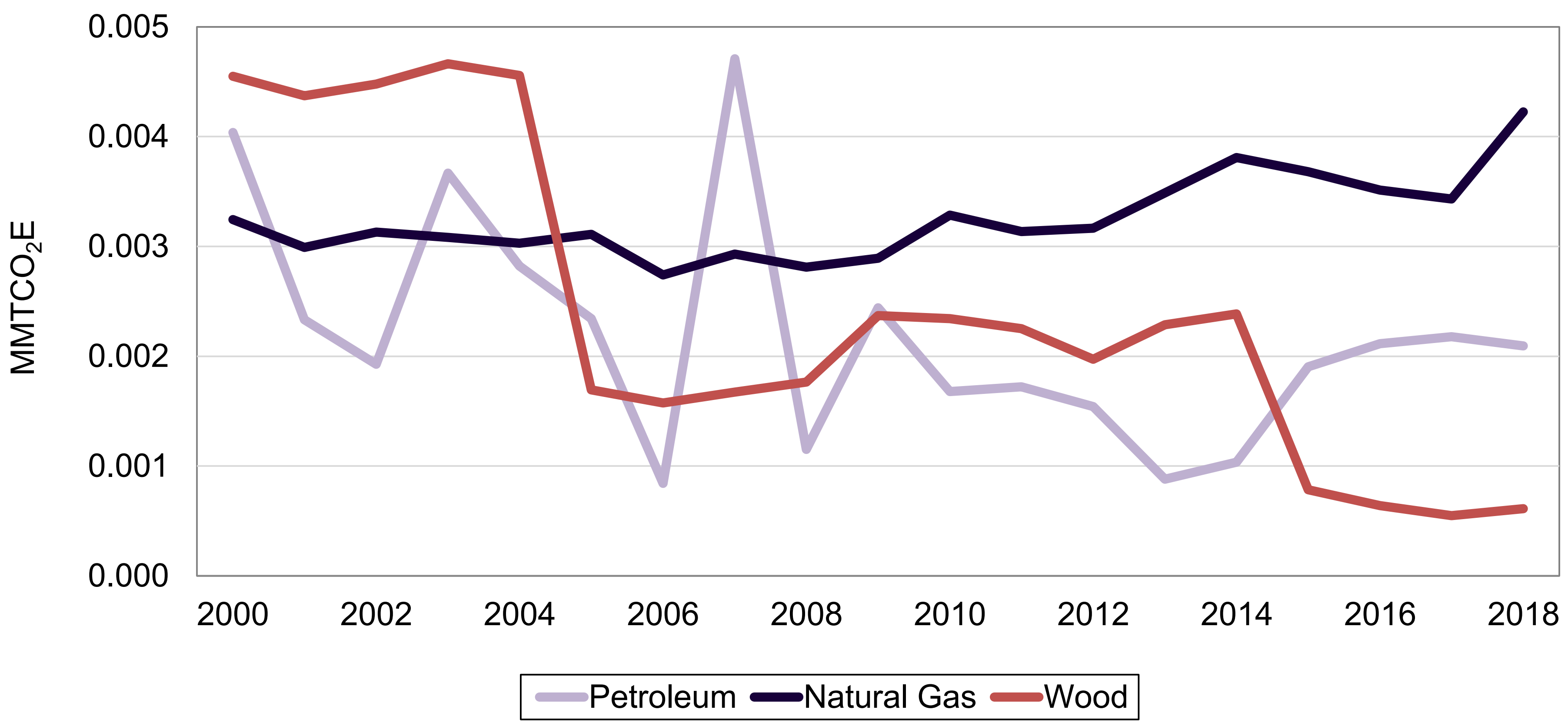
Louisiana commercial methane emissions (all fuels)

Commercial methane emissions, while very small, are highly variable and a function of annual energy use. Decreases in liquid fuel and wood use are driving commercial methane emissions down while increases in natural gas use are increasing emissions.



Source: EIA SEDS

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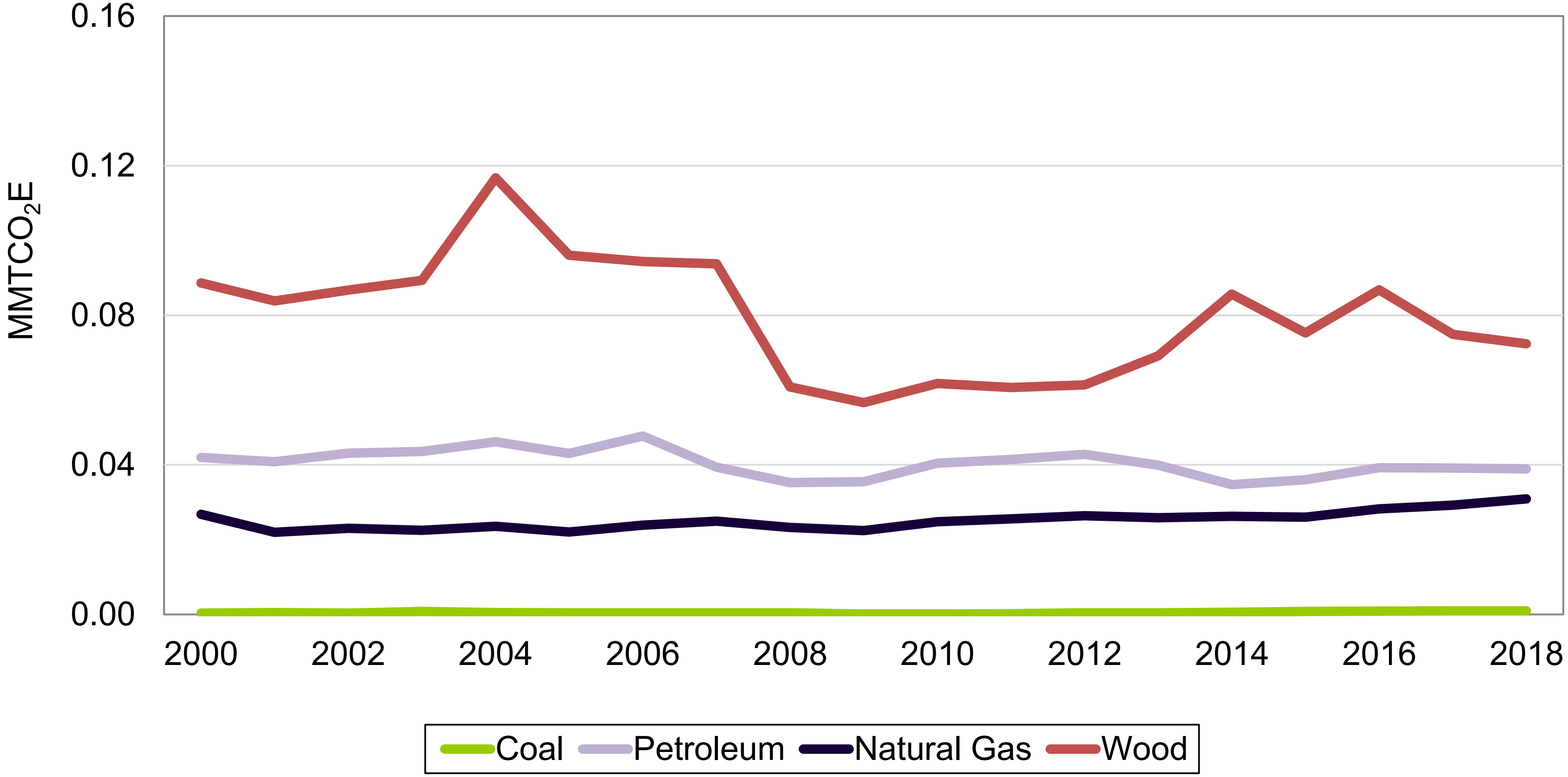
Louisiana industrial methane emissions (all fuels)

Industrial methane emission trends have been relatively constant over the past two decades. Methane emissions from increased gas usage are up slightly but far less than proportionate with the increase of natural gas usage due to the industrial renaissance.



Source: EIA SEDS

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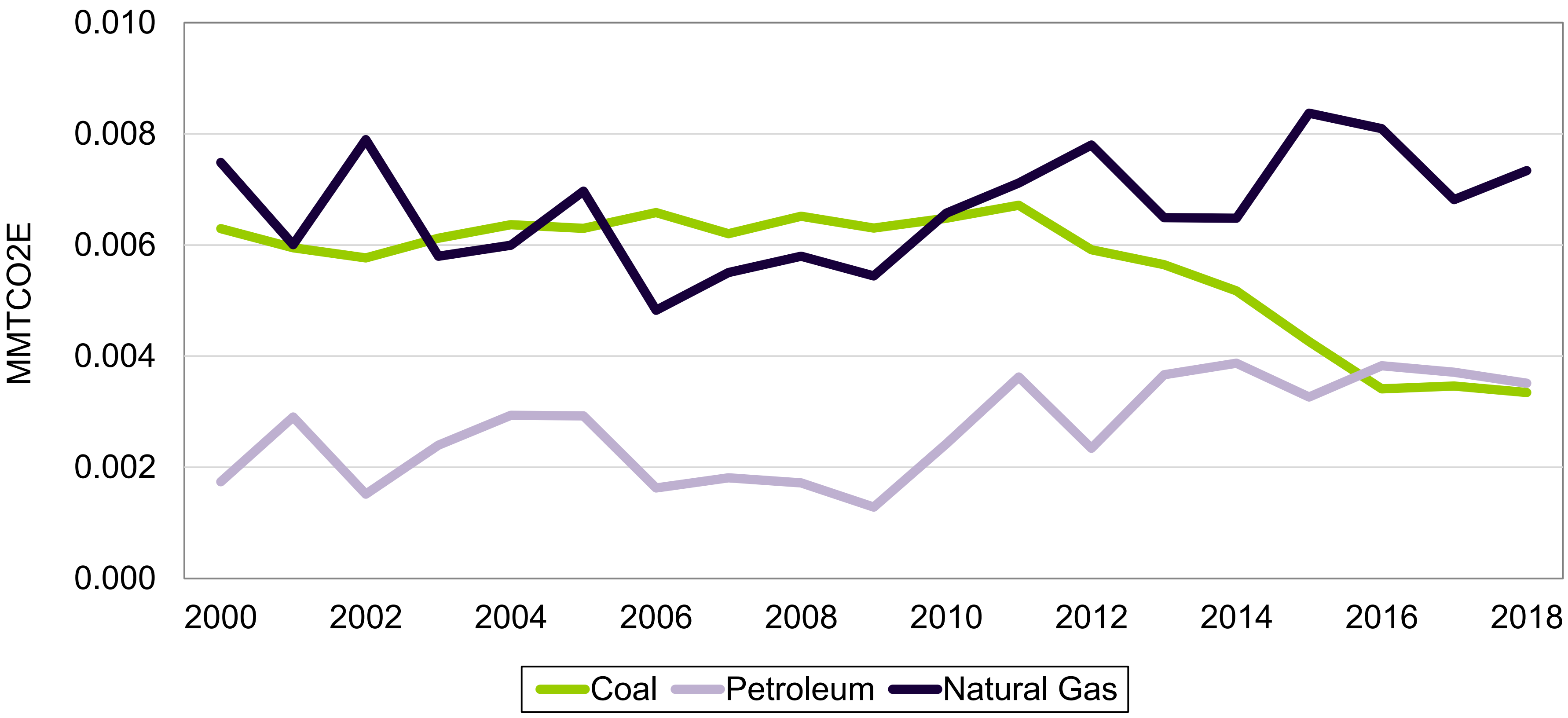
Louisiana power generation methane emissions (all fuels)

Power generation methane are relatively constant and have been low over the past twenty years. Natural gas related methane emissions are up due to increased gas usage. Methane emissions from coal combustion are down due to reductions in coal use. Petroleum emissions are up as well.



Source: EIA SEDS

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Stationary Combustion Shares

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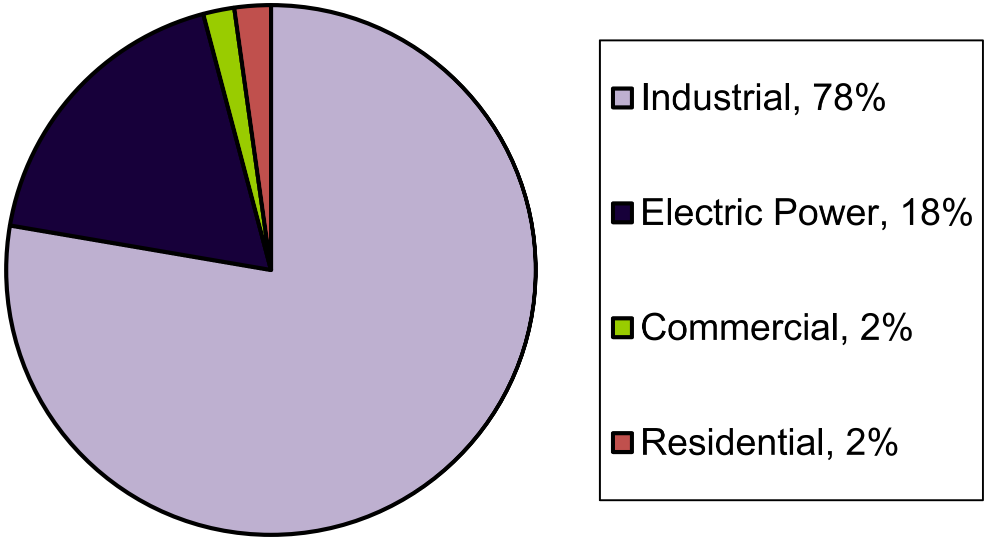
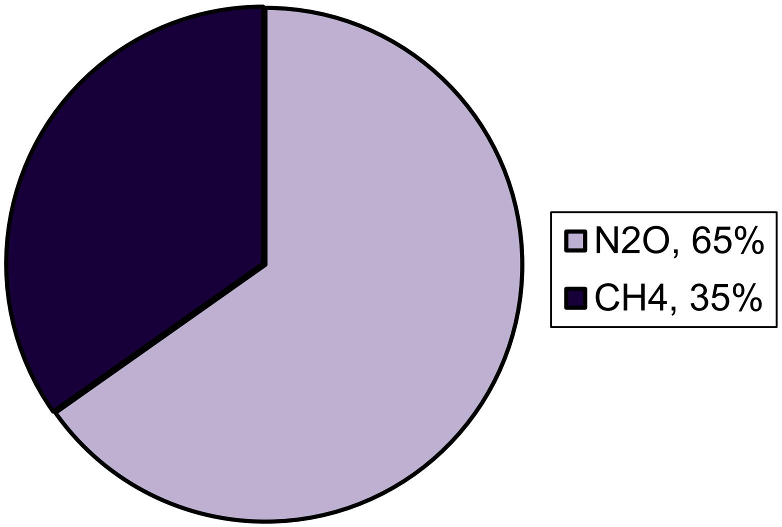
Louisiana Stationary Combustion emissions by sector and type (2018)





Source: EIA SEDS

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2018 Summary Calculation: Fossil Fuel Combustion

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2018 Summary estimates

Stationary combustion related non-CO2 GHG emissions contribute slightly under one-half million (0.498) metric tons to the 2018 Louisiana GHG inventory.

Class	2018 $MMTCO_2E$
Residential	
N2O	0.002
CH4	0.009
Total	**0.011**
Commercial	
N2O	0.003
CH4	0.007
Total	**0.009**
Industrial	
N2O	0.244
CH4	0.143
Total	**0.387**
Electric Power	
N2O	0.076
CH4	0.014
Total	**0.091**
Total (all classes)	**0.498**

Source: EIA SEDS

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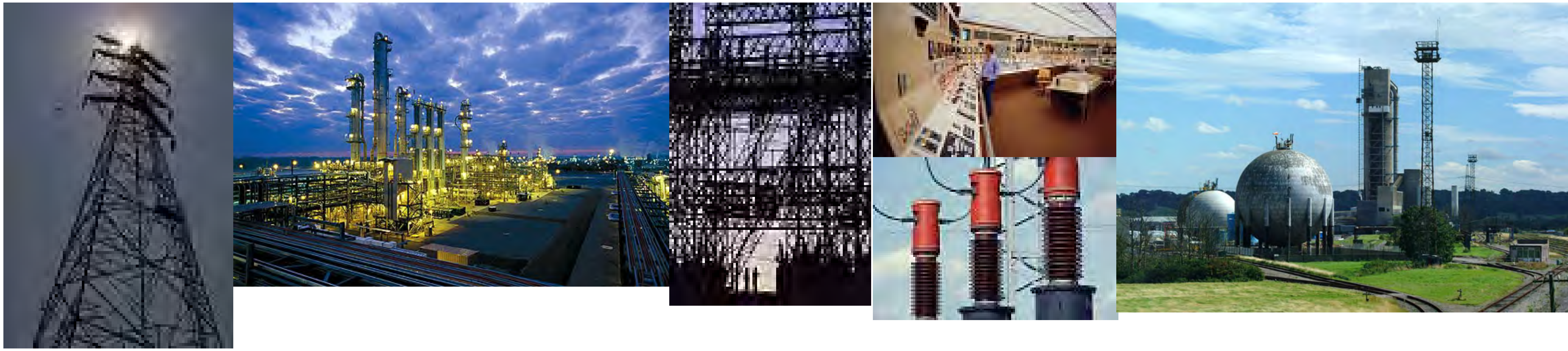

Louisiana 2021 GHG Inventory. Appendix 3: Industrial process emissions estimates.

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Background

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Definition of industrial process emissions

Most of the traditional industrial process emissions are related to production activities. These emissions are captured in the combustion of fossil fuels sections of the SIT. This section encompasses other non-combustion and alternative process emissions from the industrial sector.

Source: User Guide for Industrial processes

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Cement production GHG emissions equation

Cement emissions are estimation by using production multiplied by an emissions factor plus an additional adder for kiln dust.

Equation 1. Emission Equation for Cement Production

$$\text{Emissions } (MTCO_2E) = \text{Production (metric tons)} \times \text{Emission Factor } (t\ CO_2/t\ \text{production}) + \text{Emissions from Cement Kiln Dust (Metric tons } CO_2)$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Cement production GHG emissions estimation example

The table below provides an example of how these cement GHG emissions are estimated. However, according to the SIT default data, there are no active cement producers in Louisiana. Continued research is being conducted to verify that terminals and other supply sources that are located in Louisiana should be added here.

		Production (Metric Tons)		Emission Factor (t CO_2/t production)		Emissions (Metric Tons CO_2)		Emissions from Cement Kiln Dust (Metric Tons CO_2)		Emissions (MTCE)		Emissions (MTCO$_2$E)
1990	Clinker	-	x	0.5070	=	-	+	-	=	-	=	-
1991	Clinker	-	x	0.5070	=	-	+	-	=	-	=	-
1992	Clinker	-	x	0.5070	=	-	+	-	=	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Lime and hydrated lime GHG emissions equation

There are two equations to estimate lime-related GHG emissions. The first calculates hydrated lime emissions and the second calculates lime manufacturing from use of sugars

Equation 2. Example Calculation for Hydrated Lime Correction

Corrected Lime Content of High-Calcium Hydrated Lime (metric tons) = High-Calcium Hydrated Lime Production (metric tons) x (1 – 0.24 metric tons water/metric ton high-calcium hydrated lime)

Equation 3. Emission Equation for Lime Manufacture

Emissions (MTCO_2E) = [Production (metric tons) - Sugar Refining and Precipitated Calcium Carbonate Production (metric tons) × CO_2 Reabsorbtion Factor (80%)] × Emission Factor (MT CO_2/MT production)

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Lime-related GHG emissions estimation example

4. Lime Manufacture in Louisiana

Click here to find where these data are available.

Emissions from lime manufacture consist of emissions from high-calcium and dolomitic lime production. The production quantity of each lime type is multiplied by its respective emission factor. Because lime used in sugar refining and precipitated calcium carbonate production results in the reabsorption of atmospheric CO_2, carbon absorbed from these uses is subtracted from gross emissions. The emissions are then converted to metric tons of carbon equivalents (MTCE) and from metric tons of carbon dioxide equivalents ($MTCO_2E$). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Year	Lime Type	Production (Metric Tons)	Use In Sugar Refining and Precipitated Calcium Carbonate Production (Metric Tons)	CO_2 Reabsorption Factor	Emission Factor ($t\ CO_2$/t production)	Emissions (MTCE)	Emissions ($MTCO_2E$)
1990	High-Calcium Lime	62,476		80%	0.7500	12,779	46,857
	Dolomitic Lime	14,031		80%	0.8700	3,329	12,207
1991	High-Calcium Lime	-		80%	0.7500	-	-
	Dolomitic Lime	-		80%	0.8700	-	-
1992	High-Calcium Lime	-		80%	0.7500	-	-
	Dolomitic Lime	-		80%	0.8700	-	-
1993	High-Calcium Lime	90,095		80%	0.7500	18,428	67,571
	Dolomitic Lime	19,905		80%	0.8700	4,723	17,317

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Limestone and dolomite GHG emissions equation

Limestone and dolomite consumption are used in the industrial process for manufacturing of certain goods such as glass manufacturing, chemical stone manufacturing, and acid water treatment.

Equation 4. Emission Equation for Limestone and Dolomite Use

$$\text{Emissions } (MTCO_2E) = \text{Consumption (metric tons)} \times \text{Emission Factor } (MT\ CO_2/MT \text{ production})$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Limestone-related GHG emissions estimation example

5. Limestone and Dolomite Use in Louisiana

Emissions from limestone and dolomite use result from industrial consumption. The quantities of limest
consumed for industrial purposes, dolomite consumed for industrial purposes, and magnesium produce
dolomite are multiplied by their respective emission factors. Industrial uses include the consumption of
and dolomite for flux stone production, glass manufacturing, flue gas desulfurization (FGD), Mg product
through the thermic reduction of dolomite, chemical stone manufacturing, mine dusting or acid w ater tre
acid neutralization, and sugar refining. The emissions are then converted from metric tons of carbon eq
(MTCE) to metric tons of carbon dioxide equivalents ($MTCO_2E$). For default data, each state's total lime
consumption (as reported by USGS) is multiplied by the ratio of national limestone consumption for indu
uses to total national limestone consumption. Additional information on these calculations, including a c
of industrial uses, is available in the Industrial Processes Chapter of the User's Guide.

Click here to find where these data are available.

		Consumption (Metric Tons)		Emission Factor ($t\ CO_2/t$ production)		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990	Limestone	-	x	0.4400	=	-	=	-
	Dolomite	-	x	0.4840	=	-	=	-
	Magnesium Production from Dolomite		x	1.7970	=	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Soda ash manufacturing and consumption GHG emissions equation

Soda ash manufacturing and consumption are multiplied by emission factor to get metric tons CO_2 equivalent.

Equation 5. Emission Equation for Soda Ash Manufacture and Consumption

$$\text{Emissions } (MTCO_2E) = \text{Manufacture/Consumption (metric tons)} \times \text{Emission Factor } (MT\ CO_2/MT \text{ production})$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Soda ash GHG emissions estimation example

6. Soda Ash Manufacture and Consumption in Louisiana

Click here to find where these data are available.

Emissions from soda ash manufacture and consumption are calculated by multiplying the quantity of soda ash manufactured (Wyoming only) and the quantity of soda ash consumed by their respective emission factors. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents ($MTCO_2E$). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

		Manufacture and Consumption (Metric Tons)		Emission Factor ($t\ CO_2$/t production)		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990	Manufacture	-	x	0.0970	=	-	=	-
	Consumption	110,406	x	0.4150	=	12,496	=	45,818
1991	Manufacture	-	x	0.0970	=	-	=	-
	Consumption	105,605	x	0.4150	=	11,953	=	43,826

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Iron and steel GHG emissions equation

Iron and steel manufacturing and consumption are multiplied by emission factors to derive total emissions

Equation 6. Emission Equation for Iron and Steel Production

$$\text{Emissions } (MTCO_2E) =$$
$$\text{Manufacture/Consumption (metric tons)} \times \text{Emission Factor } (MT\ CO_2/MT\ \text{production})$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Iron and steel GHG emissions estimation example

7. Iron and Steel Production in Louisiana

Click here to find where these data are available.

Iron and steel production generate process-related emissions. The basic activity data needed are the quantities of crude steel produced (defined as first cast product suitable for sale or further processing) by production method. Default values are based on the state-level production data assigned to production method based on the national distribution of production by method. **It is strongly advised that users enter state-specific information, as default data are based on national averages, are not available for all years, and are likely to be inaccurate for states.** Activity data are then multiplied by the appropriate emission factor. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents ($MTCO_2E$). This methodology is based on the 2006 IPCC Guidelines for National GHG Inventories.

	Production Method	State Production (Metric Tons)		Emission Factor ($t\ CO_2$/t production)		Emissions (MTCE)		Emissions ($MTCO_2E$)	
1990	BOF with coke ovens	-	x	1.72	=	-	=	-	☑ Defa
	BOF without coke ovens	-	x	1.46	=	-	=	-	
	EAF	-	x	0.08	=	-	=	-	
	OHF	-	x	1.72	=	-	=	-	
	Total				=	**-**		**-**	

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Ammonia production GHG emissions equation

Ammonia production and urea consumption are estimated together, and urea application emissions are subtracted from emissions due to ammonia production. Both are then multiplied by their respective emissions factor.

Equation 7. Emission Equation for Ammonia Production

$$\text{Emissions } (MTCO_2E) = \text{Production of Ammonia (metric tons)} \times \text{Emission Factor } (MT\ CO_2/MT\ \text{activity}) - \text{Emissions from Urea } (MTCO_2E)$$

Equation 8. Emission Equation for Urea Consumption

$$\text{Emissions } (MTCO_2E) = \text{Consumption of Urea (metric tons)} \times \text{Emission Factor } (MT\ CO_2/MT\ \text{activity})$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Ammonia and urea GHG emissions estimation example

8. Ammonia Production and Urea Consumption in Louisiana

Click here to find where these data are available.

Emissions from ammonia production and urea application are calculated by multiplying the quantity of ammonia produced and urea applied by their respective emission factors. Emissions from urea application are subtracted from emissions due to ammonia production. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents ($MTCO_2E$). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Check All Boxes

Clear All Data

Year		Production & Consumption (Metric Tons)		Emission Factor (mt CO_2/mt activity)		Subtract emissions from Urea		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990	Ammonia Production	5,105,245	x	1.2	- (	6,795	) =	1,668,954	=	6,119,499
	Urea Consumption	9,309	x	0.73			=	1,853	=	6,795
1991	Ammonia Production	5,170,732	x	1.2	- (	4,991	) =	1,690,878	=	6,199,887
	Urea Consumption	6,837		0.73			=	1,361	=	4,991

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Nitric acid GHG emissions equation

Nitric acid production produces N_2O which is multiplied by its emission factor

Equation 9. Emission Equation for Nitric Acid Production

$$\text{Emissions } (MTCO_2E) = \text{Production of Nitric Acid (metric tons)} \times \text{Emission Factor } (MT\ N_2O/MT \text{ production}) \times \text{Percent } N_2O \text{ Released after Pollution Control} \times GWP\ N_2O$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Nitric acid GHG emissions estimation example.

9. Nitric Acid Production in Louisiana

Click here to find where these data are

Emissions from nitric acid production are calculated by multiplying the quantity of nitric acid produced by an emission factor and by the percentage of N_2O released after pollution controls are taken into account. These emissions are then converted from metric tons of N_2O to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents ($MTCO_2E$). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Clear All Data

Use Default Pollution Control Factor (100%, no pollution control)

	Production (Metric Tons)		Emission Factor (t N_2O/t production)		Percent N_2O Released after Pollution Control		Emissions (Metric Tons N_2O)		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990		x	0.0080	x	100%	=	-	=	-	=	-
1991		x	0.0080	x	100%	=	-	=	-	=	-
1992		x	0.0080	x	100%	=	-	=	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Adipic acid emissions GHG estimation equation

Nitric acid production produces N_2O which is multiplied by its emission factor

Equation 10. Emission Equation for Adipic Acid Production

$$\text{Emissions } (MTCO_2E) = \text{Production of Adipic Acid (metric tons)} \times \text{Emission Factor } (MT\ N_2O/MT\ \text{production}) \times \text{Percent } N_2O \text{ Released after Pollution Control} \times GWP\ N_2O$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Adipic acid GHG emissions estimation example

Note: The SIT default data indicates there is no active adipic acid production in Louisiana. Continued research is being conducted to verify this is accurate since some locations in the state have produced this in the past.

	Production (Metric Tons)		Emission Factor (t N_2O/t production)		Percent N_2O Released after Pollution Control		Emissions (Metric Tons N_2O)		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990		x	0.3000	x		=	-	=	-	=	-
1991		x	0.3000	x		=	-	=	-	=	-
1992		x	0.3000	x		=	-	=	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Aluminum emission GHG equation

Aluminum production emissions vary based on technology of prebake or soderberg. The factors are measured and multiplied by aluminum production and CO_2 factors.

Equation 11. Emission Equation for Aluminum Production

$$\text{Total Emissions } (MTCO_2E) = \text{PFC Emissions } (MTCO_2E) + CO_2 \text{ Emissions } (MTCO_2E)$$

$$\text{PFC Emissions } (MTCO_2E) = \text{Production of Aluminum (metric tons)} \times \text{Emission Factor (MT CE/MT production)}$$

$$CO_2 \text{ Emissions } (MTCO_2E) = \text{Production of Aluminum (metric tons)} \times [(\text{Percent of Production}_{\text{Prebake}} \times EF_{\text{Prebake}}) + (\text{Percent of Production}_{\text{Søderberg}} \times EF_{\text{Søderberg}})] \text{ (MT CE/MT production)}$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Aluminum production GHG emissions estimation example

The SIT indicates there is no active aluminum production in Louisiana so this tab will be blank.

	Production (Metric Tons)		PFC Emission Factor (t C E/t production)		Søderberg Facilities %		Søderberg CO_2 Emission Factor (t C E/t production)		Prebake Facilities %		Prebake CO_2 Emission Factor (t C E/t production)		PFC Emissions (MTCE)		Carbon Emissions (MTCE)		Total Emissions (MTCO$_2$E)
1990	-	x (	0.4255	+	10.00%	x	0.4636	+	90.00%	x	0.4364	) =	-	+	-	=	-
1991	-	x (	0.4255	+	10.00%	x	0.4636	+	90.00%	x	0.4364	) =	-	+	-	=	-
1992	-	x (	0.4255	+	10.00%	x	0.4636	+	90.00%	x	0.4364	) =	-	+	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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HCFC-22 GHG emissions equation

Production of HCFC-22 are multiplied by emissions factor

Equation 12. Emission Equation for HCFC-22 Production

Emissions ($MTCO_2E$) =
Production of HCFC-22 (metric tons) × Emission Factor (MT HFC-23/MT production) x GWP of HFC-23

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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HCFC-22 GHG emissions estimation example.

12. HCFC-22 Production in Louisiana

Click here to find where these data are available.

Emissions from HCFC-22 production are calculated by multiplying the quantity of HCFC-22 produced by an emission factor. The emissions are then converted from metric tons of HFC-23 to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents ($MTCO_2E$). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

	Production (Metric Tons)		Emission Factor (t HFC-23/t production)		Emissions (Metric Tons HFC-23)		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990		x	0.0200	=	-	=	-	=	-
1991		x	0.0200	=	-	=	-	=	-
1992		x	0.0200	=	-	=	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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State level ozone depleting substances (ODS) emissions allocations

National estimates proportioned to states are multiplied by state populations.

Equation 13. Emission Equation for Apportioning Emissions from the Consumption of Substitutes for ODS

$$\text{Emissions } (MTCO_2E) = [\text{National ODS Substitute Emissions } (MTCO_2E) \times \text{State Population}] / \text{National Population}$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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ODS GHG emission estimation

13. Consumption of ODS Substitutes in Louisiana

Emissions of HFCs, PFCs, and SF_6 from ODS substitute production are estimated by apportioning national emissions to each state based on population. State population data was provided by the U.S. Census Bureau (http://www.census.gov). The resulting state emissions are then converted from metric tons of CO_2 equivalents to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents ($MTCO_2E$). More detailed estimates of emissions from this source are not available. Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

	National Emissions (Metric Tons CO_2 Eq.)		State Population		National Population		Apportioned National Emissions (MTCE)		Apportioned National Emissions ($MTCO_2E$)
1990	227,175	x	4,219,179	/	249,464,396	=	1,048	=	3,842
1991	478,026	x	4,240,950	/	252,153,092	=	2,193	=	8,040
1992	1,684,617	x	4,270,849	/	255,029,699	=	7,694	=	28,211

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Semiconductor GHG emissions equation

Semiconductor production produce HFCs, PFCs, and SF_6 emissions. National emissions are multiplied by a ratio of selected state.

Equation 14. Emission Equation for Apportioning Emissions from Semiconductor Manufacture

Emissions ($MTCO_2E$) =
[National Semiconductor Manufacture Emissions ($MTCO_2E$) × Value of State Semiconductor Shipments]/ Value of State Semiconductor Shipments

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

Semiconductor GHG emissions estimation example

The SIT indicates there is no semiconductor production in Louisiana so this tab will be blank

	National Emissions (Metric Tons CO_2 Eq.)		Value of State Semiconductor Shipments-1997, 2002, 2007, or 2012 intervening years interpolated ($1000's)		Value of National Semiconductor Shipments-1997 or 2002, intervening years interpolated ($1000's)		Apportioned National Emissions (MTCE)		Apportioned National Emissions ($MTCO_2E$)
1990	3,563,688	x	$ -	/	$ 78,539,562	=	-	=	-
1991	3,563,688	x	$ -	/	$ 78,539,562	=	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Sulfur hexafluoride emissions equation

SF_6 consumption from electric power transmission and distribution (in insulation) are multiplied by SF_6 emission factors.

Equation 15. Emission Equation for Electric Power Transmission and Distribution

$$\text{Emissions } (MTCO_2E) = \text{SF}_6 \text{ Consumption (metric tons SF}_6) \times \text{Emission Factor (MT SF}_6\text{/MT Consumption)} \times \text{GWP of SF}_6$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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SF_6 GHG emissions estimation example

15. Electric Power Transmission and Distribution in Louisiana

Click here to find where these data are available.

Emissions from electric power transmission and distribution are calculated by multiplying the
consumed by an emission factor. The resulting emissions are then converted from metric to
metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents (MT
default assumption is that the emission factor is 1, i.e. all SF_6 consumed is used to replace S
emitted. Default activity data for this sector equals national SF_6 emissions apportioned by sta
sales divided by national electricity sales. Additional information on these calculations is avai
Industrial Processes Chapter of the User's Guide.

	SF_6 Consumption (Metric Tons)		Emission Factor ($t\ SF_6$/t Consumption)		Emissions (Metric Tons SF_6)		Emissions (MTCE)		Emissions ($MTCO_2E$)	
1990	23.9	x	1.0	=	23.9	=	148,590	=	544,831	☑
1991	22.8	x	1.0	=	22.8	=	141,780	=	519,861	☑
1992	22.9	x	1.0	=	22.9	=	142,157	=	521,241	☑

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Magnesium production emission equation

Magnesium production are multiplied my emission factors to get SF_6 emissions that are then converted.

Equation 16. Emission Equation for Magnesium Production and Processing

$$\text{Emissions } (MTCO_2E) = \text{Quantity of Magnesium Produced (metric tons)} \times \text{Emission Factor (MT } SF_6 \text{ / MT Magnesium)} \times \text{GWP of } SF_6$$

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Magnesium production GHG emissions estimation example

The SIT indicates there is no magnesium production in Louisiana so this tab will be blank

		Magnesium Production and Processing (Metric Tons)		Emission Factor ($t\ SF_6$/t Magnesium)		Emissions (Metric Tons SF_6)		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990	Primary Production		x	0.0012	=	-	=	-	=	-
	Secondary Production		x	0.0010	=	-	=	-	=	-
	Casting		x	0.0041	=	-	=	-	=	-

Source: EPA, State Inventory Tool Users Guide, Industrial Process. 2020.

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Estimated industrial process trends

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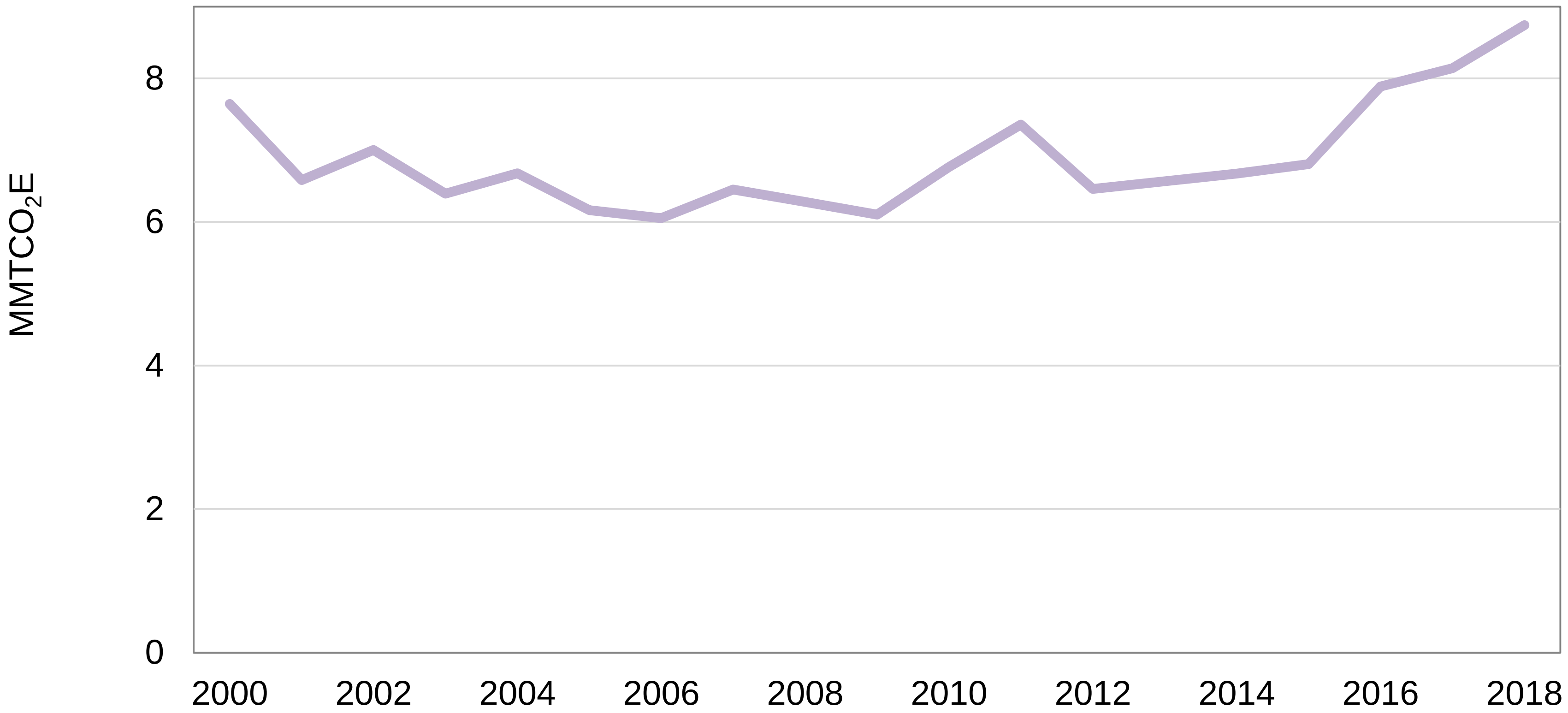
Louisiana total industrial processing GHG emission trends (non combustion)

Louisiana industrial process GHG emissions have been increasing over the past several years due to the new capacity additions from recent industrial capacity expansions.



Source: EIA

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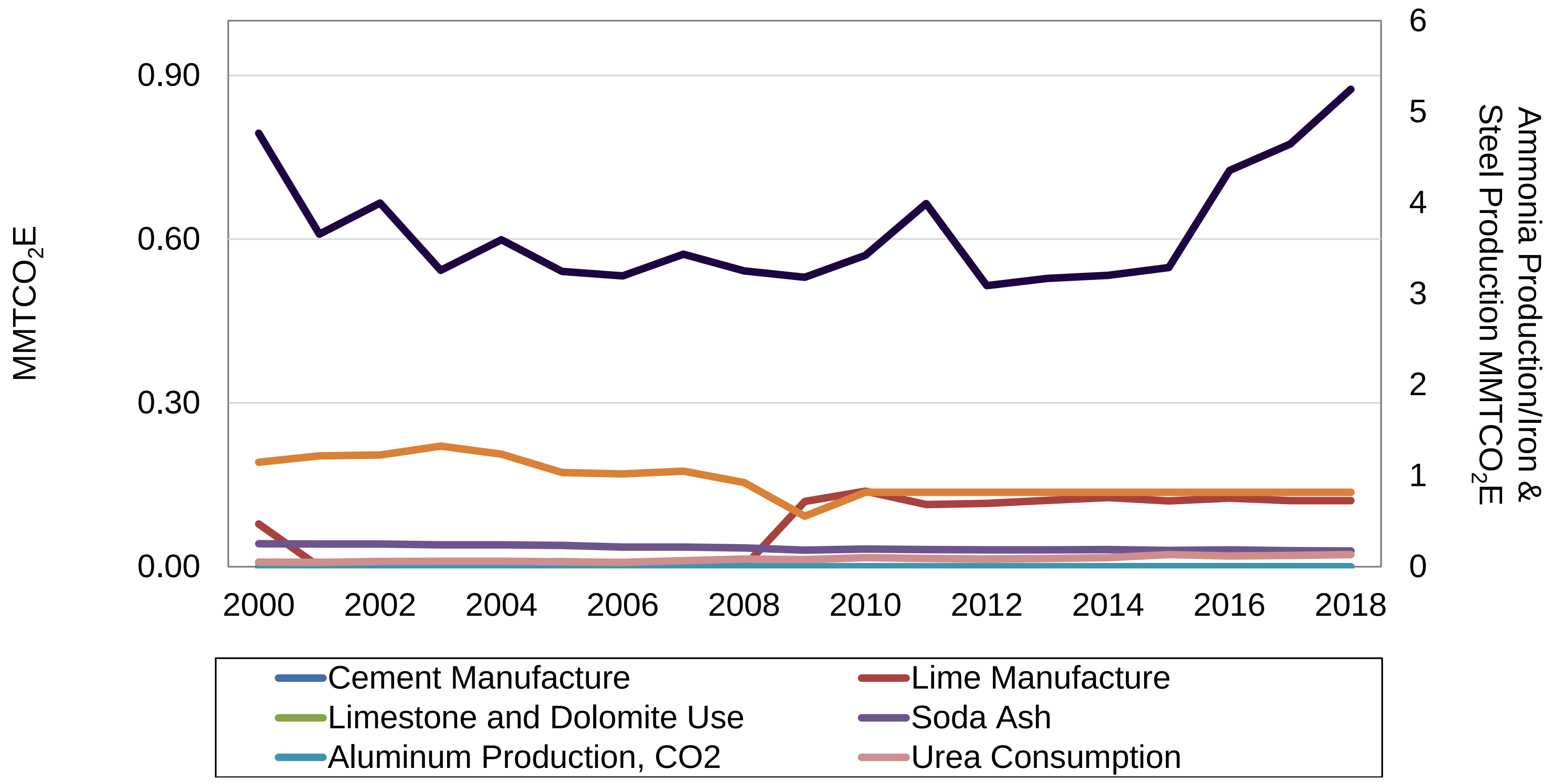
Louisiana industrial process emissions by sector

Ammonia-related process emissions dominate the industrial sector in Louisiana followed by steel production. Note these are process emissions, not combustion emissions.



Source: EIA

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2018 Industrial Processes GHG Emission Shares

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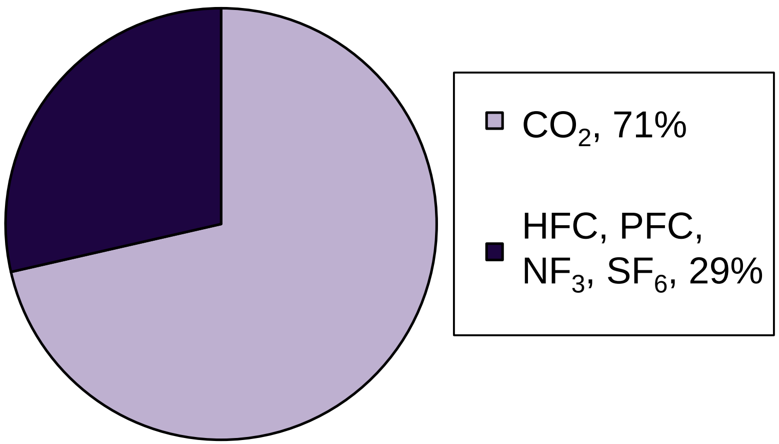
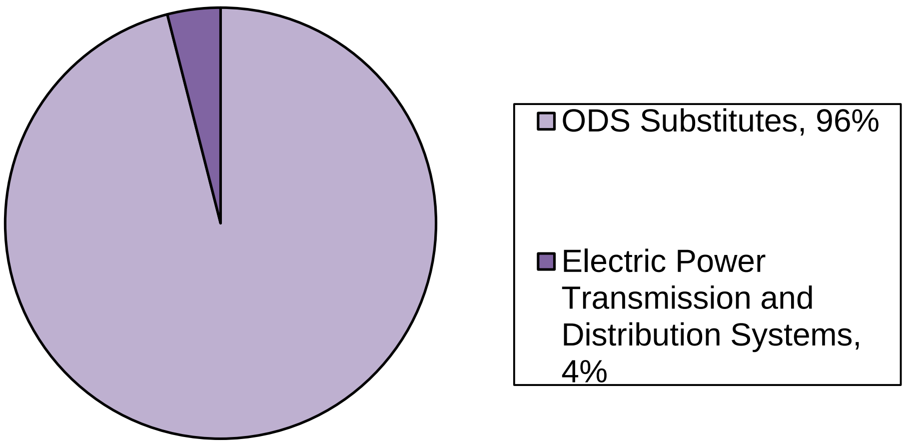
Summary emission shares – industrial processes

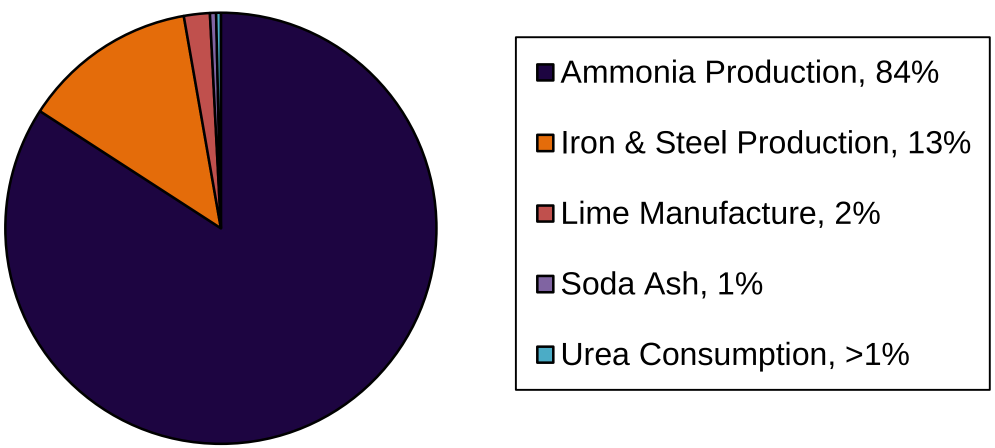
Total Emissions



HFC, PFC, NF_3, SF_6 Emissions



CO_2 Emissions



Source: EIA

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2018 Summary Calculation: Industrial Processes

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2018 Summary estimates

Industrial process emissions (which differ from industrial combustion emissions) contribute 8.7 million metric tons to Louisiana’s GHG inventory.

Class	2018 $MMTCO_2E$
Carbon Dioxide Emissions	
Cement Manufacture	-
Lime Manufacture	0.121
Limestone and Dolomite Use	-
Soda Ash	0.029
Aluminum Production, CO_2	-
Iron & Steel Production	0.817
Ammonia Production	5.247
Urea Consumption	0.022
Nitrous Oxide Emissions	
Nitric Acid Production	0.013
Adipic Acid Production	-
HFC, PFC, NF_3, and SF_6 Emissions	
ODS Substitutes	2.394
Semiconductor Manufacturing	-
Magnesium Production	-
Electric Power Transmission	0.099
HCFC-22 Production	0.003
Aluminum Production, PFCs	-
Total	**8.745**

Source: EIA

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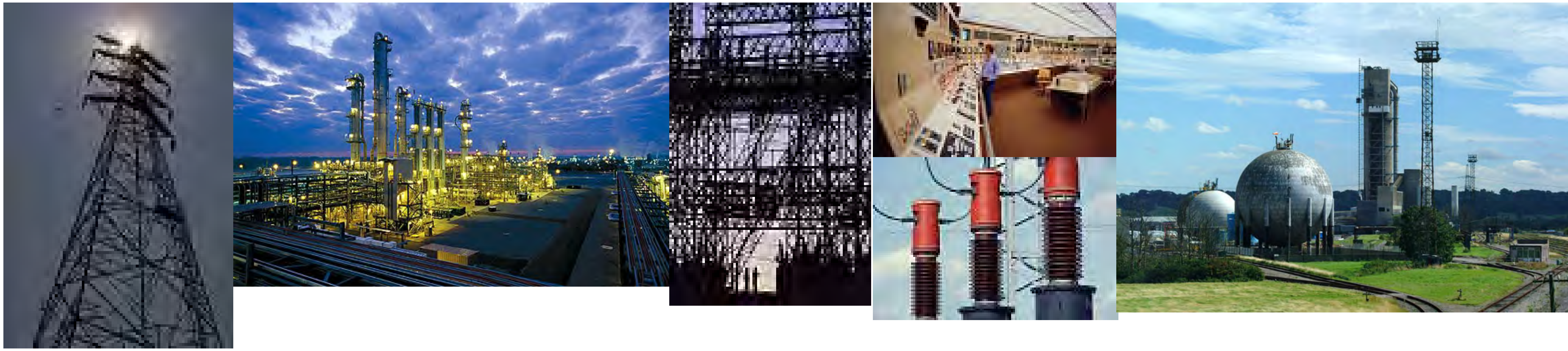

Louisiana 2021 GHG Inventory. Appendix 4: electricity consumption emissions estimates.

Prepared on the behalf of the Governor's Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Estimation methods for electricity consumption emissions

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Electricity consumption module ("ECM")

- The electricity consumption module ("ECM") is a "newer" module added to the state inventory tool ("SIT") to estimate the "indirect emissions" (or scope 2 emissions) that arise from the consumption of electricity.
- These emission are stated by EPA to be "different" since they are induced at the end-user level, not the "site" level.
- However, keep in mind that power plants generate electricity and emissions through their respective combustion processes.
- Thus, <u>**these electricity consumption emissions estimates should be viewed separately and independently from the power generation emission estimates**</u> (in the combustion module): <u>**they are not additive to power generation**</u>.
- The ECM gives states the ability to reconcile generation related emissions down to the consumption level and vice versa.

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- Electricity consumption occurs across a number of aggregate sectors that include: residential; commercial; transportation; and industrial sectors. Often referred to as utility "customer classes" at the retail level.
- Each sector, in turn, utilize electricity for a variety of differing end-uses that include space heating, air conditioning, water heating, lighting, refrigeration, light rail, process heating, machine drive, facility HVAC.
- In order to estimate electricity consumption-related emissions, knowledge about (a) generation related emission factors and (b) electricity consumption are needed.

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Electricity emission factors

- Electricity emission factors are derived from the generation that is utilized to make the electricity which is consumed across end-user classes.
- These emission factors, in turn, are a function of the fuel mix and generation profiles of the utilities in a respective state.
- Emission factors are measured in terms of pounds per megawatthour (“MWh”) generated/consumed.
- Utilities with relatively-higher shares of coal generation (and other fossil fuels) will have higher emission factors than those that are more concentrated by nuclear, high efficiency natural gas turbines, high efficiency industrial cogeneration and renewables.
- Emission factors come from EPA’s eGRID database.

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Calculation/Formulas

Equation 1. General Emission Equation

$$\text{Emissions } (MMTCO_2E) = \{(\text{Total State Consumption (kWh)} \times \text{End-Use Equipment Consumption } (\%)) \div (1 - \text{Transmission Loss Factor } (\%))\} \times \text{Emission Factor } (\text{lbs } CO_2E/\text{kWh}) \times 0.0005 \text{ short ton/lbs} \times 0.90718 \text{ (Ratio of Short Tons to Metric Tons)} \div 1{,}000{,}000$$

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ECM module layout (residential)

3. Residential Electricity Consumption in Louisiana

Click here for information on data sources

Indirect CO_2 emissions from electricity consumption in the residential sector are calculated by multiplying state energy consumption (total kWh consumed in the residential sector) by the percentage of state consumption by residential end-use. The resulting sub-sector consumption values (kWh) are then multiplied by a state-specific emission factor (lbs CO_2E/kWh) and transmission line losses. The resulting emissions values, in pounds of carbon, are converted to short tons of carbon, million metric tons of carbon equivalent (MMTCE), then to million metric tons of carbon dioxide equivalent (MMTCO$_2$E), and summed.

Go to the Control Sheet

Go to the MMTCO$_2$E Summary Sheet

Check All Boxes

Clear All Data

Residential 1990 ☑ Default Consumption Data ☑ Default Percent Data

Sub-sector	Total State Consumption (kWh)		% End Use of Sector Consumption (%)		Sub-sector Consumption (kWh)		Transmission loss Factor (%)		Emission Factor (lbs CO_2E/kWh)		Emissions (lbs carbon)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
Space Heating			10.8%	= {	2,321,445,727	÷ (1 -	6.4%	)} ×	1.18	=	795,423,812	=	397,711.91	=	0.36	=	1.32
Air-conditioning			22.4%	= {	4,797,654,502	÷ (1 -	6.4%	)} ×	1.18	=	1,643,875,878	=	821,938	=	0.75	=	2.73
Water Heating			10.8%	= {	2,321,445,727	÷ (1 -	6.4%	)} ×	1.18	=	795,423,812	=	397,712	=	0.36	=	1.32
Refrigeration			12.3%	= {	2,630,971,824	÷ (1 -	6.4%	)} ×	1.18	=	901,480,320	=	450,740	=	0.41	=	1.50
Other Appliances and Lighting			43.7%	= {	9,363,164,432	÷ (1 -	6.4%	)} ×	1.18	=	3,208,209,375	=	1,604,105	=	1.46	=	5.34
TOTAL	**21,434,682,211**	×	**100.0%**	= {	**21,434,682,211**	÷ (1 -	**6.4%**	)} ×	**1.18**	=	**7,344,413,198**	=	**3,672,207**	=	**3.33**	=	**12.21**

Residential 1991 ☑ Default Consumption Data ☑ Default Percent Data

Sub-sector	Total State Consumption (kWh)		% End Use of Sector Consumption (%)		Sub-sector Consumption (kWh)		Transmission loss Factor (%)		Emission Factor (lbs CO_2E/kWh)		Emissions (lbs carbon)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
Space Heating			10.8%	= {	2,336,968,377	÷ (1 -	6.4%	)} ×	1.18	)] =	800,742,517	=	400,371	=	0.36	=	1.33
Air-conditioning			22.4%	= {	4,829,734,647	÷ (1 -	6.4%	)} ×	1.18	)] =	1,654,867,869	=	827,434	=	0.75	=	2.75
Water Heating			10.8%	= {	2,336,968,377	÷ (1 -	6.4%	)} ×	1.18	)] =	800,742,517	=	400,371	=	0.36	=	1.33
Refrigeration			12.3%	= {	2,648,564,161	÷ (1 -	6.4%	)} ×	1.18	)] =	907,508,186	=	453,754	=	0.41	=	1.51
Other Appliances and Lighting			43.7%	= {	9,425,772,456	÷ (1 -	6.4%	)} ×	1.18	)] =	3,229,661,487	=	1,614,831	=	1.46	=	5.37
TOTAL	**21,578,008,019**	×	**100.0%**	= {	**21,578,008,019**	÷ (1 -	**6.4%**	)} ×	**1.18**	)] =	**7,393,522,578**	=	**3,696,761**	=	**3.35**	=	**12.30**

Control | EF Selection | Residential C | Commercial C | Transportation C | Industrial C | Summary-MMTCO2E | Data Sources | Transport Breakout | NTD_Pivot | CBECS Breakout | RECS Breakout

Select destination and press ENTER or choose Paste

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ECM module layout (commercial)

4. Commercial Electricity Consumption in Louisiana

Click here for information on data sources

Indirect CO_2 emissions from electricity consumption in the commercial sector are calculated by multiplying state energy consumption (total kWh consumed in the commercial sector) by the percentage of state consumption by commercial end-use. The resulting sub-sector consumption values (kWh) are then multiplied by a state-specific emission factor (lbs CO_2E/kWh) and transmission line losses. The resulting emissions values, in pounds of carbon, are converted to short tons of carbon, million metric tons of carbon equivalent (MMTCE), then to million metric tons of carbon dioxide equivalent ($MMTCO_2E$), and summed.

Go to the Control Sheet

Go to the $MMTCO_2E$ Summary Sheet

Check All Boxes

Clear All Data

Commercial 1990

☑ Default Consumption Data ☑ Default Percent Data

Sub-sector	Total State Consumption (kWh)	% End Use of Sector Consumption (%)	Sub-sector Consumption (kWh)	Transmission loss Factor (%)	Emission Factor (lbs CO_2E/kWh)	Emissions (lbs carbon)	Emissions (short tons carbon)	Emissions (MMTCE)	Emissions ($MMTCO_2E$)
Space Heating		3.3%	548,511,653	6.4%	1.18	187,942,895	93,971.45	0.09	0.31
Cooling		19.5%	3,217,935,034	6.4%	1.18	1,102,598,317	551,299	0.50	1.83
Ventilation		11.5%	1,901,507,065	6.4%	1.18	651,535,369	325,768	0.30	1.08
Water Heating		3.1%	511,944,210	6.4%	1.18	175,413,369	87,707	0.08	0.29
Lighting		35.2%	5,814,223,526	6.4%	1.18	1,992,194,686	996,097	0.90	3.31
Cooking		0.9%	146,269,774	6.4%	1.18	50,118,105	25,059	0.02	0.08
Refrigeration		10.8%	1,791,804,735	6.4%	1.18	613,946,790	306,973	0.28	1.02
Office Equipment		1.3%	219,404,661	6.4%	1.18	75,177,158	37,589	0.03	0.13
Computers		3.8%	621,646,541	6.4%	1.18	213,001,948	106,501	0.10	0.35
Other		10.6%	1,755,237,291	6.4%	1.18	601,417,264	300,709	0.27	1.00
TOTAL	**16,528,484,490**	**100.0%**	**16,528,484,490**	**6.4%**	**1.18**	**5,663,345,901**	**2,831,673**	**2.57**	**9.42**

Commercial 1991

☑ Default Consumption Data ☑ Default Percent Data

Sub-sector	Total State Consumption (kWh)	% End Use of Sector Consumption (%)	Sub-sector Consumption (kWh)	Transmission loss Factor (%)	Emission Factor (lbs CO_2E/kWh)	Emissions (lbs carbon)	Emissions (short tons carbon)	Emissions (MMTCE)	Emissions ($MMTCO_2E$)
Space Heating		3.3%	548,949,358	6.4%	1.18	188,092,871	94,046.44	0.09	0.31
Cooling		19.5%	3,220,502,899	6.4%	1.18	1,103,478,175	551,739	0.50	1.84

Control | EF Selection | Residential C | Commercial C | Transportation C | Industrial C | Summary-MMTCO2E | Data Sources | Transport Breakout | NTD_Pivot | CBECS Breakout | RECS Breakout

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ECM module layout (industrial)

Industrial 1990 ☑ Default Consumption Data ☑ Default Percent Data

Sub-sector	Total State Consumption (kWh)		% End Use of Sector Consumption		Sub-sector Consumption (kWh)		Transmission loss Factor (%)		Emission Factor (lbs CO_2E/kWh)		Emissions (lbs carbon)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions ($MMTCO_2E$)
Indirect Uses-Boiler Fuel																	
Conventional Boiler Use			0.3%	= {	87,158,958	÷ (1 -	6.4%	)} x	1.18	=	29,864,282	=	14,932	=	0.01	=	0.05
CHP and/or Cogeneration Process			0.1%	= {	37,848,014	÷ (1 -	6.4%	)} x	1.18	=	12,968,303	=	6,484	=	0.01	=	0.02
Direct Uses-Total Process																	
Process Heating			11.5%	= {	2,982,667,721	÷ (1 -	6.4%	)} x	1.18	=	1,021,985,955	=	510,993	=	0.46	=	1.70
Process Cooling and Refrigeration			7.2%	= {	1,860,860,712	÷ (1 -	6.4%	)} x	1.18	=	637,608,239	=	318,804	=	0.29	=	1.06
Machine Drive			51.4%	= {	13,296,929,945	÷ (1 -	6.4%	)} x	1.18	=	4,556,080,973	=	2,278,040	=	2.07	=	7.58
Electro-Chemical Processes			9.8%	= {	2,532,900,366	÷ (1 -	6.4%	)} x	1.18	=	867,876,962	=	433,938	=	0.39	=	1.44
Other Process Use			0.3%	= {	81,393,580	÷ (1 -	6.4%	)} x	1.18	=	27,888,824	=	13,944	=	0.01	=	0.05
Direct Uses-Total Nonprocess																	
Facility HVAC			8.8%	= {	2,284,853,433	÷ (1 -	6.4%	)} x	1.18	=	782,885,771	=	391,443	=	0.36	=	1.30
Facility Lighting			5.9%	= {	1,523,416,497	÷ (1 -	6.4%	)} x	1.18	=	521,985,822	=	260,993	=	0.24	=	0.87
Other Facility Support			1.4%	= {	361,184,009	÷ (1 -	6.4%	)} x	1.18	=	123,756,656	=	61,878	=	0.06	=	0.21
Onsite Transportation			0.1%	= {	34,456,615	÷ (1 -	6.4%	)} x	1.18	=	11,806,269	=	5,903	=	0.01	=	0.02
Other Nonprocess Use			0.1%	= {	25,028,526	÷ (1 -	6.4%	)} x	1.18	=	8,575,813	=	4,288	=	0.00	=	0.01
Other			2.9%	= {	754,721,966	÷ (1 -	6.4%	)} x	1.18	=	258,599,121	=	129,300	=	0.12	=	0.43
TOTAL	**25,863,420,342**	x	**100.0%**	= {	**25,863,420,342**	**÷ (1 -**	**6.4%**	**)} x**	**1.18**	=	**8,861,882,991**	=	**4,430,941**	=	**4.02**	=	**14.74**

ECM module layout (transportation)

Transportation   1990   ☑ Default Consumption Data   ☑ Default Percent Data

Sub-sector	Total State Consumption (kWh)		% End Use of Sector Consumption (%)		Sub-sector Consumption (kWh)		Transmission loss Factor (%)		Emission Factor (lbs CO_2E/kWh)		Emissions (lbs carbon)		Emissions (short tons carbon)		Emissions (MMTCE)		Emissions ($MMTCO_2E$)
Automated Guideway			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
Bus (charged batteries)			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
Cable Car			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
Commuter Rail			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
Heavy Rail			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
Inclined Plane			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
Light Rail			100.0%	= {	2,930,998	÷ (1 -	6.4%	)} x	1.18	=	1,004,282	=	502.14	=	0.00	=	0.00
Trolleybus			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
Other			0.0%	= {	-	÷ (1 -	6.4%	)} x	1.18	=	-	=	-	=	0.00	=	0.00
TOTAL	**2,930,998**	**x**	**100.0%**	= {	**2,930,998**	**÷ (1 -**	**6.4%**	**)} x**	**1.18**	**=**	**1,004,282**	**=**	**502**	**=**	**0.00**	**=**	**0.00**

Estimated electricity consumption emissions trends

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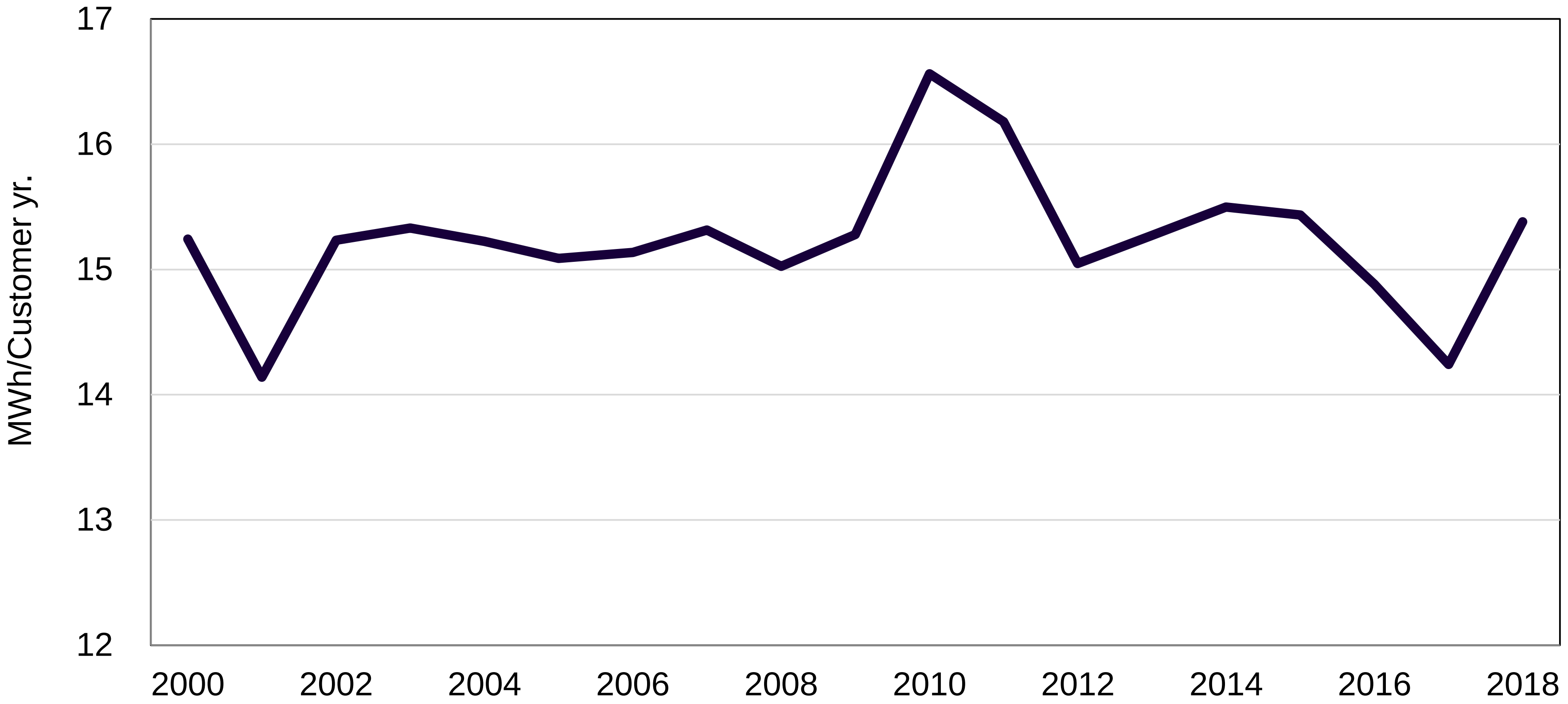
Louisiana residential use per customer

Residential use per customer (UPC) has fallen since 2010 showing some end user efficiency relative to historic trends.



Source: EIA form 861

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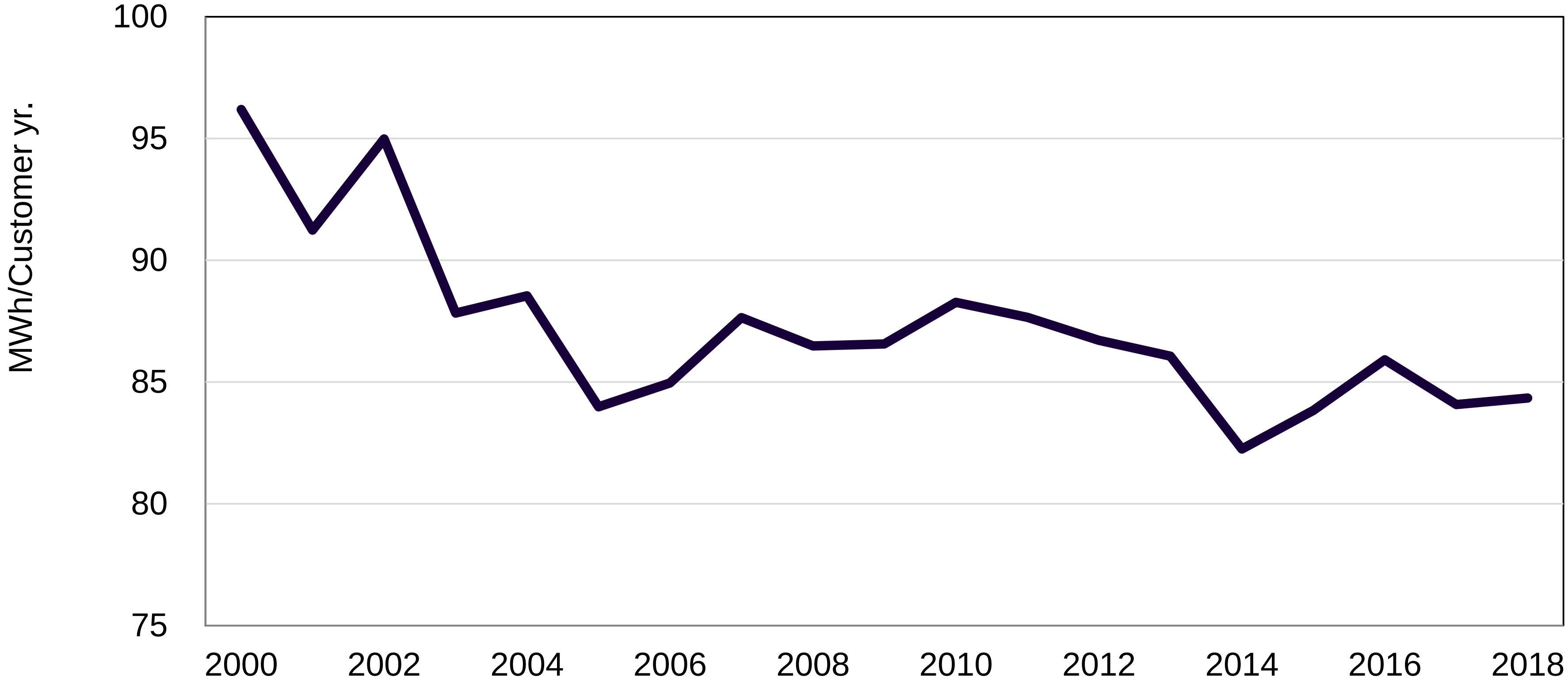
Louisiana commercial use per customer

Commercial UPC has been falling considerably since 2000 which will have end-user emissions implications.



Source: EIA form 861

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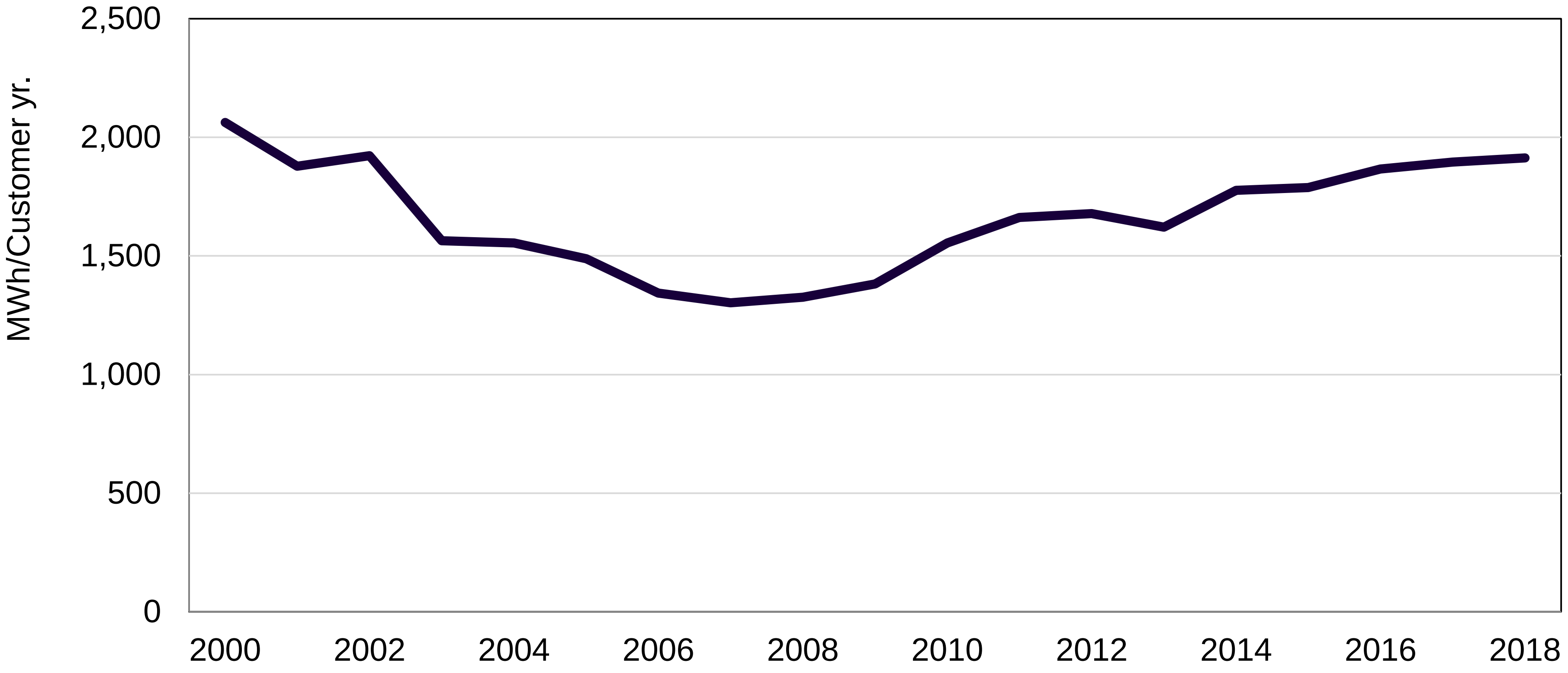
Louisiana industrial use per customer

Industrial UPC has been increasing since 2008 with the industrial capacity expansion.



