Louisiana Greenhouse Gas Inventory

Prepared for

LOUISIANA ECONOMIC DEVELOPMENT

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LSU CENTER FOR ENERGY STUDIES

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A Project Advisory Team (PAT) assembled for this research effort provided valuable direction and input for the collection and analysis of greenhouse gas data for Louisiana. PAT members were:

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EXECUTIVE SUMMARY

Background

In November 2008 Louisiana Economic Development (LED) contracted LSU's Center for Energy Studies (CES) to conduct an analysis related to ramifications of potential federal greenhouse gas regulation on the State of Louisiana. The overarching purpose of the analysis was to help prepare Louisiana for the possible federal regulation of greenhouse gases (GHG) and to assure that the state could respond intelligently to any such regulation in a manner that would mitigate potential adverse impacts on the state's economy and that would recognize any potential economic development opportunities that might be presented. Goals (or tasks) for the project were:

1. Develop a comprehensive state-wide greenhouse gas inventory.
2. Conduct a thorough review of measures being taken or contemplated by other states to accommodate climate change concerns or expected federal greenhouse gas regulations.
3. Prepare a high-level assessment of the impacts of the most likely federal greenhouse gas regulatory schemes on Louisiana's economy.
4. Prepare a list of potential state and industry strategies for responding to requirements and opportunities brought by federal greenhouse gas regulation.

This report is one of the deliverables for completion of Task 1 – development of a comprehensive state-wide greenhouse gas inventory.

Expectations for the GHG inventory work were established during early project planning. Principal among these were:

- The inventory was to employ a high level, top-down approach providing emissions summaries at essentially the sector level.
- The effort was to be guided and assisted with an advisory team of selected stakeholder representatives. Regular meetings with the Project Advisory Team were to be held throughout the inventory project to provide feedback and direction for the project and to facilitate communications with the represented stakeholder groups.
- The project was to make use of available existing information with only limited original data gathering and research.
- The inventory was to employ methods approved by the U.S. Environmental Protection Agency (EPA) and the United Nations Intergovernmental Panel on Climate Change (IPPC) to insure consistency of results and reporting with other international, national, and state efforts.

- Credibility of the inventory results was to be supported with a solid quality assurance program and thorough documentation of methods, data, and sources.

The Project Advisory Team (PAT) assembled for this research effort provided valuable direction and input for the collection and analysis of greenhouse gas data for Louisiana. PAT members were:

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Methods

The Environmental Protection Agency's State Inventory Tool (SIT) was the principal method employed in the state's GHG inventory. The SIT contains data inputs from federal agencies and is updated approximately once per year. Emission estimations are calculated within Microsoft Excel spreadsheets—or modules—that correspond to specific sources of emissions within economic sectors such as Residential, Commercial, Mobile, Industrial, and Agricultural. This inventory was prepared using the March 2007 version of the SIT released in 2008.

Although emphasis was placed on carbon dioxide (CO_2) emissions, all six internationally-recognized GHG gases were included in the inventories: CO_2, methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexaflouride (SF_6).

The year 2005 was selected for the inventory because currently proposed U.S. climate legislation employs that year as the base year against which emission reductions would be compared.

The advantages of using the State Inventory Tool (SIT) are many. It is a proven and vetted calculation tool, is consistent for all states, and is readily available. It is also a "top-down" model that uses state-level data.

In addition to the default data included in the SIT, other valuable sources of GHG emissions information included the Department of Energy's (DOE) Energy Information Administration

(EIA), The Louisiana Department of Natural Resources (LDNR), other relevant federal and state agencies, World Resources Institute Climate Analysis Indicators Tool (CAIT-US) Version 3.0, input from our Project Advisory Team, and information developed during an earlier GHG inventory prepared by CES for LDNR in 2000.

The main purpose of this GHG inventory was to develop and present information on sources and quantities of Louisiana GHG emissions to facilitate decision-making by the State of Louisiana in preparation for the possible federal regulation of greenhouse gases. Because some decisions may carry significant economic consequences for the state's public and private sectors, it is important that there be good confidence in the information being used as a basis for the decisions. To assure that the information presented in this report can be used with confidence, we employed a program of quality assurance and quality control (QA/QC) that provides for transparency, consistency, comparability, completeness, accuracy, and documentation.

Additionally, a comprehensive analysis of level of certainty was conducted for all emissions input data.

Findings

Principal findings of this GHG inventory are listed and described below. Page numbers are provided for locations within the report where more detailed information can be found for each finding.

1. Louisiana greenhouse gas emissions for 2005 totaled 228 million metric tons of carbon dioxide equivalent emissions ($MMTCO_2E$) gross and 215 $MMTCO_2E$ net of sequestration from natural sinks. The vast majority (84 percent) of GHG emissions were made up of CO_2 from fossil fuel combustion (p. 3-1).
2. On a carbon dioxide equivalent basis (CO_2E), carbon dioxide represented 86 percent of Louisiana's GHG emissions, followed by methane at 8 percent, nitrous oxide at 3 percent, and hydrofluorocarbons plus perfluorocarbons plus sulfur hexafluoride at a combined 3 percent (p. 3-2).
3. For 2005, Louisiana ranked eleventh among the states in total GHG emissions from fossil fuel combustion. Even as an energy producing state with considerable energy-intensive industrial production, Louisiana's GHG emissions were comparable to other Gulf Coast states such as Georgia, Florida, and Alabama (p. 3-3).
4. The industrial sector contributed the majority (49 percent) of carbon dioxide emissions from fossil fuel combustion in Louisiana, followed by the transportation sector (e.g. autos, trucks, trains, airplanes, marine vessels) (26 percent) and electric power (23 percent) (p. 3-10).

5. Relative contributions of fossil fuels to the state's total fossil fuel combustion CO_2 emissions were petroleum at 51 percent, natural gas at 37 percent, and coal at 12 percent (p. 3-10).
6. The great majority (76 percent) of the state's total methane emissions were contributed by operations of natural gas and oil systems (p. 3-1).
7. Energy end-use by commercial and residential buildings accounted for 8 percent and 10 percent, respectively, of total energy consumption in the state (p. 3-38, 39).
8. A comparison of Louisiana GHG emissions to total U.S. emissions shows that U.S. emissions have grown by about 18 percent from 1990 to 2005, while Louisiana emissions have decreased slightly. Comparing Louisiana GHG emissions with state population and gross state product shows Louisiana GHG emissions have fallen even as population and gross state product have grown. Additionally, Louisiana's vehicle miles traveled and gasoline use have increased by about 20 percent and 30 percent, respectively, from 1990 to 2005, while GHG emissions have remained relatively flat (p. 3-6,7).
9. Louisiana's GHG emissions intensity, a comparison of Louisiana GHG emissions against gross state product, shows a dramatic downward trend in GHG intensity relative to gross state product for the period 1990-2005. This essentially reflects flat emissions over the 15-year period compared to increasing gross state product (p. 3-9).
10. Projections of total GHG emissions, and each of the major sectors' emissions (e.g. industrial, transportation, electric power, residential, commercial) over the period 2005 – 2020 show a continuation of the relatively flat GHG emission trends seen over the preceding 15 year period (1990 – 2005) (p. 3-67).

The results of this GHG inventory will be employed in Tasks 3 and 4 of the CES project to assess potential impacts of potential federal GHG regulation on Louisiana's major economic sectors and to develop recommendations for positioning the state to best accommodate federal regulation of GHG.

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1. INTRODUCTION

1.1 BACKGROUND

The Center for Energy Studies (CES) was created by the Louisiana Legislature in 1982 in response to recommendations made by an independent group of experts and at the urging of Louisiana business and public interest groups. The primary mission of CES is to serve the state of Louisiana in three broad categories: as a research institute; as a source of objective, scholarly advice on important national and state energy issues; and as an information depository, clearinghouse and technology transfer institution. It is mandated to provide energy information and analysis that responds to the needs of the legislature, public agencies, and business and civic
groups. CES personnel act in an advisory or expert capacity for legislative, executive, and regulatory branches of both the state and national governments and represent the state on energy-related organizations at both the regional and national level.

Louisiana Economic Development (LED) contracted CES in November, 2008 to conduct an analysis related to ramifications of potential federal greenhouse gas regulation on the State of Louisiana. The overarching purpose of the project was to help prepare Louisiana for the possible federal regulation of greenhouse gases (GHG) and to assure that the state's economic competitiveness was not compromised and economic development opportunities were recognized. Goals (or tasks) for the project were:

1. Development of a comprehensive state-wide greenhouse gas inventory.
2. Conduct a thorough review of measures being taken or contemplated by other states to accommodate climate change concerns or expected federal greenhouse gas regulations.
3. Prepare a high-level assessment of the impacts of the most likely federal greenhouse gas regulatory schemes on Louisiana's economy.
4. Prepare a list of potential state and industry strategies for responding to requirements and opportunities brought by federal greenhouse gas regulation.

This report is one of the deliverable end items for completion of Task 1 – development of a comprehensive state-wide greenhouse gas inventory. A second end item was a summary PowerPoint presentation describing the project and its findings. Upon completion, both this report and the presentation will be available for review or download on the CES web page.

Earlier, in 2000, LSU CES completed an investigation and prepared a report entitled "Inventory of Greenhouse Gases in Louisiana" for the Louisiana Department of Natural Resources (Mesyanzhinov, D. V., et al. 2000). Also during 2000, the Center completed another project for the Louisiana Department of Natural Resources entitled "Modeling Greenhouse Gas Emissions in Louisiana" (Pulsipher, A. G., et al. 2000). Although the standards for GHG emission inventories are much more rigorous now, the information and experience gained in these earlier studies served the Center well in this GHG inventory work.

1.2 APPROACH

A number of expectations for the GHG inventory work were established during early project planning.

1. The inventory was to employ a high level, top-down approach providing emissions summaries at essentially the sector level.

2. The effort was to be guided and assisted with an advisory team made up of selected stakeholder representatives. Regular meetings with the Project Advisory Team were to be held throughout the inventory project to provide feedback and direction for the project and to facilitate communications with the represented stakeholder groups.

3. The project was to make use of available existing information with only limited original data gathering and research.

4. The inventory was to employ methods approved by the U.S. Environmental Protection Agency (EPA) and the United Nations Intergovernmental Panel on Climate Change (IPPC) to insure consistency of results and reporting with other international, national, and state efforts.

5. Credibility of the inventory results was to be supported with a solid quality assurance program and thorough documentation of methods, data, and sources.

6. During the course of the inventory, it was decided that for policy and decision-makers it would be helpful to provide some perspective on Louisiana GHG emissions using selected comparisons with other states and national averages. Thus, data gathering was expanded to sources of GHG emissions information for the U.S. and a number of selected states.

7. The inventory is based solely on in-state emissions, and any emissions that may be attributed to Louisiana facilities in any future GHG regulatory scheme from the supply of petroleum products, natural gas, etc., are not included in the inventory.

2. METHODOLOGY

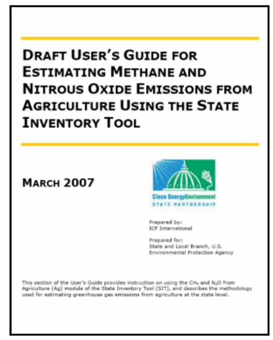
2.1 BASIC HIGH-LEVEL INVENTORY TOOLS

The Intergovernmental Panel on Climate Change (IPCC) publishes emission inventory methodologies that serve as a basis for all greenhouse gas inventories. The *IPCC Guidelines for National Greenhouse Gas Inventories* is used by the Environmental Protection Agency (EPA) to develop the *U.S. Greenhouse Gas Report* (IPPC, 1997). Consistent with international standards, the EPA offers states an inventory tool which was applied for the purposes of this project. The general formula for emissions estimations is as follows:

*Emissions = (Activity Data) * (Emission Factors)*

State Inventory Tool

The Environmental Protection Agency coordinates a national Emissions Inventory Improvement Program (EIIP) for states to establish baseline emission estimates. To assist in these efforts, a State Inventory Tool (SIT) was developed in 2002 by an outside consulting firm (ICF International, 2007). The SIT contains data inputs from federal agencies and is updated approximately once per year.


DRAFT USER'S GUIDE FOR ESTIMATING METHANE AND NITROUS OXIDE EMISSIONS FROM AGRICULTURE USING THE STATE INVENTORY TOOL

MARCH 2007

Clean Energy Environment STATE PARTNERSHIP

Prepared by:
ICF International

Prepared for:
State and Local Branch, U.S. Environmental Protection Agency

This section of the User's Guide provides instruction on using the CH_4 and N_2O from Agriculture (Ag) module of the State Inventory Tool (SIT), and describes the methodology used for estimating greenhouse gas emissions from agriculture at the state level.

Emission estimations are calculated within Microsoft Excel spreadsheets—or modules—that correspond to specific sources of emissions within economic sectors such as Residential, Commercial, Mobile, Industrial, and Agricultural. This inventory was prepared using the March 2007 version of the SIT released in 2008.

The advantages of using the State Inventory Tool are many. It is a proven and vetted calculation tool, is consistent for all states, and is readily available. It is also a "top-down" model that uses state-level data. Attempting a "bottom-up" emissions inventory would be arduous considering the large number of facilities and sources; it would also leave potentially large gaps where data were either overlooked or not obtainable at the facility level. Such an approach may be more feasible once greenhouse gas reporting becomes mandatory (currently slated for January 2010).

Global Warming Potential

Global warming potential (GWP) is a system of factors used to compare and aggregate the different greenhouse gases (GHGs). GWP estimates the ability of gases to trap heat in the atmosphere relative to carbon dioxide and is used to convert emissions to carbon equivalent (CE) or carbon dioxide equivalent (CO_2E) units. This report presents emissions as metric tons

(MT) or million metric tons (MMT) of CO_2E. The chart below shows the standard GWPs of greenhouse gases relative to CO_2 over a 100-year time period.

Table 2.1-1. Global Warming Potentials (100-Year Time Horizon)

Gas	Symbol	GWP
Carbon dioxide	CO_2	1
Methane	CH_4	21
Nitrous oxide	N_2O	310
Hydrofluorocarbon-23	HFC-23	11,700
Perfluorocarbons	PFCs	varies
-tetrafluoromethane	CF_4	6,500
-hexafluoroethane	C_2F_6	9,200
Sulfur hexafluoride	SF_6	23,900

Source: IPCC (1997)

IPCC updates the estimates shown above for reference as part of the international standards under the United Nations Framework Convention on Climate Change (UNFCCC) (U.S. EPA, 2008). EPA uses the 1996 GWP estimates (revised in 1997) to ensure consistency with inventories prepared prior to subsequent updates.

2.2 SOURCE/SECTOR-SPECIFIC INVENTORY METHODS

Source/Sector Modules

The SIT contains ten modules (Excel spreadsheets). Table 2.2-1 lists the modules and their corresponding sources and greenhouse gases. In some cases source emissions are calculated in more than one module. For instance, transportation emissions are calculated in the "CO2 from Fossil Fuel Combustion" module (CO_2) and N_2O and the "Mobile Transportation" module (N_2O and methane). In a similar manner, stationary combustion source emissions are calculated in the CO2FF module (CO_2) and the "Stationary Combustion" module (N_2O and methane).

Table 2.2-1. ICF State Inventory Modules and Emission Sources

Module	Emission Sources	Gases
Agriculture	manure mgmt., soil mgmt., rice cultivation, burning agric. waste, fertilizer, crop residues, livestock	CH_4, N_2O
CO2 from Fossil Fuel Combustion	fuel use by sector	CO_2
Coal Mining	underground and surface mines	CH_4
Industrial Processes	lime, soda ash, NH_3, iron and steel, nitric acid	CO_2, N_2O, HFC, PFC, SF_6

Module	Emission Sources	Gases
Land Use, Land-Use Change and Forestry	wood products, urban trees, landfilled yard trimmings and food scraps, forest fires, N_2O settlement soils	CO_2, CH_4, N_2O
Mobile Combustion	highway vehicles, busses, recreational boats, marine, rail, aviation and commercial aircraft, off-road farm and construction equipment	CH_4, N_2O
Natural Gas and Oil	natural gas flaring, gas wells, platforms, pipelines, compressor stations, oil production, refining, transportation	CO_2, CH_4
Solid Waste	municipal solid waste, industrial landfills	CH_4
Stationary Combustion	fuel use by sector	CH_4, N_2O
Wastewater	municipal, fruits/veg. processing, red meat, poultry, pulp and paper	CH_4, N_2O

The ICF SIT modules were used for all sources in the Louisiana state greenhouse gas emissions inventory. The modules contain a state pull-down list, default emission factors and default data for many of the inputs. Most calculations are straightforward; input data are multiplied by an emission factor and converted to metric tons of carbon and CO_2 equivalents. More complex calculations and models were used for landfill emissions (ICF International, Municipal Solid Waste Module, first order decay model) and carbon flux and sequestration in forests (ICF International, Land-Use Change and Forestry Module, USDA Forest Service Carbon Calculation Tool).

Default Data

Default data included in the SIT modules were used for most data inputs. Data sources included government agencies such as the Energy Information Administration, U.S. Department of Agriculture, and Federal Highway Administration, and other sources such as academic, trade, and industry publications.

Advantages of using default data were twofold: 1) availability and 2) reduced errors from manual data entry. Availability of data from published sources translated into substantial time savings and obviated the need to manually enter 16 years' worth of data for over 60 source types. Default emission factors were used for all sources. Module data inputs and sources are shown in the table below.

Table 2.2-2. GHG Inventory Data Inputs

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
AGRICULTURE				
Enteric Fermentation	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) -Sheep, goats, swine, horses ('000 head)	yes yes yes		U.S. Department of Agriculture, Published Estimates Data Base NASS, "Manure-N2O.xls" or "PopulationDBout.xls" http://www.nass.usda.gov/QuickStats/
Manure Management	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) -Swine ('000 head) -Poultry ('000 head) -Sheep, goats, horses ('000 head)	yes yes yes no yes	yes	USDA, NASS, Published Estimates Data Base. Default data used for hens, pullets, & chickens. Non-default data used for broilers & turkeys (USDA, National Agricultural Statistics Service, Census of Agriculture—Louisiana, 1987-2007).
Rice Cultivation	-Area harvested primary ('000 acres) -Area harvested ratoon ('000 acres)	yes yes		USDA Crop Production Summary 2000 and USDA, NASS Published Estimates Data Base.
Burning of Agricultural Crop Waste	-corn, rice, soybeans, sugarcane, & wheat crop production (metric tons)	yes		USDA, NASS, http://www.nass.usda.gov :81/ipedb/
Ag. Soils--Residues & Legumes	-corn, wheat, sorghum, rice, & soybeans crop production (metric tons)	yes		USDA, NASS, http://www.nass.usda.gov:81/ipedb/
Ag. Soils--Fertilizer	-Synthetic fertilizer use (kg N) -Organic fertilizer use (kg N)	yes yes		The Association of American Plant Food Control Officials and The Refertilizer Insitute. Commercial Fertilizers. Table 9 - Consumption of Primary Plant Nutrients. Total Nutrients-All Fertilizers (N)
Ag.Soils--Animals & Runoff	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) -Swine ('000 head) -Poultry ('000 head) -Sheep, goats, horses ('000 head)	yes yes yes no yes	yes	USDA, NASS, Published Estimates Data Base. Default data used for hens, pullets, & chickens. Non-default data used for broilers & turkeys (USDA, National Agricultural Statistics Service, Census of Agriculture—Louisiana, 1987-2007).
CO2 FROM FOSSIL FUEL COMBUSTION				
Residential Commercial Transportation Electric Power Bunker Fuels Industrial	Petroleum, coal, and natural gas energy consumption (Billion Btu)	yes		-U.S. Dept. of Energy, Energy Information Administration's State Energy Data 2005: Consumption Estimates, http://www.eia.doe.gov/emeu/states/state.html?q_state_a=la&q_state=LOUISIANA *Data gathered with Form EIA-846A, Mandatory Energy Consumption Survey
COAL MINING				
Underground Mines	None in LA	--		n/a
Surface Mines & Post-Mining Activities	Coal Production ('000 short tons)	yes		USDOE, EIA's Coal Industry Annual, http://www.eia.doe.gov/ cneaf/coal/cia/cia_sum.html.
Abandoned Mines	None in LA	--		n/a

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
INDUSTRIAL PROCESSES				
Cement Manufacture	None in LA	--		n/a
Lime Manufacture	-High-Calcium Lime Produced (metric tons) -Dolomitic Lime Produced (metric tons)	yes yes		U.S. Geological Society, Minerals Yearbook. Lime Statistics and Information, Table 2. *Lime Sold or Used by Producers in the US, by State*
Limestone and Dolomite Use	-Limestone Consumption (metric tons) -Dolomite Consumption (metric tons)	yes --		USGS Minerals Yearbook, 2005. *Crushed Stone Statistics and Information*, Table 8. *Limestone and Dolomite Sold or Used by Producers in the US, by State*
Soda Ash	-Soda Ash Manufacture (metric tons) -Soda Ash Consumption (metric tons)	-- yes		USGS Minerals Yearbook, 2005. *Trona Manufacture and Soda Ash Consumption in the US, by State*
Ammonia Production & Urea Application	-Ammonia Production (metric tons) -Urea Consumption (metric tons)	yes yes		AAPFCO (2007) Commercial Fertilizers 2005. Association of American Plant Food Control Officials and The Fertilizer Institute. University of Kentucky, Lexington, KY.
Iron & Steel Production	-Basic Oxygen Furnace w/ coke ovens -BOF w/o coke ovens -Open Hearth Furnace -Electric Arc Furnace (metric tons)	no no no yes		http://minerals.er.usgs.gov/minerals/pubs/state /index.html# contact. Default distribution by production type not used. Electric arc furnace production used in LA for iron and steel, but not basic oxygen or open hearth furnace production.
Nitric Acid Production	Nitric Acid Production Capacity (metric tons)	no	yes	Chemical Economic Handbook and The Innovation Group, Chemical Profiles, Nitric Acid. http://www.the-innovation-group.com/chemprofile.htm. Default module data not available.
Adipic Acid Production	None in LA	--		n/a
ODS Substitutes	-U.S. emissions of HFC, PFC and SF_6 (metric tons) -LA population	yes		National emissions from Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, US EPA, Report #430-R-08-005, April 2008 (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).
Semiconductor Mfg.	None in LA	--		n/a
Magnesium Production	None in LA	--		n/a
Electric Power Transmission and Distribution Systems	SF_6 Consumption (metric tons)	yes		National SF_6 emissions are apportioned to the state based on the ratio of state-to-national electricity sales data provided in EIA's Electric Power Annual (http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html).
HCFC-22 Production	HCFC-22 Production (metric tons)	no	yes	HCFC-22 production capacity data (1997) used from Chemical and Petroleum Product list (LED) in Inventory of Greenhouse Gases in Louisiana, Center for Energy Studies, LSU, 2000. Data for other years estimated by applying annual

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
				percent of national HCFC-22 production relative to 1997 to Louisiana's 1997 production capacity; national production data from Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, US EPA, April 2008, Table 4-72, 2008-main-tables.zip (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).
Aluminum Production	None in LA	--		n/a
LAND-USE CHANGE AND FORESTRY				
Liming of Agricultural Soils	-Total Limestone Applied to Soil (metric tons) -Total Dolomite Applied to Soil (metric tons)	no no	yes no	Agricultural Chemistry Program, LA Department of Agriculture (1996-1998, and 2001-2005). Surrogate data for 1990-1995 based on 1996 ratio of agricultural lime/total lime and applied to shipments of lime sold or used by producers in Louisiana. Data for 1999 and 2000 were interpolated based on 1998 and 2001 data. Data not available for dolomite applied to soil.
Urea Fertilization	Total Urea Applied to Soil (metric tons)	yes		AAPFCO (2007) Commercial Fertilizers 2005. Association of American Plant Food Control Officials and The Fertilizer Institute. University of Kentucky, Lexington, KY. Data for urea fertilization from TVA (1991 through 1994)
Forest Carbon Flux	Aboveground biomass, belowground biomass, dead wood, litter, soil organic carbon, total wood products and landfill	yes		USDA Forestry Service, estimates of states' forest carbon stocks (1990-2007) and harvested wood stocks (1987, 1992, 1997).
Urban Trees	-Urban area (km^2) -Percent urban tree cover	yes yes		-U.S. Census, 1990 and 2000 -Nowak, et al. People & trees: assessing the U.S. urban forest resource. Journal of Forestry. 2001.
Landfilled Yard Trimmings and Food Scraps	-Landfilled yard trimmings and food scraps ('000 short tons wet weight)	yes		Municipal Solid Waste in the United States: 2006 Facts and Figures (EPA 2007).
Forest Fires	Area Burned (ha)	no	yes	LA Department of Agriculture and Forestry, Ten Year Fire Data, Bret Lane, June 2009 and LDAF website: http://www.ldaf.louisiana.gov/portal/Offices/Forestry/ForestProtection/tabid/135/Default.aspx. Average area burned per year for 1996-2007 (LDAF website) used as surrogate data for 1990-1997. Default data were not available.
N_2O from Settlement Soils	-Synthetic fertilizer applied to settlement soils (metric tons N)	yes		AAPFCO (2007) Commercial Fertilizers 2006. Association of American Plant Food Control Officials and The Fertilizer Institute. University of Kentucky, Lexington, KY.
MOBILE COMBUSTION (CH_4 and N_2O)				
Highway Vehicles	-Distance traveled-VMT	yes	yes	U.S. Federal Highway Administration, "Highway

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Aviation Boats & Vessels Locomotives Other Non-Highway Vehicles Alternative Fuel Vehicles	(miles) -Gasoline, Diesel (gallons) -Jet/Distilate/Residual Fuel (mBtu) -Alternative Fuels: Bio-Mass, Natural Gas, Liquid Propane Gas, (gal.equivalents) *note: Biodiesel vehicles emissions assumed to be same as those for diesel vehicles. Ethanol vehicles are assumed to have zero net emissions.			Statistics," Tables VM-1 & VM-2 (http://www. fhwa.dot.gov///ohim/ohimstat.htm) -US DOE, EIA (2008), "State Energy Data: Consumption Estimates 2005," http://www.eia.doe.gov/emeu/states_seds.html -US EPA. "Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2002. Office of Atmospheric Programs, U.S. Environmental Protection Agency. EPA-430-R-04-003, 2004. http://yosemite.epa.gov/oar/globalwarming.nsf /content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html
NATURAL GAS AND OIL SYSTEMS				
Natural Gas Production	-# of onshore gas wells	yes		US DOE, EIA, Natural Gas Navigator. "Number of Producing Gas and Gas Condensate Wells" http://tonto.eia.doe.gov/ dnav/ng/ng_prod_wells_s1_a.htm
	-# of shallow water offshore platforms	no	yes	Louisiana Dept. of Natural Resources, Coastal Division (estimated from DNR permit database). Default data not provided in module.
	-Deepwater offshore platforms	--		No deepwater offshore platforms in LA state waters
Natural Gas Transmission	-Miles of gathering pipeline -Gas processing plants - LNG stations - Miles of transmission pipeline - gas transmission compressor stations - gas storage compressor stations	no no no no no no	yes yes yes yes yes yes	-AGA, Gas Facts 1990-1996 & 1999-2005 -Oil & Gas Journal, Worldwide Gas Processing, 1990-2005. -http://www.ferc.gov/industries/lng/indus-act/terminals/exist-prop-lng.pdf. -AGA, Gas Facts 1990-1996 & 1999-2005. -LA Dept. of Environmental Quality, 2007 Certified Emissions, and EIA, Interstate Pipeline Compressor Station Database, April 2009. LA ratios of compressor stations/mile pipeline used instead of defaults
Natural Gas Distribution	-Miles of distribution pipeline	no	yes	-AGA, Gas Facts 1991-1996 & 1999-2007
	-Total # of services - # of unprotected steel services - # of protected steel services	no no no	yes yes yes	-Pipeline and Hazardous Materials Safety Administration, Gas Distribution Systems Annual Report data files, http://phmsa.dot.gov/pipeline/library/data-stats. Data files filtered for State of Operation=LA.
Natural Gas Vented and Flared	Natural gas vented and flared (billion Btu)	yes		Source: EIA's Natural Gas Navigator. http://tonto.eia.doe.gov/ dnav/ng/ng_prod_sum_dcu_NUS_m.htm
Oil Production	Barrels of Oil (thousand barrels)	yes		-EIA Petroleum Supply Annual, http://tonto.eia. doe.gov/dnav/pet/hist/mcrfpla1a.htm
Oil Refining		no	yes	Ratio of state refining capacity to PADD district refining capacity multiplied by PADD gross crude input, EIA Petroleum Navigator, http://tonto.eia.doe.gov/dnav/pet/hist/8_na_do_sla_4a.htm.

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Oil Transportation		no	yes	Barrels of oil transported assumed to be same as barrels of oil refined
SOLID WASTE				
Municipal Solid Waste Landfills	-U.S. MSW landfilled (tons) -LA population -LA percent landfilled	yes yes yes		-Franklin Associates (2005) Municipal Solid Waste in the United States: 2003 Facts and Figures. Prepared for U.S. EPA, Washington, D.C., EPA 530-F-05-003. -U.S. Census Bureau -BioCycle, 1990-2001, 2004, 2006
Industrial Landfills	MSW landfill CH_4 emissions	yes		Assumed to be 7% of municipal solid waste landfill emissions. EPA (1993) Anthropogenic Methane Emissions in the U.S.: Global Change Division, Office of Air and Radiation, EPA 530/430-R-93-003.
Methane Flaring	Amount of CH_4 flared (tons)	yes		2006BY US Inventory, Flare Database.xls; Obtained from Melissa Weitz at EPA
Landfill Gas-to-Energy	Amount of CH_4 recovered (tons)	yes		US EPA (2005) Landfill Gas-to-Energy Project Database 2005, Landfill Methane and Outreach Program. http://www.epa.gov/lmop/proj/. No data available for 1990-1998 and 2001-2003.
Landfill Oxidation	Percent CH_4 oxidized through landfill cover or soils	yes		EPA default percent, ICF International (March 2007) Draft User's Guide for Estimating Emissions from Municipal Solid Waste Using the State Inventory Tool. Prepared for U.S. EPA
Solid Waste Combustion	Municipal solid waste combusted (short tons)	no	no	No MSW combusted in LA according to LDEQ from 1990-2006. Did not use default data listed for 1993, 2003-2006.
STATIONARY COMBUSTION (CH_4 and N_2O)				
Residential Commercial Industrial Electric Utilities	Energy consumption by fuel (Billion Btu)	yes		US DOE, EIA, State Energy Data 2005: Consumption Estimates
WASTEWATER				
Municipal Wastewater • CH_4 Emissions • Direct N_2O • N_2O from Biosolids	State population	yes		U.S. Census Bureau, www.census.gov, American Factfinder, 2000-2006 population.
Industrial Wastewater— Fruit and Vegetables	Fruit and vegetable production processed (metric tons)	no	yes	Louisiana State University Agriculture Center, Agriculture and Natural Resources, "Louisiana Summary." Data for 1993-1997 were calculated using the ratio of 1998 gross farm income from plant commodities to metric tons of fruits and vegetables processed. 1993 data used as surrogate for 1990-1992.
Industrial Wastewater-- Red Meat	Red meat production processed (metric tons)	yes		U.S. Dept. of Agriculture Quick Stats, Annual Red Meat Production. http://www.nass.usda.gov/QuickStats/Create_Federal_All.jsp

Module/Sector	Data Input Categories	Default Data Used?	Other Data Used?	Data Sources
Industrial Wastewater-- Poultry	Poultry production processed (metric tons)	yes	yes	LSU Ag. Center, Agriculture and Natural Resources, "Louisiana Summary." Data for 1993-1995 were calculated using the ratio of 1996 gross farm income from animal commodities to metric tons of poultry processed. 1993 data used as surrogate for 1990-1992.
Paper and Paperboard	Paper and paperboard processed (metric tons)	no	yes	USDA Forest Service, *United States Paper, Paperboard, and Market Pulp Capacity Trends by Process and Location*, 1970-2000; Georgia Technology University, The Center for Paper Business and Industry Studies. USDA ratio of 2000 LA to US production capacity used to estimate 1990-1999 data. GA Tech average 2000-2002 production capacity data used as surrogate for 2001-2005.

Non-Default Data

In cases where default data were incomplete or missing, data were interpolated or obtained from the same sources as those used by EPA. In other cases data were obtained by contacting agencies directly or through literature and internet searches. The table below lists non-default data inputs used in this inventory.

Table 2.2-3. GHG Inventory Non-default Data

Module/Category	Data Input
Agriculture	
Manure Management	- Poultry ('000 head)
Industrial Processes	
Iron and Steel Production	-Production method distribution
Nitric Acid Production	-Nitric acid production (metric tons)
HCFC-22 Production	-HCFC-22 production (metric tons)
Land Use, Land-Use Change and Forestry	
Liming of Agricultural Soils	-Total limestone applied to soil (metric tons)
Forest Fires	-Area burned (hectare)
Natural Gas and Oil Systems	
Natural Gas Production	-Shallow water offshore platforms
Natural Gas Transmission	-Miles of gathering pipeline -Gas processing plants -LNG stations -Miles of transmission pipeline -Total # gas transmission compressor stations -Total # gas storage compressor stations

Module/Category	Data Input
Natural Gas Distribution	-Miles of distribution pipeline -Total # of services -Total # of unprotected steel services -Total # of protected steel services
Oil Refining/Transportation	-Barrels of oil (thousand barrels)
Solid Waste	
Municipal Solid Waste	-Municipal solid waste combusted (short tons)
Wastewater	
Industrial Wastewater	-Vegetable & fruit processed (metric tons) -Poultry production processed (metric tons) -Paper & paperboard (metric tons)

2.3 QUALITY ASSURANCE/QUALITY CONTROL PROCEDURES

The main purpose of this GHG inventory was to develop and present information on sources and quantities of Louisiana GHG emissions to facilitate decision-making by the State of Louisiana in preparation for the possible federal regulation of greenhouse gases. Because some decisions may carry significant economic consequences for the state's public and private sectors, it is important that there be good confidence in the information being used as a basis for the decisions. To assure that the information presented in this report can be used with confidence, we have employed a program of quality assurance and quality control (QA/QC) that provides for transparency, consistency, comparability, completeness, accuracy, and documentation.

