Appendix C. Transportation Energy Use

Overview

Transportation is one the largest GHG source sectors in Florida. The transportation sector includes light- and heavy-duty (onroad) vehicles, aircraft, rail engines, and marine engines. Carbon dioxide (CO_2) accounts for about 98% of the transportation sector's GHG emissions in 1990 as well as in 2025. Most of the remaining GHG emissions from the transportation sector are due to nitrous oxide (N_2O) emissions from gasoline engines.

Historical Emissions and Reference Case Projections

Historical GHG emissions were estimated using the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) software and the methods provided in the Emission Inventory Improvement Program (EIIP) guidance document for the sector.[1,2] For onroad vehicles, the CO_2 emission factors are in units of pounds (lb) per million British thermal unit (MMBtu) and the methane (CH_4) and N_2O emission factors are both in units of grams per vehicle mile traveled (VMT). Key assumptions in this analysis are listed in Table C-1. The default fuel consumption data within SIT were used to estimate emissions, with the most recently available fuel consumption data (2004 or 2005) from the United States Department of Energy (US DOE) Energy Information Administration's (EIA) *State Energy Data* (SED) added.[3] The default VMT data in SIT were replaced with annual VMT from the Florida Department of Transportation (DOT).[4] Default data from the Federal Highway Administration (FHWA)[5] were used to allocate the VMT to vehicle types.

Onroad Vehicles

Total annual VMT data for the years 1990 through 2005 were obtained from Florida DOT.[6] These data were used to replace the default SIT VMT data for calculating CH_4 and N_2O emissions. The VMT data from Florida DOT were distributed to the SIT vehicle types in the same proportion as the default VMT data in the SIT. The default EIA SED data were used to calculate the CO_2 emissions from onroad vehicles for the historical years. Gasoline consumption estimates for 1990-2005 were adjusted by subtracting ethanol consumption, per the methodology used in SIT. The historical EIA ethanol consumption data show that use of ethanol in Florida has declined from 0.13% of the gasoline consumption in 1990 to less than 0.001% in 2005. Florida

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[1] CO_2 emissions were calculated using SIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 1. "Methods for Estimating Carbon Dioxide Emissions from Combustion of Fossil Fuels", August 2004.

[2] CH_4 and N_2O emissions were calculated using SIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 3. "Methods for Estimating Methane and Nitrous Oxide Emissions from Mobile Combustion", August 2004.

[3] Energy Information Administration, State Energy Consumption, Price, and Expenditure Estimates (SED), http://www.eia.doe.gov/emeu/states/_seds.html

[4] VMT provided by Gordon Morgan, Transportation Statistics Office, Florida Department of Transportation.

[5] Highway Statistics, Federal Highway Administration, http://www.fhwa.dot.gov/policy/ohpi/hss/index.htm.

[6] VMT provided by Gordon Morgan, Transportation Statistics Office, Florida Department of Transportation.

ethanol distributors have plans to increase consumption of ethanol in the state to reach around 1% of gasoline consumption.[7] However, for the reference case projections, ethanol consumption is assumed to remain at the 2005 consumption level (0.0005% of total gasoline consumption). Planned increases in ethanol consumption within the state may be included as a mitigation strategy.

Onroad vehicle gasoline and diesel emissions were projected through 2025 based on statewide VMT growth rates developed by Florida DOT from linear extrapolation of the historical Florida 2001-2005 VMT data.[8] The resulting total annual VMT data were then allocated by vehicle type based on national VMT forecasts by vehicle type reported in EIA's *Annual Energy Outlook 2007* (AEO2007).[9] The AEO2007 data were incorporated because they indicate significantly different VMT growth rates for certain vehicle types (e.g., 27 percent growth between 2005 and 2025 in light-duty gasoline vehicle VMT versus 61 percent growth in heavy-duty diesel truck VMT over this period). The AEO2007 vehicle type-based national growth rates were applied to the 2005 Florida estimates of VMT by vehicle type. These VMT data were then proportionally adjusted to total to the projected statewide VMT totals for each year. The resulting vehicle-type VMT estimates and compound annual average growth rates are displayed in Tables C-2 and C-3, respectively. These VMT growth rates were used to forecast the CH_4 and N_2O emissions from onroad gasoline and diesel vehicles.

For forecasting CO_2 emissions, growth in fuel consumption is needed. The historical onroad gasoline and diesel fuel consumption data were forecasted through 2025 by developing a set of growth factors that adjusted the VMT projections shown in Table C-3 to account for improvements in vehicle fuel efficiency. Projected calendar year fuel efficiency data were obtained from EPA. The resulting onroad fuel consumption growth rates are shown in Table C-4. Growth rates for projecting CO_2 emissions from natural gas and LPG vehicles were calculated by allocating the AEO2007 consumption of these fuels in the South Atlantic region and allocating this to Florida based on the ratio of the State's projected population to the region's projected population. The historic data for lubricants shows no significant positive or negative trend; therefore, no growth was assumed for lubricants.