Source: EIA form 861

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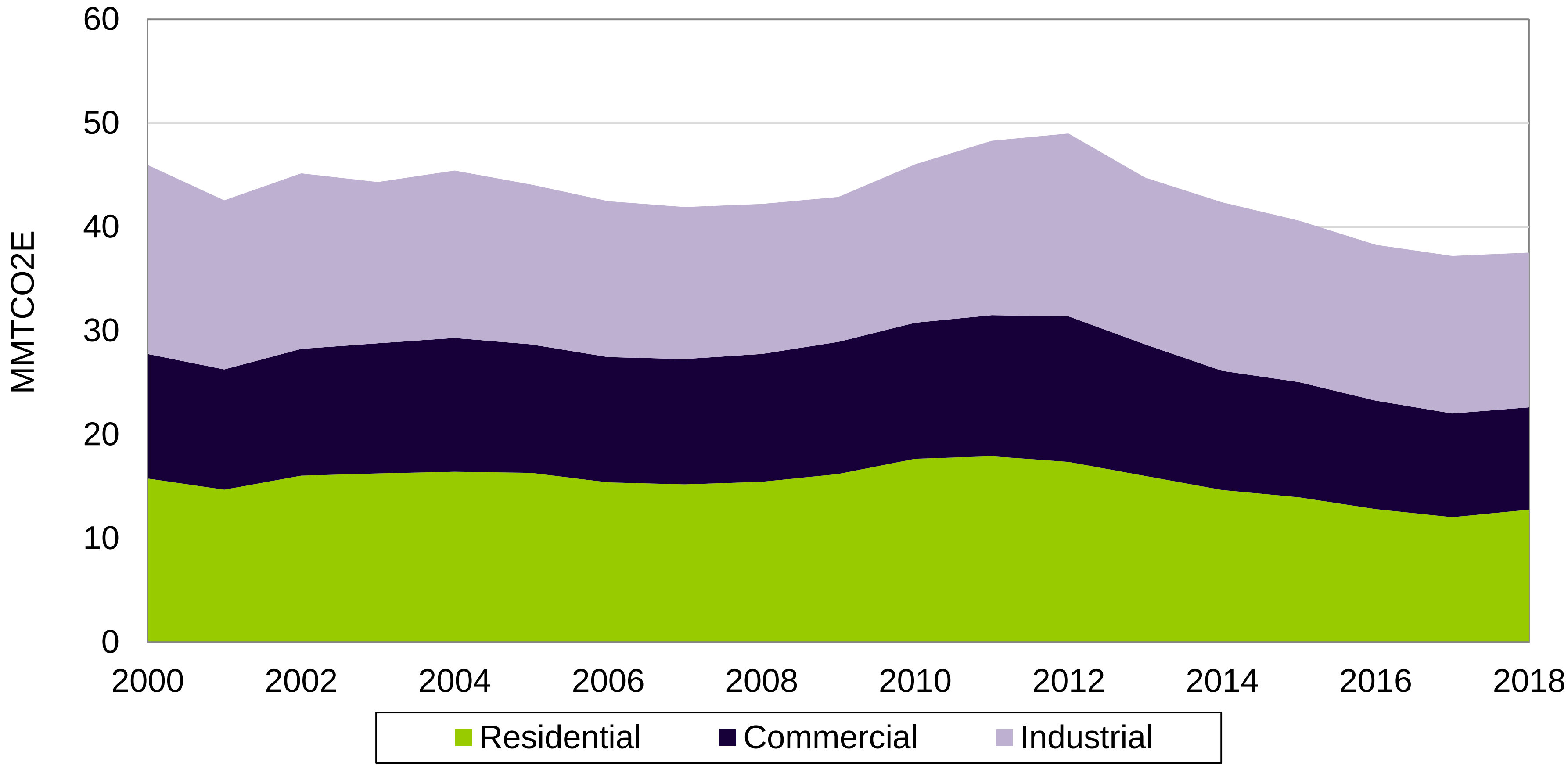
Louisiana CO2E emission trends (per sector basis, electricity consumption)

Electricity-related carbon emissions have been falling across all sectors since 2012.



Transportation not included due to negligible data

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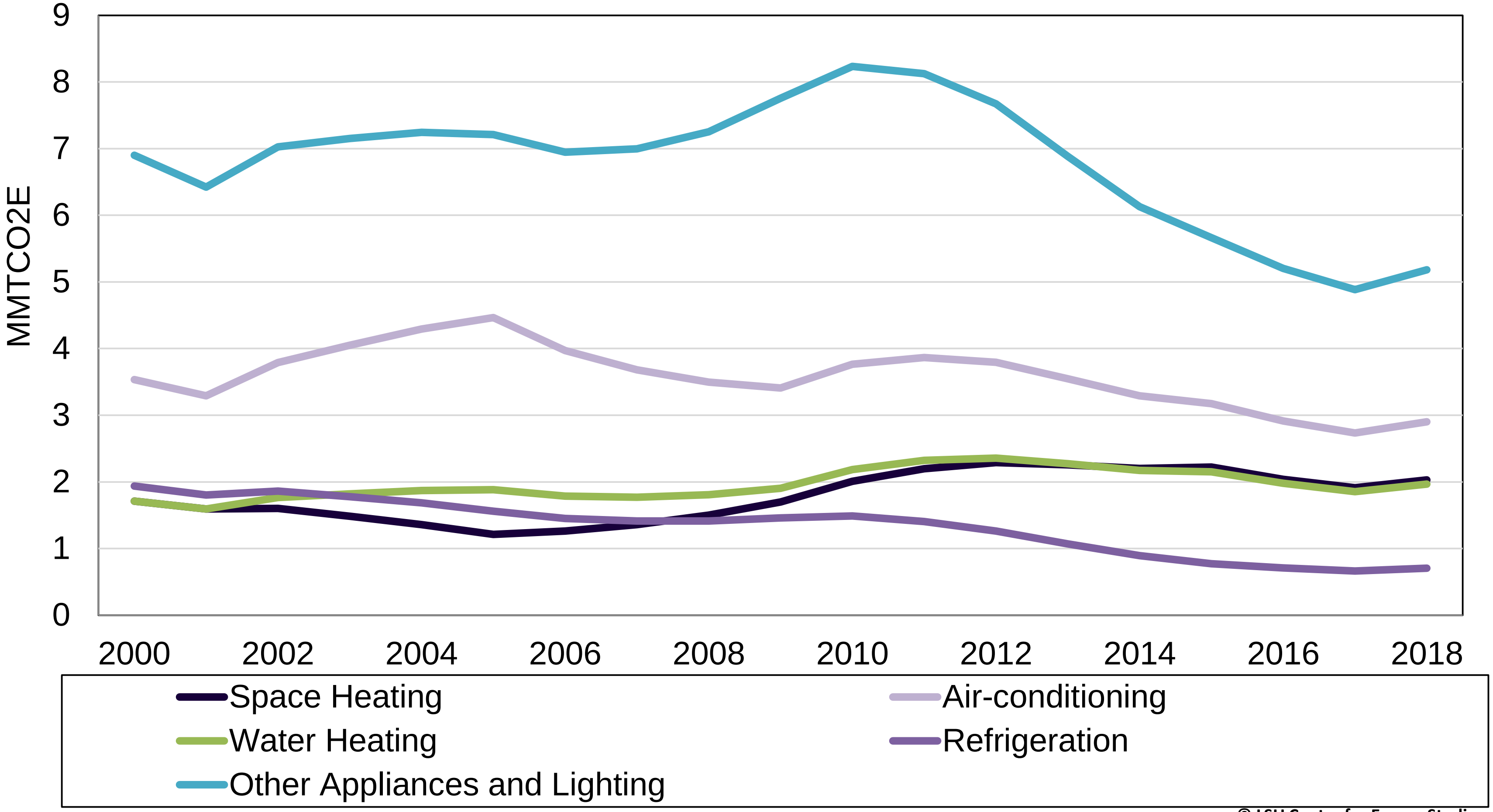
Louisiana residential electricity consumption emissions (by usage type)

Residential emissions have been on the decline since 2010. Electricity use associated with appliances have been falling rapidly since 2010 as has refrigeration. Water and space heating use is up.



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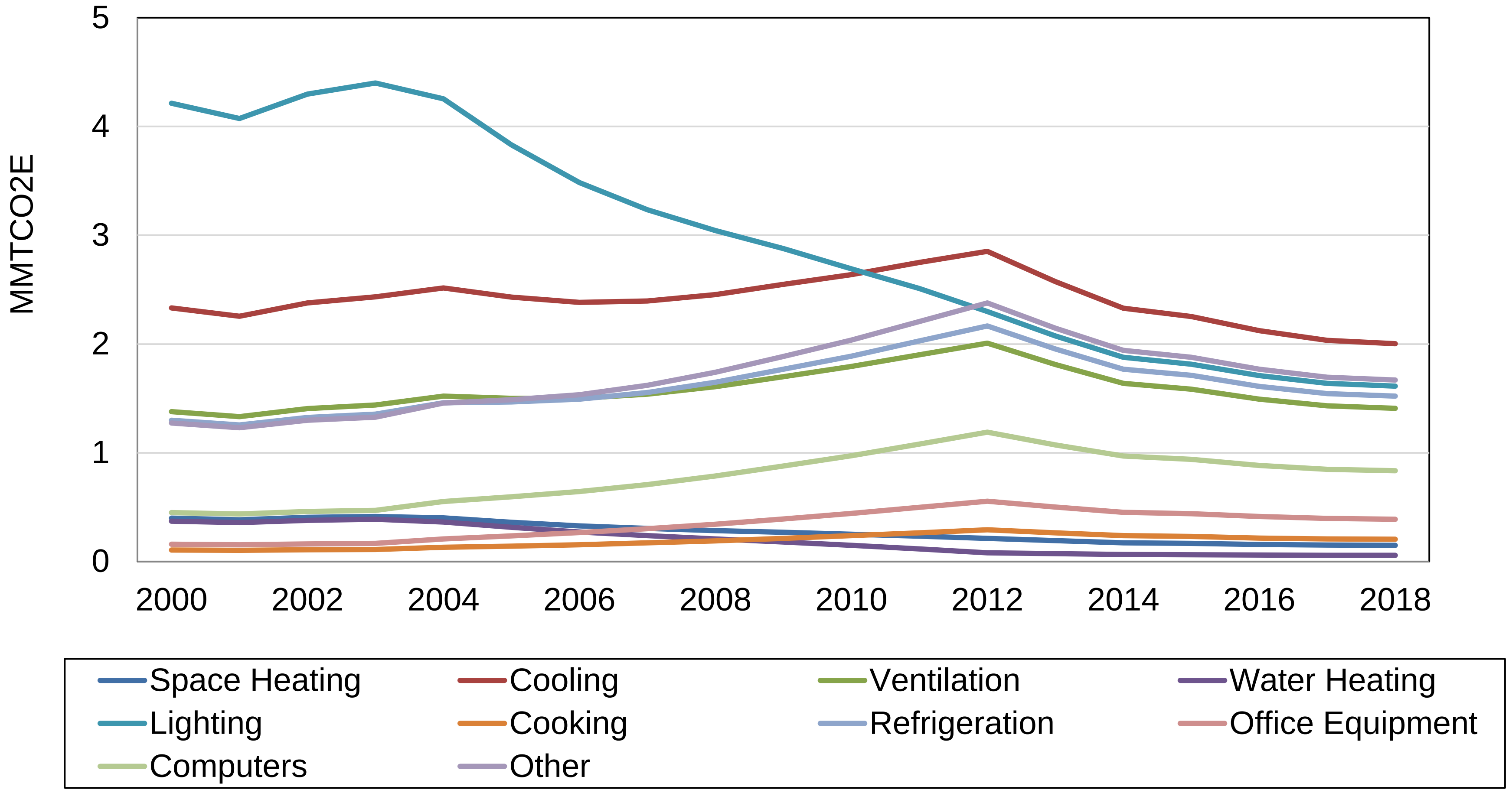
Louisiana commercial electricity emissions (by usage type)

Commercial emissions have also been on a steady decline since 2010. Lighting emissions have fallen substantially since 2000.



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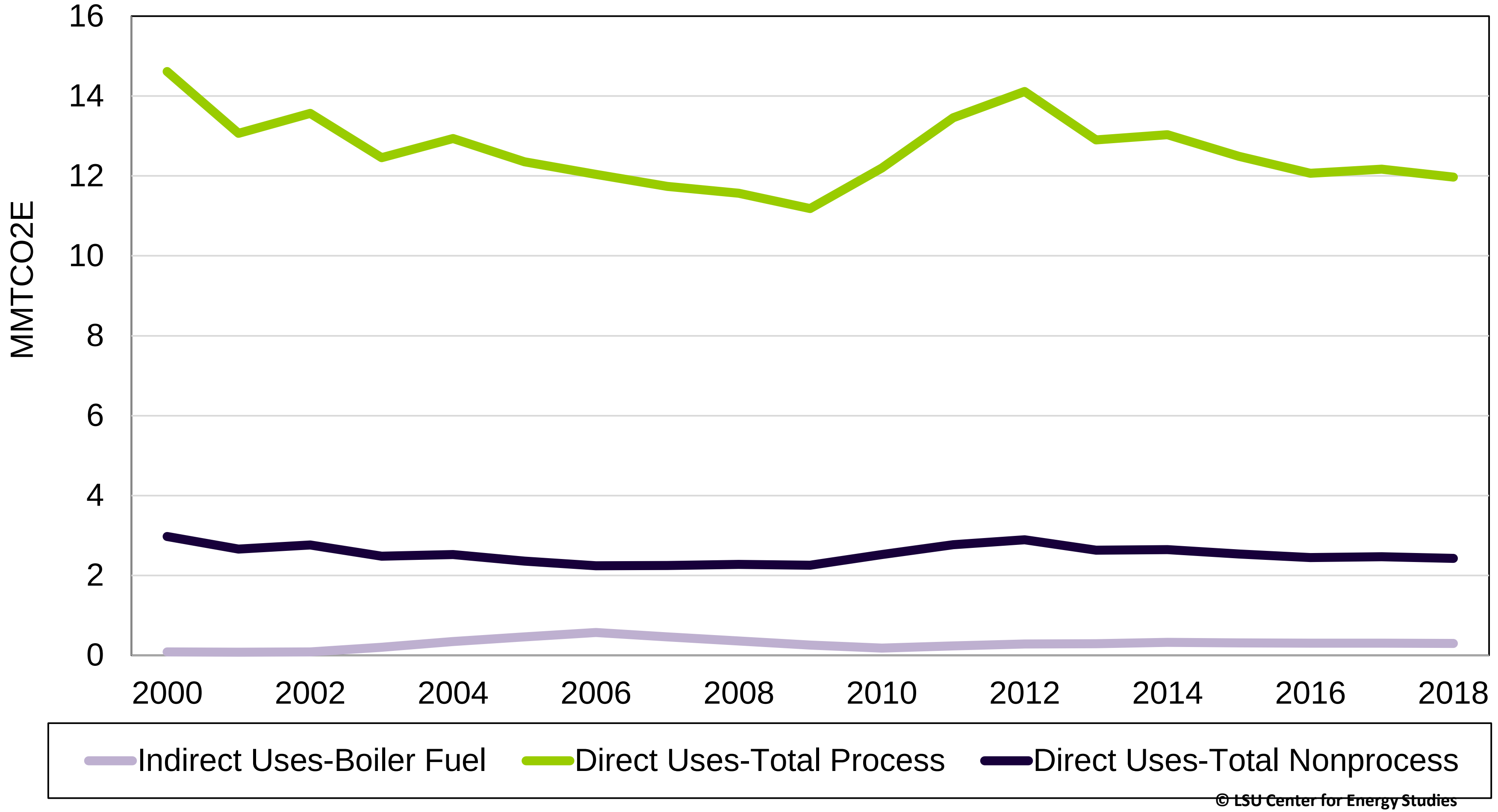
Louisiana industrial electricity emissions (by usage type)

Industrial emissions have remained relatively flat over the last 20 years with direct use maintaining the bulk of emissions.



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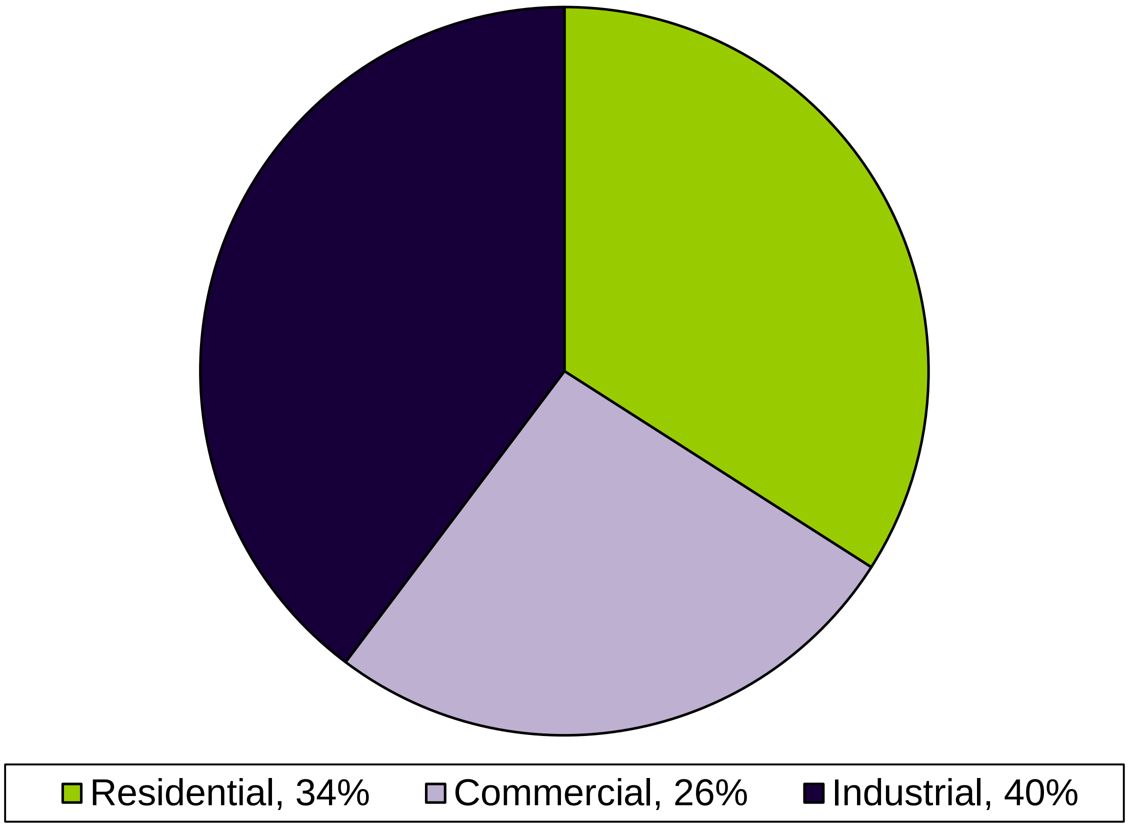
Current electricity consumption emission shares

2018 electricity consumption emission shares



Transportation not included due to negligible data

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2018 Summary Calculation: Electricity Consumption

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2018 Summary estimates

Electricity consumption shares are part of overall electricity related emissions – **they should not be counted as additive to the inventory since total power generation emissions are included in the fossil fuel combustion sector**.

Sector	2018 $MMTCO_2E$
Residential	12.78
Commercial	9.84
Industrial	14.92
Transportation	0.00
TOTAL	**37.55**

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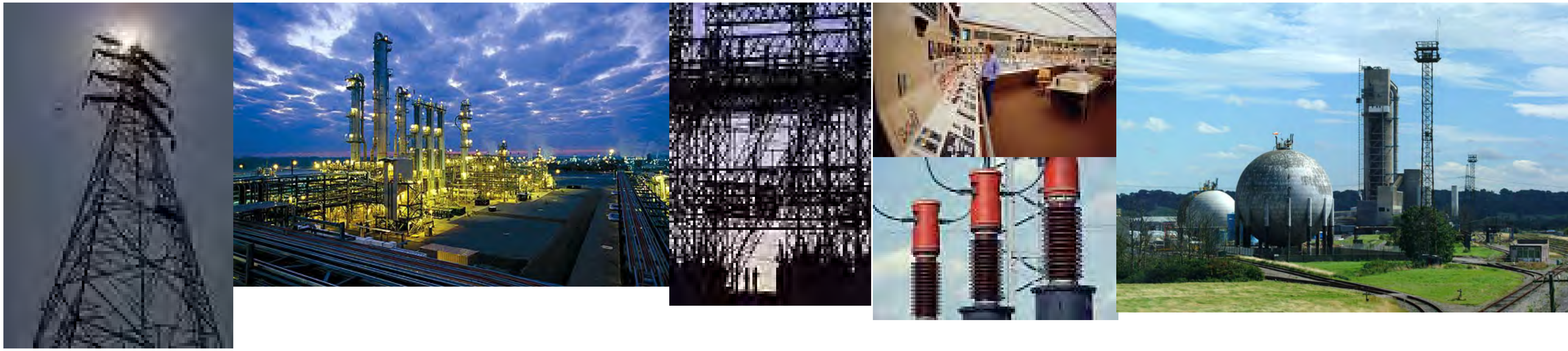

Louisiana 2021 GHG Inventory. Appendix 5: Mobile combustion emissions estimates.

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

GHG emissions of Mobile Combustion

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Definition of mobile source emissions

- Mobile emissions sources are primarily transportation related.
- These include both highway; non-highway; and alternative vehicle emissions.
- Highway vehicles include those fueled by gasoline or diesel such as passenger vehicles, light and heavy-duty trucks, and motorcycles.
- Non-highway vehicles include boats, locomotives, farm equipment, construction equipment and aircraft.
- Light and heavy-duty alternative fuel vehicles are included in this module

Source: User Guide for Mobile Combustion

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Mobile combustion emission types

- The mobile combustion module focuses exclusively on the estimation of methane (CH_4) and nitrous oxide (N_2O) releases.
- Transportation-related CO_2 emission are not included in this module: those are calculated separately in the fossil fuel combustion module (CO_2FFC module).
- Note: the mobile combustion module can estimate CO_2 emissions and can categorize those in greater emissions type detail for eight different vehicle control technologies. Total emission estimates, however, are consistent between the two modules.

Source: User Guide for Mobile Combustion

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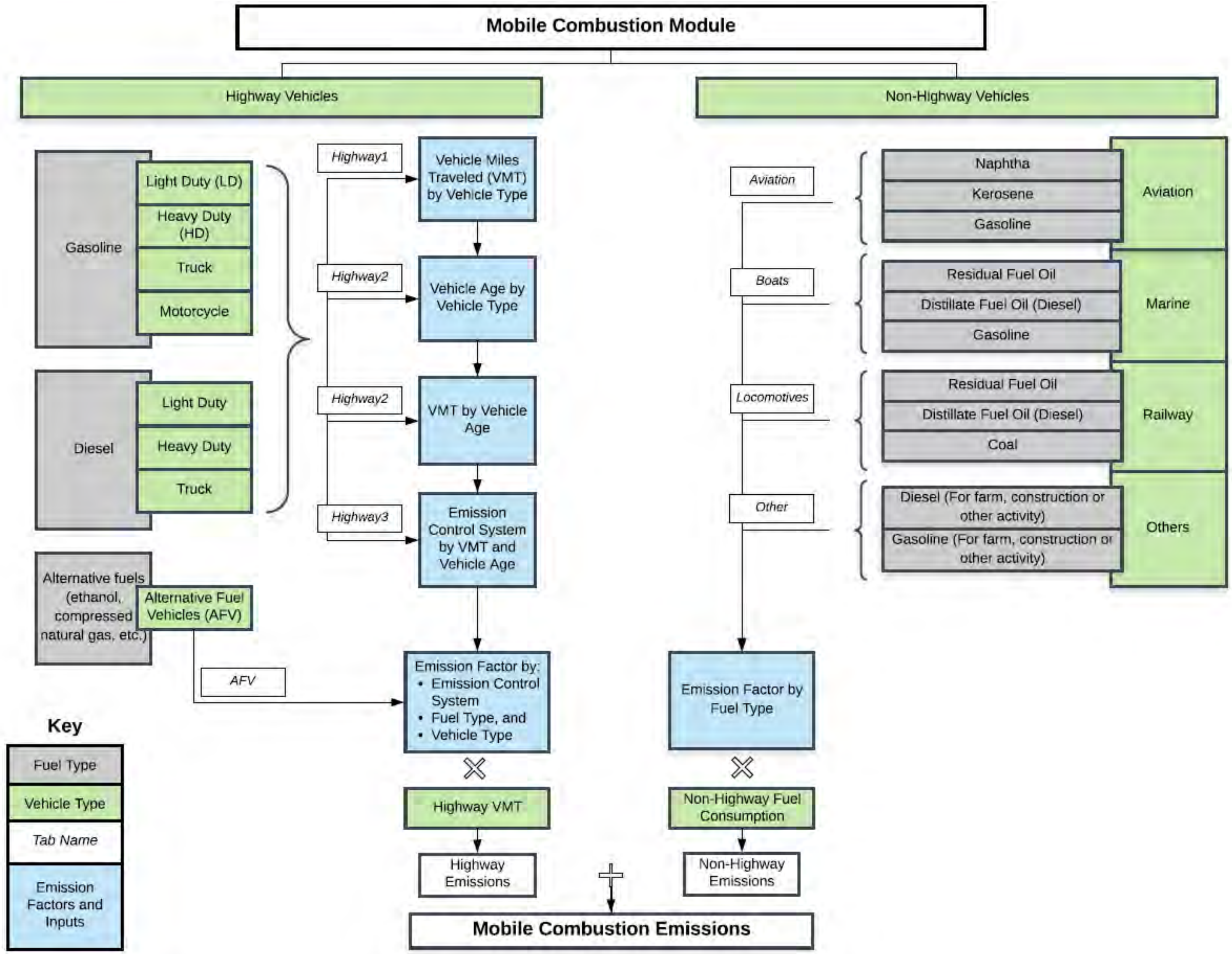
Methane and nitrous oxide emissions (mobile sources)

- There are little to no methane (CH_4) in either gasoline nor diesel – however, these emissions can arise as a combustion byproduct that is influenced by fuel types and control technologies.
- Some methane emissions can arise from the interaction of unburned or partially burned fuels and/or their interaction with various catalysts.
- Nitrous oxide emissions are influenced by engine type and fuel in two different manners.
- First, some N_2O arises in the cylinder as part of combustion process (released post-flame).
- Second, N_2O can be released in the catalytic aftertreatment of exhaust gases.

Source: User Guide for Mobile Combustion

Methodology overview of mobile combustion GHG emissions estimation



Source: User Guide for Mobile Combustion

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General mathematics of mobile combustion GHG emissions estimation.

Equation 1. General Mobile Combustion Equation

$$\text{Emissions} = \Sigma(\text{EF}_{abc} \times \text{Activity}_{abc})$$

Where,

EF = emissions factor (e.g., grams/kilometer traveled);

Activity = activity level measured in the units appropriate to the emission factor (e.g., miles);

a = fuel type (e.g., diesel or gasoline);

b = vehicle type (e.g., passenger car, light duty truck, etc.); and

c = emission control type (if any)

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Worksheet example of mobile combustion GHG emissions estimation.

State Inventory Tool - CH4 and N2O Emissions from Mobile Combustion Module

File Edit Module Options

4a. Highway Vehicles - Emission Factors and VMT

Click here for possible data sources.

Previous Continue

CH_4 and N_2O emissions from highway vehicles are calculated using four steps: 1) calculate the vehicle miles traveled for each vehicle type; 2) convert the vehicle miles traveled data for use with existing emission factors; 3) distribute vehicle miles traveled by vehicle age, and 4) determine emissions control systems for each vehicle type.

This worksheet provides input cells for vehicle miles traveled (VMT) by vehicle type, and emission factors that are used to calculate CH_4 and N_2O emissions from highway vehicles. For further information, refer to the Mobile Combustion chapter of the User's Guide.

1. Verify the Emission Factors that are used to calculate CH_4 and N_2O emissions from Highway Vehicles. Click for Code Help

emission factors

N_2O Emission Factors (g/mi traveled)

Control Technology	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
Three-way Catalyst (T2)	0.004	0.007	0.013				
Three-way Catalyst (T1)	0.043	0.087	0.175				
Early 3-way Catalyst (T0)	0.065	0.106	0.213				
Oxidation Catalyst	0.050	0.064	0.132				
Non-Catalyst	0.020	0.022	0.047				0.007
Low Emission Vehicle	0.015	0.016	[illegible]				
Advanced				0.001	0.001	0.005	
Moderate				0.001	0.001	0.005	
Uncontrolled	0.020	0.022	0.050	0.001	0.002	0.005	0.009

Source: Default values from EPA, 2010. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.

Restore Default Data Clear Data

CH_4 Emission Factors (g/mi traveled)

Control Technology	LDGV	LDGT	HDGV	LDDV	LDDT	HDDV	MC
Three-way Catalyst (T2)	0.017	0.016	0.033				
Three-way Catalyst (T1)	0.027	0.045	0.066				
Early 3-way Catalyst (T0)	0.070	0.078	0.263				
Oxidation Catalyst	0.135	0.152	0.236				
Non-Catalyst	0.170	0.191	0.418				0.067
Low Emission Vehicle	0.010	0.015	0.030				
Advanced				0.000	0.001	0.005	
Moderate				0.000	0.001	0.005	
Uncontrolled	0.178	0.202	0.460	0.001	0.001	0.005	0.090

Source: Default values from EPA, 2010. Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2008.

Restore Default Data Clear Data

vehicle miles traveled

2. Enter state-specific data on vehicle miles traveled (VMT) by vehicle type.

*Enter custom data in the table below, or use the provided default data.**

Restore Default Data Clear Data

State Total Vehicle Miles Traveled (Millions)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
HDDV	1,664	1,685	1,866	2,049	2,206	2,359	2,471	2,615	2,725	2,803	2,861	2,898	2,944	2,905	3,143
HDGV	386	407	425	429	435	441	447	451	465	470	456	417	432	434	469
LDDT	202	224	267	300	311	326	341	367	379	402	417	423	430	437	459
LDDV	172	157	167	171	167	161	156	158	153	149	145	133	134	132	140
LDGT	7,039	8,026	9,380	10,277	10,562	11,056	11,484	12,118	12,552	13,196	13,578	14,060	14,302	14,538	15,254
LDGV	17,604	17,133	18,578	19,355	19,855	20,572	21,147	21,908	22,952	23,562	24,158	24,877	25,157	24,789	26,271
MC	110	112	125	132	136	142	145	149	154	159	158	147	146	143	156
Total	**27,178**	**27,744**	**30,808**	**32,714**	**33,671**	**35,057**	**36,190**	**37,765**	**39,379**	**40,741**	**41,771**	**42,955**	**43,545**	**43,379**	**45,891**

**Default data for this table is not complete for all years and vehicle types by state. Null values signify unavailable data.*

Values are derived from tables VM-1 and VM-2 of Federal Highway Administration's "Highway Statistics" series (http://www.fhwa.dot.gov/ohim/ohimstat.htm). Please see these reports for specific notes on state-reported data.

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Estimated mobile combustion trends

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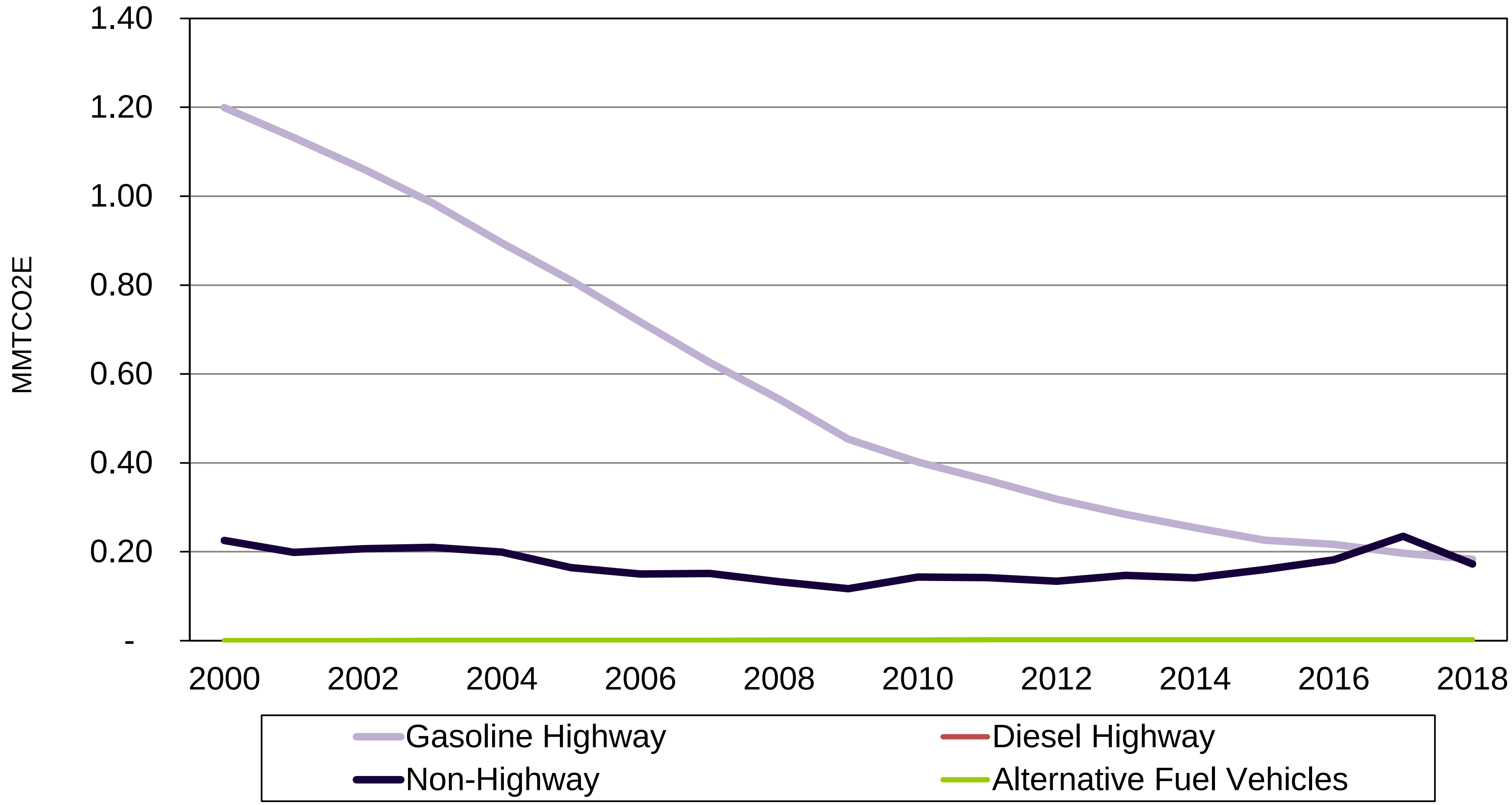
Louisiana combined methane/nitrous oxide emissions (vehicle type)

Gasoline highway-related emissions have fallen considerably since 2000 due to changing fuel standards. In 2018, gasoline and non-highway emission totals were comparable.



Source: EIA SIT

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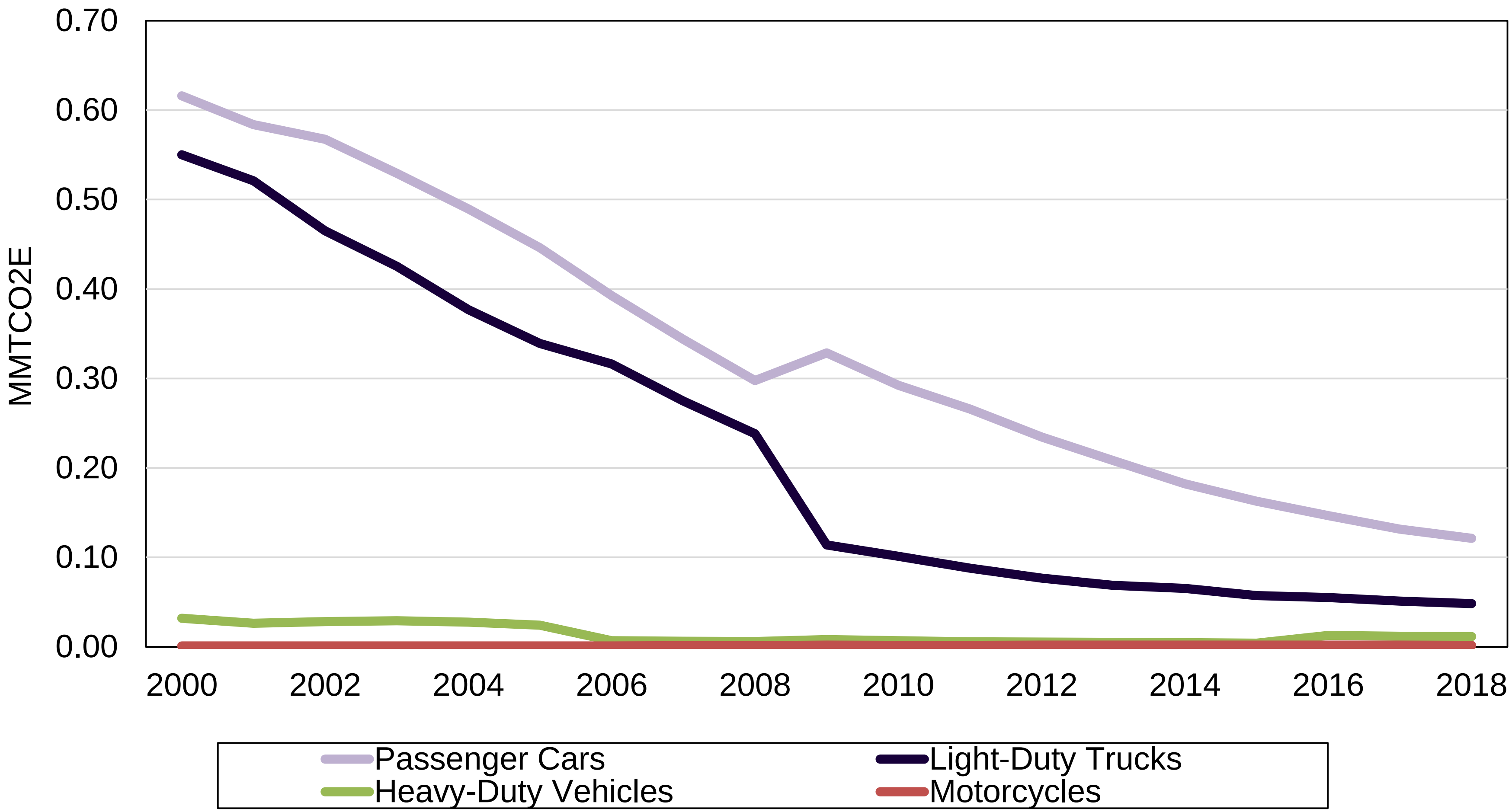
Louisiana gasoline-related emission trends (methane, nitrous oxide)

Gasoline-related emission decreases account for the bulk of the mobile combustion emission improvements. These improvements are in large part due to changing EPA fuels regulations.



Source: EIA SIT

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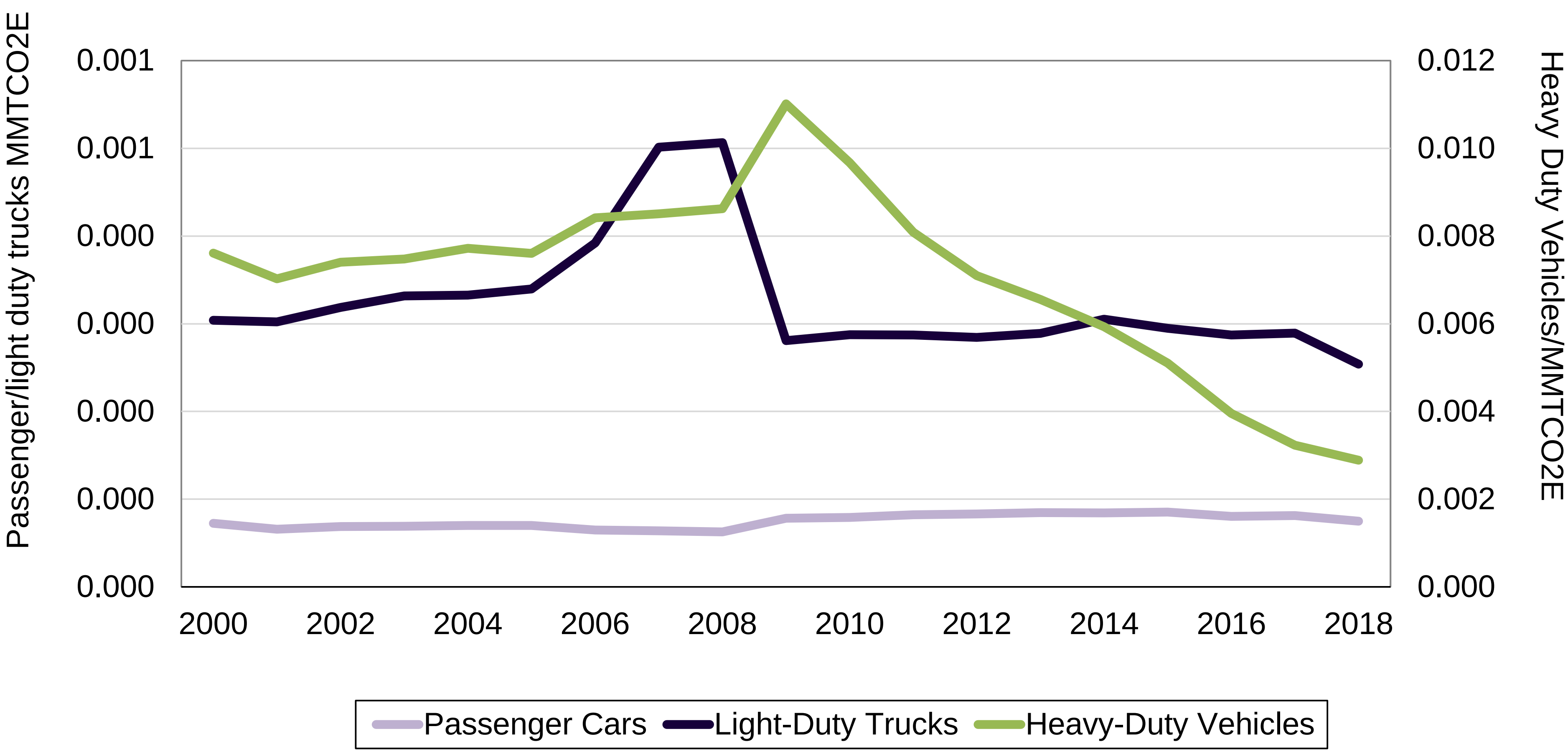
Louisiana diesel-related emission trends (methane, nitrous oxide)

Diesel-related emissions rose throughout 2010 and regional vehicle miles increased. A sharp fall in diesel emissions arose in 2010 due to changing EPA regulations.



Source: EIA SIT

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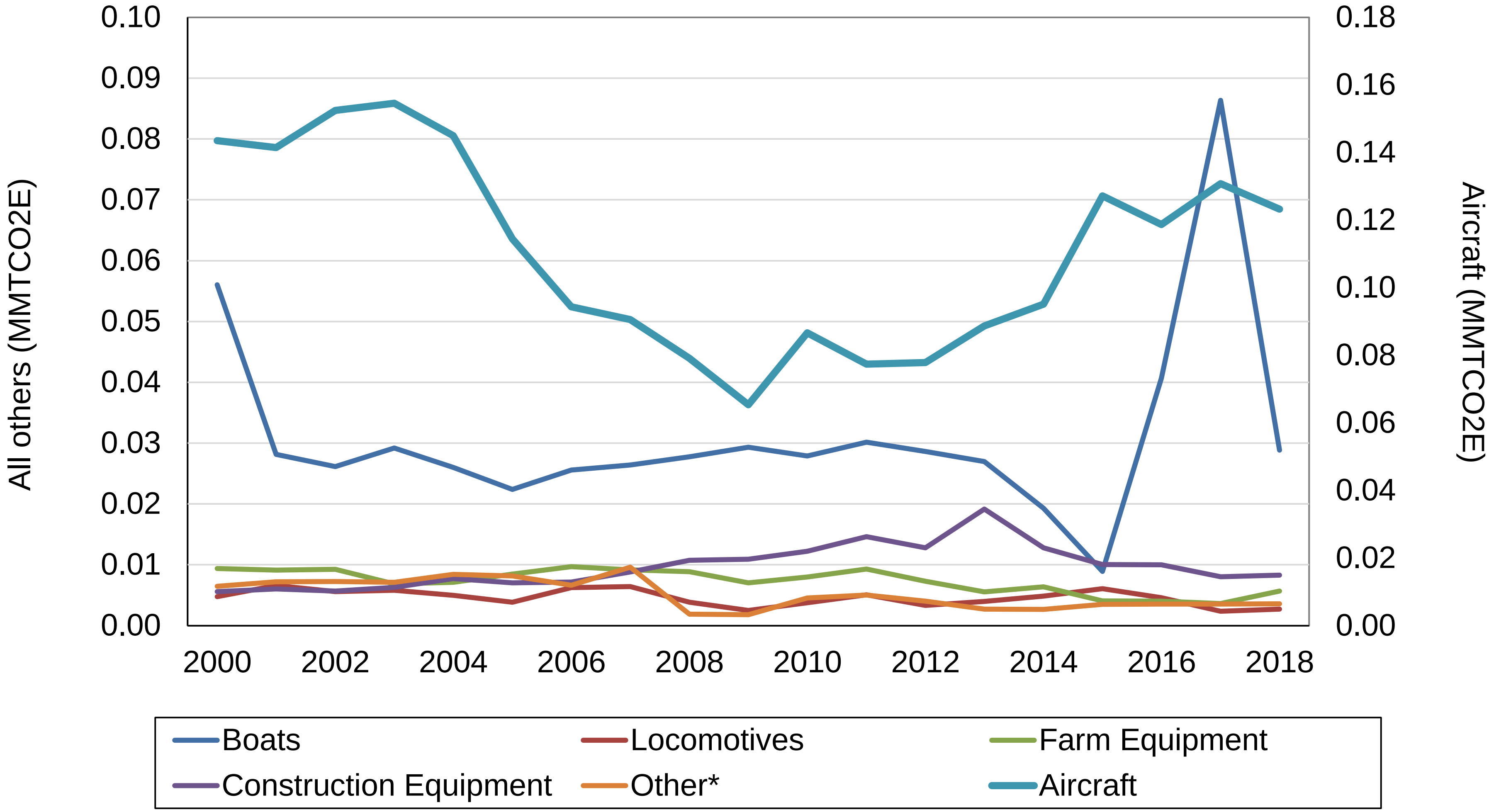
Louisiana non-highway emission trends (methane, nitrous oxide)

Non-highway transportation-related GHG emissions are dominated by the aircraft use which consistently increased since 2010.



Source: EIA SIT

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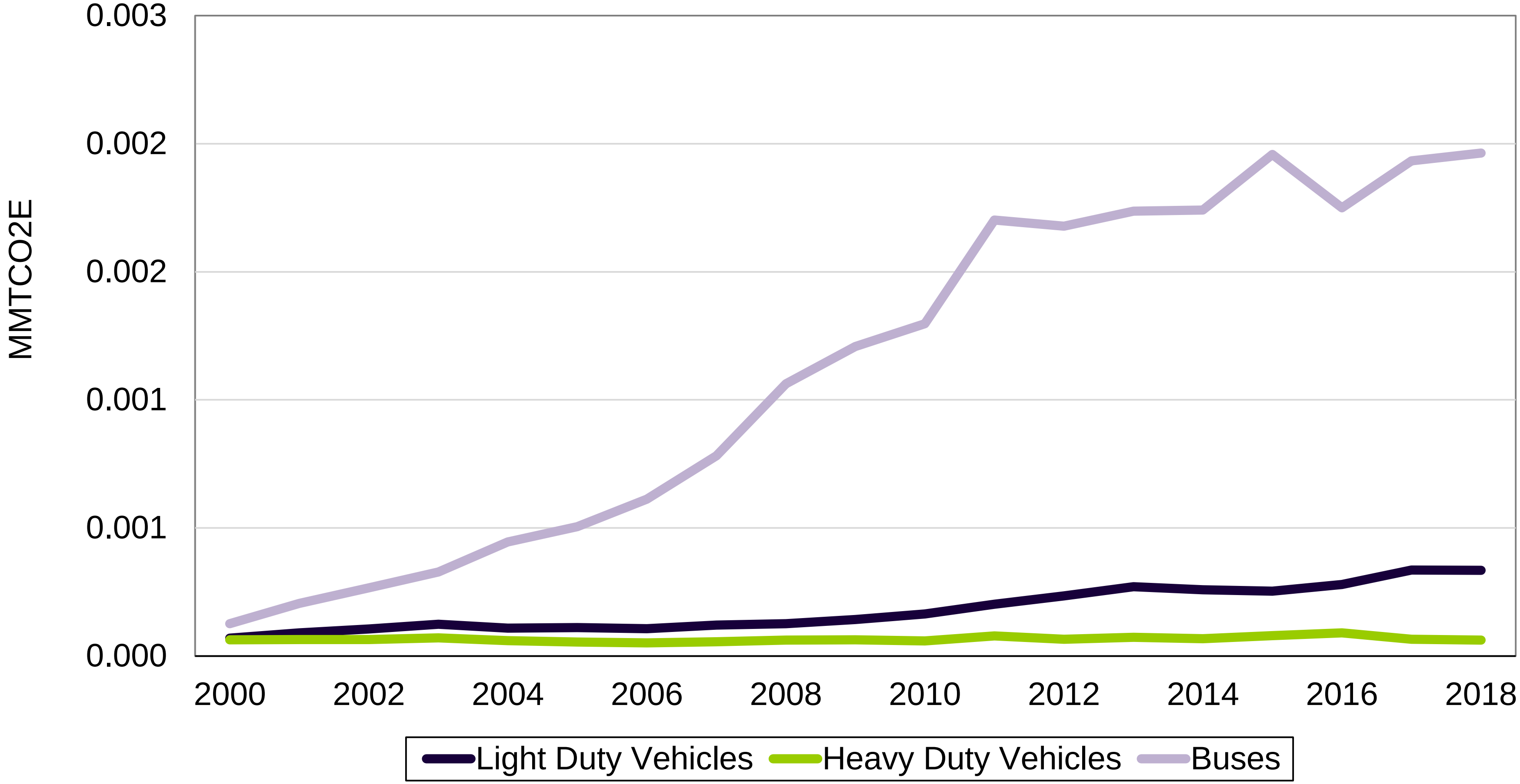
Louisiana alternative fueled vehicle trends (methane, nitrous oxide)

GHG emissions (CH_4 and N_2O) are increasing in the bus segment primarily due to many being converted to compressed natural gas ("CNG").



Source: EIA SIT

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Current mobile combustion shares

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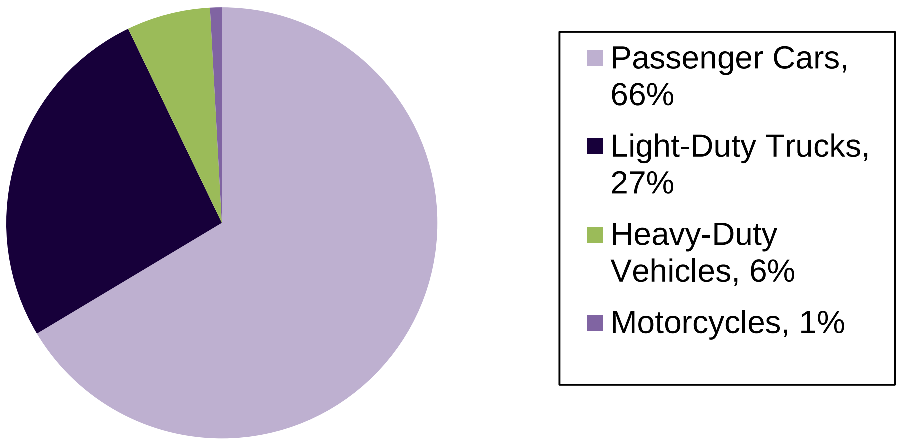
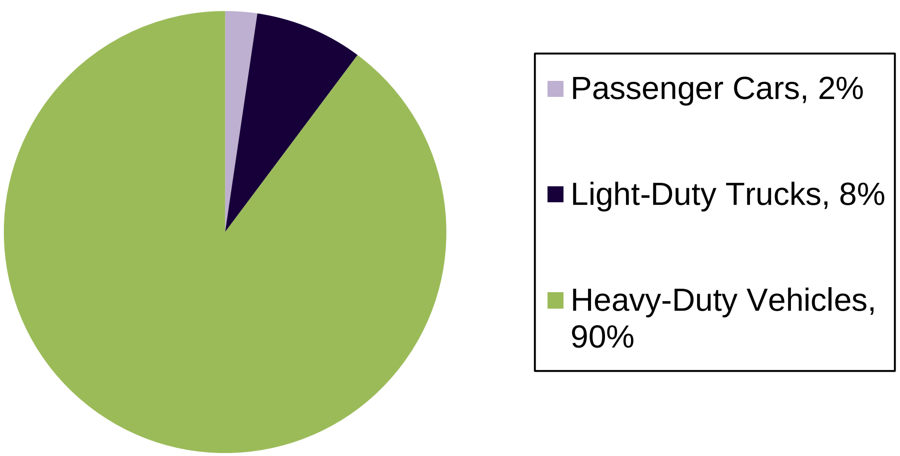
Louisiana gasoline, diesel, non-highway emission shares (2018; methane, nitrous oxide)

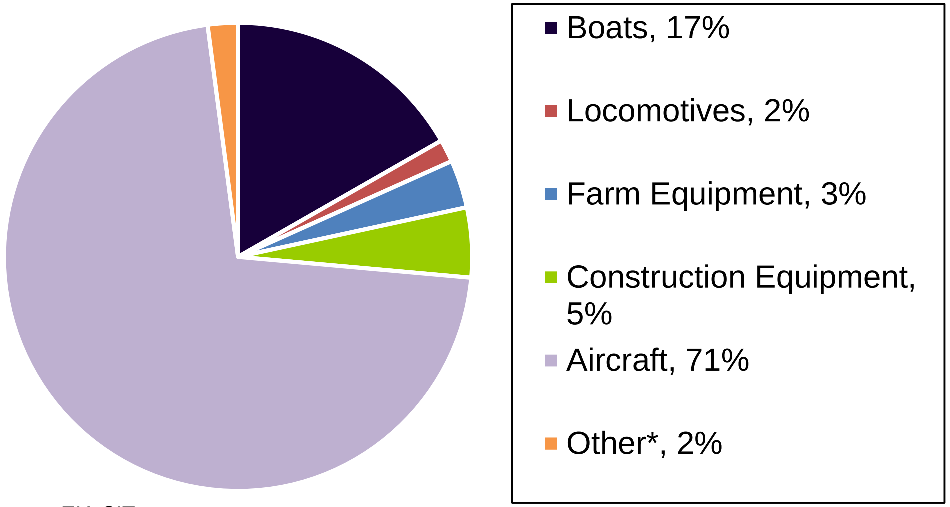
Gasoline Highway



Diesel Highway



Non-Highway



Source: EIA SIT

* "Other" includes snowmobiles, small gasoline powered utility equipment, heavy-duty gasoline powered utility equipment, and heavy-duty diesel powered utility equipment.

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2018 Summary Calculation: Mobile Combustion

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2018 Summary estimates

There are about 361,000 metric tons of transportation-related non-combustion GHG emissions that contribute to the Louisiana 2018 GHG inventory.

Class	2018 $MMTCO_2E$
Gasoline Highway	**0.183**
Passenger Cars	0.121
Light-Duty Trucks	0.048
Heavy-Duty Vehicles	0.011
Motorcycles	0.002
Diesel Highway	**0.003**
Passenger Cars	0.000
Light-Duty Trucks	0.000
Heavy-Duty Vehicles	0.003
Non-Highway	**0.172**
Boats	0.029
Locomotives	0.003
Farm Equipment	0.006
Construction Equipment	0.008
Aircraft	0.123
Other*	0.004
Alternative Fuel Vehicles	**0.002**
Light Duty Vehicles	0.000
Heavy Duty Vehicles	0.000
Buses	0.002
Total	**0.361**

Source: EIA SIT

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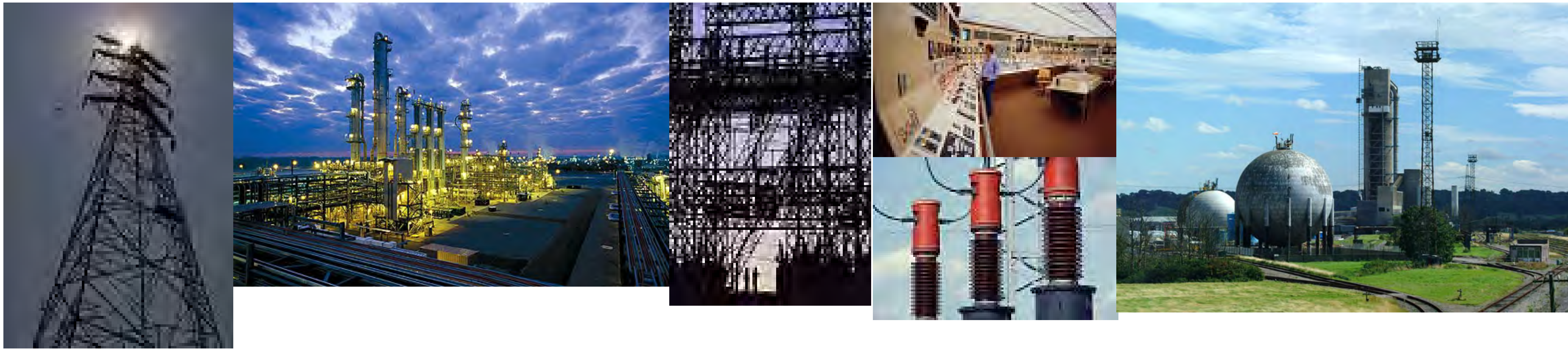

Louisiana 2021 GHG Inventory. Appendix 6: coal emissions estimates

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Coal Emissions

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- The EPA State Inventory Tool estimates GHG emissions from both coal combustion activities and from mining activities.
- The estimation of coal combustion GHG emissions takes place in the combustion of fossil fuels module.
- The coal module estimates methane (CH_4) emissions from mines and mining activities that include: underground mines; surface mines; and post-mining activity
- Louisiana does not have any underground mining activities. Some lignite is mined in the state from surface mines. This lignite is used for power generation purposes.

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Coal underground mining equation

Methane emissions from underground mines through subsurface activities and the ventilation supporting those activities. There are no underground mines in Louisiana.

Emissions ($MTCO_2E$) = {Measured Ventilation Emissions (million ft^3) + [Degasification System Emissions (million ft^3) – CH_4 Recovered from Degasification Systems and Used for Energy (million ft^3)]} × 18.92 g/ft^3 CH_4 × 10^6 ft^3/million ft^3 × 10^{-6} MT/g × 25 (GWP of CH_4)

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Coal underground mining calculation example

Coal Mining — 1990

☑ Default Activity Data?

Emissions from:	Coal Basin(s) (if applicable)	Measured Ventilation Emissions (million cubic feet)		Degasification System Emissions (mcf)		Methane Recovered from Degasification Systems and Used for Energy (mcf)		Emissions (mcf CH_4)		Emissions (MTCH_4)		Emissions (MTCO_2E)
Mines												
Underground Mines		0	+ (	0	-	0	) =	0.0000	=	-	=	-

	Coal Basin(s)	Surface Coal Production ('000 short tons)		Basin-specific EF (ft^3/short ton)		Emissions ('000 ft^3 CH_4)		Emissions (MTCH_4)		Emissions (MTCO_2E)
Surface Mines	West Interior Basin(Gulf Coast)	3,186	×	22.0	=	70,092	=	1,326	=	33,154
	---	0	×	0.0	=	---	=	---	=	---

	Coal Basin(s)	Coal Production ('000 short tons)		Basin- & Mine-specific EF (ft^3/short ton)		Emissions ('000 ft^3 CH_4)		Emissions (MTCH_4)		Emissions (MTCO_2E)
Post-Mining Activity										
Underground Mines	West Interior Basin(Gulf Coast)	0	×	41.6	=	-	=	-	=	-
	---	0	×	0.0	=	---	=	---	=	---
Surface Mines	West Interior Basin(Gulf Coast)	3,186	×	3.6	=	11,470	=	217	=	5,425
	---	0	×	0.0	=	---	=	---	=	---
Post-Mining Total						11,470	=	217	=	5,425

Total Coal Mining	(MTCO_2E)	**38,579**
	Underground Mines	-
	Surface Mines	33,154
	Post-Mining Activity	5,425

Coal surface mining equation

Methane emissions from surface mines are estimated from volumetric production originating at the strip mines. This is adjusted using a basin-specific adjustment factor that represents the quality of fuel. Note that lignite is a lower valued coal commodity and has a higher emissions factor than other types of coal.

Emissions ($MTCO_2E$) =

Surface Coal Production ('000 short tons) × Basin-Specific Emission Factor (ft^3/short ton) × 18.92 g/ft^3 CH_4 × 10^3 ft^3/'000 ft^3 × 10^{-6} MT/g × 25 (GWP of CH_4)

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Coal surface mining calculation example

Coal Mining — 1990

☑ Default Activity Data?

Emissions from:

Mines

	Coal Basin(s) (if applicable)	Measured Ventilation Emissions (million cubic feet)		Degasification System Emissions (mcf)		Methane Recovered from Degasification Systems and Used for Energy (mcf)		Emissions (mcf CH_4)		Emissions (MT CH_4)		Emissions (MT CO_2E)
Underground Mines		0	+ (	0	-	0	) =	0.0000	=	-	=	-

	Coal Basin(s)	Surface Coal Production ('000 short tons)		Basin-specific EF (ft^3/short ton)		Emissions ('000 ft^3 CH_4)		Emissions (MT CH_4)		Emissions (MT CO_2E)
Surface Mines	West Interior Basin(Gulf Coast)	3,186	×	22.0	=	70,092	=	1,326	=	33,154
	---	0	×	0.0	=	---	=	---	=	---

Post-Mining Activity

	Coal Basin(s)	Coal Production ('000 short tons)		Basin- & Mine-specific EF (ft^3/short ton)		Emissions ('000 ft^3 CH_4)		Emissions (MT CH_4)		Emissions (MT CO_2E)
Underground Mines	West Interior Basin(Gulf Coast)	0	×	41.6	=	-	=	-	=	-
	---	0	×	0.0	=	---	=	---	=	---
Surface Mines	West Interior Basin(Gulf Coast)	3,186	×	3.6	=	11,470	=	217	=	5,425
	---	0	×	0.0	=	---	=	---	=	---
Post-Mining Total						11,470	=	217	=	5,425

Total Coal Mining	(MT CO_2E)	38,579
	Underground Mines	-
	Surface Mines	33,154
	Post-Mining Activity	5,425

Coal post-mining activities equation

Methane emissions from post-mining activities are also included. These emissions are also a function of production and the quality of mined coal.

Emissions ($MTCO_2E$) =
Coal Production ('000 short tons) × Basin- and Mine-Specific Emission Factor (ft^3/short ton) × 18.92 g/ft^3 CH_4 × 10^3 ft^3/'000 ft^3 × 10^{-6} MT/g × 25 (GWP of CH_4)

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Coal post-mining calculation example

Coal Mining — 1990

☑ Default Activity Data?

Emissions from:

Mines

	Coal Basin(s) (if applicable)	Measured Ventilation Emissions (million cubic feet)		Degasification System Emissions (mcf)		Methane Recovered from Degasification Systems and Used for Energy (mcf)		Emissions (mcf CH_4)		Emissions (MTCH$_4$)		Emissions (MTCO$_2$E)
Underground Mines		0	+ (	0	-	0	) =	0.0000	=	-	=	-

	Coal Basin(s)	Surface Coal Production ('000 short tons)		Basin-specific EF (ft^3/short ton)		Emissions ('000 ft^3 CH_4)		Emissions (MTCH$_4$)		Emissions (MTCO$_2$E)
Surface Mines	West Interior Basin(Gulf Coast)	3,186	×	22.0	=	70,092	=	1,326	=	33,154
	---	0	×	0.0	=	---	=	---	=	---

Post-Mining Activity

	Coal Basin(s)	Coal Production ('000 short tons)		Basin- & Mine-specific EF (ft^3/short ton)		Emissions ('000 ft^3 CH_4)		Emissions (MTCH$_4$)		Emissions (MTCO$_2$E)
Underground Mines	West Interior Basin(Gulf Coast)	0	×	41.6	=	-	=	-	=	-
	---	0	×	0.0	=	---	=	---	=	---
Surface Mines	West Interior Basin(Gulf Coast)	3,186	×	3.6	=	11,470	=	217	=	5,425
	---	0	×	0.0	=	---	=	---	=	---
Post-Mining Total						11,470	=	217	=	5,425

Total Coal Mining	(MTCO$_2$E)	**38,579**
	Underground Mines	-
	Surface Mines	33,154
	Post-Mining Activity	5,425

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CH_4 from abandoned coal mines

Abandoned coal mines depending on how they are capped produce CH_4 emissions

Equation 4: Emissions from Abandoned Mines

$$\text{Vented:}\quad q = qi \times (1 + aT)^b$$
$$\text{Sealed:}\quad q = qi \times (1-c)*(1 + aT)^b$$
$$\text{Flooded:}\quad q = qi \times e^{(-DT)}$$

Where,

q = current emission rate, m^3/yr
qi = emission rate at abandonment, m^3/yr
a = constant unique to each decline curve
b = constant unique to each decline curve
T = time since abandonment, yr
c = degree of sealing of the mine (50%, 80%, or 95%)
D = decline rate, fraction per year (given as -0.672)

CH4 from abandoned coal mines

Note: No abandoned coal mine data for Louisiana

Abandoned Coal Mines

Please click the button on the left to view a default list of abandoned coal mines within you

☑ Default mine status?
☑ Default percent sealed?

Mine Name	County	Basin	Year Abandoned	Reported Status	Actual Status	Percent Sealed	Methane Recovered (m^3/yr)

Additional Abandoned Coal Mines

	Mine Name	County	Coal Rank	Year Abandoned	Status	Percent Sealed	Active Emissions (mmcfd)	Methane Recovered (m^3/yr)
1.								
2.								
3.								
4.								
5.								
6.								
7.								

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Coal Emission Trends

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Louisiana coal surface mines 2018 data

Mine Name	Company Name	Type	Production (Short tons)
Dolet Hills Lignite Company	Dolet Hills Lignite Company Ll	Surface	1,275,631
Five Forks Mine	Demery Resources Company	Surface	207,610

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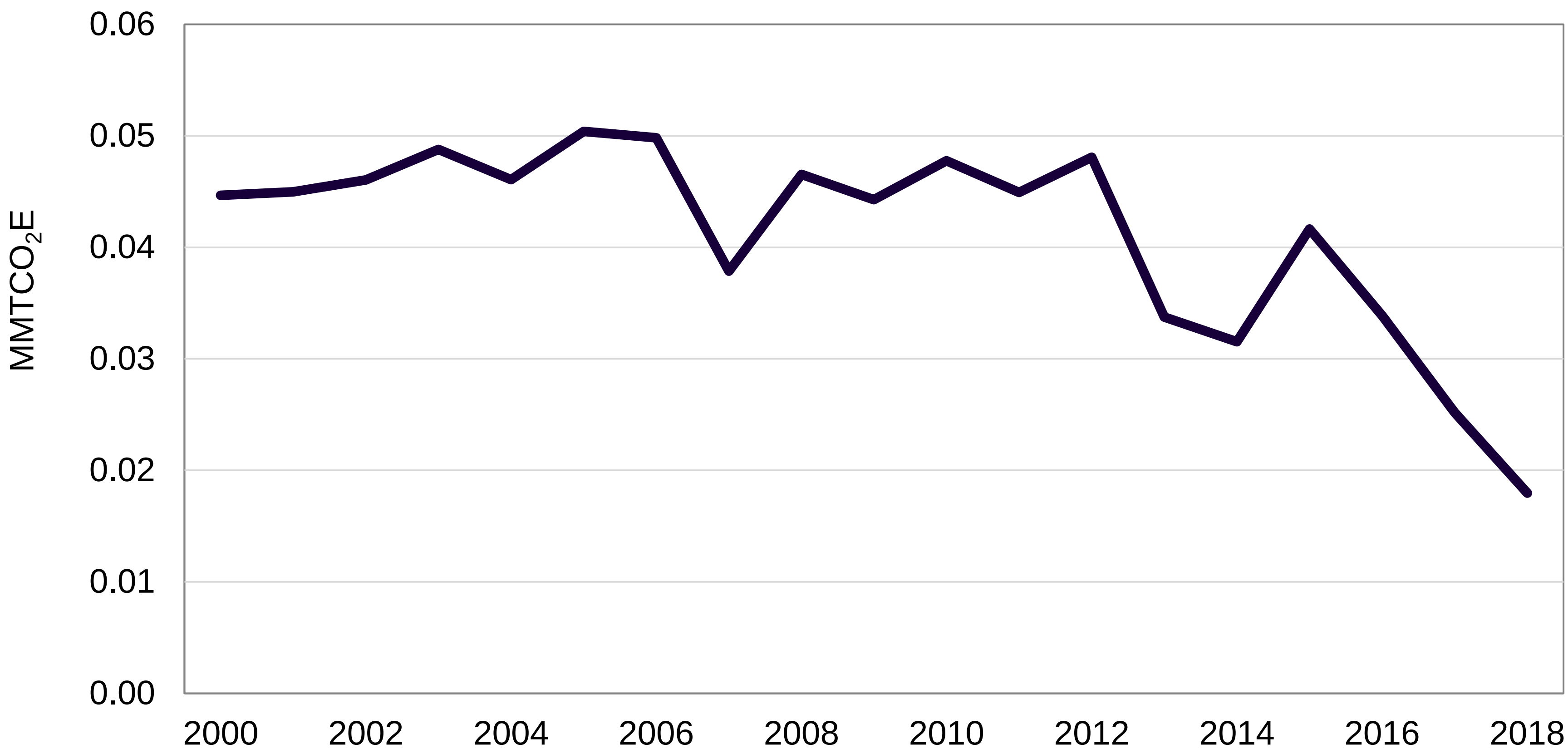
Louisiana total coal mining GHG emissions

Louisiana coal mining trends, in total, are dominated by surface mining activities and, as noted earlier, these have been falling as lignite use has fallen.