Our QC system was patterned after the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). Principal goals for the QC system were (1) to provide routine and consistent checks to ensure data integrity, correctness, and completeness; (2) to identify and address errors and omissions; and (3) to document and archive inventory material and record all QC activities. QC activities included such general methods as use of widely-accepted data sources, accuracy checks on data acquisition and calculations, and use of approved standardized procedures for emission calculations, measurements, assessing uncertainties, archiving information, and reporting.

According to the IPCC (2006), quality assurance is a planned system of review procedures conducted by personnel not directly involved in the inventory compilation/development process. Our Project Advisory Team (PAT) served as the principal QA vehicle for this project. Regular meetings of the PAT were held throughout this project, where details on inventory compilation and development were presented and discussed. This GHG inventory report was also provided to the PAT for review and comment before finalization.

This project relied heavily on emissions information developed from other sources (i.e. U.S. Environmental Protection Agency, State Inventory Tool; U.S. Department of Energy, Energy Information Administration; World Resources Institute, Climate Analysis Indicator Tool – United States). Each of these organizations employs its own program of QA/QC to assure credible and defensible data. However, we were careful to check the EPA SIT default values and EIA state energy data to make sure that there were not more accurate data available from other sources available to us. We assumed that the WRI CAIT-US data was acceptable since WRI reportedly relied on EPA and EIA data for their tables and graphs.

3. RESULTS

3.1 STATE-LEVEL EMISSION SUMMARY

3.1.1 Louisiana Greenhouse Gas Emissions Inventory

Louisiana greenhouse gas emissions for 2005 totaled 227.66 million metric tons of carbon dioxide equivalent emissions ($MMTCO_2E$) gross and 214.64 $MMTCO_2E$ net of sequestration from natural sinks. As can be seen in Table 3.1.1-1, the vast majority (84 percent) of GHG emissions were made up of CO_2 from fossil fuel combustion.

Table 3.1.1-1. Summary of Louisiana's 2005 GHG Emissions.

	Greenhouse Gas	CO_2 Equivalent Emissions MMT	Percent Total Emissions
Energy			
CO_2 from fossil fuel combustion	CO_2	191.32	84.0%
Stationary combustion (non-CO_2)	CH_4	0.18	0.1%
	N_2O	0.42	0.2%
Mobile combustion (non-CO_2)	CH_4	0.06	0.0%
	N_2O	0.92	0.4%
Natural gas & oil systems	CO_2	0.25	0.1%
	CH_4	13.13	5.8%
Coal mining	CH_4	0.04	0.0%
Industrial Processes	CO_2	3.30	1.4%
	N_2O	3.27	1.4%
	HFC, PFC,SF_6	6.85	3.0%
Wastes			
Municipal solid waste	CH_4	0.37	0.2%
Wastewater	CH_4	0.65	0.3%
	N_2O	0.13	0.1%
Agriculture	CH_4	2.76	1.2%
	N_2O	3.68	1.6%
Land-use Change & Forestry	CH_4	0.17	0.1%
	N_2O	0.13	0.1%
	CO_2	-13.02	
	Total Gross CO_2	227.66	100.00%
	Total Net CO_2	214.64	

Carbon dioxide represented 86 percent of Louisiana's GHG emissions in 2005, followed by methane at 8 percent, nitrous oxide at 3 percent, and hydrofluorocarbons plus perfluorocarbons plus sulfur hexafluoride at a combined 3 percent (Figure 3.1.1-1).

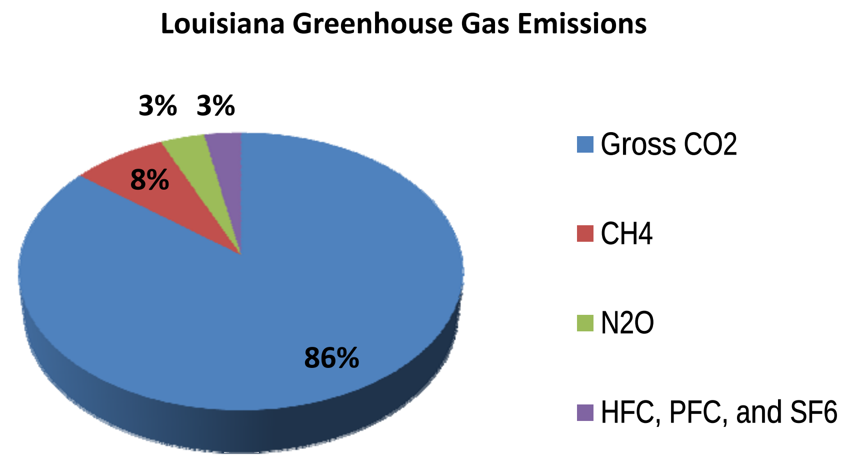


Figure 3.1.1-1. Louisiana GHG emissions by gas, 2005.

3.1.2 Emission Comparisons and Trends

For perspective on the Louisiana GHG emissions, comparisons were made with other states as well as demographic statistics to provide context with which to evaluate the state's emissions. Fossil fuel combustion emissions (which typically represent over 85 percent of GHG emissions) were used for trends and comparisons since a good historical record of these emissions are kept for all states by the Energy Information Administration (EIA). The World Resources Institute's Climate Analysis Inventory Tool (WRI CAIT-US, 2009) was used for graphing selected trends and relationships. CAIT-US also employs data from the EIA fossil fuel combustion emissions database.

The EIA fossil fuel combustion emissions data show Louisiana ranks 11th among the states in total fossil fuel combustion GHG emissions (Figure 3.1.2-1).

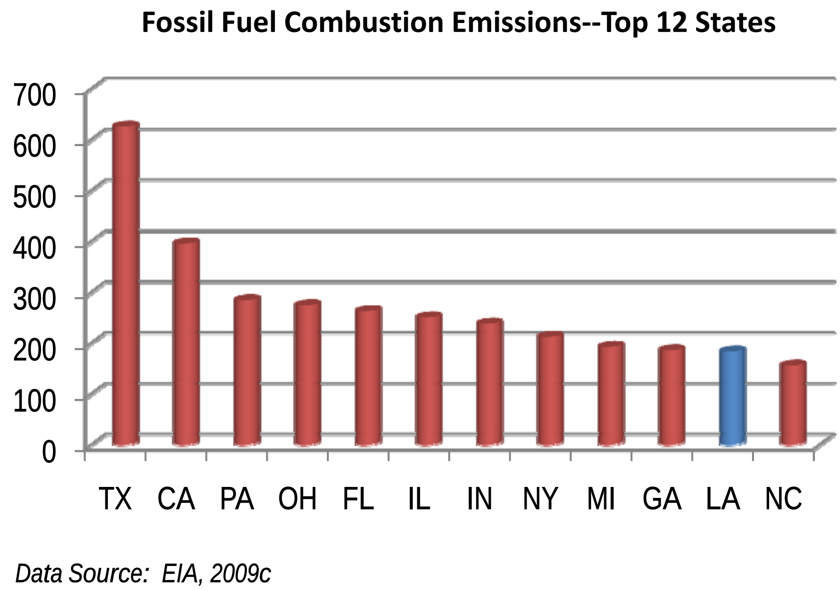


Figure 3.1.2-1. Top twelve states fossil fuel combustion emissions in 2005 (MMTCO_2).

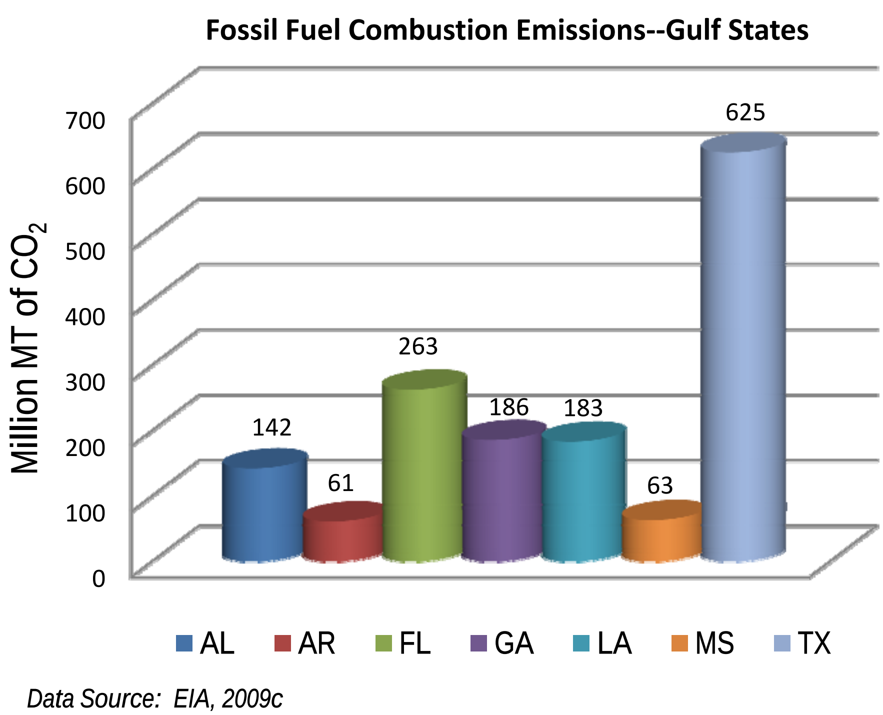


Figure 3.1.2-2. Louisiana's 2005 fossil fuel combustion CO_2 emissions compared to other Gulf South states.

As shown in Figure 3.1.3-1, states vary considerably in CO_2 emissions from fossil fuel combustion by major source sectors. Louisiana and Texas show relatively high contributions from industrial emissions, whereas Florida and Georgia show relatively higher contributions from transportation and electrical generation. Vermont is included in this graphic adjacent to

Texas because the two states represent the smallest and largest total fossil fuel combustion CO_2 emissions, respectively, for 2005.

In examining EIA's fossil fuel combustion emissions data for the period 1990 to 2005, Louisiana appears rather unique in that its emissions have remained relatively flat for the entire 15-year period (Figure 3.1.3-2). Also, distribution of Louisiana's fossil fuel combustion CO_2 emissions from major source sectors remained essentially unchanged during this same time period (Figure 3.1.3-3).

3.1.3 Energy, Economy, and Emissions

Using WRI CAIT-US graphing tools, a comparison of Louisiana GHG emissions to total U.S. emissions shows that U.S. emissions have grown by about 18 percent from 1990 to 2005, while Louisiana emissions have decreased slightly (Figure 3.1.3-4). Graphing Louisiana GHG emissions with state population and gross state product (Figure 3.1.3-5) shows Louisiana GHG emissions have fallen even as population and gross state product have grown. Additionally, Louisiana's vehicle miles traveled and gasoline use have increased by about 20 percent and 30 percent, respectively, from 1990 to 2005, while GHG emissions have remained relatively flat (Figure 3.1.3-6).

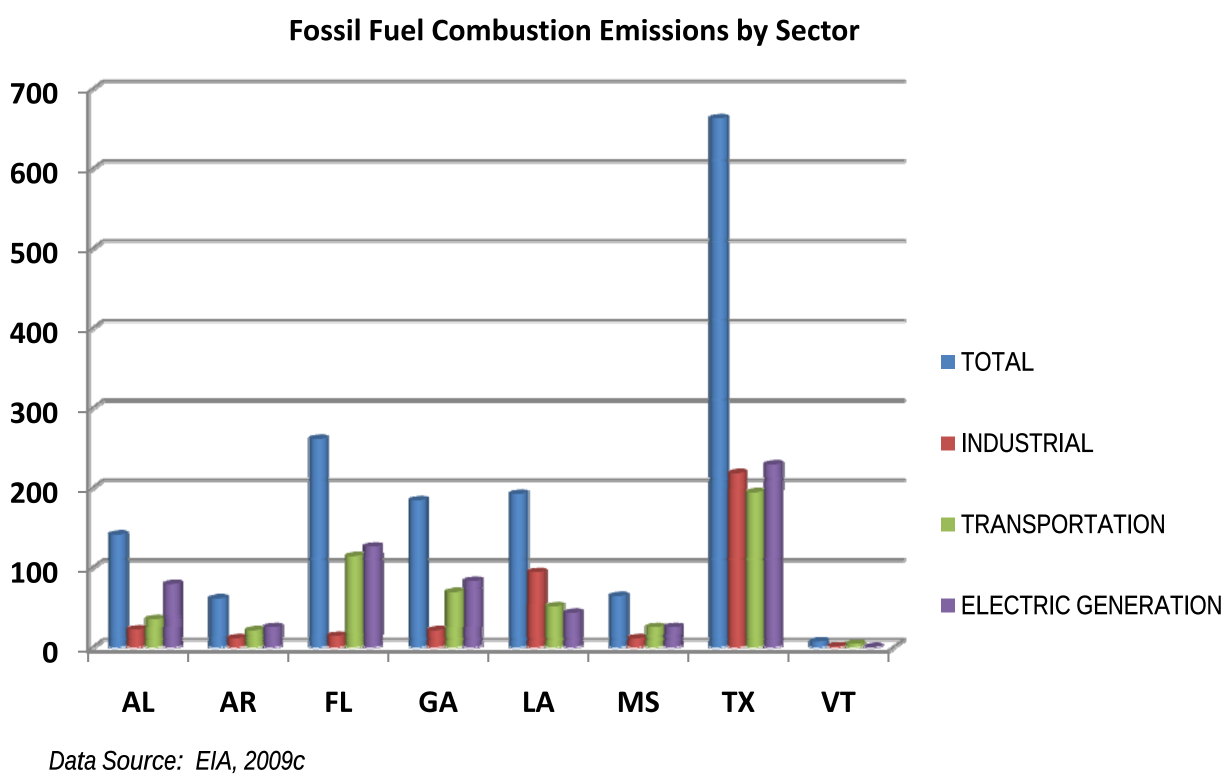


Figure 3.1.3-1. 2005 fossil fuel combustion CO_2 emissions by major source sector for selected states ($MMTCO_2$).

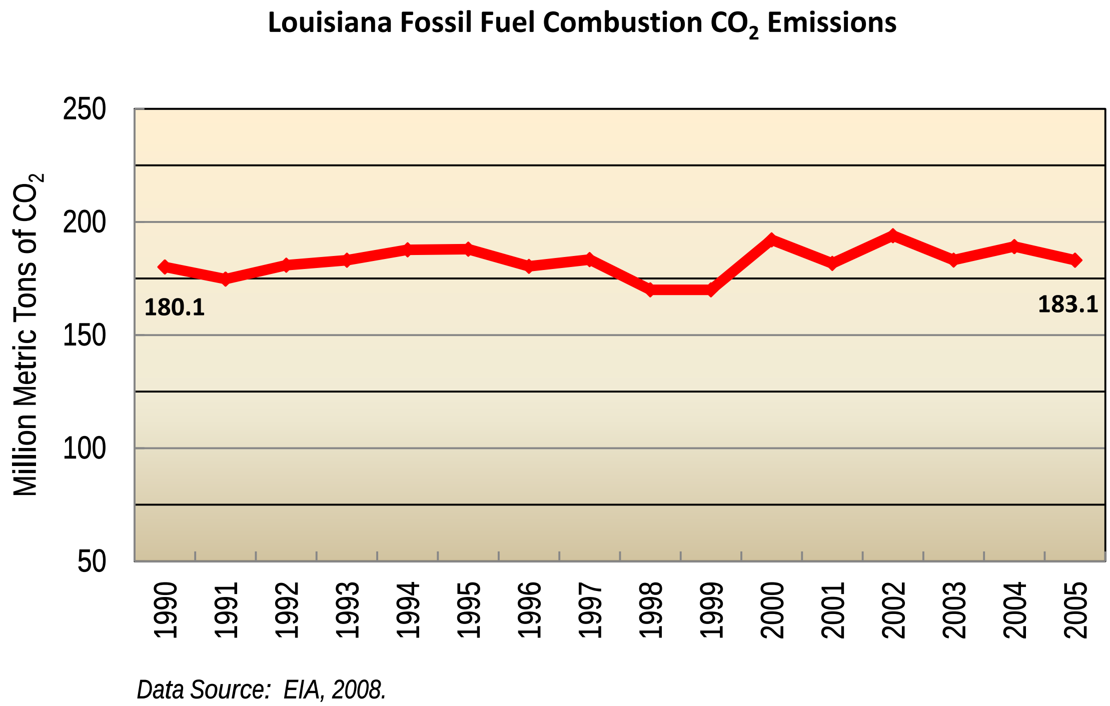


Figure 3.1.3-2. Louisiana CO_2 emissions from fossil fuel combustion, 1990-2005.

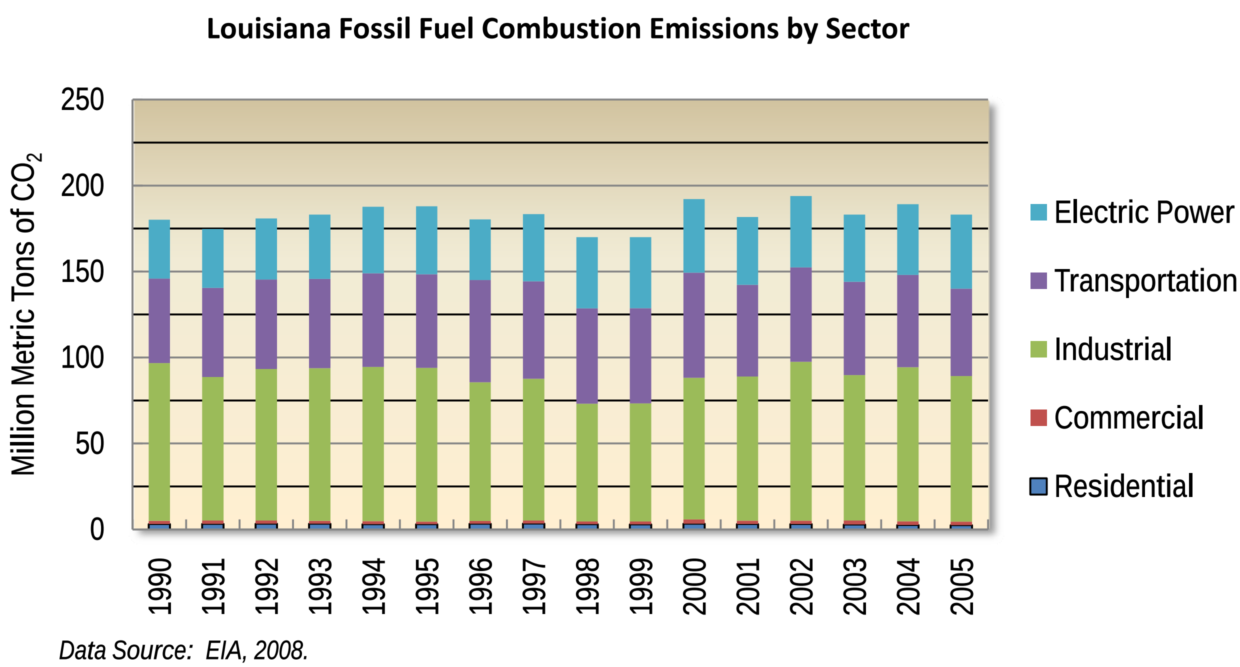
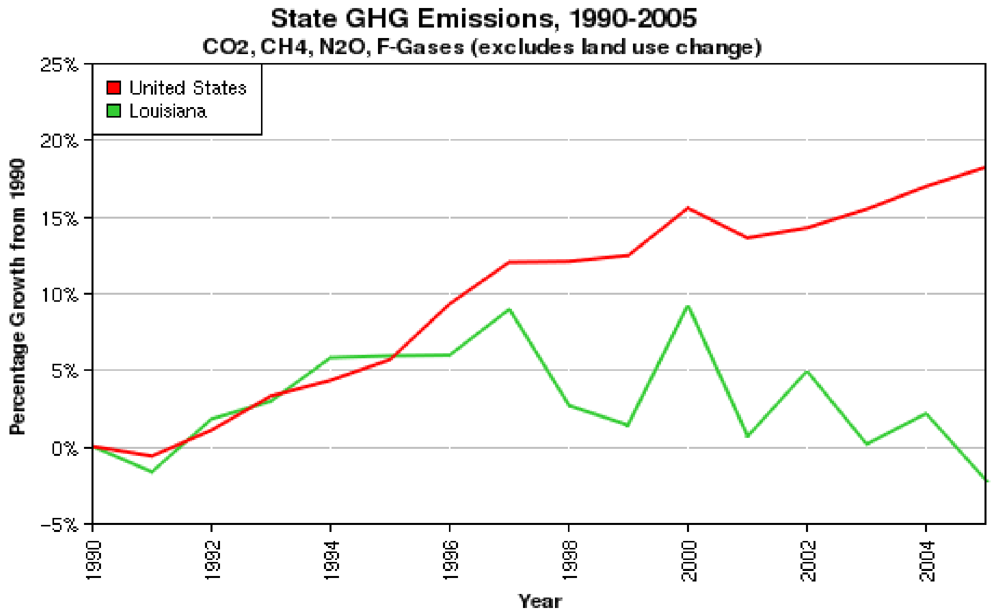
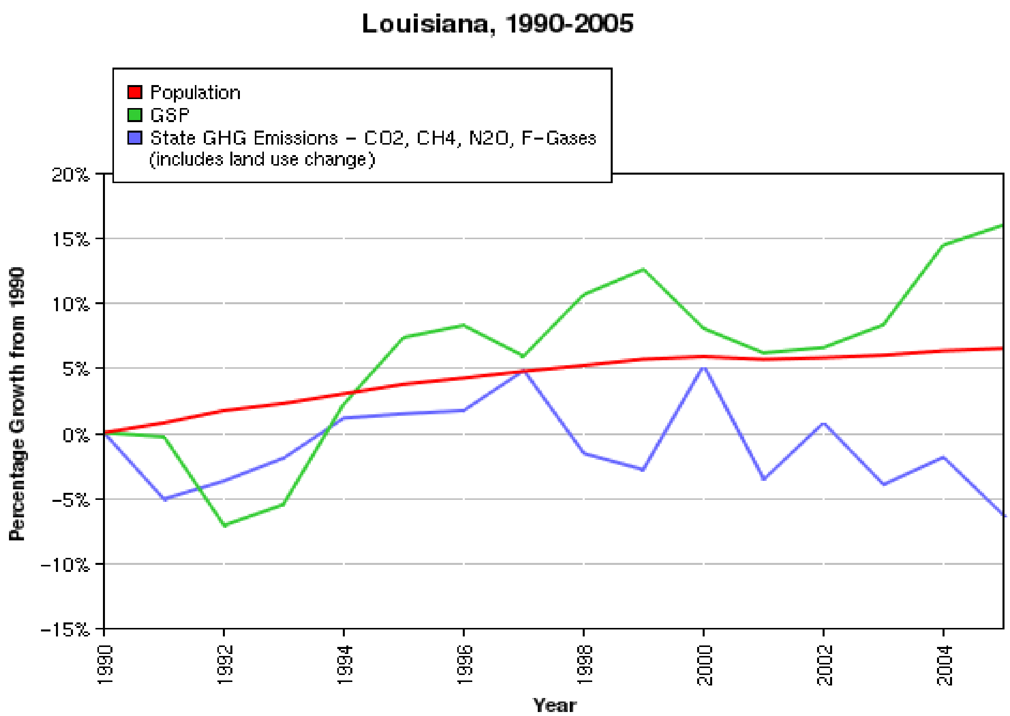


Figure 3.1.3-3. Louisiana CO_2 emissions from fossil fuel combustion by sector, 1990-2005.



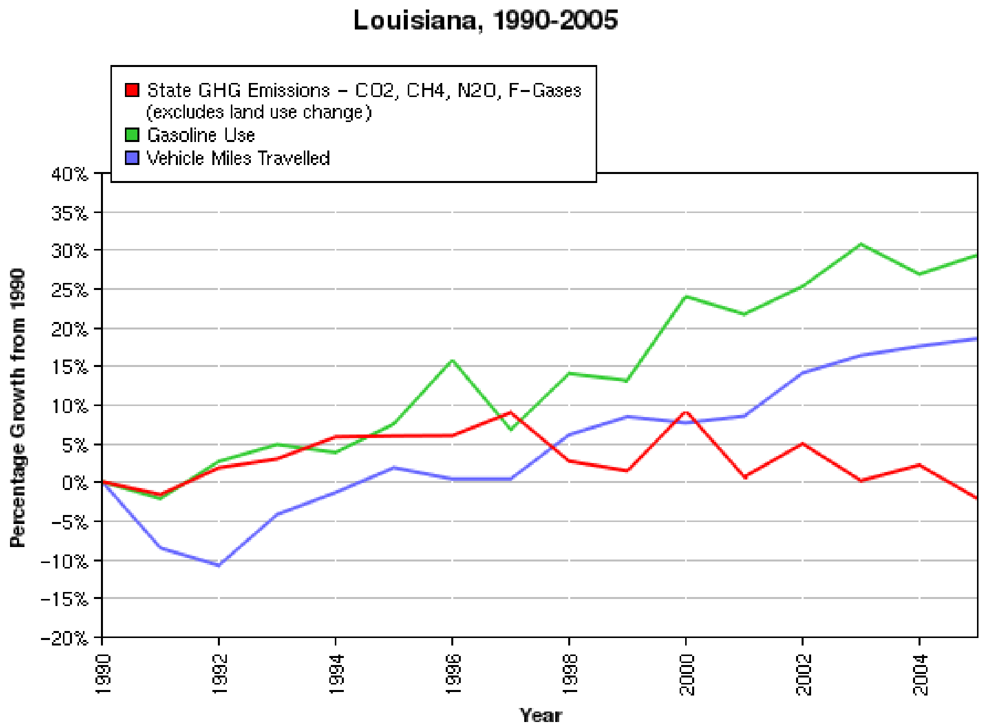
Data Source: WRI CAIT US, 2009

Figure 3.1.3-4. Comparison of changes in Louisiana and U.S. fossil fuel combustion emissions from 1990 values for the period 1990-2005.



Data Source: WRI CAIT US, 2009

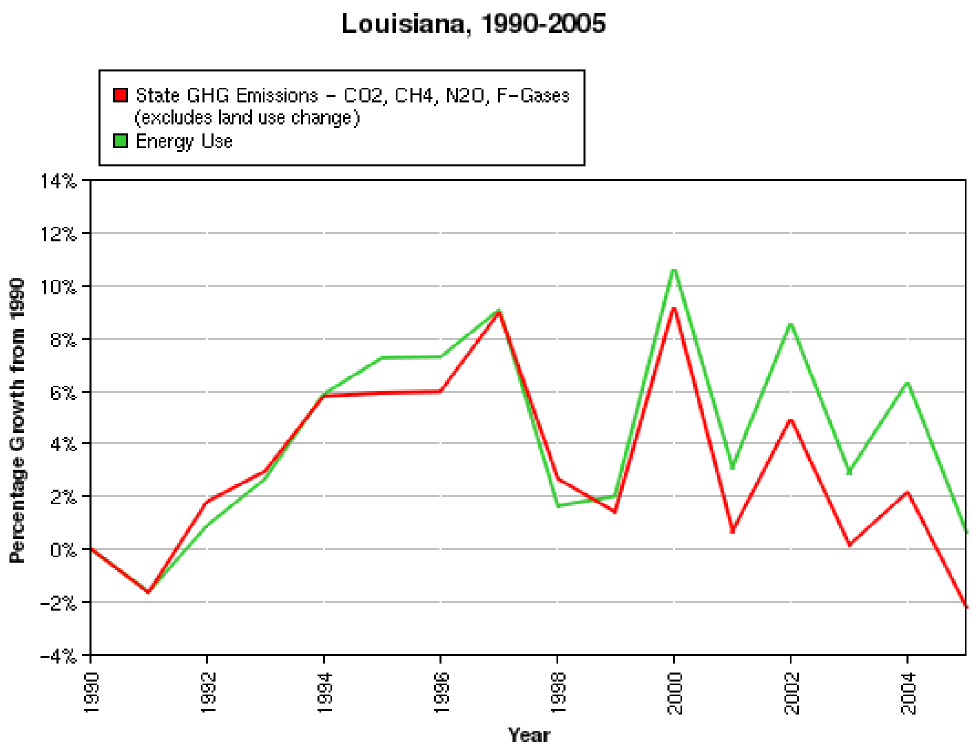
Figure 3.1.3-5. Comparison of Louisiana GHG emissions to population and gross state product growth from 1990-2005.



Data Source: WRI CAIT US, 2009

Figure 3.1.3-6. Comparison of Louisiana GHG emissions with gasoline use and vehicle miles traveled for the period 1990-2005.

As would be expected, Louisiana GHG emissions closely tracked energy use during the 15-year period from 1990 to 2005 (Figure 3.1.3-7). Although both vary from year to year, energy use and GHG emissions in 2005 had returned to levels similar to those recorded for 1990.



Data Source: WRI CAIT US, 2009

Figure 3.1.3-7. Comparison of Louisiana GHG emissions with the state's energy use.

A plot of Louisiana GHG emissions against gross state product shows a dramatic downward trend in GHG intensity relative to gross state product (Figure 3.1.3-8). This essentially reflects flat emissions over the 15-year period compared to increasing gross state product.

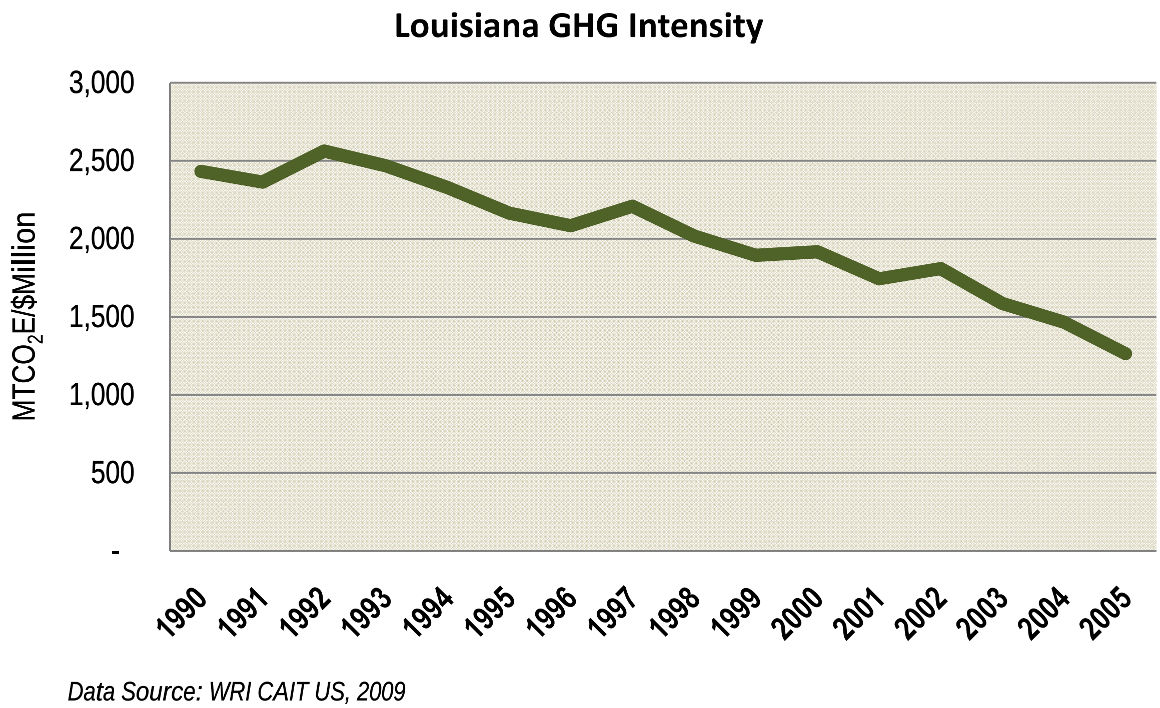


Figure 3.1.3-8. Louisiana GHG emissions per gross state product (MTCO$_2$E/$Million).

Assumptions

Attempting to analyze and explain the particular relationships between Louisiana GHG and these selected parameters and demographic statistics is beyond the scope of this project. However, there are several factors that we can assume played a role in holding Louisiana GHG emissions relatively low over the period 1990 to 2005:

- Relatively slow economic growth;
- Industry's response to increasing energy costs with energy conservation/efficiency measures;
- Motor vehicle fleet turnover to cleaner, more fuel-efficient vehicles.

3.2 SOURCE-SPECIFIC EMISSIONS INVENTORIES

3.2.1 Carbon Dioxide Emissions from Combustion of Fossil Fuels

Fossil fuels are hydrocarbon compounds including coal, natural gas, and petroleum. The combustion of these fuels is the primary source of anthropogenic CO_2 emissions. In 2005, nation-wide fossil fuel combustion contributed to **96.8 percent** of energy emissions. In Louisiana, an estimated 191.32 Million Metric Tons of Carbon Dioxide Equivalent ($MMTCO_2E$) made up **88.9 percent** of Net Emissions (84 percent of Gross Emissions). The following is an explanation of results from module calculations performed at Louisiana State University's Center for Energy Studies.