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[7] *Phase 1 Report: Florida's Energy and Climate Change Action Plan*, Governor's Action Team on Energy and Climate Change, November 1, 2007 http://www.dep.state.fl.us/climatechange/files/20071101_final_report.pdf

[8] Linear VMT projection provided to CCS by Kathy Neill, Director, Office of Policy Planning, Florida Department of Transportation, in Excel file "Annual VMT projection 032008.xls," April 16, 2008.

[9] US Department of Energy, Energy Information Administration, *Annual Energy Outlook 2007 with Projections to 2030*, DOE/EIA-0383(2007), February 2007, available at http://www.eia.doe.gov/oiaf/aeo/index.html.

Table C-1. Key Assumptions and Methods for the Transportation Inventory and Projections

Vehicle Type and Pollutants	Methods
Onroad gasoline, diesel, natural gas, and liquefied petroleum gas (LPG) vehicles – CO_2	**Inventory (1990-2005)** US EPA SIT and fuel consumption from EIA SED **Reference Case Projections (2006-2025)** Gasoline and diesel fuel use projected using linear projections of 1990-2005 VMT data and adjusted fuel efficiency improvement projections from EPA. Other onroad fuels projected using South Atlantic Region fuel consumption projections from EIA AEO2007 adjusted using state-to-regional ratio of population growth.
Onroad gasoline and diesel vehicles – CH_4 and N_2O	**Inventory (1990-2005)** State total VMT replaced with VMT provided by Florida DOT, VMT allocated by vehicle type using default data in SIT. **Reference Case Projections (2006-2025)** State total VMT forecasted to 2025 by linear projection of 2001-2005 VMT data from Florida DOT and allocated to vehicle types using vehicle specific growth rates from AEO2007.
Non-highway fuel consumption (jet aircraft, gasoline-fueled piston aircraft, boats, locomotives) – CO_2, CH_4 and N_2O	**Inventory (1990-2005)** US EPA SIT and fuel consumption from EIA SED. Commercial marine based on allocation of national fuel consumption. **Reference Case Projections (2006-2025)** Aircraft projected using aircraft operations projections from Florida DOT and Federal Aviation Administration (FAA). No growth assumed for rail diesel. Marine gasoline projected based on historical data.

Table C-2. Florida Vehicle Miles Traveled Estimates (millions)

Vehicle Type	2005	2010	2015	2020	2025
Heavy-Duty Diesel Vehicle	13,482	17,525	21,351	25,128	29,162
Heavy -Duty Gasoline Vehicle	1,990	2,117	2,311	2,575	2,927
Light-Duty Diesel Truck	2,039	2,792	3,814	5,300	7,682
Light-Duty Diesel Vehicle	612	839	1,146	1,592	2,307
Light-Duty Gasoline Truck	67,783	80,174	92,492	104,580	116,110
Light-Duty Gasoline Vehicle	114,937	135,950	156,837	177,335	196,884
Motorcycle	688	814	939	1,062	1,179
Total	201,531	240,211	278,891	317,571	356,251

Table C-3. Florida Vehicle Miles Traveled Compound Annual Growth Rates

Vehicle Type	2005-2010	2010-2015	2015-2020	2020-2025
Heavy-Duty Diesel Vehicle	5.4%	4.0%	3.3%	3.0%
Heavy-Duty Gasoline Vehicle	1.2%	1.8%	2.2%	2.6%
Light-Duty Diesel Truck	6.5%	6.4%	6.8%	7.7%
Light-Duty Diesel Vehicle	6.5%	6.4%	6.8%	7.7%
Light-Duty Gasoline Truck	3.4%	2.9%	2.5%	2.1%
Light-Duty Gasoline Vehicle	3.4%	2.9%	2.5%	2.1%
Motorcycle	3.4%	2.9%	2.5%	2.1%

Table C-4. Florida Onroad Fuel Consumption Compound Annual Growth Rates

Vehicle Type	2005-2010	2010-2015	2015-2020	2020-2025
Onroad gasoline	3.1%	2.7%	2.4%	2.1%
Light-Duty Gasoline Vehicle	*3.3%*	*2.9%*	*2.5%*	*2.1%*
Light-Duty Gasoline Truck	*2.9%*	*2.6%*	*2.3%*	*2.0%*
Heavy-Duty Gasoline Vehicle	*1.0%*	*1.6%*	*2.2%*	*2.6%*
Motorcycle	*3.4%*	*2.9%*	*2.5%*	*2.1%*
Onroad diesel	5.1%	4.2%	3.6%	3.4%
Light-Duty Diesel Vehicle	*4.6%*	*6.4%*	*6.8%*	*7.7%*
Light-Duty Diesel Truck	*5.9%*	*6.4%*	*6.6%*	*7.6%*
Heavy-Duty Diesel Vehicle	*5.1%*	*4.0%*	*3.3%*	*3.0%*