Source: EIA

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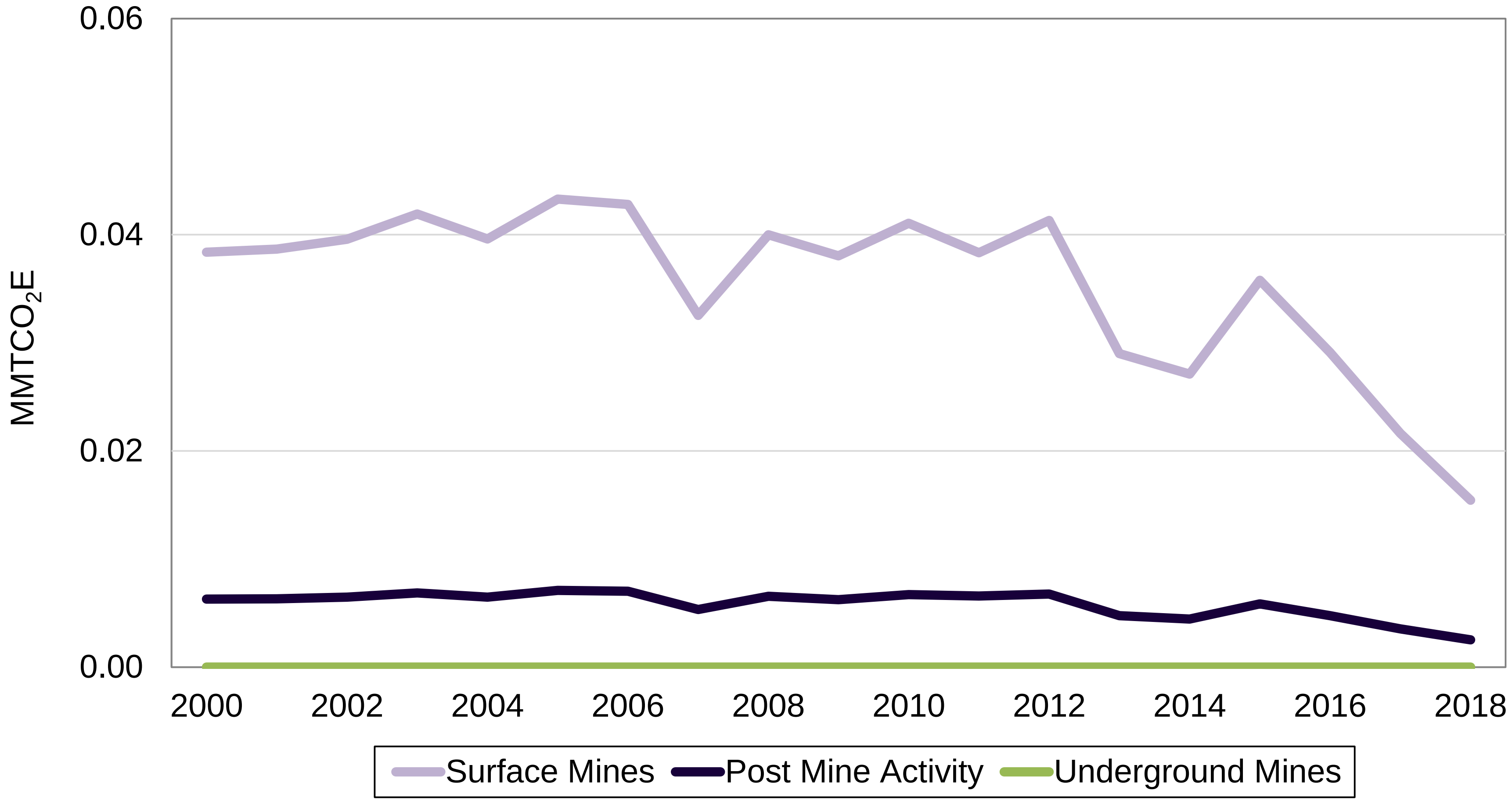
Louisiana coal mining GHG emissions by activity

Methane emissions from coal mining activities in Louisiana are restricted to surface mining activities. Overall methane emissions are down as lignite use falls.



Source: EIA

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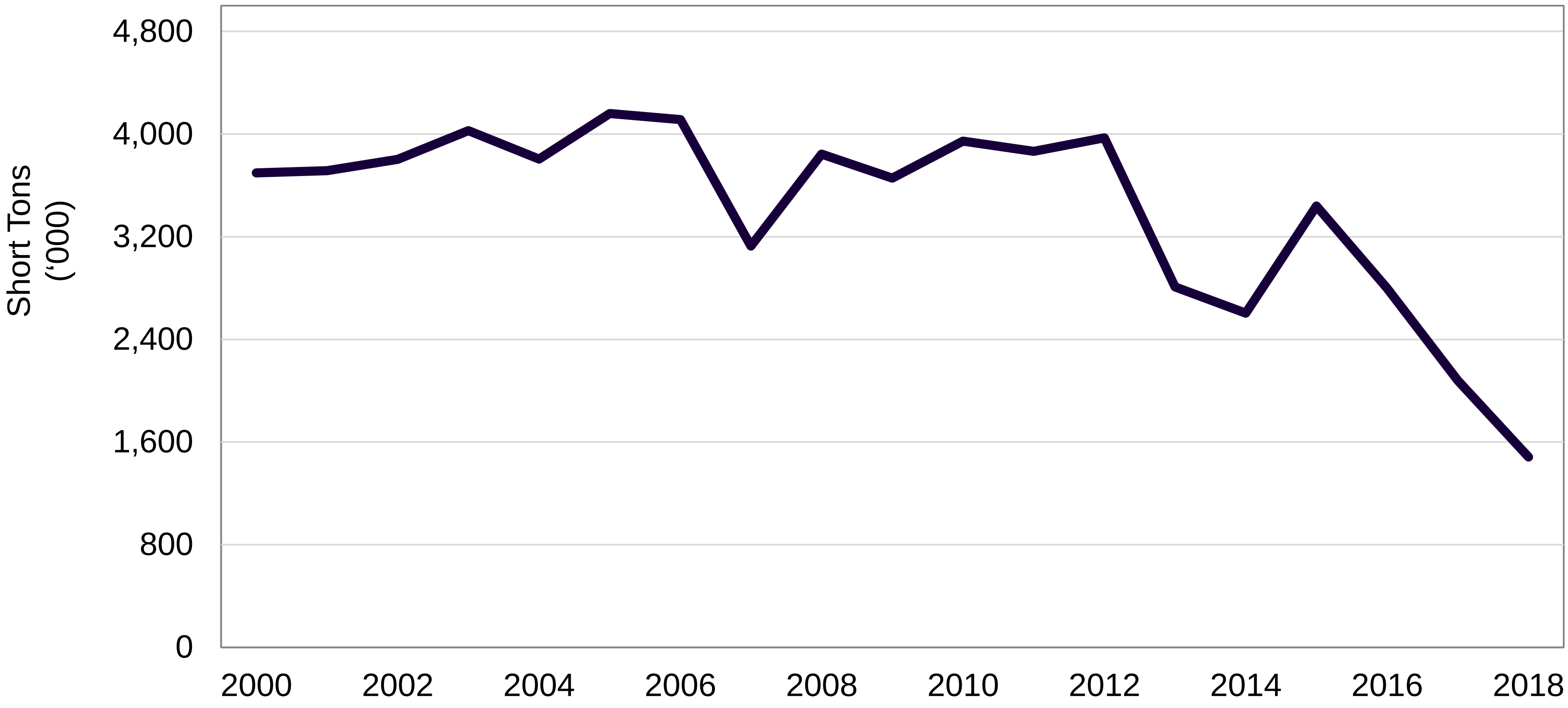
Louisiana coal mining activities

Louisiana coal production comes from surface mines. There has been significant decrease in production since 2000.



Source: EIA and US Mine Safety and Health Administration

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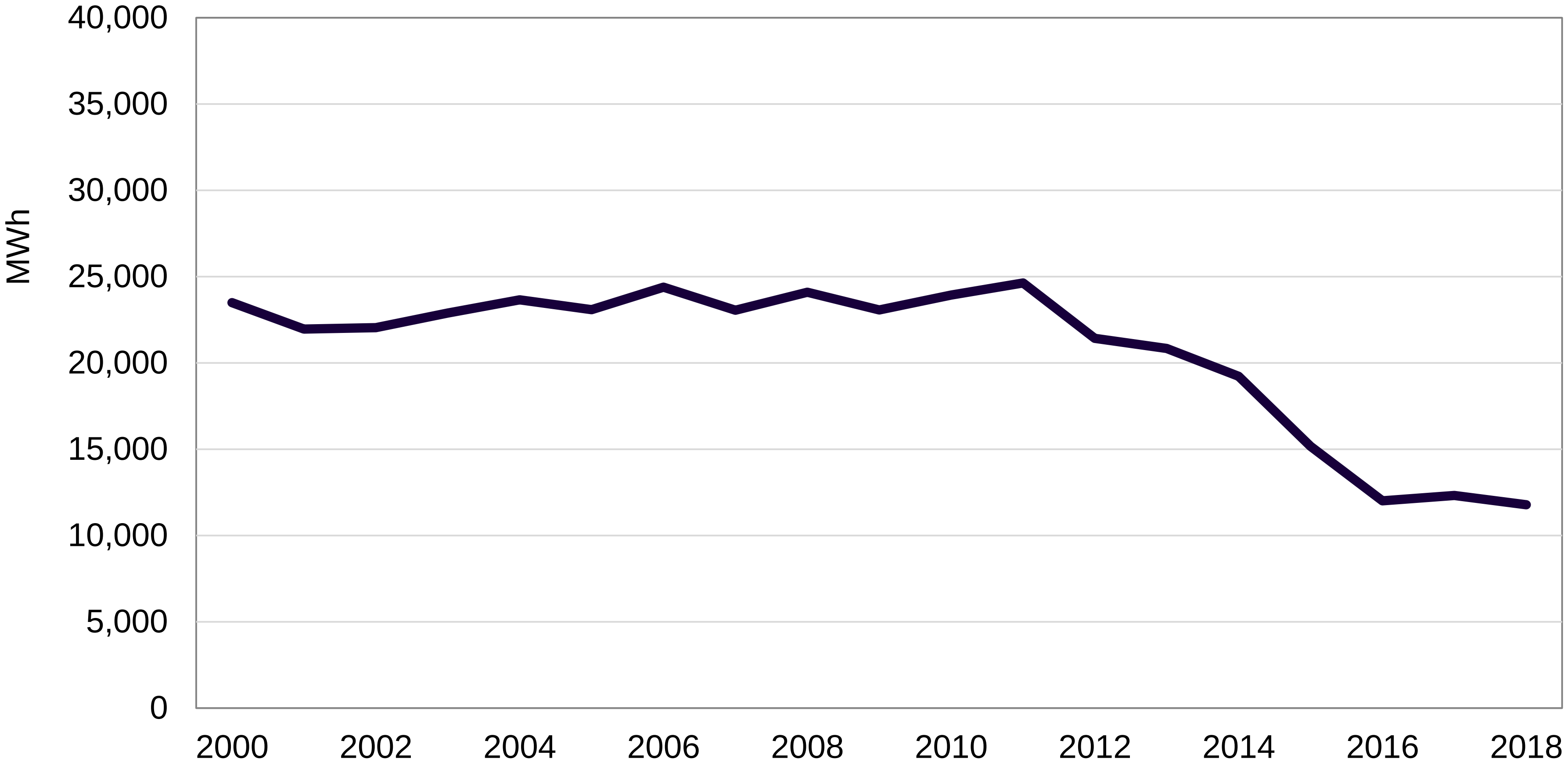
Louisiana coal-fired power generation

Coal generation has been decreasing since 2010



Source: EIA-923

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Coal Emission Shares

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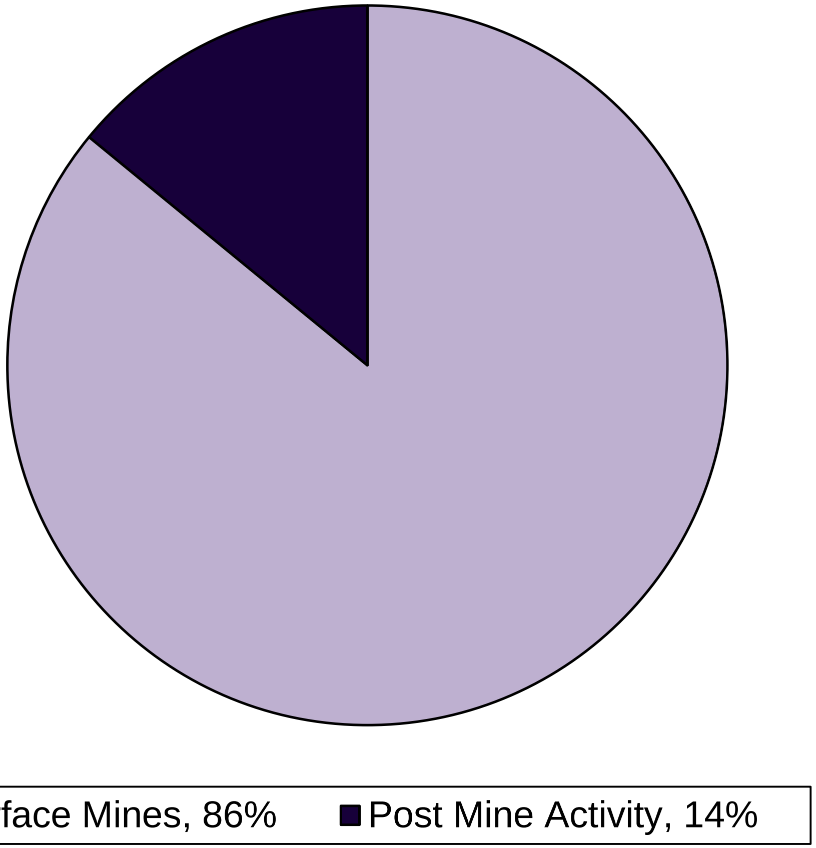
Louisiana coal mining GHG emission shares

Louisiana coal mining GHG emissions originate from the state's surface mining activities.



Source: EIA

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2018 Summary Calculations: Coal Emissions

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2018 Summary estimates

Louisiana's 2018 inventory of GHG emissions for the coal mining sector is significantly less than one million metric tons (0.018 million metric tons).

Sector	2018 $MMTCO_2E$
Coal Mining	
CH4	0.018

Source: EIA

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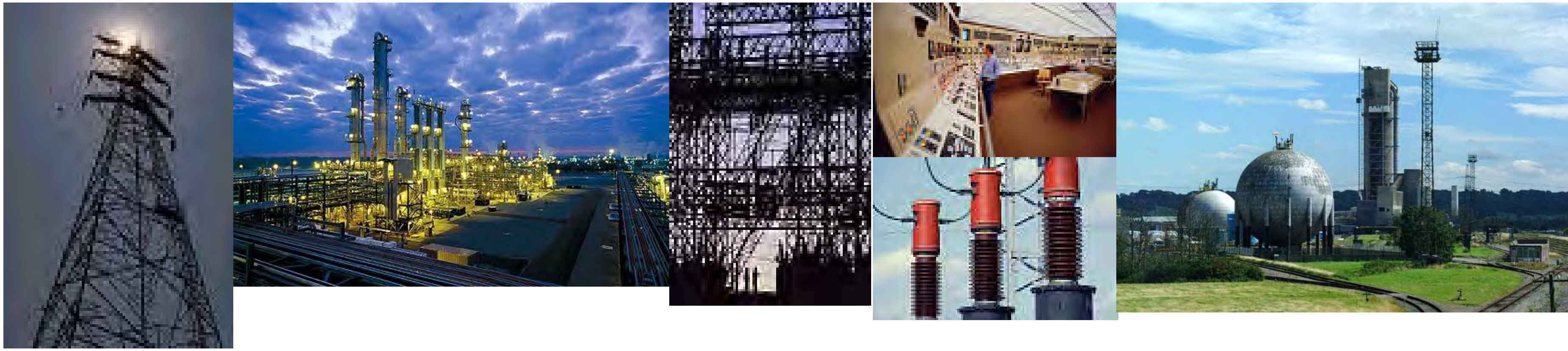

Louisiana 2021 GHG Inventory. Appendix 7: Natural gas and oil systems emissions estimates.

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

GHG emissions:
Natural Gas & Oil Systems

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Definition of natural gas and oil systems

- The natural gas and oil systems module estimates both carbon dioxide (CO_2) and methane (CH_4) emissions from the entire oil and gas sector.
- This module estimates emissions from: (a) onshore and offshore natural gas and oil production and emissions from flaring at both types of production facilities; (b) transportation, storage, processing and export facilities (i.e., liquified natural gas or “LNG”); (c) distribution, and (d) refining activities.

Source: User Guide for Natural Gas and Oil Systems

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Natural gas systems emissions estimation equation

Natural gas systems emissions are developed using activity data (typically wells, or compression units, etc.) times a methane emissions factor which is converted to a carbon dioxide equivalent.

Emissions ($MMTCO_2E$) =
Activity Data × Emission Factor (MT CH_4/unit activity data) × 25 (GWP)

Source: User Guide for Natural Gas and Oil Systems

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Natural gas production emissions estimation example

Natural Gas - Production 1990 ☑ Default Activity Data

	Activity Data		Emission Factor metric tons CH_4 per year per activity unit		Metric Tons CH_4		$MMTCO_2E$
Total number of wells	16,889	x	10.69	=	180,543	=	4.51
Number of shallow water off-shore platforms in the Gulf of Mexico and Pacific		x	8899.00	=	-	=	-
Number of deepwater off-shore platforms in the Gulf of Mexico and Pacific		x	93836.00	=	-	=	-
Total					**180,543**	=	**4.51**

GHG emissions from Louisiana natural gas production are determined by the number of wells and a emission factor – onshore and offshore wells are differentiated.

Source: User Guide for Natural Gas and Oil Systems

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Natural gas transmission emissions estimation example

Gas Transmission Compressor Stations/Mile of Transmission Pipeline	0.0060	Gas Storage Compressor Stations/Mile of Transmission Pipeline	0.0015

Natural Gas - Transmission 1990

☑ Check if you don't have data for gas transmission and storage compressor stations.

		Activity Data		Emission Factor metric tons CH_4 per year per activity unit		Metric Tons CH_4		$MMTCO_2E$
Miles of gathering pipeline	-->		x	0.4	=	-	=	-
Number of gas processing plants	-->		x	1250.0	=	-	=	-
Number of LNG storage compressor stations	-->		x	1185.0	=	-	=	-
Miles of transmission pipeline	-->		x	0.6	=	-	=	-
Number of gas transmission compressor stations		-	x	983.7	=	-	=	-
Number of gas storage compressor stations		-	x	964.2	=	-	=	-
Total						-	=	-

GHG emissions from Louisiana natural gas “midstream” activities are a function of gathering and transmission lines, gas processing facilities, LNG and pipeline compression, and underground storage compression.

Source: User Guide for Natural Gas and Oil Systems

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Natural gas distribution emissions estimation example

Natural Gas - Distribution 1990

☑ Check here if you wish to use the alternative method

		Activity Data		Emission Factor (metric tons CH_4 per year per activity unit)		Metric Tons CH_4		MMTCO$_2$E
Distribution pipeline								
Preferred Method								
Miles of cast iron distribution pipeline			x	5.80	=	-	=	-
Miles of unprotected steel distribution pipeline			x	2.12	=	-	=	-
Miles of protected steel distribution pipeline			x	0.06	=	-	=	-
Miles of plastic distribution pipeline			x	0.37	=	-	=	-
Alternate Method								
Total miles of distribution pipeline	-->		x	0.54	=	-	=	-
Services								
Total number of services	-->		x	0.02	=	-	=	-
Number of unprotected steel services	-->		x	0.03	=	-	=	-
Number of protected steel services	-->		x	0.00	=	-	=	-
Total						-	=	-

GHG emissions from Louisiana natural gas distribution systems are function of facilities materials (mains composition) and number of service lines.

Source: User Guide for Natural Gas and Oil Systems

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Natural gas venting and flaring emissions estimation equation

GHG emissions from natural gas production is taking from activity data and conversion factors which is converted to a carbon dioxide equivalent.

$$\textbf{Emissions } (MMTCO_2E) = \textbf{Activity Data } (BBtu) \times \textbf{Emission Factor } (MT\ CO_2/BBtu) \times \%\ \textbf{flared} \div 10^6\ (MT/MMT)$$

Source: User Guide for Natural Gas and Oil Systems

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Natural gas venting and flaring estimation example

Natural gas producers report vented and flared natural gas at the state level in volumetric terms. These are converted to GHG emissions through an EPA defined emissions factor.

Natural Gas - Vented and Flared   1990   ☑ Default Activity Data

	Activity Data (Billion BTU)		Emission Factor (metric tons CO_2 per year billion BTU)		Metric Tons CO_2		Percent Flared		$MMTCO_2E$
Natural Gas Vented and Flared	22,829	x	54.71	=	1,248,991	x	80%	=	1.00
Total									

Source: User Guide for Natural Gas and Oil Systems

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Petroleum systems emissions estimation equation

Petroleum (crude oil and liquids) emissions are determined by activity (production, transportation, refining). Note these emissions are estimated across the entire value chain (upstream to downstream).

Emissions ($MMTCO_2E$) =
Activity Data (‘000 barrels) × Emission Factor (kg CH_4/’000 barrels) ÷ 1,000 (kg/MT) × 25 (GWP) ÷ 10^6 (MT/MMT)

Source: User Guide for Natural Gas and Oil Systems

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Petroleum systems estimation example

Petroleum Systems 1990

☑ Default Activity Data

	Activity Data '000 barrels		Emission Factor kg CH_4 per year per 1000 bbl		Metric Tons CH_4		$MMTCO_2E$
Oil Production	147,582	x	629.32	=	92,877	=	2.32
Oil Refining		x	5.55	=	-	=	-
Oil Transportation		x	3.67	=	-	=	-
Total					**92,877**		**2.32**

Source: User Guide for Natural Gas and Oil Systems

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Estimated natural gas oil system trends

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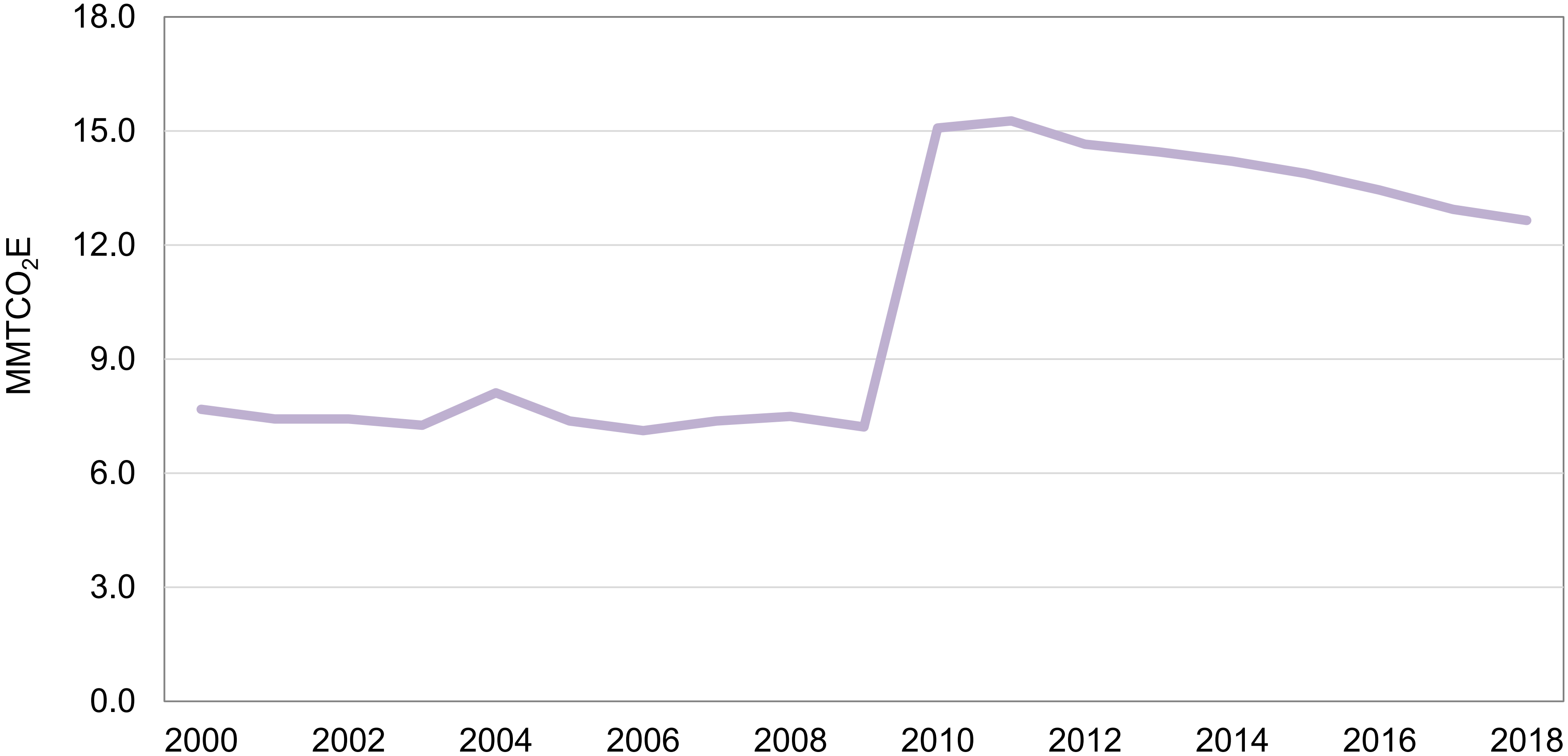
Louisiana total emissions from natural gas and oil activities.

Louisiana oil and gas GHG emissions have been falling since 2010.



Source: EIA SIT, PHMSA

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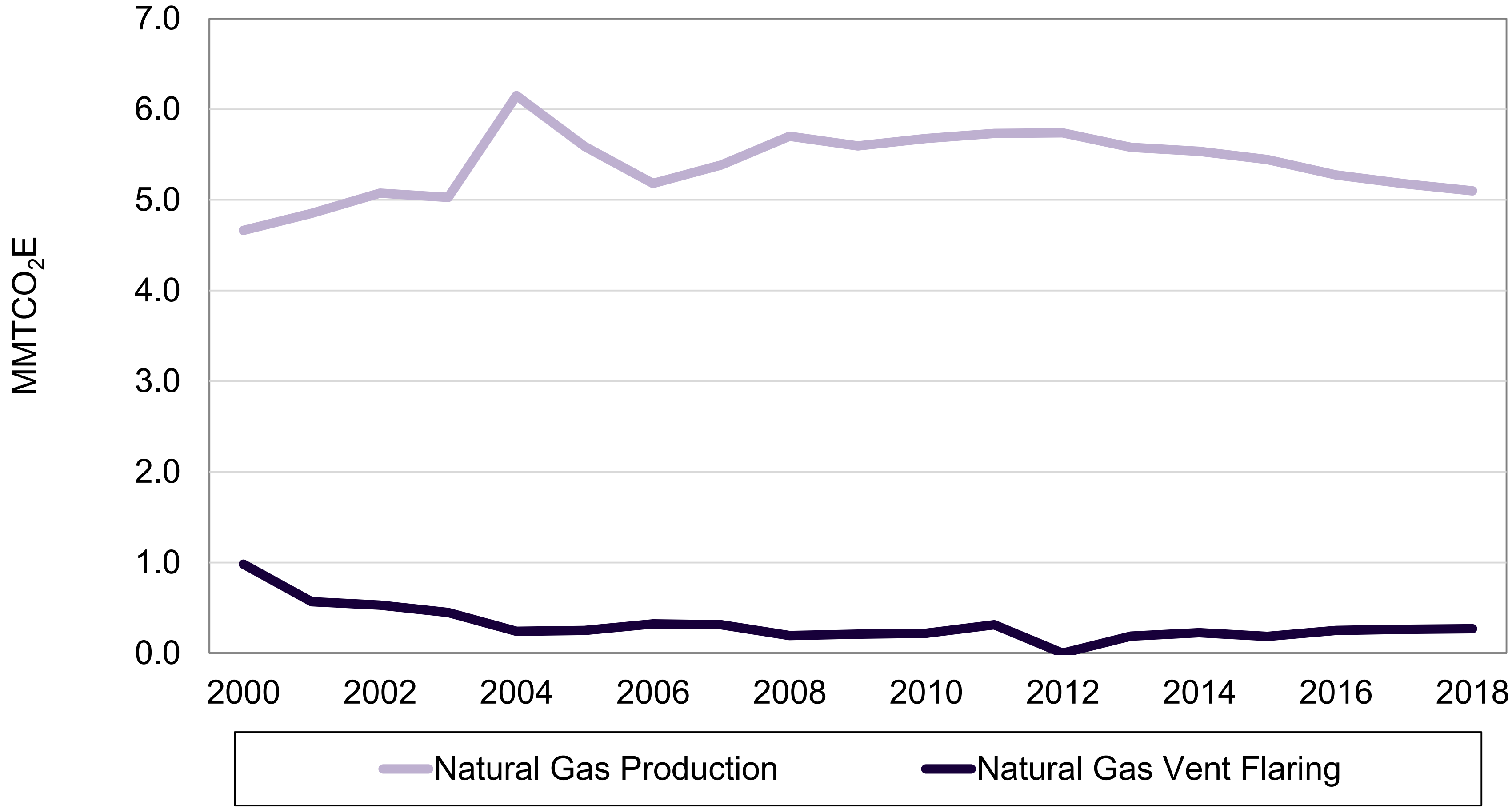
Louisiana production and venting emissions

Methane emission associated with oil and gas production have been down. Flaring related emissions, while relatively low, are flat.



Source: EIA SIT, PHMSA

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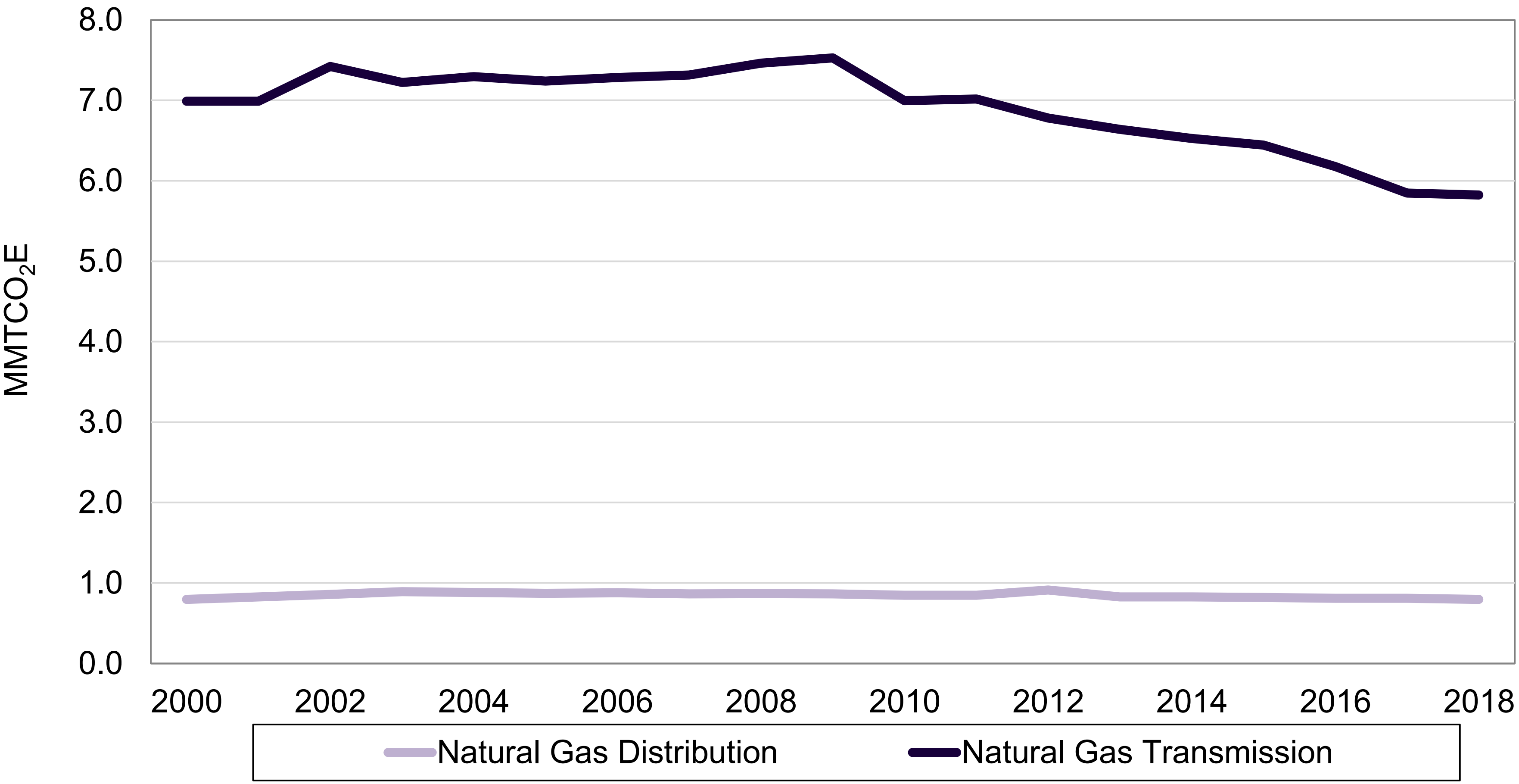
Louisiana natural gas distribution and transmission

Natural gas transmission emissions are down as newer pipe, with higher quality pipe materials are added and older pipe is retired. Gas distribution emissions are relatively constant.



Source: EIA SIT, PHMSA

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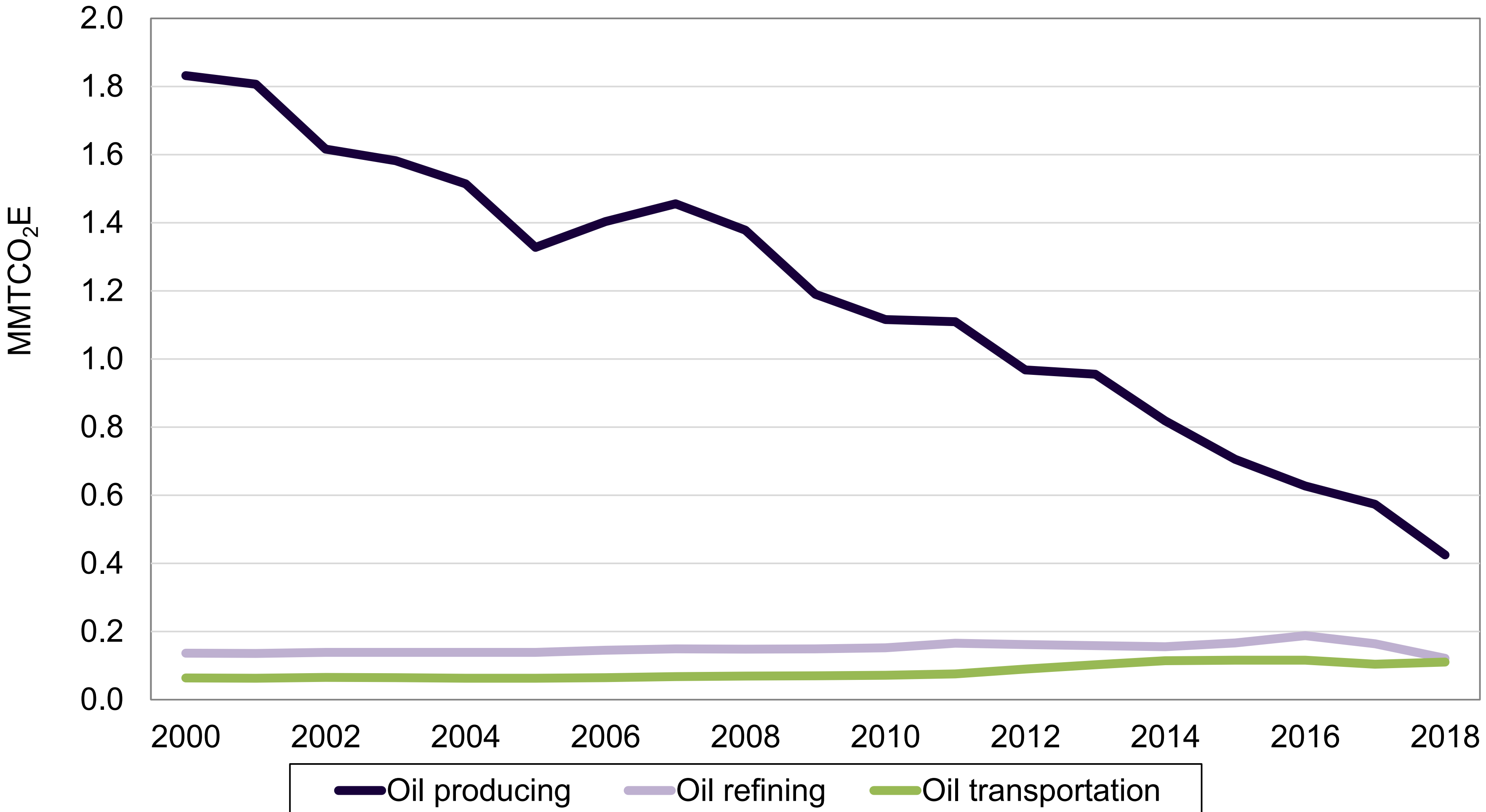
Louisiana petroleum

Oil production related emissions are falling as oil production falls. Refining (non-combustion emissions) and transportation emissions are relatively flat.



Source: EIA SIT, PHMSA

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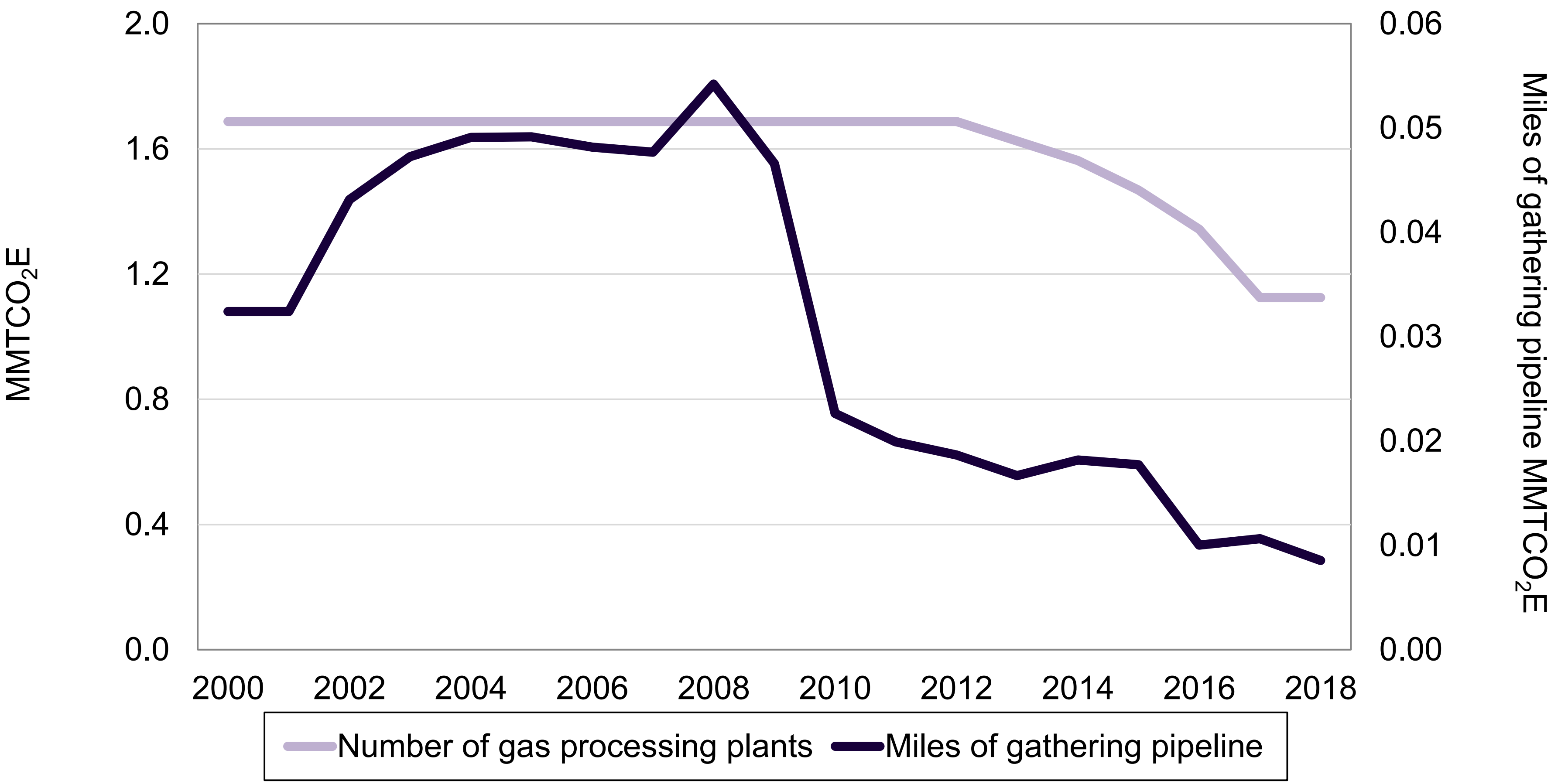
Gathering pipeline and gas processing plants

Midstream emissions have been falling given decreasing utilization (processing) and gathering line mileages in mature areas of the state particularly in south Louisiana, state waters, and OCS production.



Source: EIA SIT, PHMSA

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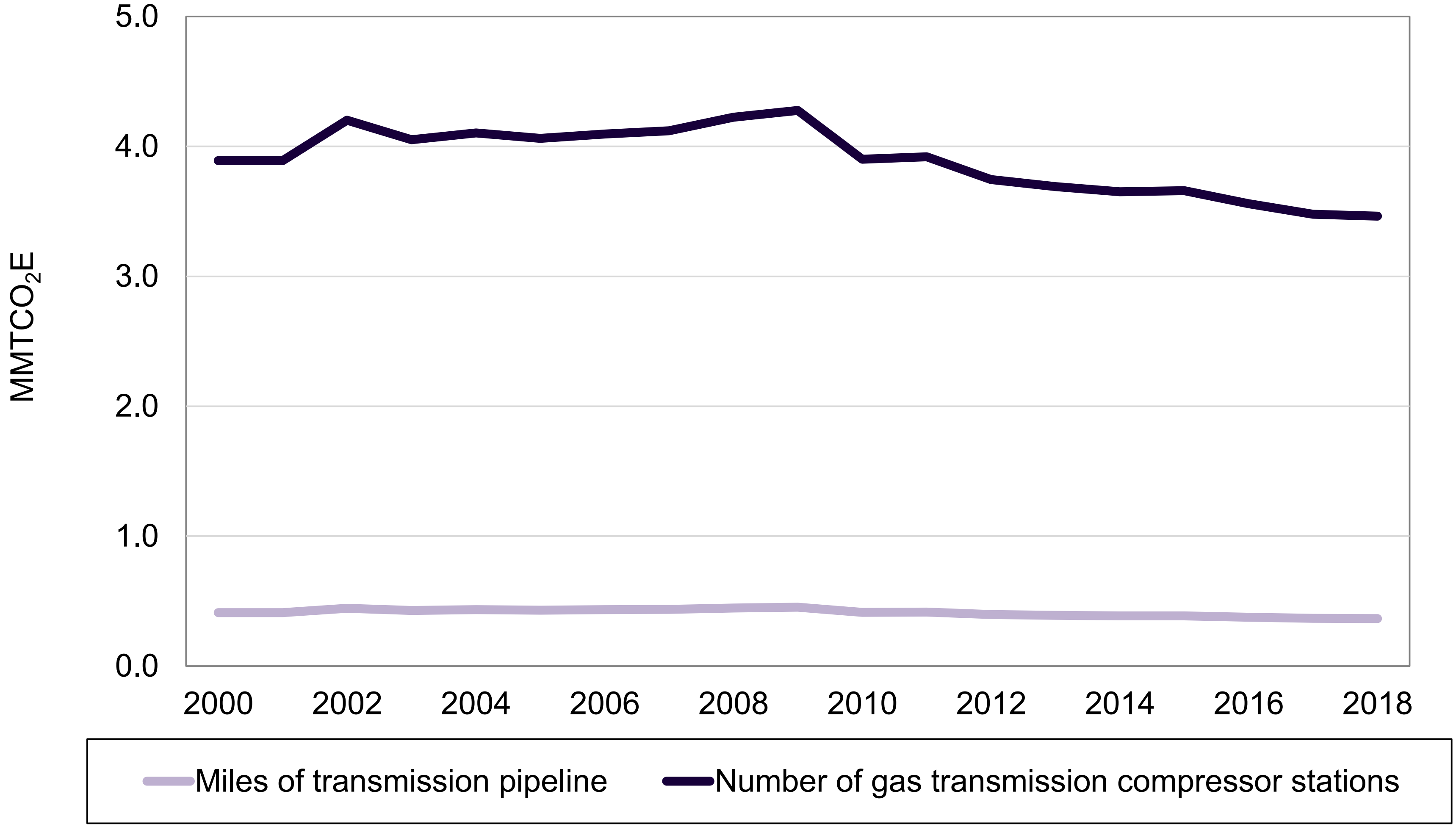
Transmission pipeline and compressor stations

Transmission line emissions are down, compression emissions are flat.



Source: EIA SIT, PHMSA

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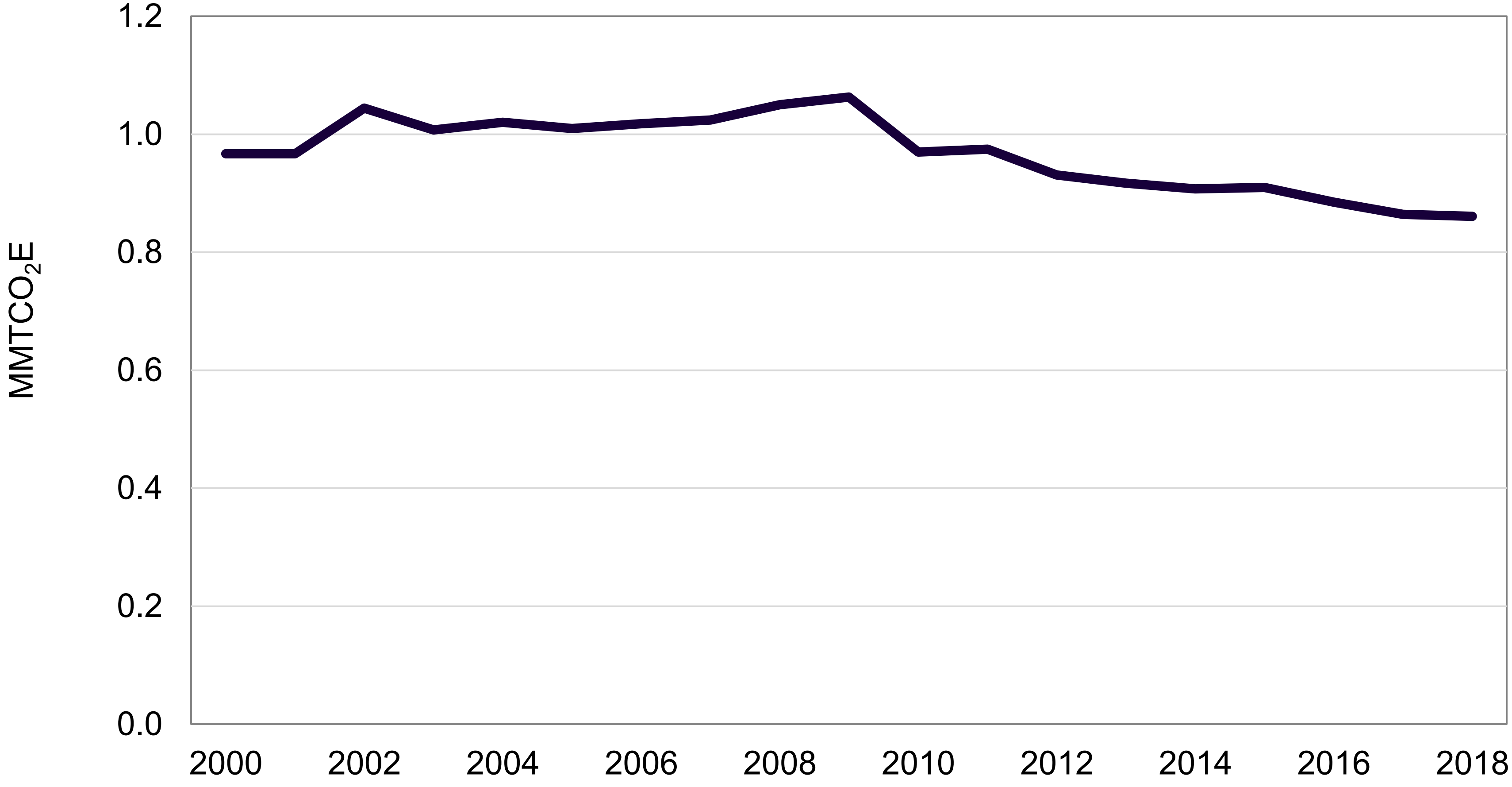
Gas storage compressor stations

Underground storage related emissions are down considerably as compressor station utilization decreases.



Source: EIA SIT, PHMSA

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Current natural gas oil system shares

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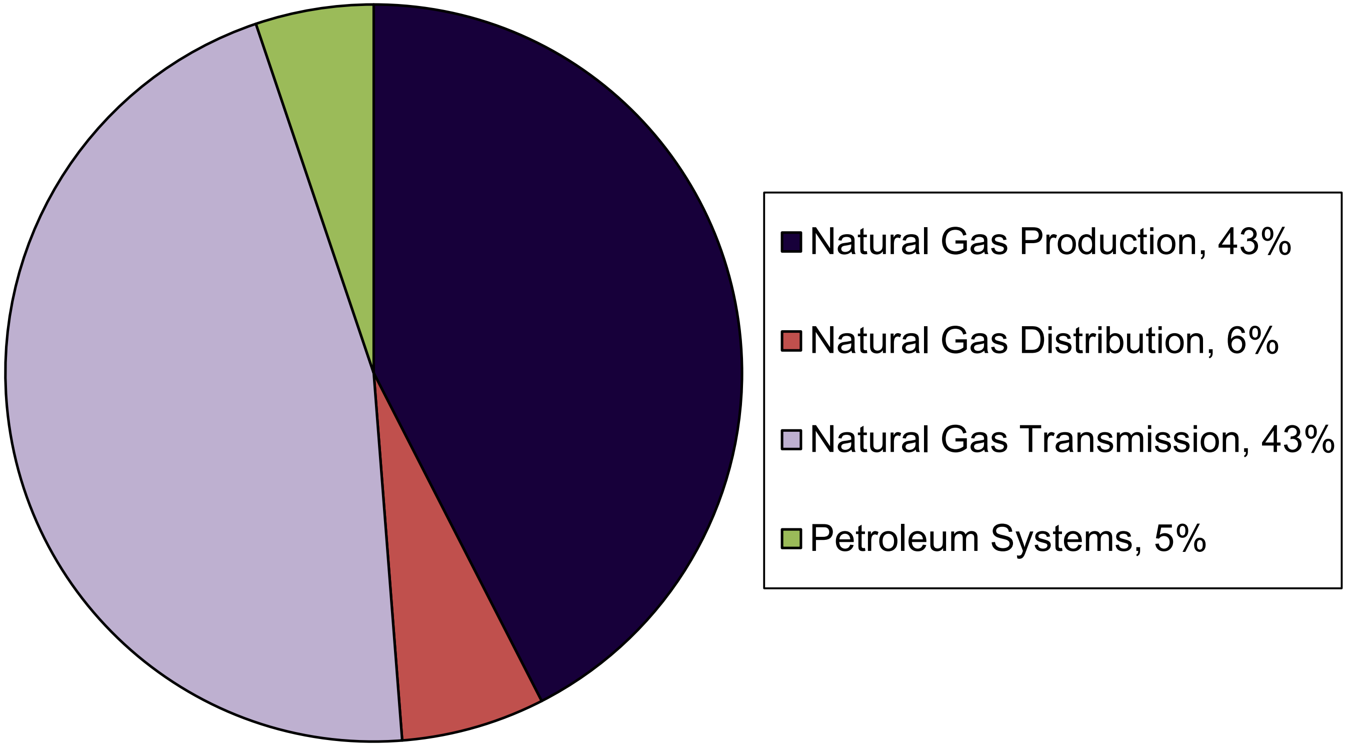
Louisiana GHG emission shares, 2018 natural gas and petroleum

Most oil and gas emissions are concentrated in the upstream and midstream portions of the industry which differs from national averages where distribution level emissions are typically relatively higher.



* "Other" includes snowmobiles, small gasoline powered utility equipment, heavy-duty gasoline powered utility equipment, and heavy-duty diesel powered utility equipment.
Source: EIA SIT, PHMSA

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2018 Summary Calculation: Natural gas and crude oil systems

2018 Summary estimates

Louisiana oil and gas emissions contribute 12.6 million metric tons to the state's 2018 GHG inventory.

Sector	2018 $MMTCO_2E$
Natural Gas Production	5.37
Natural Gas Transmission	5.82
Natural Gas Distribution	0.80
Petroleum Systems	0.66
Total	**12.646**

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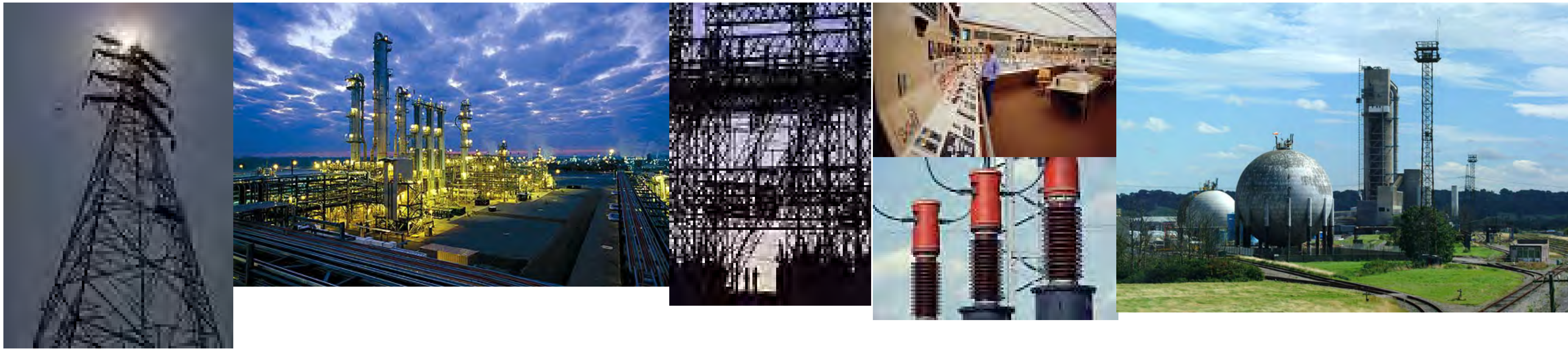

Louisiana 2021 GHG Inventory. Appendix 8: wastewater systems emissions estimates.

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

GHG emissions: Wastewater

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- The wastewater model calculates CH_4 and N_2O emissions from the treatment of municipal and industrial wastewater.
- The process of disposing or treating wastewater can result in CH_4 emissions
- N_2O is released from organic matter through natural processes such as nitrification through anerobic and aerobic processes

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Municipal wastewater CH_4 emissions estimation equation

CH4 emissions from the treatment of municipal wastewater are derived from state populations and factors of treatment and emissions factors to get total emissions

Equation 1. CH_4 Emissions from Municipal Wastewater Treatment

CH_4 Emissions ($MMTCO_2E$) =
State Population × BOD_5 Production (kg/day) × 365 days/year × 0.001 (metric ton/kg) × Fraction Treated Anaerobically × Emission Factor (Gg CH_4/Gg BOD_5) × 10^{-6} (MMT/metric ton) × 25 (GWP)

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Municipal wastewater CH_4 emissions estimation example

	State Population		Per Capita BOD_5 (kg/day)		Days per Year (days)		Unit Conversion (metric tons/kg)		Emission Factor (Gg CH_4/Gg BOD_5)		WW BOD_5 anaerobically digested (percent)		Emissions (metric tons CH_4)		CH_4 GWP (CO_2 Eq.)		Unit Conversion (MMT/MT)		C/CO_2		Emissions (MMTCE)		Emissions (MMTCO_2E)
1990	4,219,179	x	0.0900	x	365	x	0.001	x	0.60	x	16.25%	=	13,513.5	x	25	x	0.000001	x	0.27	=	0.092	=	0.338
1991	4,240,950	x	0.0900	x	365	x	0.001	x	0.60	x	16.25%	=	13,583.2	x	25	x	0.000001	x	0.27	=	0.093	=	0.340
1992	4,270,849	x	0.0900	x	365	x	0.001	x	0.60	x	16.25%	=	13,679.0	x	25	x	0.000001	x	0.27	=	0.093	=	0.342

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Municipal wastewater N_2O emissions estimation equation

N2O emissions from wastewater treatment uses state population multiplied by a given emissions factor to obtain emissions

Equation 2. Direct N_2O Emissions from Municipal Wastewater Treatment

Direct N_2O Emissions (MMTCO2E) =
State Population × Fraction of Population not on Septic (%) ×
Emission Factor (g N_2O/person/year) × 10^{-6} (metric ton/g) ×
10^{-6} (MMT/metric ton) × 298 (GWP)

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Municipal wastewater N_2O emissions estimation example

	State Population		Fraction of Population not on Septic		Direct N2O Emissions from Wastewater Treatment (g N_2O/person/year)		Unit Conversion (g/metric ton)		Emissions (Metric Tons N_2O)		N_2O GWP (CO_2 Eq.)		Unit Conversion (MMT/MT)		C/CO_2		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
1990	4,219,179	x	81%	x	4.0	x	1E-06	=	13.74	x	298	x	0.000001	x	0.27	=	0.001	=	0.004
1991	4,240,950	x	81%	x	4.0	x	1E-06	=	13.81	x	298	x	0.000001	x	0.27	=	0.001	=	0.004
1992	4,270,849	x	81%	x	4.0	x	1E-06	=	13.91	x	298	x	0.000001	x	0.27	=	0.001	=	0.004

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N2O emissions biosolids wastewater treatment emission equation estimation

Bisolid wastewater treatment takes state population multiplied by protein consumption and percent of nitrogen not consumed and subtracts direct emissions from nitrogen.

Equation 3. N_2O Emissions from Biosolids Municipal Wastewater Treatment

N_2O Emissions ($MMTCO_2E$) =
[State Population × Protein Consumption (kg/person/year) ×
$FRAC_{NPR}$ (kg N/kg protein) × Fraction of Nitrogen not Consumed
0.001 (metric ton/kg) – Direct N Emissions (metric tons)] ×
[1 – Percentage of Biosolids used as Fertilizer (%)] ×
Emission Factor (kg N_2O-N/kg sewage N produced) ×
44/28 (kg N_2O /kg N) × 10^{-6} (MMT/metric ton) × 298 (GWP) +
Direct N_2O Emissions

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	State Population		Protein (kg/ person/ year)		Frac $_{NPR}$ (kg N/kg protein)		Fraction Non-Consumption N		Unit Conversion (metric tons/kg)		N in Domestic Wastewater (metric tons)		Direct N Emissions from Domestic Wastewater (metric tons)		Biosolids Available N (metric tons)		Percentage of Biosolids Used as Fertilizer		Emission Factor (kg N_2O-N/ kg sewage N-produced)		N_2O/N_2		Emissions (metric tons N_2O)		N_2O GWP (CO_2 Eq.)		Unit Conversion (MMT/MT)		C/CO_2		Emissions from Biosolids (MMTCE)		Direct Emissions (MMTCE)		Total Emissions (MMTCE)		Emissions (MMTCO $_2$E)
1990	4,219,179	x	43.1	x	16%	x	1.75	x	0.001	=	50,916	-	9	=	50,908	x (1 -		) x	0.01	x	1.571	=	399.99	x	298	x	0.000001	x	0.27	=	0.033	+	0.001	=	0.034	=	0.123
1991	4,240,950	x	43.5	x	16%	x	1.75	x	0.001	=	51,613	-	9	=	51,604	x (1 -		) x	0.01	x	1.571	=	405.46	x	298	x	0.000001	x	0.27	=	0.033	+	0.001	=	0.034	=	0.125
1992	4,270,849	x	43.8	x	16%	x	1.75	x	0.001	=	52,414	-	9	=	52,405	x (1 -		) x	0.01	x	1.571	=	411.75	x	298	x	0.000001	x	0.27	=	0.033	+	0.001	=	0.035	=	0.127

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Industrial wastewater of fruits and vegetables emissions equation estimation

Wastewater from fruits and vegetables metric tons are multiplied by organic matter content and anerobic percent of treatment as well as emissions factor.

Equation 4. CH_4 Emissions from Industrial Wastewater for Fruits and Vegetables

$$\begin{gathered}\text{CH}_4\text{ Emissions (MMTCO}_2\text{E)} = \\ \text{Production Processed (Metric Tons)} \times \text{Wastewater Produced (m}^3\text{/metric ton)} \times \\ 1{,}000\ (\text{L/m}^3) \times \text{Organic Matter Content (g COD/L)} \times \\ \text{Emission Factor (g CH}_4\text{/g COD)} \times \text{Percent Treated Anaerobically (\%)} \times \\ 10^{-12}\ (\text{MMT/g}) \times 25\ (\text{GWP})\end{gathered}$$

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Industrial wastewater of fruits and vegetables emissions equation example

	Production Processed (metric tons)		WW Outflow (m^3/metric ton)		Unit Conversion (l/m^3)		COD (g COD/l)		Emission Factor (g CH_4/g COD)		COD Degraded (percent)		Emissions (g CH_4)		Unit Conversion (g/Tg)		Emissions (Tg or MMT CH_4)		CH_4 GWP (CO_2 Eq.)		C/CO_2		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
1990		x	5.6	x	1,000	x	5	x	0.25	x	5%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000
1991		x	5.6	x	1,000	x	5	x	0.25	x	5%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000
1992		x	5.6	x	1,000	x	5	x	0.25	x	5%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000

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Industrial wastewater of red meat emissions equation estimation

Wastewater from red meat takes metric tons multiplied by organic matter content and emissions factor to obtain CH_4 emissions

Equation 5. CH_4 Emissions from Industrial Wastewater for Red Meat

$$
\begin{gathered}
CH_4 \text{ Emissions (MMTCO}_2\text{E)} = \\
\text{Production Processed (Metric Tons)} \times \text{Wastewater Produced (m}^3\text{/metric ton)} \times \\
1{,}000 \text{ (L/m}^3) \times \text{Organic Matter Content (g COD/L)} \times \\
\text{Emission Factor (g CH}_4\text{/g COD)} \times \text{Percent Treated Anaerobically (\%)} \times \\
10^{-12} \text{ (MMT/g)} \times 25 \text{ (GWP)}
\end{gathered}
$$

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Industrial wastewater of red meat emissions equation example

	Production Processed (metric tons)		WW Outflow (m^3/metric ton)		Unit Conversion (l/m^3)		COD (g COD/l)		Emission Factor (g CH_4/g COD)		COD Degraded (percent)		Emissions (g CH_4)		Unit Conversion (g/Tg)		Emissions (Tg or MMT CH_4)		CH_4 GWP (CO_2 Eq.)		C/CO_2		Emissions (MMTCE)		Emissions (MMTCO_2E)
1990	16,828.56	x	8	x	1,000	x	4.1	x	0.25	x	33%	=	44,968,857	x	1E-12	=	0.00	x	25	x	0.27	=	0.000	=	0.001
1991	14,424.48	x	8	x	1,000	x	4.1	x	0.25	x	33%	=	38,544,735	x	1E-12	=	0.00	x	25	x	0.27	=	0.000	=	0.001
1992	13,471.92	x	8	x	1,000	x	4.1	x	0.25	x	33%	=	35,999,328	x	1E-12	=	0.00	x	25	x	0.27	=	0.000	=	0.001

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Industrial wastewater of poultry emissions equation estimation

Wastewater from poultry takes metric tons multiplied by organic matter content and emissions factor to obtain CH_4 emissions

Equation 6. CH_4 Emissions from Industrial Wastewater for Poultry

$$\begin{gathered}CH_4 \text{ Emissions } (MMTCO_2E) = \\ \text{Production Processed (Metric Tons)} \times \text{Wastewater Produced } (m^3/\text{metric ton}) \times \\ 1{,}000\ (L/m^3) \times \text{Organic Matter Content (g COD/L)} \times \\ \text{Emission Factor } (g\ CH_4/g\ COD) \times \text{Percent Treated Anaerobically } (\%) \times \\ 10^{-12}\ (MMT/g) \times 25\ (GWP)\end{gathered}$$

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Industrial wastewater of poultry emissions equation example

	Production Processed (metric tons)		WW Outflow (m^3/metric ton)		Unit Conversion (l/m^3)		COD (g COD/l)		Emission Factor (g CH_4/g COD)		COD Degraded (percent)		Emissions (g CH_4)		Unit Conversion (g/Tg)		Emissions (Tg or MMT CH_4)		CH_4 GWP (CO_2 Eq.)		C/CO_2		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
1990		x	17	x	1,000	x	4.1	x	0.25	x	25.0%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000
1991		x	17	x	1,000	x	4.1	x	0.25	x	25.0%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000
1992		x	17	x	1,000	x	4.1	x	0.25	x	25.0%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000

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Industrial wastewater of pulp and paper emissions equation estimation

Wastewater from pulp and paper takes metric tons multiplied by organic matter content as well as an emission factor and anerobic percent factor.

Equation 7. CH_4 Emissions from Industrial Wastewater for Pulp and Paper

CH_4 Emissions ($MMTCO_2E$) =
[Production Processed Woodpulp (Metric Tons) + Production Processed Paper & Paperboard (Metric Tons)] × Wastewater Produced (m^3/metric ton) × 1,000 (L/m^3) × Organic Matter Content (g BOD/L) ×
Emission Factor (g CH_4/g BOD) × Percent Treated Anaerobically (%) ×
10^{-12} (MMT/g) × 25 (GWP)

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Industrial wastewater of pulp and paper emissions equation example

Wastewater from poultry takes metric tons multiplied by organic matter content and emissions factor to obtain CH_4 emissions

Year	Production Processed (metric tons) Woodpulp		Production Processed (metric tons) Paper & Paperboard		WW Outflow (m^3/metric ton)		Unit Conversion (l/m^3)		BOD Degraded (g BOD / l)		Emission Factor (g CH_4/g BOD)		TA (percent)		Emissions (g CH_4)		Unit Conversion (g/Tg)		Emissions (Tg or MMT CH_4)		CH_4 GWP (CO_2 Eq.)		C/CO_2		Emissions (MMTCE)		Emissions (MMTCO $_2$E)
1990 (		+		) x	85	x	1,000	x	0.4	x	0.6	x	10.3%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000
1991 (		+		) x	85	x	1,000	x	0.4	x	0.6	x	10.3%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000
1992 (		+		) x	85	x	1,000	x	0.4	x	0.6	x	10.3%	=	-	x	1E-12	=	-	x	25	x	0.27	=	0.000	=	0.000

Estimated wastewater trends

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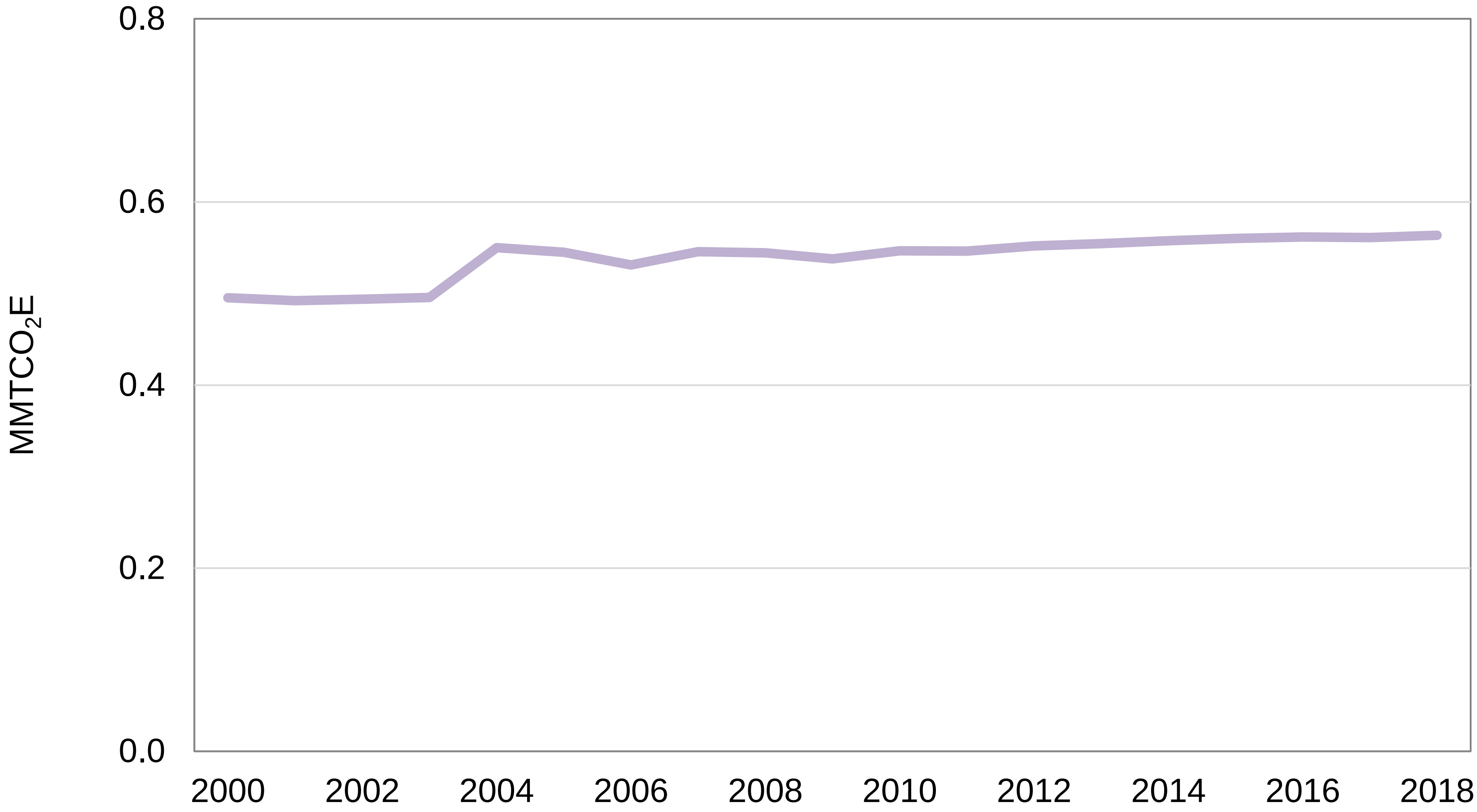
Louisiana total emissions from wastewater

GHG emissions from all Louisiana wastewater facilities has been relatively constant.



Source: EIA SIT, EPA, LSU AG report

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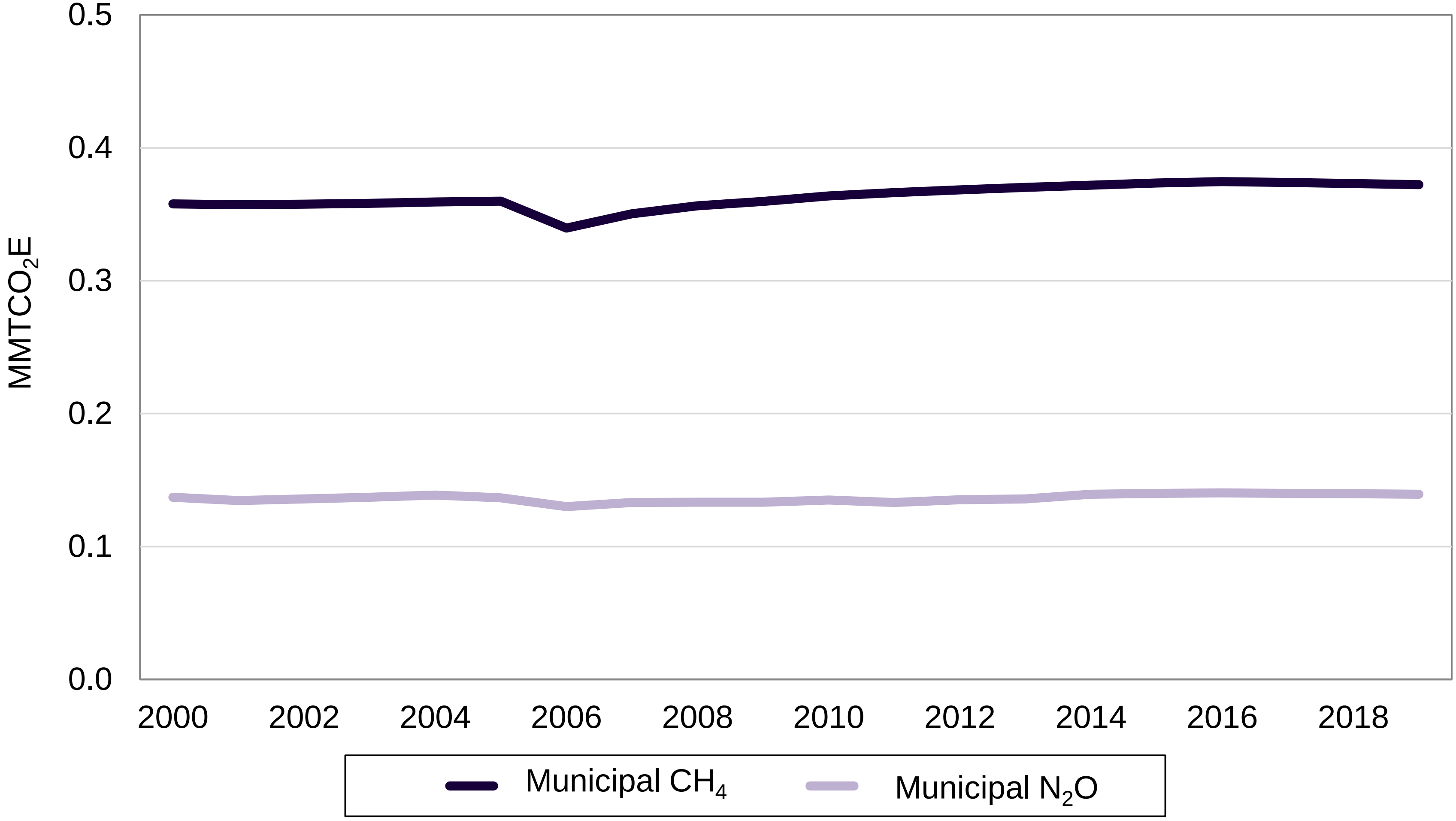
Louisiana municipal wastewater emissions (CH_4 and N_2O)

GHG emissions from Louisiana municipal water treatment facilities has been relatively constant.