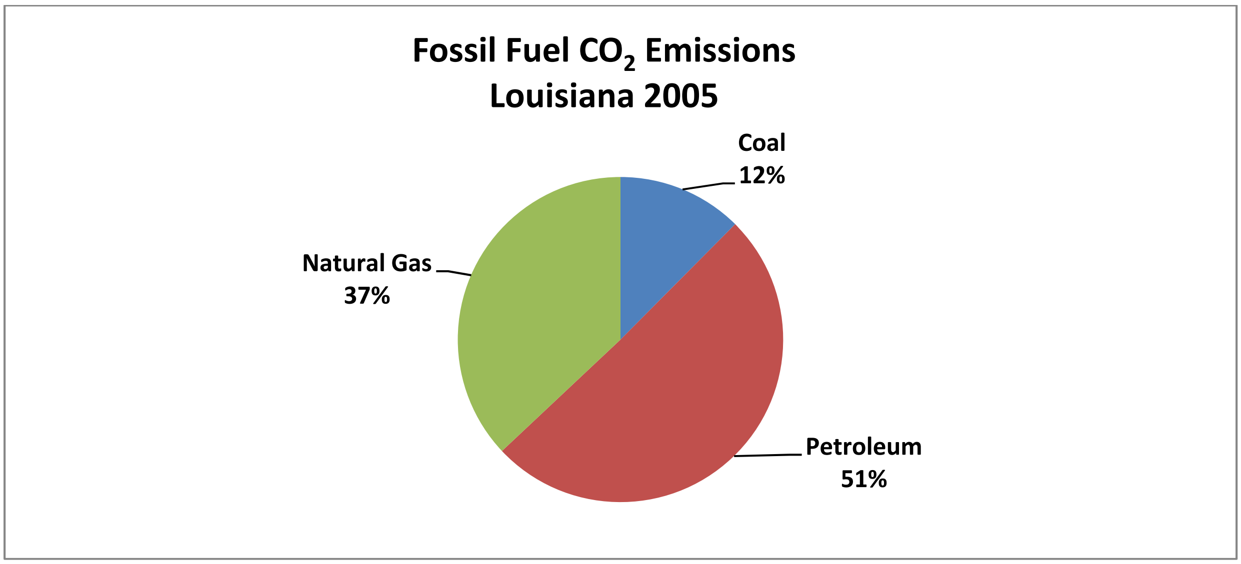


Figure 3.2.1-1. Aggregate sources of fossil fuel emissions in Louisiana.

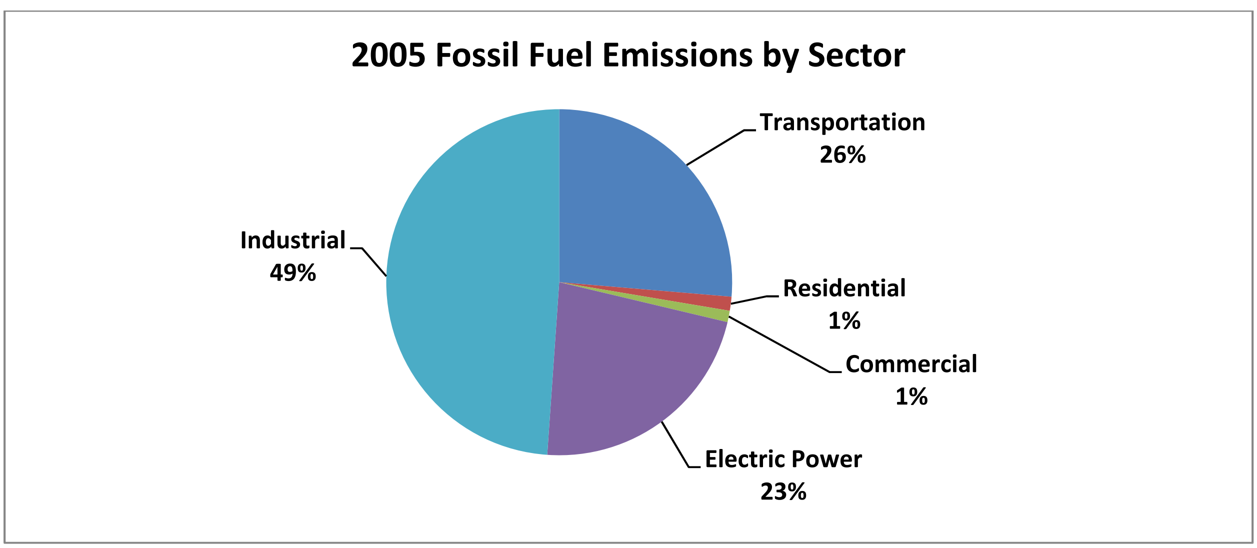


Figure 3.2.1-2. Louisiana fossil fuel emissions by sector, percentage of total.

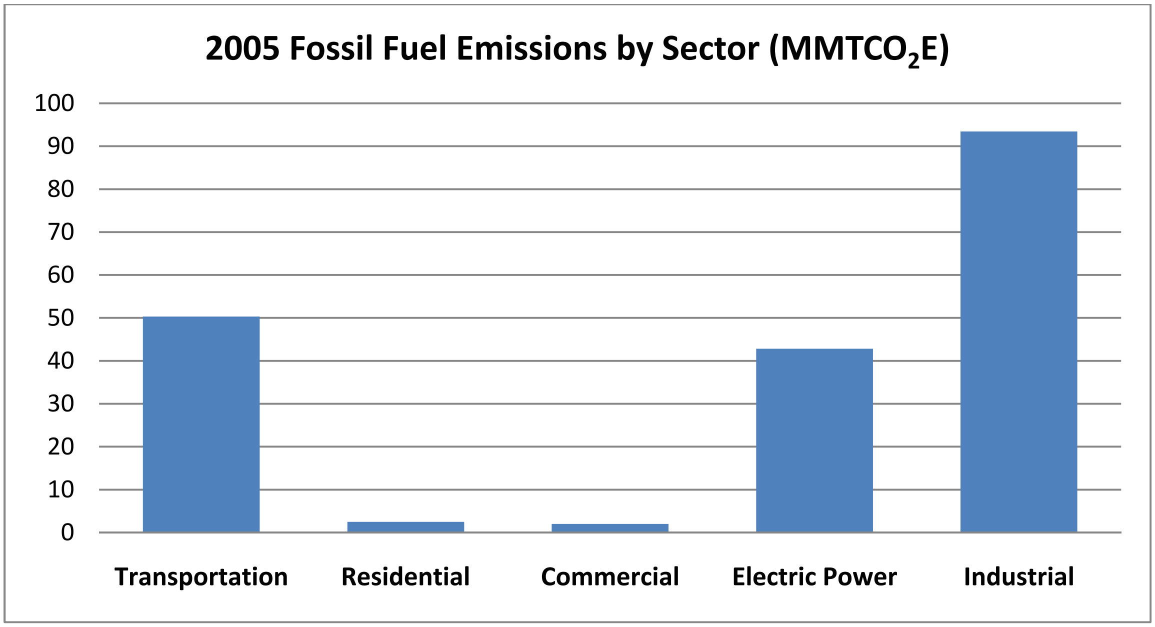


Figure 3.2.1-3. Louisiana fossil fuel emissions by sector—MMTCO$_2$E

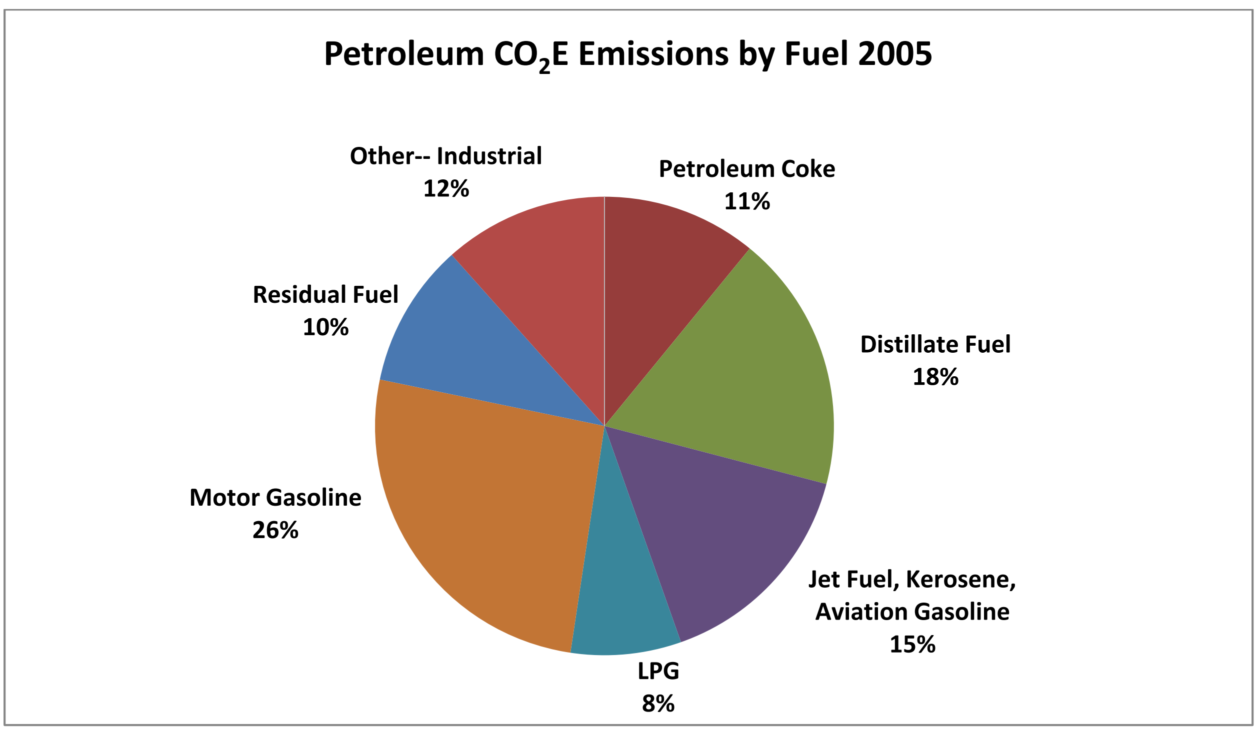


Figure 3.2.1-4. Petroleum CO_2 emissions by fuel for year 2005.

Methodology

This section estimates economy-wide carbon dioxide emissions from combustion of fossil fuels in Louisiana during the year 2005. The Fossil Fuel Combustion module estimates CO_2 emissions using consumption information from the annual State Energy Data System (EIA, 2008). Data is gathered from each sector including: residential, commercial, transportation, electric power, bunker fuels, and industrial. This data is the baseline for emission inventory calculations.

Each fuel source is assigned default proportions of total carbon content, carbon sequestered in products, and the percentage of carbon oxidized during combustion. These factors indicate the amount of carbon emitted per unit of energy released. Emission calculations incorporate the *fuel combustion efficiency*, the *carbon emission factor*, and the *conversion factor* (EIA, 2005). The resulting level of carbon is adjusted to *carbon-dioxide equivalents,* for purposes of comparison. Formulas and guidance from the Emission Inventory Improvement Program (EIIP) ensures that methods used in preparation of this inventory are consistent with national standards (EPA, 2006).

Equation 1. General Emission Equation

Emissions (MMTCO2E) =
Consumption (BBtu) x Emission Factor (lbs C/BBtu) x Combustion Efficiency (%)
x .090718 (*Ratio of Short Tons to Metric Tons*) ÷ 1,000,000 x (44/12) (*to yield $C0_2$ equivalents*)

Equation 2. Emission Equation for the Industrial Sector

Emissions (MMTCO2E) =
Total Consumption (BBtu) – [Non-Energy Consumption (BBtu) x Storage Factor (%)]
x Emission Factor (lbs C/BBtu) x Combustion Efficiency (%) x .090718 (*Ratio of Short Tons to Metric Tons*) ÷ 1,000,000 x (44/12) (*to yield $C0_2$ equivalents*)

The variables are explained as part of the *User's Guide for Estimating Carbon Dioxide Emissions from Fossil Fuel Combustion Using the State Inventory Tool* published through EPA. The combustion efficiency factor is assumed to be 100 percent for this inventory's purposes. Although not all of the fuel actually oxidizes during combustion, the remaining amount oxidizes in the atmosphere shortly after combustion. The storage factor represents the amount of carbon content sequestered to some extent in a product and ranges between 0-100 percent depending on how long it takes for the resulting matter to be burned or decompose (ICF International, 2007a).

The carbon content of each fuel varies by year to some extent. The source of this variable is EIA's *Electric Power Annual.* Assuming 100 percent combustion efficiency, this factor incorporates the maximum amount of carbon emitted per unit of energy released. For example, coal has higher carbon content than petroleum, which has a higher average amount than natural gas. Coal has a high level of variability and the natural gas factor is dependent upon relative proportions of methane, ethane, propane, and other hydrocarbon components. For petroleum, the American Petroleum Institute gravity fractions are used to define carbon content (ICF International, 2007a).

Louisiana Fossil Fuel Combustion Emission Trends

Louisiana's fossil fuel combustion emissions decreased slightly between 1990 and 2005, despite sporadic spikes throughout the years. Nationwide, 2005 fossil fuel combustion emissions rose 19 percent above 1990 levels. In Louisiana, total emissions remained relatively flat over the fifteen-year period. During this same time, petroleum emissions rose and there was a decrease in natural gas emissions. This trend is visible in Figure 3.2.1-5.

Between 2004 and 2005, Louisiana emissions from fossil fuel combustion decreased by 3.5 percent. This decrease was not unprecedented in the state, yet it has only been more dramatic in three years: 1998, 2001, and 2003. The average change over the course of this period is a subtle -.01 percent.

The year 2005 is a unique case in Louisiana's history, due to the impact of hurricanes Katrina and Rita. The extended loss of electricity across the state did not decrease electrical power emissions (which rose from 13.36 $MMTCO_2E$ in 2004 to 15.56 in 2005). However, the industrial emissions decreased by 5.9 percent. This is explained by the temporary closure of several processing and chemical plants along the hurricane paths.

Table 3.2.1-1. Emissions from the Combustion of Fossil Fuel ($MMTCO_2E$).

Fuel Type	**1990**	**1995**	**2000**	**2005**
Coal	20.12	20.93	23.79	23.81
Petroleum	85.25	92.70	102.89	96.68
Natural Gas	86.40	90.67	84.34	70.83
TOTAL	**191.77**	**204.30**	**211.02**	**191.32**

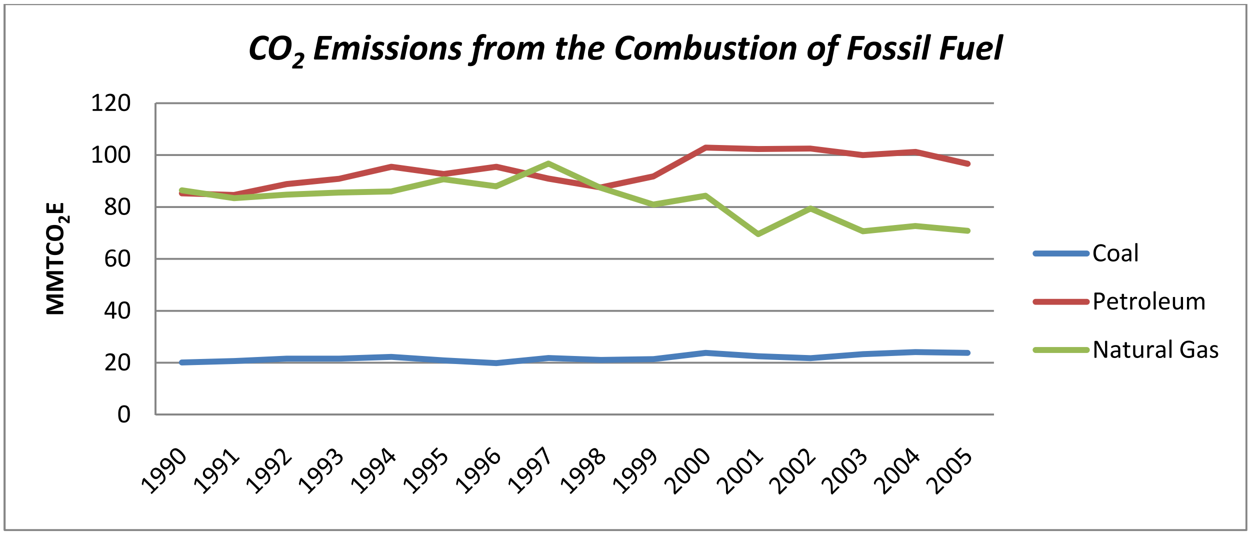


Figure 3.2.1-5. CO_2 emissions from the combustion of fossil fuel by source.

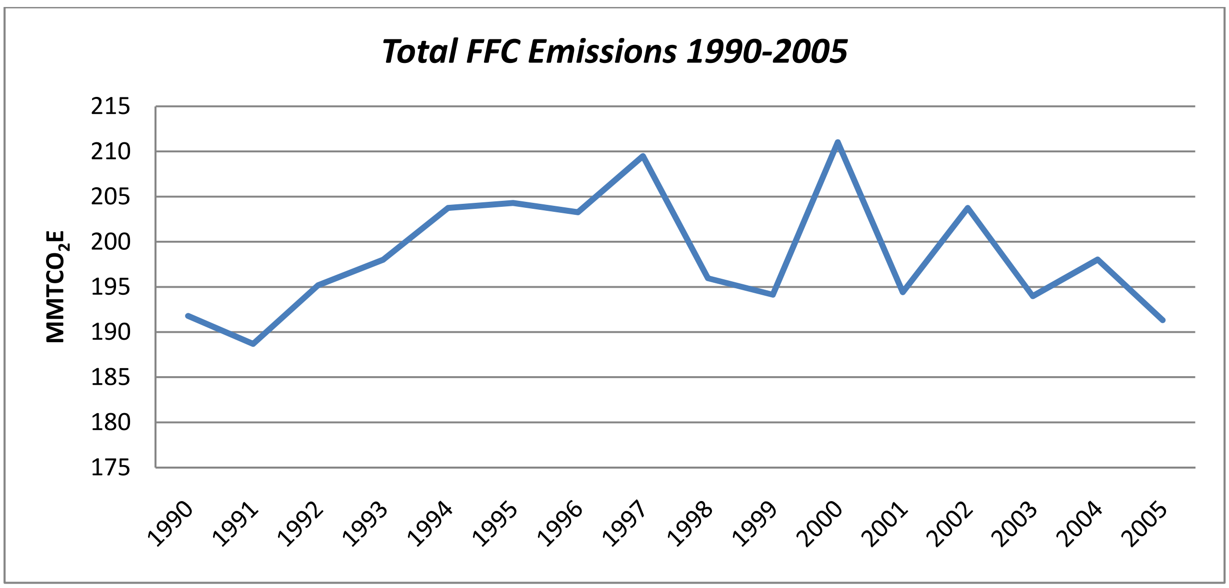


Figure 3.2.1-6. Total CO_2 emissions from the combustion of fossil fuel.

3.2.2 Industrial Processes (Non-combustion)

Overview

Emissions in the industrial process category reflect non-combustion sources of greenhouse gas (GHG) emissions from several industries. Industrial processes in Louisiana for which emissions are calculated in this inventory include the following:

- Carbon dioxide (CO_2) from:

  - Production of high-calcium and dolomitic lime, iron and steel, and ammonia
  - Consumption of limestone and soda ash
- Nitrous oxide (N_2O) from nitric acid production
- Sulfur hexafluoride (SF_6) from transformers used in electric power transmission and distribution (T&D) systems
- Hydrofluorocarbons (HFC) and perfluorocarbons (PFC) from consumption of substitutes for ozone-depleting substances (ODS) used in cooling and refrigeration equipment
- HFC from HCFC-22 production

Other industrial processes that are sources of GHG emissions but are not found in Louisiana are listed below.

- CO_2 from cement and soda ash production
- CO_2 from dolomite consumption
- N_2O from adipic acid production
- PFCs from aluminum production
- SF_6 from magnesium production and processing
- HFCs, PFCs, and SF_6 from semiconductor manufacture

Historical Emissions

Greenhouse gas emissions for 1990 through 2005 were estimated using the U.S. EPA State Greenhouse Gas Inventory Tool (SIT) software. Table 3.2.2-1 identifies data inputs by source category, data sources, and the years for which data were available.

Table 3.2.2-1. Approach to Estimating Historical Emissions: Industrial Processes.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
Lime Manufacture	1990, 1993-2000	High-calcium and dolomitic lime produced (metric tons)	Historical production for Louisiana from USGS Minerals Yearbook, Lime Statistics and Information. Default production data are not available in SIT for 1991-1992 and 2001-2005; it is possible that no high-calcium/dolomitic lime was produced in those years. (http://minerals.usgs.gov/minerals/pubs/commodity/lime/index.html)
Limestone Consumption	1999-2005	limestone consumed (metric tons)	Historical consumption (sales) for Louisiana from USGS Minerals Yearbook, Crushed Stone Statistics and Information. (http://minerals.usgs.gov/minerals/pubs/commodity/stone_crushed/) In SIT, the state's total limestone consumption (as reported by USGS) is multiplied by the ratio of national limestone consumption for industrial uses to total national limestone consumption. Default limestone consumption data were not available in SIT for 1990-1998.
Soda Ash Consumption	1990-2005	soda ash consumed for use in consumer products (tons)	Historical consumption for Louisiana from USGS Minerals Yearbook, Soda Ash. (http://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/)
Iron and Steel Production	1997-2005	crude steel produced by production method (metric tons)	Total default state-level production data were assigned to the electric arc furnace (EAF) production method. Default production data not available in SIT for 1990-1996.
Ammonia Production and Urea Application	1990-2005	ammonia produced and urea consumed (metric tons)	Historical production for Louisiana from USGS Minerals Yearbook, Nitrogen. (http://minerals.usgs.gov/minerals/pubs/commodity/nitrogen/)
Nitric Acid Production	1992, 1993, 1996, 1997, and 2002	nitric acid produced (metric tons)	Historical nitric acid production capacity for Louisiana from Chemical Economic Handbook (1992, 1993, 1996, 1997) and The Innovation Group, Chemical Profiles, Nitric Acid (http://www.the-innovation-group.com/chemprofile.htm). Data for 1992 were used as surrogate for 1990-1991; data for 1996 used as surrogate for 1993-1995; average of 1997 and 2002 used as surrogate for 1998 and 1999; data for 2002 used as surrogate for 2000-2001 and 2003-2005.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
HCFC-22 Production	1997	HCFC-22 produced (metric tons)	HCFC-22 production capacity data (1997) from Chemical and Petroleum Product list (LED) in Mesyanzhinov et al. (2000) Inventory of Greenhouse Gases in Louisiana, Center for Energy Studies, LSU. Data for other years estimated by applying annual percent of national HCFC-22 production relative to 1997 to Louisiana's 1997 production capacity; national production data from Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, U.S. EPA, April 2008, Table 4-72, 2008-main-tables.zip (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).
ODS Substitutes	1990-2005	Based on state's population and estimates of emissions per capita from the U.S. EPA national GHG inventory	National emissions from Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2006, U.S. EPA, Report #430-R-08-005, April 2008 (http://www.epa.gov/climatechange/emissions/usinventoryreport.html).
Electric Power T&D Systems	1990-2005	SF_6 consumption (metric tons)	National SF_6 emissions are apportioned to the state based on the ratio of state-to-national electricity sales data provided in EIA's Electric Power Annual (http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html). Default emission factor assumption is that all SF_6 consumed is used to replace SF_6 that was emitted.

Data Assessment

Data availability varied across the industry sectors. In some cases surrogate data was used to fill in for missing years, for some years no data was available, and for others state-national ratios or per capita estimates were used. Default ratios are those supplied in the SIT module while "other" ratios are those devised by this analysis to estimate missing data. Data characteristics are shown in the table below.

Table 3.2.2-2. Industrial Processes Data Availability.

Industry	Data Availability				
	All years	Some surrogate	Some missing	Default Ratios	Other Ratios
Lime Manufacture		•	•		
Limestone Use			•	•	
Soda Ash Use	•				
Iron and Steel			•		•
Ammonia & Urea	•				
Nitric Acid		•			
HCFC-22 Production					•
ODS Substitutes	•			•	
Electricity Distribution	•			•	

Results

Figures 3.2.2-1 and 3.2.2-2 show historical emissions for the industrial processes sector from 1990 to 2005. Table 3.2.2-2 shows the historical emission values upon which the figures are based. Total Louisiana emissions for this sector were about 13.39 $MMTCO_2E$ in 1990 and 14.01 $MMTCO_2E$ in 2005.

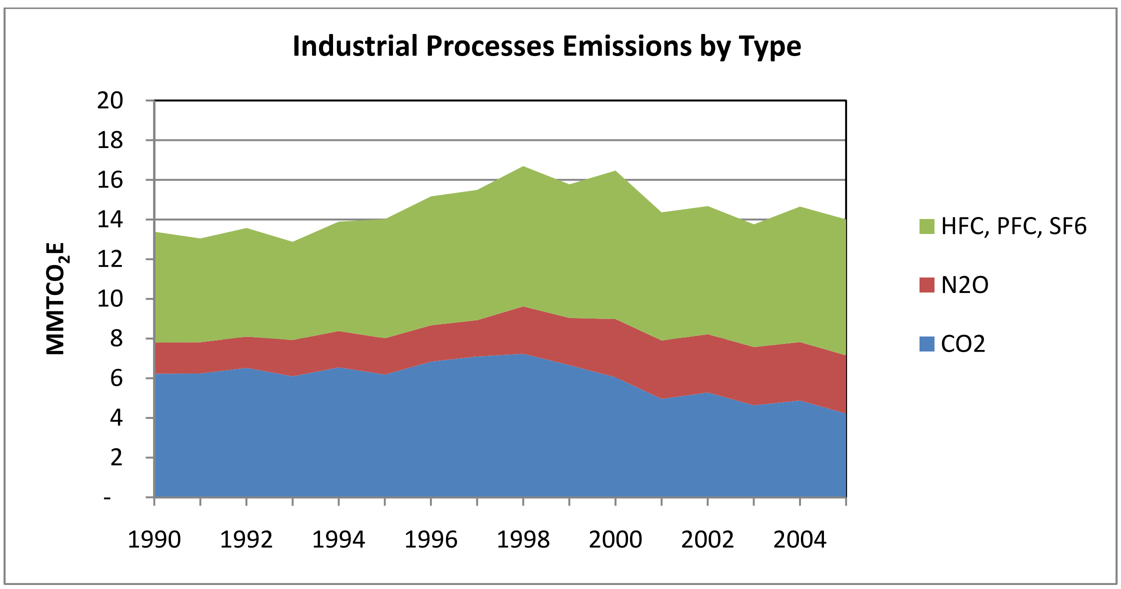


Figure 3.2.2-1. GHG emissions from industrial processes, 1990-2005.

As shown in Figure 3.2.2-1, during the period 1990-2005 CO_2 emissions showed a declining trend, N_2O emissions increased and then leveled, and HFC, PFC, and SF_6 emissions also increased and leveled. The main component of CO_2 emissions was ammonia production and urea application, which decreased by 50 percent from 6.13 to 3.14 $MMTCO_2E$. Lime production

CO_2 emissions decreased to zero by 2005, and limestone use, soda ash use, and iron and steel production emissions remained steady. Nitrous oxide emissions increased due to estimated increases in production capacity. Hydrofluorocarbon, perfluorocarbon, and SF_6 emissions remained steady from HCFC-22 production capacity but increased from increased production of ODS substitutes.

Figure 3.2.2-1 also highlights the relative contribution of fluorocarbons and sulfur hexafluoride. Total emissions of HFC, PFC, and SF_6 for 2005 were approximately 571 metric tons; 12 MT from the electric power industry, 431 MT from HCFC-22 production, and an estimated 128 MT from ODS substitutes (1.51 $MMTCO_2E$ emissions divided by 11,700 for estimating purposes). These emissions when converted to carbon dioxide equivalents were 6.85 million metric tons due to the high global warming potential of these gases.

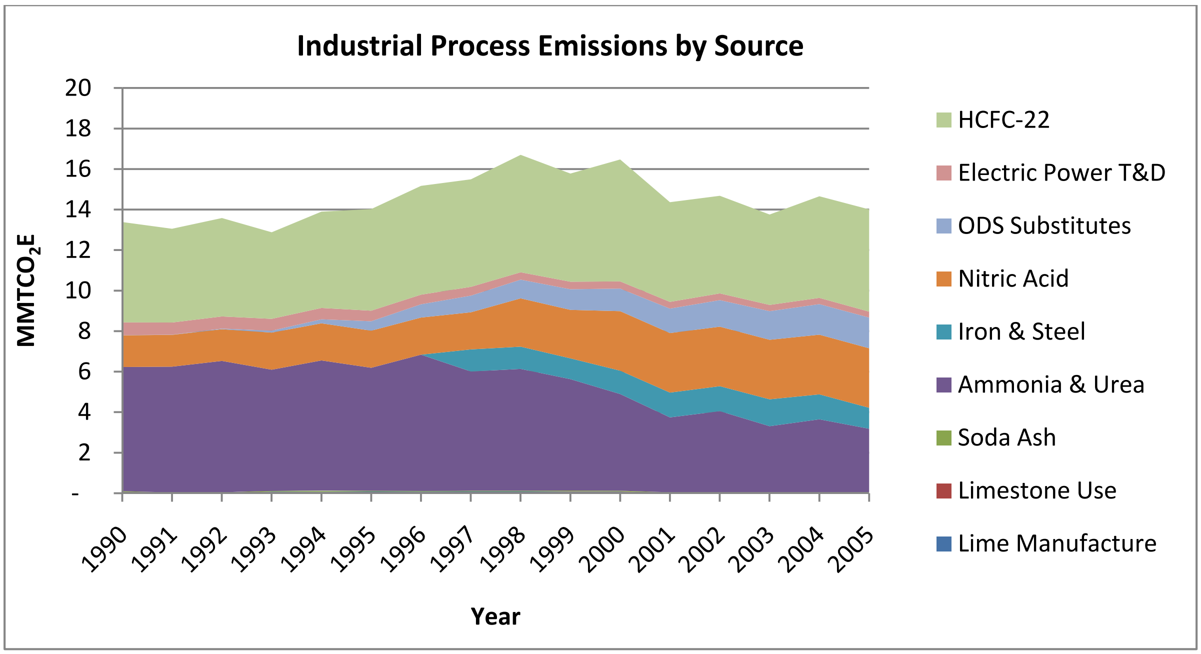


Figure 3.2.2-2. GHG emissions from industrial processes by source, 1990-2005.

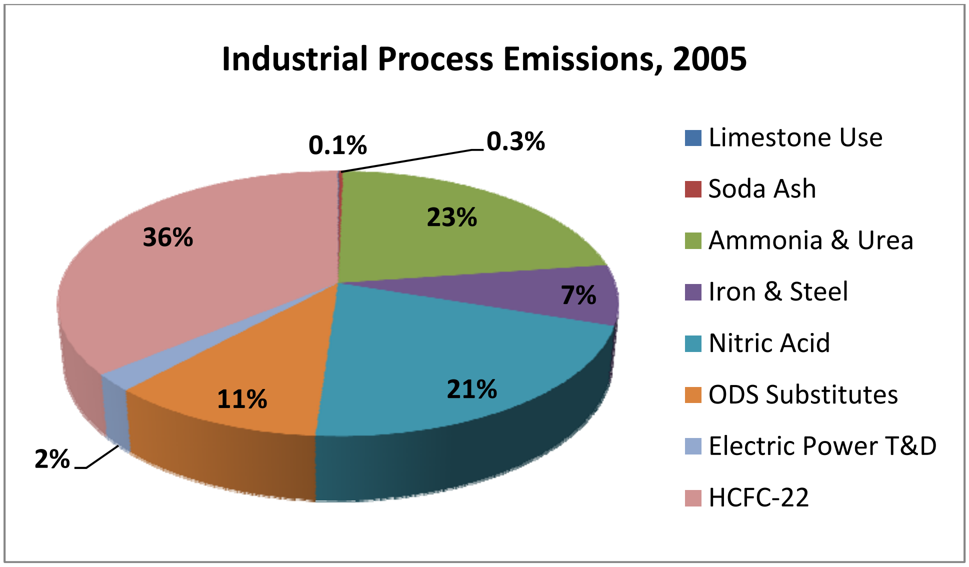


Figure 3.2.2-3: GHG emissions from industrial processes by source, 2005

Table 3.2.2-3. Historical Emissions for the Industrial Processes Sector ($MMTCO_2E$).

Industry/Pollutant	1990	1995	2000	2005
Lime Manufacture (CO_2)	0.06	0.09	0.08	--
Limestone Use (CO_2)	--	--	0.01	0.01
Soda Ash Use (CO_2)	0.05	0.04	0.04	0.04
Iron and Steel (CO_2)	--	--	1.15	1.03
Ammonia & Urea (CO_2)	6.13	6.06	4.77	3.14
Nitric Acid (N_2O)	1.57	1.83	2.94	2.94
HCFC-22 Production (HFC)	4.96	5.02	6.02	5.05
ODS Substitutes (HFC, PFC)	0.01	0.47	1.11	1.51
Electricity Distribution (SF_6)	0.63	0.56	0.36	0.30
Total	**13.39**	**14.03**	**16.48**	**14.01**

Lime Manufacture

Lime is a manufactured product that is used in steel production, flue gas desulphurization systems, construction, and water purification (U.S. EPA, 2008). Lime production consists of three main processes: stone preparation, calcinations, and hydration. Carbon dioxide is emitted during the calcination stage, in which limestone is roasted in a kiln at high temperatures (U.S. EPA, 2008).

In the 1990s Louisiana had at least two lime production facilities, U.S. Gypsum Company and Dravo Lime Company. USG closed its New Orleans area plant in 2004 (USGS, 2005) and the remaining facility is the Carmeuse Lime Pelican terminal and hydrator in East Baton Rouge Parish (USGS, 2006). CO_2 emissions are not calculated for hydrating facilities and no default lime production data were available for 2001-2005. It is likely that no non-combustion greenhouse gas emissions from lime production were generated during that period as U.S. Gypsum ceased production sometime before 2004.

One factor not included in this calculation was the amount of lime used in sugar refining and precipitated calcium carbonate production. These amounts would be subtracted from total lime production. These data were not available but would represent a small sink of CO_2 emissions.

Limestone Consumption

Limestone is used by a variety of industries, including the construction, agriculture, chemical, glass manufacturing, environmental pollution control, and metallurgical industries. Crushed limestone consumed for road construction or similar uses do not result in CO_2 emissions, and limestone used for agricultural purposes is included in the Agriculture module. Relative to total industrial non-combustion process emissions, CO_2 emissions from limestone consumption are small (less than 0.01 percent).

Soda Ash Consumption

Soda ash is used in consumer products such as glass, soap and detergent, paper, textiles, and food. CO_2 is released when soda ash is consumed. SIT estimates emissions based on Louisiana consumption data from the USGS Mineral Yearbook. Relative to total industry non-combustion process emissions, CO_2 emissions from soda ash consumption are very low. Emissions also declined slightly from 1990 to 2005 (0.05 $MMTCO_2E$ to 0.04 $MMTCO_2E$).

Iron and Steel Production

Louisiana has one steel "mini-mill," Bayou Steel Corporation in LaPlace, which recycles steel scrap using electric arc furnaces (EAFs), continuous casters, and rolling mills (Bayou Steel, 2005). CO_2 emissions result from EAF use. The SIT module uses the national distribution of production by method, which include basic oxygen furnaces with and without coke ovens, EAFs, and open hearth furnaces. State production amounts were manually totaled and entered for the EAF production method only to reflect Louisiana steel industry production methods.

Louisiana steel production data are missing for 1990 to 1996. Research revealed that a worker strike in 1993 at the LaPlace facility effectively shut down production for almost four years (FundingUniverse, 2000). An agreement was reached in September 1996. This would explain missing data for the strike period from 1993 to 1996, leaving only the period 1990-1992 potentially unaccounted for.

Ammonia Production/Urea Application

Ammonia is produced by a catalytic reaction of nitrogen and hydrogen. Carbon dioxide is released during the process that extracts pure hydrogen from fossil fuel hydrocarbons, predominantly natural gas. Ammonia is primarily used as a fertilizer but is also used in intermediate chemical processes, pulp and paper, and refrigeration. Urea is used as a fertilizer and in other industrial and chemical processes. Urea is created with ammonia as a key component.

Louisiana is a major ammonia producer with about one-third of U.S. production capacity. Natural gas price increases contributed to four plant closings from 1999-2001 in Luling (Solutia), Geismar (Borden), Pollock (Farmland), and Waggaman (Cytec Industries). In 2002 an additional three plants were idled in Sterlington (Koch Industries), Geismar (PCS), and Donaldsonville (CF Industries) (The Innovation Group, 2002a).

Ammonia production emissions reflected these declines and decreased from 6.13 $MMTCO_2E$ in 1990 to 3.14 $MMTCO_2E$ in 2005. Ammonia production may increase in the future as demand for corn used in ethanol production increases. Urea application emissions are accounted for in the Land-Use Change and Forestry module; urea emissions are subtracted in this module to eliminate double counting.

Nitric Acid Production

In 2002 Louisiana had four nitric acid production facilities—ANGUS Chemical (Sterlington), Arco Chemical (Lake Charles), CF Industries (Donaldsonville), and PCS Nitrogen Fertilizer (Geismar) (The Innovation Group, 2002b). The manufacture of nitric acid produces N_2O as a by-product, via the oxidation of ammonia. Nitric acid is a raw material used primarily to make synthetic commercial fertilizer.

Nitric acid production capacity was used as a surrogate for production data; in addition, data were only available for a few years. Based on this information nitrous oxide emissions increased from 1.57 $MMTCO_2E$ in 1990 to 2.94 $MMTCO_2E$ in 2005. The veracity of this trend may be questioned, however, given that nitric acid is produced using ammonia, and ammonia production largely declined from 1990 to 2005.

HCFC-22 Production

The hydrofluorocarbon HFC-23 is emitted in significant quantities as a by-product of HCFC-22 production. Production data were only available for 1997 so emissions were estimated using that year's state-to-national production ratio and national annual HCFC-22 production. Using this national trend, HFC emissions stayed at about 5-6 million metric tons per year; 4.96 $MMTCO_2E$ in 1990, 6.02 MMT in 2000, and back down to 5.05 MMT in 2005.

Substitutes for Ozone-Depleting Substances (ODS)

HFCs and PFCs are used as substitutes for several classes of ODS that are being phased out under the terms of the Montreal Protocol and the Clean Air Act Amendments of 1990 (ICF International, 2007b). ODSs are used in a variety of industrial applications including refrigeration and air conditioning equipment, aerosols, solvent cleaning, and fire extinguishing. Emissions are estimated by apportioning national emissions to each state based on population. Emissions have increased from 5,600 metric tons in 1990 to 1.57 million metric tons in 2005, and are expected to continue increasing rapidly due to substitutions of these gases for ODS.

Electric Power Transmission and Distribution

Sulfur hexafluoride is used as an electrical insulator and interrupter in the electric power T&D system. Emissions declined from 0.63 $MMTCO_2E$ in 1990 to 0.30 $MMTCO_2E$ in 2005, mostly due to voluntary action by industry (Iowa DNR, October 2008). Emissions in Louisiana from 1990 to 2005 were estimated based on the estimated emissions per kilowatt-hour (kWh) of electricity consumed from the U.S. EPA greenhouse gas inventory, and the ratio of Louisiana's to the U.S. electricity consumption (sales) estimates available from the EIA's *Electric Power Annual* and provided in the SIT. Calculated emissions were 12 metric tons of SF_6 in 2005 which converts to 295,134 metric tons of CO_2E.

Industrial Gases - Hydrogen Production

Research at CES related to hydrogen as an alternative fuel alerted us to the possibility of substantial emissions of CO_2 related to industrial gas facilities that were producing hydrogen via the steam reforming of methane (SMR). Communications with EPA left us with the conclusion that although CO_2 produced in the hydrogen production for ammonia production was included in EPA SIT modules (i.e. industrial processes – ammonia and urea), the SIT modules did not account for CO_2 production from industrial gas facilities producing hydrogen by SM. Internet research and assistance by one of the project advisory team members suggested that there were approximately seven refineries and 10 industrial gas facilities producing hydrogen via SMR that would be emitting CO_2 not accounted for in EPA's SIT modules. Requests for GHG emissions data for these facilities were made through the industry representative on the Project Advisory Team, but only a few of the facilities were willing to provide emissions data.

To get an idea of the order of magnitude of the CO_2 emissions from SMR hydrogen production, CES worked around the absence of direct emissions data through employing hydrogen production statistics available for the facilities and conversion factors. Using the factor 5.5 tons CO_2 produced for each ton of hydrogen produced by SMR (computed for the two-step process), CES arrived at estimates of a little less than 1 $MMTCO_2$ for hydrogen refinery production and a little more than 2.5 $MMTCO_2$ for merchant hydrogen production for a total of about 3.5 $MMTCO_2$.

This source of emissions represents only about 1.5 percent of total GHG emissions estimated for the state. Since we were late in the project, the number was relatively small and there was considerable uncertainty about our assumptions for estimates for these sources, CES elected not to include the emissions in the state GHG inventory, but to make sure and note them here. These numbers should be available in March 2011, when the first reporting of GHG emissions is required under federal reporting requirements.

3.2.3 Natural Gas and Oil Systems

Overview

The Natural Gas and Oil Systems module calculates methane and carbon dioxide emissions from all phases of natural gas and oil production, distribution, and transportation. Calculations in this section include "fugitive" emissions (equipment and process leaks), combustion sources used for natural gas production such as pipeline compressors and equipment used for offshore collection and processing, and flaring of excess natural gas. CO_2 emissions from energy use are included in Section 3.3.5, Industrial Combustion Emissions. Data for this module by sub-sector are listed below.

- Natural gas production (CH_4)
  - Wells
  - Shallow water offshore platforms
- Natural gas transmission (CH_4)
  - Miles of gathering pipeline
  - Gas processing plants
  - LNG storage compressor stations
  - Miles of transmission pipeline
  - Gas transmission compressor stations
  - Gas storage compressor stations
- Natural gas distribution (CH_4)
  - Miles of distribution pipeline
  - Total number of services
  - Number of unprotected steel services
  - Number of protected steel services
- Natural gas vented and flared (CO_2)
- Petroleum systems (CH_4)
  - Oil production
  - Oil refining
  - Oil transportation

Natural gas production sources for which emissions were not calculated are as follows:

- Deepwater offshore platforms in the Gulf of Mexico

Historical Emissions

Greenhouse gas emissions for 1990 through 2005 were estimated using the U.S. EPA State Greenhouse Gas Inventory Tool (SIT) software. Table 3.2.5.3-1 identifies data inputs by source category, data sources, and the years for which data were available.

Table 3.2.3-1. Approach to Estimating Historical Emissions: Natural Gas and Oil Systems.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
Natural Gas Production	1990-2005	Number of onshore gas wells	EIA's Natural Gas Navigator. "Number of Producing Gas and Gas Condensate Wells" http://tonto.eia.doe.gov/dnav/ng/ng_prod_wells_s1_a.htm;
	All years estimated	Number of shallow water offshore platforms	Louisiana Dept. of Natural Resources, Coastal Division (estimated from DNR permit database)
Natural Gas Transmission	1990-1996 & 1999-2005	Miles of gathering pipeline	AGA, Gas Facts. Data interpolated for 1997 & 1998.
	1990-2005	Gas processing plants	Oil & Gas Journal, Worldwide Gas Processing.
	1990-2005	LNG stations	http://www.ferc.gov/industries/lng/indus-act/terminals/exist-prop-lng.pdf.
	1990-1996 & 1999-2005	Miles of transmission pipeline	AGA, Gas Facts. Data interpolated for 1997 & 1998.
	2007	Gas transmission compressor stations	LDEQ, 2007 Certified Emissions, and EIA, Interstate Pipeline Compressor Station Database, April 2009. Calculated ratio of transmission compressors per mile of transmission pipeline for 2007 and back-calculated other years based on miles of transmission pipeline.
	2007	Gas storage compressor stations	2007 ratio of gas storage compressor stations to miles of transmission pipeline used to calculate # of gas storage compressor stations instead of worksheet defaults.
Natural Gas Distribution	1990-1996 & 1999-2005	-Miles of distribution pipeline	AGA, Gas Facts. Data interpolated for 1997 & 1998.
	1990-2005	-Total # of services - # of unprotected steel services - # of protected steel services	Pipeline and Hazardous Materials Safety Administration, Gas Distribution Systems Annual Report data files, http://phmsa.dot.gov/pipeline/library/data-stats. Data files filtered for state of operation=LA.
Natural Gas Vented and Flared	1990-2005	Natural gas vented and flared (billion Btu)	Source: EIA's Natural Gas Navigator. http://tonto.eia.doe.gov/ dnav/ng/ng_prod_sum_dcu_NUS_m.htm
Petroleum Systems	1990-2005	Barrels of oil ('000) produced, refined and transported	Produced: EIA Petroleum Supply Annual, http://tonto.eia.doe.gov/dnav/pet/hist/mcrfpla1a.htm; Refined: Ratio of state refining capacity to PADD district refining capacity multiplied by PADD gross crude input, EIA Petroleum Navigator, http://tonto.eia. doe.gov/ dnav/pet/hist/8_na_do_sla_4a.htm. Transported: same as amount refined

Data Assessment

Data availability for the natural gas and oil sectors is shown in the table below.

Table 3.2.3-2. Natural Gas and Oil Systems Data Availability.

Source Category	Data Availability				
	All years	Some surrogate	Some missing	Default Ratios	Other Ratios
Onshore gas wells	●				
Offshore platforms		●			
Gathering pipeline		●			
Processing plants	●				
LNG stations	●				
Transmission pipeline		●			
Transmission compressor stations					●
Storage compressor stations					●
Distribution pipeline		●			
Number services	●				
Nat. gas flared	●				
Oil production	●				
Oil refined				●	
Oil transported				●	

Results

Historical emissions for natural gas and oil systems from 1990 to 2005 are shown in Figure 3.2.3-1 while breakdown by sector is shown in Figure 3.2.3-2. Figure 3.2.3-3 shows the contributions of each source type to total emissions for 1990-2005. Table 3.2.3-3 shows the historical emission values upon which the figures are based. Total Louisiana emissions for this sector were about 13.15 $MMTCO_2E$ in 1990 and 13.39 $MMTCO_2E$ in 2005.

As shown in the figures below, overall emissions stayed relatively flat from 1990 to 2005. The largest portion of emissions in 2005 was from natural gas production (46 percent) followed by natural gas transmission (38 percent), oil production (9 percent), natural gas distribution (5 percent), and natural gas venting and flaring (2 percent). Discernible trends in Figure 3 show emission decreases for oil production and natural gas venting and flaring, and emission increases for onshore gas wells and offshore shallow water platforms.

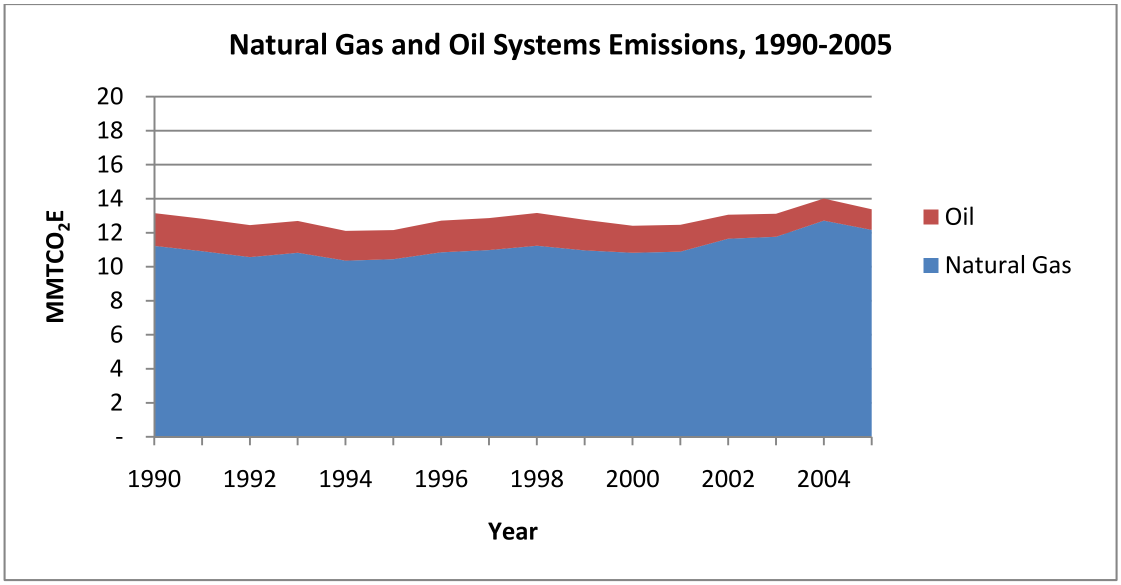


Figure 3.2.3-1: GHG emissions from natural gas and oil systems, 1990-2005.

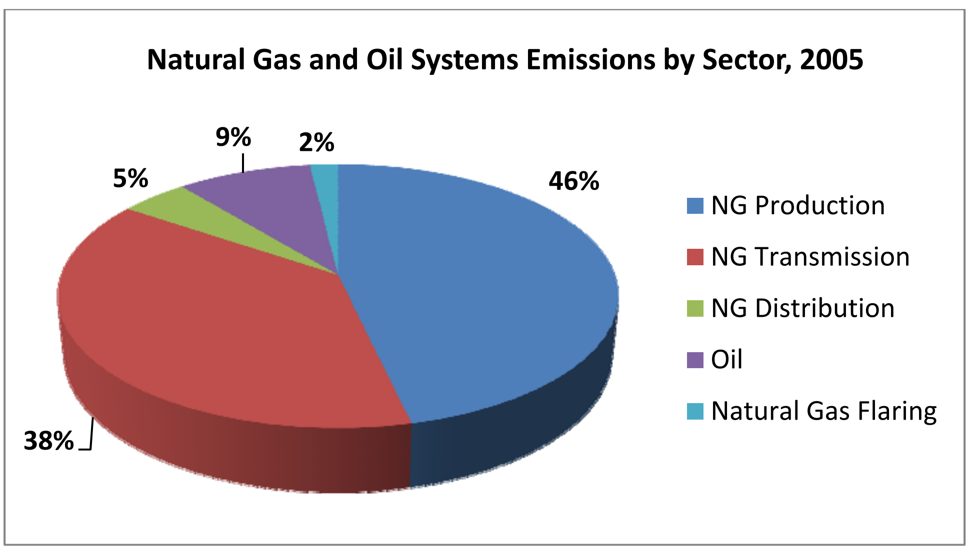


Figure 3.2.3-2. GHG emissions from natural gas and oil systems by sector, 2005.

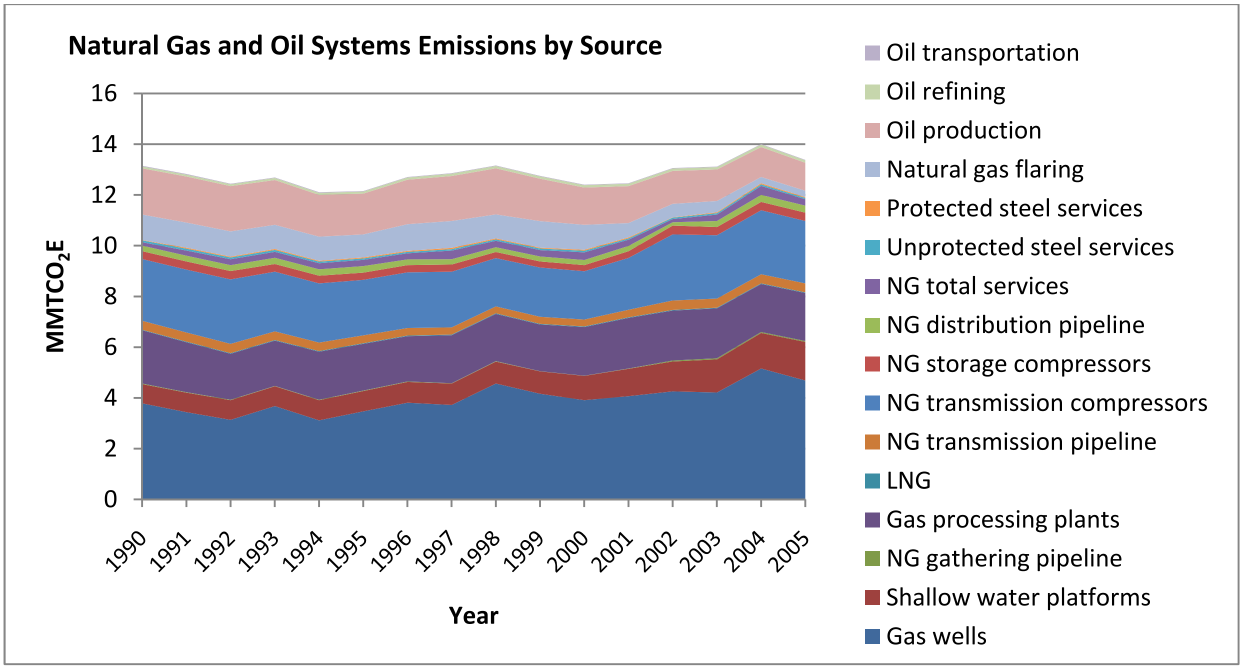


Figure 3.2.3-3. GHG emissions from natural gas and oil systems by source, 1990-2005.

Table 3.2.3-3. Historical Emissions for Natural Gas and Oil Systems (MMTCO$_2$E).

Sector	1990	1995	2000	2005
Natural Gas Systems (CH$_4$)	***10.23***	***9.54***	***9.85***	***11.92***
Production	4.55	4.28	4.87	6.21
Transmission	5.23	4.67	4.37	5.09
Distribution	0.44	0.60	0.61	0.61
Oil Systems (CH$_4$)	***1.92***	***1.71***	***1.58***	***1.21***
Production	1.82	1.61	1.47	1.10
Refining	0.08	0.08	0.10	0.09
Transportation	0.02	0.02	0.02	0.02
Natural Gas Flaring (CO$_2$)	***1.00***	***0.91***	***0.98***	***0.25***
Total	**13.15**	**12.16**	**12.41**	**13.39**

Natural Gas Production

Gas production sources include onshore wells, shallow water offshore platforms, and deepwater platforms in the Gulf of Mexico. The latter were not considered here as deepwater platforms are outside of Louisiana state waters. The number of platforms in state waters was estimated from Louisiana Department of Natural Resources (LDNR) Coastal Division permit databases. Start-up dates could be identified with likely platforms but not plug and abandon dates; for this reason platform estimates increase annually as new start-ups are added and are likely overestimated.

Methane emissions are estimated from wells, pneumatic devices, dehydrator vents, Kimray pumps, gas engines, and well clean-ups (ICF International, 2007c). Natural gas well emissions increased from 3.79 $MMTCO_2E$ in 1990 to 4.69 $MMTCO_2E$ in 2005. During the same period, shallow water platform emissions increased from an estimated 0.76 to 1.52 $MMTCO_2E$ due to the methodology limitation discussed above.

Natural Gas Transmission

Natural gas is processed in plants to remove liquids and impurities and prepare it for pipeline transmission. High pressure pipelines transport the gas and include metering stations, maintenance facilities, and compressor stations to maintain pressure. Data inputs for this category include miles of gathering and transmission pipeline, number of processing plants, and number of LNG, transmission and storage compressor stations. Methane emission sources include leaks, compressor fugitives, compressor exhaust, vents, pneumatic devices, blow down and upstream scrubbers for compressor stations.

Overall emissions for natural gas transmission from 1990 to 2005 decreased slightly from 5.23 to 5.09 $MMTCO_2E$. Slight increases in emissions from gathering pipeline, transmission compressor stations, and storage compressor stations were offset by decreases in processing plant emissions (2.10 to 1.89 $MMTCO_2E$) between 1990 and 2005.

Natural Gas Distribution

Distribution networks consist of "main" and "service" pipelines that deliver gas to the consumer. Gas enters these networks at city gate stations, where pressure is reduced for distribution within cities or towns (ICF International, 2007c). Industrial customers ordinarily receive gas service through high-pressure distribution mains. Commercial and residential customers receive gas via service lines connected to distribution mains. Most residential customers have one service line; businesses however can have several service lines.

Service lines can be made from a variety of materials including protected steel, plastic, unprotected steel or cast iron. Module data inputs used for the natural gas distribution sector were total miles of pipeline distribution mains, total number of connecting service lines, number of protected steel service lines, and number of unprotected steel service lines. Methane emission sources are chronic leaks, meters, regulators, and accidental releases. Emission levels increased from about 0.44 to 0.61 $MMTCO_2E$ from 1990 to 2005.

Natural Gas Venting and Flaring

Venting and flaring activities are associated with combined oil and gas production and refer to the disposal of gas that cannot be contained or otherwise handled. Data inputs are for the amount of gas vented and flared and the percent of gas flared (80 percent). CO_2 emissions are calculated for the amount flared and the remaining 20 percent of vented gas emissions are assumed to be accounted for in the petroleum systems production category (ICF International, 2007c). Emissions decreased from 1 million metric tons of CO_2 in 1990 to 0.25 MMT in 2005.

Petroleum Systems

Oil systems emissions are calculated using state-level data on oil production, refining, and transportation. This type of approach is not as detailed as the method used for natural gas systems and is therefore less accurate, but it is used in the SIT for simplicity of data collection and calculations (ICF International, 2007c). Methane emissions occur from normal operations, routine maintenance, and system upsets and accidents. Emission sources include pneumatic devices, component and process vent leaks, starting and stopping reciprocating engines or turbines, drilling activities, launching scrapers in pipelines, well maintenance, and gases released through relief valves.

Oil production data are barrels of oil reported in EIA's *Petroleum Supply Annual*. These emissions account for the bulk of oil system emissions and decreased from about 1.82 to 1.10 $MMTCO_2E$ from 1990 to 2005. Oil refining emissions are based on the ratio of the state to PAD (Petroleum Administration Defense) District 3 production capacity multiplied by the district's gross crude oil input. These emissions remained relatively flat from 1990 to 2005 (0.08 to 0.09 $MMTCO_2E$). The amount of oil transported is assumed to be the same as the amount refined. These emissions were about 0.02 $MMTCO_2E$ annually.

3.2.4 Coal Mining

Overview

The primary greenhouse gas from coal mining activities is methane. Emissions were calculated for the following Louisiana sources:

- Surface mines (CH_4)
- Post-mining activities (CH_4)

Mining activities that are sources of GHG emissions, but are not found in Louisiana, are listed below.

- CH_4 from underground mines
- CH_4 from abandoned mines

Historical Emissions

Greenhouse gas emissions for 1990 through 2005 were estimated using the U.S. EPA State Greenhouse Gas Inventory Tool (SIT) software. Table 3.2.4-1 identifies data inputs for mining activities, data sources, and the years for which data were available.

Table 3.2.4-1. Approach to Estimating Historical Emissions: Coal Mining.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
Surface mines & post-mining activities	1990-2005	'000 short tons of surface mine production	Historical production data for Louisiana from Energy Information Administration's Coal Industry Annual. (http://www.eia.doe.gov/cneaf/coal/cia/cia_sum.html.)

Data Assessment

Default data were available for all years. Data were not available for underground mines for 1991 and 1992 but Louisiana has surface mines only. Post-mining activities are calculated based on total coal production .

Results

Figure 3.2.4-1 shows historical emissions for coal mining from 1990 to 2005. Table 3.2.4-2 shows the historical emission values upon which the figures are based. Total Louisiana emissions for this sector were about 0.03 $MMTCO_2E$ in 1990 and 0.04 $MMTCO_2E$ in 2005.

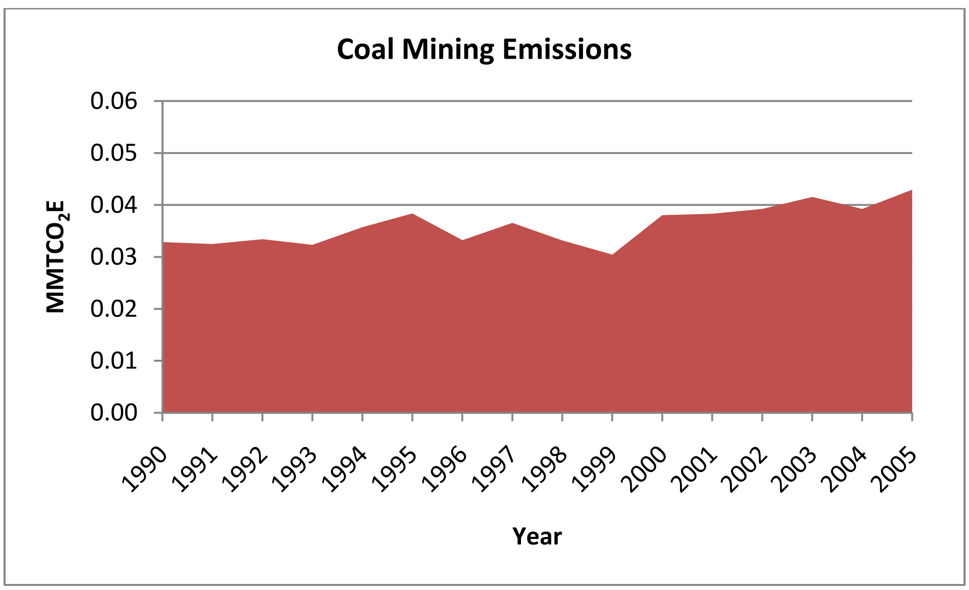


Figure 3.2.4-1. GHG emissions from coal mining, 1990-2005.

Table 3.2.4-2. Historical Emissions for the Coal Mining Sector (MTCO$_2$E).

Activity	1990	1995	2000	2005
Surface mines and post-mining activity	32,886	38,387	38,067	42,950

Surface Mines

Surface mine emissions (CH_4) are the product of coal production and basin specific emission factors. The geographic basin for Louisiana is the West Interior Basin—Gulf Coast. All of Louisiana's coal is lignite from two surface mines: Dolet Hills (DeSoto Parish) and Oxbow (Red River Parish). Annual coal production is between three and four million tons. Lignite is a low-ranked coal with relatively low heat content and provides approximately four percent of electric power generation in the state (Troy, 1993).

Post-mining Activity

Post mining activities include transportation and coal handling. Post-mining emissions are the product of coal production and basin and mine-type specific emission factors (i.e. underground or surface mine).

3.3 SECTOR-SPECIFIC EMISSIONS INVENTORIES

3.3.1 Electrical Generation and Consumption

Louisiana's total electric power generation in 2005 totaled 92,616,878 megawatt hours (EIA, 2009c), using primarily natural gas, coal, and nuclear energy as energy sources (Figure 3.3.1-1).

Total renewable net generation for Louisiana in 2005 was 3.5 megawatt hours or about four percent of total electric power generation. Wood and derived fuels represented the largest source of renewable energy employed in generation of electricity.

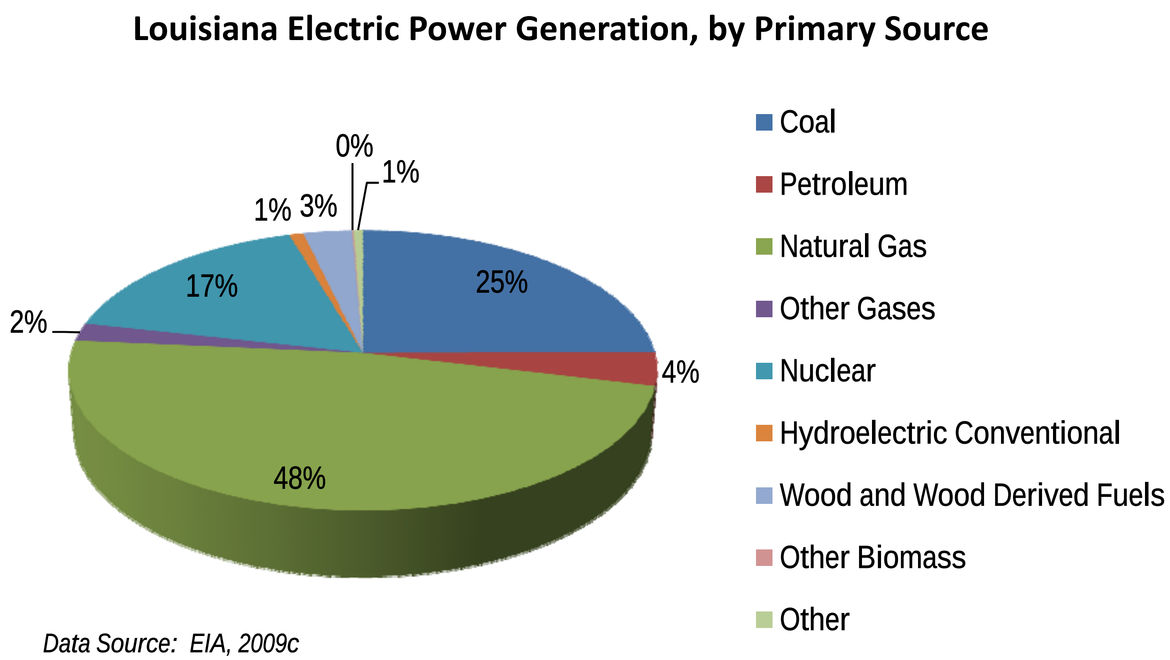


Figure 3.3.1-1. Louisiana's total electric power industry generation by primary energy source, 2005.

Greenhouse gas (CO_2) emissions reported for 2005 for all sources of the Louisiana electric power industry totaled a little over 43 million metric tons (EIA, 2009c), representing about 23 percent of total fossil fuel combustion emissions for the state. According to recent EIA (2009c) reports, Louisiana ranked 17th among the states in carbon dioxide emissions from the electric power industry in 2007. This modest ranking for a state with such a large share of energy intensive industries is undoubtedly related to the fact that natural gas and nuclear energy account for such a large share of energy employed in electrical generation.

According to WRI CAIT US (2009), Louisiana ranked 19th among the states in growth in carbon intensity of electricity production for the period 1990 to 2005, with an annual growth of 0.1 percent. Carbon intensity of electricity production for 1990 and 2005, was reported at 452.5 and 462.0 (Grams CO_2e per kWh), respectively.

EIA (2009c) estimates of consumption of electricity by major sector in Louisiana during 2005 are detailed in Table 3.3.1-1. Values shown are for retail electricity sales.

Table 3.3.1-1. Louisiana Consumption of Electricity by Major Sector, 2005.

Sector	Million kWh	Trillion Btu
Industrial	27,031	92.2
Commercial	21,692	74.0
Residential	28,654	97.8
Transportation	12	<0.1

3.3.2 Transportation

Overview

Transportation for freight and passengers composes the vast majority of mobile emissions, while other non-travel mobile fuel combustion is also part of the same category. This includes fuel consumption from cars, trucks, motorcycles, aviation, marine transport, and recreational boating, as well as equipment used for farm, construction, and utility purposes. Combined, mobile sources comprise approximately 26 percent of total Louisiana state emissions in the year 2005.