Source: EIA SIT, EPA, LSU AG report

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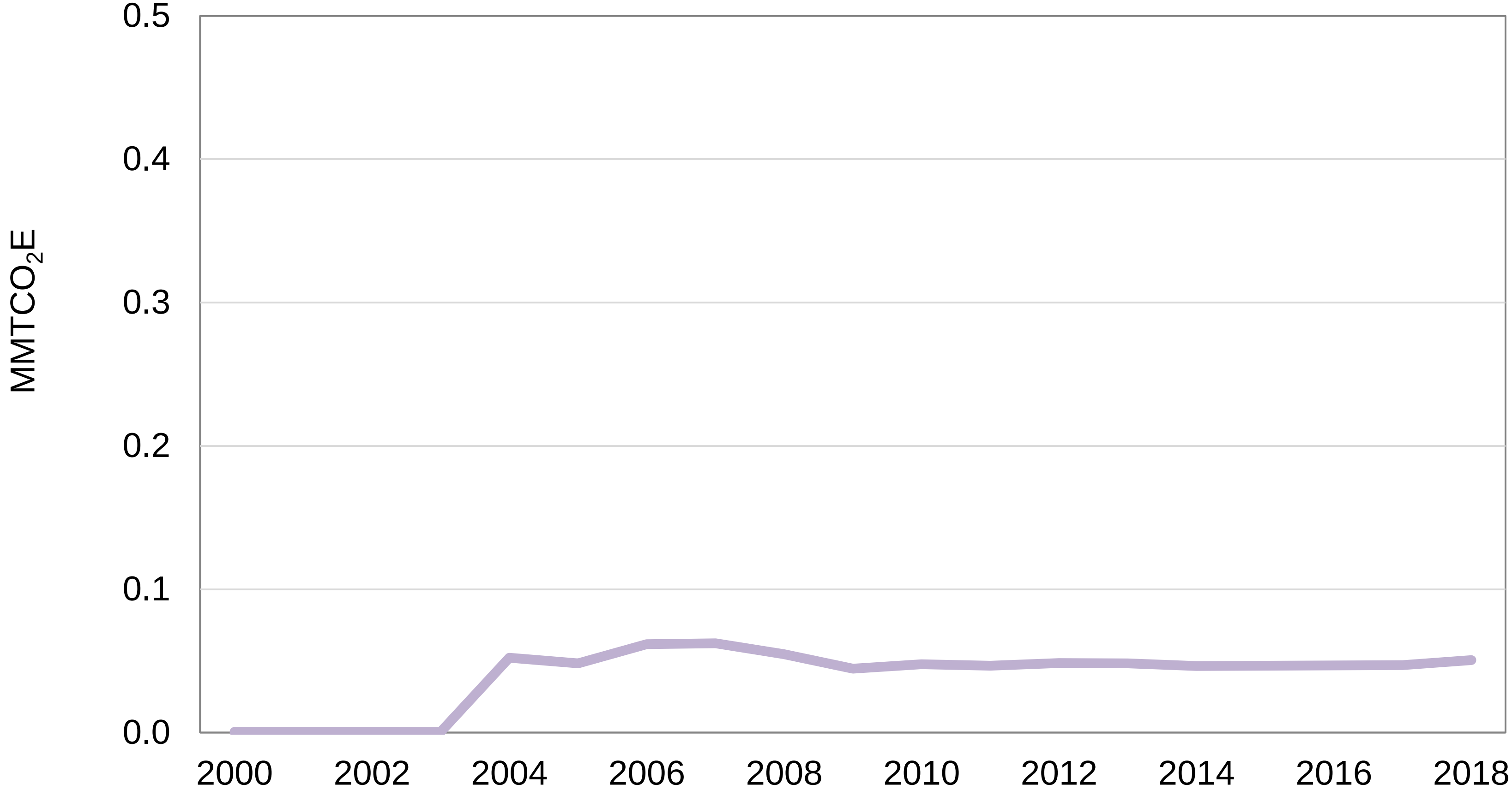
Industrial CH_4 emissions

GHG emissions from Louisiana industrial water treatment facilities has also been relatively constant.



Source: EIA SIT, EPA, LSU AG report
Note: data gaps in 200-2002

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Current wastewater shares

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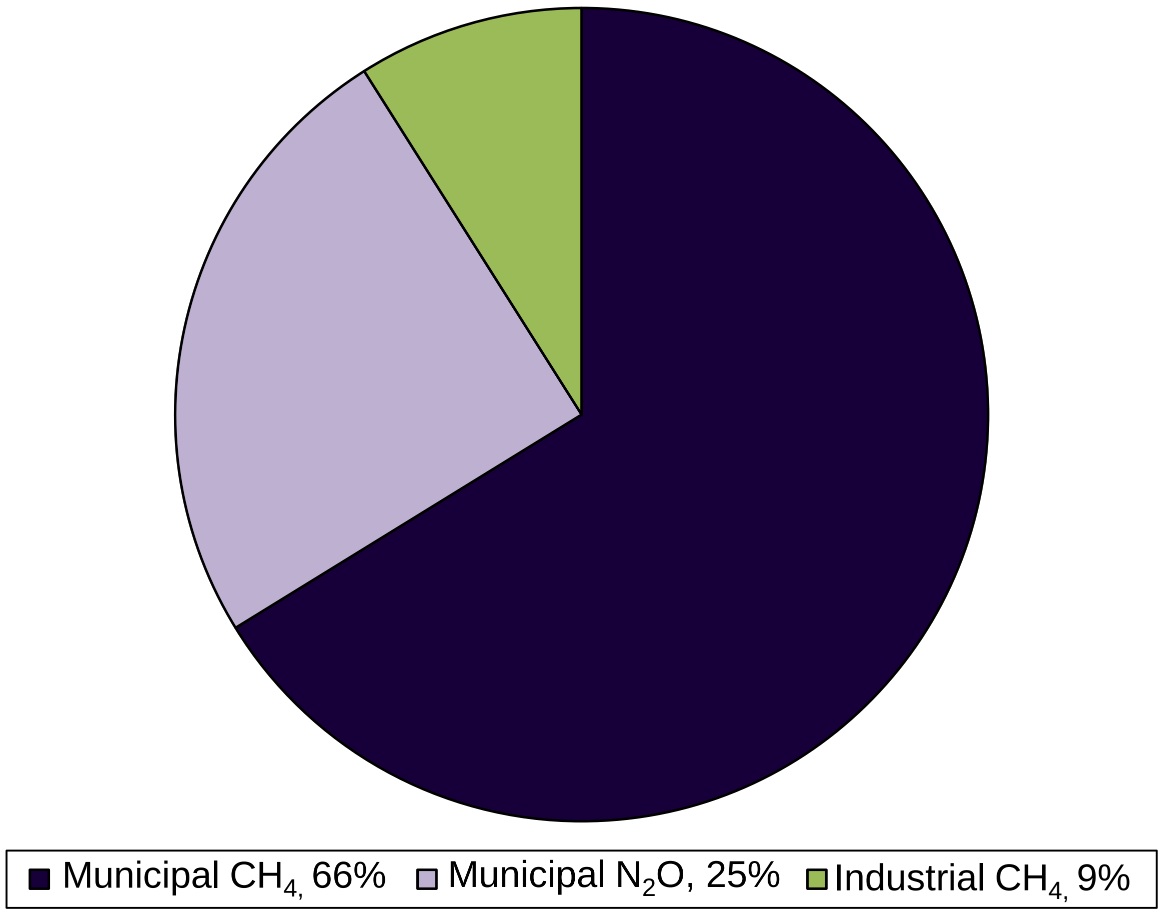
Louisiana GHG emission shares, 2018 wastewater



Source: EIA SIT, EPA, LSU AG report

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2018 Summary Calculation: Wastewater

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2018 Summary estimates

In 2018, Louisiana's wastewater treatment facilities contributed slightly over one-half of one million metric tons to the state's overall GHG inventory.

Sector	2018 $MMTCO_2E$
Municipal CH_4	0.37
Municipal N_2O	0.14
Industrial CH_4	0.05
Total	**0.563**

Source: EIA SIT, EPA, LSU AG report

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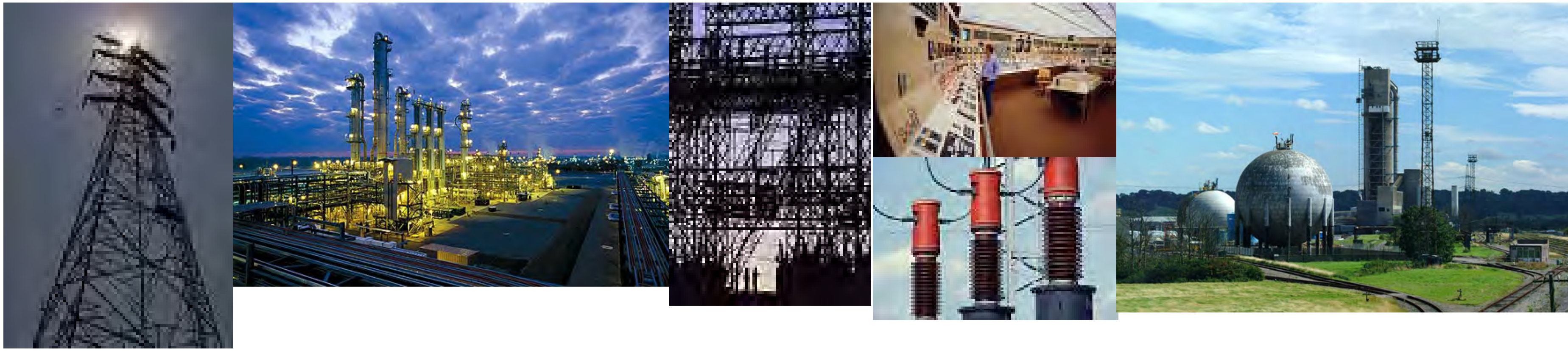

Louisiana GHG Inventory. Appendix 9: Solid waste emissions estimates.

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Estimation methods for solid waste emissions

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- Two sets of GHG emissions are calculated in the MSW module.
- First, carbon dioxide (CO_2) and methane (CH_4) emissions are calculated from landfilling of municipal solid waste (MSW).
- Second, CO_2 and nitrous oxide (N_2O) emissions are calculated from the combustion of MSW from landfill wastes.
- The anerobic and aerobic breakdown of waste produces green house gases that eventually turns into biogas that emits CH_4 and CO_2
- Some landfills are used for electricity production from burning commonly known as landfill-gas-to-energy projects (LFGTE) which release CO_2 and N_2O.

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Solid Waste Module – Calculation of emissions from plastics combustion

10. CO2 from Plastics Combustion in Louisiana

In the calculation of CO_2 emissions from plastics combustion, the key value is the amount of waste combusted. Default values or user-supplied data are entered on the waste combustion data sheet. This value is then multiplied by the proportion of combusted waste that is plastics, the carbon content of the waste, and the fraction oxidized to determine CO_2 emissions. These values are then converted to MTCE and $MTCO_2E$. The methodology and factors used for these calculations are discussed in detail in Solid Waste Chapter of the User's Guide.

Return to the Control Sheet | Go to the Synthetic Rubber Combustion

Select All Defaults

Clear All Data

CO_2 from Plastics Combustion 1990

☑ Default Proportion of Discards

	Proportion of Discards		State MSW Combusted (short tons)		Carbon Content		Fraction Oxidized		Emissions (MTCE)		Emissions ($MTCO_2E$)
Plastics	**9.8%**	x	**0**	x	**79%**	x	**0.98**	=	-	=	-
PET	0.7%	x	0	x	63%	x	0.98	=	-	=	-
HDPE	1.7%	x	0	x	86%	x	0.98	=	-	=	-
PVC	0.8%	x	0	x	38%	x	0.98	=	-	=	-
LDPE/LLDPE	2.7%	x	0	x	86%	x	0.98	=	-	=	-
PP	1.5%	x	0	x	86%	x	0.98	=	-	=	-
PS	1.2%	x	0	x	92%	x	0.98	=	-	=	-
Other	1.1%	x	0	x	66%	x	0.98	=	-	=	-

CO_2 from Plastics Combustion 1991

☑ Default Proportion of Discards

	Proportion of Discards		State MSW Combusted (short tons)		Carbon Content		Fraction Oxidized		Emissions (MTCE)		Emissions ($MTCO_2E$)
Plastics	**10.8%**	x	**0**	x	**79%**	x	**0.98**	=	-	=	-
PET	0.8%	x	0	x	63%	x	0.98	=	-	=	-
HDPE	1.9%	x	0	x	86%	x	0.98	=	-	=	-
PVC	0.9%	x	0	x	38%	x	0.98	=	-	=	-
LDPE/LLDPE	3.0%	x	0	x	86%	x	0.98	=	-	=	-
PP	1.7%	x	0	x	86%	x	0.98	=	-	=	-
PS	1.3%	x	0	x	92%	x	0.98	=	-	=	-
Other	1.2%	x	0	x	66%	x	0.98	=	-	=	-

CO_2 from Plastics Combustion 1992

☑ Default Proportion of Discards

	Proportion of Discards		State MSW Combusted (short tons)		Carbon Content		Fraction Oxidized		Emissions (MTCE)		Emissions ($MTCO_2E$)
Plastics	**10.6%**	x	**0**	x	**79%**	x	**0.98**	=	-	=	-
PET	0.8%	x	0	x	63%	x	0.98	=			

Control | Results | Uncertainty | Flaring | LFGTE | State Population | State Disposal | FOD Calcs | State MSW Combusted | CO2 Plastics | CO2

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Solid Waste Module – calculation of N_2O emissions from MSW combustion

13. N2O from MSW Combustion in Louisiana

The N_2O emissions from waste combustion are calculated by factoring the amount of waste combusted by an N_2O emissions factor. The N_2O emissions are then converted to MTCE by multiplying by the global warming potential (GWP) for N_2O, a conversion factor to convert from short tons to metric tons, and the ratio of the molecular weight of carbon to that of carbon dioxide. These emissions are then converted to $MTCO_2E$. The methodology used for these calculations are discussed in detail in the Solid Waste Chapter of the User's Guide.

Return to the Control Sheet

Go to the CH_4 from MSW Combustion Sheet

N_2O from MSW Combustion

Year	State MSW Combusted (short tons)		Emission Factor (tons N_2O/ton MSW)		N_2O GWP		Metric Tons / Short Ton		C/CO_2		Emissions (MTCE)		Emissions ($MTCO_2E$)
1990	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1991	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1992	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1993	557,440	x	0.00005	x	298	x	0.9072	x	0.27	=	2,055.0	=	7,534.9
1994	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1995	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1996	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1997	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1998	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
1999	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
2000	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
2001	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
2002	0	x	0.00005	x	298	x	0.9072	x	0.27	=	-	=	-
2003	83,308	x	0.00005	x	298	x	0.9072	x	0.27	=	307.1	=	1,126.1
2004	195,793	x	0.00005	x	298	x	0.9072	x	0.27	=	721.8	=	2,646.5
2005	224,971	x	0.00005	x	298	x	0.9072	x	0.27	=	829.3	=	3,040.9
2006	254,149	x	0.00005	x	298	x	0.9072	x	0.27	=	936.9	=	3,435.3
2007	249,619	x	0.00005	x	298	x	0.9072	x	0.27	=	920.2	=	3,374.1
2008	245,090	x	0.00005	x	298	x	0.9072	x	0.27	=	903.5	=	3,312.9
2009	153,710	x	0.00005	x	298	x	0.9072	x	0.27	=	566.6	=	2,077.7
2010	157,976	x	0.00005	x	298	x	0.9072	x	0.27	=	582.4	=	2,135.4
2011	158,555	x	0.00005	x	298	x	0.9072	x	0.27	=	584.5	=	2,143.2
2012	158,756	x	0.00005	x	298	x	0.9072	x	0.27	=	585.3	=	2,145.9
2013	160,506	x	0.00005	x	298	x	0.9072	x	0.27	=	591.7	=	2,169.6
2014	162,601	x	0.00005	x	298	x	0.9072	x	0.27	=	599.4	=	2,197.9
2015	164,936	x	0.00005	x	298	x	0.9072	x	0.27	=	608.0	=	2,229.4
2016	167,900	x	0.00005	x	298	x	0.9072	x	0.27	=	619.0	=	2,269.5
2017	168,510	x	0.00005	x	298	x	0.9072	x	0.27	=	621.2	=	2,277.8

Control | Results | Uncertainty | Flaring | LFGTE | State Population | State Disposal | FOD Calcs | State MSW Combusted | CO2_Plastics | CO2_Syn. Rubber | CO2_Syn. Fibers | N2O_MS

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Estimated solid waste emissions trends

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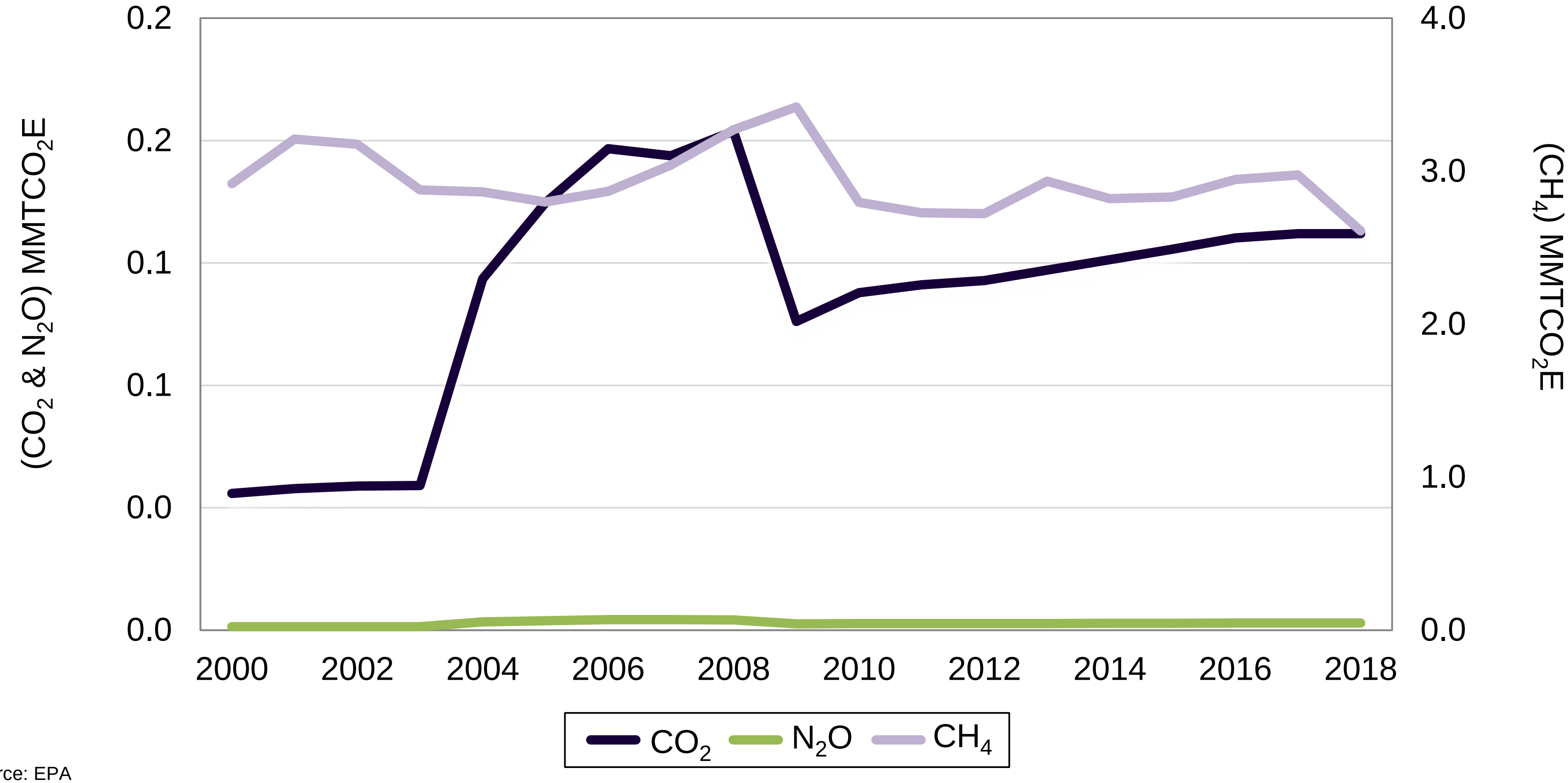
Louisiana MSW GHG emissions by pollutant

Carbon dioxide emissions have grown, on percent basis, considerably since 2000 (note scale on left hand axis is orders of magnitude lower). Methane emissions, however, have remained relatively stable (note scale on right hand axis).



Source: EPA
Note: Data for CO2 and N2O for 2000-2002 was missing so 2003 data was used

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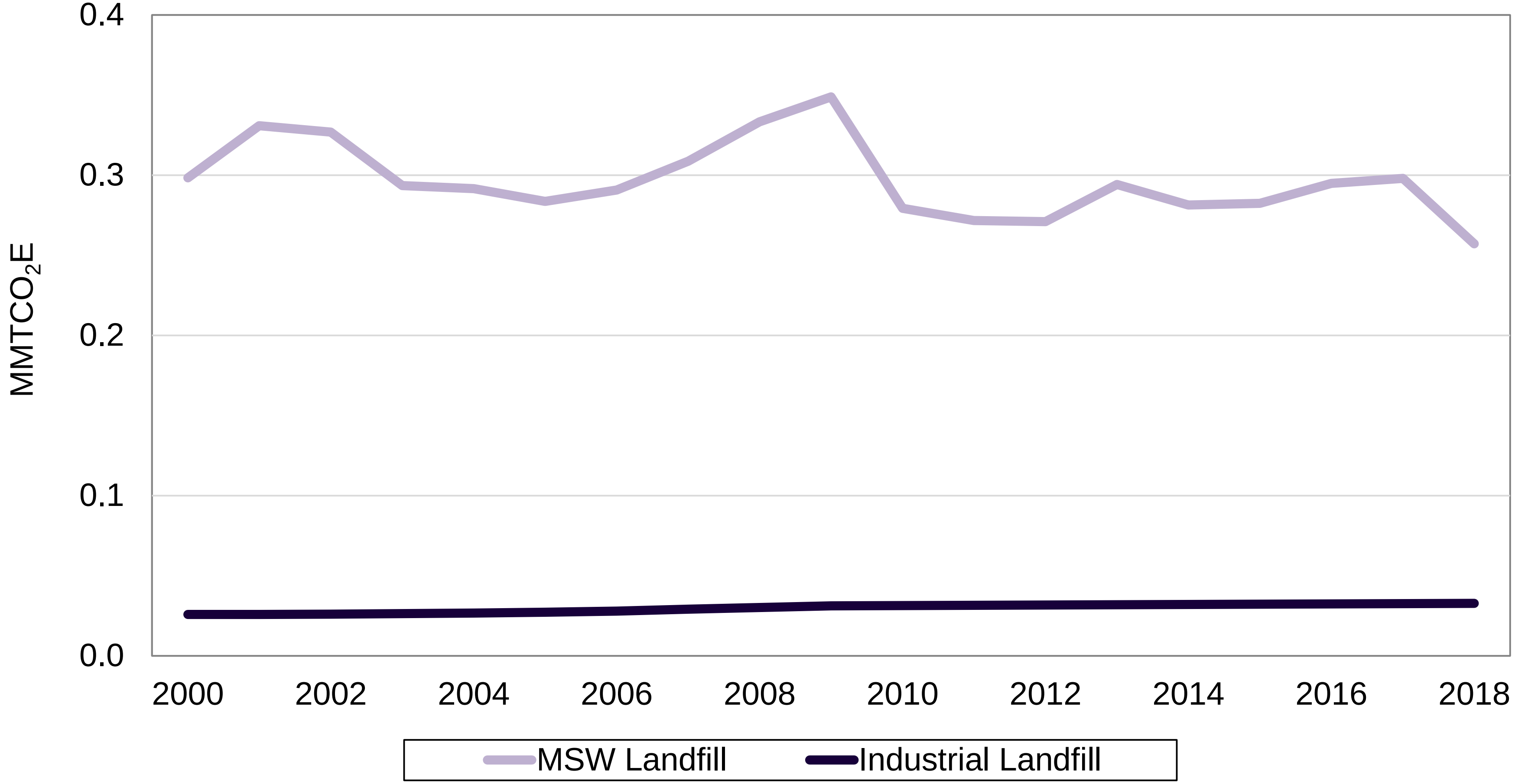
Louisiana MSW GHG emissions, oxidation-related emissions

The relative share of oxidation related emissions has been stable over the past two decades. There has been a slight decrease in overall emissions from MSW facilities relative to industrial landfills.



Source: EPA

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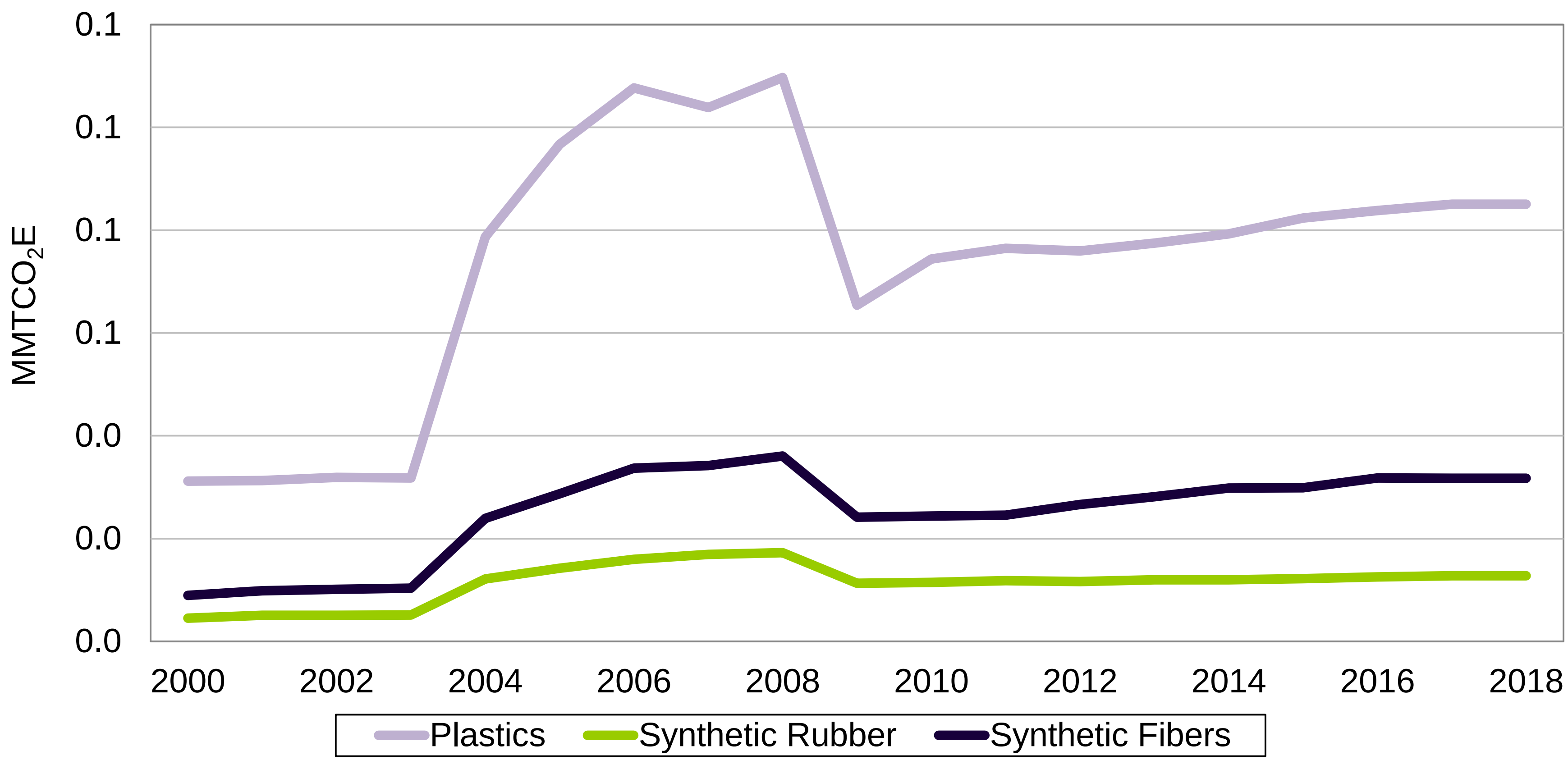
Louisiana MSW GHG emissions, waste combustion emissions

Waste combustion GHG emissions fell after 2008. While down relative to peaks, all GHG emissions have been growing since hitting a 2008 trough.



Source: EPA

Note: Data for CO2 and N2O for 2000-2002 was missing so 2003 data was used

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Estimated MSW emission shares

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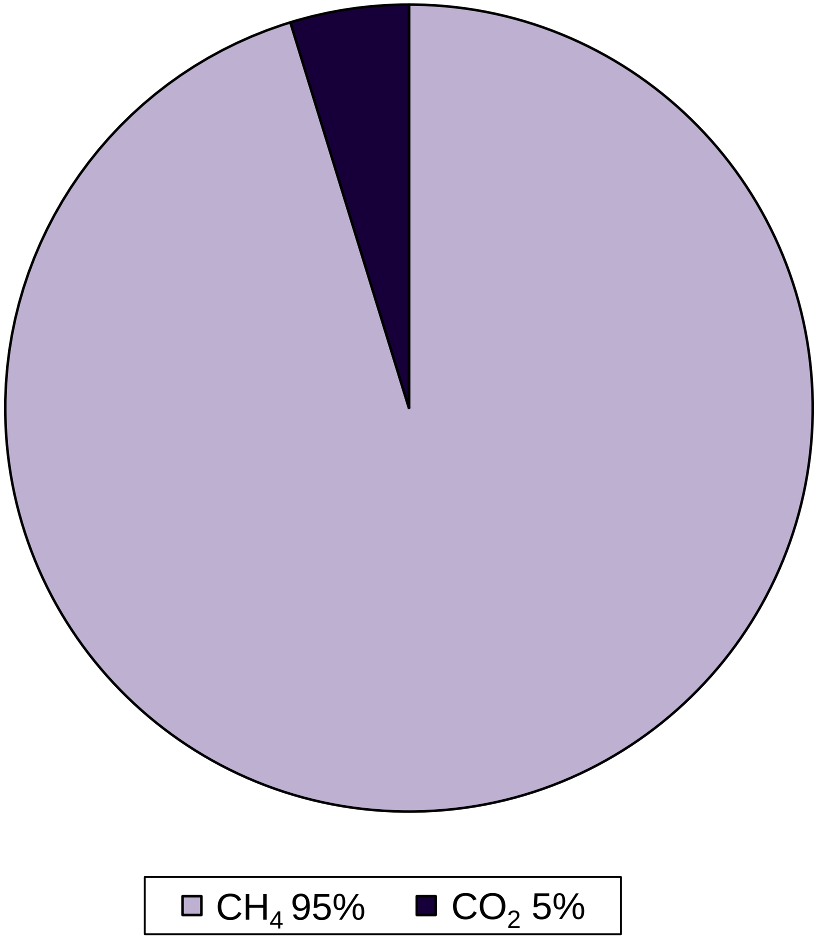
Louisiana municipal solid waste GHG emission shares, but pollutant

Not surprisingly, methane emission dominate most MSW-related emissions.



Source: EPA

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2018 Summary Calculation: MSW Emissions

2018 Summary estimates

Landfill and waste-related GHG emissions contribute 2.7 million metric tons to the state's overall 2018 GHG inventory in 2018.

Sector	2018 $MMTCO_2E$
Landfill Emissions	
CH_4	2.610
Waste Combustion Emissions	
CO_2	0.130
N_2O	0.002
CH_4	0.000
Total	**2.742**

Source: EPA

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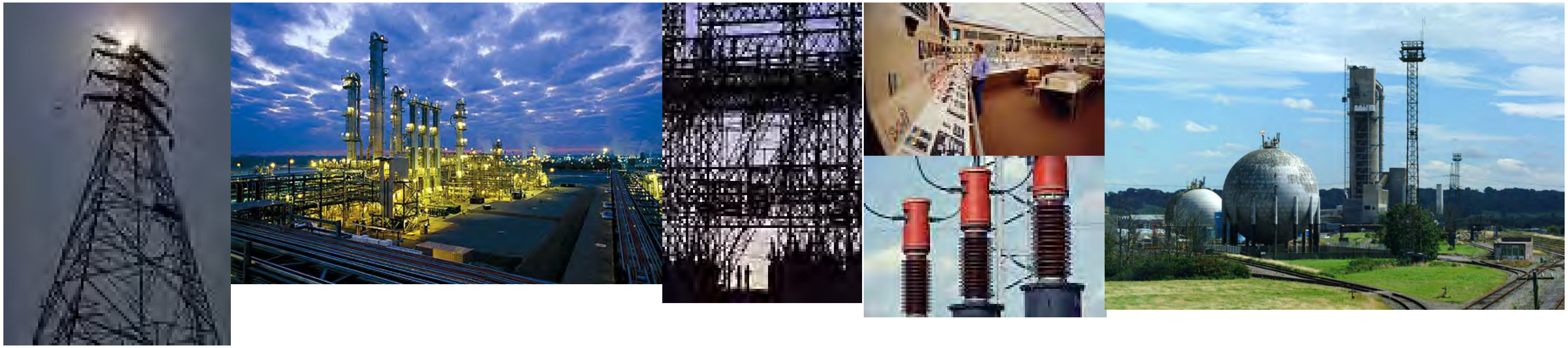

Louisiana 2021 GHG Inventory. Appendix 10: Agricultural emission estimates.

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Introduction: Agricultural GHG Emissions Estimation Process

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Agricultural GHG emissions

- The agricultural sector has a number of GHG emissions that arise from livestock and soil management, among other farm activities.
- The agricultural module estimates emissions from enteric fermentation, manure management, AG soil fertilizers, rice cultivation, residue burning, animals, and urea fertilization.
- A national adjustment factor has been applied given EPA guidance that the default method underestimates indirect emissions from fertilizers and overestimates indirect emissions from livestock and all direct sources of agricultural soils emissions relative to the national inventory.

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Enteric fermentation emissions estimation equation (methane)

The enteric fermentation estimation process is a function of the livestock population. As this stock grows, methane emissions will grow, holding other factors constant.

$$\textbf{Emissions } (MMTCO_2E) =$$
$$\textbf{Animal Population ('000 head)} \times \textbf{Emission Factor } (kg\ CH_4/head) \times 25\ (GWP)$$
$$\div\ 1{,}000{,}000{,}000\ (kg/MMTCO_2E)$$

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Enteric fermentation emissions estimation (CH_4 to CO_2E)

Enteric Fermentation 2018

☑ Default Animal Data?

	Number of Animals ('000 head)		Emission Factor (kg CH_4/head)		Emissions (kg CH_4)		Emissions (MMTCH$_4$)		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
Dairy Cattle											
Dairy Cows	12.0	x	118.2	=	1,418,561	=	0.0014	=	0.010	=	0.035
Dairy Replacement Heifers	4.0	x	66.9	=	267,587	=	0.0003	=	0.002	=	0.007
Replacements 0-12 mos.	0.0	x	48.9	=	-	=	0.0000	=	0.000	=	0.000
Replacements 12-24 mos.	0.0	x	73.8	=	-	=	0.0000	=	0.000	=	0.000
Beef Cattle											
Beef Cows	473.0	x	94.1	=	44,515,015	=	0.0445	=	0.304	=	1.11
Beef Replacement Heifers	90.0	x	66.5	=	5,984,517	=	0.0060	=	0.041	=	0.150
Replacements 0-12 mos.	0.0	x	59.8	=	-	=	0.0000	=	0.000	=	0.000
Replacements 12-24 mos.	0.0	x	69.2	=	-	=	0.0000	=	0.000	=	0.000
Heifer Stockers	20.0	x	60.2	=	1,203,018	=	0.0012	=	0.008	=	0.030
Steer Stockers	23.0	x	57.9	=	1,332,035	=	0.0013	=	0.009	=	0.033
Feedlot Heifers	0.5	x	43.0	=	20,124	=	0.0000	=	0.000	=	0.001
Feedlot Steer	0.9	x	41.8	=	36,569	=	0.0000	=	0.000	=	0.001
Bulls	31.0	x	97.3	=	3,016,683	=	0.0030	=	0.021	=	0.075
Other											
Sheep	12.9	x	8.0	=	103,333	=	0.0001	=	0.001	=	0.003
Goats	18.9	x	5.0	=	94,585	=	0.0001	=	0.001	=	0.002
Swine	6.0	x	1.5	=	9,000	=	0.0000	=	0.000	=	0.000
Horses	40.5	x	18.0	=	728,370	=	0.0007	=	0.005	=	0.018
TOTAL					**58,729,398**		**0.0587**		**0.400**		**1.468**

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Manure management emissions estimation equation (methane, nitrous oxide)

Two equations estimate GHG emissions from manure management. One (first below) is for methane releases and the second is (second below) is for nitrous oxide emissions.

VS Produced$_{\text{Cattle, excluding calves}}$ = Animal Population ('000 head) × 1,000 × VS (kg/head/yr)

VS Produced$_{\text{Calves and all other livestock}}$ = Animal Population ('000 head) × TAM × VS (kg/1,000 kg animal mass/day) × 365 (days/yr)

Emissions ($MMTCO_2E$) =
VS Produced (kg) × B_o (m^3 CH_4/kg VS) × MCF × 0.678 kg/m^3 × 25 (GWP) ÷ 1,000,000,000 ($MMTCO_2E$)

K-Nitrogen Excreted$_{\text{Cattle, excluding calves}}$ = Animal Population ('000 head) × 1,000 × K-Nitrogen (kg/head/day)

K-Nitrogen Excreted$_{\text{Calves and all other livestock}}$ = Animal Population ('000 head) × TAM × K-Nitrogen (kg/1,000 kg animal mass/day) × 365 (days/yr)

Emissions ($MMTCO_2E$) =
K-Nitrogen Excreted × Emission Factor (liquid or dry) × 298 (GWP) ÷ 1,000,000,000 (kg/$MMTCO_2E$)

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Manure management emissions estimation (methane)

CH_4 from Manure Management 2018

☑ Default Animal Data?

	Number of Animals ('000 head)		Typical Animal Mass (TAM) (kg)		Volatile Solids (VS)		Total VS (kg/yr)		Max Pot. Emissions (m^3 CH_4 / kg VS)		Weighted MCF		Emissions (m^3 CH_4)		Emissions (Metric Tons CH_4)		Emissions (MMTCH$_4$)		Emissions (MMTCE)		Emissions (MMTCO$_2$E)
Dairy Cattle					[kg VS/head/year]																
Dairy Cows	12.0		x		2,099.7	=	25,196,380	x	0.24	x	0.270	=	1,634,320	=	1,105	=	0.001	=	0.008	=	0.028
Dairy Replacement Heifers	4.0		x		1,251.8	=	5,007,232	x	0.17	x	0.020	=	17,021	=	12	=	0.000	=	0.000	=	0.000
Beef Cattle																					
Feedlot Heifers	0.5		x		690.9	=	323,091	x	0.33	x	0.022	=	2,318	=	2	=	0.000	=	0.000	=	0.000
Feedlot Steer	0.9		x		668.8	=	585,464	x	0.33	x	0.022	=	4,200	=	3	=	0.000	=	0.000	=	0.000
Bulls	31.0		x		1,721.0	=	53,349,688	x	0.17	x	0.014	=	126,972	=	86	=	0.000	=	0.001	=	0.002
Calves	167.0	x	123	x	7.7	=	57,510,715	x	0.17	x	0.014	=	136,876	=	93	=	0.000	=	0.001	=	0.002
Beef Cows	473.0		x		1,664.4	=	787,242,801	x	0.17	x	0.014	=	1,873,638	=	1,267	=	0.001	=	0.009	=	0.032
Beef Replacement Heifers	90.0		x		1,103.4	=	99,302,503	x	0.17	x	0.014	=	236,340	=	160	=	0.000	=	0.001	=	0.004
Steer Stockers	23.0		x		974.8	=	22,419,551	x	0.17	x	0.014	=	53,359	=	36	=	0.000	=	0.000	=	0.001
Heifer Stockers	20.0		x		1,103.4	=	22,067,223	x	0.17	x	0.014	=	52,520	=	36	=	0.000	=	0.000	=	0.001
Swine					[kg VS/1000 kg animal mass/day]																
Breeding Swine	2.0	x	198	x	2.7	=	395,317	x	0.48	x	0.199	=	37,821	=	26	=	0.000	=	0.000	=	0.001
Market Under 60 lbs	1.0	x	16	x	8.8	=	51,007	x	0.48	x	0.199	=	4,880	=	3	=	0.000	=	0.000	=	0.000
Market 60-119 lbs	1.0	x	41	x	5.4	=	80,023	x	0.48	x	0.199	=	7,656	=	5	=	0.000	=	0.000	=	0.000
Market 120-179 lbs	1.0	x	68	x	5.4	=	133,673	x	0.48	x	0.199	=	12,790	=	9	=	0.000	=	0.000	=	0.000
Market over 180 lbs	1.0	x	91	x	5.4	=	178,868	x	0.48	x	0.199	=	17,114	=	12	=	0.000	=	0.000	=	0.000
Poultry																					
Layers																					
Hens > 1 yr	2,078.0	x	2	x	10.2	=	13,873,630	x	0.39	x	0.471	=	2,549,828	=	1,724	=	0.002	=	0.012	=	0.043
Pullets	637.0	x	2	x	10.2	=	4,252,888	x	0.39	x	0.471	=	781,636	=	528	=	0.001	=	0.004	=	0.013
Chickens	99.0	x	2	x	11.0	=	715,473	x	0.39	x	0.471	=	131,496	=	89	=	0.000	=	0.001	=	0.002
Broilers	10,423.6	x	1	x	17.0	=	58,210,797	x	0.36	x	0.015	=	314,338	=	213	=	0.000	=	0.001	=	0.005
Turkeys	303.6	x	7	x	8.5	=	6,367,448	x	0.36	x	0.015	=	34,384	=	23	=	0.000	=	0.000	=	0.001
Other																					
Sheep on Feed	6.4	x	25	x	8.3	=	486,721	x	0.36	x	0.017	=	2,929	=	2	=	0.000	=	0.000	=	0.000
Sheep Not on Feed	6.5	x	80	x	8.3	=	1,572,975	x	0.19	x	0.005	=	1,625	=	1	=	0.000	=	0.000	=	0.000
Goats	18.9	x	64	x	9.5	=	4,198,061	x	0.17	x	0.014	=	9,991	=	7	=	0.000	=	0.000	=	0.000
Horses	40.5	x	450	x	6.1	=	40,542,895	x	0.33	x	0.014	=	187,308	=	127	=	0.000	=	0.001	=	0.003
TOTAL													**8,231,362**		**5,565**		**0.006**		**0.038**		**0.139**

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Manure management emissions estimation (nitrous oxide)

3b. N2O from Manure Management in Louisiana

N_2O emissions from Manure Management are calculated by multiplying each animal population by the Kjeldahl nitrogen (K-N) excretion rate for total K-N excreted. For cattle, total K-N excreted is calculated by multiplying the animal population by the amount K-N excreted per animal head per year. For calves and other livestock, total K-N excreted is calculated by multiplying the animal population by the typical animal mass (TAM) and by the amount of K-N produced per kilogram of animal mass per year. This value is then multiplied by a non-volatization factor and the proportion of w aste processed in liquid and solid management systems to give tw o totals of unvolatized N. Each of these are multiplied by an emission factor specific to the management system to give tw o totals of nitrogen emissions. These totals are then summed and converted to N_2O. This amount is then converted to MMTCE, MMT carbon dioxide equivalent ($MMTCO_2E$), and then summed. Note that default emission factors are available through 2017. To facilitate emission calculations for later years, the tool utilizes 2017 emission factors as proxies for emission factors in subsequent years (2018 through 2020). Emission factors for 2018 and beyond w ill be updated as soon as new data become available. For more information, please refer to the Agriculture Chapter of the User's Guide.

Return to Control Sheet

N_2O from Manure Management 1990

	Number of Animals ('000 head)	Total K-Nitrogen Excreted (kg)	Unvolatilized N from Manure in Anaerobic Lagoons and Liquid Systems (kg)	Unvolatilized N from Manure in Solid Storage, Drylot & Other Systems (kg)	Emissions from Anaerobic Lagoons and Liquid Systems (kg N_2O-N)		Emissions from Solid Storage, Drylot, & Other Systems (kg N_2O-N)		Total N_2O Emissions (kg N_2O)		Emissions (MTCE)		Emissions (MMTCE)		Emissions ($MMTCO_2E$)
Dairy Cattle															
Dairy Cows	85.0	11,813,700	1,505,922	1,233,379	1,506	+	24,668	=	41,130	=	3,343	=	0.00334	=	0.01226
Dairy Replacement Heifers	23.0	1,819,221	NA	417,614	NA	+	8,352	=	13,125	=	1,067	=	0.00107	=	0.00391
Beef Cattle															
Feedlot Heifers	2.5	140,771	NA	140,771	NA	+	2,815	=	4,424	=	360	=	0.00036	=	0.00132
Feedlot Steer	4.9	292,657	NA	292,657	NA	+	5,853	=	9,198	=	748	=	0.00075	=	0.00274
Swine															
Breeding Swine	9.0	152,851	100,293	4,282	100	+	86	=	292	=	24	=	0.00002	=	0.00009
Market Under 60 lbs	13.0	45,210	29,665	1,266	30	+	25	=	86	=	7	=	0.00001	=	0.00003
Market 60-119 lbs	12.0	74,688	49,006	2,092	49	+	42	=	143	=	12	=	0.00001	=	0.00004
Market 120-179 lbs	9.0	93,571	61,397	2,621	61	+	52	=	179	=	15	=	0.00001	=	0.00005
Market over 180 lbs	7.0	97,384	63,898	2,728	64	+	55	=	186	=	15	=	0.00002	=	0.00006
Poultry															
Layers															
Hens > 1 yr	1,270.0	579,901	550,906	28,995	551	+	580	=	1,777	=	144	=	0.00014	=	0.00053
Pullets	670.0	305,932	290,635	15,297	291	+	306	=	937	=	76	=	0.00008	=	0.00028
Chickens	120.0	65,437	62,165	3,272	62	+	65	=	201	=	16	=	0.00002	=	0.00006
Broilers	7,073.2	2,555,894	NA	2,555,894	NA	+	51,118	=	80,328	=	6,528	=	0.00653	=	0.02394
Turkeys	0.0	-	NA	-	NA	+	-	=	-	=	-	=	-	=	-
Other															
Sheep on Feed	1.8	6,771	NA	2,630	NA	+	53	=	83	=	7	=	0.00001	=	0.00002
Sheep Not on Feed	15.2	186,821	NA	114,267	NA	+	2,285	=	3,591	=	292	=	0.00029	=	0.00107
TOTAL		**18,230,810**	**2,713,888**	**4,817,764**	**2,714**		**96,355**		**155,680**		**12,653**		**0.01265**		0.04639

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Agriculture soils emissions estimation equation

There are direct and indirect nitrous oxide emissions generated by agricultural soils. The direct emissions are given in the first box below while the indirect emissions are estimated using the equation in the second box.

Emissions ($MMTCO_2E$) =
Total N × fraction unvolatilized (0.9 synthetic or 0.8 organic)
× 0.01 (kg N_2O-N/kg N) × 44/28 (Ratio of N_2O to N_2O-N) × 298 (GWP)
÷ 1,000,000,000 (kg/$MMTCO_2E$)

Emissions ($MMTCO_2E$) =
Total N × fraction volatilized (0.1 synthetic or 0.2 organic)
× 0.001 (kg N_2O-N/kg N) × 44/28 (Ratio of N_2O to N_2O-N) × 298 (GWP)
÷ 1,000,000,000 (kg/$MMTCO_2E$)

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Agricultural soils - animals & runoff (nitrous oxide)

Agriculture Soils - Emissions from Animals & Runoff 2018

	Number of Animals ('000 head)	Total K-Nitrogen Excreted (kg)	Indirect Animal N_2O Emissions (metric tons N)	K-NITROGEN EXCRETED BY MANAGEMENT SYSTEM (kg): Managed Systems	Unmanaged Systems - Pasture, Range, and Paddock	Unmanaged Systems - Daily Spread	DIRECT EMISSIONS (MT N) Manure Applied to Soils	Pasture, Range and Paddock	Leaching and Runoff	
Dairy Cattle										
Dairy Cows	12.0	1,522,918	3	784,885	738,033	-	8	15	6,826	Unvolatilized N fror
Dairy Replacement Heifers	4.0	275,488	1	70,635	164,306	39,840	1	3	121,056,149	Unvolatilized N fror
Beef Cattle									**36,319**	**Fertilizer Runoff/L**
Feedlot Heifers	0.5	26,017	0	26,017	NA	NA	0	NA		
Feedlot Steer	0.9	49,764	0	49,764	NA	NA	0	NA	58,875,402	Total N excreted by
Bulls	31.0	2,566,674	5	NA	2,566,674	NA	NA	51	**17,663**	**Manure Runoff/Le**
Calves	167.0	3,361,016	7	NA	3,361,016	NA	NA	67		
Beef Cows	473.0	34,497,790	69	NA	34,497,790	NA	NA	690	**405**	**TOTAL Runoff/Lea**
Steer Stockers	90.0	3,745,249	7	NA	3,745,249	NA	NA	75		
Total Beef Heifers	110.0	5,578,864	11	NA	5,578,864	NA	NA	112		
Swine										
Breeding Swine	2.0	29,269	0	9,212	19,529	NA	0	0		
Market Under 60 lbs	1.0	5,333	0	1,678	3,558	NA	0	0		
Market 60-119 lbs	1.0	8,002	0	2,519	5,339	NA	0	0		
Market 120-179 lbs	1.0	13,367	0	4,207	8,919	NA	0	0		
Market over 180 lbs	1.0	17,887	0	5,630	11,934	NA	0	0		
Poultry										
Layers										
Hens > 1 yr	2,078.0	1,078,544	2	1,078,544	NA	NA	10	NA		
Pullets	637.0	330,622	1	330,622	NA	NA	3	NA		
Chickens	99.0	71,547	0	71,547	NA	NA	1	NA		
Broilers	10,423.6	3,287,198	7	3,287,198	NA	NA	31	NA		
Turkeys	303.6	470,965	0.9	466,255	4,710	NA	4	0		
Other										
Sheep on Feed	6.4	26,389	0	10,248	16,140	NA	0	0		
Sheep Not on Feed	6.5	85,282	0	52,162	33,120	NA	1	1		
Goats	18.9	198,856	0	NA	198,856	NA	NA	4		
Horses	40.5	1,628,362	3	NA	1,628,362.18	NA	NA	33		
TOTAL		**58,875,402**	**118**	**6,251,125**	**52,582,397**	**39,840**	**61**	**1,052**		

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Agriculture soils - Fertilizer related emissions (nitrous oxide)

Agriculture Soils - Emissions from Fertilizers 2018

☑ Default Fertilizer

Fertilizer Calculations

Growing Year Entry	Total Fertilizer Use (kg N)	Total N in Fertilizers (Calendar Year)	Unvolatized N (kg)	Volatized N (kg)	Direct N_2O Emissions (metric tons)	Indirect N_2O Emissions (metric tons)	Direct Emissions (MMTCE)	Indirect Emissions (MMTCE)	Direct Emissions (MMTCO$_2$E)	Indirect Emissions (MMTCO$_2$E)
Synthetic	134,506,832	134,506,832	121,056,149	13,450,683	1,902	211	0.15461	0.01718	0.5669	0.0630
Organic	217,811	217,811	6,826	1,707						
Dried Blood		-								
Compost		-								
Dried Manure	9,687	9,687								
Activated Sewage Sludge	56,260	56,260								
Other Sewage Sludge		-								
Tankage		-								
Other	151,865	151,865								
Dried Manure %	4%	4%								
Non-Manure Organics	208,125	208,125								
Manure Organics	9,687	9,687								

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Agriculture soils – residues and legumes

Agriculture Soils - Emissions from Residues, Legumes, & Histosols 1990

Default Crop Data? ☑

Legumes and Crop Residue Calculations

	Units	Crop Production	Crop Production (metric tons)	N Returned to Soils (kg)	N-Fixed by Crops (kg)
Alfalfa	'000 tons		-	NA	-
Corn for Grain	'000 bushels		548,055	2,603,372	NA
All Wheat	'000 bushels		350,263	2,362,950	NA
Barley	'000 bushels		-	-	NA
Sorghum for Grain	'000 bushels		211,338	2,617,054	NA
Oats	'000 bushels		-	-	NA
Rye	'000 bushels		-	-	NA
Millet	'000 bushels		-	-	NA
Rice	'000 hundredweight		1,201,693	11,022,886	NA
Soybeans	'000 bushels		1,143,059	43,229,237	92,484,909
Peanuts	'000 lbs		-	-	-
Dry Edible Beans	'000 hundredweight		-	-	-
Dry Edible Peas	'000 hundredweight		-	-	-
Austrian Winter Peas	'000 hundredweight		-	-	-
Lentils	'000 hundredweight		-	-	-
Wrinkled Seed Peas	'000 hundredweight		-	-	-
Red Clover	metric tons		-	NA	-
White Clover	metric tons		-	NA	-
Birdsfoot Trefoil	metric tons		-	NA	-
Arrowleaf Clover	metric tons		-	NA	-
Crimson Clover	metric tons		-	NA	-
TOTAL			**3,454,407**	**61,835,498**	92,484,909

	Direct N_2O Emissions (metric tons N_2O)	Direct Emissions (MMTCE)	Direct Emissions ($MMTCO_2E$)
Residues	971.7	0.0790	0.2896
Legumes	1,453.3	0.1181	0.4331

	Acreage Cultivated	Hectares Cultivated	Emissions (kg N_2O-N)	Direct N_2O Emissions (metric tons N_2O)	Direct Emissions (MMTCE)	Direct Emissions ($MMTCO_2E$)
Temperate Climate		-	-	-	-	-
Sub-tropical Climate		-	-	-	-	-
TOTAL			-	-		

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Rice cultivation emissions estimation equation

Rice cultivation is calculated by multiplying the primary and ratoon crop to seasonal emissions factors then converting to $MMTCO_2E$

Equation 9. Emission Equation for Rice Cultivation

Emissions (($MMTCO_2E$) =
Area Harvested ('000 acres) × 1/2.471 (ha/acre) × Emission Factor (kg CH_4/ha-season) × 25 (GWP) ÷ 1,000,000,000 (kg/($MMTCO_2E$)

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Rice Cultivation

5. Rice Cultivation in Louisiana

Check All Boxes

Clear All Data

Rice Cultivation 1990 ☑ Default Harvested Area?

Crop Season	Area Harvested ('000 acres)		Area Harvested (hectares)		Seasonal Emission Factor (kg CH_4/ha-season)		Emissions (kg CH_4)		Emissions (MMTCH_4)		Emissions (MMTCE)		Emissions (MMTCO_2E)
Primary	545	=	220,558	x	237	=	52,292,945	=	0.052	=	0.35654	=	1.30732
Ratoon	174	=	70,579	x	780	=	55,051,396	=	0.055	=	0.37535	=	1.37628
TOTAL							**107,344,341**		**0.107**		**0.732**		**2.684**

Rice Cultivation 1991 ☑ Default Harvested Area?

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Liming of soils emissions estimation equation

Carbon emissions for limestone and dolomite are summed and multiplied by a carbon emissions factor

Equation 10. Emission Equation for Liming of Soils

Emissions ($MMTCO_2E$) =
Total Limestone or Dolomite Applied to Soil (1,000 metric tons) × Emission Factor (tons C/ton limestone or dolomite) × 44/12 (ratio of CO_2 to C) ÷ 1,000,000 (to yield $MMTCO_2E$)

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Liming of Soils

6. Liming of Soils in Louisiana

Return to Control Sheet

Click here to find possible data sources.

Emissions from Liming of Soils are calculated by summing carbon emissions from the application of both limestone and dolomite to soil. The masses of limestone and dolomite are multiplied by their carbon emission factors, converted to million metric tons carbon dioxide equivalent, and then summed. For more information, please refer to the Agriculture Chapter of the User's Guide.

Check All

Clear All Data

Year		Total Applied to Soil ('000 Metric Tons)		Emission Factor (Ton C/Ton limestone)		Carbon Dioxide Emissions ($MTCO_2E$)		Total Carbon Dioxide Emissions ($MMTCO_2E$)	
1990	Limestone	-	x	0.059	=	-	=	-	Default Activity Data?
	Dolomite	-	x	0.064	=	-			
1991	Limestone	-	x	0.059	=	-	=	-	Default Activity Data?
	Dolomite	-	x	0.064	=	-			

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Urea fertilization emissions estimation equation (CO_2)

Urea use result in CO_2 emissions. Total urea applied to soils is multiplied by emissions factor

Equation 11. Emission Equation for Urea Fertilization

Emissions ($MMTCO_2E$) =
Total Urea Applied to Soil (metric tons) × Emission Factor (tons C/ton urea) × 44/12 (ratio of CO_2 to C) ÷ 1,000,000 (to yield $MMTCO_2E$)

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Urea fertilization (CO_2)

7. CO2 from Urea Fertilization in Louisiana

Return to Control Sheet

Click here to find possible data sources.

The use of urea as a fertilizer results in CO_2 emissions that were previously fixed during the industrial production process. The amount of urea applied to soil is multiplied by the carbon emission factor, and then converted to million metric tons carbon dioxide equivalent. For more information, please refer to the Agriculture Chapter of the User's Guide.

Check All

Clear All Data

Year	Total Urea Applied to Soil (Metric Tons)		Emission Factor (Ton C/Ton urea)		Carbon Dioxide Emissions ($MTCO_2E$)		Carbon Dioxide Emissions ($MMTCO_2E$)	
1990	71,605	x	0.20	=	52,510	=	0.053	☑ Default Activity Data?
1991	52,591	x	0.20	=	38,566	=	0.039	☑ Default Activity Data?

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Agricultural residue burning emissions estimation equation

Agricultural residue burning results in CH_4 and N_2O emissions. Crop production is multiplied by a residue factor then burning efficiency and dry matter are applied to determine the amount of CH_4 and N_2O emitted.

Equation 12. General Emission Equation for Agricultural Residue Burning

Emissions (($MMTCO_2E$) =
Crop Production (metric tons) × Residue/Crop Ratio × Fraction Residue Burned Dry Matter Fraction × Burning Efficiency × Combustion Efficiency × C or N Content × Emission Ratio (CH_4-C or N_2O-N) × Mass Ratio (CH_4/C or N_2O/N) × GWP ÷ 1,000,000 (MT/($MMTCO_2E$)

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Agricultural residue burning (CH_4)

CH_4 from Agricultural Residue Burning 1990

☑ Default Crop Production Data?

Crop	Units	Crop Production		Crop Production (metric tons)		Residue/Crop Ratio		Fraction Residue Burned		Dry Matter Fraction		Burning Efficiency		Combustion Efficiency		Carbon Content		Total C Released (metric tons C)		CH4 Emissions (metric tons CH4)		CH_4 Emissions (MMTCE)		CH_4 Emissions ($MMTCO_2E$)
Barley	'000 bushels	0	=	-	x	1.2	x	0.18	x	0.93	x	0.930	x	0.880	x	0.4485	=	-	=	-	=	-	=	-
Corn	'000 bushels	21,576	=	548,055	x	1.0	x	0.00	x	0.91	x	0.930	x	0.880	x	0.4478	=	340	=	2.27	=	0.0000154	=	0.0000566
Peanuts	'000 pounds	0	=	-	x	1.0	x	0.00	x	0.86	x	0.930	x	0.880	x	0.4500	=	-	=	-	=	-	=	-
Rice	'000 cwt	26,469	=	1,201,693	x	1.4	x	0.02	x	0.91	x	0.930	x	0.880	x	0.3806	=	7,635	=	50.90	=	0.0003470	=	0.0012725
Soybeans	'000 bushels	42,000	=	1,143,059	x	2.1	x	0.00	x	0.87	x	0.930	x	0.880	x	0.4500	=	1,068	=	7.12	=	0.0000486	=	0.0001781
Sugarcane	'000 tons	5,056	=	4,586,803	x	0.2	x	1.00	x	0.62	x	0.930	x	0.880	x	0.4235	=	196,192	=	1,307.95	=	0.0089178	=	0.0326987
Wheat	'000 bushels	12,870	=	350,263	x	1.3	x	0.18	x	0.93	x	0.930	x	0.880	x	0.4428	=	28,097	=	187.31	=	0.0012771	=	0.0046828
Other	metric tons		=	-	x		x		x		x		x		x		=	-	=	-	=	-	=	-
________	metric tons		=	-	x		x		x		x		x		x		=	-	=	-	=	-	=	-
TOTAL																		233,333		1,555.55		0.011		0.039

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Agricultural residue burning (N_2O)

N_2O from Agricultural Residue Burning 1990

Crop	Units	Crop Production		Crop Production (metric tons)		Residue/ Crop Ratio		Fraction Residue Burned		Dry Matter Fraction		Burning Efficiency		Combustion Efficiency		Nitrogen Content		Total N Released (metric tons)		N2O Emissions (metric tons)		N_2O Emissions (MMTCE)		N_2O Emissions (MMTCO$_2$E)
Barley	'000 bushels	-	=	-	x	1.2	x	0.18	x	0.93	x	0.93	x	0.88	x	0.0077	=	-	=	-	=	0.0000000	=	0.0000000
Corn	'000 bushels	21,576	=	548,055	x	1.0	x	0.00	x	0.91	x	0.93	x	0.88	x	0.0058	=	4.40	=	0.05	=	0.0000039	=	0.0000144
Peanuts	'000 pounds	-	=	-	x	1.0	x	0.00	x	0.86	x	0.93	x	0.88	x	0.0106	=	-	=	-	=	0.0000000	=	0.0000000
Rice	'000 cwt	26,469	=	1,201,693	x	1.4	x	0.02	x	0.91	x	0.93	x	0.88	x	0.0072	=	144.43	=	1.59	=	0.0001291	=	0.0004735
Soybeans	'000 bushels	42,000	=	1,143,059	x	2.1	x	0.00	x	0.87	x	0.93	x	0.88	x	0.0230	=	54.60	=	0.60	=	0.0000488	=	0.0001790
Sugarcane	'000 tons	5,056	=	4,586,803	x	0.2	x	1.00	x	0.62	x	0.93	x	0.88	x	0.0040	=	1,853.06	=	20.38	=	0.0016566	=	0.0060743
Wheat	'000 bushels	12,870	=	350,263	x	1.3	x	0.18	x	0.93	x	0.93	x	0.88	x	0.0062	=	393.41	=	4.33	=	0.0003517	=	0.0012896
Other		-	=	-	x	-	x	-	x	-	x	-	x	-	x		=	-	=	-	=	0.0000000	=	0.0000000
		-	=	-	x	-	x	-	x	-	x	-	x	-	x		=	-	=	-	=	0.0000000	=	0.0000000
TOTAL																		2,449.90		26.95		0.00219		0.00803

Source: EPA, State Inventory Tool Users Guide, Agriculture. 2020.

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Louisiana Agricultural GHG Emission Trends

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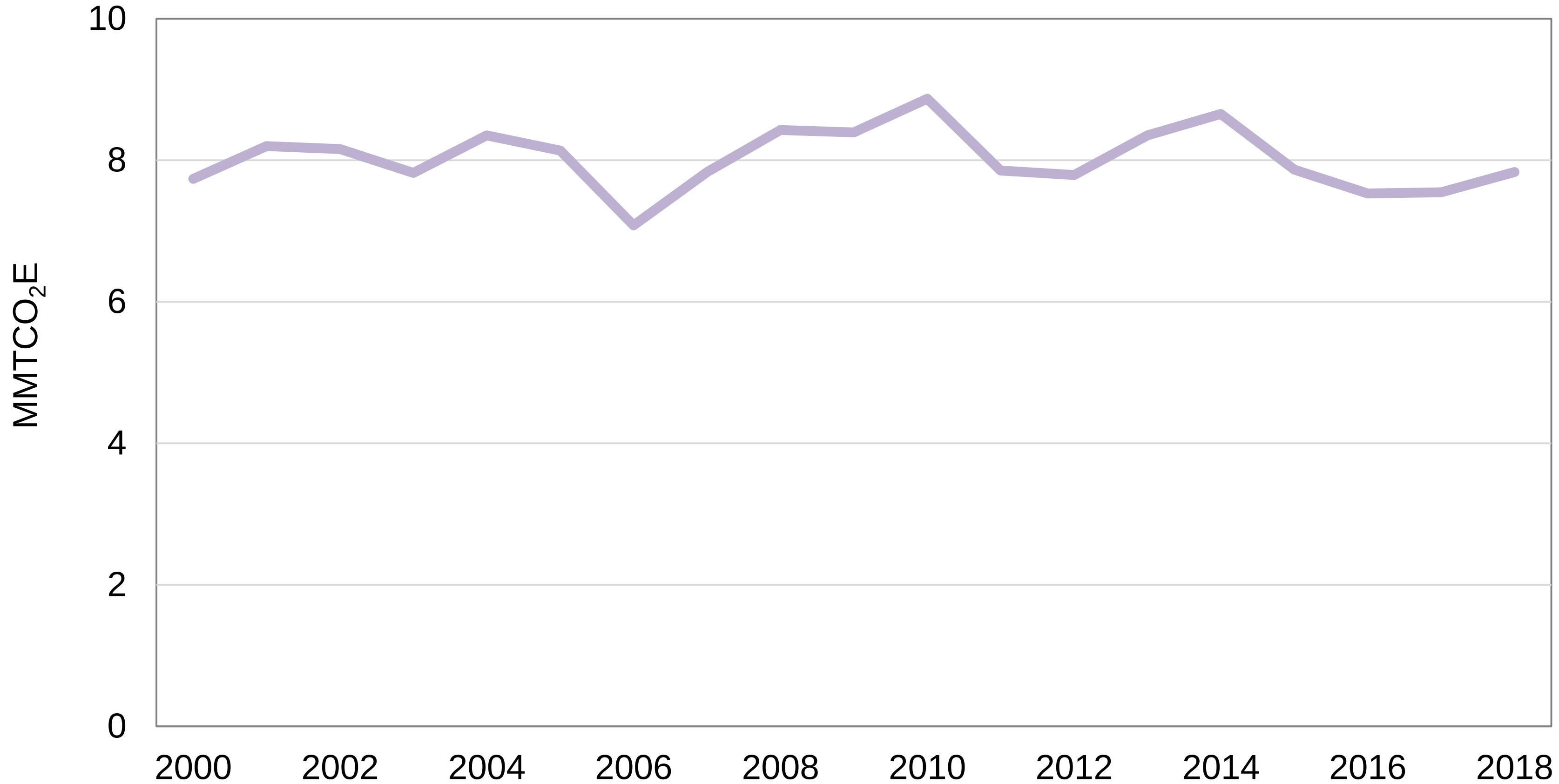
Louisiana total agricultural emission trends

GHG agricultural emissions in Louisiana have been relatively flat over the past two decades. Total GHG emissions hover, annually, around 8 million metric tons.



Source: USDA, AAPFC, USGS

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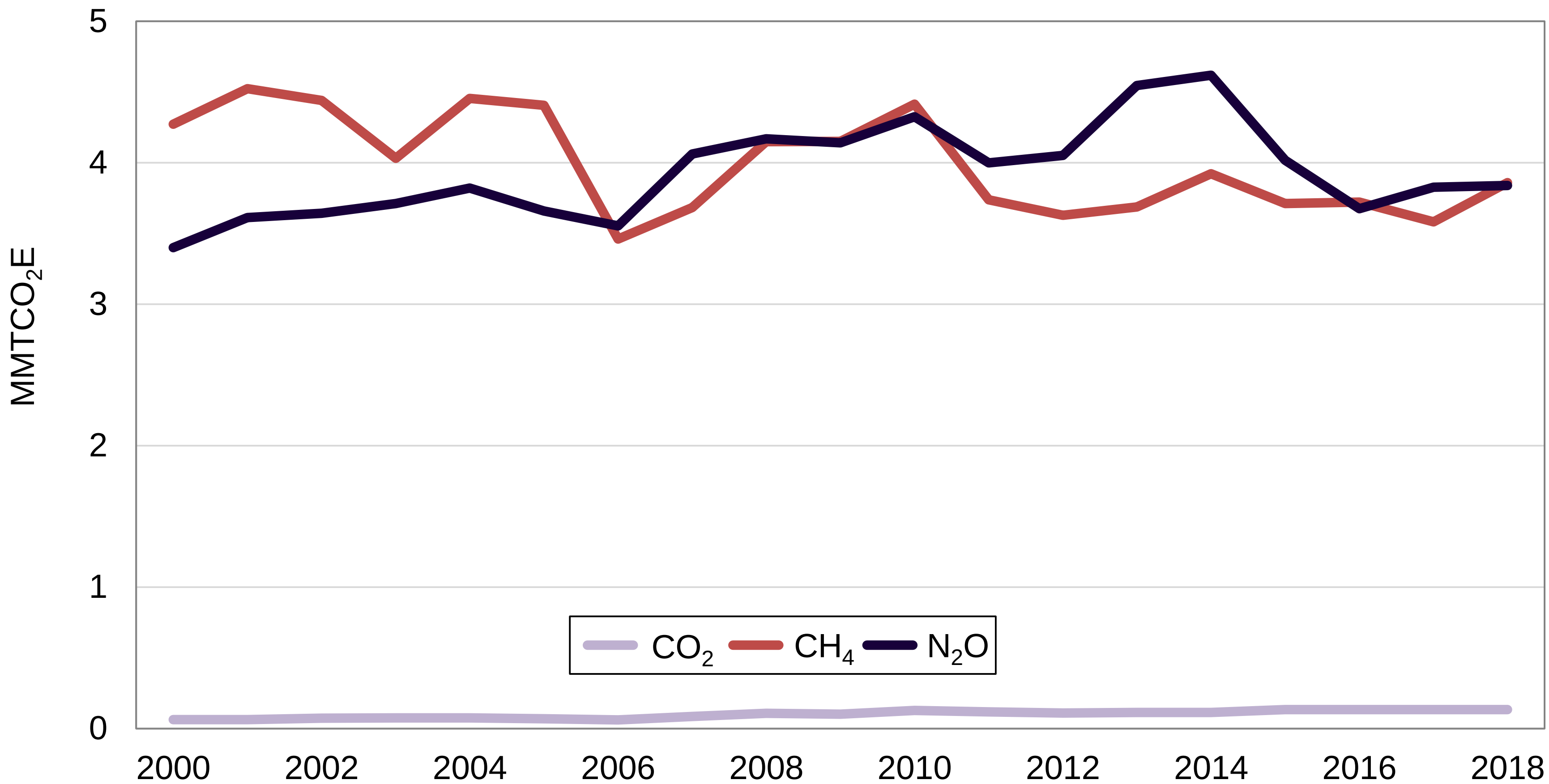
Louisiana agricultural GHG emissions by type

Methane and carbon dioxide emissions dominate agricultural sector GHG emissions. Nitrous oxide are a very small share of the total GHG emissions for this sector in Louisiana



Source: USDA, AAPFC, USGS

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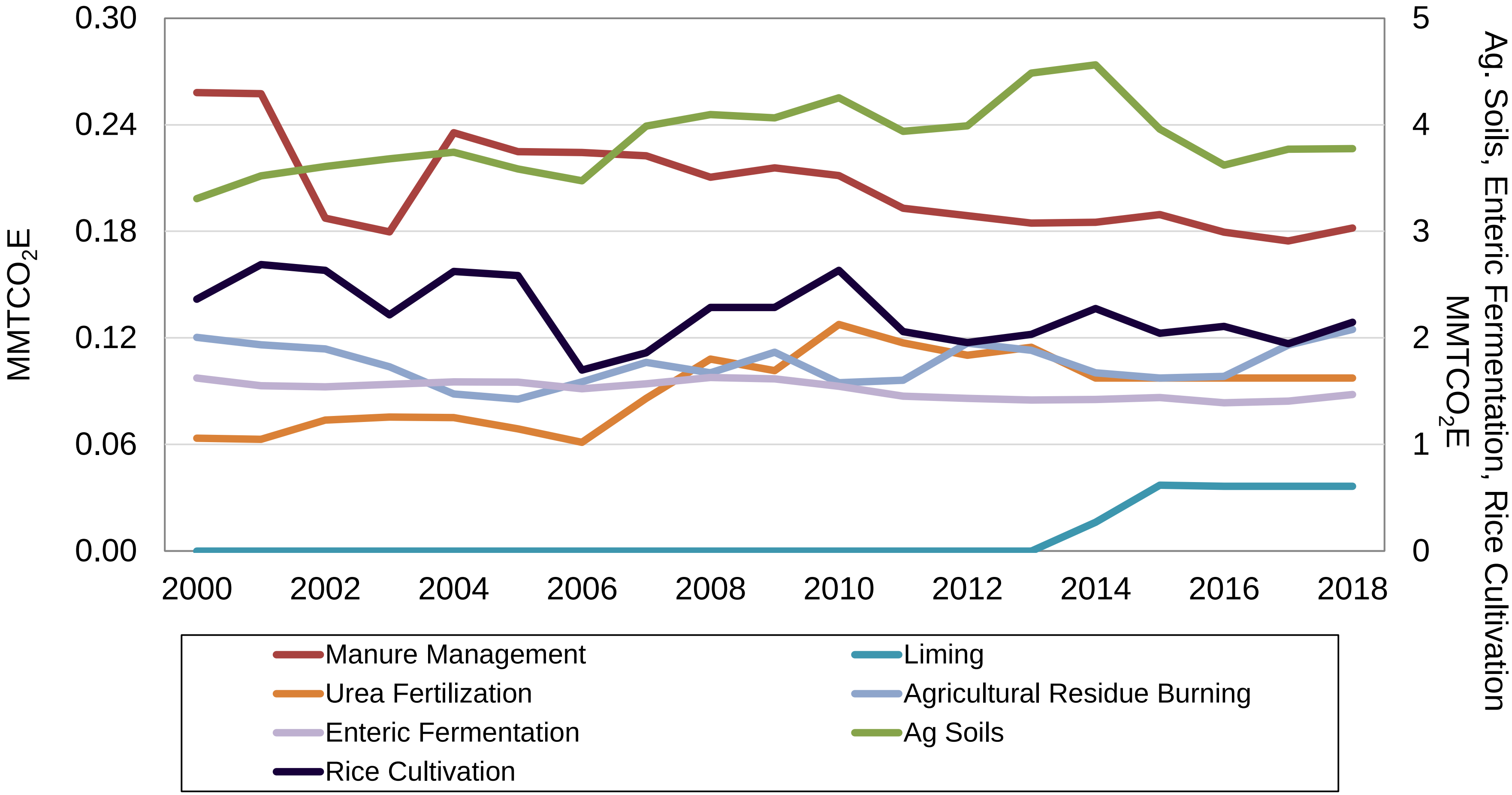
Louisiana agricultural emission trends by agricultural activity

Agricultural sector GHG emissions have been relatively stable across all activity types. GHG emissions associated with rice cultivation have fallen from their 2004 peak by close to one million metric tons.