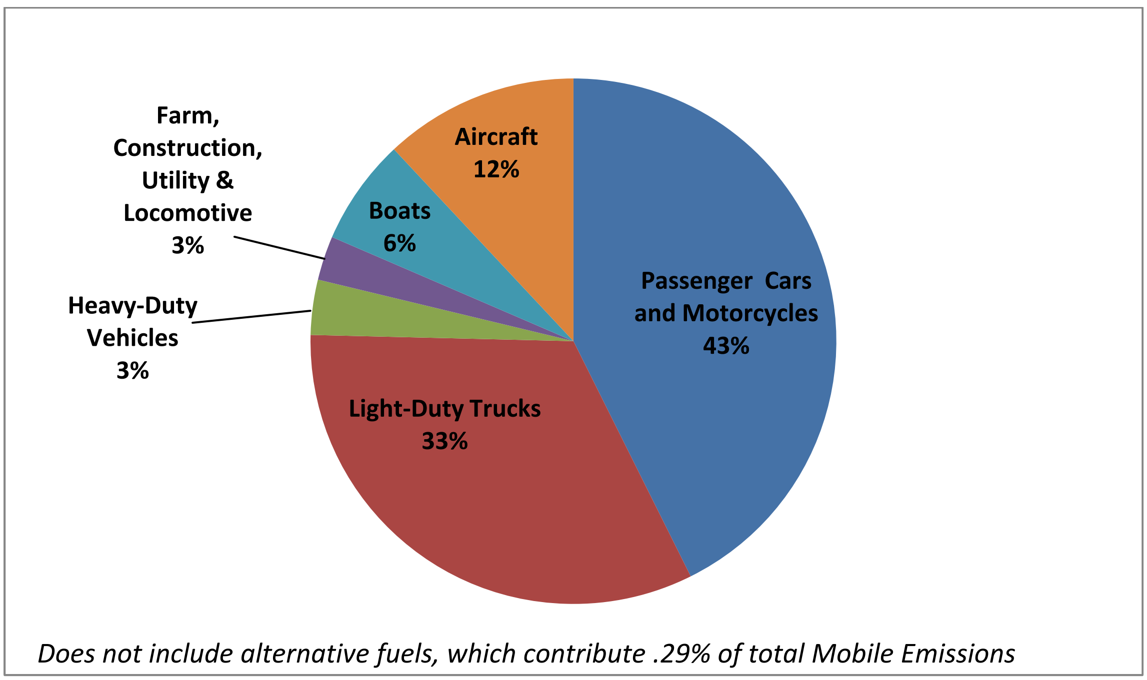


Figure 3.3.2-1: Highway and non-highway mobile emission sources.

Methodology

The EPA State Inventory Tool calculates emissions from mobile sources with activity data along with combustion coefficients for each respective type of fuel, vehicle, and emission control equipment. (ICF Consulting, 2004) The emission estimation is measured in terms of methane (CH_4) and nitrous oxide (NO_2). These two pollutants are finally converted from units of grams to units of Million Tons of Carbon Equivalent (MTCE) using the respective Global Warming Potential (GWP) factors.

Highway Vehicles

The number of vehicle miles traveled (VMT) is gathered by the Federal Highway Administration (FHWA) and categorized by state and vehicle type in the annual *Highway Statistics* report. Emission factors are applied to each on-road vehicle category—i.e. light duty gasoline vehicles (LDGV), light duty gasoline trucks (LDGT), heavy duty gasoline vehicles (HDGV), light duty diesel vehicles (LDDV), light duty diesel trucks (LDDT), heavy duty diesel vehicles (HDDV), and motorcycles (MC).

VMT is also distributed by vehicle age and mileage accumulation using overall U.S. averages. The last vehicle-specific factor in the calculation is the emission control technology, including uncontrolled engines, non-catalyst controls, oxidation catalysts, low emission vehicle ratings, and diesel moderate/advanced control equipment. (ICF Consulting, 2004).

Non-road Mobile Sources

Major sources of mobile emissions that do not come from highway transport are jet aircraft, gasoline-fueled piston aircraft, agricultural and construction equipment, railway locomotives, boats, and ships. Activity levels are gauged by fuel consumption for each type of non-highway vehicle.

Data for aviation gasoline and jet fuel consumption are published in the Department of Energy *State Energy Data System* (EIA, 2009c). Locomotive coal consumption is estimated using the EIA *Fuel and Kerosene Sales*, with information collected from companies through survey form EIA-821 (EIA, 2006). Data from all other modes is collected through the Environmental Protection Agency (EPA, 2006).

Trends

Despite an 18 percent increase in total vehicle miles traveled between 1990 and 2005, mobile source emission levels have gone down in the state of Louisiana. Emissions have decreased by 35 percent for gasoline highway vehicles. Diesel highway vehicle emissions have increased by 28 percent. The Federal Highway Administration attributes this positive trend to cleaner burning fuels and more efficient vehicles (FHWA, 2002).

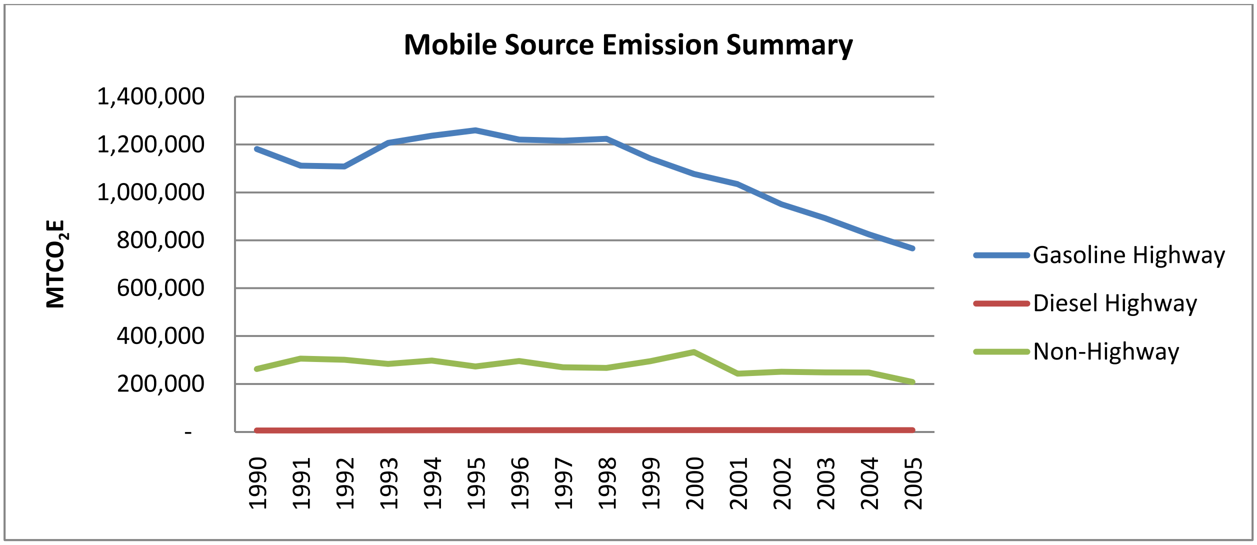


Figure 3.3.2-2: Mobile source emission summary for Louisiana, 1990-2005.

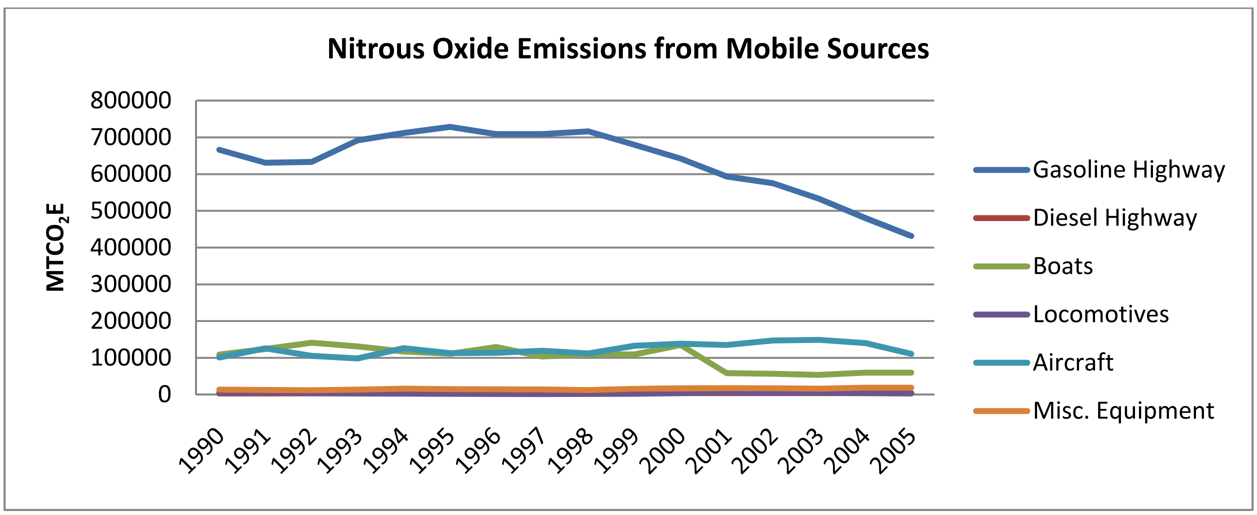


Figure 3.3.2-3: Nitrous oxide emissions from mobile sources for Louisiana, 1990-2005.

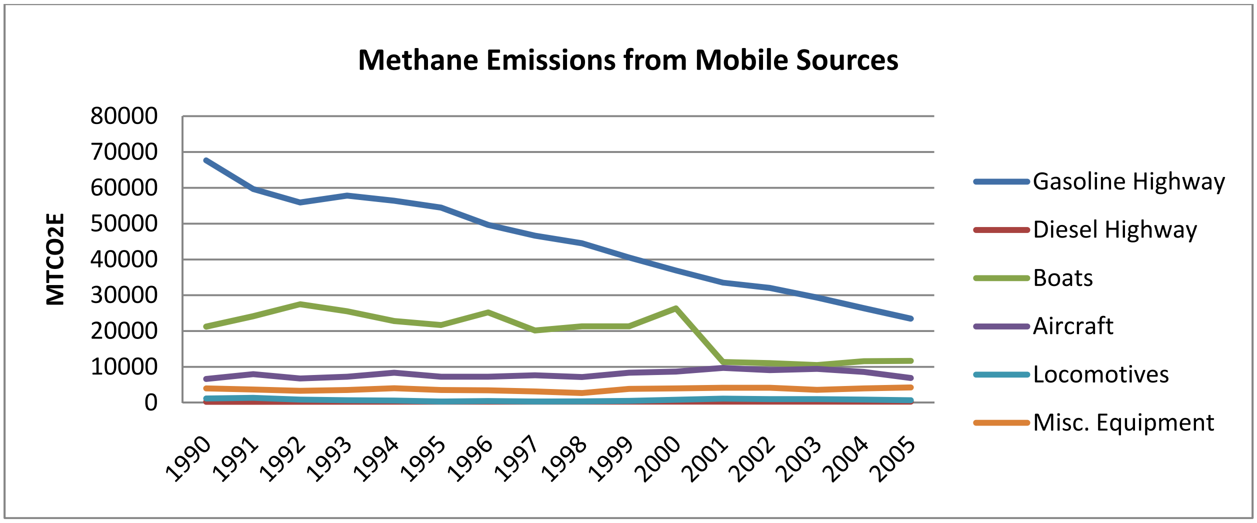


Figure 3.3.2-4: Methane emissions from mobile sources for Louisiana, 1990-2005.

3.3.3 Commercial Buildings

In Section 3.2.1, the contributions from the commercial and residential sectors to Louisiana's total fossil fuel combustion emissions are shown as very small numbers: 2.02 and 2.52 $MMTCO_2E$, respectively, representing about one percent each of total emissions. The percentage is small because emissions produced in providing energy (e.g. electricity and natural gas) to commercial and residential buildings are included in the category of total fossil fuel combustion emissions. However, when emissions produced in providing energy to maintain these sectors is attributed directly to them, they represent a much greater consumption of energy and production of emissions as shown otherwise. This fact is important when examining strategies for reduction of GHG emissions, since opportunities in energy conservation and efficiency can lower energy production requirements and, thus, accompanying GHG emissions.

The Pew Center (2009) reports that total GHG emissions, including both direct and end-use emissions, from residential and commercial buildings in the United States accounted for about 38 percent of the total U.S. carbon dioxide emissions in 2006. However, this percentage would be expected to be smaller in Louisiana, where industrial emissions represent such a large proportion of total emissions.

When looking at energy consumption by end-use sector (Figure 3.3.3-1), the commercial sector is shown to have represented eight percent of the state's total energy consumption in 2005 (Crouch, 2009). EIA reports that 25,085 million cubic feet of natural gas was delivered to Louisiana commercial customers in 2005 (EIA, 2009b). For electricity, EERE reports that Louisiana's electricity consumption in the commercial sector in 2005 was 21,692 million Kwh or about 28 percent of total electricity consumption that year (EERE, 2009).

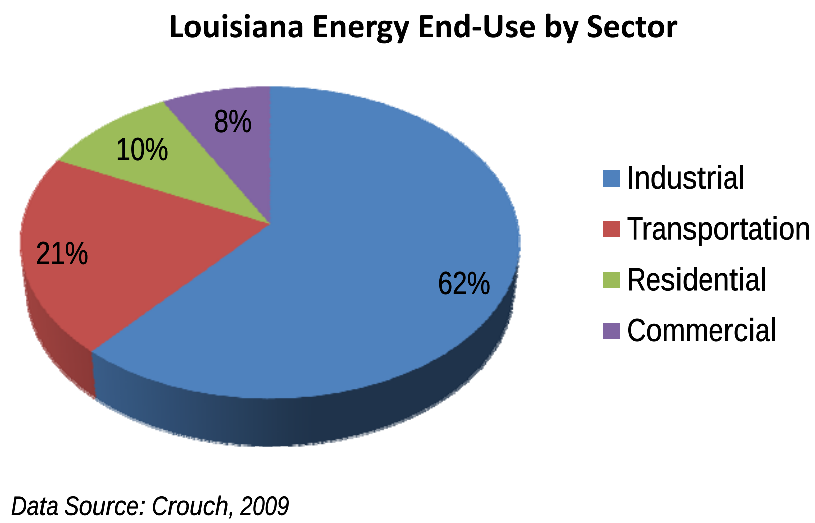


Figure 3.3.3-1. Louisiana's energy consumption by end-use sector, 2005.

According to DOE (2009), lighting, heating and cooling account for about half of commercial buildings' end-use CO_2 emissions (Figure 3.3.3-2).

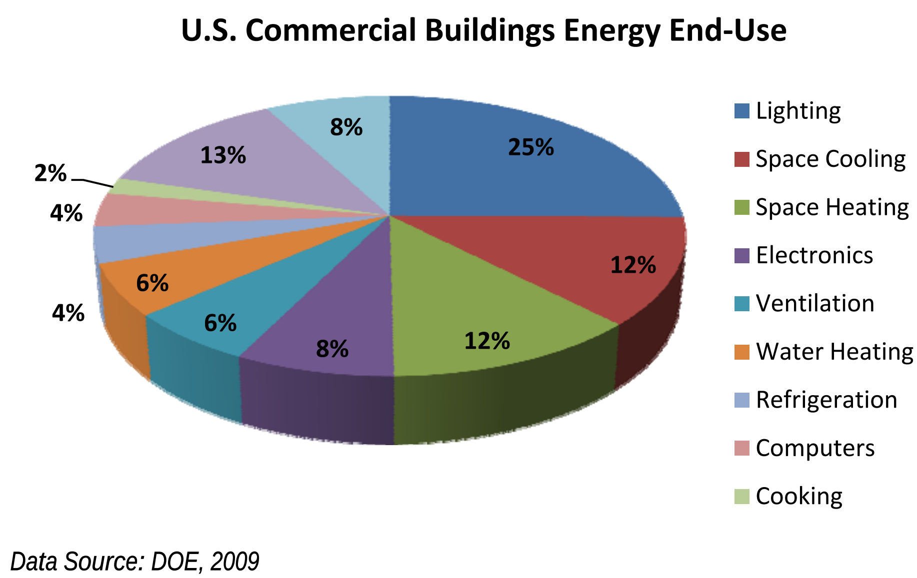


Figure 3.3.3-2. U.S. commercial buildings end-use CO_2 emissions split, 2006.

3.3.4 Residential Buildings

According to Crouch (2009), the residential end use sector represented about 10 percent of total energy consumption in Louisiana during 2005 (Figure 3.3.3-1). EERE reports that Louisiana's residential sector consumed 28,654 million kWh in 2005, about 37 percent of the total electricity generated (EERE, 2009). EIA reports 41,155 million cubic feet of natural gas were consumed by this sector in the same year (EIA, 2009b). This represents about 3.7 percent of total natural gas deliveries to customers. The state's largest consumers of natural gas in 2005 were the industrial and electric power customers, consuming 769,883 and 285,022 million cubic feet, respectively.

On a national basis, heating, cooling and water heating account for about half of residential end-use CO_2 emissions (DOE, 2009) (Figure 3.3.4-1). Other significant sources of end-use CO_2 emissions in the residential sector include lighting, electronics, and refrigeration.

Since heating and cooling represent such a large contribution to residential end-use CO_2 emissions in the U.S., this sector is fairly sensitive to weather and varies both by region in a single year, as well as through time in a given location (Pew Center, 2009). Regional energy end-use data for average households presented by DOE (2009), illustrate regional (climate) patterns in energy use for heating and cooling (Figure 3.3.4-2).

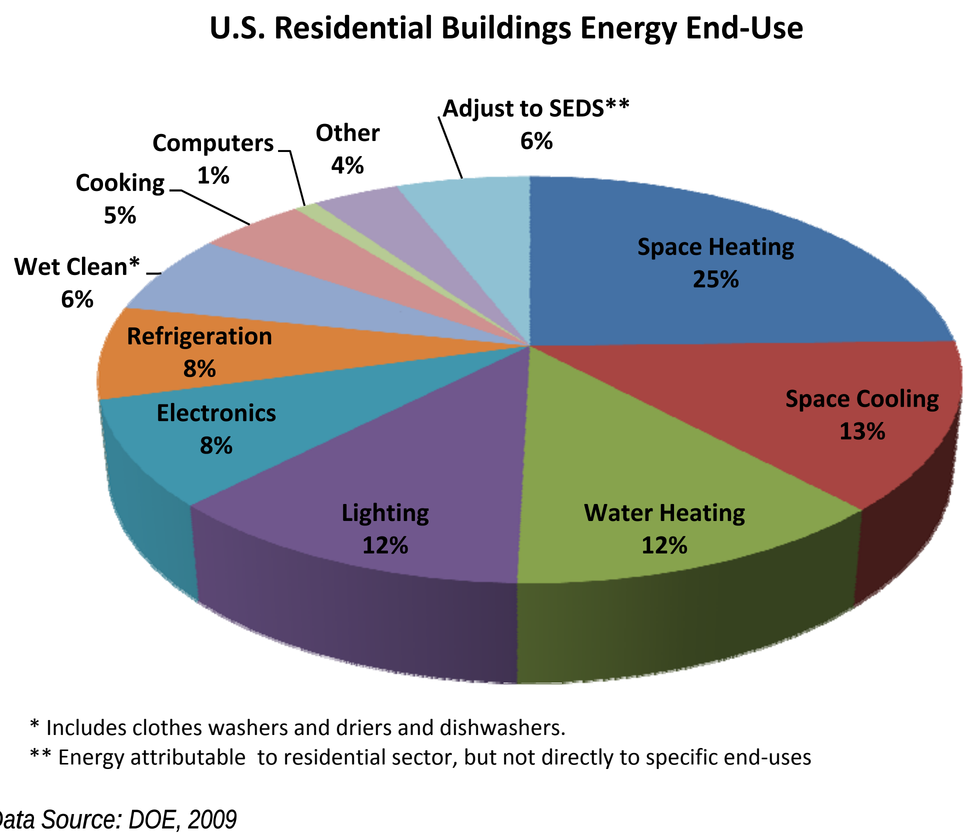
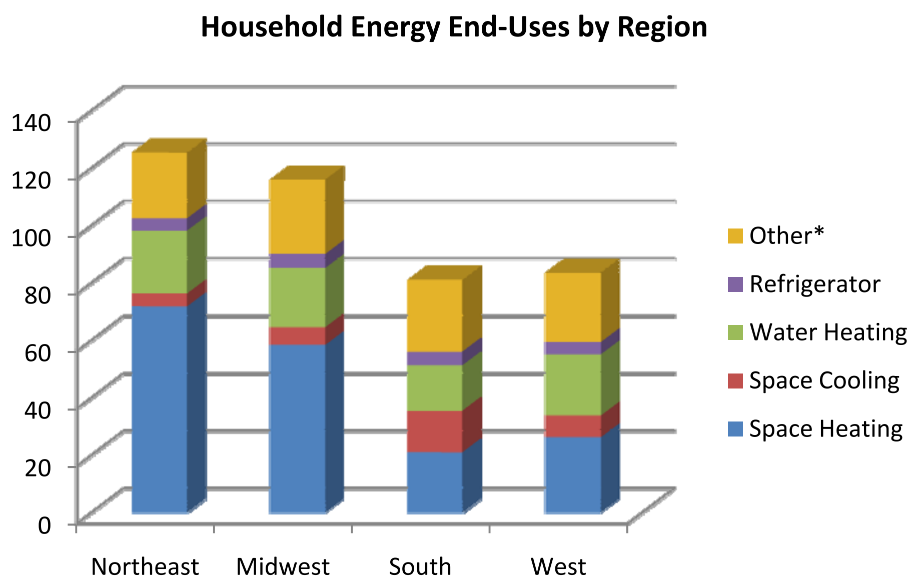


Figure 3.3.4-1. U.S. residential buildings energy end-use CO_2 emissions split, 2006.



Data Source: DOE, 2009

Figure 3.3.4-2. 2005 delivered energy end-uses for an average household by region (million Btu per household).

3.3.5 Industrial Combustion Emissions

As was presented in the state summary information in Section 3.1, Louisiana's greenhouse gas emissions are predominated by fossil fuel combustion emissions from the industrial sector. In 2005, Louisiana's industrial sector fossil fuel combustion emissions totaled 93.7 $MMTCO_2E$, representing about 49 percent of total fossil fuel combustion emissions for the state (see Figure 3.2.1-2).

According to WRI CAIT US (2009), Louisiana, in 2005, ranked second among the states in industrial GHG emissions far behind Texas with 271.5 $MMTCO_2E$ and ahead of third-ranked California at 76.5 $MMTCO_2E$.

Industrial GHG emissions from fossil fuel combustion have remained relatively flat over the period 1990-2005. And, as presented earlier in Figure 3.1-6, relative contributions of fossil fuel combustion emissions from Louisiana's industrial sector to total GHG emissions for the state also remained essentially unchanged over that 15-year period.

No attempt was made during this project to break out emissions by industrial sub-sectors for the overall industrial sector.

3.3.6 Agriculture

Overview

The Agriculture module calculates CH_4 and N_2O emissions from animal and crop sources. Data inputs required for this module are listed below.

- Enteric fermentation (CH_4)
  - Dairy cattle
  - Beef cattle
  - Other animals (sheep, goats, swine, and horses)
- Manure management (CH_4 and N_2O)
  - Dairy cattle
  - Beef cattle
  - Swine
  - Poultry
  - Other
- Agricultural soils management (N_2O)
  - Plant residues and legumes
  - Plant fertilizers
  - Animals and runoff
- Rice cultivation (CH_4)
- Agricultural residue burning (CH_4 and N_2O)

Agricultural sources for which emissions were not calculated include crops not grown in Louisiana (or for which no data was available) such as oats, rye, lentils, and red clover, and histosols (high organic content soils).

Historical Emissions

Greenhouse gas emissions for 1990 through 2005 were estimated using the U.S. EPA State Greenhouse Gas Inventory Tool (SIT) software. Table 3.3.6-1 identifies data inputs by source category, data sources, and the years for which data were available.

Table 3.3.6-1. Approach to Estimating Historical Emissions: Agriculture.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
Enteric Fermentation	1990-2005	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) -Sheep, goats, swine, horses ('000 head)	Inventory Spreadsheets, "Manure-N2O.xls" or "PopulationDBout.xls". From USDA, NASS, Published Estimates Data Base http://www.nass.usda.gov/QuickStats/
Manure Management	1990-2005; 1987, 1992, 1997, 2002, 2007 (broilers & turkeys)	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) -Swine ('000 head) -Poultry ('000 head) -Sheep, goats, horses ('000 head)	USDA, NASS, Published Estimates Data Base. Default data used for hens, pullets, & chickens. Non-default data used for broilers & turkeys (USDA, National Agricultural Statistics Service, Census of Agriculture—Louisiana, 1987-2007).
Ag. Soils--Residues & Legumes	1990-2005	-corn, wheat, sorghum, rice, & soybeans crop production (metric tons)	USDA, NASS, http://www.nass.usda.gov:81/ipedb/
Ag. Soils--Fertilizer	1990-2005	-Synthetic fertilizer use (kg N) -Organic fertilizer use (kg N)	The Association of American Plant Food Control Officials and The Refertilizer Institute. Commercial Fertilizers. Table 9 - Consumption of Primary Plant Nutrients. Total Nutrients-All Fertilizers (N)
Ag.Soils--Animals & Runoff	1998-2005	-Dairy Cattle ('000 head) -Beef Cattle ('000 head) -Swine ('000 head) -Poultry ('000 head) -Sheep, goats, horses ('000 head)	USDA, NASS, Published Estimates Data Base. Broilers and turkeys from 1987- 2007 agriculture census. USDA, National Agricultural Statistics Service, Census of Agriculture--Louisiana. Default data used for hens, pullets, & chickens.
Rice Cultivation	1990-2005	-Area harvested primary ('000 acres) -Area harvested ratoon ('000 acres)	USDA Crop Production Summary 2000 and USDA, NASS Published Estimates Data Base.
Burning of Agricultural Crop Waste	1990-2005	-corn, rice, soybeans, sugarcane, & wheat crop production (metric tons)	USDA, NASS, http://www.nass.usda.gov:81/ipedb/

Data Assessment

Data availability for agricultural sources is shown in the table below.

Table 3.3.6-2. Agriculture Sources Data Availability.

Source Category	Data Availability				
	All years	Some surrogate	Some missing	Default Ratios	Other Ratios
Enteric Fermentation	●				
Manure Management					
Cattle, swine, sheep, goats, horses, hens, pullets	●				
Broilers, turkeys		●			●
Agricultural Soils	●				
Rice Cultivation	●				
Agricultural Residue Burning	●				

Results

Historical emissions for agriculture from 1990 to 2005 are shown in Figures 3.3.6-1 and 3.3.6-2. Table 3.3.6-3 shows the historical emission values upon which the figures are based. Total emissions decreased between 1990 and 2005 from 7.26 to 6.43 $MMTCO_2E$.

The main component of agriculture emissions is N_2O from agricultural soil management, including nitrogen-fixing crops and residues, organic and synthetic fertilizers, and animal waste and runoff from pasture and agricultural lands. These emissions stayed fairly stable and increased slightly from 3.45 to 3.52 $MMTCO_2E$. The sector with the most variation between 1990 and 2005 was rice cultivation which had small peaks in 1992, 1994, and 2004, and a noticeable decrease in 2002.

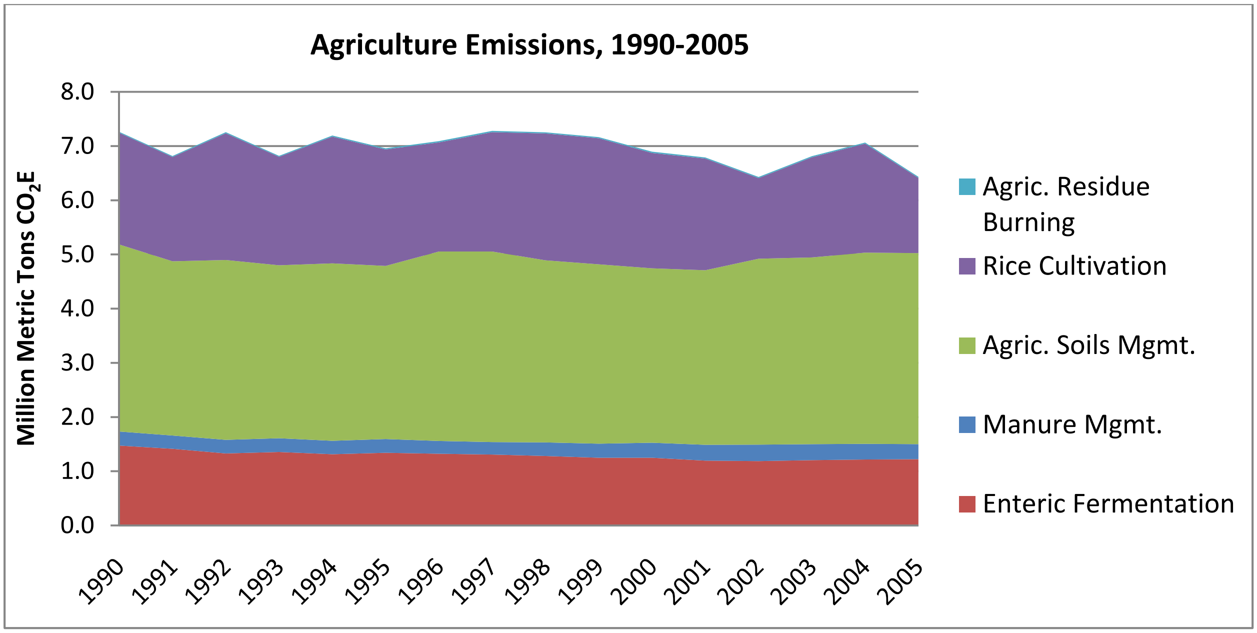


Figure 3.3.6-1: GHG emissions from agriculture, 1990-2005.

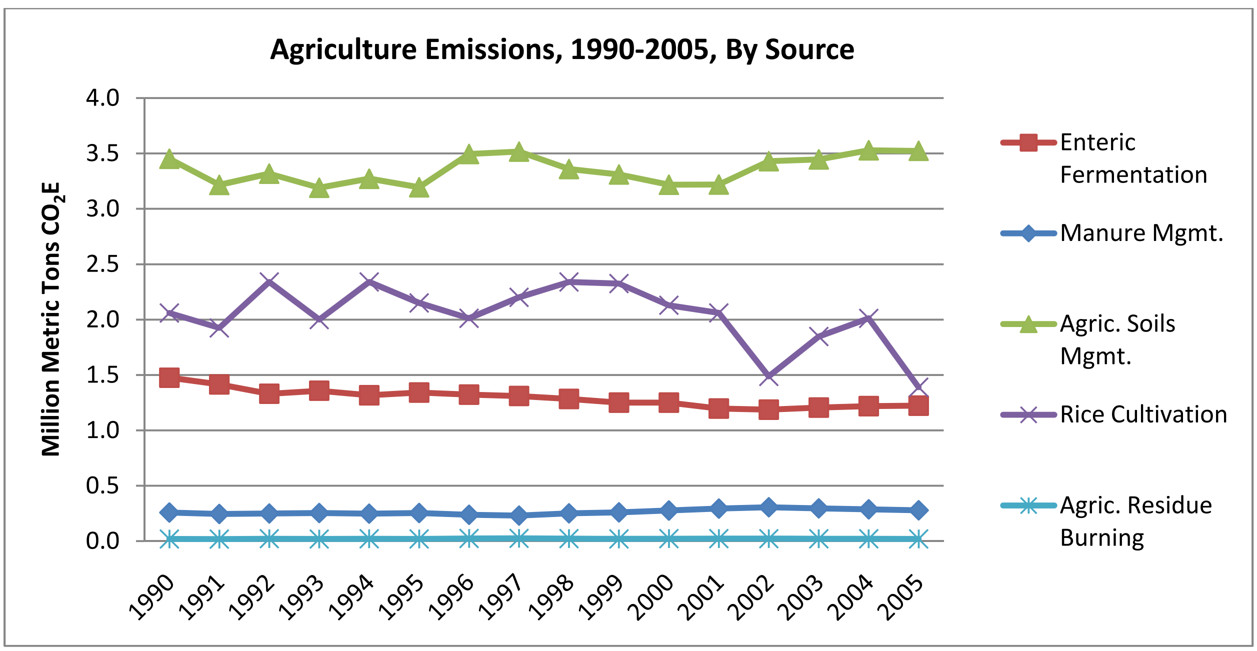


Figure 3.3.6-2: GHG emissions from agriculture by source, 1990-2005.

Table 3.3.6-3: Historical Emissions for Agriculture (MMTCO$_2$E).

Sector	1990	1995	2000	2005
Enteric Fermentation	1.48	1.34	1.25	1.22
Manure Management	0.26	0.25	0.28	0.28
Agricultural Soils	3.45	3.20	3.22	3.52
Rice Cultivation	2.06	2.15	2.13	1.39
Agricultural Residue Burning	0.02	0.02	0.02	0.02
Total	**7.26**	**6.96**	**6.90**	**6.43**

Enteric Fermentation

Animals produce methane during normal digestive processes. The amount of methane depends on the type of animal, its age and weight, and quantity and quality of the feed consumed (ICF International, 2007d). Ruminants—cud-chewing animals with stomachs divided into three or four compartments—usually produce more methane than non-ruminants. Domesticated ruminants include cows, goats, and sheep. EPA provides default emission factors for cattle on a regional basis; default emission factors for other livestock types use national averages. Enteric fermentation emissions do not include calves up to six months of age as those emissions are considered close to zero.

Manure Management

Emissions from manure management include methane and nitrous oxide. Methane emissions occur during anaerobic decomposition and are calculated using typical animal mass (TAM), average volatile solids production per kilogram of animal mass, and maximum CH_4 producing capacity from volatile solids. Production of N_2O occurs from the nitrification and denitrification of nitrogen contained in ammonia present in the wastes. N_2O emissions are calculated using TAM, amount of Kjejdahl nitrogen (K-nitrogen) excreted, and amounts treated by liquid systems (lagoons and liquid/slurry) and dry systems (drylot and solid storage).

Specific sub categories of animals differed between the USDA published estimates database (SIT default data) and the USDA Census of Agriculture but totals by animal type were in close agreement with the exception of total poultry. Default data for 2002 were 2.6 million poultry versus 47.5 million in the USDA agriculture census. SIT default data was missing for broiler chickens and turkeys in 2002 and 2003 while the census listed 44.8 million broilers and 946 turkeys in 2002. Data for these two poultry subcategories were interpolated using agriculture census data from 1987, 1992, 1997, 2002, and 2007.

Agricultural Soils Management

Nitrous oxide emission sources from agricultural soils management include crop residues, legumes, plant fertilizers (organic and inorganic), and animals. Default module data were available for soybeans, a legume and nitrogen fixing crop. Another source of nitrogen and nitrous oxide emissions comes from crop residues worked into the soil. These crops included corn, wheat, sorghum, and rice. Synthetic fertilizers contribute 99 percent of nitrogen from plant fertilizers while organic sources such as dried manure and activated sewage sludge contribute the remaining one percent.