Source: USDA, AAPFC, USGS

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Louisiana Agricultural GHG Emission Shares

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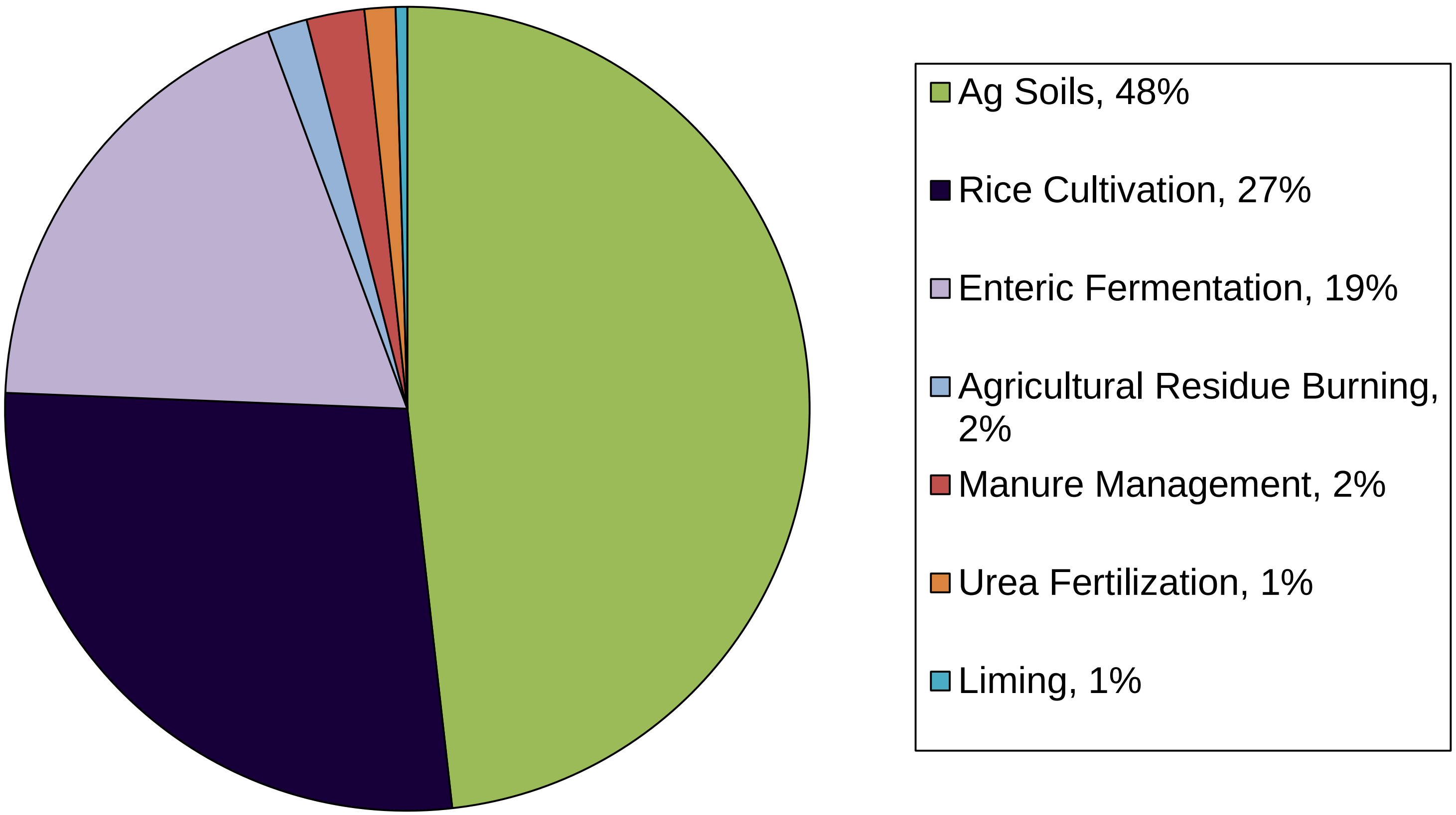
Louisiana agricultural GHG emission shares by source (2018).

Agricultural solids and rice cultivation dominate Louisiana agricultural GHG emissions.



Source: USDA, AAPFC, USGS

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2018 Summary Calculation: Agricultural GHG Emissions

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2018 Summary estimates

Louisiana's agricultural activities contribution 7.8 million metric tons to its 2018 GHG inventory.

GHG emissions by type/activity	2018 $MMTCO_2E$
CO_2	
Liming	0.036
Urea Fertilization	0.097
CH_4	
Enteric Fermentation	1.468
Manure Management	0.139
Rice Cultivation	2.147
Agricultural Residue Burning	0.105
N_2O	
Manure Management	0.043
Agricultural Soils	3.777
Agricultural Residue Burning	0.020
Total	**7.832**

Source: USDA, AAPFC, USGS

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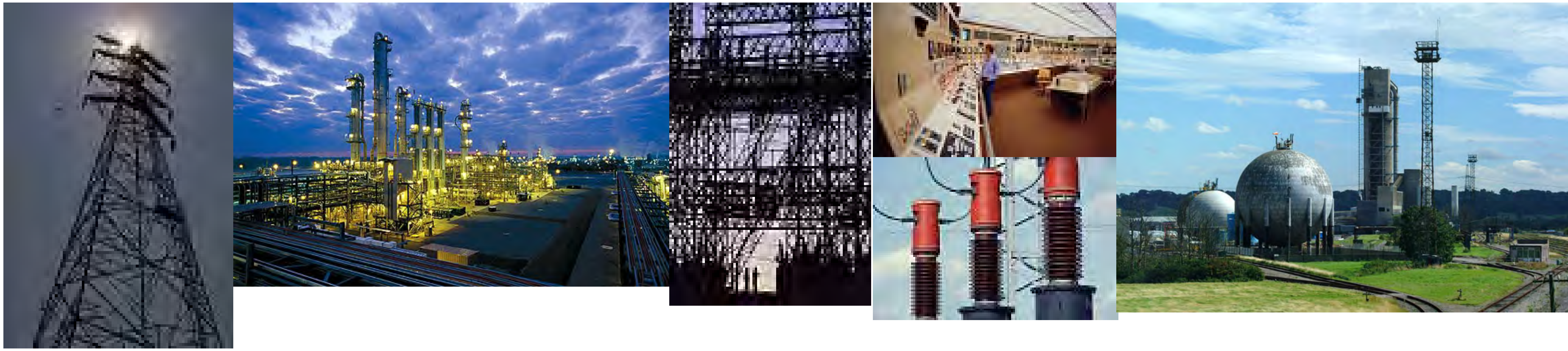

Louisiana 2021 GHG Inventory. Appendix 11: Land, land use, and wetlands emissions estimates

Prepared on the behalf of the Governor’s Office of Coastal Affairs.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

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Background

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How land and land use impact GHG emissions/concentrations

- Human activity uses land and alternatives the biosphere in many ways. One important activity is how humans use land and forestry.
- Human use of land and forestry can change the balance between GHG emissions, on the one hand, and the uptake of those GHG emissions, on the other.
- These activities can include such things as clearing an area of forest to create cropland, restocking a logged forest, draining a wetland, or allowing a pasture to revert to grassland.
- Carbon in the form of yard debris and food scraps that are in landfills are also considered.
- Carbon contained in wetlands is also added per additional EPA data that was independently provided by EPA from national inventory estimates to the author.

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Land and land use GHG module

- The land and land use module is designed to measure net GHG emissions from land use and forestry.
- This module estimates CO_2, CH_4, and N_2O emissions from the fertilization of settlement soils and forest fires.
- This module also estimates carbon flux from forest management, urban trees, landfilled yard trimmings and food scraps and agricultural soils.
- Note that the liming of soils and urea fertilizer were previously measured in this section but now fall under the agricultural module.

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Forest carbon flux equation (net CO_2 emissions)

The forest flux estimation process is a function of carbon emitted from or sequestered in various soils and forestry waste/residue.

Emissions or Sequestration ($MMTCO_2E$) =
Sum of carbon fluxes from aboveground biomass, belowground biomass, dead wood, litter, mineral and organic soils, drained organic soil, and wood products and landfills

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Forest carbon flux equation (net CO_2 emissions)

MMTCO$_2$E (million metric tons of carbon dioxide equivalent)

	Aboveground Biomass		Belowground Biomass		Dead Wood		Litter		Soil (Mineral)		Soil (Organic)		Drained Organic Soil		Wood products and landfills		Total
1990		+		+		+		+		+		+		+		=	-
1991		+		+		+		+		+		+		+		=	-
1992		+		+		+		+		+		+		+		=	-

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Urban trees equation (sequestered CO_2)

The estimation process focusses exclusively on the sequestration benefits of urban trees and tree cover area. The higher the tree cover area, the greater the sequestration benefits.

Sequestration ($MMTCO_2E$) =
Total Urban Area (km^2) × Urban Area with Tree Cover (%) × 100 (ha/km^2) × C Sequestration Factor (metric tons C/ha/yr) × 44/12 (ratio of CO_2 to C) ÷ 1,000,000 (to yield $MMTCO_2E$)

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Urban trees equation (sequestered CO_2)

Year	Total Urban Area (km^2)		Percent of Urban Area with Tree Cover		hectare/ km^2		Carbon Sequestration Factor (metric ton C/hectare/year)		Carbon Sequestration ($MMTCO_2E$)
1990	3,650.00	x	35%	x	100	x	2.94	=	1.37
1991	3,716.50	x	35%	x	100	x	2.94	=	1.40
1992	3,783.00	x	35%	x	100	x	2.94	=	1.42

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Settlement soils equation (N_2O)

This equation estimates the nitrous oxide emissions that arise from fertilizer use on managed soils.

Emissions ($MMTCO_2E$) =
Total Synthetic Fertilizer Applied to Settlement Soils (metric ton N) × Emission Factor (percent) × 0.01 (metric tons N_2O-N/metric ton N) × 44/28 (Ratio of N_2O to N_2O-N) × 298 (GWP) ÷ 1,000,000 (MT/$MMTCO_2E$)

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Settlement soils equation (N_2O)

Year	Total Synthetic Fertilizer Applied to Settlements (Metric Tons N)		Emission Factor (percent)		N_2O-N		Direct N_2O Emissions (Metric Tons N_2O Emitted)		N_2O GWP		Carbon Dioxide Emissions (MTCO$_2$E)		Total Carbon Dioxide Emissions (MMTCO$_2$E)
1990	15,453	x	1%	x	1.57	=	242.8	x	298	x	72,364	=	0.072
1991	15,463	x	1%	x	1.57	=	243.0	x	298	x	72,413	=	0.072

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Forest fires equation (CH_4, N_2O)

This equation estimates the nitrous oxide emissions that arise from fertilizer use on managed soils.

Emissions ($MMTCO_2E$) =
Area Burned (ha) × Average Biomass Density (kg dry matter/ha) × Combustion Efficiency (%) × Emission Factor (g gas/kg dry matter burned) × GWP

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Forest fires equation (CH_4, N_2O)

Forest Fires 1990

Forest Type	Area Burned (ha)		Average Biomass Density (kg d.m. / ha)		Combustion efficiency		Emission Factor (g/kg dry matter burned)		MTCH$_4$ Emitted		CH$_4$ GWP		Emissions MMTCO$_2$E
Primary tropical forests		x	139,984	x	36%	x	8.1	=	-	x	25	=	-
Secondary tropical forests		x	139,984	x	55%	x	8.1	=	-	x	25	=	-
Tertiary tropical forests		x	139,984	x	59%	x	8.1	=	-	x	25	=	-
Boreal forest		x	139,984	x	34%	x	8.1	=	-	x	25	=	-
Eucalypt forests		x	139,984	x	63%	x	8.1	=	-	x	25	=	-
Other temperate forests		x	139,984	x	45%	x	8.1	=	-	x	25	=	-
Shrublands		x	139,984	x	72%	x	8.1	=	-	x	25	=	-
Savanna woodlands (early dry season burns)		x	139,984	x	40%	x	4.6	=	-	x	25	=	-
Savanna woodlands (mid/late season burns)		x	139,984	x	74%	x	4.6	=	-	x	25	=	-
Total													-

Forest Fires 1990

Forest Type	Area Burned (ha)		Average Biomass Density (kg d.m. / ha)		Combustion efficiency		Emission Factor (g/kg dry matter burned)		MTN$_2$O Emitted		N$_2$O GWP		Emissions MMTCO$_2$E
Primary tropical forests	0	x	139,984	x	36%	x	0.11	=	-	x	298	=	-
Secondary tropical forests	0	x	139,984	x	55%	x	0.11	=	-	x	298	=	-
Tertiary tropical forests	0	x	139,984	x	59%	x	0.11	=	-	x	298	=	-
Boreal forest	0	x	139,984	x	34%	x	0.11	=	-	x	298	=	-
Eucalypt forests	0	x	139,984	x	63%	x	0.11	=	-	x	298	=	-
Other temperate forests	0	x	139,984	x	45%	x	0.11	=	-	x	298	=	-
Shrublands	0	x	139,984	x	72%	x	0.11	=	-	x	298	=	-
Savanna woodlands (early dry season burns)	0	x	139,984	x	40%	x	0.12	=	-	x	298	=	-
Savanna woodlands (mid/late season burns)	0	x	139,984	x	74%	x	0.12	=	-	x	298	=	-
Total													-

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Yard waste and trimmings equation

This equation estimates the carbon sequestered in landfilled yard trimmings and yard wastes.

$$LFC_{i,t} = \sum_{n} W_{i,n} \times (1 - MC_i) \times ICC_i \times \{[CS_i \times ICC_i] + [(1 - (CS_i \times ICC_i)) \times e^{-k \times (t - n)}]\}$$

where,

t	**= the year for which carbon stocks are being estimated,**
LFC i,t	**= the stock of carbon in landfills in year t, for waste i (grass, leaves, branches, food scraps)**
Wi,n	**= the mass of waste i disposed in landfills in year n, in units of wet weight**
n	**= the year in which the waste was disposed, where 1960 < n < t**
MCi	**= moisture content of waste i,**
CSi	**= the proportion of initial carbon that is stored for waste i,**
ICCi	**= the initial carbon content of waste i,**
e	**= the natural logarithm, and**
k	**= the first order rate constant for waste i, and is equal to 0.693 divided by the half-life for decomposition.**

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Yard waste and trimmings equation

1. Enter the composition of yard trimmings, and the amount of annually landfilled yard trimmings and food scraps

☑ Use Default Percent for All

Content of yard trimmings	Default		Use the Default? (Check for Yes)
% Grass	30.3%	30.3%	☑
% Leaves	40.1%	40.1%	☑
% Branches	29.6%	29.6%	☑
Check -- must add up to 100% in order to continue:		100%	OK

Landfilled yard trimmings and scraps, '000 short tons, wet weight

Default landfilled yard trimmings and food scraps = state population x national landfilled yard trimmings and food scraps per capit

Default grass, leaves, and branches = total landfilled yard trimmings x percentages entered above

2. Calculate the amount of carbon added to landfills annually

Key Assumptions

Initial Carbon Content	Default		Use the Default? (Check for Yes)
Grass	44.9%	44.9%	☑
Leaves	45.5%	45.5%	☑
Branches	49.4%	49.4%	☑
Food Scraps	50.8%	50.8%	☑

Dry Weight/Wet Weight ratio	Default		Use the Default? (Check for Yes)
Grass	30.0%	30.0%	☑
Leaves	70.0%	70.0%	☑
Branches	90.0%	90.0%	☑
Food Scraps	30.0%	30.0%	☑

3. Calculate the total annual stocks of landfilled carbon

Proportion of Carbon Stored Permanently	Default		Use the Default? (Check for Yes)
Grass	53.5%	53.5%	☑
Leaves	84.6%	84.6%	☑
Branches	76.9%	76.9%	☑
Food Scraps	15.7%	15.7%	☑

Half-life of degradable carbon (years)	Default		Use the Default? (Check for Yes)
Grass	5	5	☑
Leaves	20	20	☑
Branches	23.1	23.1	☑
Food Scraps	3.8	3.8	☑

4. Calculate annual flux of carbon stored in landfills

Annual Flux of Carbon Stored in Landfills, '000 metric tons C

Annual flux is calculated by subtracting the current year's C stocks from the previous year's s

	1960	1961	1962	1963	1964
Grass	(9)	(9)	(9)	(8)	(8)
Leaves	(28)	(29)	(30)	(30)	(31)
Branches	(29)	(30)	(30)	(31)	(32)
Food Scraps	(21)	(18)	(17)	(15)	(14)
Total	**(87)**	**(85)**	**(85)**	**(84)**	**(85)**

Source: EPA, State Inventory Tool Users Guide, Land Use, Land Use Change, and Forestry. 2020.

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Forestry and land use GHG emission trends

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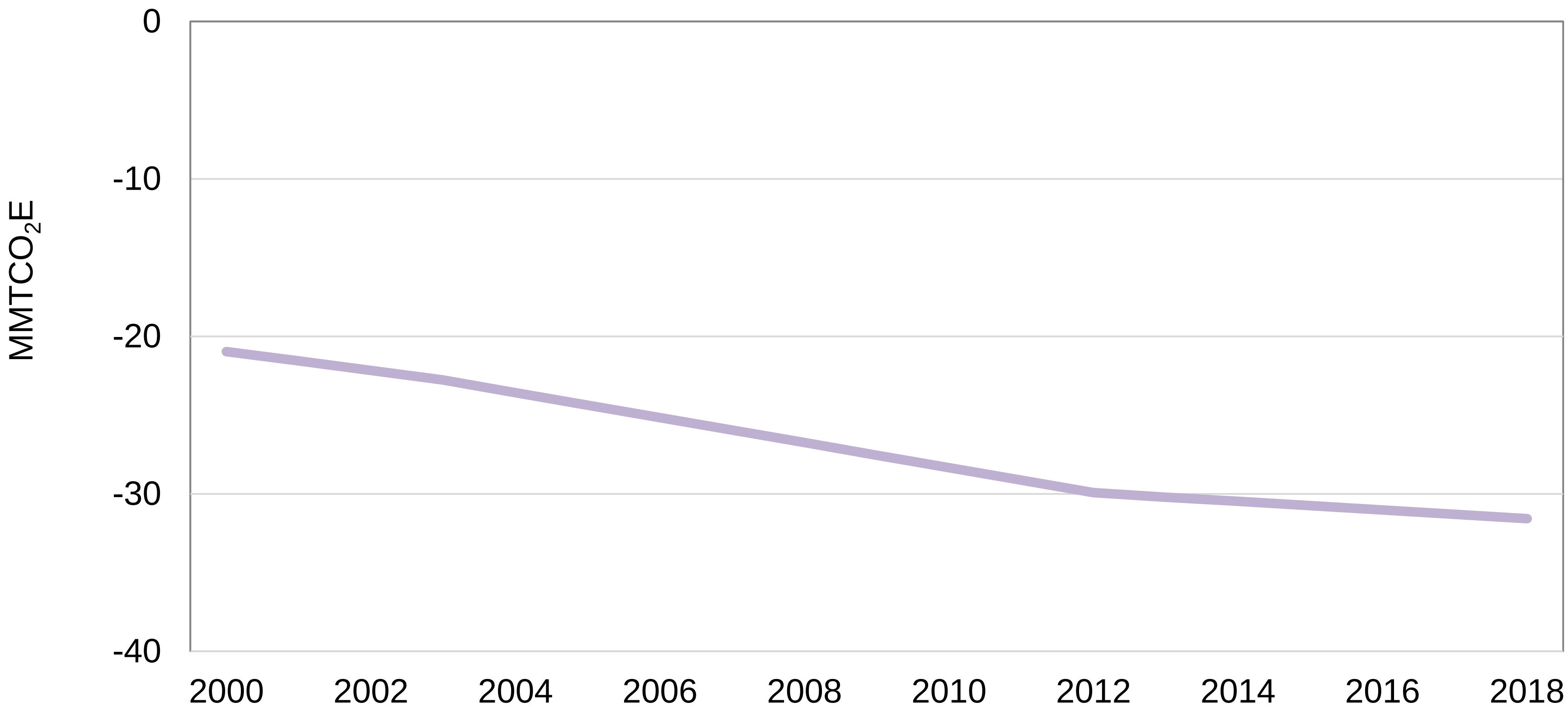
Louisiana net forest carbon flux trends

Net carbon fluxes continue to rise (net sequestered carbon) in Louisiana due to expanded forest land remaining as forest land.



Source: EIA, US Forest Service, EPA

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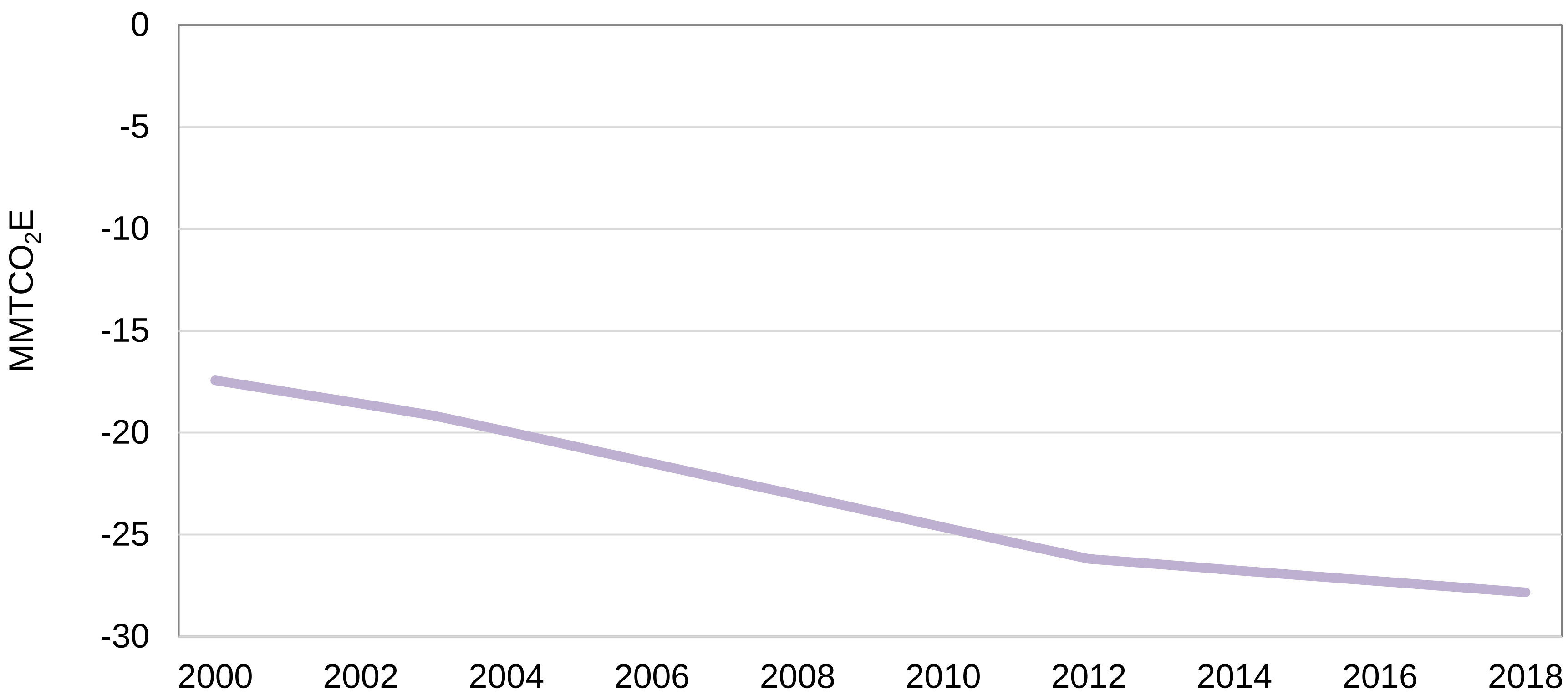
Louisiana forest land remaining as forest land

Over the past two decades, an increasing level of acreage is reverting to standard forests and opposed to forestry lands.



Source: EIA, US Forest Service, EPA

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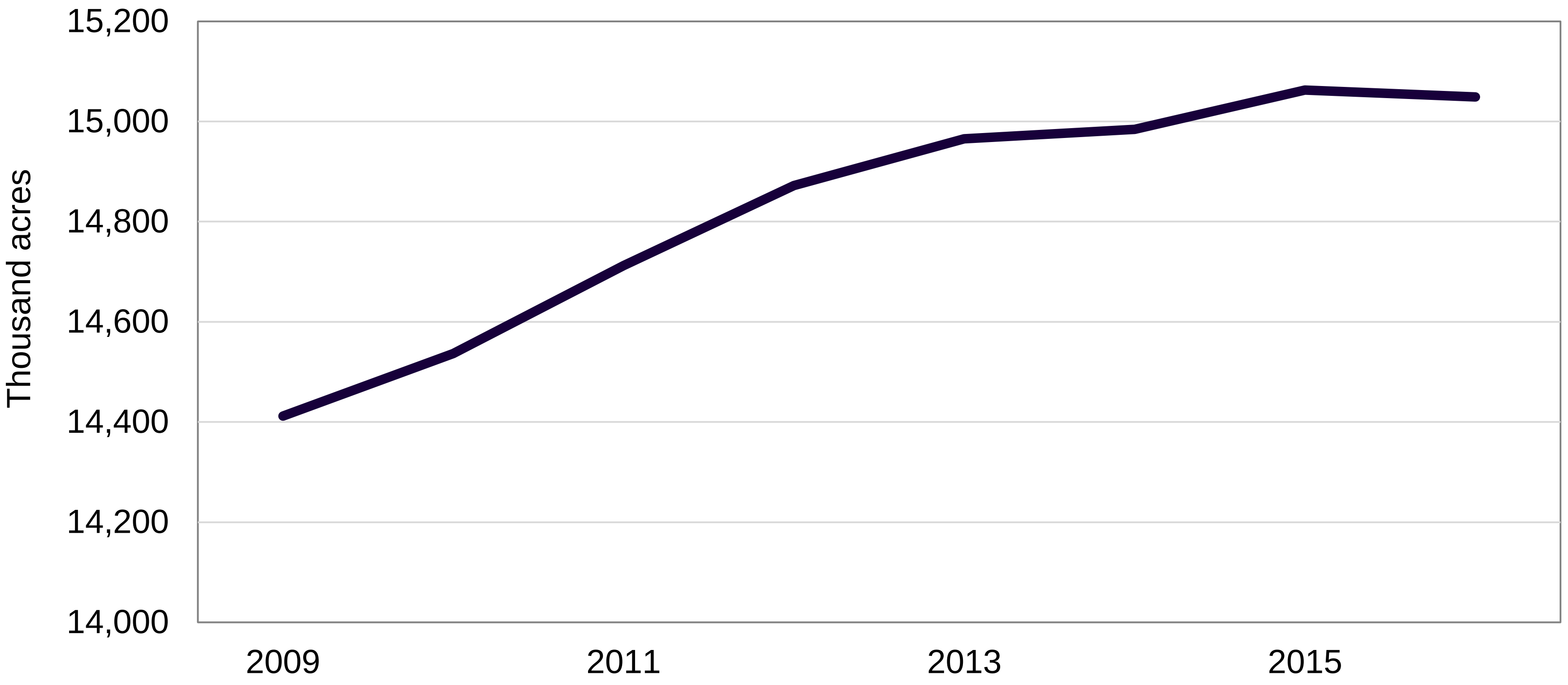
Louisiana area of forest land

The U.S. forest service reports that total Louisiana forest land has been increasing since 2009, particularly during the 2009-2013 time period..



Source: US Forest Service inventory and analysis

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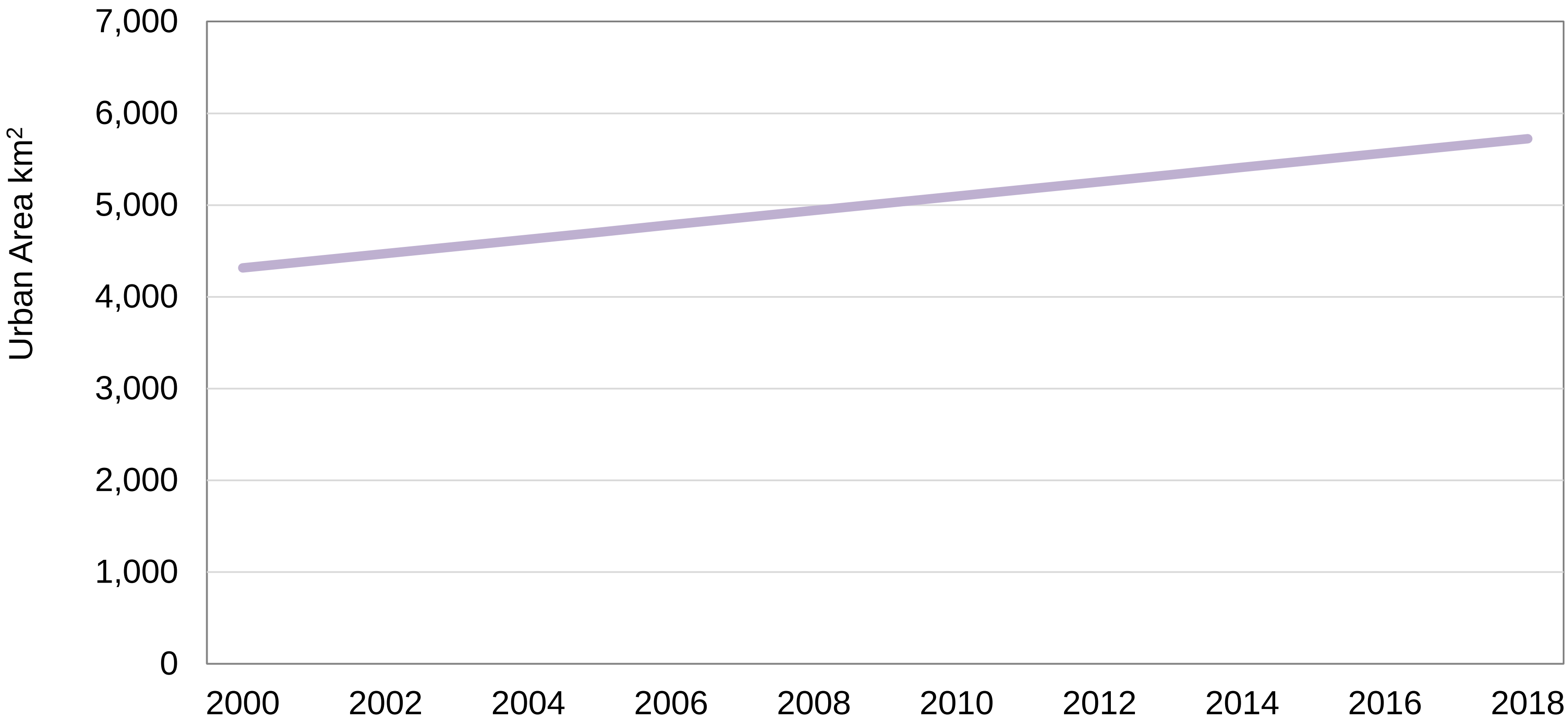
Louisiana urban area trends

In addition, urban area coverage has been on a slight increase since 2000. Thus, the produce per urban tree leads to increasing emissions offsets.



Source: EIA, US Forest Service, EPA

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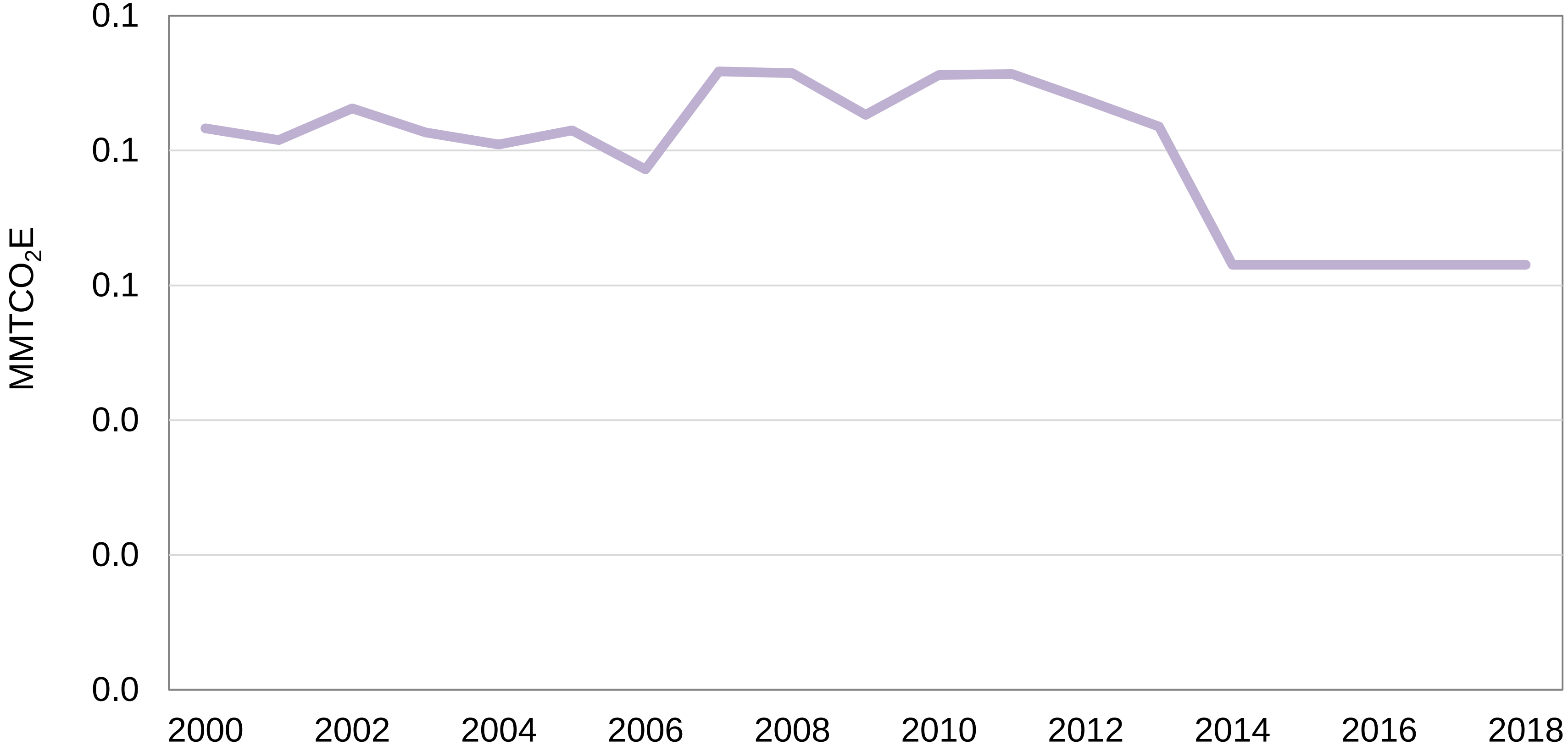
Louisiana settlement soils GHG emissions trends

The application of settlement soils has been decreasing since the mid 2000s.



Source: EIA, US Forest Service, EPA

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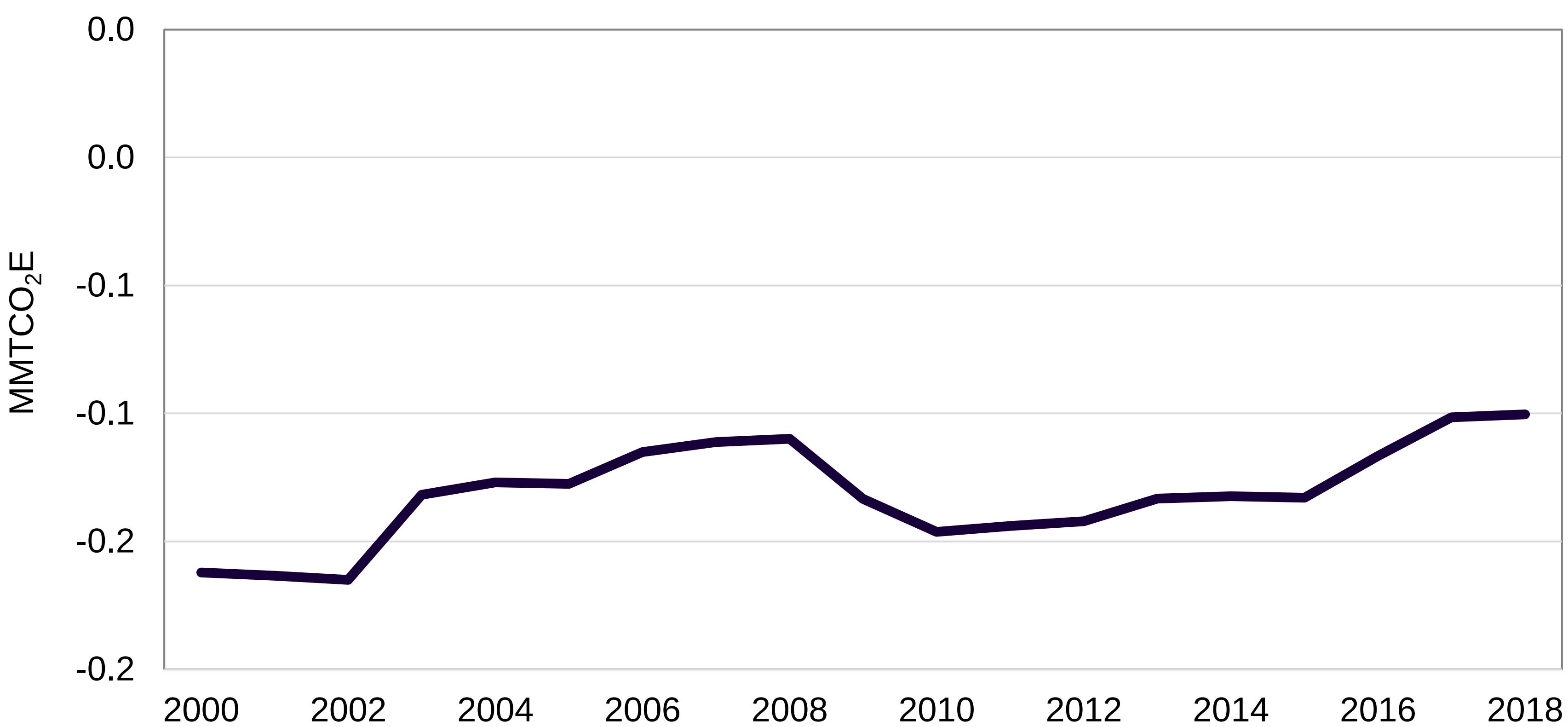
Louisiana landfilled yard trimmings GHG emissions trends

Yard trimmings emissions offsets have been variable. There were down (lower offset) until the 2008-2009 recession, then started to increase until 2012, and have fallen again to a level comparable to 2008.



Source: EIA, US Forest Service, EPA

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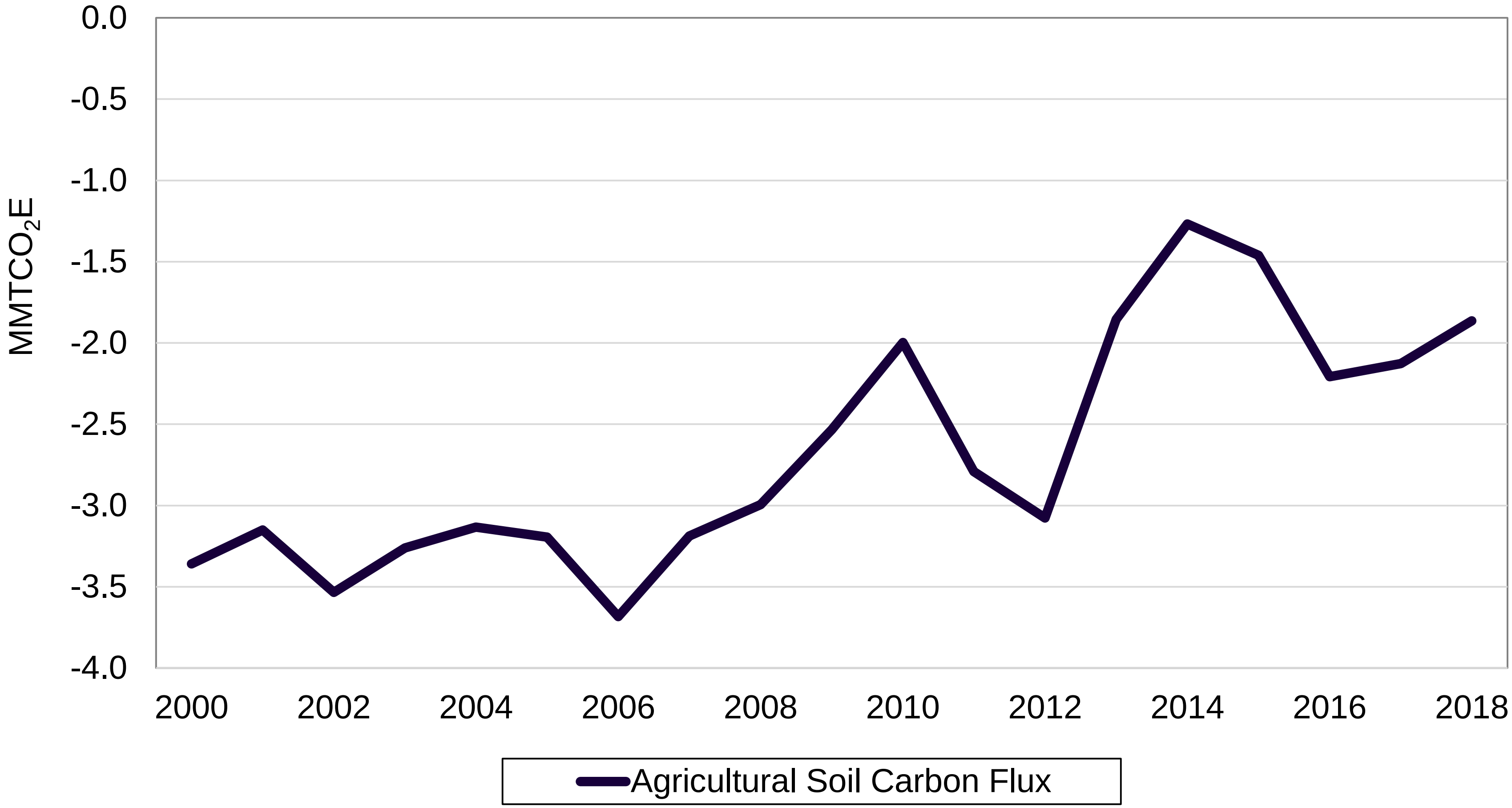
Louisiana agricultural soil carbon flux

Carbon stored in croplands vary with crop composition and land management. Current flux levels are down considerably relative to past trends.



Source: EIA, US Forest Service, EPA

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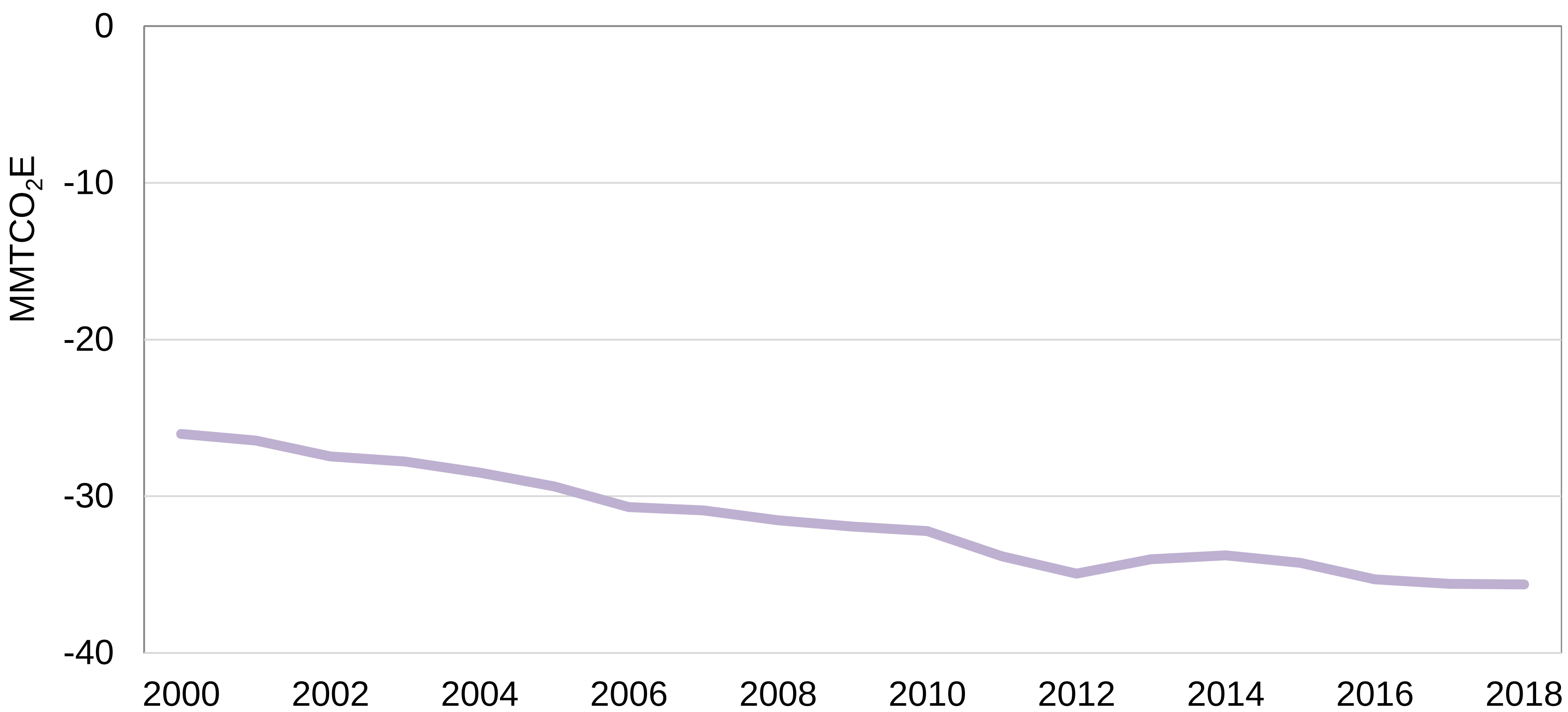
Total net emissions trends, all land and forestry usage

Total sequestered carbon from forestry and land use is up by over 5 million metric tons since 2005. However, this level appears to be flattening out over the past four to five years at a total level of 35 million metric tons sequestered.



Source: EIA, US Forest Service, EPA

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Wetland emissions estimation

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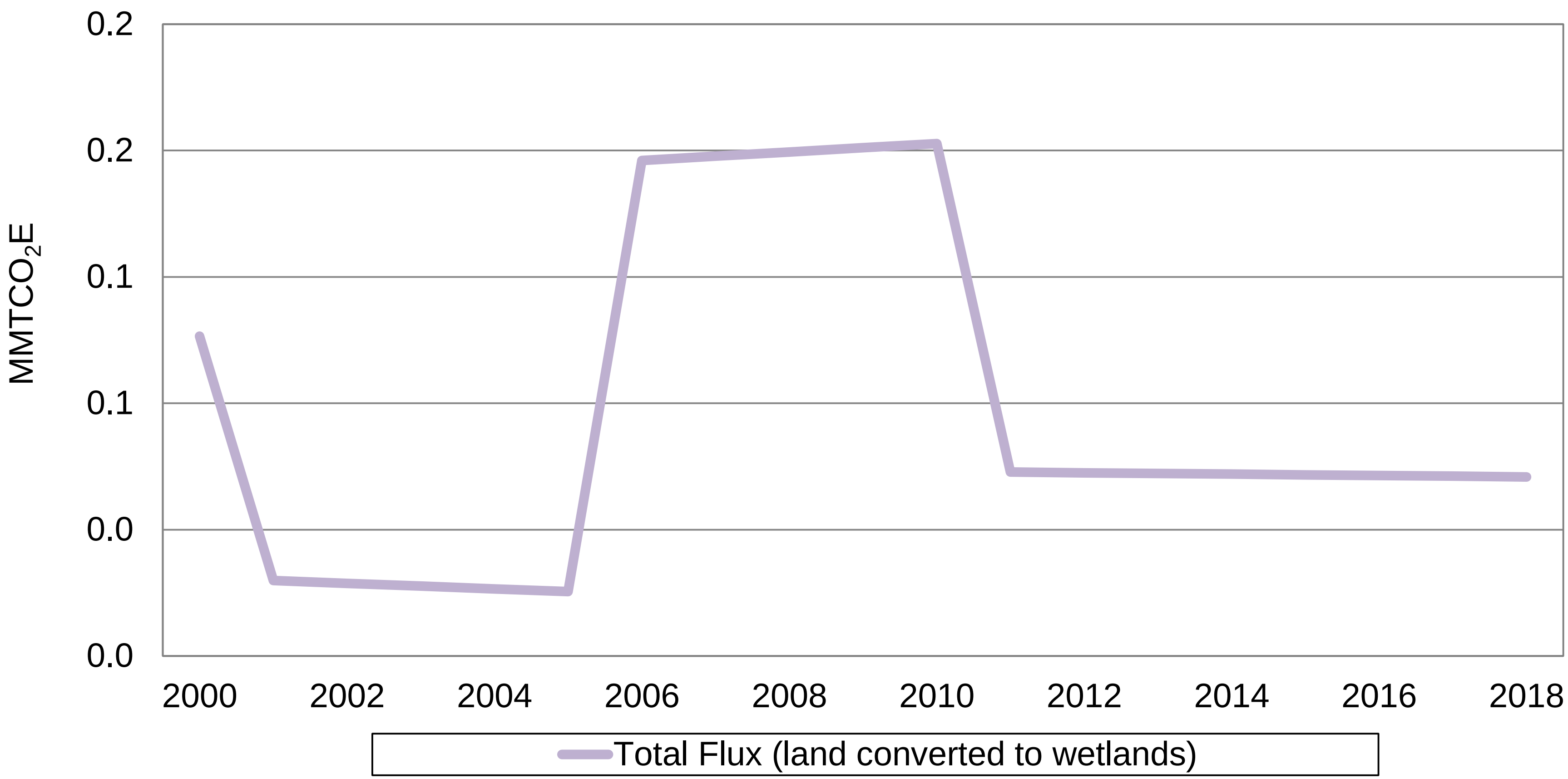
Total land converted to wetlands

Louisiana is a major wetland state and total flux of land converted to wetlands is showed below. Soil C flux is the reason for increase from 2005-2011.



Source: EIA, US Forest Service, EPA

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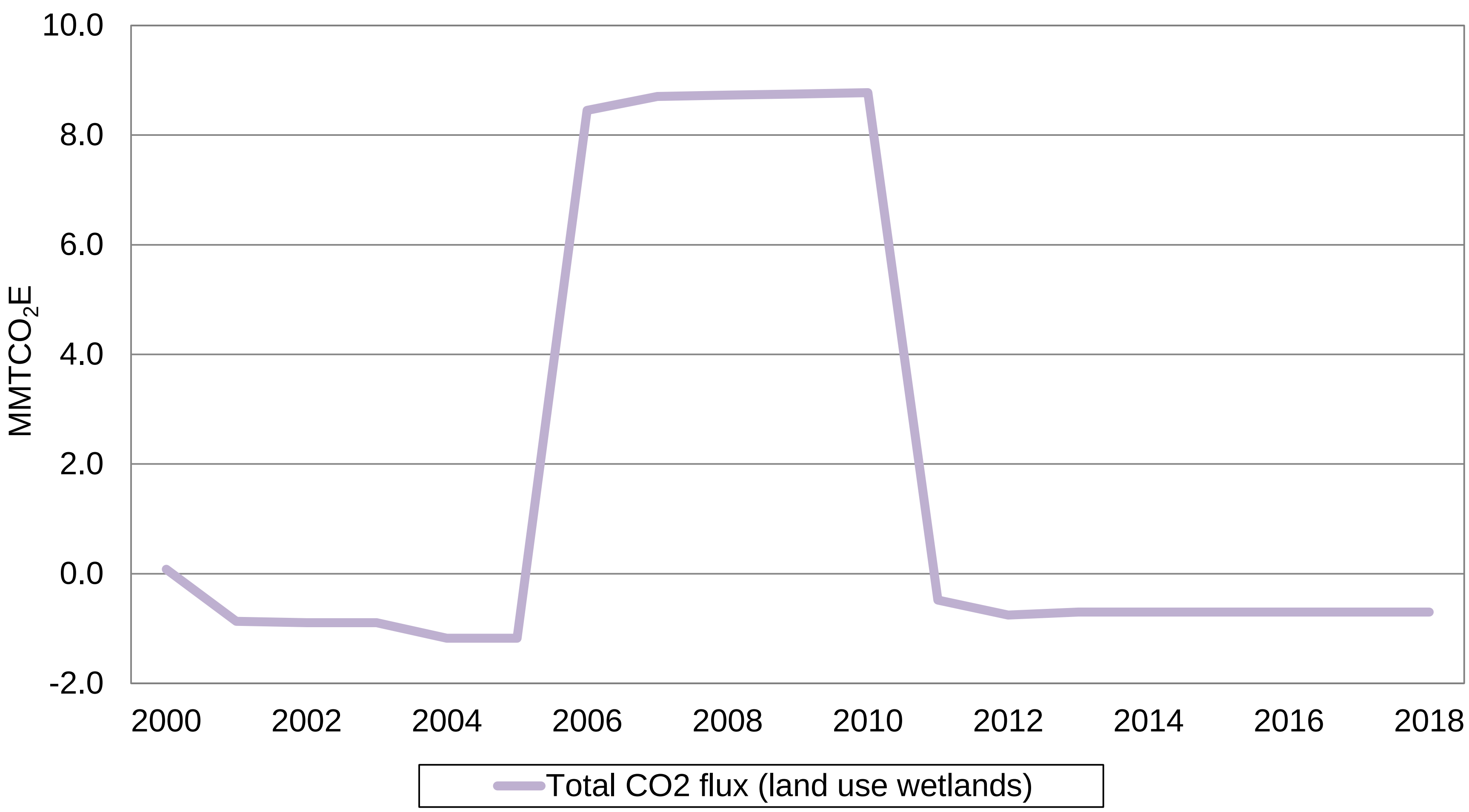
Total wetlands remaining wetlands

Soil C flux is the main driver for increase in flux from 2005-2011.



Source: EIA, US Forest Service, EPA

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Land use and forestry emission shares

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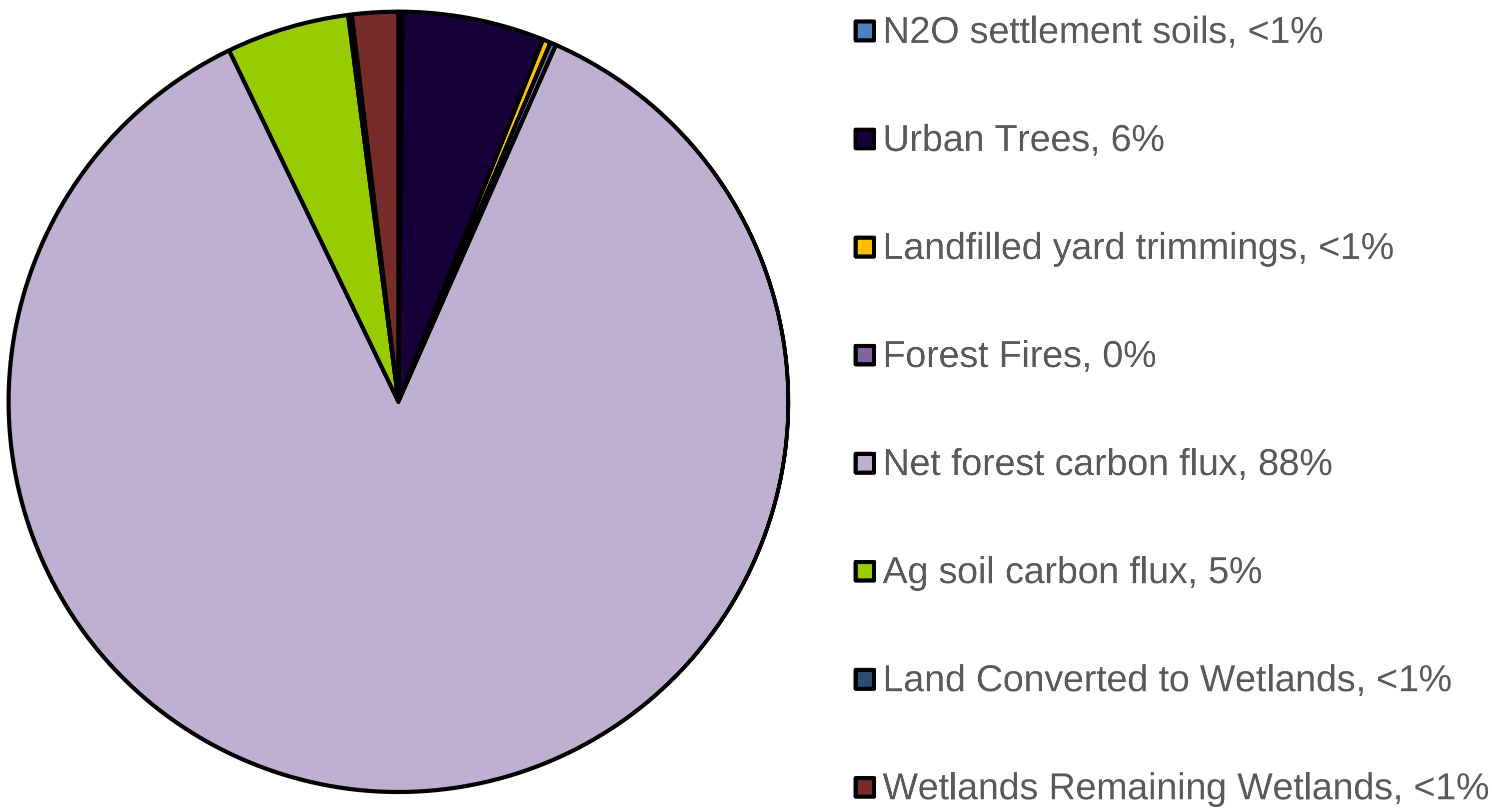

Source: EIA, US Forest Service, EPA

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2018 Summary Calculation: Land and Land-Use

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2018 Summary estimates.

Louisiana land use and forestry represent a net carbon sink for the state and reduce the overall 2018 GHG inventory by 3.8 million metric tons.

Sector	2018 $MMTCO_2E$
Net forest carbon flux	(31.567)
Urban Trees	(2.152)
Agricultural soil carbon flux	(1.864)
Forest Fires	0.090
N_2O settlement soils	0.063
Landfilled yard trimmings	(0.120)
Land Use Wetlands	(0.698)
Land Converted to Wetlands	0.057
Total	**(36.191)**

Source: EIA, US Forest Service, EPA

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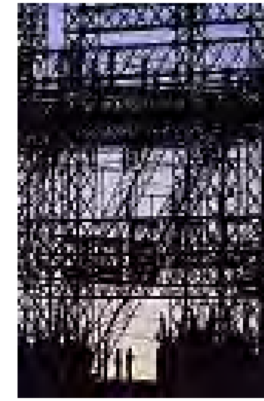


Louisiana 2021 GHG Inventory. Appendix 12: Detailed plant-specific industrial emissions analysis.

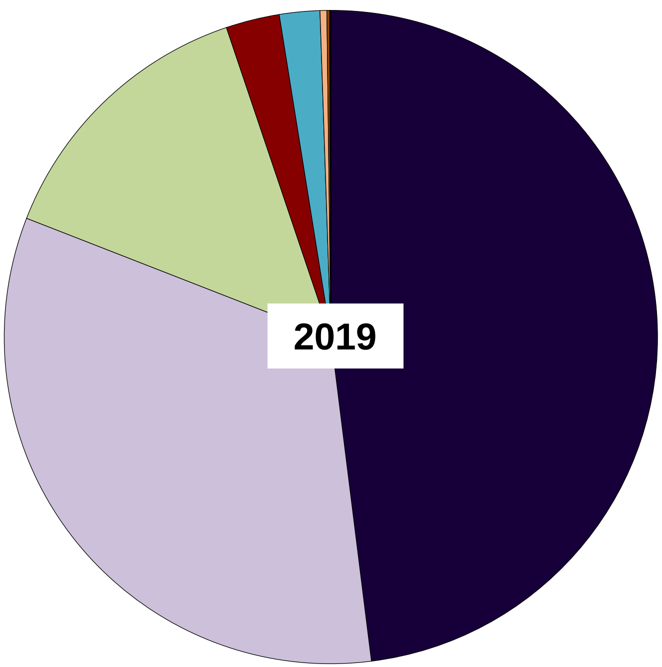
Prepared on the behalf of the Governor’s Office of Coastal Affairs.

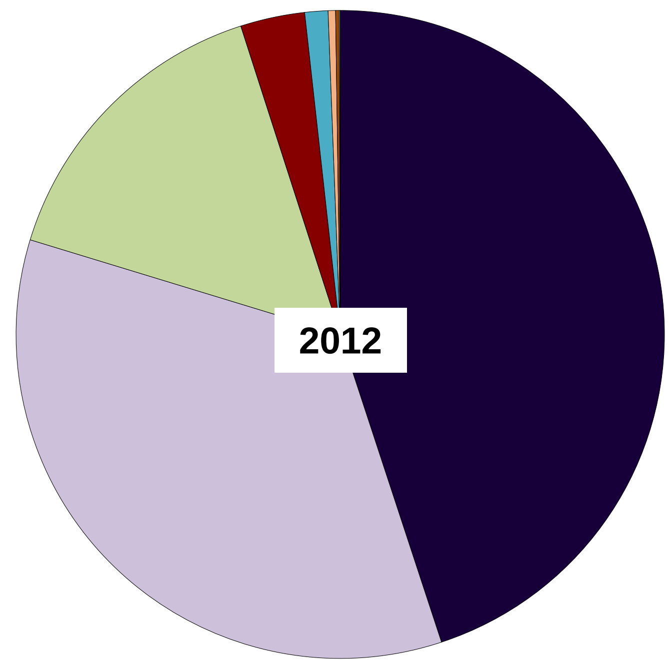
David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Louisiana industrial carbon emissions by sector, 2012 and 2019

Industrial emission shares continue to be concentrated in the chemical (48%) and the refining (35%) sectors. Natural gas processing holds the third position (13.9%). Share of chemicals have increased over the last seven years whilst both refining and natural gas emissions have decreased their relative GHG emissions shares.





Source: EPA FLIGHT

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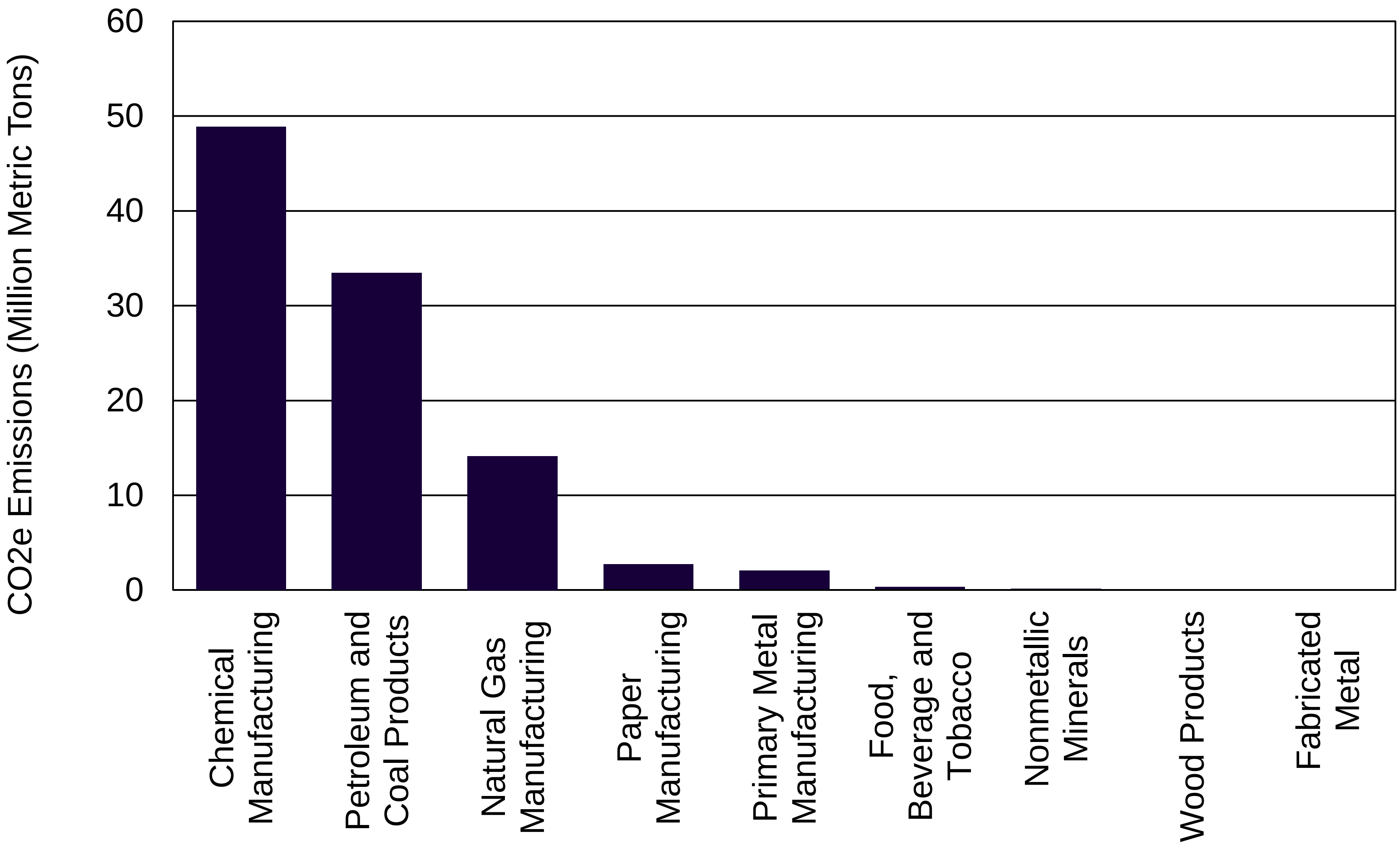
Louisiana industrial emissions, 2019

Chemical, refining, and gas processing industries account for over 96 million tons of GHG emissions (2019).



Source: EPA FLIGHT

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Louisiana industrial carbon emissions: comparisons

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Louisiana industrial carbon emissions, SIT, EPA and EIA (combustion only).

The three primary sources of Louisiana GHG emissions data all have relatively good comparability. Note that EIA data is estimated only for the combustion of fossil fuels and does not include other GHG releases (like methane and nitrous oxides). Thus, the comparison to the right is on CO_2 (combustion) alone.

For 2018, the SIT combustion-based estimates are the highest total industrial emissions (~139 million tons) followed by the EPA FLIGHT data (~135 million tons, combustion/CO_2 only).