Animal emission sources include application of animal waste through daily spread operations, application of managed animal wastes, and wastes deposited directly on soils by animals in pastures, ranges, and paddocks. Indirect emissions result from volatilization, leaching, and run-off.

Rice Cultivation

Methane emissions result from primary and ratoon rice cultivation. A ratoon rice crop is the second crop grown from the stubble after harvest of the primary rice crop. The rice straw produced during the first harvest increases methane emissions during the second harvest and so separate emission factors are used for the two crops. Default data were used for all years.

Agricultural Residue Burning

Agricultural crop wastes are often burned in the field to clear straw and stubble after harvest, and to prepare the field for the next growing cycle. Emission factors for CO_2 and CH_4 include residue to crop ratio, fraction of residue burned, burning efficiency, combustion efficiency, and carbon content of crops. The default fraction of residue burned was 3 percent for corn, soybeans, sugarcane, and wheat; the default fraction for rice varied by year and dropped from 6 percent in 1990 to 3 percent in 2005. In Louisiana only sugarcane and wheat are normally burned, and rice residue burning is no longer common so actual emissions could be lower than the default calculations presented here.

3.3.7 Land-use Change and Forestry

Overview

The Land-Use Change and Forestry module calculates CO_2, CH_4, and N_2O emissions from liming of soils, fertilization of settlement soils, and forest fires, as well as carbon flux from forest management, urban trees, and landfilled yard trimmings and food scraps. Data for this module are listed below.

- Forest carbon flux (CO_2/carbon storage)
    - Aboveground biomass
    - Belowground biomass
    - Dead wood
    - Litter
    - Soil organic carbon
- Liming of agricultural soils (CO_2)
    - Limestone
- Urea applied to soil (CO_2)
- Urban trees (carbon storage)
    - Total urban area
    - Percent of urban area with tree cover
- Forest fires (CH_4 and N_2O)
    - Dry matter combusted (forest)
- Landfilled yard trimmings and food scraps (CO_2/carbon storage)
    - Grass
    - Leaves
    - Branches
    - Food Scraps
- Settlement soils (N_2O)

Land-use change and forestry sources for which emissions were not calculated are as follows.

- Liming of agricultural soils (dolomite)
- Dry matter combusted (savanna)

Historical Emissions

Greenhouse gas emissions for 1990 through 2005 were estimated using the U.S. EPA State Greenhouse Gas Inventory Tool (SIT) software. Table 3.3.7-1 identifies data inputs by source category, data sources, and the years for which data were available.

Table 3.3.7-1. Approach to Estimating Historical Emissions: Land-use Change and Forestry.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
Forest Carbon Flux	1990-2005	Aboveground biomass, belowground biomass, dead wood, litter, soil organic carbon	USDA Forestry Service, estimates of states' forest carbon stocks (1990-2007) and harvested wood stocks (1987, 1992, 1997).
Liming of Agricultural Soils	1996-1998, 2001-2005	Limestone applied to soil (metric tons)	Agricultural Chemistry Program, LA Department of Agriculture (1996-1998, and 2001-2005). Surrogate data for 1990-1995 based on 1996 ratio of agricultural lime/total lime and applied to shipments of lime sold or used by producers in Louisiana. Data for 1999 and 2000 were interpolated based on 1998 and 2001 data.
Urea Fertilization	1990-2005	Urea applied to soil (metric tons)	AAPFCO (2007) Commercial Fertilizers 2005. Association of American Plant Food Control Officials and The Fertilizer Institute. University of Kentucky, Lexington, KY. Data for urea fertilization from TVA (1991 through 1994)
Urban Trees	1990 and 2000	Urban area (km^2)	U.S. Census, 1990 and 2000
	2000	Percent urban tree cover	Nowak, et al. People & trees: assessing the U.S. urban forest resource. Journal of Forestry. 2001.
Forest Fires	1998-2005	Area burned (ha)	LA Department of Agriculture and Forestry, Ten Year Fire Data, Bret Lane, June 2009 and LDAF website: http://www.ldaf.louisiana.gov/portal/Offices/Forestry/ForestProtection/tabid/135/Default.aspx. Average area burned per year for 1996-2007 (LDAF website) used as surrogate data for 1990-1997.
Landfilled Yard Trimmings and Food Scraps	1990-2005	Landfilled yard trimmings and food scraps ('000 short tons wet weight)	Municipal Solid Waste in the United States: 2006 Facts and Figures (EPA 2007).
N_2O from Settlement Soils	1990-2005	Synthetic fertilizer applied to settlement soils (metric tons N)	AAPFCO (2007) Commercial Fertilizers 2006. Association of American Plant Food Control Officials and The Fertilizer Institute. University of Kentucky, Lexington, KY.

Data Assessment

Data availability for land-use change and forestry sources are shown in the table below.

Table 3.3.7-2. Land-use Change and Forestry Data Availability.

Source Category	Data Availability				
	All years	Some surrogate	Some missing	Default Ratios	Other Ratios
Forest Carbon Flux	●			●	
Liming of Agricultural Soils		●			●
Urea Fertilization	●				
Urban Trees				●	
Forest Fires		●			
Landfilled Yard Trimmings and Food Scraps	●				
N_2O from Settlement Soils	●				

Results

Historical emissions for land-use change and forestry from 1990 to 2005 are shown in Figures 3.3.7-1 and 3.3.7-2. Table 3.3.7-3 shows the historical emission values upon which the figures are based. Net sequestered CO_2 emissions (i.e. carbon storage) for this category increased from about -4 to -13 $MMTCO_2E$ from 1990 to 2005.

The main component of carbon sequestration was forest carbon flux, largely due to harvested wood products and landfills. Other sequestration sources included soil organic carbon, urban trees, and landfilled yard trimmings and food scraps. Small but positive contributions of greenhouse gases came from liming of agricultural soils, urea fertilization, forest fires, and N_2O from settlement soils.

Total emissions increased at a slight upward trend (or conversely carbon storage decreased) from 1992 to 2005 (-15.75 to -12.72 $MMTCO_2E$). The large drop from 1990 to 1992 was due to estimates of aboveground biomass emissions for those years declining from 7.55 $MMTCO_2E$ in 1990 to 0.87 in 1992. This may be an artifact of the data available to USDA for those years. Figure 3.3.7-3 shows the components of forest carbon flux.

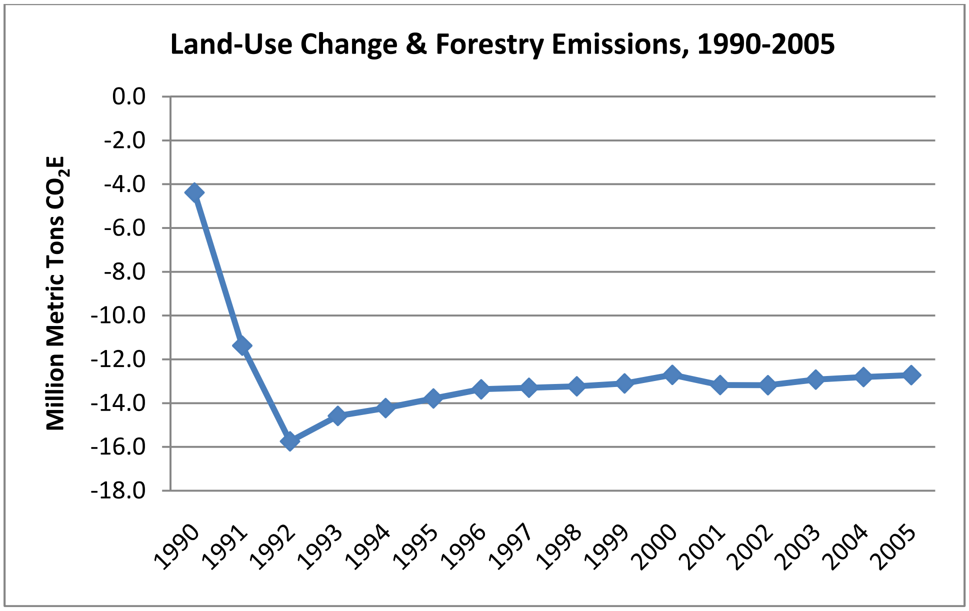


Figure 3.3.7-1. GHG emissions from land-use change and forestry, 1990-2005.

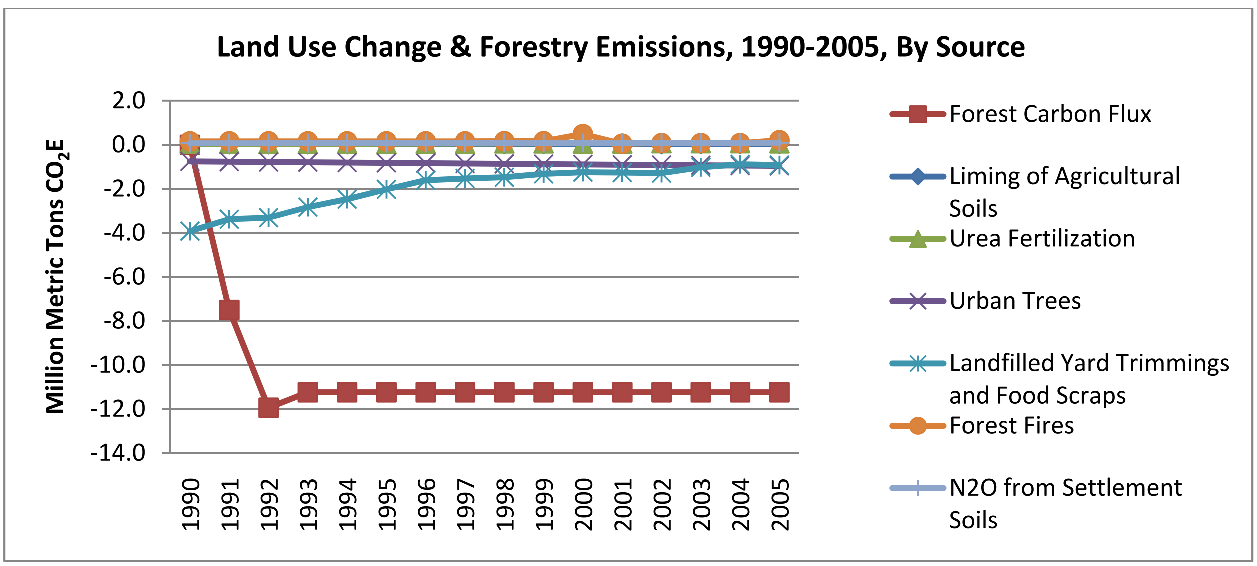


Figure 3.3.7-2. GHG emissions from land-use change and forestry by source, 1990-2005.

Table 3.3.7-3. Historical Emissions for Land-use Change and Forestry (MMTCO$_2$E).

Sector	1990	1995	2000	2005
Forest Carbon Flux	(0.004)	(11.24)	(11.24)	(11.24)
Liming of Agricultural Soils	0.03	0.03	0.04	0.04
Urea Fertilization	0.05	0.04	0.06	0.07
Urban Trees	(0.76)	(0.82)	(0.89)	(0.96)
Forest Fires	0.15	0.15	0.48	0.21
Landfilled Yard Trimmings and Food Scraps	(3.92)	(2.02)	(1.25)	(0.92)
N_2O from Settlement Soils	0.07	0.07	0.08	0.09
Total	**(4.38)**	**(13.79)**	**(12.71)**	**(12.72)**

Forest Carbon Flux

Land-use change and forest management activities can affect the balance between the emission and uptake of greenhouse gases, also known as GHG or carbon flux (ICF International, 2007b). The USDA Forest Service uses the *Carbon Calculation Tool* (CCT) to produce estimates of carbon stock and flux for aboveground biomass, belowground biomass, dead wood, litter, and soil organic carbon. Carbon flux for harvested wood products and landfill are calculated using USDA five-year data and filling in the intervening years. Net sequestration is calculated as the annual change in total carbon storage for both groups of data.

Default data supplied in the SIT are used for all years for this category. Forest carbon flux results in a net sequestration or storage of carbon for all years except 1990. As shown below, a large difference exists between 1990 and 2005 aboveground biomass emissions calculated in the USDA CCT model (7.55 and 0.87 MMTCO$_2$E respectively). The reason for the large drop-off in emissions is not clear and is beyond the scope of this project using the default SIT modules.

Table 3.3.7-4. Historical Emissions for Forest Carbon Flux (MMTCO$_2$E).

Category	1990	1991	1992	1995	2000	2005
Aboveground Biomass	7.55	3.35	0.87	0.87	0.87	0.87
Belowground Biomass	1.55	0.68	0.16	0.16	0.16	0.16
Dead Wood	0.71	0.53	0.41	0.41	0.41	0.41
Litter	0.26	0.29	0.31	0.31	0.31	0.31
Soil Organic Carbon	0.78	(1.49)	(2.84)	(2.84)	(2.84)	(2.84)
Wood Products & Landfills	(10.86)	(10.86)	(10.86)	(10.16)	(10.16)	(10.16)
Total	**0.00**	**(7.51)**	**(11.94)**	**(11.24)**	**(11.24)**	**(11.24)**

Source: SIT Module, "Land Use, Land-Use Change, and Forestry Module_2006.xlsm\Land Use (C Flux-Default), Louisiana data.

Liming of Agricultural Soils

Limestone is applied to soils to reduce acidity. As limestone degrades it produces CO_2. Amounts of lime applied to agricultural soils were supplied by the Louisiana Department of Agriculture. Missing data were either interpolated (for years 1999 and 2000) or estimated using the 1996 ratio of agricultural lime to total shipments of lime sold or used by producers in Louisiana (for years 1990 to 1995).

Emissions from agricultural liming of soils stayed essentially flat and ranged from 0.029 to 0.036 $MMTCO_2E$ for 1990 and 2005, respectively.

Urea Fertilization

Urea is a nitrogen fertilizer used primarily for agricultural crops. Application of urea as a fertilizer releases CO_2 that was previously fixed during the original manufacturing process (ICF International, 2007b). Default data were available from the Association of American Plant Food Control Officials. Emissions increased slightly for the 1990 to 2005 period from 0.053 to 0.069 $MMTCO_2E$.

Urban Trees

Trees provide a net source of carbon sequestration due to their uptake of carbon dioxide. While urban trees represent only 2.8 percent of total U.S. tree canopy, they grow in relatively open surroundings and their growth and carbon sequestration are disproportionately large relative to forests (ICF International, 2007b). Default data were used for urban tree cover in Louisiana (Nowak, Noble, Sisinni, & Dwyer, 2001). Default data for urban land area were derived from the 1990 and 2000 U.S. Census (ICF International, 2007b).

Urban trees provided close to a million metric tons of carbon sequestration according to the module estimates (0.76 million metric tons of CO_2 equivalents in 1990 and 0.96 MMT in 2005).

N_2O from Settlement Soils

Settlement soils are settled areas, such as lawns, golf courses, and landscaping, to which fertilizer is applied. These synthetic fertilizers contain nitrogen which oxidizes and converts to nitrous oxide. The SIT uses the IPPC (2006) default emission factor of one percent for direct N_2O emissions from nitrogen. Nitrous oxide emissions from these sources increased slightly from 0.07 MMTCO$_2$E in 1990 to 0.09 MMTCO$_2$E in 2005.

Forest Fires

Forest fire data were obtained from the Louisiana Department of Agriculture and Forestry (LDAF) for 1998 to 2005. Average acreage burned between 1996 and 2007 was used as surrogate data for years with missing data (i.e. 1990 to 1997).

Forest fires are sources of CO_2, CH_4, N_2O and other gases and pollutants. CO_2 emissions are accounted for in forest carbon flux calculations (ICF International, 2007b). Methane and nitrous oxide emissions ranged from 0.15 MMTCO$_2$E in 1990 to 0.21 MMTCO$_2$E in 2005, with a spike to 0.48 MMT occurring in 2000. Louisiana experienced extreme drought conditions in 2000 that were second only to the drought of 1925 (NOAA, 2000). Forest fires were higher than usual across the state, particularly in the parishes of Allen, Beauregard, Rapides, and Vernon.

Landfilled Yard Trimmings and Food Scraps

Emissions are estimated based on methodologies in IPCC (2003) and IPCC (2006a) which calculate the net change in landfilled carbon stocks between years (ICF International, 2007b). Necessary data inputs include the following:

- Composition of yard trimmings (grass, leaves, branches)
- Mass of yard trimmings and food scraps disposed in landfills
- Carbon storage factor of yard trimmings/food scraps
- Decomposition rate of degradable carbon

The results show a net carbon sequestration of -3.92 MMTCO$_2$E in 1990 which decreased to -0.92 MMTCO$_2$E in 2005. Detailed graphs for this category (Figure 3.3.7-3 below) show that the net change was largest for leaves and branches. This may reflect greater collection efforts by local governments of “woody waste” to reduce total waste disposed of in landfills.

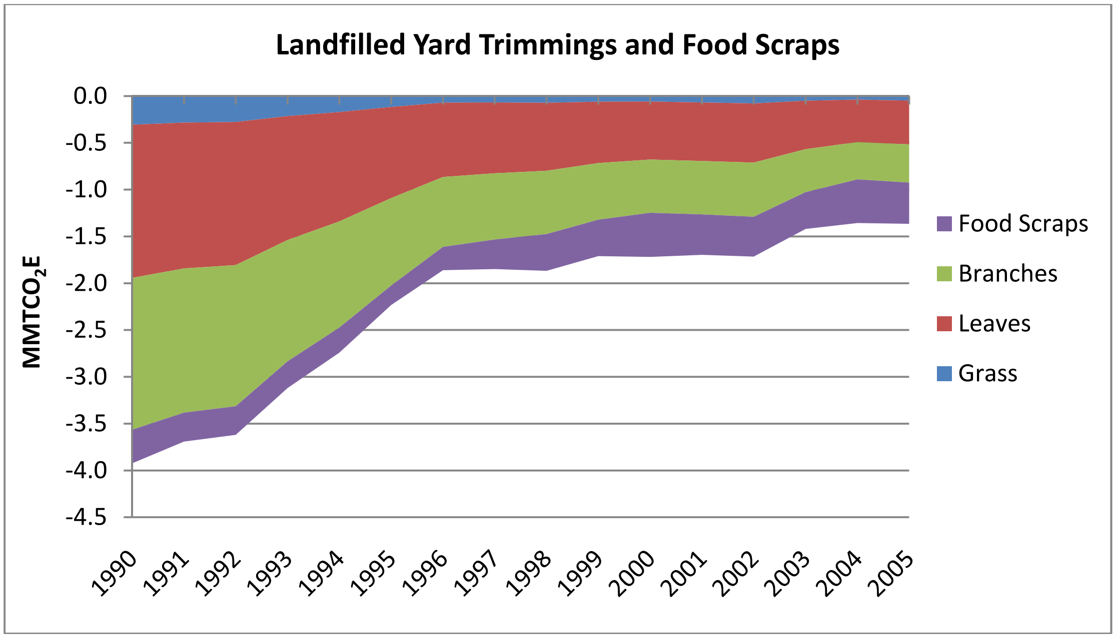


Figure 3.3.7-3. Annual carbon flux of landfilled yard trimmings and food scraps, 1990-2005.

3.3.8 Waste Management

3.3.8.1 Municipal Solid Wastes

Overview

The Municipal Solid Wastes module calculates CH_4 emissions from municipal solid waste and industrial landfills. Data inputs for this module are listed below.

- Municipal solid waste landfills (CH_4)
- Industrial landfills (CH_4)
- Methane flaring at landfills (CH_4)
- Landfill gas recovered (CH_4)
- Oxidation at landfills (CH_4)

According to LDEQ, no solid waste was incinerated between 1990 and 2005 so no CO_2 or N_2O emissions were calculated for solid waste combustion. Municipal solid waste landfills and industrial landfills are potential sources of methane emissions while flaring, gas recovery, and oxidation represent methane emissions avoided.

Historical Emissions

Greenhouse gas emissions for 1990 through 2005 were estimated using the U.S. EPA State Greenhouse Gas Inventory Tool (SIT) software. Table 3.3.8.1-1 identifies data inputs by source category, data sources, and the years for which data were available.

Table 3.3.8.1-1. Approach to Estimating Historical Emissions: Municipal Solid Wastes.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
Municipal Solid Waste Landfills	1960-2005	-U.S. MSW landfilled (tons) -LA population -LA percent landfilled	-Franklin Associates (2005) Municipal Solid Waste in the United States: 2003 Facts and Figures. Prepared for U.S. EPA, Washington, D.C., EPA 530-F-05-003. -U.S. Census Bureau -BioCycle, 1990-2001, 2004, 2006
Industrial Landfills	1960-2005	MSW landfill CH_4 emissions	7 percent of MSW landfill methane emissions. EPA (1993) Anthropogenic Methane Emissions in the U.S.: Global Change Division, Office of Air and Radiation, EPA 530/430-R-93-003.
Methane Flaring	1994-2005	Amount of CH_4 flared (tons)	2006BY US Inventory, Flare Database.xls; Obtained from Melissa Weitz at EPA. No data available for 1990-1993.
Landfill Gas-to-Energy	1999-2000, 2004-2005	Amount of CH_4 recovered (tons)	EPA (2005) Landfill Gas-to-Energy Project Database 2005, Landfill Methane and Outreach Program. http://www.epa.gov/lmop/proj/. No data available for 1990-1998 and 2001-2003.
Landfill Oxidation	1990-2005	Percent CH_4 oxidized through landfill cover or soils	EPA default percent, ICF International (March 2007) Draft User's Guide for Estimating Emissions from Municipal Solid Waste Using the State Inventory Tool. Prepared for U.S. EPA.

Data Assessment

Data availability for the solid waste category is shown in the table below.

Table 3.3.8.1-2. Municipal Solid Waste Data Availability.

Source Category	Data Availability				
	All years	Some surrogate	Some missing	Default Ratios	Other Ratios
MSW Landfills	•			•	
Industrial Landfills	•			•	
Methane Flaring			•		
LFGTE			•		
Landfill Oxidation				•	

Results

Historical emissions for municipal and industrial solid waste from 1990 to 2005 are shown in Figure 3.3.8.1-1. Table 3.3.8.1-3 shows the historical emission values upon which the figures are based. Negative values represent methane emissions avoided, such as flaring, landfill gas-to-energy projects, and oxidation at landfills. As shown in the figure below, emissions avoided were nearly as large as emissions generated in 2005.

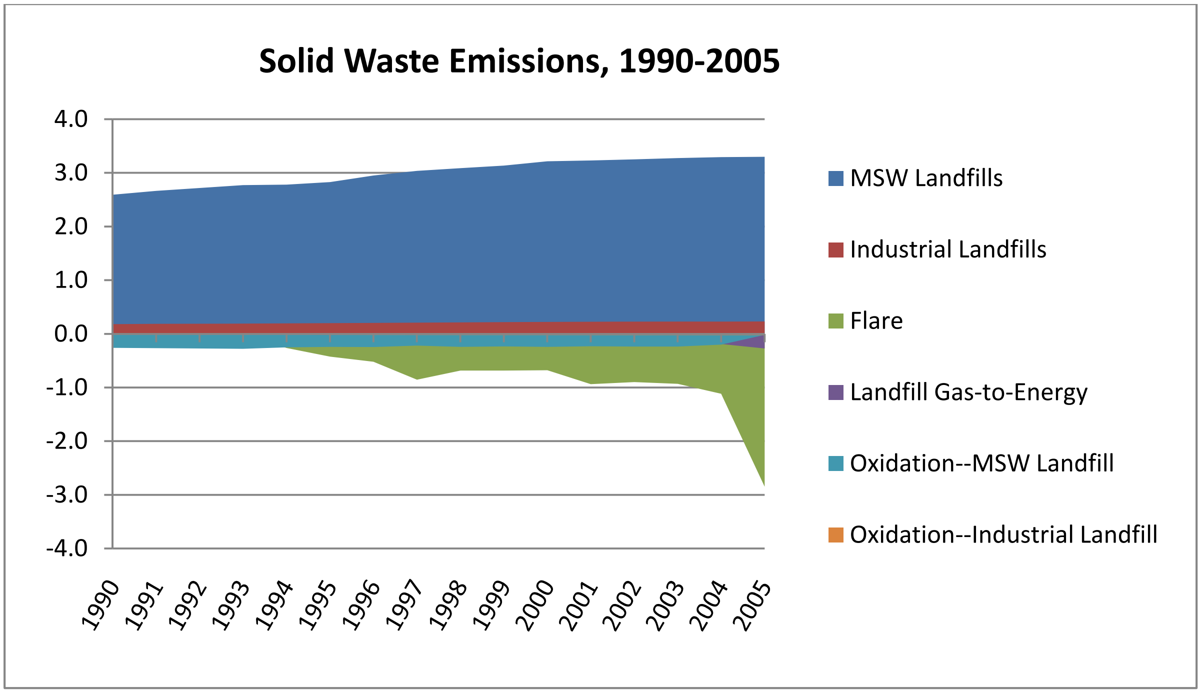


Figure 3.3.8.1-1. GHG emissions from municipal solid waste by source, 1990-2005.

Table 3.3.8.1-3. Historical Emissions for Municipal Solid Waste (MMTCO$_2$E).

Category	1990	1995	2000	2005
MSW Landfill	2.59	2.83	3.22	3.30
Industrial Landfill	0.18	0.20	0.23	0.23
Flare	--	(0.42)	(0.68)	(2.85)
Landfill Gas-to-Energy	--	--	(0.12)	(0.27)
MSW Landfill Oxidation	(0.26)	(0.24)	(0.24)	(0.02)
Industrial Landfill Oxidation	(0.02)	(0.02)	(0.02)	(0.02)
Total	**2.50**	**2.34**	**2.38**	**0.37**

Municipal Solid Waste Landfills

Default values were used to calculate methane emissions from municipal landfills. The module uses a first order decay (FOD) model in which CH_4 emission rates are a function of quantity of waste deposited in landfills in the current year as well as over the previous 30 years. Total U.S. landfill data for 1960 to 2005, per capita landfill estimates, and Louisiana annual population were data inputs for disposal amounts. Emissions increased from 2.59 to 3.30 MMTCO$_2$E from 1990 to 2005.

Industrial Landfills

Methane generation from non-hazardous industrial landfills does not include CH_4 generation from industrial waste disposed of in MSW landfills (already accounted for under municipal solid waste). A flat percentage (7 percent) of municipal landfill methane emissions was used to calculate industrial landfill emissions. This percentage is based on estimates of quantities of waste and organic content in industrial landfills compared to MSW landfills and is applied prior to adjusting for flaring, recovery, and oxidation (U.S. EPA, 1993). Industrial landfill emissions follow the same trend as MSW emissions and increased from 0.18 to 0.23 MMTCO_2E from 1990 to 2005.

Landfill Methane Flaring

Gas collection systems are used at many landfills to flare methane emissions. Carbon dioxide produced by flaring is not counted as anthropogenic GHG emissions because the CO_2 is mostly from the decomposition of organic materials from crops and forests which in the United States are grown and harvested on a sustainable basis. This implies that CO_2 removed from the atmosphere during photosynthesis is equal to the CO_2 released back to the atmosphere during decomposition and flaring (ICF International, 2007d).

The SIT module supplied default data from the U.S. EPA "2006BY U.S. Inventory" flare database for 1994 to 2005 (ICF International, 2007d). No data were filled in for missing years. The amount of methane flared increased dramatically from 0.263 to 2.847 million metric tons CO_2E. This increase in landfill flaring accounted for most of the reduction in total emissions for municipal solid waste in 2005.

Landfill Gas-to-Energy (LFGTE)

Default data from EPA's Landfill Methane Outreach Project (LMOP) database were available for 1999, 2000, 2004, and 2005 for Louisiana, which corresponded to years when LFGTE projects were operational. A landfill gas energy project operated in Caddo Parish in 1999 and 2000, and resumed operations in late 2003. In addition, a facility on the former Devil's Swamp Landfill site in Baton Rouge began operations in 2005. Landfill gas recovered and used for energy ranged from 123,842 metric tons CO_2E in 1999 to 272,744 metric tons CO_2E in 2005.

Landfill Oxidation

EPA estimates that 10 percent of landfill methane not flared or recovered is oxidized in the cover or top layer of soil over the landfill. The percentage used is the same for municipal solid waste and industrial landfills and represents methane emissions avoided. Emissions in 1990 were 0.26 and 0.02 $MMTCO_2E$, respectively. MSW landfill oxidation amounts dropped in 2005 to 0.02 $MMTCO_2$ due to the decrease in net emissions after flaring.

3.3.8.2 Wastewater Treatment

Overview

The Wastewater module calculates CH_4 and N_2O emissions from the treatment of municipal and industrial wastewater. Emission categories for this module are listed below.

- Municipal wastewater
  - Methane emissions
  - Direct N_2O emissions
  - N_2O emissions from biosolids
- Industrial wastewater
  - Fruits and vegetable production processing
  - Red meat production processing
  - Poultry production processing
  - Paper and paperboard production processing

Total production capacity was used for paper, paperboard, and market pulp processed in Louisiana using data available from 2000 and 2002 (USDA, 2001 and Georgia Tech, 2002).

Historical Emissions

Greenhouse gas emissions for 1990 through 2005 were estimated using the U.S. EPA State Greenhouse Gas Inventory Tool (SIT) software. Table 3.3.8.2-1 identifies data inputs by source category, data sources, and the years for which data were available.

Table 3.3.8.2-1. Approach to Estimating Historical Emissions: Wastewater Treatment.

Source Category	Time Period for which Data Available	Required Data for SIT	Data Source
Municipal Wastewater			
• CH_4 Emissions • Direct N_2O • N_2O from Biosolids	1990-2005	State Population	U.S. Census Bureau, www.census.gov, American Factfinder, 2000-2006 population.
Industrial Wastewater			
Fruits and Vegetables	1998-2005	Fruit and vegetable production processed (metric tons)	LSU AgCenter, Louisiana Summary, Agriculture and Natural Resources, Louisiana Summary. Data for 1993-1997 were calculated using the ratio of 1998 gross farm income from plant commodities to metric tons of fruits and vegetables processed. 1993 data used as surrogate for 1990-1992.
Red Meat	1990-2005	Red meat production processed (metric tons)	USDA Quick Stats, Annual Red Meat Production. http://www.nass.usda.gov/QuickStats/Create_Federal_All.jsp
Poultry	1996-2005	Poultry production processed (metric tons)	LSU AgCenter, Louisiana Summary, Agriculture and Natural Resources. Data for 1993-1995 were calculated using the ratio of 1996 gross farm income from animal commodities to metric tons of poultry processed. 1993 data used as surrogate for 1990-1992.
Pulp and Paper	2000, 2002	Paper, paperboard, and market pulp processed (metric tons)	USDA Forest Service, *United States Paper, Paperboard, and Market Pulp Capacity Trends by Process and Location*, 1970-2000; Georgia Technology University, The Center for Paper Business and Industry Studies. USDA ratio of 2000 LA to U.S. production capacity used to estimate 1990-1999 data. GA Tech average 2000-2002 production capacity data used as surrogate for 2001-2005.

Data Assessment

Data availability for wastewater treatment sources is shown in the table below.

Table 3.3.8.2-2. Wastewater Data Availability.

Source Category	Data Availability				
	All years	**Some surrogate**	**Some missing**	**Default Ratios**	**Other Ratios**
Municipal Wastewater					
LA state population	●				
Industrial Wastewater					
Fruits and Vegetables		●			●
Red Meat	●				
Poultry		●			●
Pulp and Paper		●			●

Results

Historical emissions for wastewater treatment from 1990 to 2005 are shown in Figures 3.3.8.2-1 and 3.3.8.2-2. Table 3.3.8.2-1 shows the historical emission values upon which the figures are based. Total emissions for this category increased during the period 1990 to 2005 from 0.68 to 0.79 $MMTCO_2E$.

Disposal and treatment of wastewater result in CH_4 emissions when organic material is treated in an anaerobic environment and when untreated wastewater degrades anaerobically (ICF International, 2007d). Municipal wastewater emissions increased slightly as state population increased. Industrial wastewater emissions increased due mostly to increased paper and paperboard production (from 5.5 to 7.1 million metric tons in 1990 and 1995, respectively).

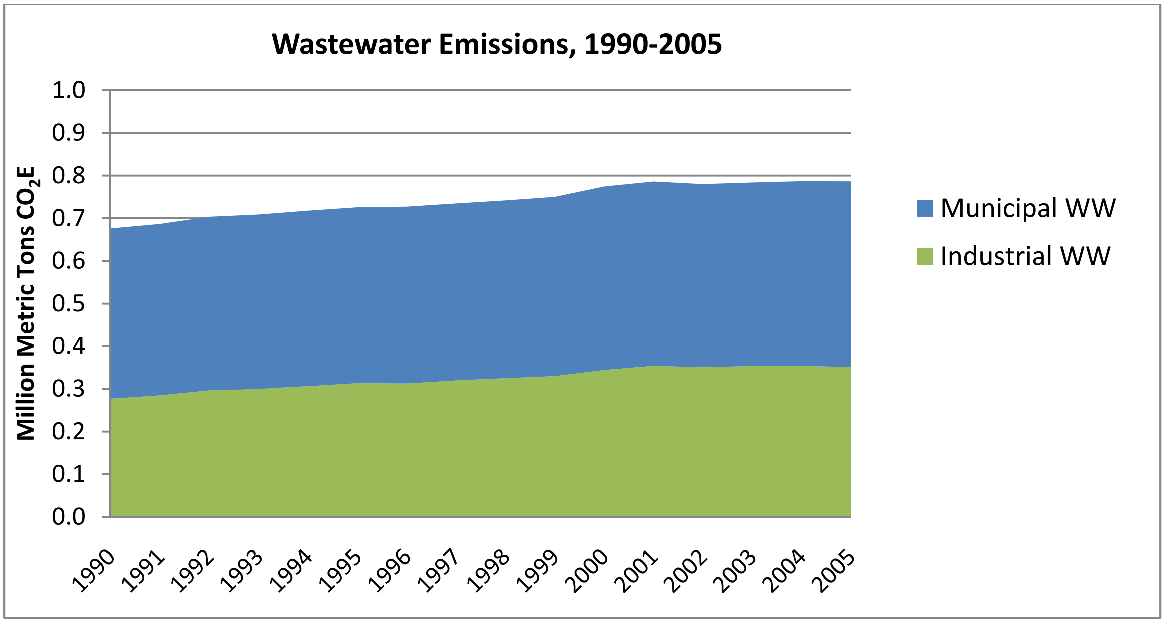


Figure 3.3.8.2-1. GHG emissions from wastewater treatment, 1990-2005.

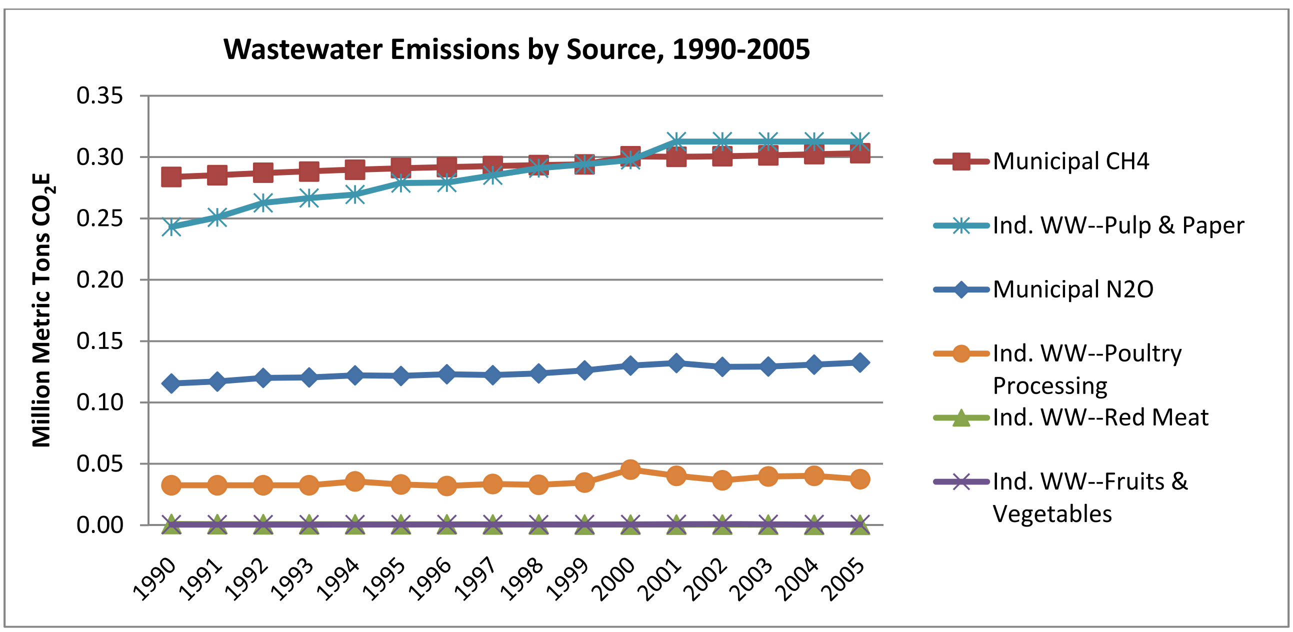


Figure 3.3.8.2-2. GHG emissions from wastewater treatment by source, 1990-2005.

Table 3.3.8.2-3. Historical Emissions for Wastewater Treatment (MMTCO$_2$E).

Sector	1990	1995	2000	2005
Municipal WW—CH_4	0.28	0.29	0.30	0.30
Municipal WW—N_2O	0.12	0.12	0.13	0.13
Industrial WW—Fruits & Vegetables	0.0004	0.0005	0.0005	0.0006
Industrial WW—Red Meat	0.0009	0.0007	0.0004	0.0003
Industrial WW—Poultry Processing	0.03	0.03	0.05	0.04
Industrial WW—Pulp & Paper	0.24	0.28	0.30	0.31
Total	**0.68**	**0.73**	**0.77**	**0.79**

Municipal Wastewater

Municipal wastewater treatment results in CH_4 and N_2O emissions which, because of the underlying calculation, are directly proportional to population. Methane emissions are dependent on total annual biological oxygen demand for a five day period (BOD_5) production and the percentage of wastewater treated anaerobically. Direct N_2O emissions are calculated based on the number of people using the municipal wastewater treatment system and an N_2O emission factor per person. Nitrous oxide emissions from biosolids are determined by per capita protein consumption, nitrogen content of protein ($FRAC_{NPR}$), fraction of nitrogen not consumed, and an N_2O emission factor per ton of nitrogen treated. The calculation subtracts direct nitrogen emissions and accounts for the percentage of biosolids used as fertilizer.

Industrial Wastewater

LSU AgCenter (1997)

Default data in this category were available only for red meat processing. LSU AgCenter data were used for poultry production and fruit and vegetable processing, including 14 types of fruit and 50 types of vegetables (LSU AgCenter, 1997-2005). Fruits and vegetables were converted from agricultural units (bunches, ears, bushels, etc.) to metric tons. Average paper and paperboard production capacity for Louisiana from 2000-2002 were obtained from Georgia Technology University (Georgia Tech, 2002). Louisiana production capacity in 2000 and U.S. production capacity data for 1990-2000 were obtained from the USDA Forest Service (USDA, 2001).

The largest component of 2005 industrial wastewater emissions is from paper and paperboard production followed by wastewater from poultry production processing. Total emissions from industrial wastewater increased from about 0.28 to 0.36 MMTCO_2E from 1990 to 2005, due largely from estimated paper and paperboard production capacity.

3.4 GREENHOUSE GAS EMISSIONS PROJECTIONS

3.4.1 Projection Module Overview

The Projection Tool was designed as a companion to the EPA's State Inventory Tool (SIT), which estimates state-level GHG emissions for 1990-2005. Both tools are based on EPA's Emissions Inventory Improvement Program (EIIP) State Guidance (EPA, 2006). States that have completed the historical emission estimation process using the SIT modules can import the historical emissions into the Projection Module to obtain a complete time series of emissions from 1990 to 2020. Explanations and directions for use of the Projection Tool are provided in Draft State Greenhouse Gas Inventory Tool User's Guide for the Projection Tool (EPA, 2007).

The Projection Module is based on future energy consumption estimates published by the EIA's *Annual Energy Outlook* (AEO) (EIA, 2009a). According to the SIT's "Description of Projection Methodologies" the projected regional consumption is disaggregated to state-level estimates by applying the relative proportion of consumption (EPA, 2007).

The AEO has a projection horizon of twenty-five years into the future. The report uses the National Energy Modeling System (NEMS) to project the production, imports, conversion, consumption, and prices of energy. Assumptions are made about macroeconomic and financial conditions, energy markets, resource availability and cost, technology performance, and demographics. Variable factors such as population growth are also projected in order to reflect an accurate level of energy demand. EIA reports that the NEMS results "are not considered to be statements of what will happen but of what might happen, given the assumptions and methodologies used" (EIA, 2009a).

3.4.2 Projection Results Summary

The integration of 1990–2005 GHG emissions estimates from the SIT modules into the Projection Module reveal a continuation of essentially no growth in Louisiana GHG emissions seen over the past fifteen years (1990-2005) and on out to 2020. This is true for total GHG emissions, total energy-related emissions, and CO_2 from fossil fuel combustion (Figures 3.4-1 and 3.4-2). Non-energy related GHG emissions present the same flat trend (Figure 3.4-3).

Fossil Fuel Combustion

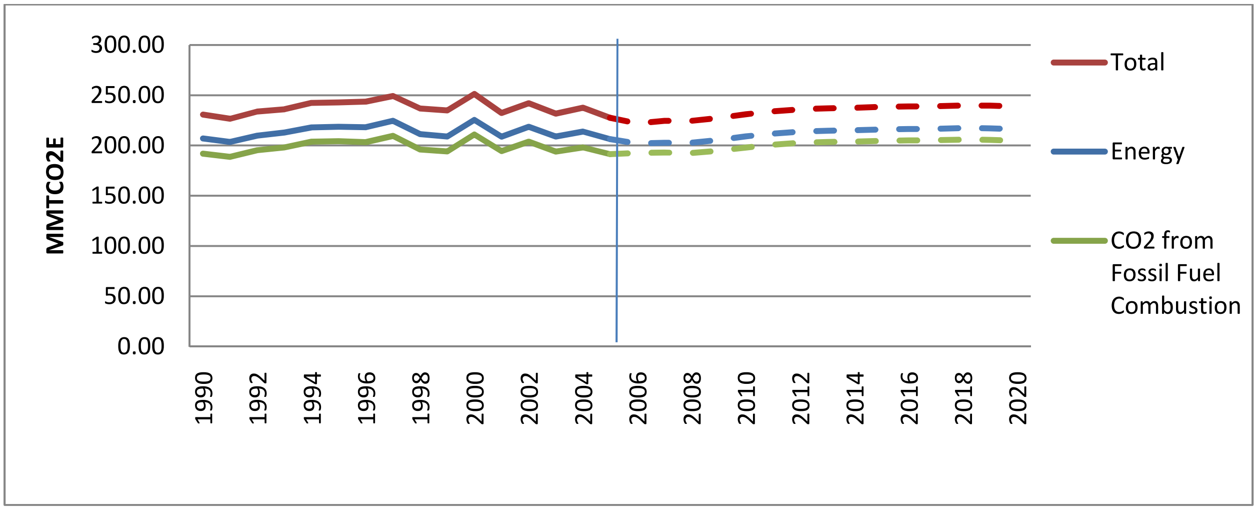


Figure 3.4-1. Estimates of energy and fossil-fuel related GHG emissions for Louisiana, 1990-2020.

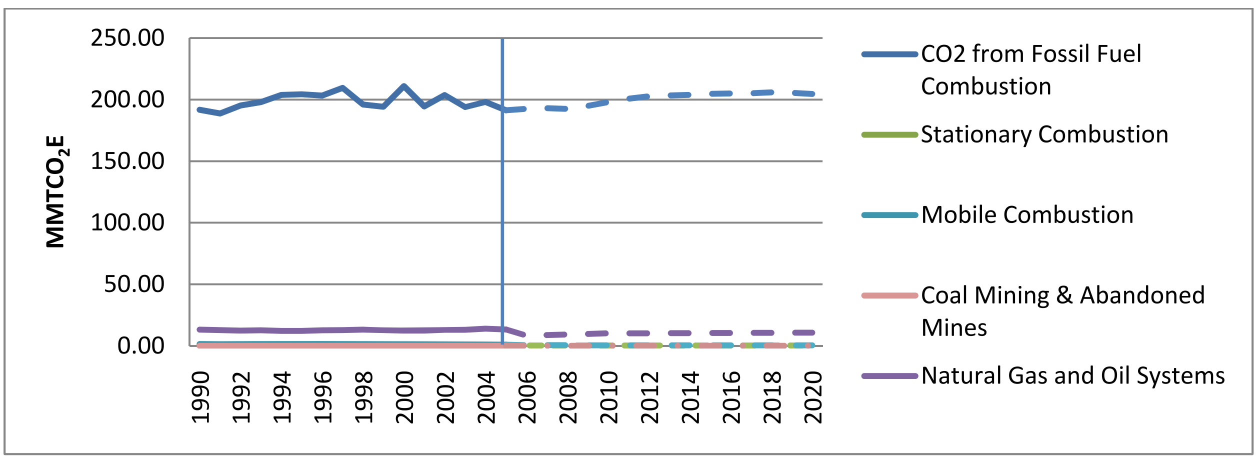


Figure 3.4-2. Estimates of fossil-fuel related GHG emissions for Louisiana, 1990-2020.

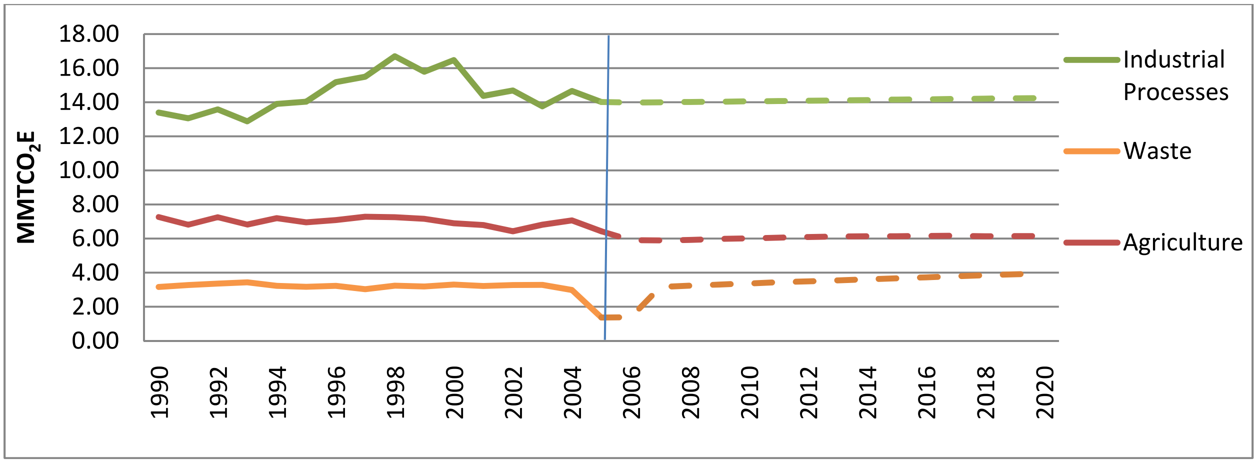


Figure 3.4-3. Estimates of non-energy related GHG emissions for Louisiana, 1990-2020.

As described previously in this report, the CO_2 emissions from fossil fuel combustion constitute around 86 percent of Louisiana's total GHG emissions. Thus, projections of Louisiana's fossil fuel consumption provide a good indication of GHG emissions over the projection period. As can be seen in Figure 3.4-4, GHG emissions related to combustion of petroleum, natural gas, and coal are expected to remain essentially unchanged out to 2020. As shown in Figure 3.4-5, GHG emissions attributed to the major sectors based on energy consumption and fossil fuel combustion show no significant changes looking forward from 2005 to 2020.

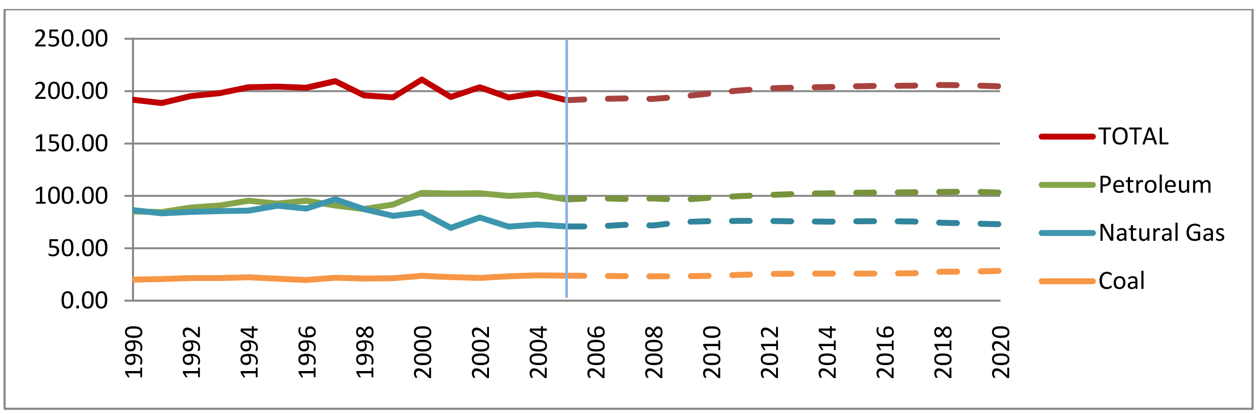


Figure 3.4-4. Estimates of Louisiana's GHG emissions from fossil fuel combustion for the period 1990- 2020.

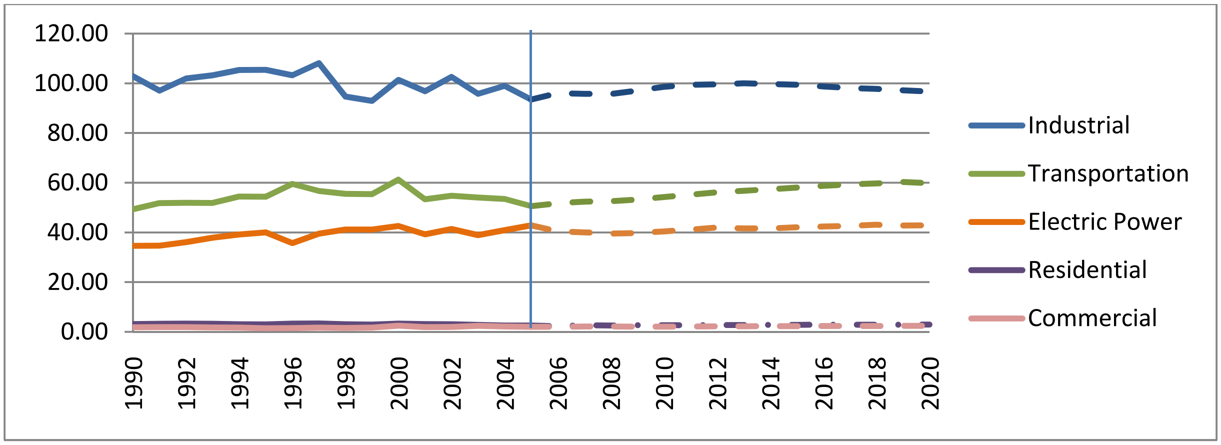


Figure 3.4-5. Estimates of Louisiana's GHG emissions by major sector over the period 1990-2020.

Stationary Combustion

The non-fossil fuel combustion emissions are expected to follow similar trends (see Figure 3.4-8), resulting in negligible net change over the fifteen year projection period. One exception to this summary is the mobile source emission levels, which will most likely continue a historic decline. The decrease in nitrous oxide and sulfur from mobile sources is explained by increasingly stringent fuel economy standards and the incorporation of additional alternative fueling capacity.

The other two exceptions to the steady emission level trend are emissions from coal mining (see Figure 3.4-10) and emissions from solid waste combustion (see Figure 3.4-18). Both industries comprise a relatively small proportion of economy-wide emissions. These projections are based on the historic increases in activity related to in-state population growth.

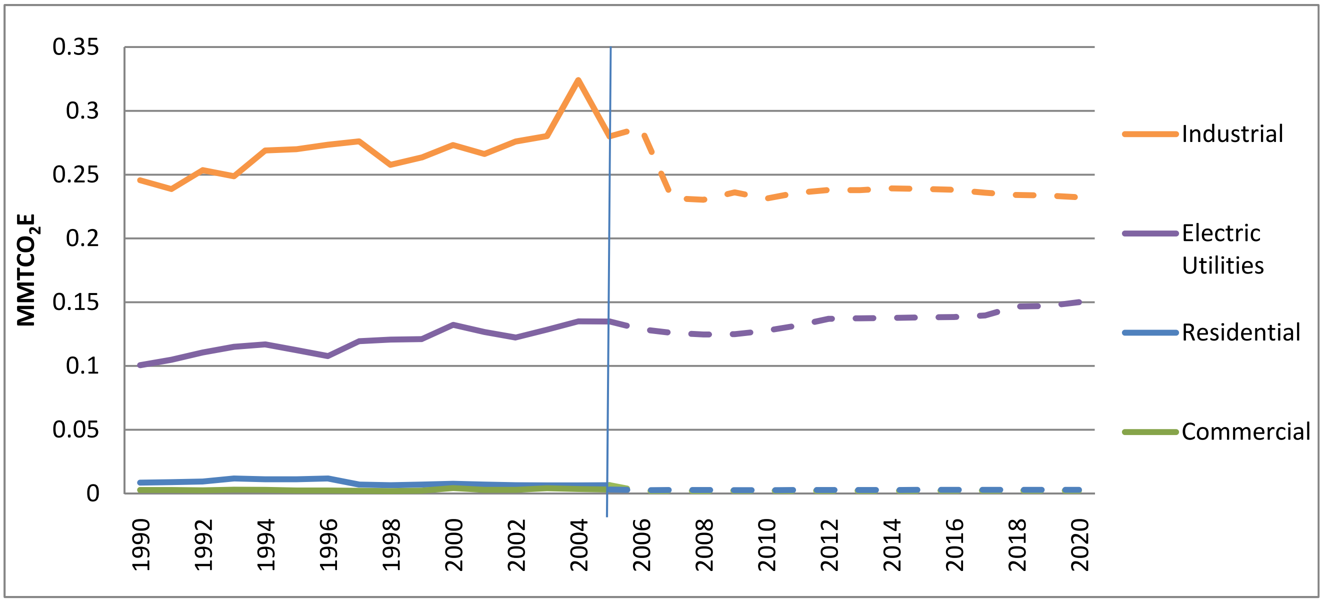


Figure 3.4-6. Estimates of Louisiana's nitrous oxide (N_20) emissions from stationary combustion sources, by sector, over the period 1990-2020.

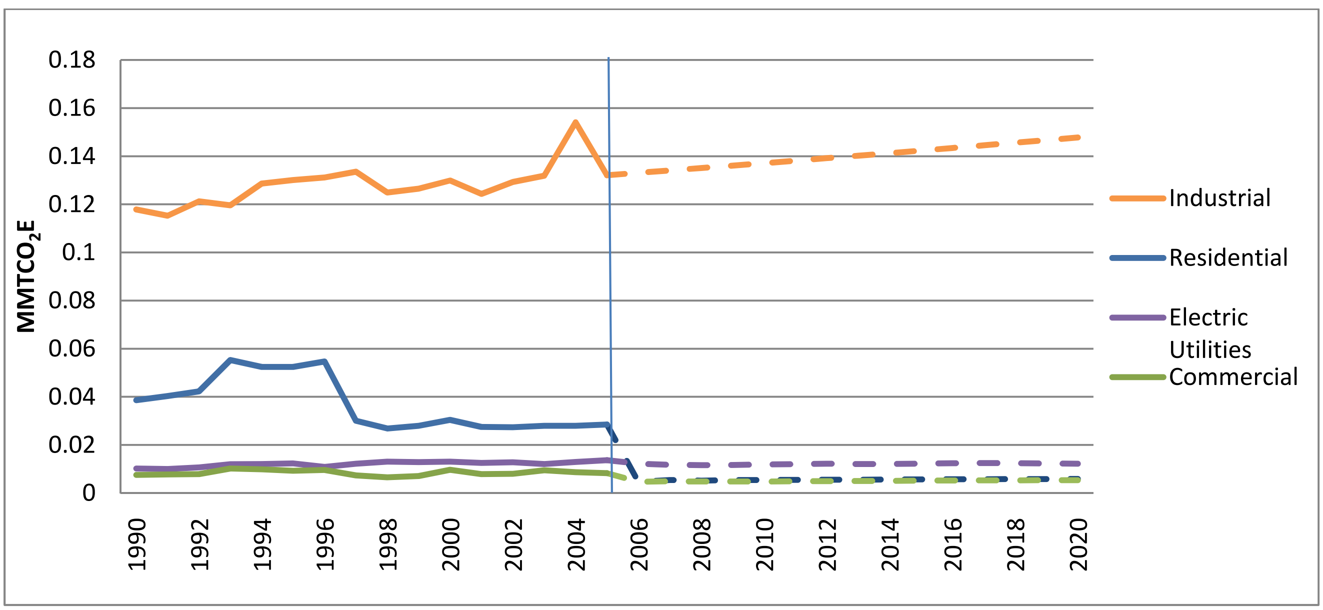


Figure 3.4-7. Estimates of Louisiana's methane (CH_4) emissions from stationary combustion sources, by sector, over the period 1990-2020.

Mobile Sources

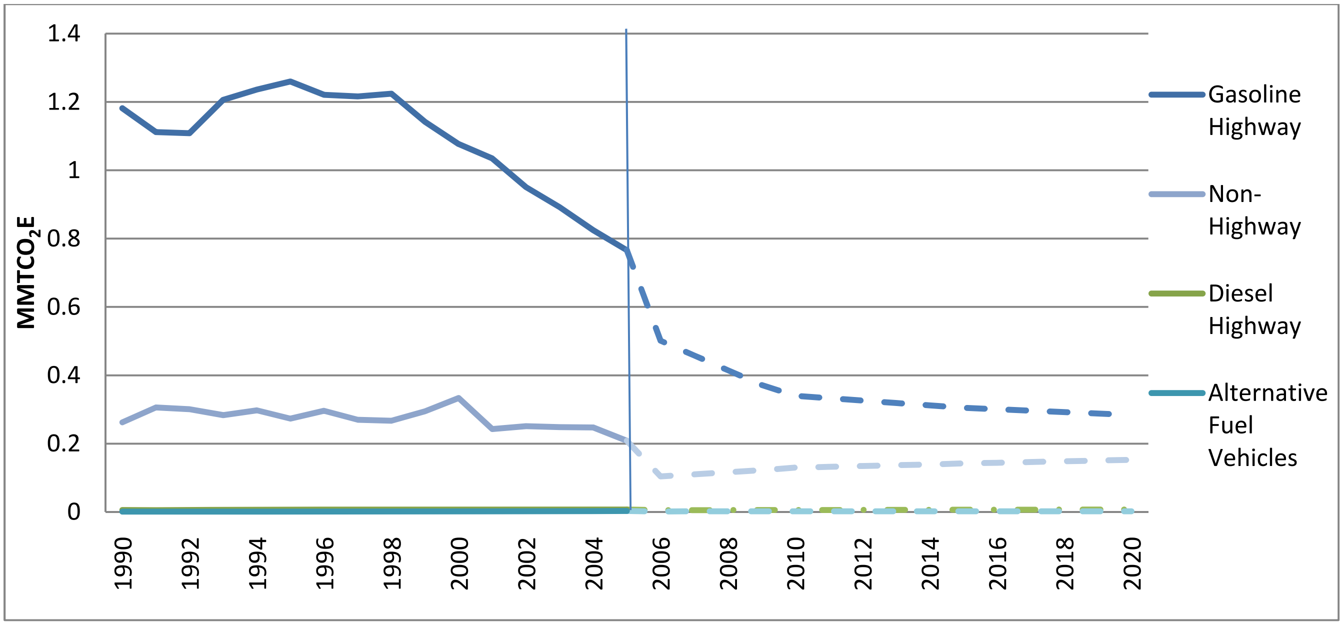


Figure 3.4-8. Estimates of Louisiana's GHG emissions from mobile sources, by fuel, over the period 1990-2020.

Industrial Processes

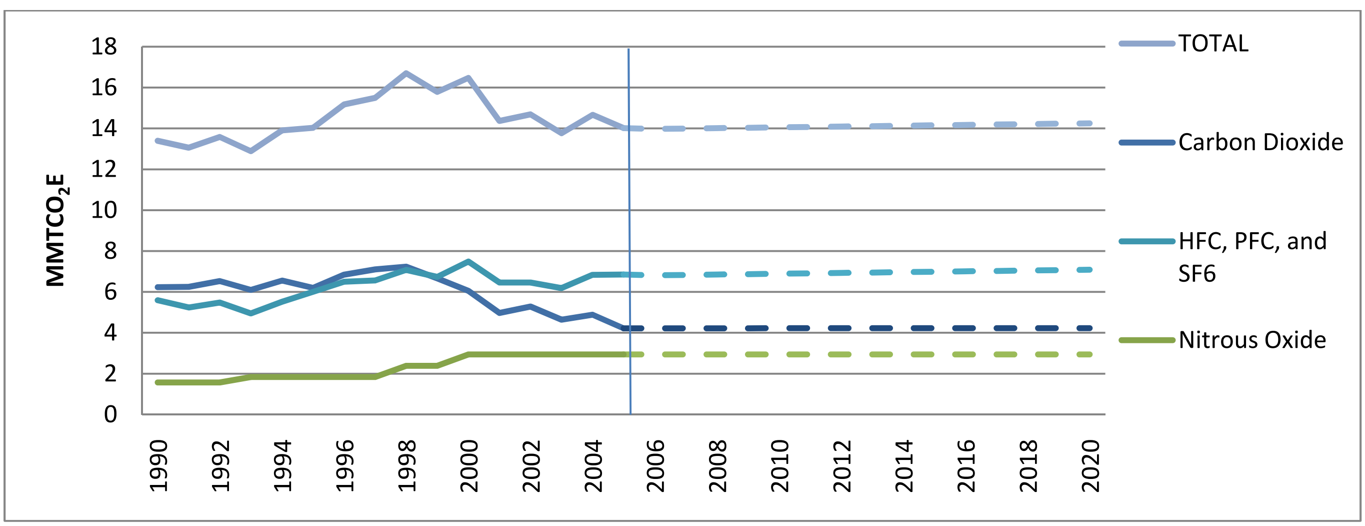


Figure 3.4-9. Estimates of Louisiana's GHG emissions from industrial processes, by gas, over the period 1990-2020.

Table 3.4-1. Sources of GHG Emissions from Industrial Processes.

Carbon Dioxide Emissions
Cement Manufacture *
Lime Manufacture *
Limestone and Dolomite Use
Soda Ash
Ammonia & Urea
Iron & Steel Production
Nitrous Oxide Emissions
Nitric Acid Production
Adipic Acid Production *
HFC, PFC, and SF6 Emissions
ODS Substitutes
Semiconductor Manufacturing *
Magnesium Production *
Electric Power Transmission and Distribution Systems
HCFC-22 Production
Aluminum Production *
*** Processes with no projected emissions in Louisiana**

Coal Mining

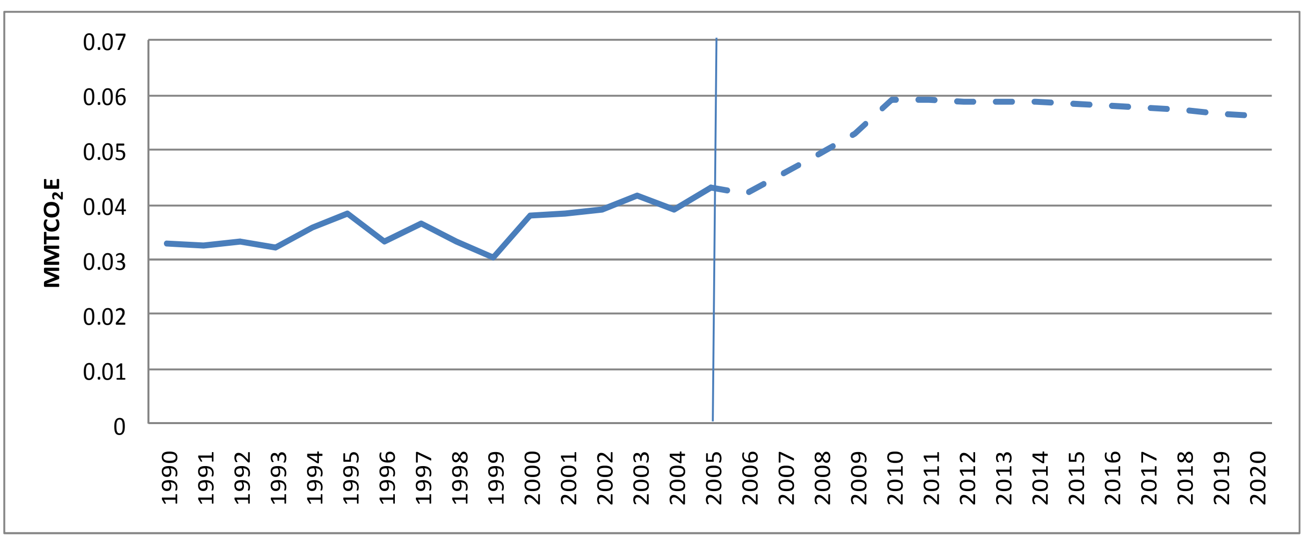


Figure 3.4-10. Estimates of Louisiana's methane (CH_4) emissions from coal mining over the period 1990-2020.

Natural Gas and Oil Systems

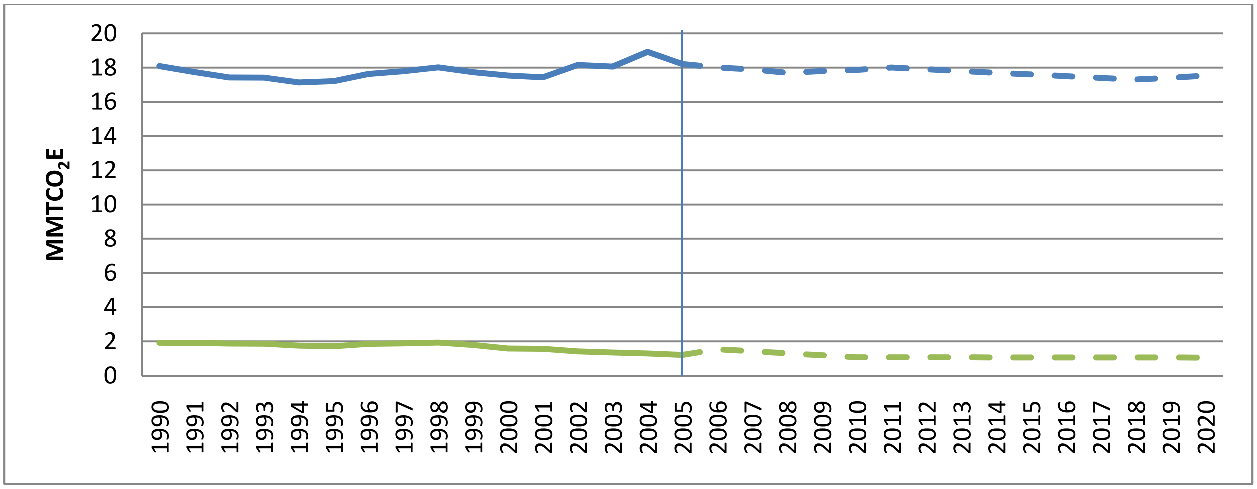


Figure 3.4-11. Estimates of Louisiana's nitrous oxide (N_20) and methane (CH_4) from natural gas and oil systems over the period 1990-2020.