	CO_2 emissions ($MMTCO_2E$) (total of CO_2 emissions)			
Year	SIT	EPA	EIA	Total U.S. (EPA)
2000	128.19		114.8	
2001	115.01		99.7	
2002	119.39		105.8	
2003	116.95		103.9	
2004	123.91		113.2	
2005	116.96		106.7	
2006	126.69		115.2	
2007	125.42		118.8	
2008	121.28		122.9	
2009	115.19		111.3	
2010	127.33		116.2	3,049.3
2011	129.05		115.8	2,984.9
2012	128.07	129.70	112.6	2,847.7
2013	124.51	127.90	107.7	2,869.6
2014	122.71	128.65	109.0	2,879.3
2015	122.63	129.00	109.0	2,738.6
2016	130.85	130.37	114.3	2,614.8
2017	134.82	132.25	121.2	2,545.8
2018	138.52	135.18	123.7	2,586.4

Note: EPA (FLIGHT) data not available prior to 2012

Sources: EPA FLIGHT, EPA SIT, EIA

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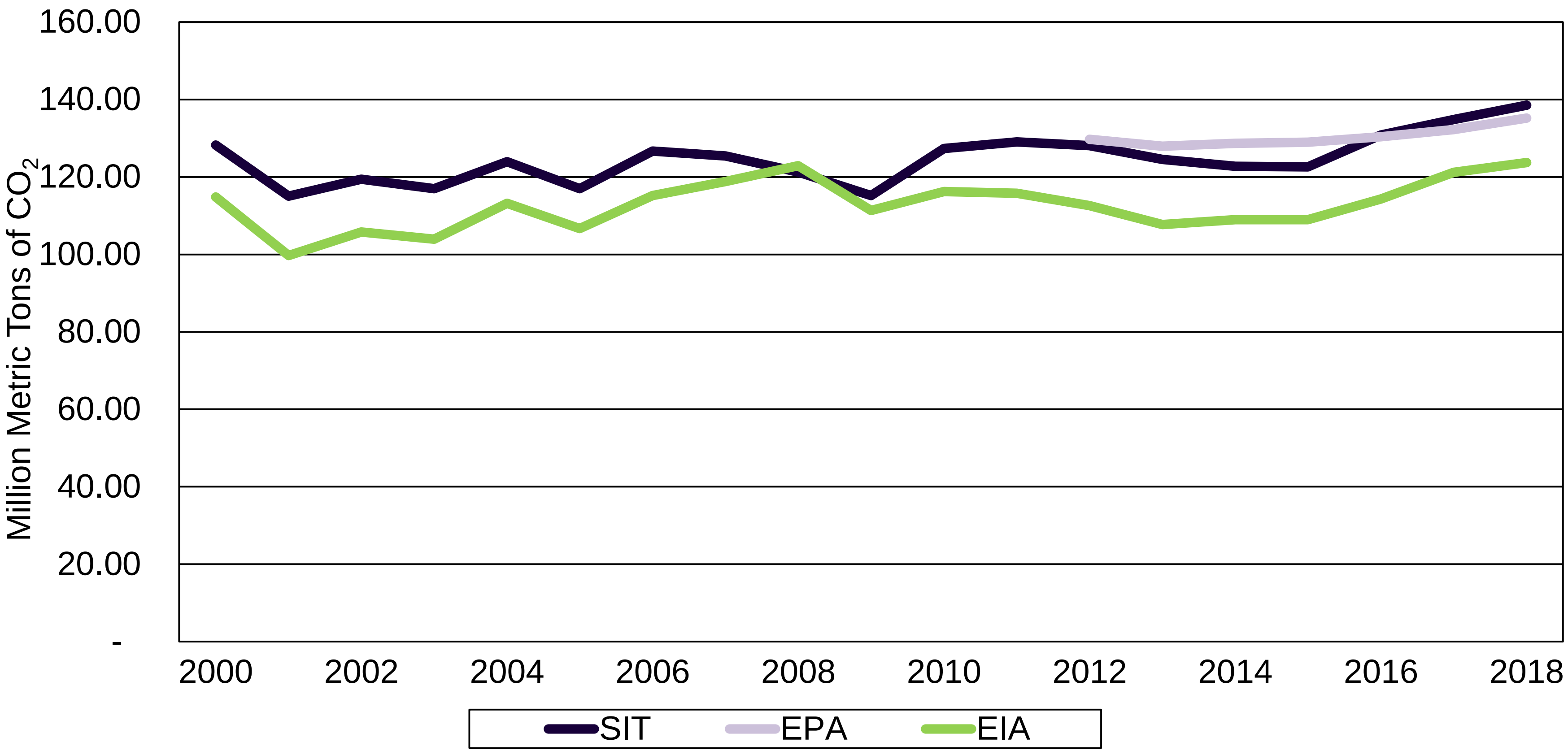
Louisiana industrial carbon emissions, SIT, EPA and EIA.

Over time all series estimate relatively comparable Louisiana industrial GHG emissions. EIA estimates the lowest GHG emissions level whereas the SIT and the EPA FLIGHT data are generally in very close agreement.



Note: EPA (FLIGHT) data not available prior to 2012

Source: EPA FLIGHT, EPA SIT, EIA.

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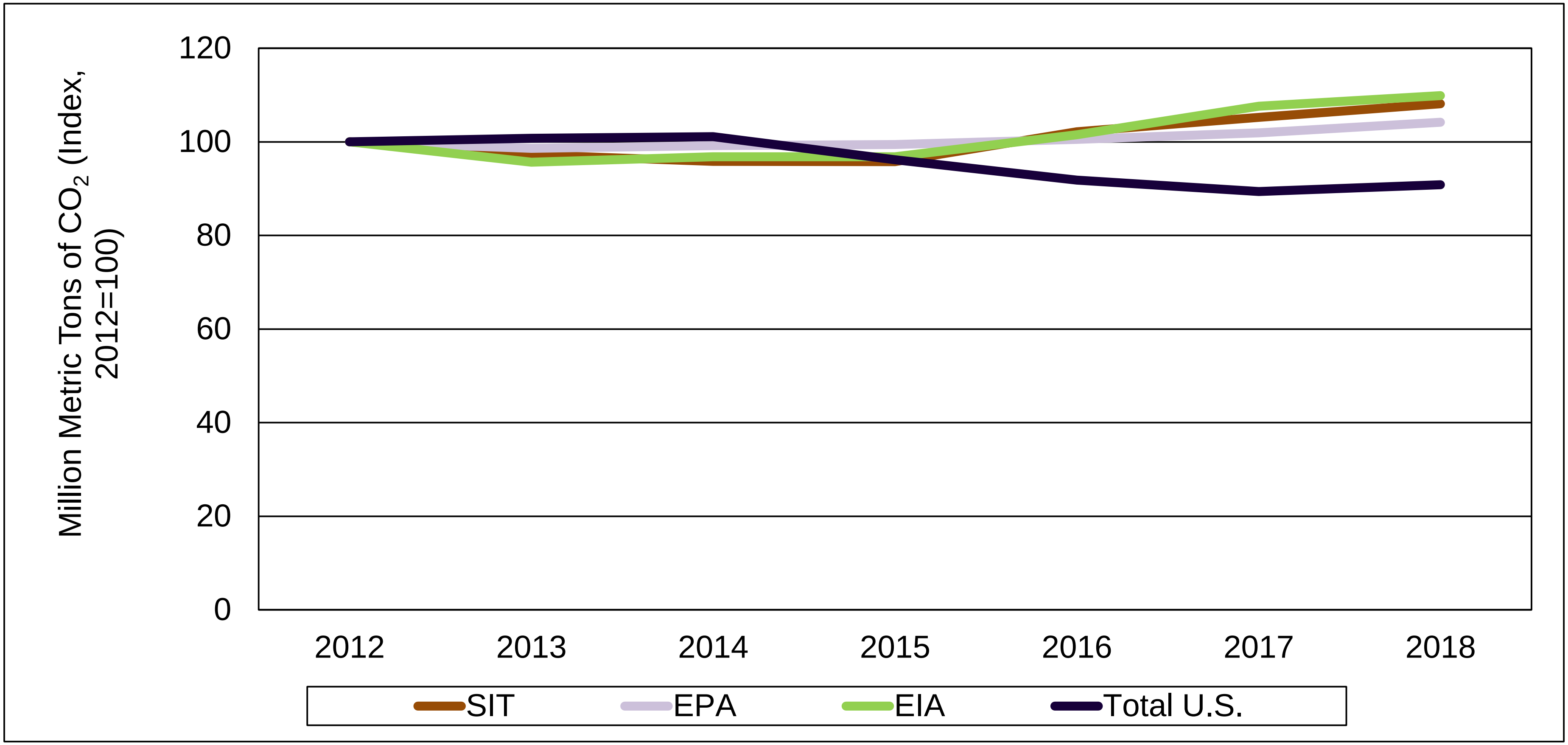
U.S. and Louisiana industrial carbon emissions (indexed)

All three series estimate Louisiana industrial GHG emissions are up by about 8% to 10% since 2012. Total U.S. industrial emissions are down by about 10% over a comparable time period.



Source: EPA FLIGHT, EPA SIT, EIA.

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Louisiana industrial GHG emissions: top sources (all GHGs)

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Top 20 Louisiana industrial GHG emission sources

The top 20 industrial facilities in Louisiana account for over half of the state's industrial GHG emissions totaling between ~48 million tons and ~61 million tons per year (collectively). GHG emissions for these 20 facilities have been increasing by 3.4 percent on an annual average basis.

Facility Name	Facility Type	2012	2013	2014	2015	2016	2017	2018	2019
		(metric tons CO2)							
CF Industries Nitrogen - Donaldsonville	Chemical Manufacturing	6,854,462	6,921,307	6,716,321	7,985,546	7,829,243	8,730,636	8,685,862	10,005,456
ExxonMobil - Baton Rouge Refinery	Petroleum and Coal Products	6,475,810	6,355,424	6,286,678	6,000,189	6,213,242	6,131,245	6,380,368	6,360,077
Sabine Pass LNG	Petroleum and Coal Products	62,003	59,472	173,625	181,518	1,259,324	3,383,744	4,197,628	5,093,801
CITGO Petroleum Corp-Lake Carles	Petroleum and Coal Products	4,370,519	4,587,270	4,792,825	4,723,531	4,652,445	4,681,829	4,895,572	4,703,535
Marathon Petroleum Company	Petroleum and Coal Products	3,958,139	3,946,970	3,956,022	3,978,498	3,806,019	4,040,303	4,103,370	3,967,921
Norco Manufacturing Complex	Petroleum and Coal Products	4,032,242	3,586,525	3,596,965	3,522,732	3,981,844	4,071,427	3,901,231	3,961,652
Eagle US 2 LLC	Chemical Manufacturing	2,991,200	3,053,842	2,843,695	2,787,825	2,673,863	2,894,510	2,962,654	3,307,323
Union Carbide Corp- St. Charles	Chemical Manufacturing	2,089,716	2,830,069	2,905,740	2,868,338	2,881,109	2,957,077	3,053,784	2,970,876
Phillips 66 - Alliance Refinery	Petroleum and Coal Products	2,175,659	2,416,372	2,122,581	1,973,789	2,582,034	2,803,216	2,741,632	2,697,634
Valero Refining-New Orleans	Petroleum and Coal Products	2,395,982	2,764,110	2,606,177	2,529,869	2,800,860	2,535,694	2,528,290	2,312,540
Motiva Enterprises - Convent Refinery	Petroleum and Coal Products	2,044,250	1,985,611	2,089,138	2,271,203	2,371,145	2,370,044	2,165,013	2,301,471
Sasol Chemicals (USA) LLC, Lake Charles Chemical Complex	Chemical Manufacturing	724,244	743,325	808,304	781,522	771,955	780,782	818,956	1,798,680
The Dow Chemical Company -- Louisiana Operations	Chemical Manufacturing	2,736,145	2,684,825	2,728,810	2,527,725	2,418,381	2,659,951	2,152,003	1,919,713
Phillips 66 - Lake Charles Refinery	Petroleum and Coal Products	1,624,822	1,682,175	1,584,268	1,739,973	1,730,893	1,779,721	1,896,562	1,730,933
Chalmette Refining LLC	Petroleum and Coal Products	1,582,620	1,473,867	1,533,904	1,601,253	1,614,862	1,604,410	1,653,272	1,601,075
Georgia Gulf Chemicals & Vinyls LLC	Chemical Manufacturing	1,377,625	1,349,492	1,291,403	1,271,561	1,137,967	1,168,226	1,215,427	1,149,415
Air Products and Chemicals- Norco	Chemical Manufacturing	-	-	844,232	1,139,730	1,156,879	1,169,458	1,073,525	1,072,351
Shell Chemical Co.-Geismar Plant	Chemical Manufacturing	918,606	907,640	939,534	933,213	898,534	917,053	980,823	1,064,539
PCS Nitrogen Fertilizer	Chemical Manufacturing	342,861	1,439,791	1,684,388	1,452,448	1,302,763	1,244,129	1,230,111	1,428,934
Westlake Petrochemicals LP	Chemical Manufacturing	1,055,582	1,157,973	2,102,927	901,198	785,374	896,666	740,227	1,034,631
Total		**47,812,487**	**49,946,058**	**51,607,536**	**51,171,663**	**52,868,737**	**56,820,121**	**57,376,309**	**60,482,558**
Average		**2,390,624**	**2,497,303**	**2,580,377**	**2,558,583**	**2,643,437**	**2,841,006**	**2,868,815**	**3,024,128**

Note: Table ranked based on 2019 emissions level
Source: EPA FLIGHT

Top 20 Louisiana industrial GHG emission sources

There is a high degree of variability in the reported annual GHG emissions for the top 20 locations in Louisiana.

Facility Name	Facility Type	2012	2013	2014	2015	2016	2017	2018	2019
		----- (metric tons CO_2) -----							
CF Industries Nitrogen - Donaldsonville	Chemical Manufacturing		1.0%	-3.0%	18.9%	-2.0%	11.5%	-0.5%	15.2%
ExxonMobil - Baton Rouge Refinery	Petroleum and Coal Products		-1.9%	-1.1%	-4.6%	3.6%	-1.3%	4.1%	-0.3%
Sabine Pass LNG	Petroleum and Coal Products		-4.1%	191.9%	4.5%	593.8%	168.7%	24.1%	21.3%
CITGO Petroleum Corp-Lake Carles	Petroleum and Coal Products		5.0%	4.5%	-1.4%	-1.5%	0.6%	4.6%	-3.9%
Marathon Petroleum Company	Petroleum and Coal Products		-0.3%	0.2%	0.6%	-4.3%	6.2%	1.6%	-3.3%
Norco Manufacturing Complex	Petroleum and Coal Products		-11.1%	0.3%	-2.1%	13.0%	2.2%	-4.2%	1.5%
Eagle US 2 LLC	Chemical Manufacturing		2.1%	-6.9%	-2.0%	-4.1%	8.3%	2.4%	11.6%
Union Carbide Corp- St. Charles	Chemical Manufacturing		35.4%	2.7%	-1.3%	0.4%	2.6%	3.3%	-2.7%
Phillips 66 - Alliance Refinery	Petroleum and Coal Products		11.1%	-12.2%	-7.0%	30.8%	8.6%	-2.2%	-1.6%
Valero Refining-New Orleans	Petroleum and Coal Products		15.4%	-5.7%	-2.9%	10.7%	-9.5%	-0.3%	-8.5%
Motiva Enterprises - Convent Refinery	Petroleum and Coal Products		-2.9%	5.2%	8.7%	4.4%	0.0%	-8.7%	6.3%
Sasol Chemicals (USA) LLC, Lake Charles Chemical Complex	Chemical Manufacturing		2.6%	8.7%	-3.3%	-1.2%	1.1%	4.9%	119.6%
The Dow Chemical Company -- Louisiana Operations	Chemical Manufacturing		-1.9%	1.6%	-7.4%	-4.3%	10.0%	-19.1%	-10.8%
Phillips 66 - Lake Charles Refinery	Petroleum and Coal Products		3.5%	-5.8%	9.8%	-0.5%	2.8%	6.6%	-8.7%
Chalmette Refining LLC	Petroleum and Coal Products		-6.9%	4.1%	4.4%	0.8%	-0.6%	3.0%	-3.2%
Georgia Gulf Chemicals & Vinyls LLC	Chemical Manufacturing		-2.0%	-4.3%	-1.5%	-10.5%	2.7%	4.0%	-5.4%
Air Products and Chemicals- Norco	Chemical Manufacturing		-	-	35.0%	1.5%	1.1%	-8.2%	-0.1%
Shell Chemical Co.-Geismar Plant	Chemical Manufacturing		-1.2%	3.5%	-0.7%	-3.7%	2.1%	7.0%	8.5%
PCS Nitrogen Fertilizer	Chemical Manufacturing		319.9%	17.0%	-13.8%	-10.3%	-4.5%	-1.1%	16.2%
Westlake Petrochemicals LP	Chemical Manufacturing		9.7%	81.6%	-57.1%	-12.9%	14.2%	-17.4%	39.8%
Total			**4.5%**	**3.3%**	**0.8%**	**3.3%**	**7.5%**	**1.0%**	**5.4%**
Average			**4.5%**	**3.3%**	**0.8%**	**3.3%**	**7.5%**	**1.0%**	**5.4%**

Note: Table ranked based on 2019 emissions level
Source: EPA FLIGHT

Top 20 Louisiana industrial GHG emission sources (cumulative 2012-2019, by type).

Most Louisiana industrial GHG emissions come from stationary combustion. Refining accounts for the second highest share followed by ammonia production.

Facility Name	Facility Type	Stationary Combustion	Electricity Generation	Ammonia Production	Hydrogen Production	Nitric Acid	Petrochemical Production	Refining	Other Sources	Total Emissions
			--- (metric tons total emissions, 2012-2019)							
CF Industries Nitrogen - Donaldsonville	Chemical Manufacturing	20,137,193	-	31,052,002	-	12,539,639	-	-	-	63,728,834
ExxonMobil - Baton Rouge Refinery	Petroleum and Coal Products	36,003,391	-	-	-	-	293,329	13,906,312	-	50,203,032
Sabine Pass LNG	Petroleum and Coal Products	13,473,534	-	-	-	-	-	-	937,581	14,411,116
CITGO Petroleum Corp-Lake Carles	Petroleum and Coal Products	28,020,909	-	-	-	-	-	9,386,617	-	37,407,526
Marathon Petroleum Company	Petroleum and Coal Products	22,485,177	-	-	-	-	-	9,272,065	-	31,757,242
Norco Manufacturing Complex	Petroleum and Coal Products	20,970,293	-	-	126,668	-	575,438	8,982,219	-	30,654,617
Eagle US 2 LLC	Chemical Manufacturing	10,891,419	12,425,358	-	-	-	176,316	-	21,819	23,514,912
Union Carbide Corp- St. Charles	Chemical Manufacturing	18,649,062	-	-	-	-	3,907,646	-	-	22,556,708
Phillips 66 - Alliance Refinery	Petroleum and Coal Products	12,249,354	-	-	-	-	-	7,263,561	-	19,512,916
Valero Refining-New Orleans	Petroleum and Coal Products	7,846,141	-	-	4,803,063	-	-	7,824,317	-	20,473,522
Motiva Enterprises - Convent Refinery	Petroleum and Coal Products	10,370,904	-	-	130,006	-	-	7,096,966	-	17,597,876
Sasol Chemicals (USA) LLC, Lake Charles Chemical Complex	Chemical Manufacturing	5,356,691	-	-	-	-	1,871,076	-	-	7,227,767
The Dow Chemical Company -- Louisiana Operations	Chemical Manufacturing	17,681,390	-	-	-	-	1,475,009	-	671,155	19,827,553
Phillips 66 - Lake Charles Refinery	Petroleum and Coal Products	9,527,009	-	-	-	-	-	4,242,338	-	13,769,347
Chalmette Refining LLC	Petroleum and Coal Products	8,116,049	-	-	-	-	-	4,549,216	-	12,665,265
Georgia Gulf Chemicals & Vinyls LLC	Chemical Manufacturing	9,658,863	-	-	-	-	302,253	-	-	9,961,115
Air Products and Chemicals- Norco	Chemical Manufacturing	-	-	-	6,456,175	-	-	-	-	6,456,175
Shell Chemical Co.-Geismar Plant	Chemical Manufacturing	6,346,685	-	-	-	-	1,213,257	-	-	7,559,942
PCS Nitrogen Fertilizer	Chemical Manufacturing	3,016,284	-	3,782,501	-	3,299,196	-	-	27,445	10,125,426
Westlake Petrochemicals LP	Chemical Manufacturing	6,952,045	-	-	-	-	1,722,533	-	-	8,674,578
Total (2012-2019)		**267,752,393**	**12,425,358**	**34,834,502**	**11,515,912**	**15,838,835**	**11,536,857**	**72,523,611**	**1,658,000**	**428,085,469**
Share of Total Emissions (%)		**62.55%**	**2.90%**	**8.14%**	**2.69%**	**3.70%**	**2.69%**	**16.94%**	**0.39%**	**100.00%**

Source: EPA FLIGHT

Louisiana industrial GHG emissions by sector, 2012- 2019

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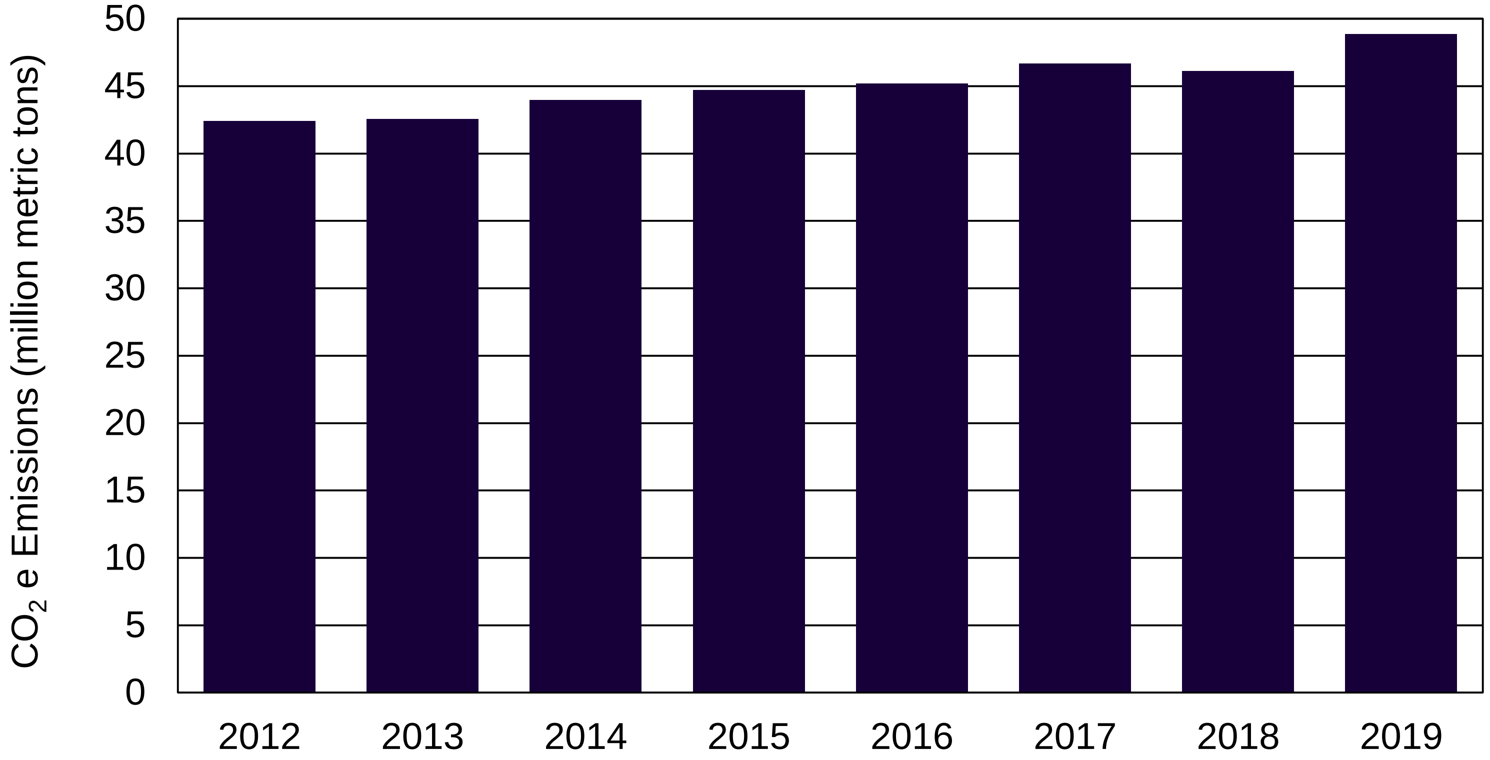
Louisiana chemical manufacturing (NAICS 325) GHG emissions

Chemical industry GHG emissions have been steadily increasing since 2012. This sector’s emissions have been increasing at an annual average rate of 2.06 percent.



Source: EPA FLIGHT

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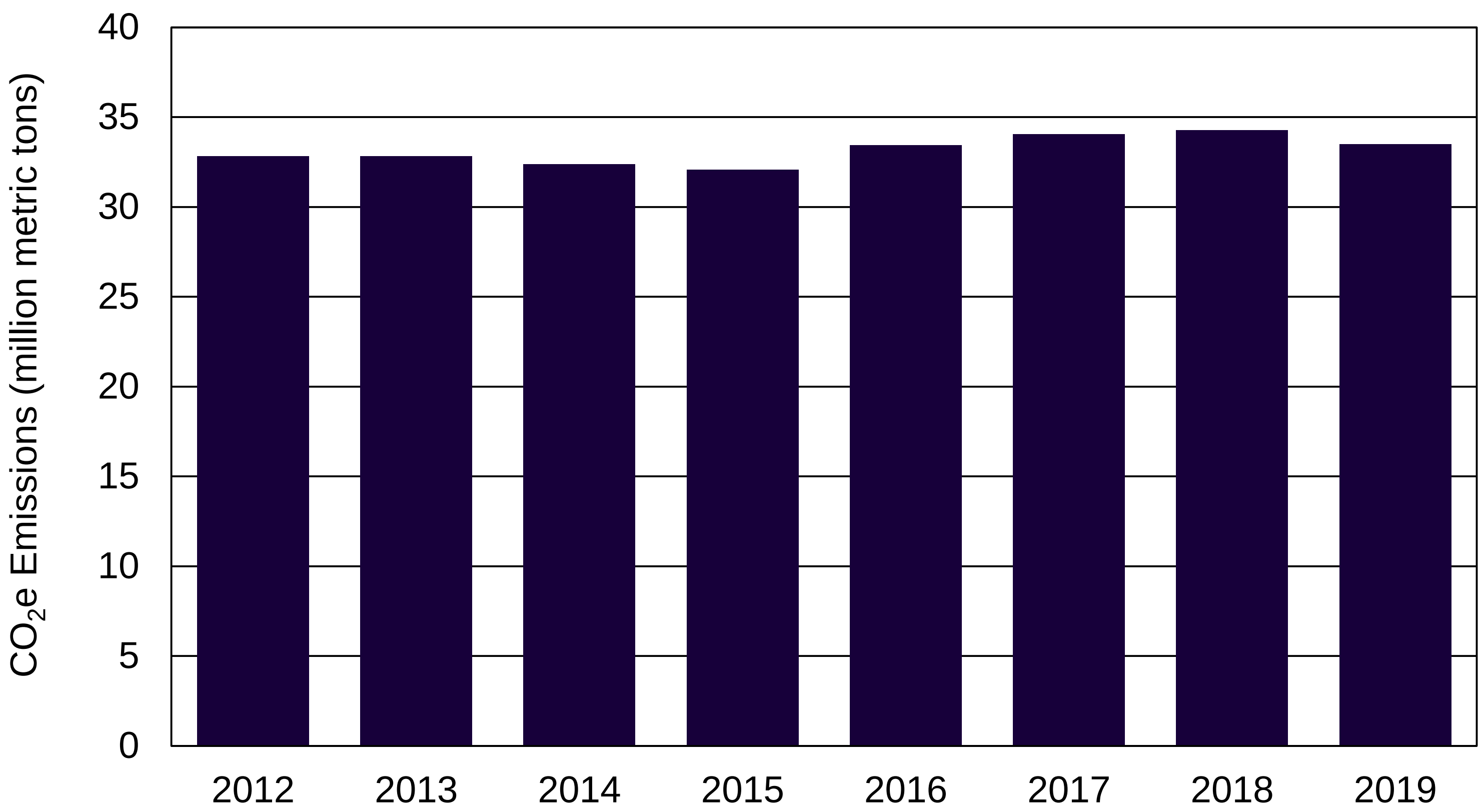
Louisiana refining (NAICS 324) GHG emissions

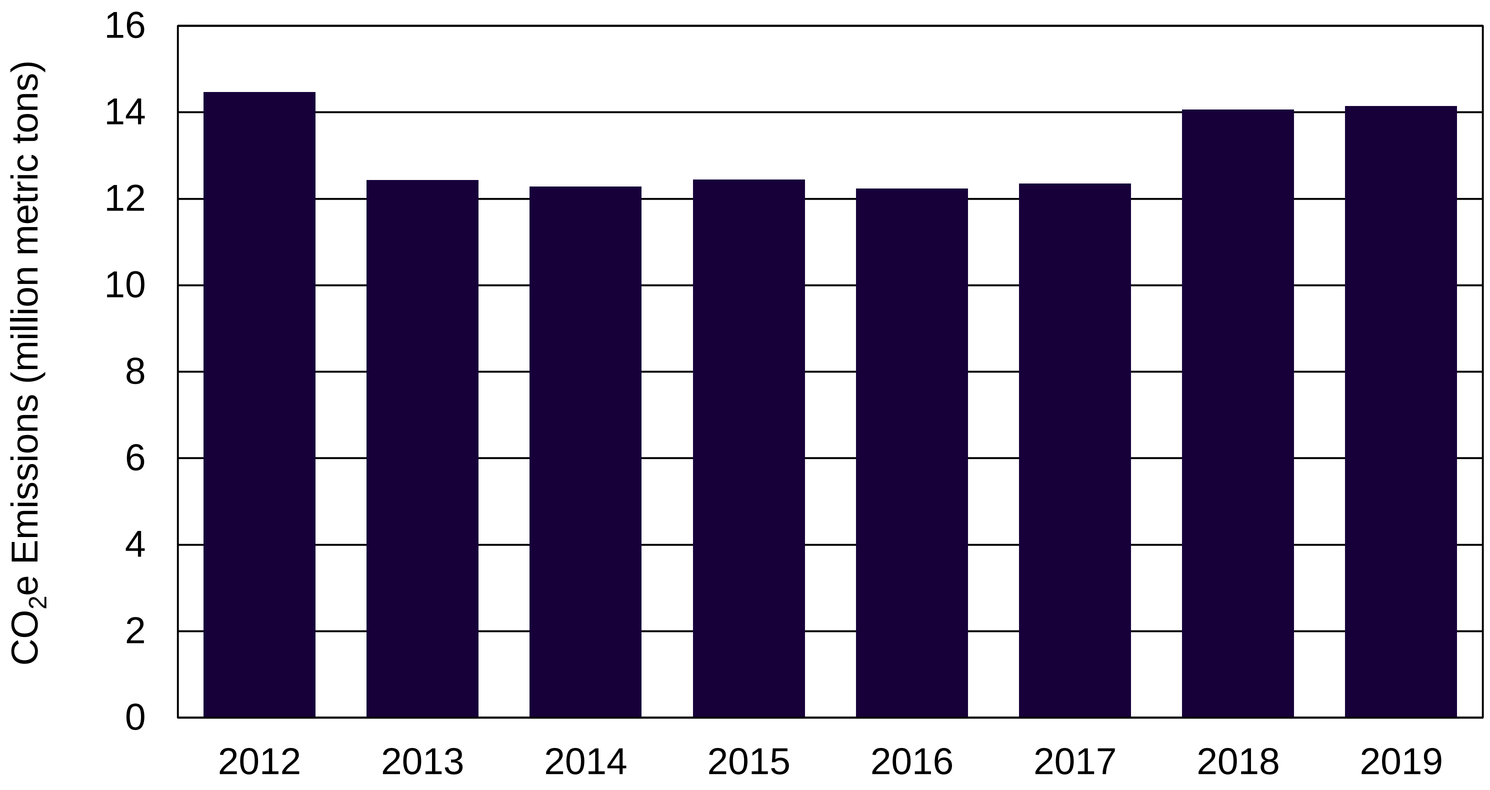
Louisiana refining GHG emissions have been relatively constant since 2012. Current refining GHG emissions (33.5 million tons) are comparable to 2012 levels (32.8 million tons).



Source: EPA FLIGHT

Louisiana natural gas manufacturing (NAICS 211, 213 & 486) GHG emissions

Natural gas processing GHG emissions fell and remained relatively lower up to 2017 but have increased in the last two years of reported information.



Source: EPA FLIGHT

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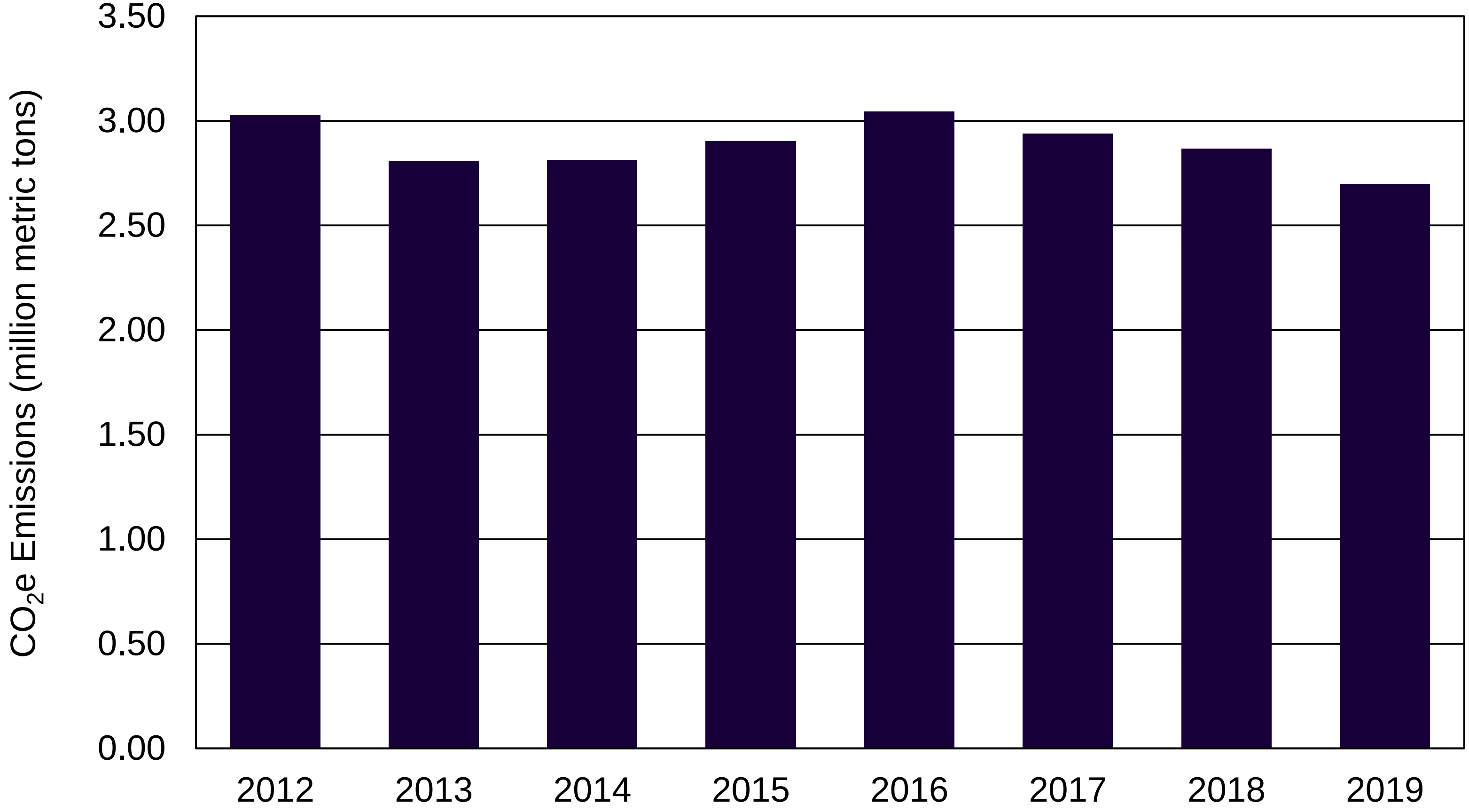
Louisiana paper manufacturing (NAICS 324) GHG emissions

Louisiana paper industry GHG emissions have been relatively constant since 2012.



Source: EPA FLIGHT

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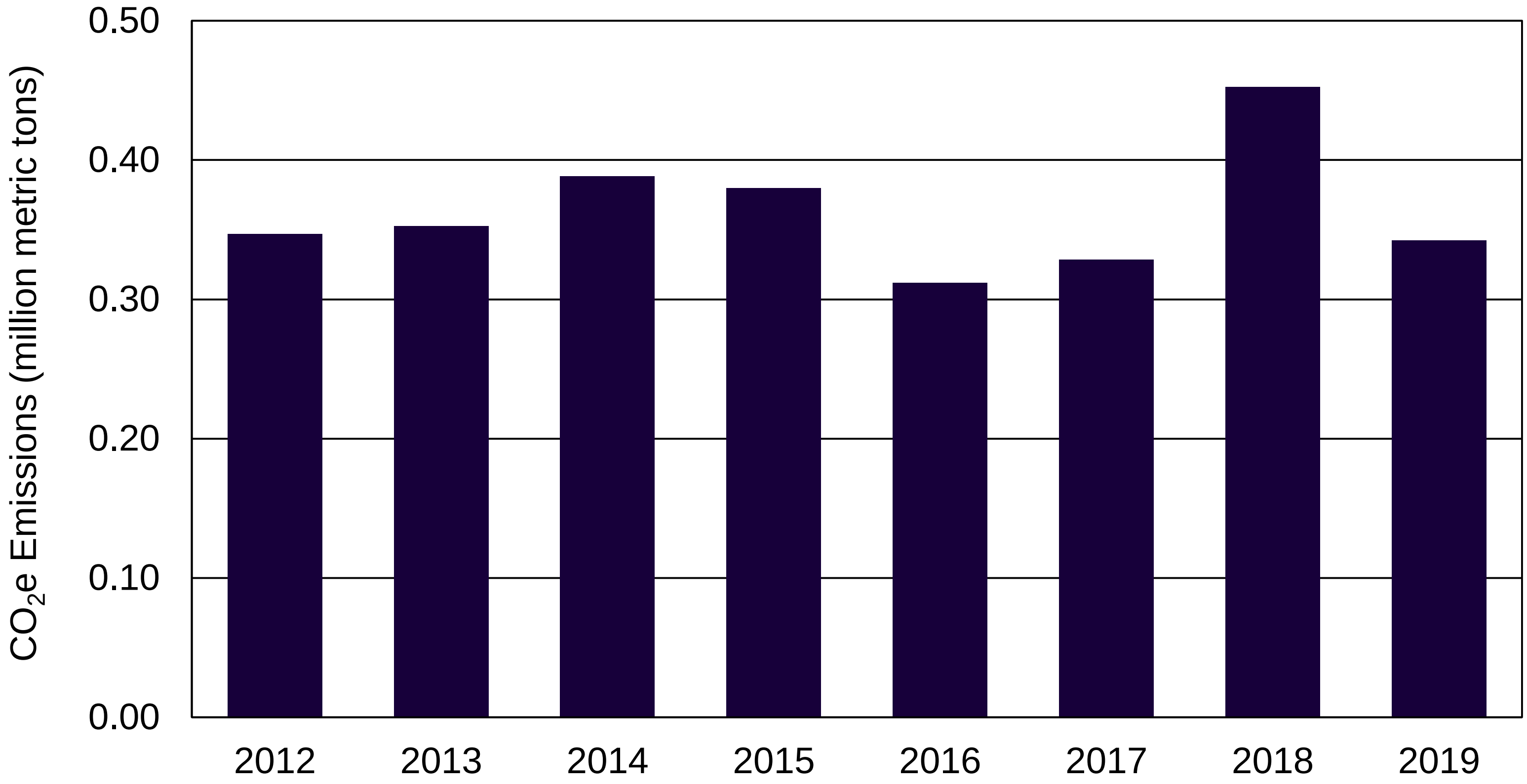
Louisiana food, beverage and tobacco (NAICS 311) GHG emissions

Louisiana food, beverage, and tobacco industry GHG emissions have been relatively constant since 2012; excepting the one time increase in 2018 driven largely by a one-time reported emission increase at the American Sugar Refining location.



Source: EPA FLIGHT

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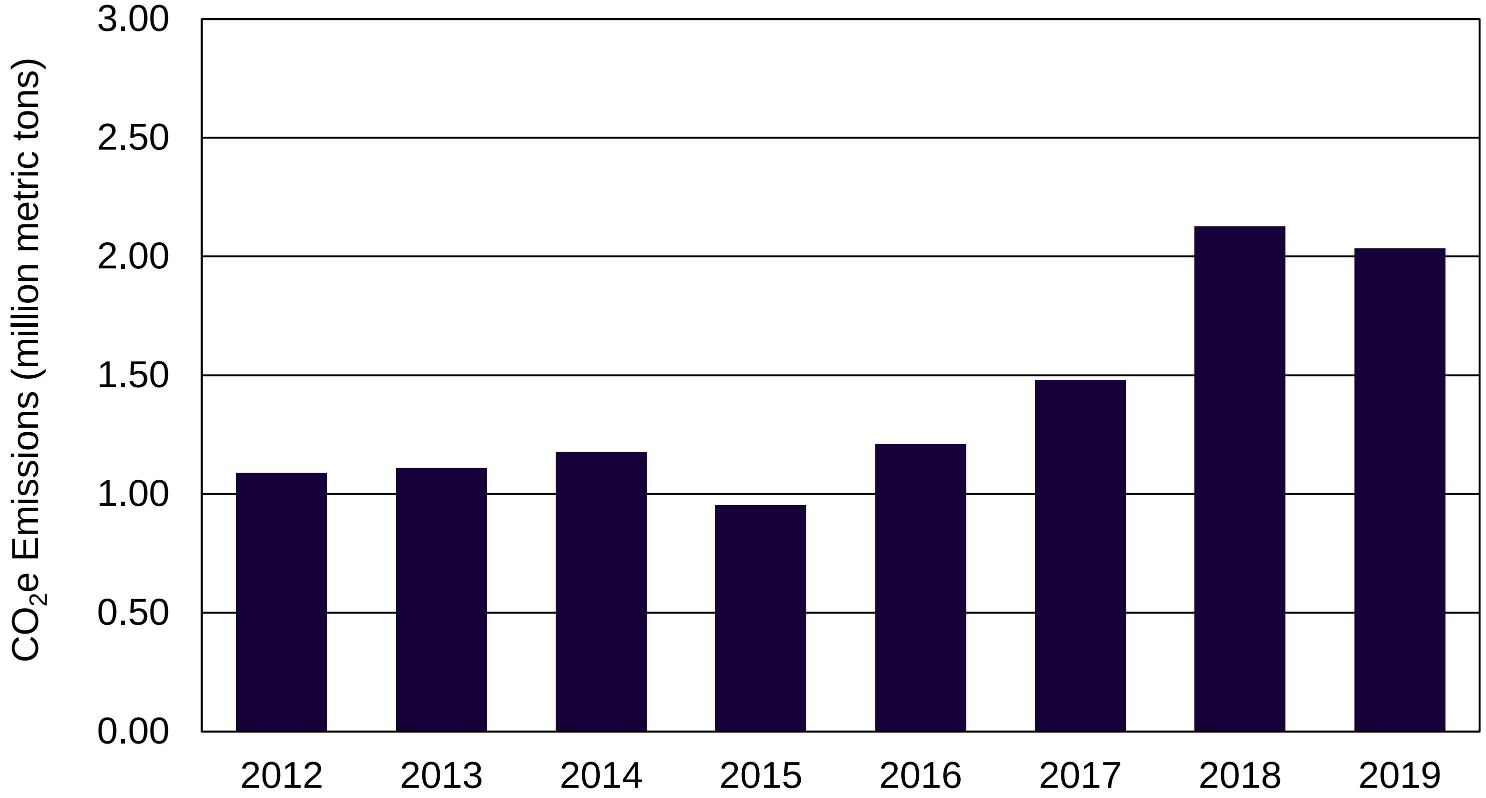
Louisiana primary metal manufacturing (NAICS 331) GHG emissions

Historically, primary metals GHG emission have been constant but started to increase in 2017 given activities at the Nucor steel facility.



Source: EPA FLIGHT

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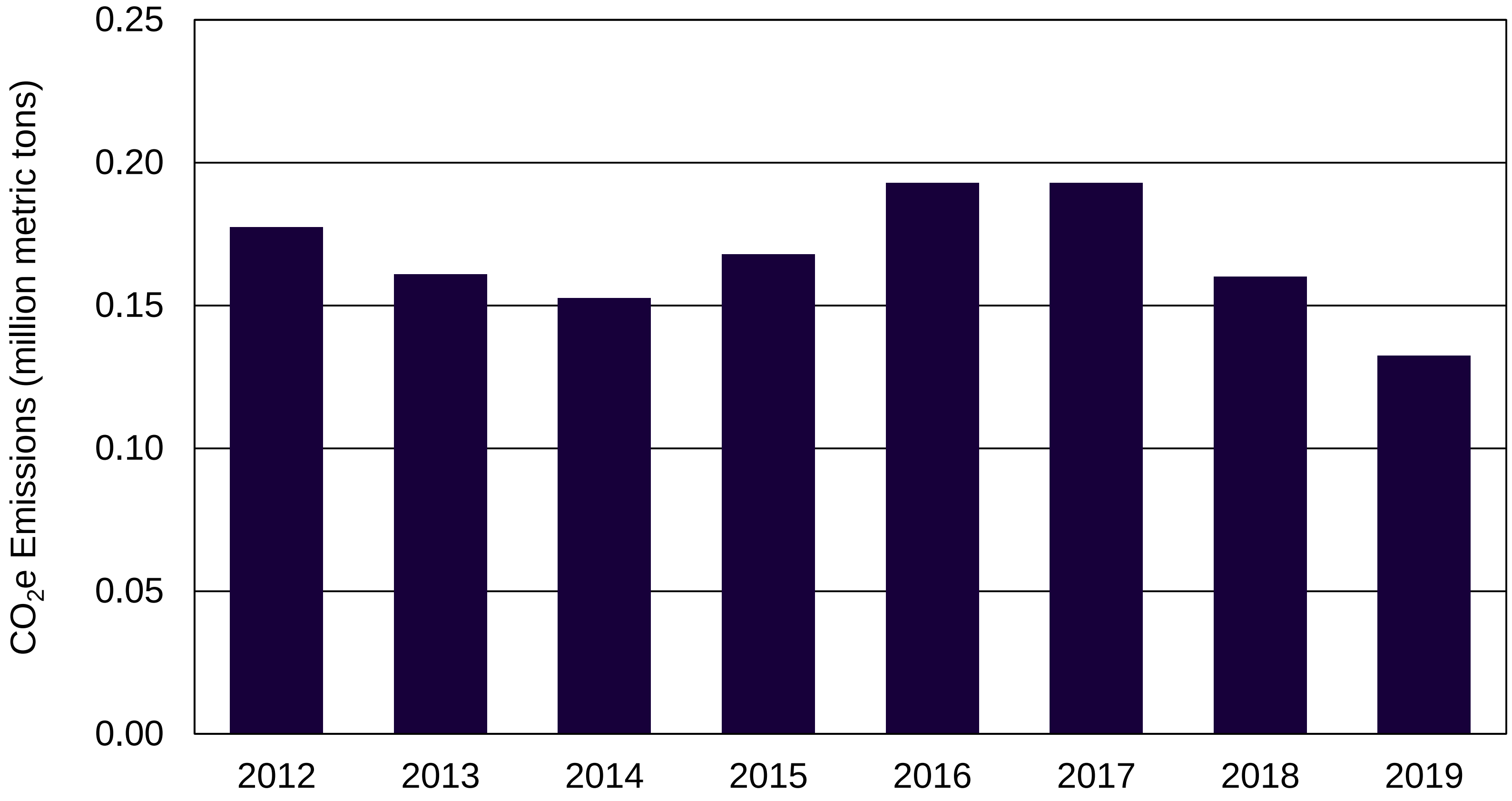
Louisiana nonmetallic minerals (NAICS 327) GHG emissions

Louisiana nonmetallic minerals GHG emissions have been falling since 2017.



Source: EPA FLIGHT

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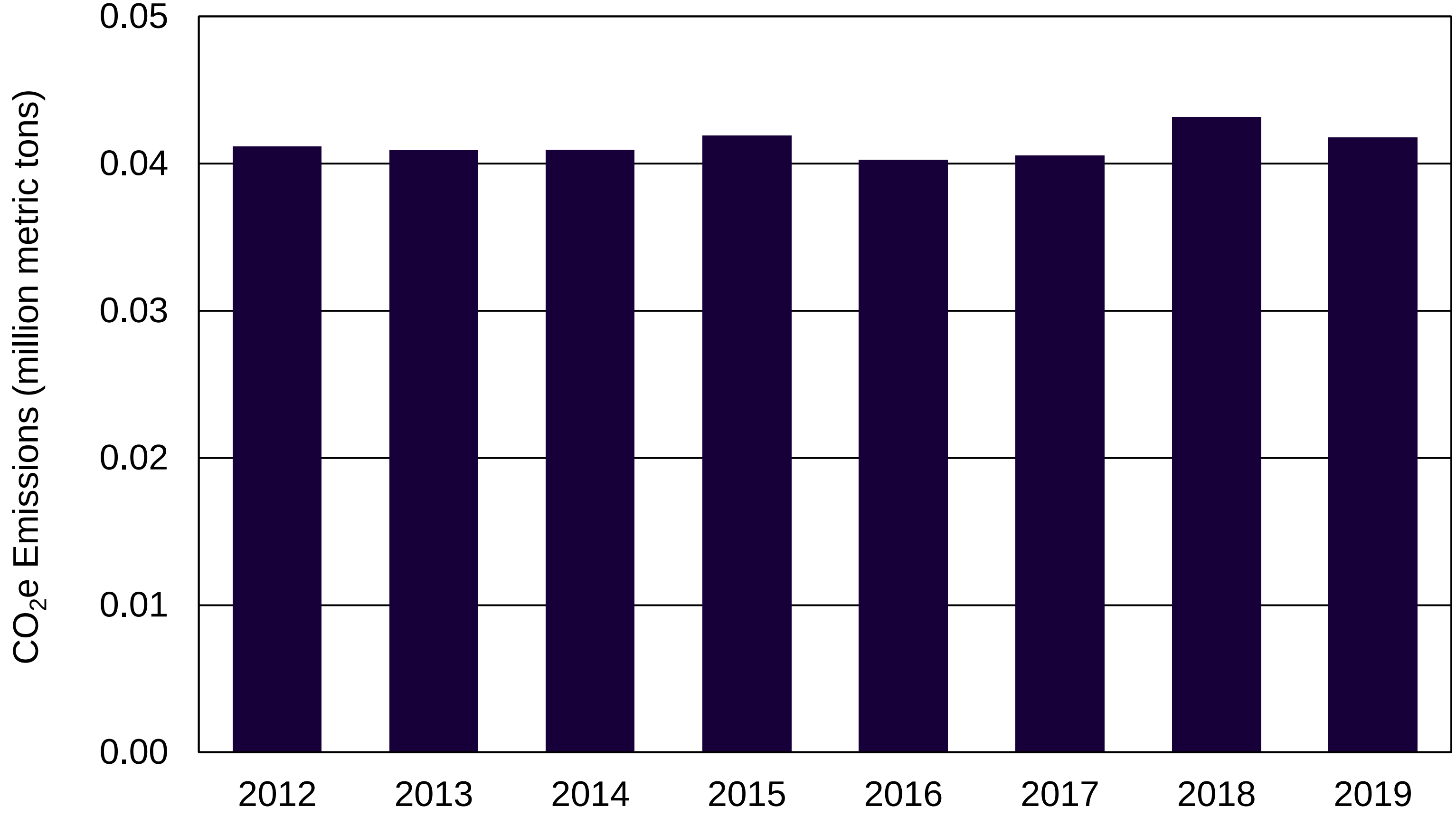
Louisiana wood products (NAICS 321) GHG emissions

Louisiana wood products GHG emissions have been relatively constant since 2012.



Source: EPA FLIGHT

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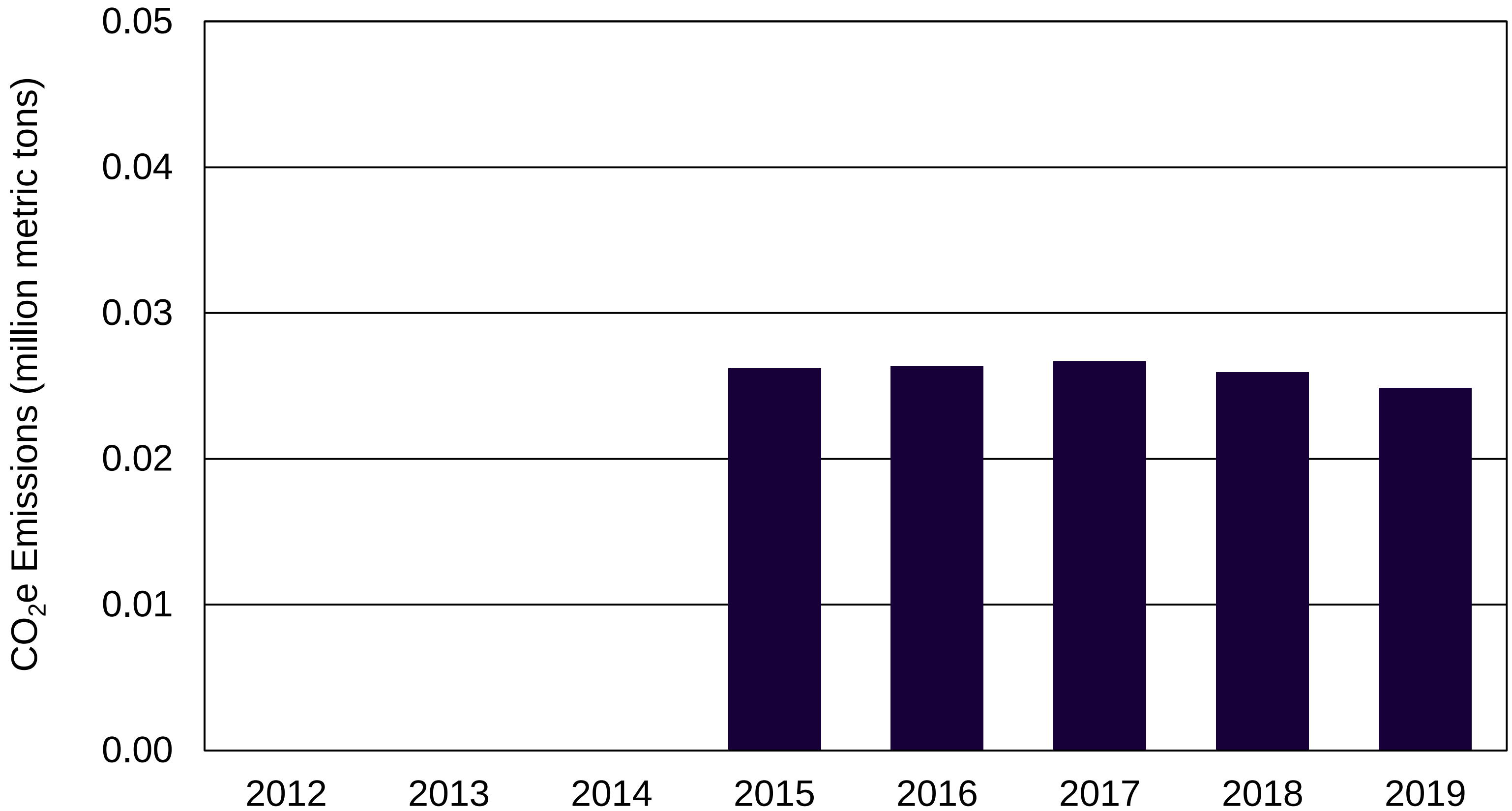
Louisiana fabricated metal (NAICS 332) GHG emissions

Louisiana fabricated metals industries had emissions lower than the report threshold until 2015.



Source: EPA FLIGHT

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Conclusions

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Conclusions

- Over 69.87% of Louisiana's 2018 GHG emissions come from the industrial sector (143.3 million tons), half of which are concentrated in the chemical and refining sectors.
- Aggregate industrial GHG emissions have been growing around 1.0% to 2.5% per year over the last seven years. Emissions at the top 20 industrial locations have been growing around 3.4 percent per year.
- Louisiana's top industrial GHG emission source is the CF Industries plant (~10 million tons per year) followed by the ExxonMobil refinery (~6 million tons per year).
- Prior to 2008, industrial GHG emissions hovered around 120 million tons per year. Plant expansions appear to have driven this steady state level up to 135 to 140 million tons.

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Louisiana 2021 GHG Inventory. Appendix 13: Detailed power generation emissions estimates and analysis.

David E. Dismukes, Ph.D.
Center for Energy Studies
Louisiana State University

October 2021

Section 1: Introduction

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Data

The federal government publishes several data series that report power generation related carbon emissions. Some of this data is published by the U.S. Environmental Protection Agency (EPA) while other data sets are maintained and published by the U.S. Department of Energy, Energy Information Administration (EIA).

Overall aggregate trends, like the ones used in this report to assess longer run trends, come from EIA. This detailed state data is collected from several EIA survey forms and compiled annually. This includes generation capacity, net generation, and fuel consumption by generator type and fuel type.

More specific, generator-level data, however, are reported every two years by the EPA. This data is included in the Emissions & Generation Resource Integrated Database (eGRID). The data includes emissions, emission rates, generation, heat input, resource mix, and several other attributes. eGrid is a comprehensive inventory of environmental attributes of electric power systems and is based on data from the EIA’s Forms EIA-860 and EIA-932, as well as the EPA’s Clean Air Markets Program Data.

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Section 2: Historic power Generation trends

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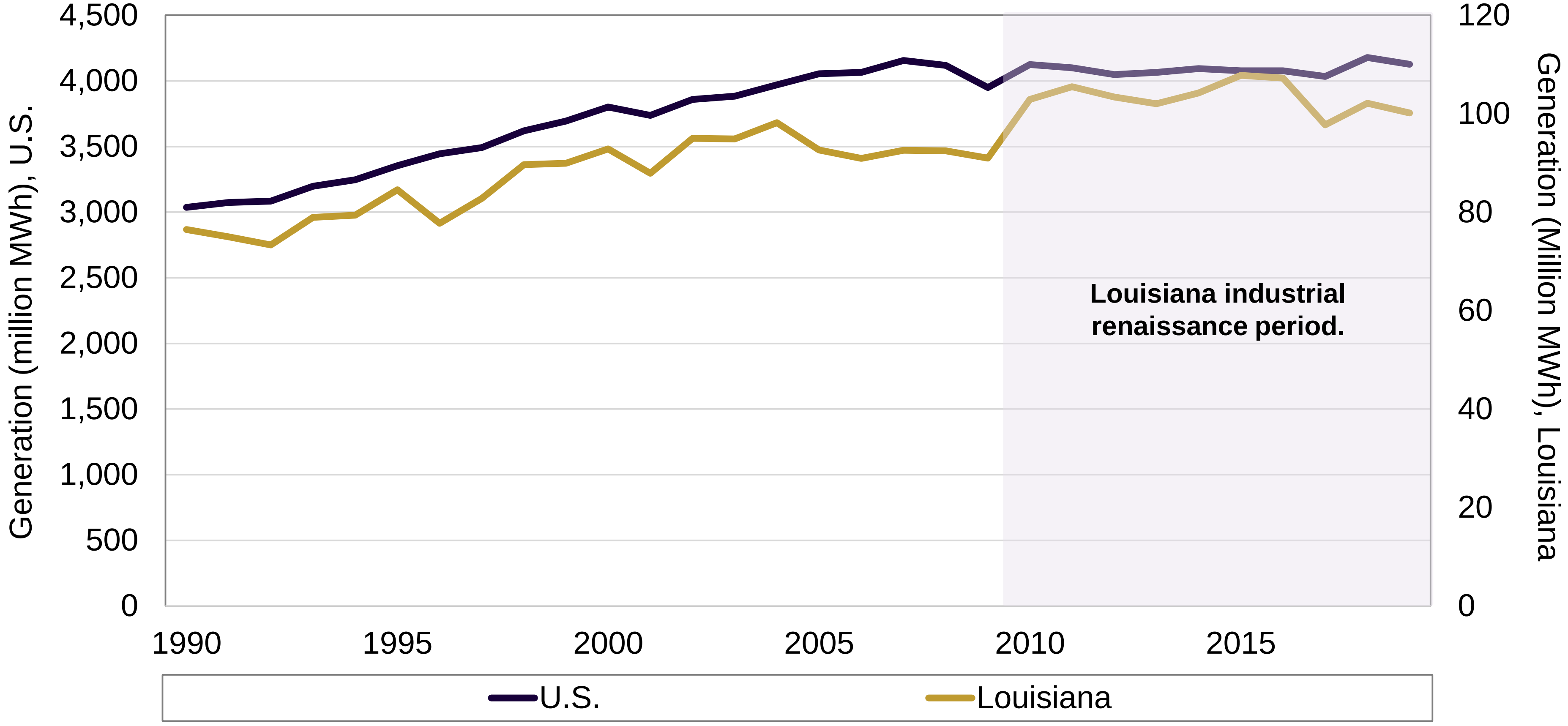
Historic Trends: Total generation (U.S., LA)

U.S. electric generation has **increased at an average annual rate of 1.1 percent** over the last 30 years; mostly prior to 2005. Louisiana is comparable to U.S. trends, increasing at a rate of 1.4 percent until 2005; **industrial growth drives post 2019 growth**.



Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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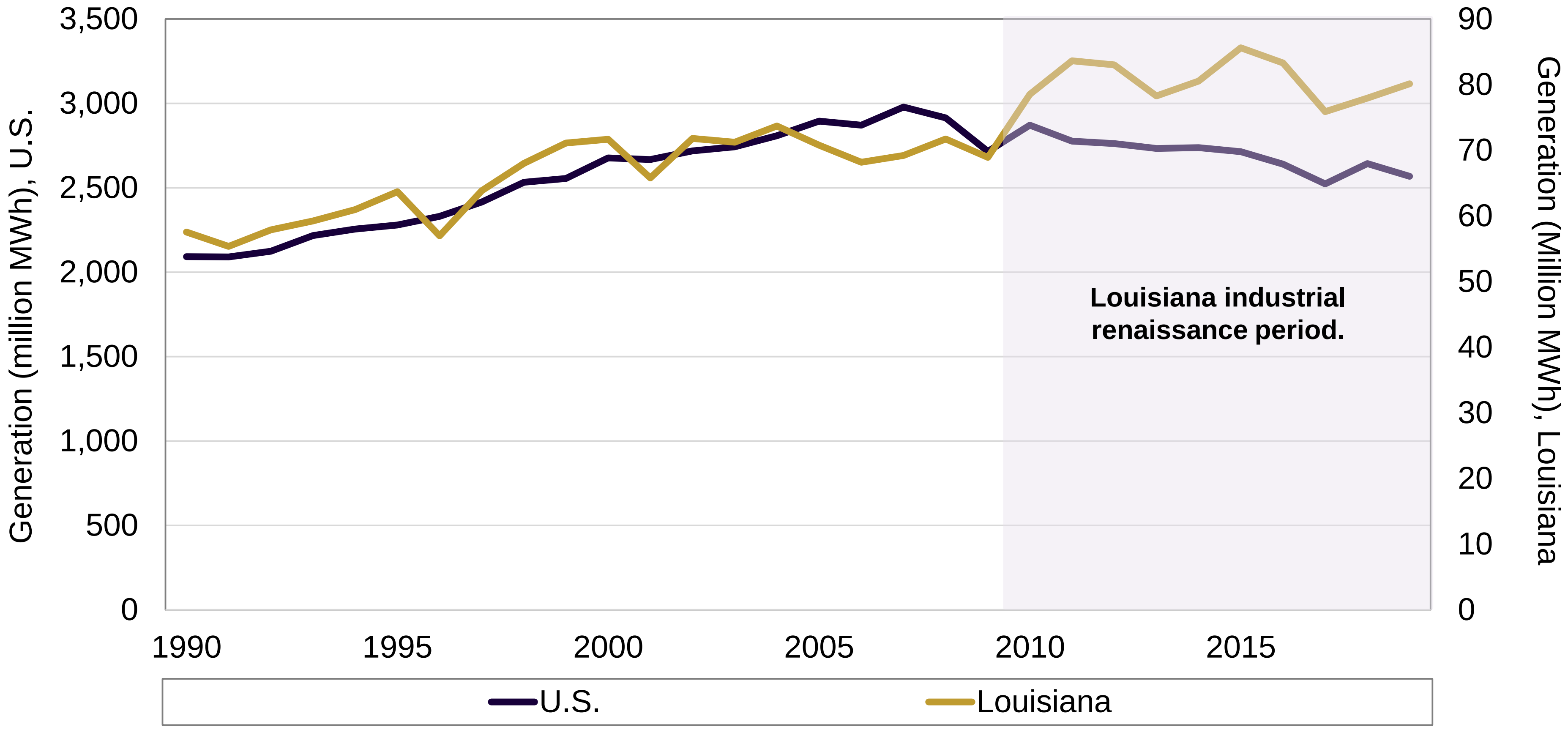
Historic Trends: Fossil-fueled generation (U.S., LA)

U.S. fossil-fueled generation increased at an average annual rate of 2.2 percent, decreasing to an annual growth rate of 0.8 percent per year post-2007. In Louisiana, **fossil fuel generation has increased steadily, particularly post 2010.**



Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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Historic trends: Top 10 states, power generation.

Louisiana's relative position in total power generation **has held steady over the past decade**.

2009	
State	**Total Generation (MWh)**
1. Texas	397,167,910
2. Pennsylvania	219,496,144
3. Florida	217,952,308
4. California	204,776,132
5. Illinois	193,864,357
6. Alabama	143,255,556
7. Ohio	136,090,225
8. New York	133,150,550
9. Georgia	128,698,376
10. North Carolina	118,407,403
16. Louisiana	**90,993,676**

2019	
State	**Total Generation (MWh)**
1. Texas	483,201,031
2. Florida	245,603,485
3. Pennsylvania	228,995,331
4. California	201,784,204
5. Illinois	184,470,052
6. Alabama	142,679,433
7. New York	131,603,289
8. North Carolina	131,173,861
9. Georgia	128,691,569
10. Ohio	120,001,126
15. Louisiana	**100,174,762**

Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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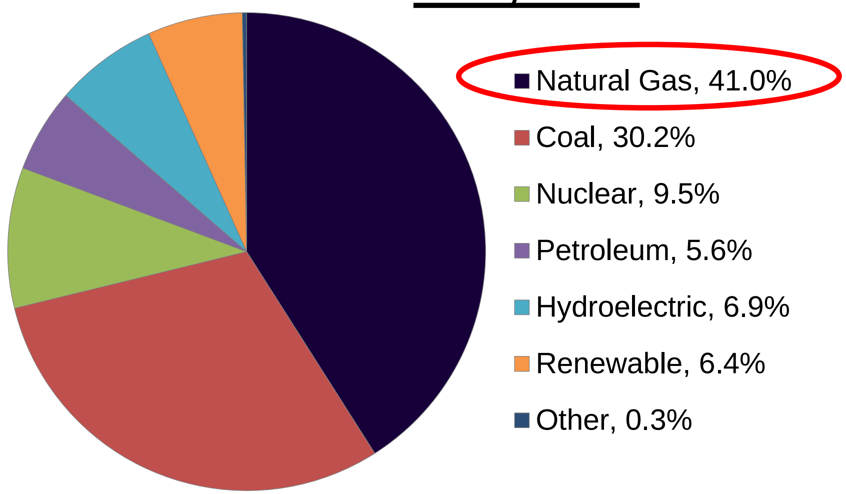
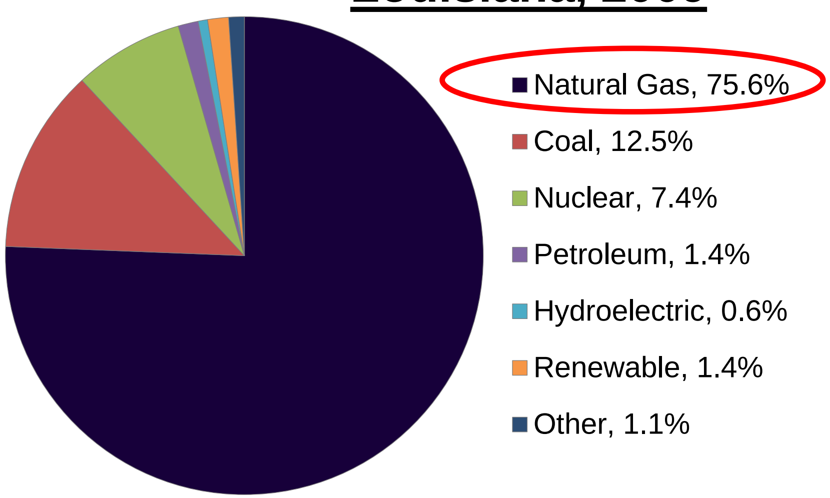
Historic generation fuel mix comparison (capacity, U.S., LA, 2009)

U.S., 2009



Louisiana, 2009



Louisiana's generation fuel mix has been heavily weighted towards natural gas. Louisiana generation has been considerably more leveraged in natural gas generation than the U.S. average.

Louisiana has historically relied very little on coal-fired generation: only 12.5 percent relative to the 2009 U.S. average of over 30 percent.

Source: U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

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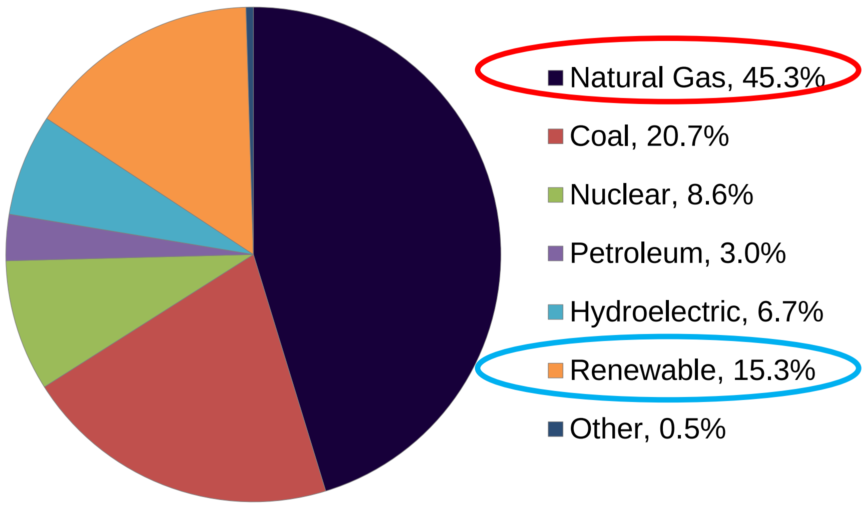
Historic generation fuel mix comparison (capacity, U.S., LA, 2019)

Today, **Louisiana continues to be heavily reliant upon natural gas generation.**

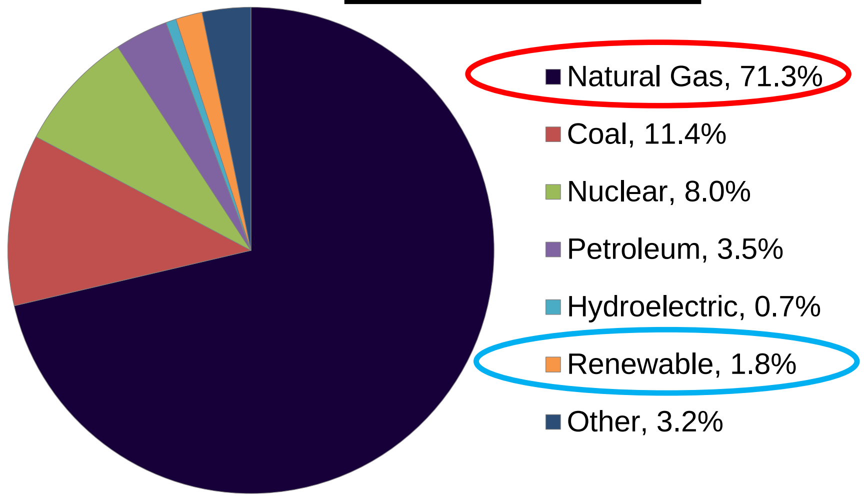
The small amount of coal generation that exists in the state has fallen relative to other fuel types.