Enteric Fermentation

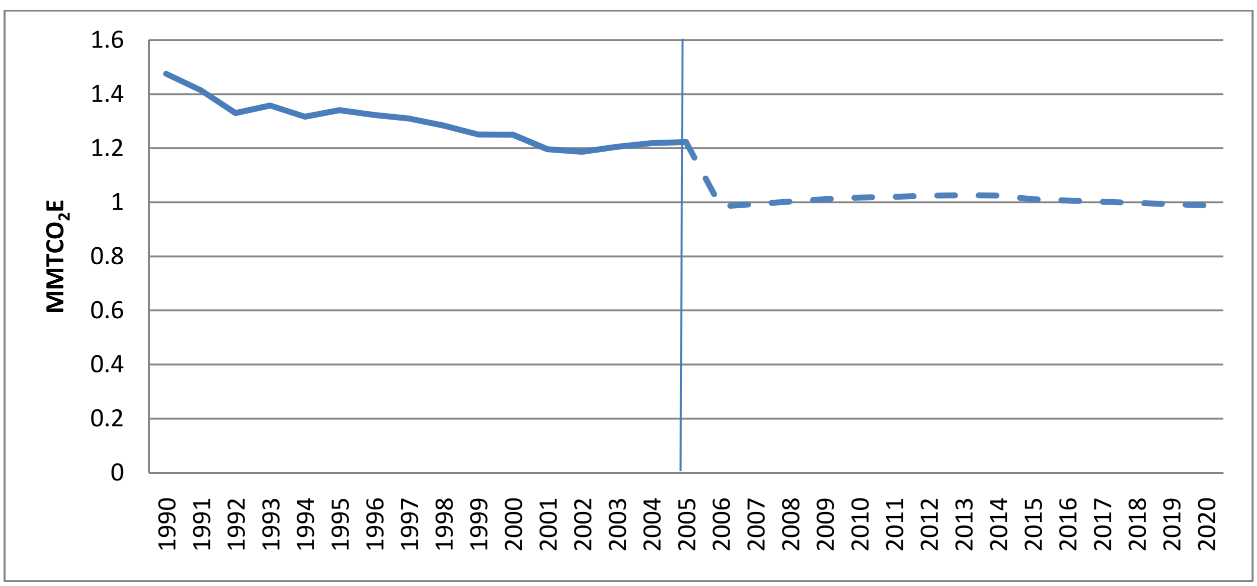


Figure 3.4-12. Estimates of Louisiana's GHG emissions from enteric fermentation over the period 1990-2020.

Manure Management

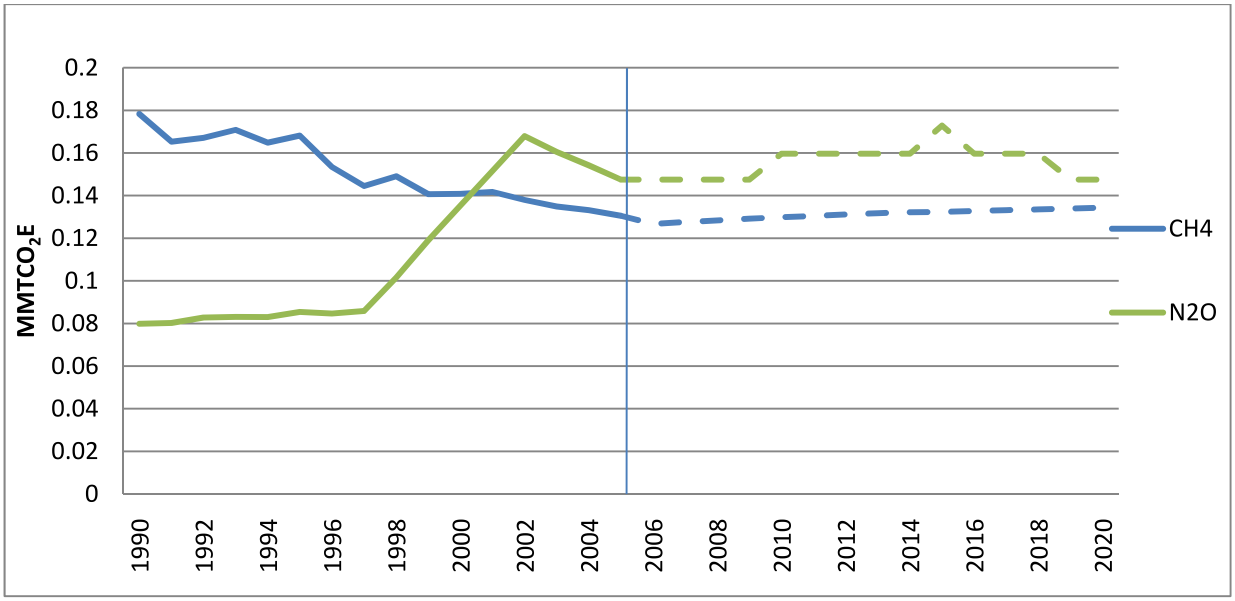


Figure 3.4-13. Estimates of Louisiana's nitrous oxide (N_20) and methane (CH_4) emissions from manure management over the period 1990-2020.

Table 3.4-2. Livestock Included in the Manure Management Emission Estimation.

Dairy Cattle	Beef Cattle	Swine	Poultry	Other
Dairy Cows	Feedlot Heifers/Steer	Breeding	Hens > 1 yr	Sheep on Feed
Dairy Replacement Heifers	Beef Heifers/ Cows	Market < 60 lb	Pullets	Sheep Not on Feed
	Bulls	Market 60-119 lb	Chickens	Goats
	Calves	Market 120-179 lb	Broilers	Horses
	Steer/Heifer Stockers	Market 180+ lb	Turkeys	

Rice Cultivation

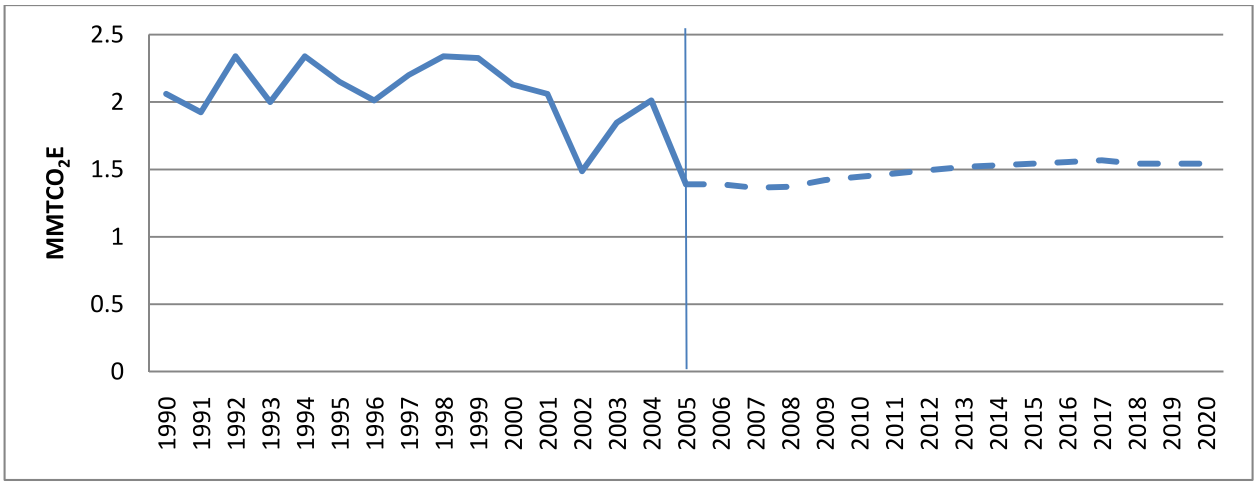


Figure 3.4-14. Estimates of Louisiana's methane (CH_4) emissions from rice cultivation over the period 1990-2020.

Agricultural Soils

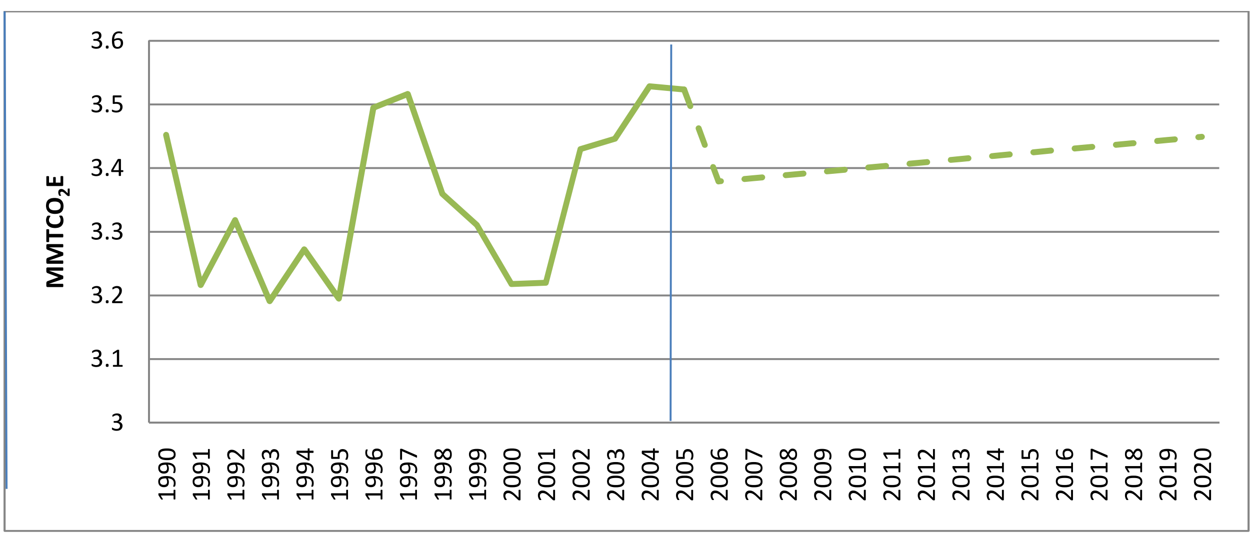


Figure 3.4-15. Estimates of Louisiana's nitrous oxide (N_20) emissions from agricultural soils over the period 1990-2020.

Agricultural Residue

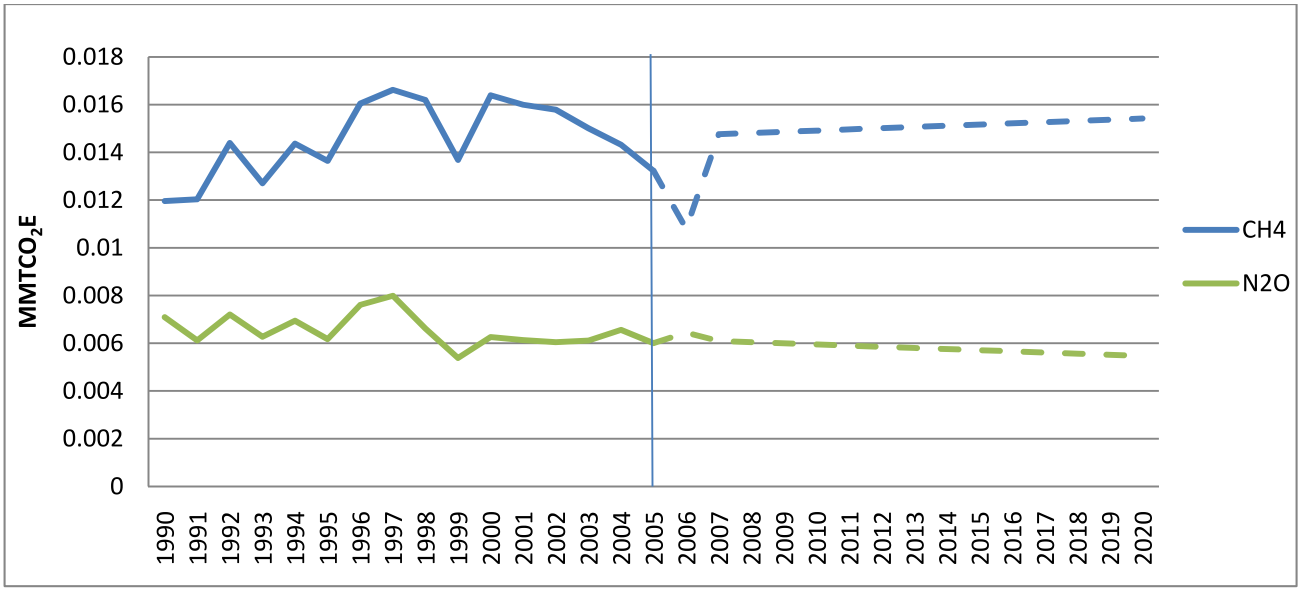


Figure 3.4-16. Estimates of Louisiana's nitrous oxide (N_20) and methane (CH_4) emissions from agricultural residue over the period 1990-2020.

Landfills and Waste Combustion

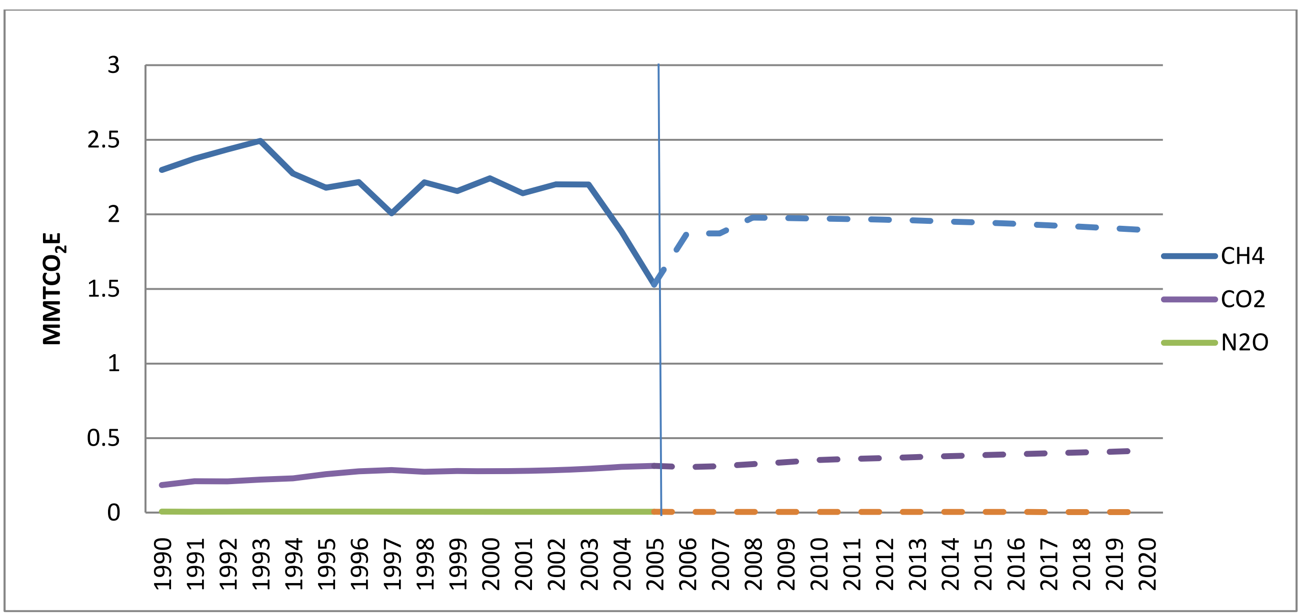


Figure 3.4-17. Estimates of Louisiana's carbon dioxide (CO_2), nitrous oxide (N_20) and methane (CH_4) emissions from landfills over the period 1990-2020.

Waste Combustion

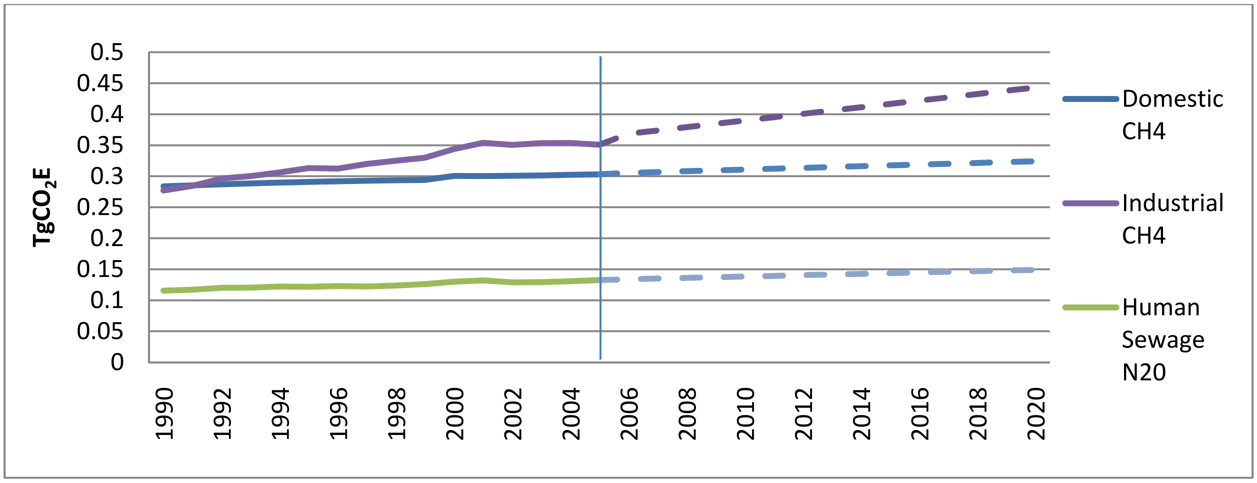


Figure 3.4-18. Estimates of Louisiana's carbon dioxide (CO_2), nitrous oxide (N_20) and methane (CH_4) emissions from solid waste combustion over the period 1990-2020.

3.5 UNCERTAINTY ASSESSMENT

3.5.1 Background

The 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006b) devotes an entire chapter (Chapter 3) to analysis of uncertainty in greenhouse gas inventories. Frey (2007) discusses the increasing demand for quantification of variability and uncertainty in emission factors and inventories, citing the importance of understanding the nature of emissions inventory data to making better decisions based on the data. He relates that inventories are used for a wide variety of decision making purposes such as:

- development of control strategies for reducing emissions;
- strategy development for emissions permit trading activities under "cap and trade" programs;
- emissions trends analysis and projection of future emissions
- permit limit determination;
- emission statements for fee collection purposes;
- permit limit determinations;
- federal and international GHG reporting requirements;
- environmental impact modeling;
- compliance determination;
- real-time air quality forecasting;
- exposure and risk analysis;
- accountability and assessments; and
- prioritization of data needs, among others.

Although the need for good quality data and an understanding of the inherent variability and uncertainty of the data is acknowledged, practical limitations are recognized. The Greenhouse Gas Protocol (2003) reports that "almost all comprehensive estimates of uncertainty for greenhouse gas inventories will be not only imperfect but will also have a subjective component." In other words, estimates of uncertainty for GHG inventories must themselves be considered highly uncertain.

IPCEA (2007) also points to the need for better assessments of uncertainty for GHG inventories. However, they recognize weaknesses in current methodology including that for accounting for fugitive emissions and the use of component-based emission factors that are mostly outdated.

This project effort was fortunate to have participants on the project team and Project Advisory Team with considerable knowledge and experience with emissions inventories stemming from direct experience (in several cases over 20 years) with emissions reporting requirements under state and federal clean air requirements as well as inventories developed for purposes of regional airshed modeling for ozone abatement. This intimate knowledge of the various sources and methods for inventorying GHG provided guidance for our approach to assessing uncertainty in our emissions estimates. This project also benefitted from data compiled in the previous Louisiana GHG survey conducted by CES in 2000.

The approach selected for uncertainty assessment for this project was primarily a qualitative one based on the working knowledge and familiarity with data sources gained through working with data sources and tools in preparing this inventory. Some of the factors that led to this approach include:

- This was a top-down inventory based on data developed by others assumed to have good quality assurance programs (e.g. EPA and EIA).
- It was recognized that GHG emission inventory methods for many sources were not yet mature.
- It was known that basic emissions characteristics for some sources were poorly understood.
- Experience with well-developed measurement techniques and emission factors for certain air pollutants were known to have variable uncertainties, almost impossible to quantify.
- Beyond our qualitative approach, little information of value was to be gained from a greater investment of effort to characterize uncertainties.

3.5.2 Level of Data Certainty

In Table 3.5.2-1, we provide a summary overview of uncertainty by major EPA SIT GHG nventory categories. Within the table, an assessment of data certainty for each category is characterized based on an assignment of "high", "medium", or "low" by consensus of the project team. A designation of "high" indicates data sources from agencies/organizations with established data gathering techniques and accepted analysis and reporting protocols. A designation of "low" implies data known to have high variability/uncertainty for any number of reasons including poorly understood emissions characteristics, questionable measurement accuracy, or inadequate emissions factors. A designation of "medium" might imply a mix of reliable and questionable data over different periods of time or data known to be reasonably reliable but with unexplained variability. Comments about the source/quality of the data are provided for the major SIT categories as appropriate to help explain the quality assignments.

Table 3.5.2-1. GHG Inventory Uncertainties, by SIT Module.

Module	Category	Default Data	Non-Default Data	Level of Certainty	Comments
AGRICULTURE	Enteric Fermentation	X		High	USDA, NASS Published Estimates Data Base
	Manure Management	X	X	Medium	Used USDA 5-year census data for broilers & turkeys
	Rice Cultivation	X		High	USDA, NASS Published Estimates Data Base
	Burning of Agricultural Crop Waste	X		High	USDA, NASS data
	Residues & Legumes	X		High	USDA, NASS data
	Fertilizer	X		High	AAPFCO and The Refertilizer Institute data
	Animals & Runoff	X	X	Medium	Used USDA 5-year census data for broilers & turkeys
CO2 FROM FOSSIL FUEL COMBUSTION	Residential	X		High	US DOE, EIA (2008), "State Energy Data: Consumption Estimates 2005," http://www.eia.doe.gov/emeu/states_seds.html
	Commercial	X		High	
	Transportation	X		Medium	
	Electric Power	X		High	
	Bunker Fuels	X		Medium	
	Industrial	X		High	
COAL MINING	Surface Mines	X		High	EIA Coal Industry Annual
INDUSTRIAL PROCESSES	Lime Manufacture	X		Medium	USGS data might be missing for lime calcining for 1991-1992
	Limestone Use (non-agricul.)	X		Medium	USGS Minerals Yearbook data not available for 1990-1998
	Soda Ash Consumption	X		High	USGS Minerals Yearbook
	Ammonia Production	X		High	USGS Minerals Yearbook
	Urea Application	X		High	USGS Minerals Yearbook; (note: emissions subtracted to avoid double-counting in Agriculture Module)

Module	Category	Default Data	Non-Default Data	Level of Certainty	Comments
	Iron & Steel Production	X		Medium	Default data not available for 1990-1996
	Nitric Acid Production		X	Low	Capacity data only for limited years
	ODS Substitutes	X		Medium	Based on LA population & national per capita estimates
	Electric Power Transm. & Distr.	X		Medium	Based on LA electricity sales and national SF_6 consumption
	HCFC-22 Production		X	Low	Based on LA 1997 capacity and national production data
LAND-USE CHANGE AND FORESTRY	Liming of Agricultural Soils		X	Medium	Data not available for 1990-1995 and 1999-2000.
	Urea Fertilization	X		High	AAPFCO (2007) Commercial Fertilizers 2005
	Forest Carbon Flux	X		Low	1990 sequestration level much lower than 1991-2005
	Urban Trees	X		Medium	LA urban tree cover percent only available for 2000
	Landfilled Yard Trimmings and Food Scraps	X		Medium	Data from state sources not readily available
	Forest Fires	X	X	Medium	Data not available for 1990-1997
	N_2O from Settlement Soils	X		High	AAPFCO (2007) Commercial Fertilizers 2006.
MOBILE COMBUSTION (CH_4 and N_2O)	Highway Vehicles	X		Medium	U.S. Federal Highway Administration, "Highway Statistics," Tables VM-1 & VM-2 (http://www. fhwa.dot.gov///ohim/ohimstat.htm) US DOE, EIA (2008), “State Energy Data: Consumption Estimates 2005,” http://www.eia.doe.gov/emeu/states_seds.html US EPA. “Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2002.” EPA-430-R-04-003, 2004. http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2004.html
	Aviation	X		Medium	
	Boats & Vessels	X		Medium	
	Locomotives	X		High	
	Other Non-Highway Vehicles	X		Low	
	Alternative Fuel Vehicles	X		High	

Module	Category	Default Data	Non-Default Data	Level of Certainty	Comments
NATURAL GAS AND OIL SYSTEMS	**Natural Gas Production**				
	Onshore gas wells	X		High	EIA's Natural Gas Navigator
	Shallow water platforms		X	Low	Platform count not available
	Natural Gas Transmission				
	Miles of gathering pipeline		X	High	AGA, Gas Facts (1997-1998 interpolated)
	Gas processing plants		X	Medium	Plant count from Oil & Gas Journal; module emission factor not based on plant size
	LNG stations		X	High	FERC count of existing LNG stations
	Miles of transmission pipeline		X	High	AGA, Gas Facts (1997-1998 interpolated)
	Transmission compressor stations	Not used	X	Medium	Used 2007 estimate and ratio of transm. compressor stations to mile of transm. pipeline
	Storage compressor stations	Not used	X	Medium	Used 2007 estimate and ratio of storage compressor stations to mile of transm. pipeline
	Natural Gas Distribution				
	NaturalGas Distribution Miles of distribution pipeline		X	High	AGA, Gas Facts (1997-1998 interpolated)
	Total # of services		X	Medium	PHMSA data filtered for state of operation = LA
	# of unprotected steel services		X	Medium	PHMSA data filtered for state of operation = LA
	# of protected steel services		X	Medium	PHMSA data filtered for state of operation = LA
	Natural Gas Vented and Flared	X		High	EIA's Natural Gas Navigator
	Petroleum Systems				
	Oil Production	X		High	EIA Petroleum Supply Annual
	Oil Refining		X	Medium	Ratio of state/PADD refining capacity multiplied by PADD gross crude input

Module	Category	Default Data	Non-Default Data	Level of Certainty	Comments
	Oil Transportation		X	Medium	Oil transported same as refined
SOLID WASTE	Municipal Solid Waste Landfills	X		Medium	Used default; state data not available in summary form
	Industrial Landfills	X		Medium	Assumed to be 7% of MSW landfill emissions
	Methane Flaring	X		High	EPA 2006BY US Inventory, Flare Database.xls
	Landfill Gas-to-Energy	X		High	EPA Landfill Methane and Outreach Program database
	Landfill Oxidation	X		Medium	EPA default percent
	Solid Waste Combustion	Not used	Not used	High	No MSW combusted in LA according to LDEQ 1990-2005
STATIONARY COMBUSTION (CH_4 and N_2O)	Residential	X		High	US DOE, EIA (2008), "State Energy Data: Consumption Estimates 2005," http://www.eia.doe.gov/emeu/states_seds.html
	Commercial	X		High	
	Industrial	X		High	
	Electric Utilities	X		High	
WASTEWATER	**Municipal Wastewater**	X		Medium	Based on default emission factors and state population
	Industrial Wastewater Fruit and Vegetables		X	Medium	LSU AgCenter, data estimated for 1990-1997
	Red Meat	X		High	USDA Quick Stats, Annual Red Meat Production.
	Poultry		X	Medium	LSU AgCenter, data estimated for 1990-1995.
	Pulp and Paper		X	Low	Capacity data only available for 2000

3.5.3 Issues with Major Inventory Tools

Emissions Data Concerns

In addition to the assessment of uncertainties within our GHG inventory, we felt it was important to delineate some of the weaknesses we found in the several major sources of information we used in developing our inventory. Hopefully, this will be helpful for others in their GHG inventory efforts.

EPA State Inventory Tool (SIT)

Although overall an outstanding and helpful tool for putting together a state GHG inventory, it should be recognized that there are areas of weakness within the SIT modules.

1. Default values – Although the overwhelming majority of default values provided for Louisiana in the SIT modules, there were some that were clearly out of line when compared to other sources of Louisiana data. One example was in the oil and gas activities module where default values were clearly at odds with locally derived data. It is suggested that all SIT module default value series be checked where possible against other sources of comparable data.

2. Fossil fuel combustion (FFC) CO_2 data presented in the EPA SIT was consistently higher than corresponding EIA data – In this analysis we relied heavily on EIA FFC data for trend analyses and comparison with other states. It was recognized early on that there was a fairly consistent discrepancy between FCC CO_2 emissions reported by EIA and those for the same source categories reported in the EPA SIT tool. The major differences appeared to be in the industrial FFC emissions reporting as shown in Figures 3.5.3-1 and 3.5.3-2.

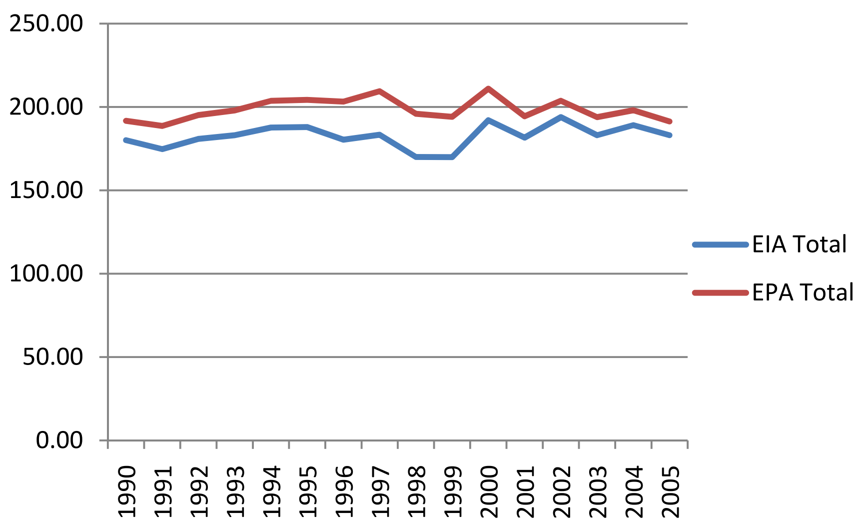


Figure 3.5.3-1. Comparison of EPA and EIA total fossil fuel combustion CO_2 emission estimates ($MMTCO_2E$) for Louisiana, 1990-2005.

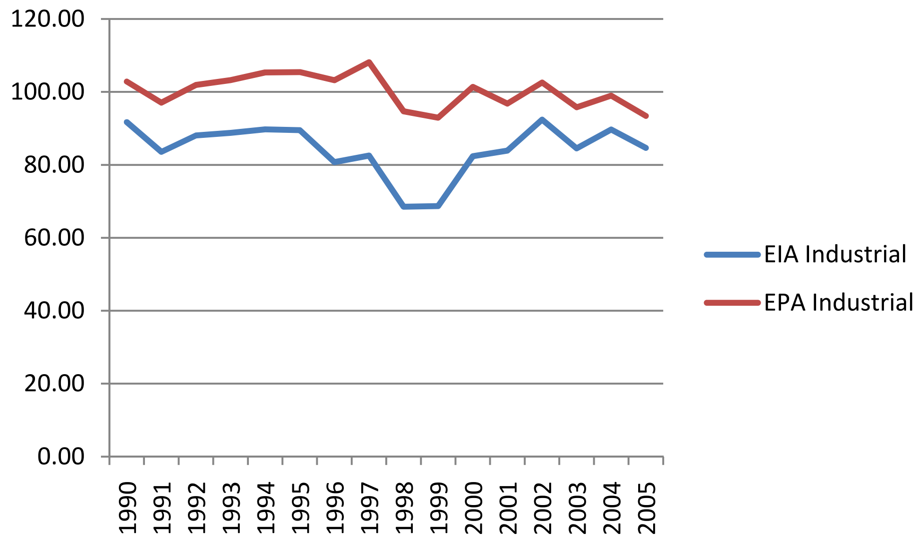


Figure 3.5.3-2. Comparison of EPA and EIA industrial fossil fuel combustion CO_2 emission estimates ($MMTCO_2E$) for Louisiana, 1990-2005.

3. CO2 emissions from industrial processes – During the course of this project our research uncovered several significant sources of CO_2 not addressed in the EPA SIT module. In the Industrial Processes module, CO_2 emissions from ammonia production are covered. However, CO_2 emissions from industrial gas facilities and refineries producing hydrogen via steam methane reforming were not addressed in the SIT. This was confirmed through communication with EPA and its SIT contractor, ICF. Additionally, we also learned late in the project that there were sources of CO_2 emissions from chemical manufacturing that were not related to fuel combustion that were also not addressed in the SIT modules.

4. Projection Module – When working with the Projection Module, we found that a number of projections for Louisiana emission sources were clearly off the mark. It appeared that projections were often based on algorithms or trends for several previous years that we recognized were clearly inappropriate for known circumstances. It is suggested that projections for all source categories be checked before the projections are combined into a projection of total GHG emissions.

DOE Energy Information Administration

1. Inconsistencies between different annual reports/tables – Overall, the EIA data were considered to be of high quality, and information obtained through the State Emissions Data System (SEDS) were particularly helpful for our efforts. However, we did run into some inconsistencies with specific reported values between tables. These may be explained by corrections or adjustments for one table not being carried back to earlier tables.

2. FFC CO_2 data consistently lower than corresponding EPA data – See discussion in Item 2 under EPA SIT above.

WRI Climate Analysis Indicators Tool (CAIT-US)

1. Incomplete understanding of sources of their data (e.g. EPA/EIA) – The CAIT-US tool was very helpful for looking at trends and relationships between GHG emissions and other parameters, such as economic indicators, energy use, and vehicle miles traveled. Although it appears that CAIT-US relied on both EPA and EIA sources, it is not clear specifically what sources were used for some datasets. This could probably have been elucidated with communications to the World Resources Institute.

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