Over the past decade, **the U.S. has significantly reduced its dependence on coal generation** switching to natural gas and, increasingly, **renewable energy.**

U.S., 2019



Louisiana, 2019



Source: U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

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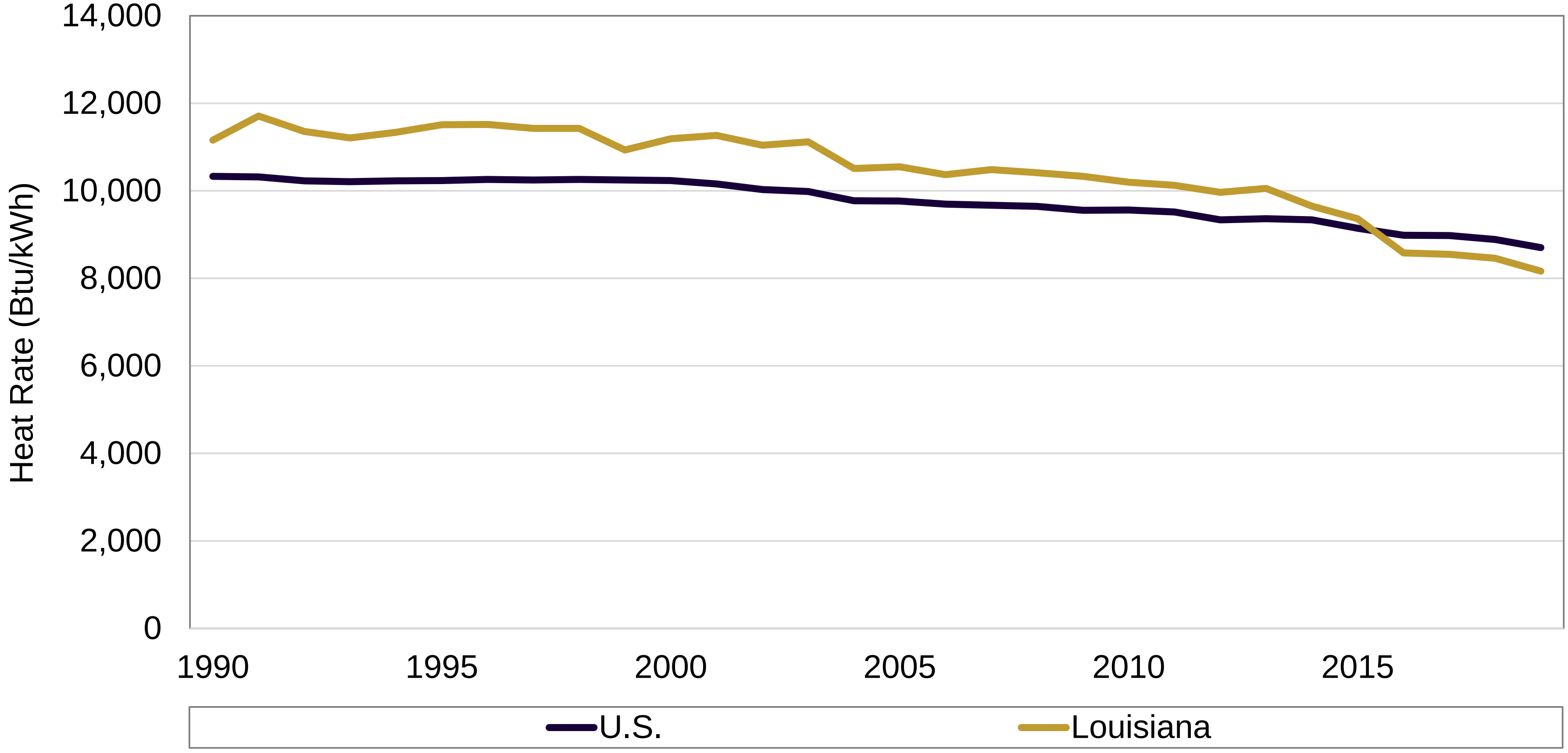
Historic trends: Fossil generation thermal efficiencies (Btu/kWh)

U.S. average heat rates (thermal efficiencies) for **all fossil generation** (coal, natural gas, and petroleum) have fallen (improved) from 10,300 Btu/kWh to about 8,700 Btu/kWh; **a 16 percent improvement**. In **Louisiana, the overall fossil heat rate has improved** from 11,160 Btu/kWh to just over 8,000 Btu/kWh; or **by 27 percent**.



Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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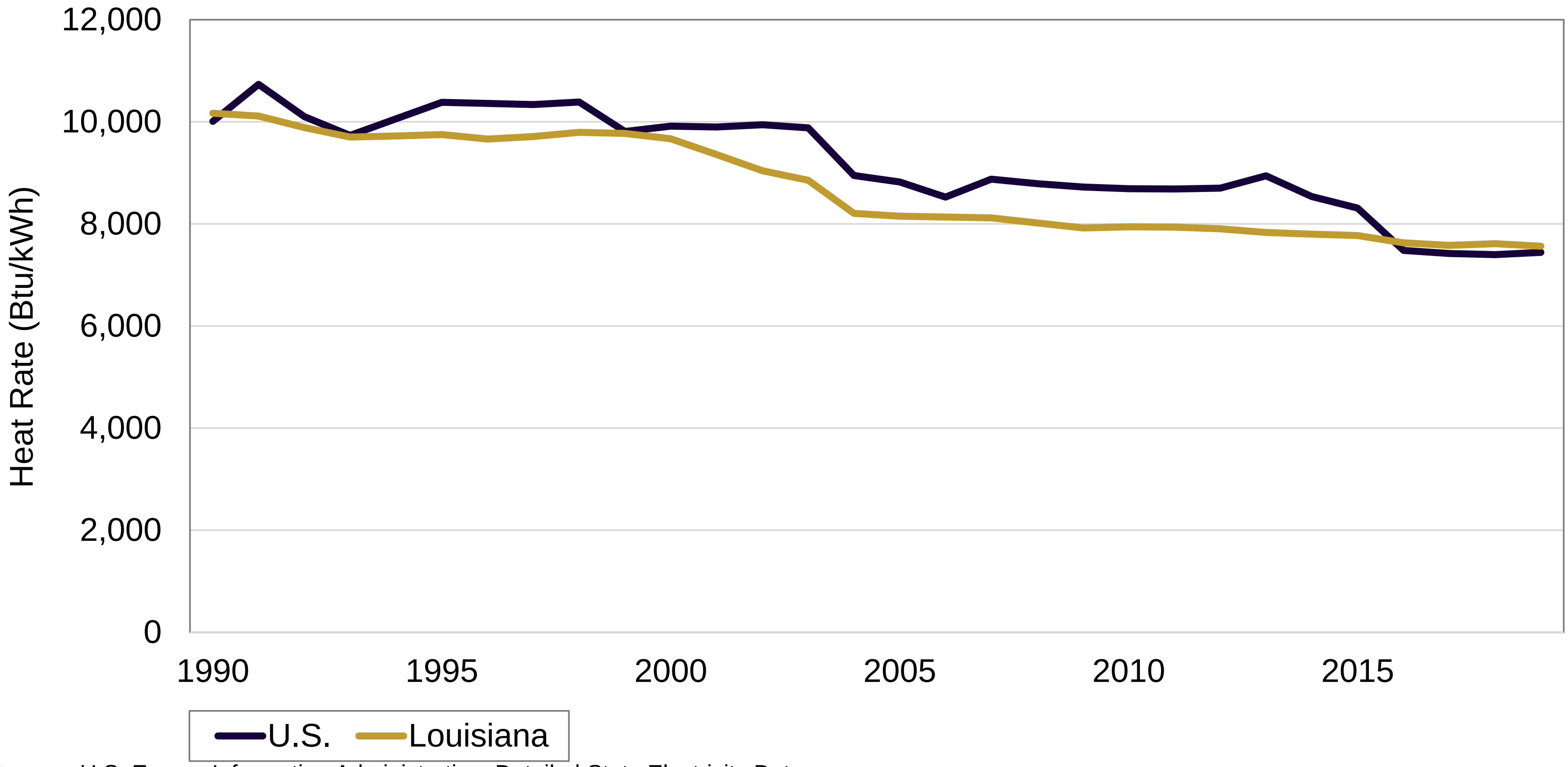
Historic trends: Natural gas generation thermal efficiencies (Btu/kWh)

U.S. average heat rates for natural gas generation alone **have improved** from 10,000 Btu/kWh to about 7,400 Btu/kWh, or **by 26 percent**. In **Louisiana, natural gas heat rates have also improved by 26 percent,** falling from 10,170 Btu/kWh to about 7,500 Btu/kWh.



Source: U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

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Historic trends: Top 10 states, fossil thermal efficiencies.

Louisiana's fossil generation thermal efficiencies have improved considerably, on absolute and relative basis over the past decade moving up in rank from #36 to #21.

2009		
	State	Heat Rate (Btu/kWh)
1.	Maine	7,383
2.	California	7,567
3.	Rhode Island	7,619
4.	Idaho	7,654
5.	New Hampshire	7,693
6.	Oregon	7,740
7.	Connectricut	7,847
8.	Massachusetts	7,902
9.	North Carolina	7,939
10.	South Carolina	7,952
36.	**Louisiana**	**10,334**

2019		
	State	Heat Rate (Btu/kWh)
1.	Maine	6,658
2.	New Jersey	7,068
3.	Connecticut	7,201
4.	California	7,341
5.	Delaware	7,363
6.	Massachusetts	7,449
7.	Virginia	7,514
8.	Oregon	7,516
9.	New Hampshire	7,518
10.	Florida	7,636
21.	**Louisiana**	**8,159**

Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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Historic trends: Top 10 states, natural gas thermal efficiencies.

Louisiana's natural gas generation thermal efficiencies have improved considerably on a relative basis over the past decade moving up in rank from #35 to #16.

2009		
	State	Heat Rate (Btu/kWh)
1.	Wyoming	6,845
2.	Oregon	7,031
3.	Arkansas	7,189
4.	Georgia	7,224
5.	New Hampshire	7,325
6.	Washington	7,329
7.	Maine	7,336
8.	Pennsylvania	7,339
9.	Connecticut	7,477
10.	California	7,509
35.	**Louisiana**	**8,727**

2019		
	State	Heat Rate (Btu/kWh)
1.	Iowa	6,524
2.	Maine	6,690
3.	Minnesota	6,993
4.	Oregon	7,038
5.	New Jersey	7,039
6.	Pennsylvania	7,044
7.	Washington	7,096
8.	Connecticut	7,157
9.	Delaware	7,185
10.	Ohio	7,266
16.	**Louisiana**	**7,381**

Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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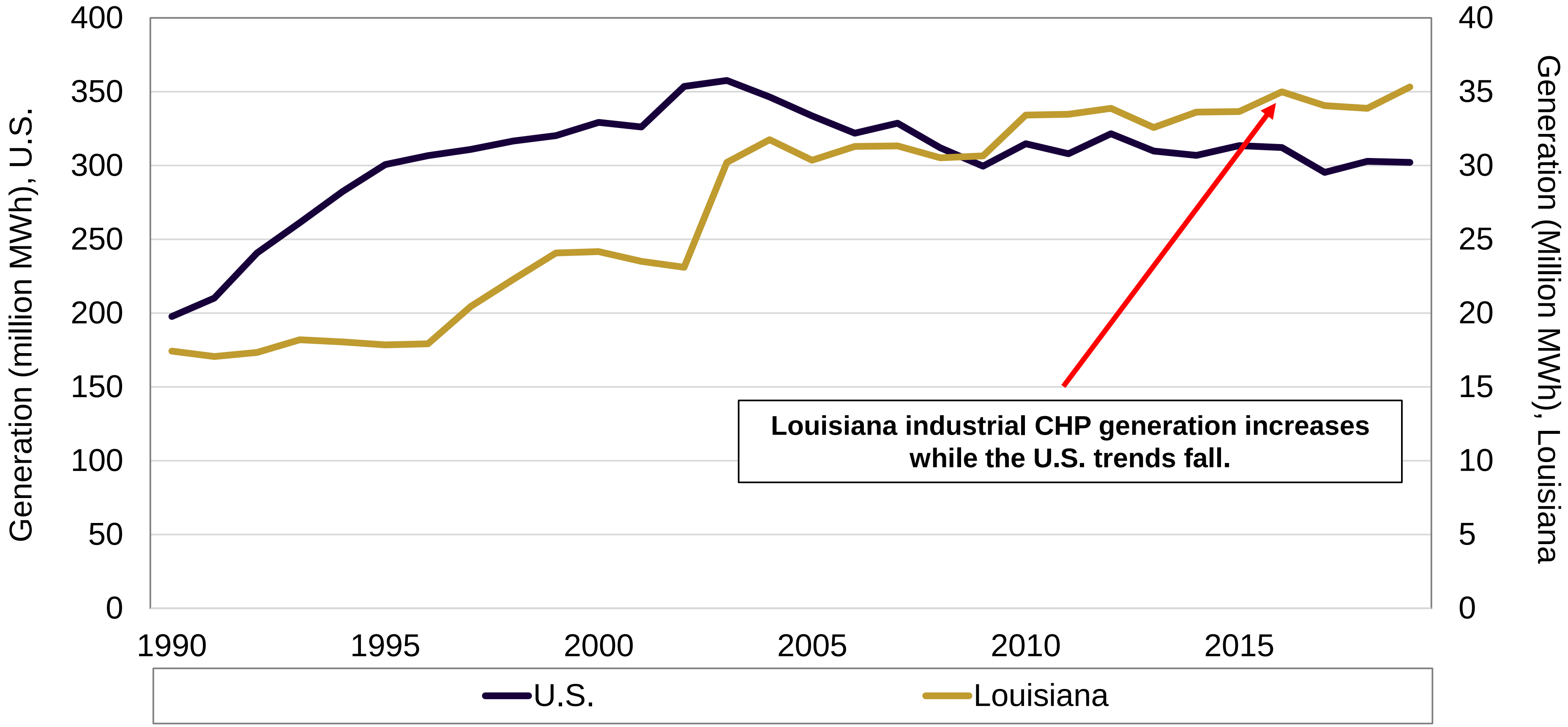
Historic trends: Combined heat and power generation (U.S., LA)

Industrial combined heat and power ("CHP") generation increased significantly in both the U.S. (75 percent) and Louisiana (82 percent) until 2004. **Louisiana continues to be an industrial CHP leader,** with generation increasing by 11 percent since 2004, while the U.S. fell by 13 percent.



Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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Historic trends: Top 10 states, CHP generation comparison

Louisiana's industrial CHP generation dominates all other states as share of total generation.

2009	
State	CHP as a Percent of Total Generation (%)
1. Louisiana	**33.7%**
2. Hawaii	33.6%
3. Maine	33.0%
4. Delaware	23.4%
5. Texas	20.1%
6. California	19.0%
7. New Jersey	15.9%
8. Oregon	13.0%
9. Alaska	8.0%
10. New York	7.9%

2019	
State	CHP as a Percent of Total Generation (%)
1. Louisiana	**35.3%**
2. Hawaii	33.5%
3. Delaware	27.4%
4. Maine	24.7%
5. Texas	18.2%
6. Michigan	15.5%
7. California	14.7%
8. Massachusetts	12.5%
9. New Jersey	11.7%
10. Indiana	11.6%

Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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Section 3: Recent Louisiana power generation trends.

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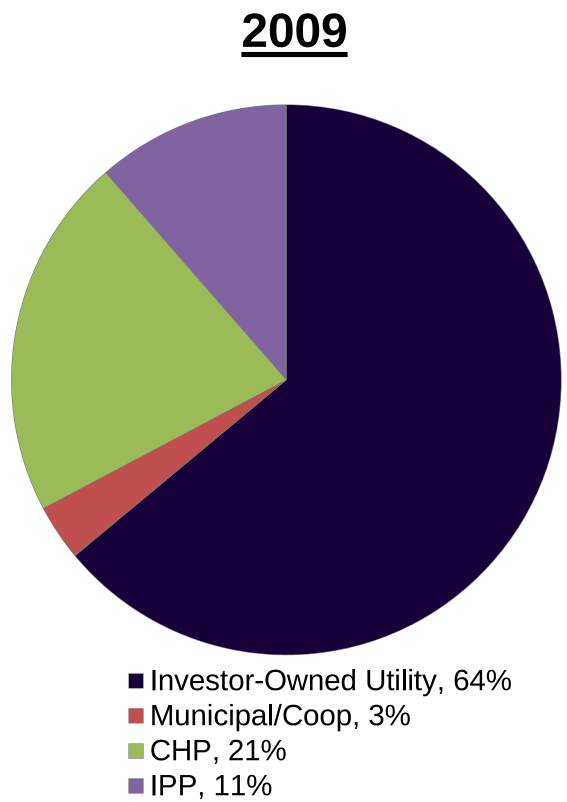
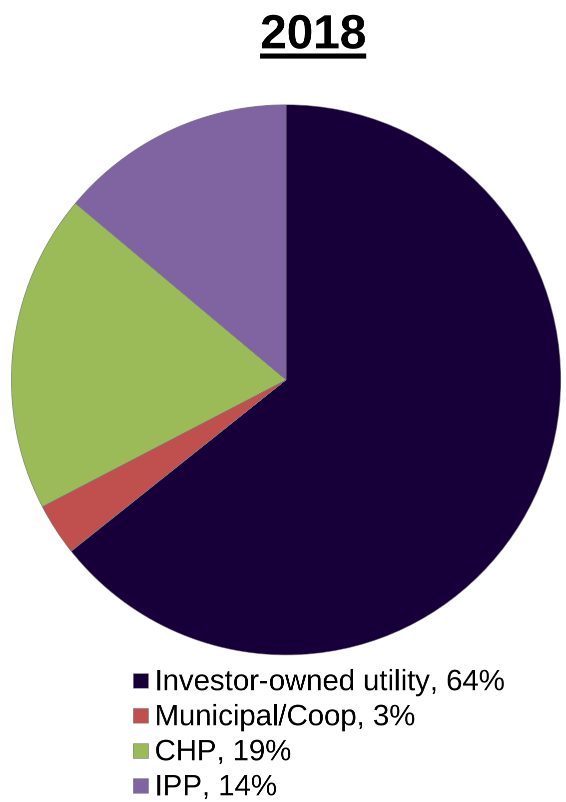
Louisiana power generation capacity by type.

While there are several power generation facilities in the state, owned by different types of market participants, **most of the nameplate capacity is owned by utilities**. Industrial CHP generators hold the second largest concentration of capacity followed by independent power producers ("IPPs").





Source: U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

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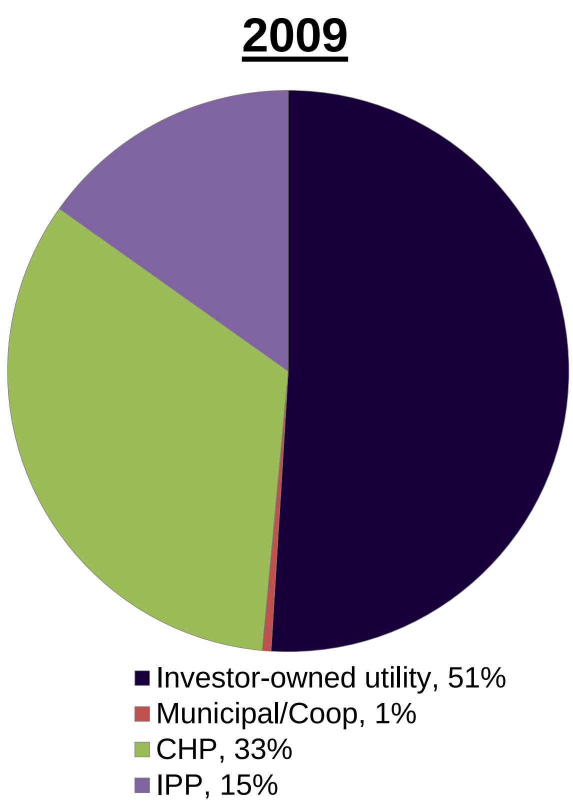
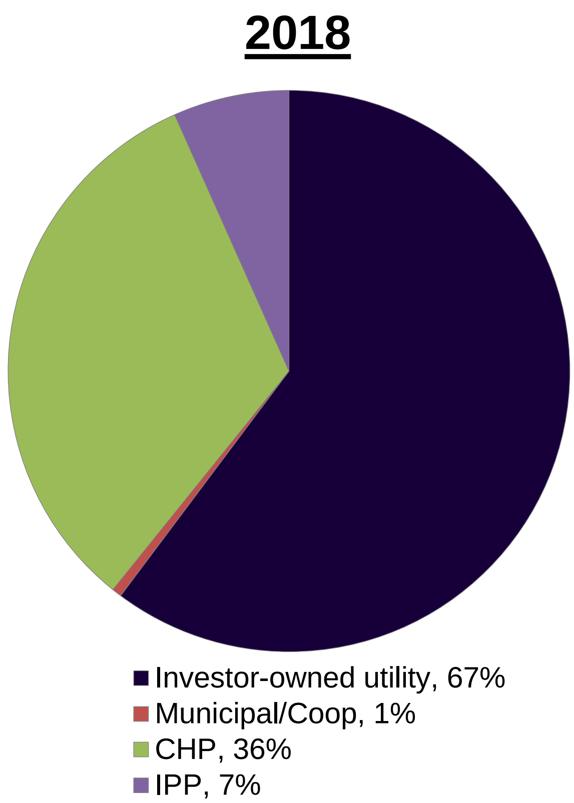
Louisiana power generation by type.

Most of the generation (actual power generated from the capacity) comes from utilities, followed by industrial CHP facilities and IPPs. The IPP share is down considerably from prior years.





Source: U.S. Energy Information Administration, Detailed State Electricity Data.
Available at: https://www.eia.gov/electricity/data/state/

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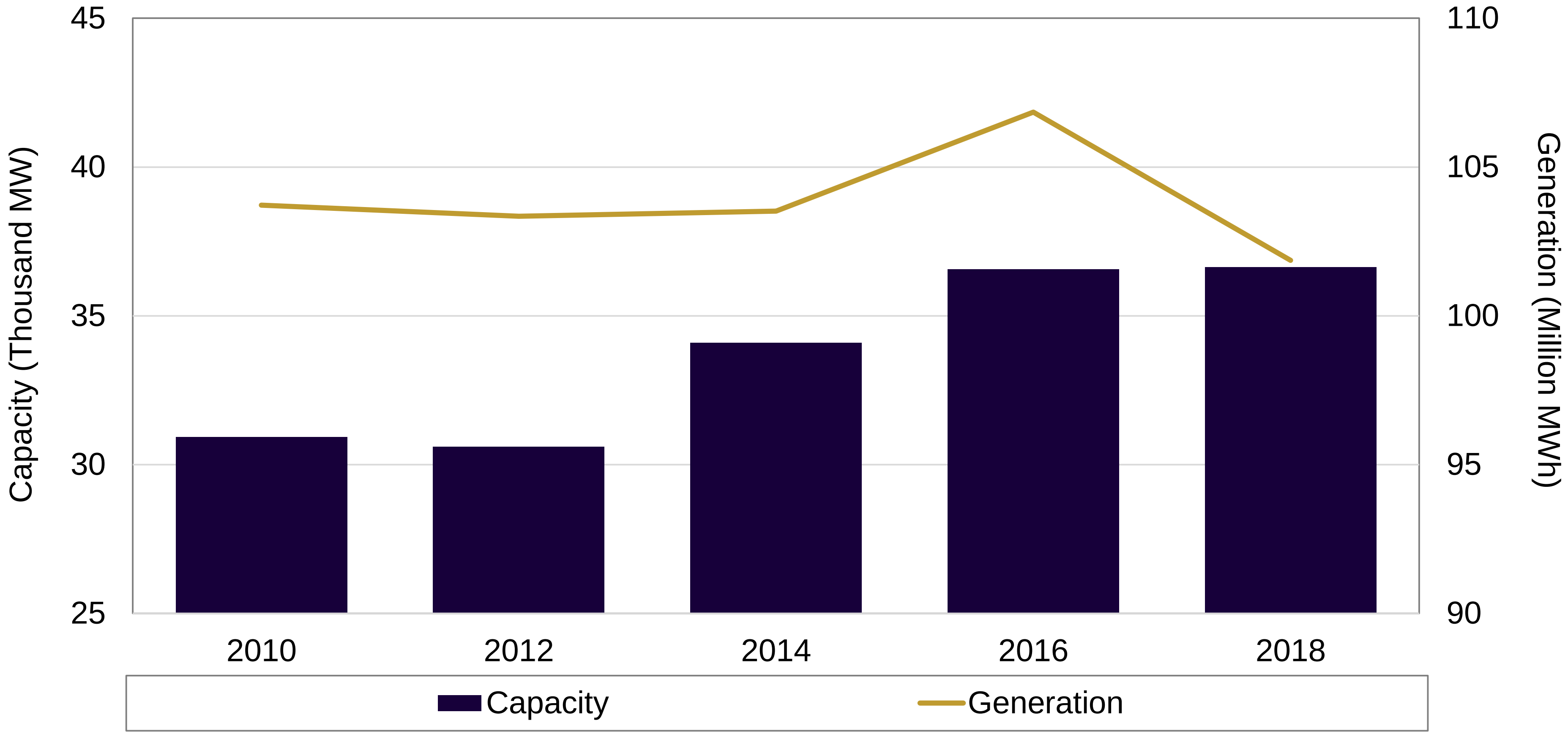
Louisiana electric generating capacity and generation

Louisiana electric generating capacity has increased 5,700 MW since 2010, or 18 percent. Generation has remained relatively constant, between 100 and 105 million MWh.



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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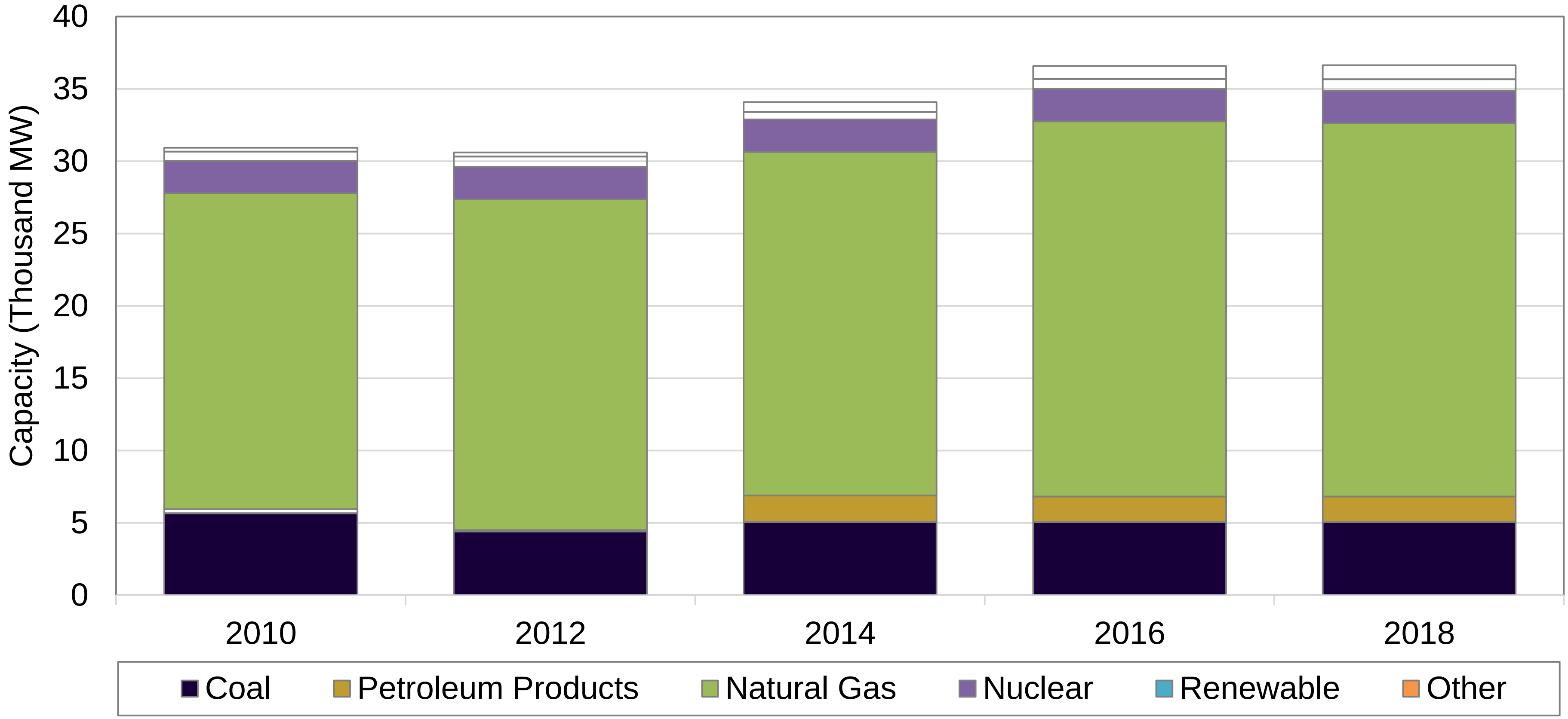
Louisiana electric generating capacity by fuel type

Natural gas generation dominates Louisiana's generation capacity mix (63 percent). The remainder has been in petroleum products (24 percent) and other fuels (11 percent).[1] **Meanwhile, Louisiana's coal capacity has decreased by over 600 MW.**



Note: Petroleum products includes diesel fuel oil and petroleum coke; other fuels include process gas, purchased steam, waste heat and other gases.
Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID).Available at: https://www.epa.gov/egrid

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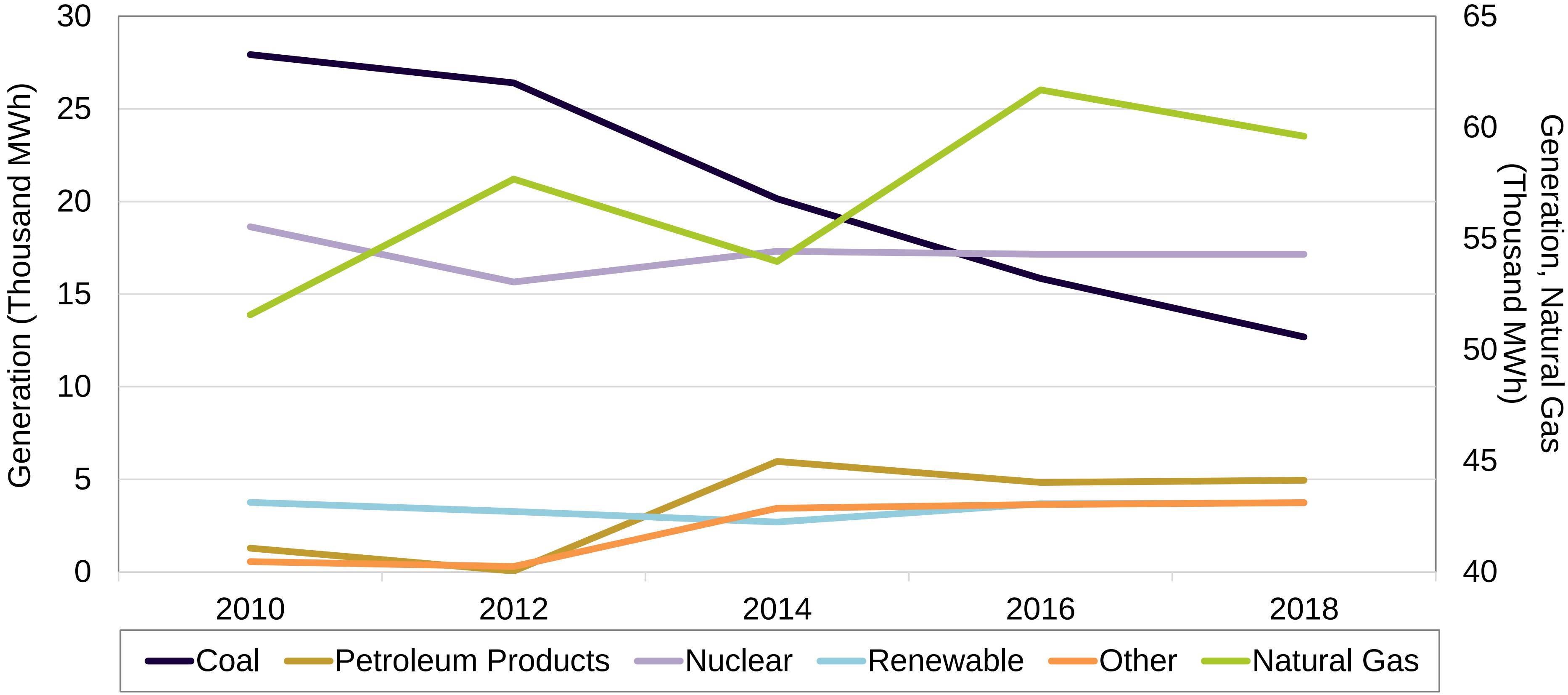
Louisiana electric generation by fuel type

The share of natural gas fired generation in Louisiana increased from 50 percent to 60 percent of total between 2010-2018. Conversely, **coal fired generation declined from 27 percent to 12 percent of total generation**.



Note: Petroleum products includes diesel fuel oil and petroleum coke; other fuels include process gas, purchased steam, waste heat and other gases.
Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID).Available at: https://www.epa.gov/egrid

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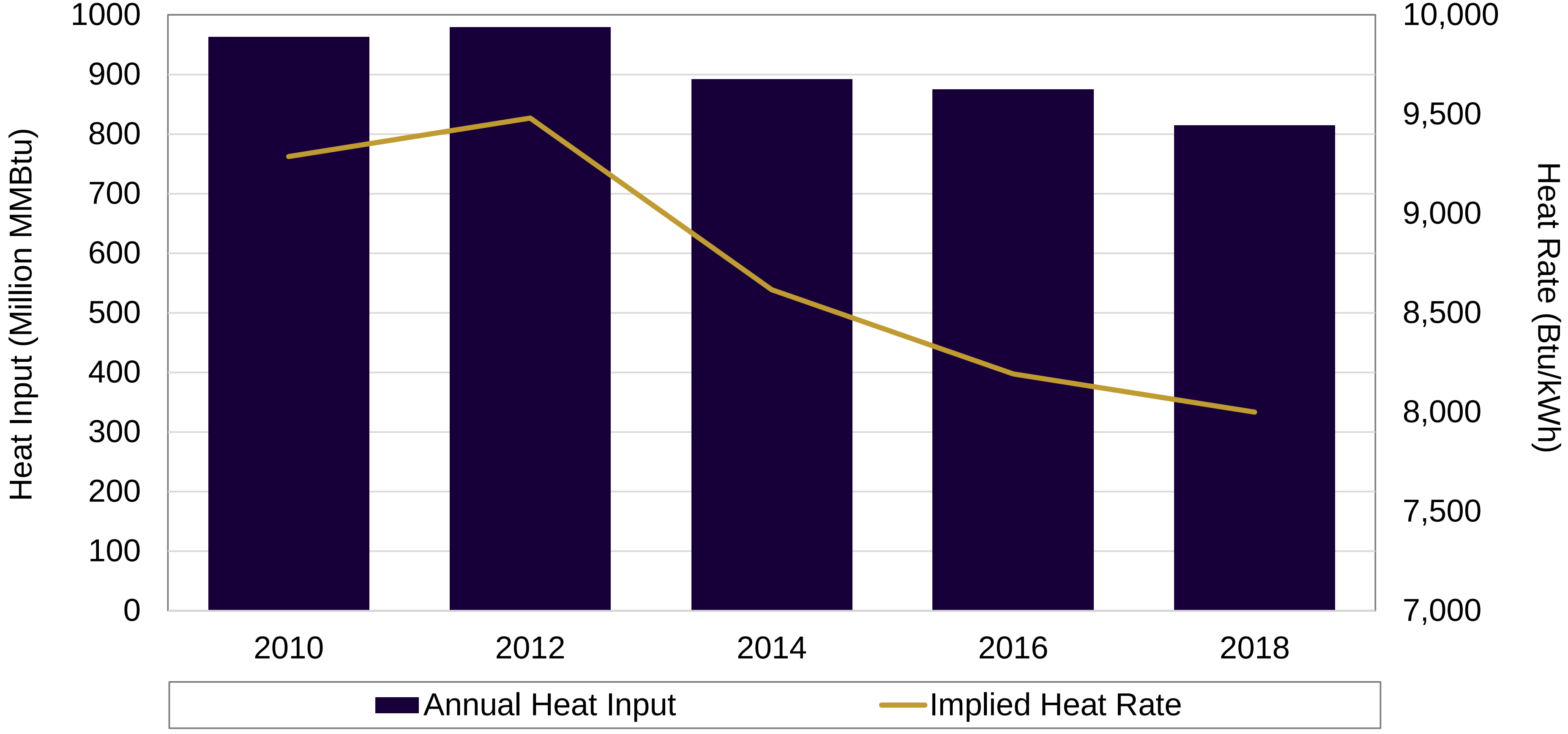
Louisiana electric generation heat input and implied heat rate

Heat input has decreased 15 percent while overall generation has remained constant. This results in a **Louisiana thermal efficiency improvement from close to 9,500 (2012) to around 8,000 Btu/kWh.**



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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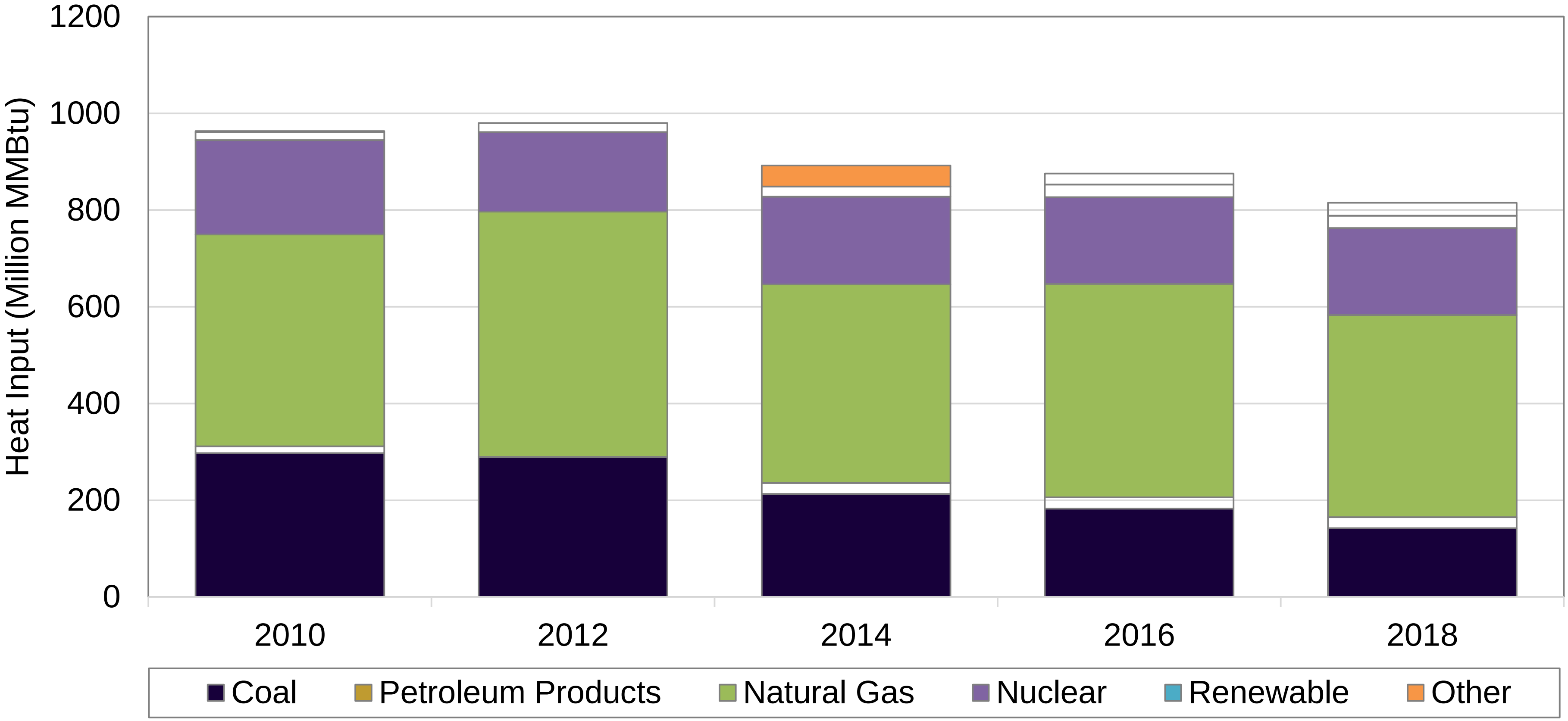
Louisiana electric generation heat input by fuel type

Overall, heat input by electric generation units has been falling. **Heat input by coal fired units is one-half of what it was in 2010 (almost 300 million MMBtu vs 142 million MMBtu)**. Heat input by natural gas units has decreased slightly, by about 5 percent. Heat input by petroleum products and other fuels, however, has increased.



Note: Petroleum products includes diesel fuel oil and petroleum coke; other fuels include process gas, purchased steam, waste heat and other gases.
Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID).Available at: https://www.epa.gov/egrid

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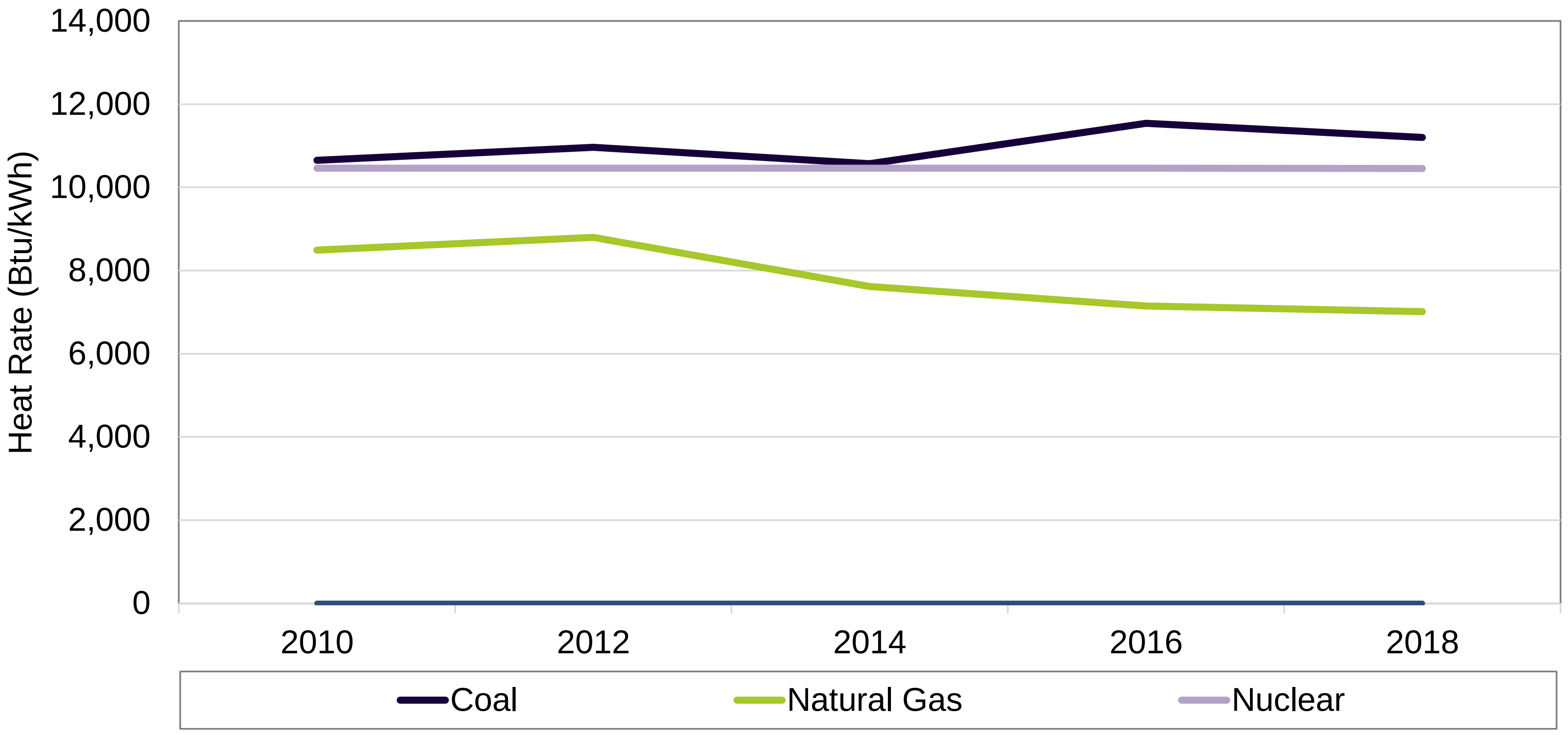
Louisiana electric generation implied heat rate by fuel type

Only natural gas units have gained in their thermal efficiency, falling from an implied heat rate of 8,491 Btu/kWh in 2010 to about 7,015 Btu/kWh in 2018.



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID).
Available at: https://www.epa.gov/egrid

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Louisiana power generation thermal efficiencies, comparison (2018).

Most of the **highly efficient (low heat rate) units** operating in Louisiana are **located at industrial CHP facilities**. **Louisiana only has a handful considerably inefficient power generators** (over 15,000 heat rate) that are run very infrequently (less than 15 percent)

Top 10 Plants	Heat Rate Btu/kWh	Bottom 10 Plants	Heat Rate Btu/kWh
Nelson Industrial Steam Company	4,442	Hargis-Hebert Electric Generating Statio	12,081
ExxonMobil Baton Rouge Turbine Generator	4,956	T J Labbe Electric Generating Station	12,538
Port Allen (LA)	5,022	Big Cajun 1	12,632
Louisiana 1	5,026	Bayou Cove Peaking Power Plant	12,708
Geismar Cogen	5,125	Alliance Refinery	12,971
LSU Cogen	5,156	Agrilectric Power Partners Ltd	16,715
Oak Point Cogen	5,169	NRG Sterlington Power	18,197
Axiall Plaquemine	5,232	Buras	19,497
Mansfield Mill	5,242	Stingray Facility	23,673
Louisiana Tech University Power Plant	5,276	Sterlington	26,102

These units are used primarily for backup/standby service and operate at less than 15 percent annual capacity factor.

Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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Section 4: Historic power generation GHG emissions trends.

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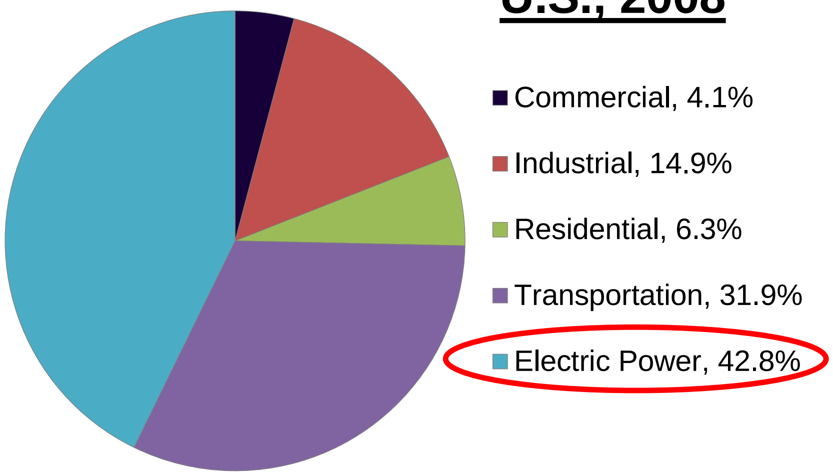
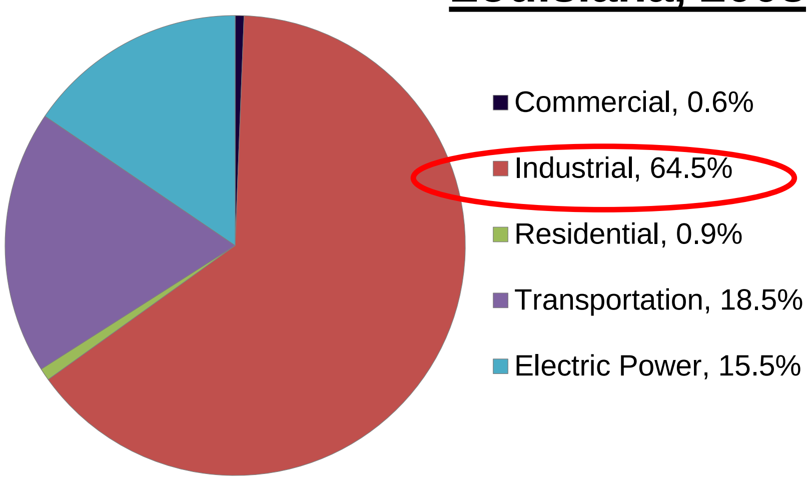
Historic emissions comparisons, CO2 (U.S. LA, 2008)

U.S., 2008



Louisiana, 2008



The underlying sources that contribute to carbon emissions in the U.S. and Louisiana differ.

Historically, **average U.S. carbon emissions have been mostly attributable to the power generation and transportation sectors**. U.S. carbon emissions for **industry, for instance, only accounted for about 15 percent of total.**

In Louisiana, **industry has accounted for most carbon emissions followed by transportation.** Power generation emissions typically accounted for only 16 percent.

Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion. Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion

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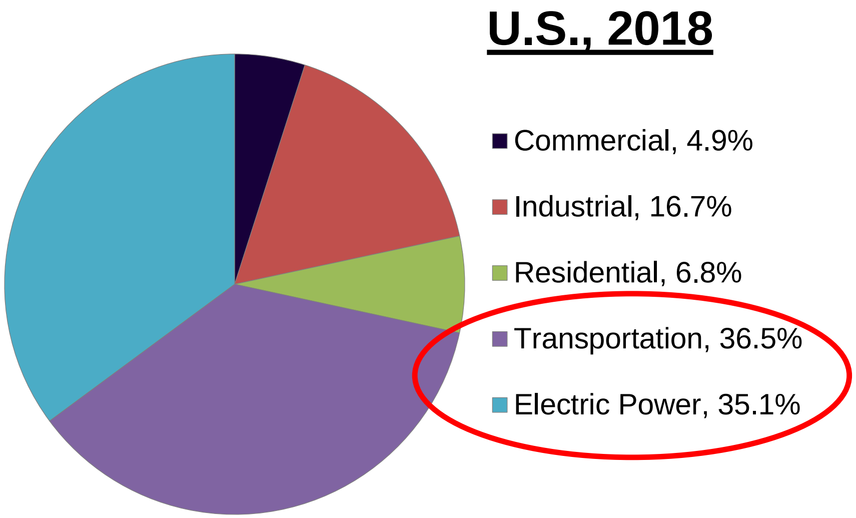
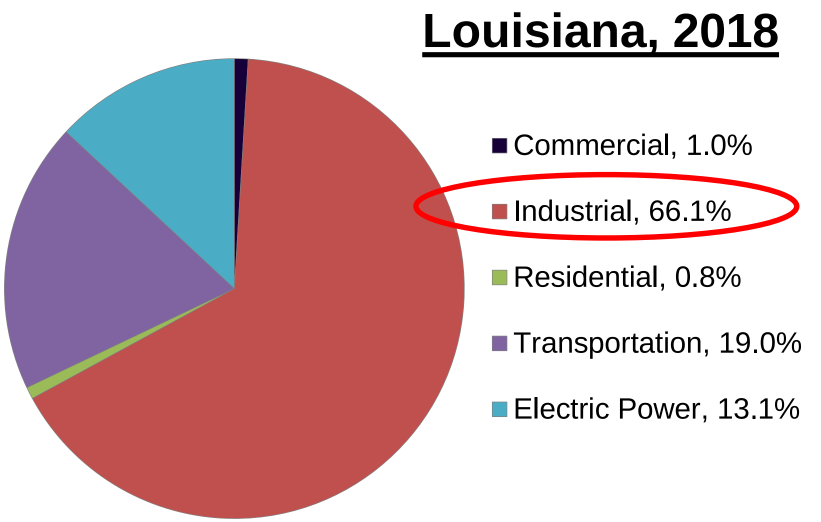
Historic emissions comparisons, CO2 (U.S. LA, 2018)

U.S. carbon emission concentrations have changed some over the past decade.

Today, **U.S. carbon emissions are more equally balanced between transportation and power generation** given the more widespread adoption of renewables in the power generation sector.

In Louisiana, **greater power sector fuel efficiencies have lowered this sector's relative carbon emission shares** with a continued high concentration at industrial locations.





Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion. Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion

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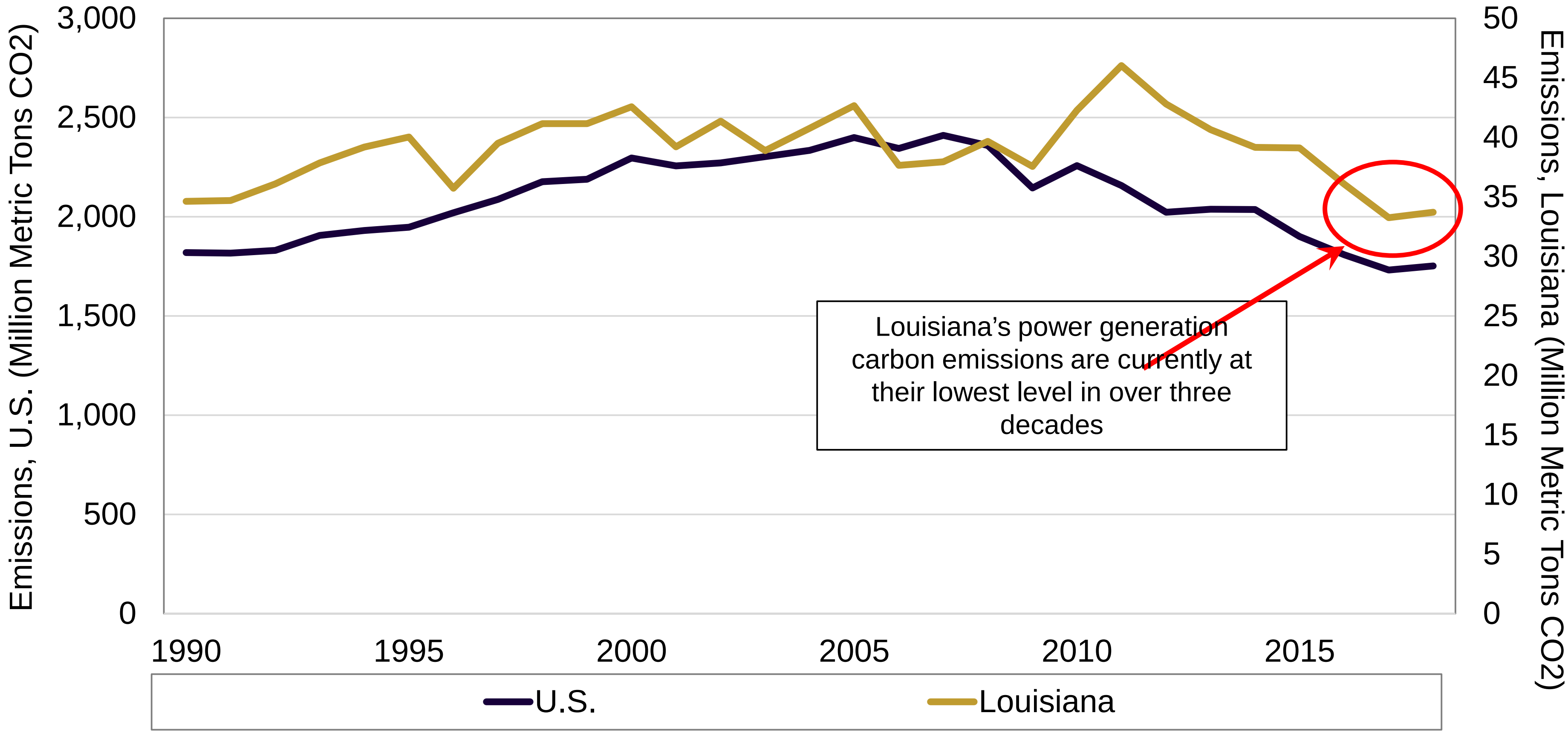
Historic power generation emissions (U.S., LA)

Louisiana power generation emissions have followed trends comparable to the U.S., rising throughout the past decade, and falling rapidly since around 2010. **Louisiana's power generation carbon emissions peaked in 2011 at 46 million tons** and has **fallen by 27 percent** since that time.



Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion.
Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion

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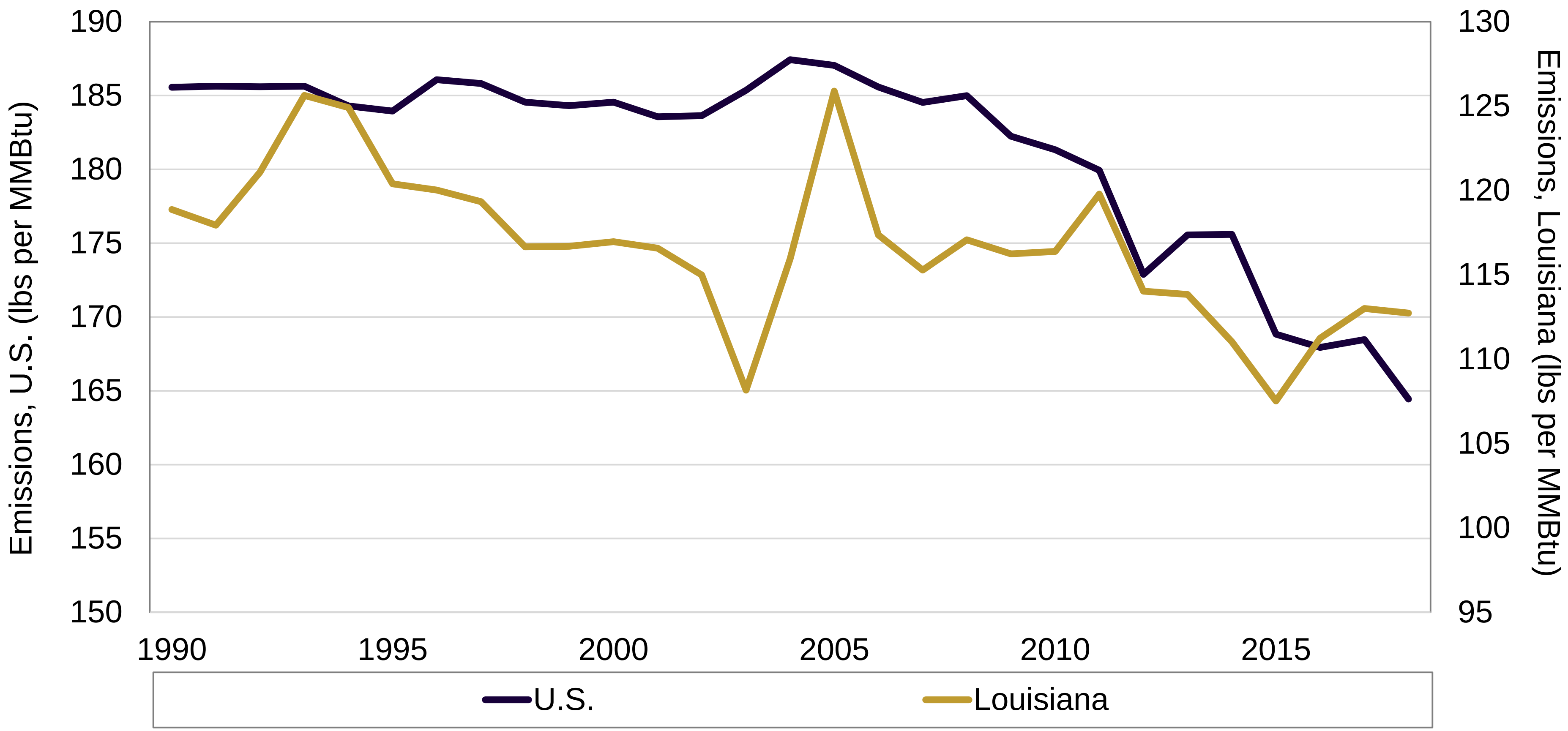
Historic emissions per heat input (U.S., LA)

Louisiana's overall emission efficiencies (measured by emissions per fuel burned) **have always been considerably better than U.S. averages.** Louisiana power generation carbon emission efficiencies have improved significantly since 2011.



Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion. Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion; and U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

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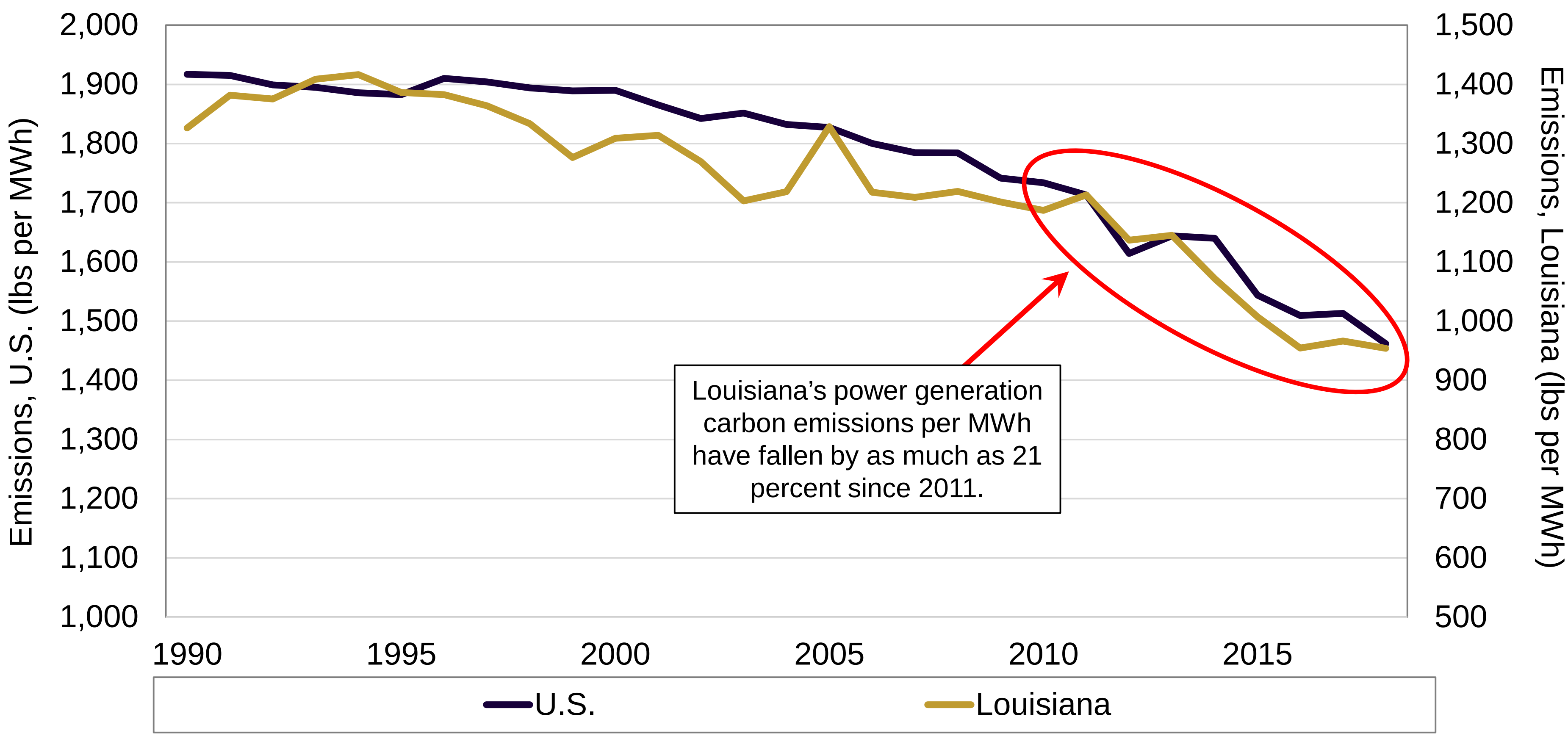
Historic emissions per MWh (U.S., LA)

Louisiana's overall emission efficiencies (measured by emissions per output) **have always been better than U.S. averages.** Louisiana power generation carbon emission per MWh have fallen at a much faster rate since 2011.



Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion. Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion; and U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

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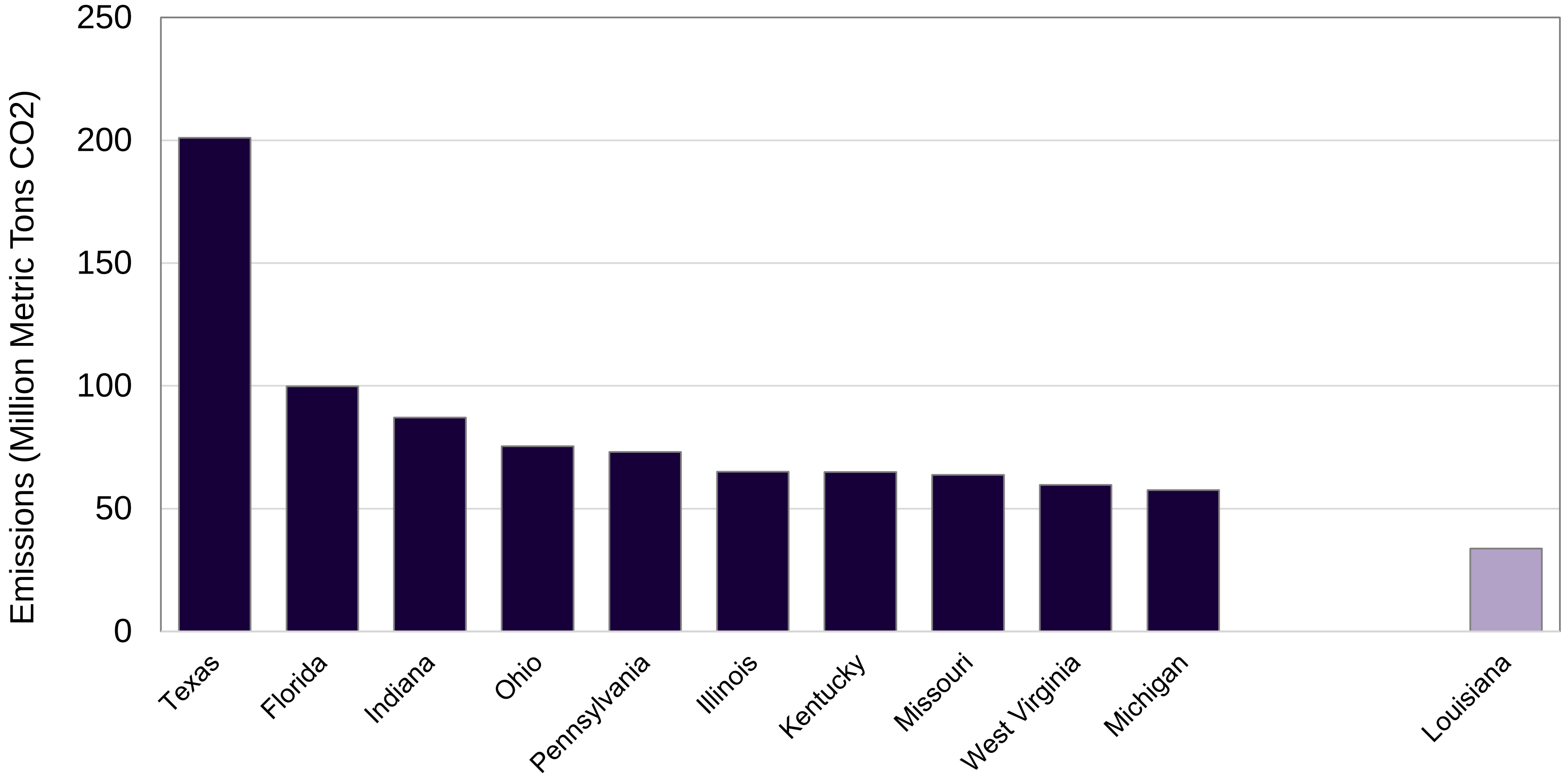
Historic power generation emissions (top 10 states), 2018

Louisiana's power generation related carbon emissions are not among the leading top ten emitters like Texas and Florida. Louisiana ranks 18th in total carbon emissions from power generation.



Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion.
Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion

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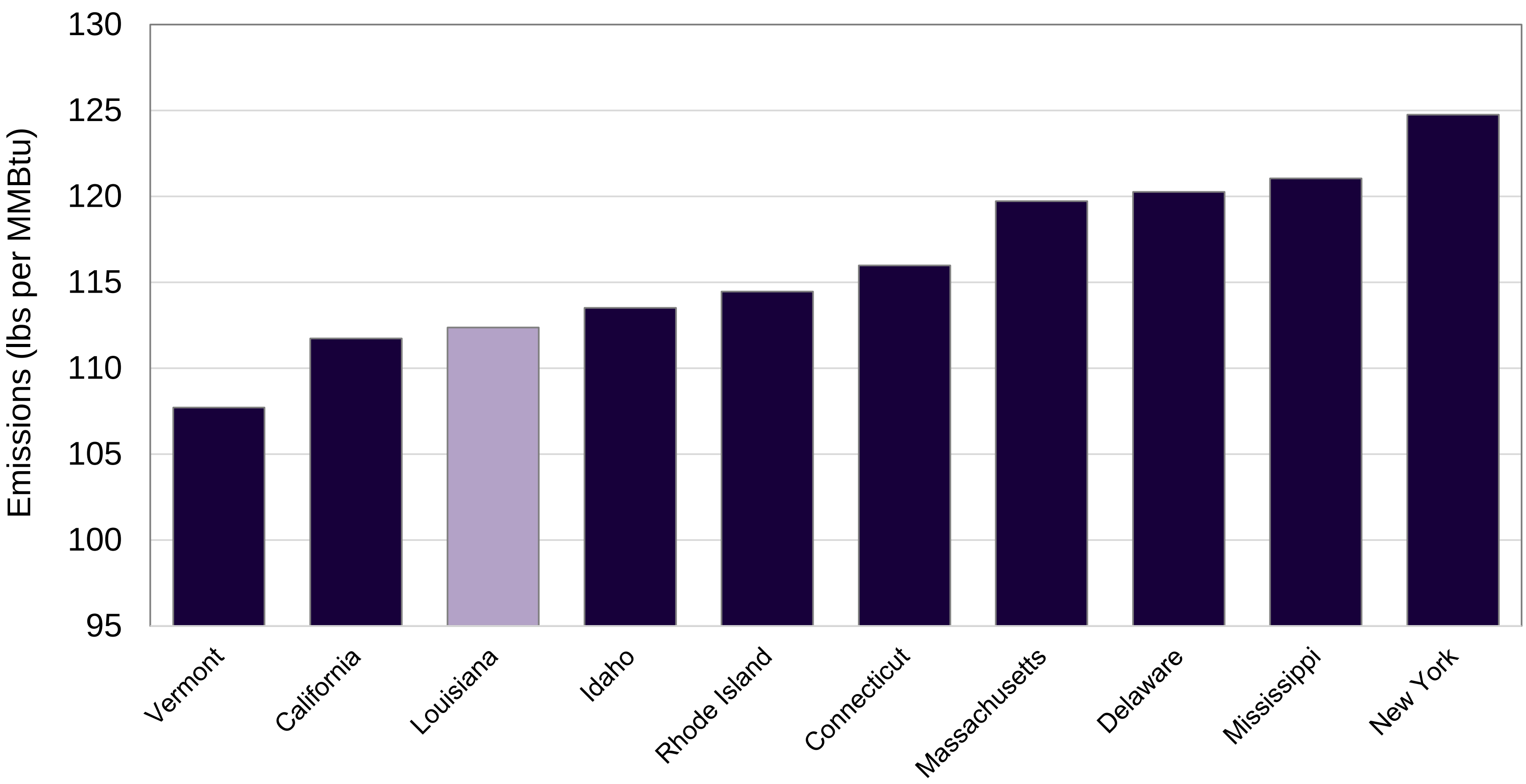
Historic power generation emissions per heat input (lowest 10 states)

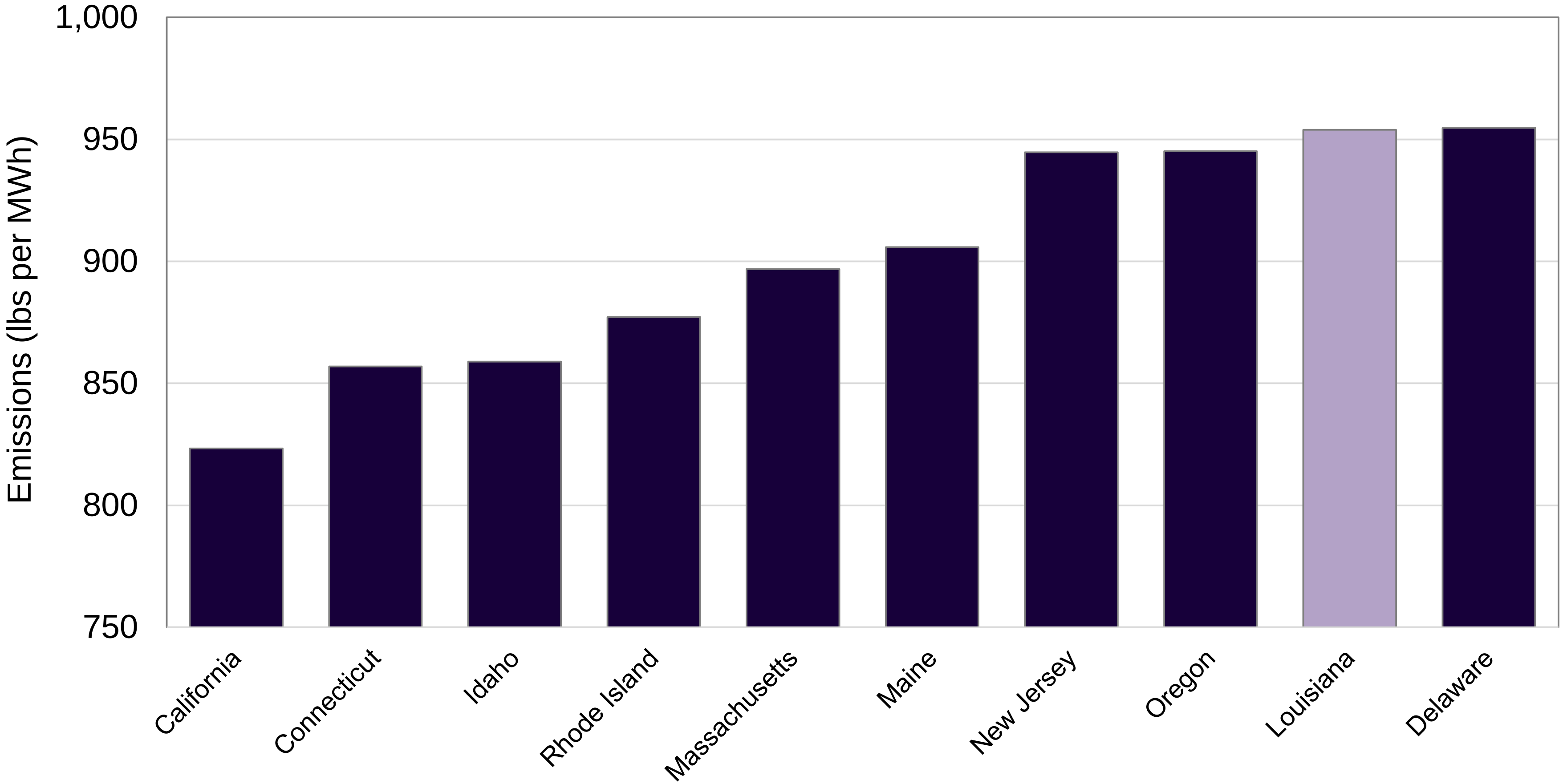
Louisiana has one of the best emissions efficiency ranks (carbon emissions per fuel burned) relative to other states. **Louisiana ranks third in carbon emissions per heat fuel burned** in the power generation sector.



Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion. Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion; and U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

Historic power generation emissions per output (rank order)

Louisiana also ranks in the top ten in terms of power generation emissions per unit of output (MWh).



Source: U.S. Environmental Protection Agency, State CO2 Emissions from Fossil Fuel Combustion. Available at: https://www.epa.gov/statelocalenergy/state-co2-emissions-fossil-fuel-combustion; and U.S. Energy Information Administration, Detailed State Electricity Data. Available at: https://www.eia.gov/electricity/data/state/

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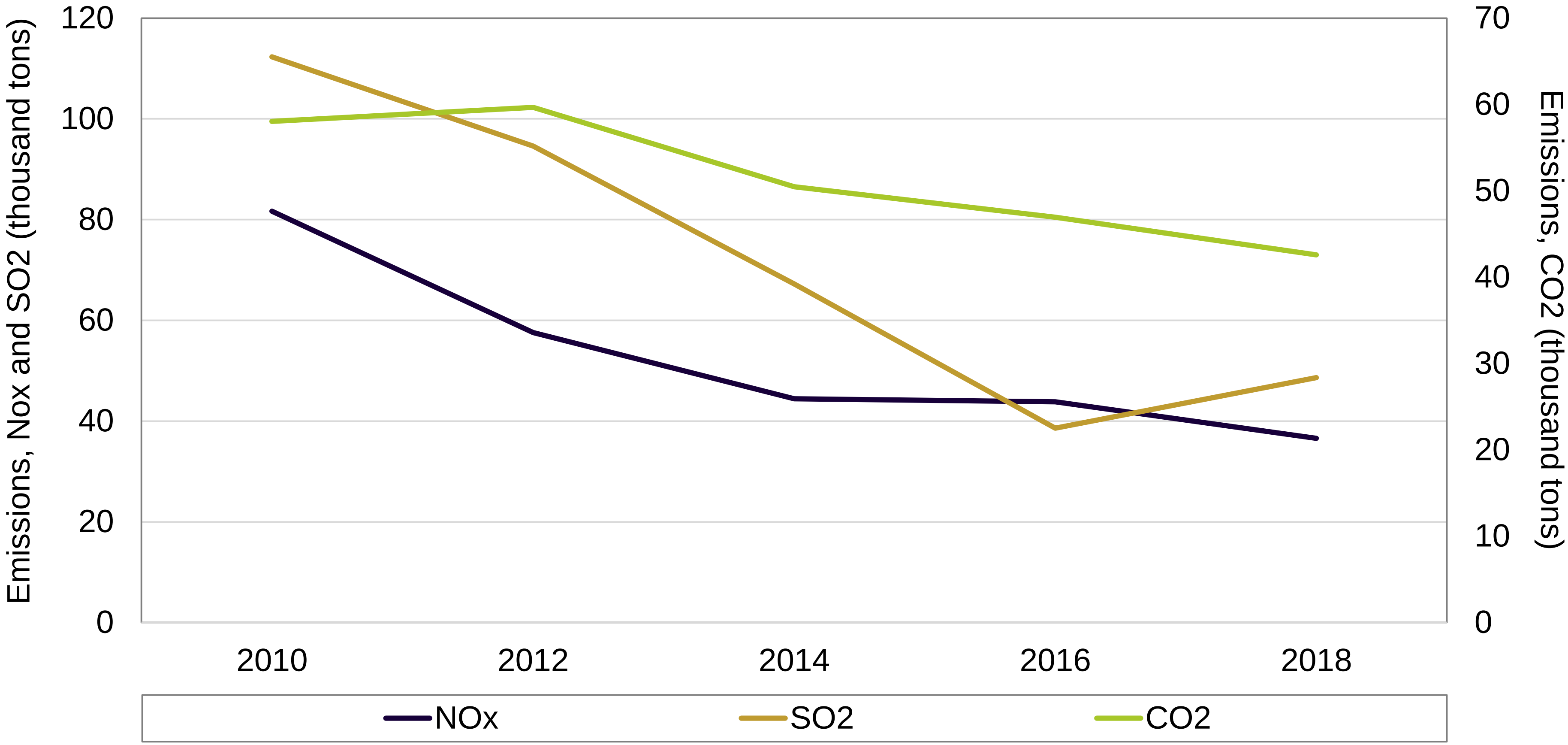
Section 5: Recent Louisiana power generation GHG emissions trends.

Louisiana emissions from electric generation (all major pollutants).

All major air pollutant emissions from Louisiana electric generation have fallen. Since 2010, NOx emissions have decreased 55 percent; SO2 emissions have decreased 57 percent; and CO2 emissions have decreased 27 percent.



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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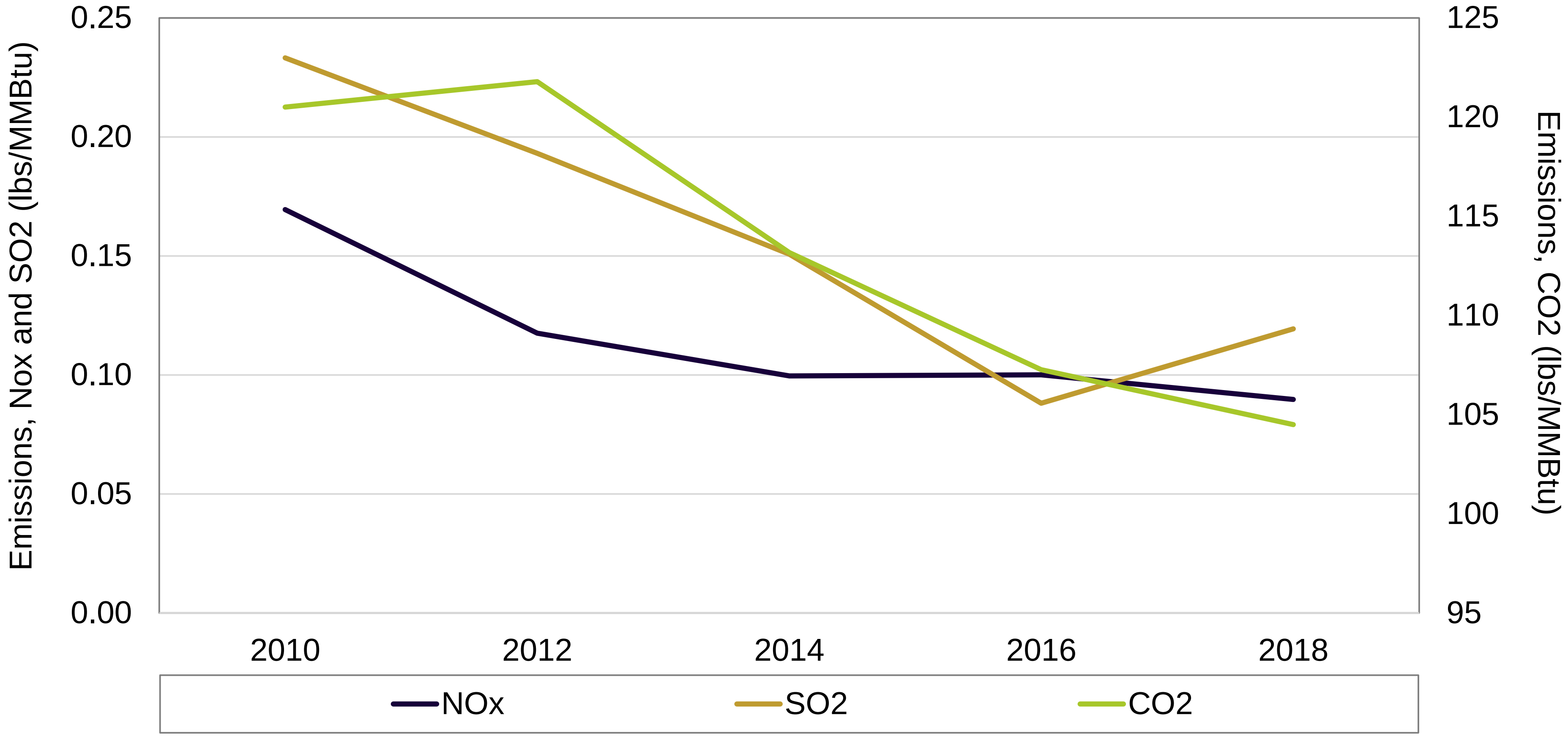
Louisiana emissions from electric generation, per input (all major pollutants).

Likewise, **all major air pollutant emissions from Louisiana generators have fallen on a per heat input basis,** particularly since 2012.



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID).
Available at: https://www.epa.gov/egrid

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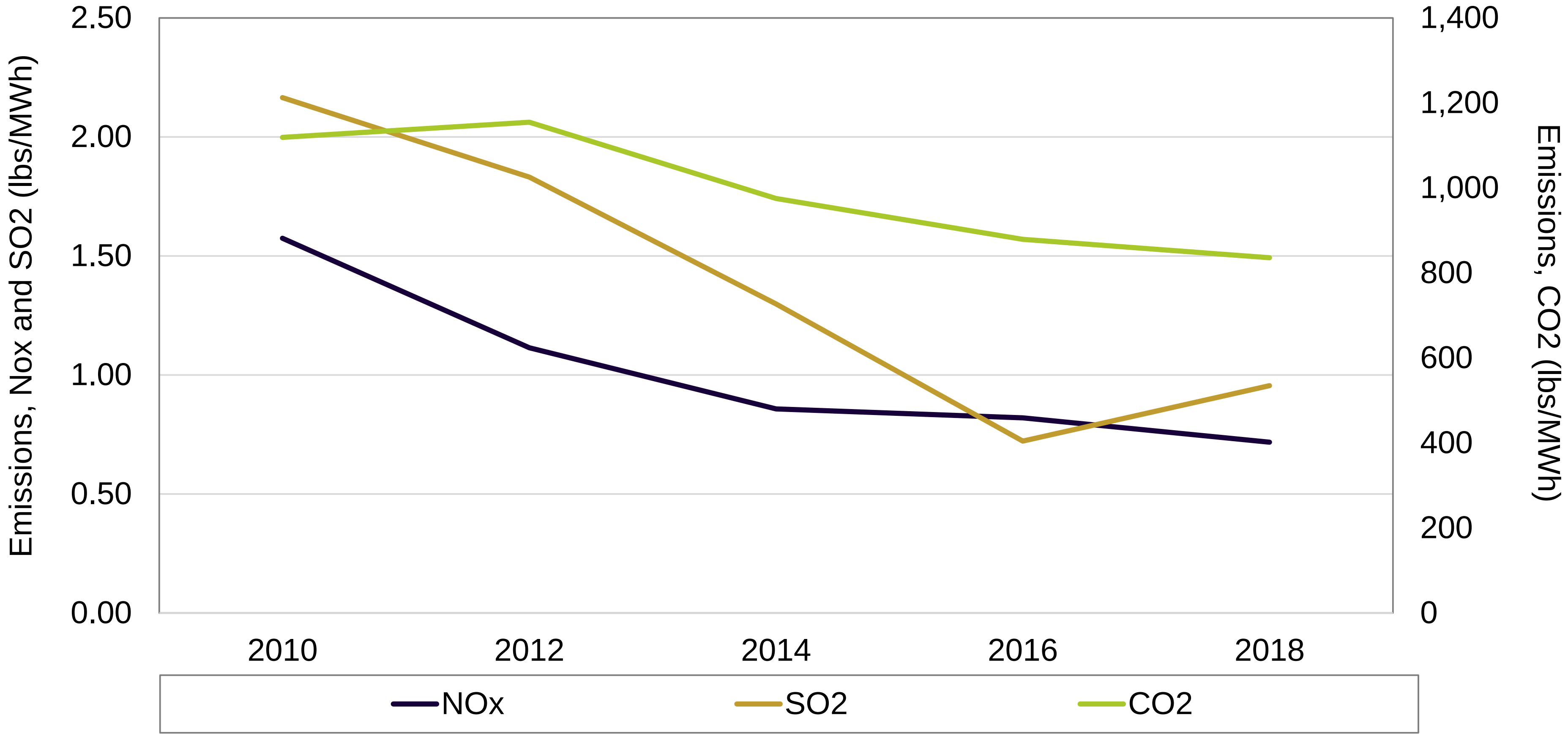
Louisiana emissions from electric generation, per output (all major pollutants).

In addition, **all major air pollutants from Louisiana generators have fallen on a per output (MWh) basis** as well since 2010.



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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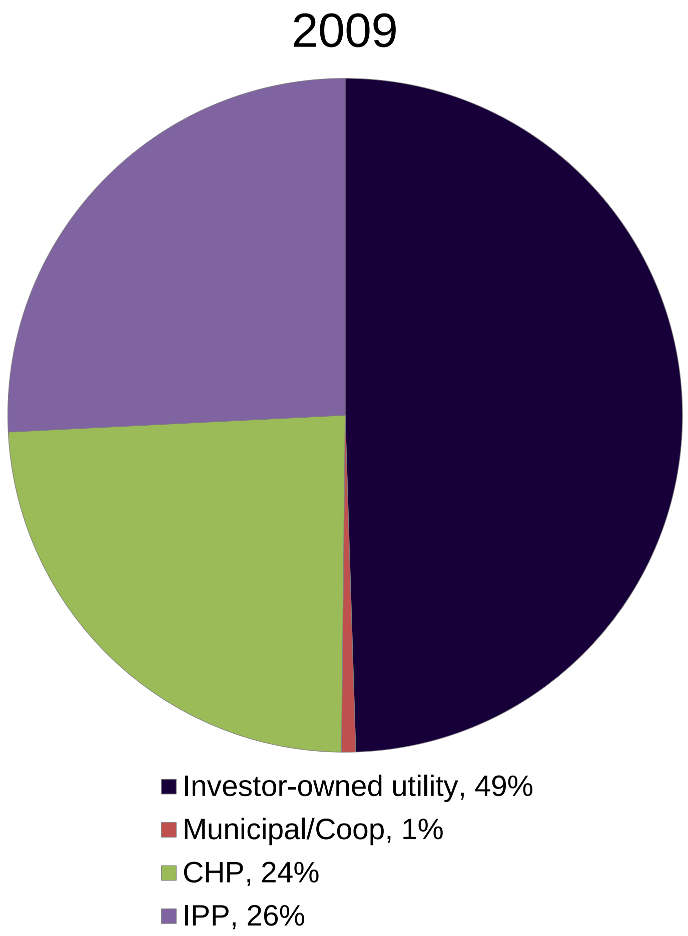
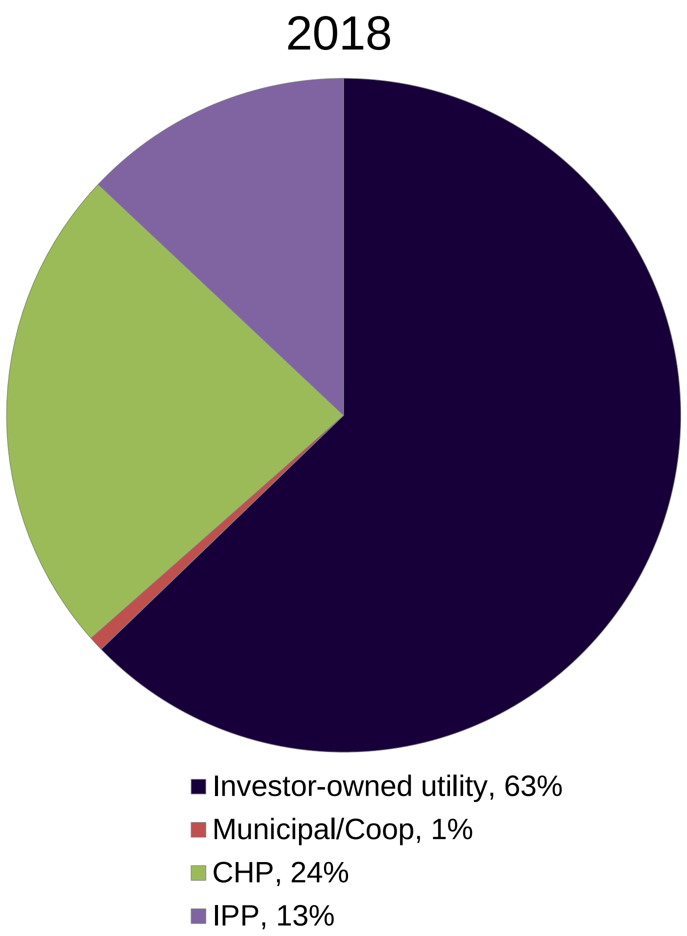
Louisiana power generation emission by ownership, CO2

IOUs have increased their share of carbon emissions over the past decade, in large part due to the expansion of capacity ownership.





Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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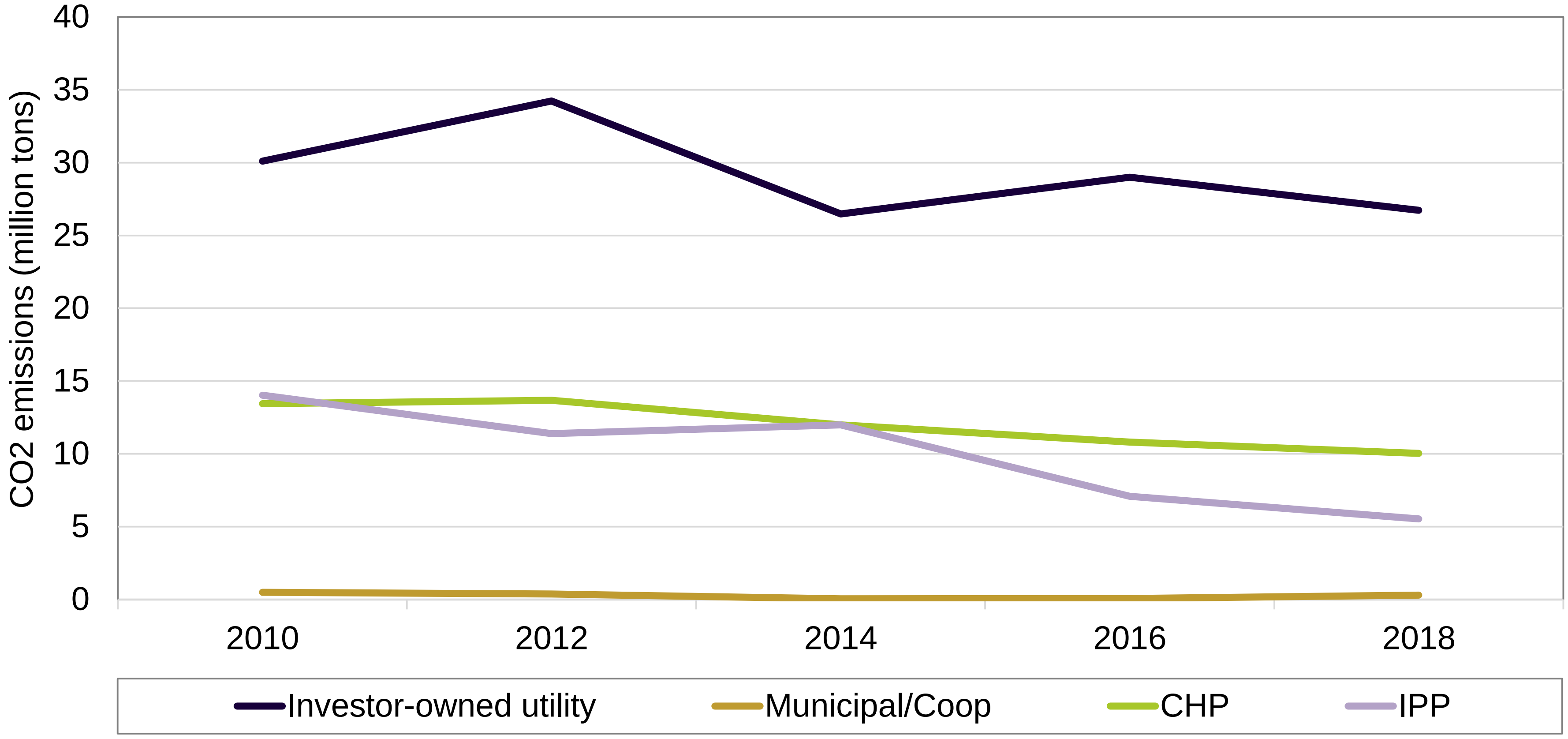
Louisiana electric generation CO2 emissions by ownership type

CO2 emissions have also fallen across ownership types in Louisiana. IPPs have seen a 61 percent decrease while CHP generators have reduced CO2 emissions by 25 percent, municipal and coops by 37 percent and investor-owned utilities have reduced CO2 emissions by 11 percent.



Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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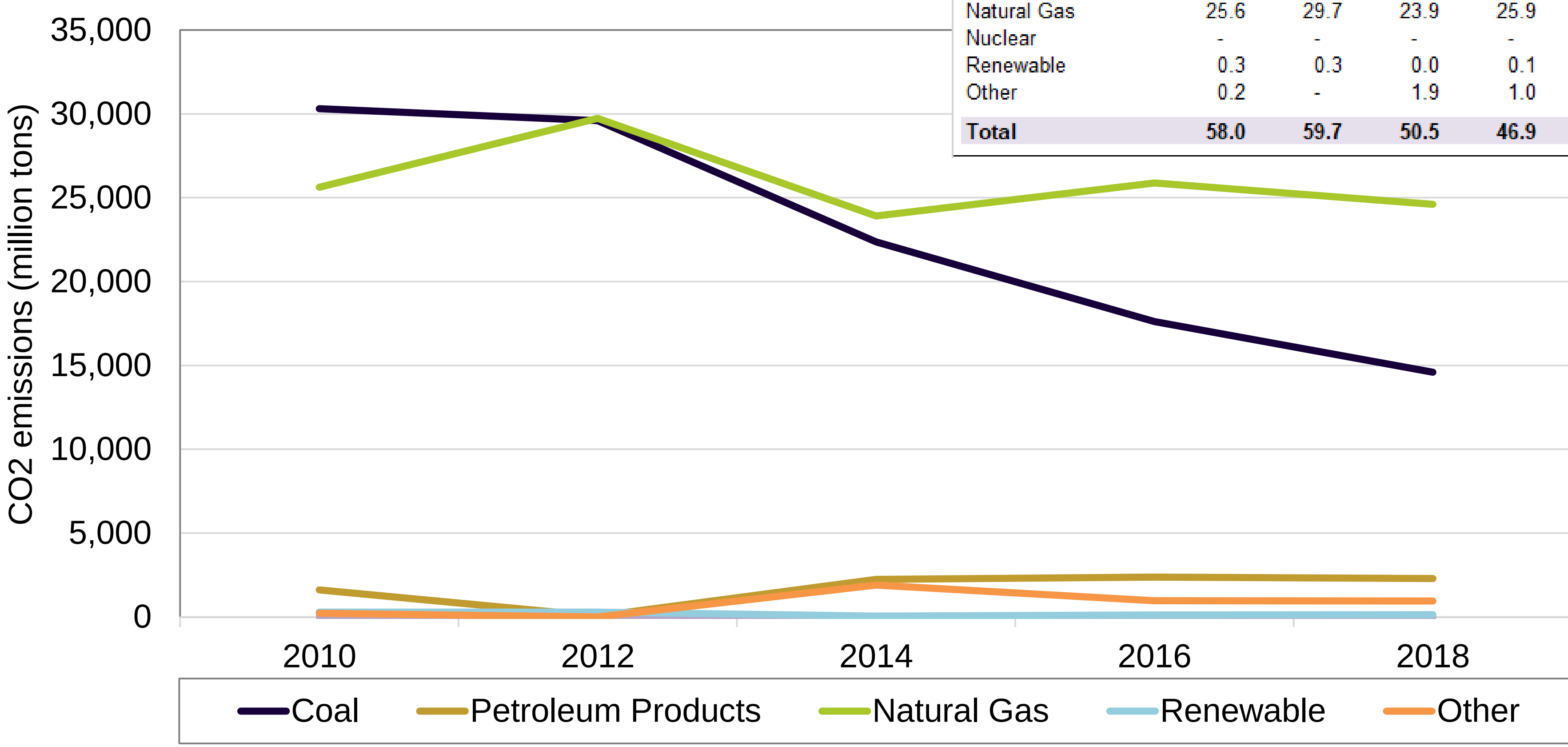
Louisiana electric generation CO2 emissions by fuel type

Louisiana CO2 emissions have also decreased across all generator types. **CO2 emissions from coal fired units are one half of 2010 levels.**

	Annual CO2 emissions (million tons)				
	2010	2012	2014	2016	2018
Coal	30.3	29.6	22.4	17.6	14.6
Petroleum Products	1.6	0.1	2.2	2.4	2.3
Natural Gas	25.6	29.7	23.9	25.9	24.6
Nuclear	-	-	-	-	-
Renewable	0.3	0.3	0.0	0.1	0.1
Other	0.2	-	1.9	1.0	0.9
Total	**58.0**	**59.7**	**50.5**	**46.9**	**42.6**



Note: Petroleum products includes diesel fuel oil and petroleum coke; other fuels include process gas, purchased steam, waste heat and other gases.

Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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Louisiana electric generators, top 20 generators on total emissions basis.

Louisiana's twenty largest generators (non-nuclear) account for 70 percent of generation, 71 percent of NOx emissions, 76 percent of SO2 emissions and 89 percent of CO2 emissions.

				2018 Emissions					
				NOx		SO2		CO2	
Facility	Primary Fuel	2018 Generation (MWh)	% of Total (%)	Emissions (tons)	% of Total	Emissions (tons)	% of Total	Emissions (tons)	% of Total
Ninemile Point	Natural Gas	9,256,076	9%	6,262	17%	23	0%	4,540,252	11%
Brame Energy Center	Coal	6,617,254	6%	4,362	12%	7,042	14%	7,706,781	18%
Taft Cogeneration Facility	Natural Gas	5,289,832	5%	504	1%	2	0%	2,117,677	5%
Big Cajun 2	Coal	4,590,185	5%	3,226	9%	12,963	27%	5,222,001	12%
Acadia Power Station	Natural Gas	4,556,482	4%	155	0%	10	0%	1,953,255	5%
Plaquemine Cogen Facility	Natural Gas	4,441,565	4%	226	1%	4	0%	1,565,446	4%
Nelson Industrial Steam Co.	Petroleum Coke	4,283,308	4%	986	3%	16,717	34%	2,147,748	5%
Ouachita Plant	Natural Gas	4,009,907	4%	207	1%	8	0%	1,627,090	4%
Perryville Power Station	Natural Gas	3,827,526	4%	188	1%	8	0%	1,637,373	4%
Carville Energy Center	Natural Gas	3,064,512	3%	294	1%	6	0%	1,107,316	3%
Coughlin Power Station	Natural Gas	3,008,114	3%	520	1%	8	0%	1,505,790	4%
Louisiana 1	Process Gas	2,818,921	3%	577	2%	8	0%	841,934	2%
Arsenal Hill Power Plant	Natural Gas	2,702,657	3%	122	0%	6	0%	1,139,309	3%
R S Cogen LLC	Natural Gas	2,523,096	2%	475	1%	5	0%	957,128	2%
Dow St Charles Operations	Natural Gas	1,980,789	2%	1,515	4%	16	0%	616,136	1%
PPG Powerhouse C	Natural Gas	1,899,836	2%	120	0%	0	0%	98,173	0%
LaO Energy Systems	Natural Gas	1,717,938	2%	1,103	3%	7	0%	628,356	1%
Little Gypsy	Natural Gas	1,618,180	2%	2,020	6%	5	0%	1,018,212	2%
Waterford 1 & 2	Natural Gas	1,613,666	2%	1,697	5%	8	0%	1,011,955	2%
Axiall Plaquemine	Natural Gas	1,606,430	2%	1,251	3%	13	0%	491,228	1%
Rest of Louisiana		30,436,150	30%	10,748	29%	11,788	24%	4,647,298	11%
Total		**101,862,424**	**100%**	**36,558**	**100%**	**48,647**	**100%**	**42,580,456**	**100%**

Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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Louisiana electric generators, top ten power generation emissions sources (CO2)

The top 10 largest carbon emissions sources (power generation) are concentrated at coal facilities as well as a few larger natural gas and CHP facilities. Note that total emissions do not necessarily reflect emissions efficiencies. **Many of the natural gas generators in this list are very large but have relatively lower emissions on a per heat input, or per output basis.**

Facility	Primary Fuel	CO2 Emissions 2010	2012	2014	2016	2018
		(tons)				
Brame Energy Center	Coal	6,056,503	5,891,000	7,413,244	7,085,451	7,706,781
Big Cajun 2	Coal	13,707,365	11,034,921	11,710,895	6,491,832	5,222,001
Ninemile Point	Natural Gas	3,108,900	2,889,195	2,671,810	4,603,281	4,540,252
Nelson Industrial Steam Co.	Petroleum Coke	1,508,339	n.a.	2,046,282	2,204,305	2,147,748
Taft Cogeneration Facility	Natural Gas	2,400,920	2,232,926	2,446,573	2,390,342	2,117,677
Acadia Power Station	Natural Gas	1,350,490	2,060,818	1,973,816	2,878,268	1,953,255
Dolet Hills Power Station	Coal	5,424,155	5,678,438	3,244,987	3,750,931	1,674,703
Perryville Power Station	Natural Gas	847,109	1,138,930	1,425,702	1,373,639	1,637,373
Ouachita Plant	Natural Gas	499,904	673,382	1,458,381	1,562,408	1,627,090
Plaquemine Cogen Facility	Natural Gas	1,470,373	1,689,653	1,459,147	1,866,356	1,565,446
Total		**36,374,058**	**33,289,264**	**35,850,838**	**34,206,814**	**30,192,324**
Percent of Total Louisiana		**63%**	**56%**	**71%**	**73%**	**71%**

Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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Louisiana electric generators, CO2 (lbs per MMBtu)

The top ten generation facilities in Louisiana, from a carbon emissions per heat input perspective are those that are relatively less efficient and/or burn other hydrocarbons or other byproducts such as black liquor.

Facility	Primary Fuel	CO2 Emissions 2010	2012	2014	2016	2018
		---------------------------- (lbs/MMBtu) ----------------------------				
T J Labbe Electric Generating St.	Natural Gas	3,464	8,538	46,599	29,647	18,943
Oak Point Cogen	Natural Gas	1,587	2,169	4,402	6,240	6,499
Big Cajun 1	Natural Gas	33,330	16,150	48,642	14,540	5,661
Alliance Refinery	Other Gas	1,672	n.a.	5,959	4,287	5,607
Lieberman Power Plant	Natural Gas	1,529	1,812	2,105	5,093	2,859
CITGO Refinery Powerhouse	Other Gas	425	736	1,252	1,948	2,194
NRG Sterlington Power	Natural Gas	20,742	17,445	1,025	1,763	2,086
DeRidder Mill	Black Liquor	5,508	5,779	3,093	3,311	1,556
Burnside Alumina Plant	Natural Gas	n.a.	135	n.a.	n.a.	1,104
Calcasieu Plant	Natural Gas	627	713	702	393	788

Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID). Available at: https://www.epa.gov/egrid

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Louisiana electric generators, CO2 (lbs per MWh)

The top ten generation facilities in Louisiana from an output perspective are also those that are relatively less efficient and/or burn other hydrocarbons or other byproducts such as black liquor.

Facility	Primary Fuel	CO2 Emissions 2010	2012	2014	2016	2018
		---------- (lbs/MWh) ----------				
T J Labbe Electric Generating St.	Natural Gas	45,050	94,734	674,917	387,037	237,514
Alliance Refinery	Other Gas	16,501	n.a.	87,297	54,799	72,721
Big Cajun 1	Natural Gas	449,739	205,129	595,066	181,768	71,505
NRG Sterlington Power	Natural Gas	430,599	321,185	17,751	31,659	37,955
Oak Point Cogen	Natural Gas	11,667	15,549	32,135	32,777	33,596
Lieberman Power Plant	Natural Gas	25,422	27,371	31,345	58,569	30,527
CITGO Refinery Powerhouse	Other Gas	3,903	6,727	7,042	10,800	12,145
DeRidder Mill	Black Liquor	32,600	32,221	17,234	18,378	8,642
Calcasieu Plant	Natural Gas	7,245	8,128	7,704	4,300	8,538
Burnside Alumina Plant	Natural Gas	n.a.	6,546	n.a.	n.a.	6,419

Source: U.S. Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID).
Available at: https://www.epa.gov/egrid

Section 6: Conclusions.

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Conclusions

Louisiana’s power generation-related GHG emissions comprise a smaller share of overall state GHG emission than the national average. Most Louisiana GHG emissions are concentrated with industry, not power generation.

Louisiana has historically relied upon large shares of nuclear and natural gas generation that has helped minimize overall GHG emissions.

In addition, Louisiana has one of the highest share of high efficiency combined heat and power (“CHP”) generation of any state in the U.S. This also helps to keep GHG emissions lower.

Over the past decade, Louisiana’s power generation sector has:

(1) Reduced overall GHG emissions by 27 percent.
(2) Reduced GHG emissions per heat input (Btu) by 6 percent.
(3) Reduced GHG emissions per output (MWh) by 21 percent.

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LSU CENTER FOR ENERGY STUDIES
RESPONSE TO SCIENTIFIC ADVISORY GROUP COMMENTS
CLIMATE INITIATIVES TASK FORCE

INTRODUCTION

On April 30, 2021, the LSU Center for Energy Studies ("CES") submitted a preliminary draft report to the Governor's Office of Coastal Activities ("OCA"), who in turn, provided this work to the Scientific Advisory Group ("SAG") for the Governor's Climate Initiatives Task Force. This report, provided in multiple powerpoint files, includes an analysis of Louisiana's greenhouse gas ("GHG") emission trends as compiled from an updated estimate of the state's GHG Inventory. These GHG emission estimates were compiled using the GHG State Inventory Tool ("SIT") developed and annually maintained by the Environmental Protection Agency ("EPA"). The preliminary workpaper supporting the updated GHG Inventory estimates was also provided at this time. The purpose of this submission to OCA and the SAG was to attain a peer review, and to seek input and comments, on the SIT methods and final quantitative results.

CES provided the GHG Inventory materials in separate files corresponding to each SIT module that includes:

- Combustion of Fossil Fuels
- Stationary Combustion
- Industrial Processes
- Electricity Consumption
- Mobile Combustion
- Coal
- Oil and Natural Gas Systems
- Wastewater
- Municipal Solid Waste
- Agricultural Resources
- Land and Land Use

CES appreciates having the opportunity to respond to the SAG's comments and peer review. The following pages provide the original comments, as codified by the Governor's OCA. Each set of comments are organized by individual SIT modules. CES' reply and follow up are provided subsequent to each set of comments.

SAG Comments and CES Comment Responses

Natural Gas and Oil Systems – SAG Comments

- #2. **Utilized Methods** – Methods look robust for methane and CO2 emissions but measurements for nitrous oxide not included. Why? Are they negligible? How were uncertainties estimated?
- #3. **Deviations** – No deviations compared to EPA SIT spreadsheet.
- #4. **Data Sources** – What are the uncertainties with the activity data presented herein? Looks like data are obtained by self-monitoring programs of private companies. Comparisons with independent methods could help cross-check methods. Though, truly independent estimates for comparisons are rare, estimating uncertainties can provide adequate idea of reliability of inventory.
- #5. **Results** – Expected to see some increase in gas flaring given some deregulations in recent years, but flaring levels seem to be steady.
- #6. **Range of Expectations** – Preliminary data should be cross-checked to confirm data given by private companies through their self-monitoring programs.
- #7. **Outside Sources** – Yes.
- #8. **Recommendations** – None.

Natural Gas and Oil Systems – CES Comments/Response

Response to Comments: The natural gas and oil systems module in the EPA's SIT focuses exclusively on carbon dioxide and methane emissions. The drivers in this module are primarily focused on pipelines and pipeline materials composition to account for more "leaky" pipe that can release methane emissions (i.e., bare steel and cast iron, for which Louisiana has very little), an exceptionally potent GHG, particularly in the near term. Some refinery releases of methane are considered in this module, but most of the GHG emissions associated with refinery activity are concentrated in the combustion of fossil fuels module (CO_2) and the stationary combustion module (NO_X).

There are no provisions in the SIT for nitrous oxide emissions, likely because (a) they are not large for pipelines and production (wells) and (b) while there are such emissions for refineries, those are accounted for in the stationary combustion module.

In terms of uncertainties, the EPA SIT includes a variety of emission factors (parameters) that, when multiplied by certain emissions "drivers," result in total emissions. For example, in the natural gas and oil systems module, there are emission factors that are used that estimate the CH_4 releases that arise from a typical pipeline mile of bare steel distribution mains. These factors (parameters) are developed/collected from a variety of sources, including engineering estimates and the academic literature, by the EPA. The variability and uncertainty of releases will be likely apparent in the standard deviation of the factors compiled to develop an “average” emission factor; the higher the standard deviation, the higher the uncertainty.

While an uncertainty analysis of this nature can have merit, CES did not do a sensitivity analysis nor any parametric/statistical/simulation type of analysis on potential GHG emissions since (a) that is usually not done in developing a state level GHG inventory and (b) this was beyond the scope of our work, particularly given the timing of the study’s deliverables.

Regarding data sources, CES has no reason to question the information and underlying data used in the natural gas and oil systems SIT module. First, it is important to note that the default data and information used in this module is recommended by EPA who has vetted this information over multiple years. Most of this information is collected in large part by federal executive agencies and has civil and, in some instances, criminal penalties for any data misrepresentation.

For instance, all U.S. pipeline operators are required by law to provide the Pipeline and Hazardous Materials Safety Administration (“PHMSA”) accurate information about their pipe inventories. Federal law requires transmission operations to prepare and maintain Transmission Integrity Management Plans (“TIMPs”) and distribution operators are required to prepare and maintain Distribution Integrity Management Plans (“DIMPs”). Both of these IM reports and analyses require that operators provide full pipeline inventories and to “know their systems” on a complete and thorough basis and to understand and accurately report leaks and leak risks.

The same can be said for production data. Misrepresentation of the number of wells and production information can result in civil and potentially criminal sanctions, particularly for publicly traded oil and gas corporations. Misrepresentation can also lead to civil liability issues and potential state action through the Louisiana Office of Mineral Resources (state leases), the Louisiana Mineral Board (state leases), and the Office of Conservation (all leases).

Lastly, large compression stations, another important driver of GHG emissions in this module, are typically located on large interstate pipeline systems. These compression stations are regulated, in part, by PHMSA and the Federal Energy Regulatory Commission ("FERC") for ratemaking purposes. Consistent and intentional misrepresentation of information to either regulator could result in a series legal and enforcement actions.

CES appreciates the reviewer's comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders as well the underlying data. Lastly, the underlying data will be identified and sourced in the final report.

Coal, Industrial Processes, Electricity Combustion, and Stationary Combustion – SAG Comments

- #2. **Methods** – Acceptable. Release original calculation spreadsheet and provide summary of emission factors for quality control and potential uncertainty analysis.
- #3. **Deviations** – Could be more accurate to utilize FLIGHT model for GHG reporting of industrial process emissions, which reports emissions from 417 facilities and can split emissions from fuel combustion and industrial processes. Compare report data against FLIGHT model data for validation or uncertainty analysis.
- #4. **Data Sources** – Release original calculation spreadsheet used in EPA SIT model and provide summary of emission factors for each category for quality control and potential uncertainty analysis.
- #5. **Results** – Consistent.
- #6. **Range** – Cross checked data with other sources including EIA state profile/estimates and EPA GHG reporting program, and results are consistent.
- #7. **Outside Resources** – Yes. EIA state profile/energy estimate; EPA FLIGHT; EPA GHGRP, EPA SIT, EPA eGRID
- #8. **Recommendations** – 1) Consult EPA FLIGHT model. 2) Release original calculation spreadsheet and provide summary of emission factors for quality control and uncertainty analysis.

Coal, Industrial Processes, Electricity Combustion, and Stationary Combustion – CES Comments/Response

Response to Comments: The naming conventions, and organization of the EPA SIT is admittedly very confusing, even to those that work with this system and its component data on a consistent basis. The coal SIT module is one such example since one would assume this module would be dedicated to coal consumption, given the importance such consumption can have on GHG emissions. Instead, the coal SIT module is dedicated to coal mining, not coal combustion or usage. Thus, the use of the EPA FLIGHT data, while helpful for combustion analysis, does not have any use for examining mining GHG releases.

The coal SIT module is dedicated to estimating GHG releases from underground mines, surface mines, and some surface mining activities. This module does not estimate CO_2 releases but CH_4 releases from coal mining activities. Louisiana's mining activities are limited to surface lignite mines. Combustion related CO_2 releases for coal generation are estimated in the Combustion of Fossil Fuels module.

On the issue of industrial and power generation emissions, the final report will include a reconciliation of the SIT, the EPA FLIGHT data, and Energy Information Administration (“EIA”) data. The reconciliations provided in the final report show very good reconciliation between all sources of data. CES recommends that the SAG treat all GHG estimates in this study, and any other study, as inputs and tools in understanding a “range” of GHG emissions that come from Louisiana households, business, industries, and its natural environment. Upper end estimates can be used as conservative indicators of potential Louisiana GHG emissions.

CES appreciates the reviewer’s comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Coal – SAG Comments

- #2. **Methods** – Explicitly list data sources. Should emissions be associated with coal transport? Are any emissions associated with coal storage and transport along the Mississippi River? Is there any methane outgassing associated with large piles of coal?
- #3. **Deviations** – None.
- #4. **Data Sources** – Need to explicitly list.
- #5. **Results** – Is this module from coal production only, or production and power generation? If power generation is in another module, slide 17 (showing power gen from coal) should be eliminated to minimize confusion.
- #6. **Range** – Reasonable and identical to 2018 EIA data.
- #7. **Outside Resources** – US EIA.
- #8. **Recommendations** – Include coal transport and storage to reflect major use along Mississippi River.

Coal – CES Comments/Response

Response to Comments: As noted in response to prior SAG coal module comments, this module is dedicated to only methane emissions from mining and coal handling activities and does not include (a) coal transportation-related emissions nor (b) coal combustion emissions. Coal combustion CO_2 releases are estimated in the Combustion of Fossil Fuels module.

Slide 17, showing coal power generation is provided to show that there is a one-for-one relationship between coal mining and coal power generation. The mines in the state are used primarily to run power generation and as coal power generation falls, so too does coal mining and any associated methane releases from the mining and fuel handling activities. If the SAG, and ultimately, the Task Force, decides that one policy direction for the state should be the elimination of coal-fired generation, this charge helps to understand the CH_4 implications of such a decision. However, this point needs to be better developed with the chart and the final report will include such a revision/clarification.

CES appreciates the reviewer's comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Electricity Consumption – SAG Comments

- #2. **Methods** – SIT-excel "Electricity Consumption" module only has projections for future trends not actual data based on current/past electricity usage, which is quite different from PPT slides.
  - Slides 15-18 assume electricity used in state come from fossil fuels not hydropower or renewables. Was electricity generated for hydropower or other renewables accounted for? If so, how?
  - Slides 15-18 how is electricity generated from out-of-state incorporated into this module?
  - See original data used and sources of data.
- #3. **Deviations** – SIT-excel was only future trends for electricity consumption not actual data based on current/past usage.
- #4. **Data Sources** – Original data?
- #5. **Results** –
  - Assume all electricity generated from fossil fuels, not hydropower or renewables. Was electricity generated from hydropower or other renewables accounted for?
  - How is electricity generated from out-of-state incorporated into this module? How is the source (coal, renewables, gas) out-of-state electricity accounted for?
  - Slides 12-14 should be presented in terms of total electricity across the state for comparison.
- #6. **Range** – Hard to tell since units don't align with EIA.
- #7. **Outside Resources** – US EIA.
- #8. **Recommendations** – Clear indication of how renewables (at industrial/residential scale) were incorporated.

Electricity Consumption – CES Comments/Response

Response to Comments: As noted in the prior response to the coal, industrial process, and mobile combustion comments, the naming conventions of the individual SIT modules is confusing and distracts from their individual purposes.

Most importantly, is that the electricity consumption module will not be used, and should not be used, to estimate the total state GHG inventory. CES corroborated this with EPA on a June 16, 2021 meeting that included LDEQ staff. The electricity consumption module exists to inform stakeholders about how certain end uses can influence emissions that ultimately arise from power generation. Thus, if the state were interested in how changes in building code efficiencies could impact emissions, the electricity consumption module could provide some insights into these strategies.

The use of both the electricity consumption module, along with the power generation emissions in the Combustion of Fossil Fuels module will result in double counting. In theory, supply equals demand in all power systems. Supply is power generation, demand is consumption; thus, if both are included in the inventory, emissions are double counted.

In practice, there are some differences between supply and demand since some supply comes from out of state (imports), some generation leaves the state, and there are thermal losses at generators and various transmission and distribution lines that are largely a function of their voltage levels.

However, the primary module for estimating electricity related emissions is part of the Combustion of Fossil Fuels module. This module estimates the emissions arising from power generation by fossil fuel type. Coal emission factors, therefore, are higher than natural gas. Liquid petroleum fuels used in power generation also have higher emission factors than natural gas.

All fossil fuel generation is estimated to emit GHGs. Non-fossil generation in the state does not emit GHGs and, therefore, is not included in the calculation. Thus, no nuclear generation contributes to Louisiana's GHG emissions, nor do any of the emerging renewable resources that are primarily solar. There is limited hydroelectric capacity in the state, and the capacity that does exist does not contribute to the state's GHG emissions. Louisiana currently does not important any significant hydroelectricity production.

There are no reported industrial sources of renewable energy in Louisiana, most of the renewable power generation in Louisiana comes from the state's regulated utilities or are behind-the-meter applications. As noted earlier, renewables and nuclear do not generate GHG emissions so they are not part of the inventory. Combined heat and power ("CHP") generation that arises within the fence line of many Louisiana industrial facilities, is included in the estimation process. Aggregate level industrial generation estimated by the SIT was compared to plant-level generation at the industrial level showing good comparability.

Lastly, CES has provided a very detailed power generation analysis that was developed in a "bottoms up" fashion and is part of the final report that can be utilized by the SAG and the Task Force in getting better resolution about power generation related GHG emissions. This database is developed at the generator level (utility and industrial) and is not aggregated by fuel type like those emissions estimated in the SIT. However, a comparison of the two series shows good comparability and has also been provided in the final report.

CES appreciates the reviewer's comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Stationary Combustion and Industrial Processes – SAG Comments

- #2. **Methods** – SIT model is adequate for broad macro analysis but inadequate for process analysis and business decision making. For emissions from process, recommend FLIGHT model which is a site-by-side/bottom-up reporting system updated annually by company standardized annual reports audited by EPA.
- #3. **Deviations** – 1) Use EPA FLIGHT model, though only require plants emitting more than 25,000 tons/year of CO2e required to file annual report. 2) Doesn't cover universe of emitters and sinks in SIT model.
    - One distortion associated with the SIT model has to do with its convention of apportioning top down derived greenhouse gases other than CO2 using state population as a guide. For a heavily industrialized state with a relatively small population, such as Louisiana, this is simply a bad assumption. It has the effect of under reporting non CO2 emissions. Given the significant EPA multipliers associated with the non CO2 Green House Gases, this is a significant shortcoming.
- #4. **Data Sources** – Under industrial processes, better list and explain databases used and actual number of facilities counted under each sub-category. Where data came from.
- #5. **Results** – As mentioned, the handling of Methane, N20, HFCs, PFCs, and SF6 are all distorted by the SIT apportionment methodology. It may be that for other sectors have little choice, but, operating on the principle that we should use the best data that is available, I would recommend substituting the EPA's "Flight" model which is based on annual industrial site reports, for the SIT methodology. The tool minimizes the chance of double counting emissions and allows for modifications such as the loss of production from the Convent Refinery this year.
- #6. **Range** – Since I do not agree with the segmentation used in generating the top down SIT estimates, I have no way of knowing whether the reported emissions have been counted multiple times or not. I would submit that it is more likely that double counting has taken place than would be the case using a bottom up approach focused on standardized reports from the limited number of relevant industrial sites. My expectation was that emissions for the power generation, refining and petrochemical sectors would correlate with those generated by the Dismukes-CES study issued last year which did utilize the EPA "Flight" methodology.
- #7. **Outside Resources** – LSU NREL study last year covering emissions from fixed sources (power plants, refineries, petrochem).
- #8. **Recommendations** – Use preliminary SIT data for all areas other than those covered by EPA FLIGHT- areas not focused on industrial processes and locations, specifically dealing ith refineries, power plants, and petrochemical.

Stationary Combustion and Industrial Processes – CES Comments/Response

Response to Comments: CES notes that the accuracy of the SIT and the FLIGHT data is an empirical issue and one that is easily corroborated. The Final Report includes a comparison of the two sets of information and both show good resolution: the SIT is very close to the actually-reported FLIGHT data. This should come as no surprise since the EPA uses the detailed location-specific data to help corroborate and inform the higher level estimates.

However, CES does agree with the reviewer that more detailed data, that is reported at the facility level, that represents “primary” rather than “secondary” source information, is always preferable. The final report will include an entirely separate section that includes a detailed analysis of each Louisiana industrial facility. Timing constraints prevented this analysis from being provided with the original preliminary draft.

Both modules use emission factors from a range of sources that include empirical measures, engineering estimates, statistical analysis, academic studies, to name a few. In addition, the SIT itself is subject to regular and repeated input from academia, industry, and various stakeholder groups including non-profit research organizations. While the SIT has shortcomings, it has a number of important and useful attributes and should be used as one of several tools in any state’s analysis of its GHG emissions reduction potentials.

CES appreciates the reviewer’s comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Mobile and Fossil Fuel Combustion—SAG Comments

- #2. **Methods** – Methane and nitrous oxide are evaluated for mobile combustion modules but not CO2. Why?
- #2. **Methods** – Seemed to follow EPA methods. Would be nice to better explain source values and detail how they were obtained, assuming EPA values were used.
- #4. **Data Sources** – Share more info on how data were obtained. What are uncertainties of data presented? List references/databases used. Were these data compared with DEQ data?
- #5 **Results** – About expected. Error in slide deck that industrial emissions are ~160M, but there are no emission sources that approach 160M to be noted.
- #8. **Recommendations** – Stick to EPA methods for state-to-state comparison. Don't deviate official report from standardized methods.

Mobile and Fossil Fuel Combustion -- CES Comments/Response

Response to Comments: The CO2 emissions from transportation are included in the fossil fuels module, not the mobile combustion module. This is admittedly confusing, but the mobile module is designed to capture the remaining GHG emissions not included in the combustion process.

CES agrees that sticking to EPA methods is preferrable such that comparisons across time, state, and other studies can be made.

CES appreciates the reviewer's comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Land and Land Use – SAG Comments

- #2. **Methods** – Generally felt methods follow EPA guidelines, but additional questions on methods and areas of concerns:
  - SIT methodology is very general, based on national default emission factors. State-specific data are strongly encouraged to improve GHG estimates and reduce uncertainty. Were state-specific factors used? If so, in what situations and how were they applied?
  - Analysis didn't explicitly state sources of datasets used or provide clear links to data sources. Would like to see these sources listed more explicitly. Methods for deriving state-level data from default data should be explained. Not possible to perform a comprehensive review without information on data source.
  - Does not include coastal wetlands nor carbon flux in open water environments.
  - Question on how forested wetlands are counted. Would forested wetlands be included in ongoing analysis by TWI to quantify carbon flux for coastal wetlands? Were forested wetlands included as "forests" in SIT module? Use of maps delineating forests might help clarify.
  - Carbon in aquaculture land use is also excluded.
  - For urban trees, percent of urban areas constant at 35%. Why was this number chosen? Is it standard to use one value for all cities in one state? Does 35% accurately or reasonably reflect cities in Louisiana?
  - For urban trees, there is an increase in amount of carbon sequestered by urban trees because amount of urban area is growing, and urban areas are assumed to have 35% tree coverage. Concern if open land or forested lands were converted to urban land, this spreadsheet could see it as growth in forested area when in reality it might be deforestation. Can this issue be reconciled?
  - Does final amount of carbon sequestration reflect forest biomass or change in forest biomass ("Forest Lands Remaining Forest" / "Land Converted to Forests" / "Forest Land Converted to Land"). Sequestration should be based on change in biomass from one year to next. Can the calculations be clarified?
  - In many cases, the spreadsheet doesn't contain all formulas used, which make it hard to cross check results.
- #3. **Deviations** – Generally yes but areas of concern:
  - Utilize state-level data for wetland carbon by Camille and Melissa.
  - Update land use component of inventory to include aquaculture by using biomass as end-product to calculate emissions.
  - Ensure amount of sequestration was determined from change in biomass rather than simply noting biomass itself.
  - No references or citations.
- #4. **Data Sources** –
  - Land representation Is determined for all lad use types except coastal wetlands.
  - Unclear how "activity" data is derived for Louisiana. Further, it's not clear how default emission factors were defined. What is the data source?
  - Maps showing forested areas would be helpful.
- #5. **Results** –

- Omissions need to be corrected: carbon flux in histosols in cropped wetlands, coastal wetland carbon, open water carbon, and aquaculture land use.
- Include formulas in spreadsheet to double check calculations in module spreadsheets.

- #6. **Range** –
  - Land use sink for this GHG budget is 2x land use sink from last budget (13 vs. 35). What accounts for this difference? Is it methodological or environmental? Are we just better at accounting for land use sinks? Are we over-counting sinks relative to 2005? Or is the state becoming greener and more forested?
- #7. **Outside Resources** – IPCC methods and SIT methods, maps of Louisiana from NASA Worldview Tool.
- #8. **Recommendations** –
  - 1) State needs accurate maps and GIS tracking of carbon for 22 classes of land cover available at 30m resolution with remote sensing data available.
  - 2) IPCC Approach 2 will help with transition.
  - 3) State needs to differentiate between fresh/intermediate/brackish and saline systems because salinity influences methane emissions. Lack of differentiation among wetland types.
  - 4) If wetlands become "open water", EPA classifies this as emissions; we need to know more about the fate of carbon in wetlands to know if this was a correct assumption? For example, is the carbon buried in the coastal zone? Are shallow estuarine habitats productive, and how does this productivity compare to the productivity of coastal wetlands.
  - 5) Need to integrate remote sensing in the next inventory update. There is a wealth of remotely sensed data (e.g. satellites) on land use/land cover, and these data should be accessed and analyzed to improve counting of land use sources and sinks. Data from USGS Colorado State U.
  - 6) The exclusion of wetlands from the LULUCF land category needs to be addressed. The addition of the coastal wetland data is a significant improvement to the current EPA SIT methodology; however, there are additional improvements that should be considered. In both EPA methods (both national-level and state-level), forested wetlands are categorized as terrestrial forests. Therefore, the (much higher) carbon sequestration rates in forested wetlands are missing from the inventory. In other words, there is likely a significant underestimate of forest carbon sequestration without the inclusion of forested wetland carbon flux rates. Secondly, inland wetlands are not included in either the national-level or state-level EPA methodologies. Inland wetlands include non-tidal, non-coastal, forested and herbaceous wetlands. This is another significant source of uncertainty that should be addressed in future iterations of the inventory.

Land and Land Use – CES Comments/Response

Response to Comments: The SIT does use some state specific factors and are not based on national average estimates. For instance, the SIT utilizes an EPA study "Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States 1990-2018" which has state specific emission data. However, the reviewer is correct that there are several other aspects of this modeling approach that are based upon large national averages as applied to state-wide level data. The advantage of models of this nature is that they allow for a relatively quick, proven, and transparent method for estimating emissions, and in this instance, emission sinks. The downside is that the more aggregated approach results in less specific, detailed information.

Ultimately, the difference between the more aggregated SIT, and the less aggregated state-specific approach is an empirical issue: sometimes, the differences, while obvious, are actually not that large from a quantitative basis. As noted in the response to earlier SAG comments above, CES has found, particularly in the industrial and power generation sectors, the SIT provides very good comparability to granular, plant/generator-specific information.

Note that CES did not use any unique or state-specific emission or sink factors and relied upon the SIT for the land, land use and wetlands module.

Regarding data and final calculations: all final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. The underlying data will be identified and sourced in the final report.

Regarding wetlands and open water estimates, CES did not include the carbon flux in open water environments since there is no readily available, Louisiana-specific estimates. CES and other stakeholders at the Water Institute and USGS have met with EPA to discuss the opportunities for developing this line of research. Unfortunately, this will take additional time, far outside the window needed for the Task Force. The final report does, however, include wetlands sink estimates from information directly provided by EPA. This information is taken from the national inventory, where the emission factors/drivers are from national estimates, whereas the activity levels (land/wetlands) comes from Louisiana-specific series. This is an area that EPA has indicated will be included in future SITs without committing to a specific timetable on when this inclusion will occur.

On forested wetlands, note that wetland information that was developed for the national SIT and the national inventory was provided to CES by EPA after the initial draft was released. These estimates are based upon national level parameters and state level input data. This data and the module used to make the estimates are included with the workpapers accompanying the final report.

Land dedicated to aquaculture, and its corresponding carbon contribution was not included in the study since it is not part of the SIT. CES understands, in discussions with EPA, that EPA is beginning to incorporate aquaculture into its national inventory tool and this will be part of future state inventory models. However, the inclusion of aquaculture was beyond the scope of the current study. CES recognizes and agrees this is an area that should be explored. The overall importance is indeterminant.

Regarding the constant percent on urban trees, please note that the urban tree percentage allocation by state is based on a 2012 study entitled “Tree and impervious cover change in the US” by David Nowak and Eric Greenfield. This information suggests that a 35 percent level was selected from this study for Louisiana and that percent was heled constant over time. It also appears that, for default purposes, EPA also used aerial photography to estimate the acre amount of urban area. So for instance in 1990 Louisiana urban area was 3,650 km^2 and 4,315 km^2 in 2000.

On the reconciliation with urban trees, there is no tab that converts forest land or open land to urban area, although that conclusion could make sense given the increase in urban land coverage. However, this reconciliation is almost impossible to work out given the way the module is set up such that it is difficult to estimate what percent or if any forested and open land was converted to urban land. This module in general seems to be the one most in question given the limited amount of data that is reported by states between these categories so further adjustments to the module may be useful to accommodate this.

On the final calculations, and their change in forest biomass rather than levels, the calculations on the summary tab are net carbon flux so these would be year over year or annual change in forest biomass.

Regarding missing calculations and formulas, CES notes that some calculations and formulas were suppressed in order to make the spreadsheets tractable for conveying to

SAG members. The full workpapers for each module area available with all formulas and data intact and in native format.

Regarding the comparability to the last 2010 GHG inventory, note that the current SIT land and land use module incorporates a large change in the scope of “land use.” Specifically, the “forest land remaining” that is estimating in the current inventory was not included in previous 2010 SIT module and has significant net flux that can be seen in the discrepancy of total land and land use.

Lastly, CES agrees with all of the recommendations on how to better estimate and understand the carbon contributions of land, and, in particular, wetlands. This is a significant shortcoming in the SIT for Louisiana. However, this is simply beyond the scope of the project. CES has discussed these issues with the OCA, the Water Institute and USGS. It is CES’ understanding that future prioritization is going to be placed in these areas such that these estimates will be more readily available in future GHG inventory estimation.

Agriculture – SAG Comments

- #2. **Methods** – Robust.
- #3. **Deviations** – Did not identify any deviations from EPA methods.
- #4. **Data Sources** – Default data.
- #5. **Results** – No.
- #6. **Range of expectations** – Yes.
- #7. **Outside Sources** – Yes.
- #8. **Recommendations** – None.

Agriculture – CES Comments/Response

Response to Comments: CES appreciates the reviewer's comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Waste & Wastewater

- #2. **Methods** – Estimates only for methane and nitrous oxide for wastewater treatments but no CO2. Methods are missing for landfill waste. Methods for plastic combustion CO2 briefly mentioned.
- #3. **Deviations** – Validate this data of N2O/methane emissions by sampling at various plants to confirm estimates.
- #4. **Data Sources** – Since no methods were given for municipal solid waste, how was CO2 data obtained? Need to cross check and validate data.
- #5. **Results** – No comment.
- #6. **Range** – Cross check preliminary data to confirm data given by estimates by real time monitoring of a few plants.
- #7. **Outside Resources** – None.
- #8. **Recommendations** – Stick to EPA methods for state-to-state comparison. Don't deviate official report from standardized methods.

Waste and Wastewater -- CES Comments/Response

Response to Comments: Any CO_2 emissions that are associated with Water and Wastewater treatment are mostly captured in the combustion of fossil fuels module. This module includes all direct on-site energy use, like natural gas used for various motors and other on-site applications. Note that EPA cross-checks and validates default data on a regular basis. CES did not deviate from the EPA methods in developing estimates for this sector.

CES appreciates the reviewer's comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Municipal Solid Waste

- #2. **Methods** – Robust.
- #3. **Deviations** – Did not identify any deviations from EPA methods.
- #4. **Data Sources** – Default data.
- #5. **Results** – Surprising CH4 emission from MSW sources remained same while CO2 content went up considerably, but why? Question early data and not recent trends – biogas about 50/50 CH4/CO2.
- #6. **Range of expectations** – Yes.
- #7. **Outside Sources** – Yes.
- #8. **Recommendations** – Stick to EPA methods for state-to-state comparison. Don't deviate official report from standardized methods.

Municipal Solid Waste – CES Comments/Response

Response to Comments: On the methane emissions and carbon dioxide emissions, the text box discussing the chart is confusing and has been changed. Another confusing aspect of the chart is that there are two axes and the orders of magnitude of the two axes are very different. Lastly, as noted in the footnotes of the chart, 2000 to 2002 data was missing so 2003 was used instead as conservative estimate.

CES appreciates the reviewer's comments and the recommendations. All final calculations for this module, and all other SIT modules, will be provided and made available to the SAG and all stakeholders. Lastly, the underlying data will be identified and sourced in the final report.

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Source
Agriculture				
Enteric Fermentation	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) - Other (('000 head)	Yes Yes Yes		National Agriculture Statistics Service of the U.S. Department of Agriculture (USDA). http://quickstats.nass.usda.gov/
Manure Management	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) -Swine, Poultry, Other	Yes Yes Yes		National Agriculture Statistics Service of the U.S. Department of Agriculture (USDA). http://quickstats.nass.usda.gov/
Ag. Soils – plant residues and legumes	-residues, legumes, histosols	Yes		National Agriculture Statistics Service of the U.S. Department of Agriculture (USDA). http://quickstats.nass.usda.gov/
Ag. Soils- plant fertilizer	-Synthetic fertilizer use (kg N) -Organic fertilizer use (kg N)	Yes		*Commercial Fertilizers,* Association of American Plant Food Control Officials.
Ag. Soils- animals	-dairy cattle ('000 head) -beef cattle ('000 head) -swine, poultry, sheep, goat, horses (('000 head)	Yes		National Agriculture Statistics Service of the U.S. Department of Agriculture (USDA). http://quickstats.nass.usda.gov/
Rice Cultivation	-Area harvested primary ('000 acres)	Yes		National Agriculture Statistics Service of the U.S. Department of Agriculture (USDA). http://quickstats.nass.usda.gov/

	-Area harvested ratoon (‘000 acres)			
Liming	Metric tons (‘000)	Yes		Annual Report (U.S. Geological Survey). and Agricultural lime consumption by state. http://minerals.usgs.gov
Urea Fertilization	-urea fertilizer	Yes		AAPFCO (2017) Commercial Fertilizers 2014, Table 5.
Ag. Residue burning	-corn, rice, soybean, sugarcane, &wheat crop production (metric tons)	Yes		National Agriculture Statistics Service of the U.S. Department of Agriculture (USDA). http://quickstats.nass.usda.gov/

Module/Sector	**Data Input Categories**	**Default Data Used?**	**Other Data Used?**	**Data Sources**
Combustion of Fossil Fuels				
Residential	Petroleum, Coal, and Natural Gas, Other, energy consumption (Billion Btu)	Yes		EIA State Energy Data. http://www.eia.gov/state/seds/seds-data-complete.cfm?sid=US
Commercial				
Transportation				
Electric Power				
Bunker Fuels				
Industrial				

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Coal				
Underground Mines	None in LA			
Surface Mines & Post-Mining Activities	Coal Production (‘000 short tons)	Yes		EIA Annual http://arlweb.msha.gov/drs/drshome.htm
Abandoned Mines	None in LA			

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Industrial Process				
Cement Manufacture	None in LA	Yes		USGS Cement MIS Archive. December 2019, Table T4P4. http://minerals.usgs.gov
Lime Manufacture	-High Calcium Lime produced (metric tons) -Dolomite Lime produced (metric tons)	Yes		USGS Mineral Yearbook, 2017. Lime Stats and info. http://minerals.usgs.gov
Limestone and Dolomite Use	-Limestone Consumption (metric tons) -Dolomite Consumption (metric tons)	Yes		USGS Mineral Yearbook, 2016. http://minerals.usgs.gov
Soda Ash	-Soda Ash Manufacture (metric tons) -Soda Ash Consumption (metric tons)	Yes		http://minerals.usgs.gov

Ammonia Production & Urea Application	-Ammonia Production (metric tons) -Urea Consumption (metric tons)	Yes		http://minerals.usgs.gov
Iron & Steel Production	-Basic Oxygen Furnace w/coke ovens -BOF w/o coke ovens -Open Hearth Furnace -Electric Arc Furnace (metric tons)	Yes		http://minerals.usgs.gov
Nitric Acid Production	Nitric Acid Production Capacity (metric tons)	No	Yes	US EPA Greenhouse Gas Envirofacts. "Nitric Acid Production" http://epa.gov/enviro/greenhouse-gas-customized-search
Adipic Acid Production	None in LA			
ODS Substitutes	-U.S. emissions of HFC, PFC, SF6 (metric tons) -LA Population	No	Yes	US EPA Greenhouse Gas Envirofacts. "ODS Substitutes" http://epa.gov/enviro/greenhouse-gas-customized-search
Semiconductor Mfg.	None in LA			
Magnesium Production	None in LA			
Electric Power Transmission and Distribution Systems	SF6 consumption (metric tons)	No	Yes	US EPA Greenhouse Gas Envirofacts. "Manufacture of Electric Transmission and Distribution Equipment" http://epa.gov/enviro/greenhouse-gas-customized-search

HCFC-22 Production	HCFC-22 Production (metric tons)	Yes	Yes	US EPA Greenhouse Gas Envirofacts. "ODS Substitutes" http://epa.gov/enviro/greenhouse-gas-customized-search
Aluminum Production	None in LA			

Module/Sector	**Data Input Categories**	**Default Data Used?**	**Other Data Used?**	**Data Sources**
Land-Use Change and Forestry				
Forest Carbon Flux		Yes		"Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018" (see appendix 1): https://www.nrs.fs.fed.us/pubs/59852
Forest Land Remaining Forest		Yes		"Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018" (see appendix 1): https://www.nrs.fs.fed.us/pubs/59852
Land Converted to Forest Land		Yes		"Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018" (see appendix 1): https://www.nrs.fs.fed.us/pubs/59852
Forest Land Converted to Land		Yes		"Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990-2018" (see appendix 1): https://www.nrs.fs.fed.us/pubs/59852

Urban Trees		Yes		Nowak, D.J., Greenfield (2012). “Tree and impervious cover in the United States” Journal of Landscape and Urban Planning. (107) pp. 21-30
Settlement Soils		Yes		AAPFCO (2017). Commercial Fertilizers 2014.
Yard Trimmings		Yes		EPA Advancing Sustainable Materials Management: Facts and Figures 2017 (EPA 2019).
Ag Soil C-Flux		Yes		US EPA “CroplandGrassland_Carbon_1990-2018”
Wetlands		No	Yes	Tom Wirth. “Preliminary estimates of Louisiana coastal wetlands GHG emissions sinks.” EPA. Provided via electronic email, April 23, 2021.
Burning CH4 and N2O		No	Yes	Department of Agriculture and Forestry. Louisiana.gov “Protection”

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Mobile Combustion (CH4 and N2O)				
Highway Vehicles	-Distance traveled-VMT	Yes		Federal Highway Administration (FHWA). https://www.fhwa.dot.gov/policyinformation/statistics.cfm
Aviation Boats & Vessels Locomotives	-Gasoline, diesel (gallons)	Yes		EIA Petroleum Sales and Consumption: Fuel Oil and Kerosene Sales, Table 16. https://www.eia.gov/petroleum/fueloilkerosene/pdf/foks.pdf

Other Non-Highway Vehicles Alternative Fuel Vehicles	-Jet/distillate/residual fuel (mBtu)			U.S. Department of Energy publication State Energy Data System (EIA 2018). https://www.eia.gov/state/seds/

Module/Sector	**Data Input Categories**	**Default Data Used?**	**Other Data Used?**	**Data Sources**
Natural Gas and Oil Systems				
Natural Gas Production	Total number of wells	Yes		EIA Natural Gas Navigator. https://www.eia.gov
Natural Gas Transmission	-Miles of gathering pipeline -gas processing plants -LNG stations -Miles of transmission pipeline -Gas transmission compressor stations -gas storage compressor stations	Yes	Yes	PHMSA gas transmission annual data http://www.phmsa.dot.gov
Natural Gas Distribution	-miles of distribution pipeline -total # of services -# of unprotected steel services	Yes	Yes	PHMSA gas distribution annual data http://www.phmsa.dot.gov

Natural Gas Vented and Flared	Natural gas vented and flared (billion Btu)	Yes		EIA Natural Gas Navigator. https://www.eia.gov
Oil Production	Barrels of Oil (thousand barrels)			EIA Petroleum Supply Annual. http://eia.doe.gov
Oil Refining				
Oil Transportation				

Module/Sector	**Data Input Categories**	**Default Data Used?**	**Other Data Used?**	**Data Sources**
Solid Waste				
MSW Generation	-MSW landfilled -LA population -LA percent landfill	Yes		EPA, Operational and candidate landfill projects. https://www.epa.gov/lmop EPA Landfill Methane and Outreach Program https://www.epa.gov/lmop
Flare	Amount of CH4 flared (tons)	Yes		CH4Reds_StateInvTool.xls Data obtained from Lauren Aepli at EPA 7.20.20
Landfill gas-to-energy	Amount of CH4 flared (tons)	Yes		EPA (2020) LMOP Landfill and Landfill Gas Energy Project Database. https://www.epa.gov
Plastics	Amount of CO2 (tons)	Yes	Yes (2000-2002 estimated)	US EPA 2019. Advancing Sustainable Materials Management: 2016 and 2017 Tables and Figures.
Synthetic Rubber	Amount of CO2 (tons)	Yes	Yes (2000-2002 estimated)	US EPA 2019. Advancing Sustainable Materials Management: 2016 and 2017 Tables and Figures.
Synthetic Fibers	Amount of CO2 (tons)	Yes	Yes (2000-2002 estimated)	US EPA 2019. Advancing Sustainable Materials

				Management: 2016 and 2017 Tables and Figures.

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Stationary Combustion				
Residential Commercial Industrial Electric Utilities	Energy consumption by fuel (billion btu)	Yes		EIA State Energy Data 2018: Consumption Estimates EIA Historical Natural Gas Annual (EIA 2020) Table 8 of Natural Gas Annual from 2001-2018. http://www.eia.doe.gov http://www.eia.gov/state/seds/seds-data-complet.cfm?sid=US#CompleteDataFile

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Wastewater				
Municipal Wastewater	State population	Yes		Inventory of U.S. Greenhouse Gas Emissions and Sinks (US EPA 2020).
Industrial Wastewater-fruits and vegetables	Fruit and vegetable production processed (metric tons)	No	Yes	LSU Agriculture Center, Agriculture and Natural Resources. “Louisiana Summary.” Data 2000-2018 Lindgren, Dale and Hodges, Laurie. “Weights and Measures for Horticultural Crops” (2006). University of Nebraska Institute of Agriculture and Natural Resources.

				“Weights and Processed Yields of Fruits and Vegetables” University of Georgia.
Industrial Wastewater- red meat	Red meat production processed (metric tons)	Yes		USDA quick stats 2.0. Annual Red Meat Production. http://quickstats.nass.usda.gov/

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