Aviation

For the aircraft sector, emission estimates for 1990 to 2005 are based on SIT methods and fuel consumption from EIA. Emissions were projected from 2005 to 2025 using general aviation and commercial aircraft operations for 2005 through 2025 from Florida DOT[10] and military operations for 2005 through 2025 from the Federal Aviation Administration's (FAA) Terminal Area Forecast System[11] and national aircraft fuel efficiency forecasts. To estimate changes in jet fuel consumption, aircraft operations from air carrier, air taxi/commuter, and military aircraft were first summed for each year of interest. The post-2005 estimates were adjusted to reflect the projected increase in national aircraft fuel efficiency (indicated by increased number of seat miles per gallon), as reported in AEO2007. Because AEO2007 does not estimate fuel efficiency changes for general aviation aircraft, forecast changes in aviation gasoline consumption were based solely on the projected number of itinerant general aviation aircraft operations in Florida, which was obtained from the FAA source noted above. The resulting compound annual average growth rates are displayed in Table C-5.

[10] Aviation Data and Forecasts, Florida Department of Transportation. http://www.dot.state.fl.us/aviation/dataforecasts.htm.
[11] Terminal Area Forecast, Federal Aviation Administration, http://www.apo.data.faa.gov/main/taf.asp.

Table C-5. Florida Aviation Fuels Compound Annual Growth Rates

Fuel	2005-2010	2010-2015	2015-2020	2020-2025
Aviation Gasoline	0.8%	1.5%	1.5%	1.5%
Jet Fuel	0.4%	1.7%	1.8%	1.9%

Rail and Marine Vehicles

For the rail and recreational marine sectors, 1990-2005 estimates are based on SIT methods and fuel consumption from EIA. Marine gasoline consumption was projected to 2025 based on a linear regression of the 1990 through 2005 historical data. The historic data for rail shows no significant positive or negative trend; therefore, no growth was assumed for this sector.

For the commercial marine sector (marine diesel and residual fuel), 1990-2005 emission estimates are based on SIT emission rates applied to estimates of Florida marine vessel diesel and residual fuel consumption. Because the SIT default relies on marine vessel fuel consumption estimates that represent the State in which fuel is sold rather than consumed, an alternative method was used to estimate Florida marine vessel fuel consumption. Florida fuel consumption estimates were developed by allocating 1990-2005 national diesel and residual oil vessel bunkering fuel consumption estimates obtained from EIA.[12] Marine vessel fuel consumption was allocated to Florida using the marine vessel activity allocation methods/data compiled to support the development of EPA's National Emissions Inventory (NEI).[13] In keeping with the NEI, 75% of each year's distillate fuel and 25% of each year's residual fuel were assumed to be consumed within the port area (remaining consumption was assumed to occur while ships are underway). National port area fuel consumption was allocated to Florida based on year-specific freight tonnage data by state as reported in "Waterborne Commerce of the United States, Part 5 – Waterways and Harbors National Summaries."[14] Offshore CO_2 and hydrocarbon (HC) emissions for Florida's exclusive economic zone (EEZ) were taken from a study by James Corbett for the Commission for Environmental Cooperation (CEC) in North America.[15] Offshore CH_4 emissions were estimated by speciating the HC emissions using the California Air Resources Board's total organic gas (TOG) profile (#818).[16] Offshore N_2O emissions were estimated by applying the ratio of N_2O to CH_4 emission factors to the CH_4 emission estimate. The 2002 offshore emissions from the CEC inventory were scaled to other historic years based on the estimated underway

[12] US Department of Energy, Energy Information Administration, "Petroleum Navigator" (diesel data obtained from http://tonto.eia.doe.gov/dnav/pet/hist/kd0vabnus1a.htm; residual data obtained from http://tonto.eia.doe.gov/dnav/pet/hist/kprvatnus1a.htm).
[13] See methods described in ftp://ftp.epa.gov/EmisInventory/2002finalnei/documentation/mobile/2002nei_mobile_nonroad_methods.pdf
[14] Waterborne Commerce Statistics Center, http://www.iwr.usace.army.mil/ndc/wcsc/wcsc.htm.
[15] Estimate, Validation, and Forecasts of Regional Commercial Marine Vessel Inventories, submitted by J. Corbett, prepared for the California Air Resources Board, California Environmental Protection Agency, and Commission for Environmental Cooperation in North America, http://coast.cms.udel.edu/NorthAmericanSTEEM/.
[16] California Air Resources Board, Speciation Profiles, http://www.arb.ca.gov/ei/speciate/speciate.htm.

diesel and residual fuel consumption. Port and offshore commercial marine emissions were projected using linear regression based on the 1990 through 2005 emission data.

Nonroad Engines

It should be noted that fuel consumption data from EIA includes nonroad gasoline and diesel fuel consumption in the commercial and industrial sectors. Emissions from these nonroad engines, including nonroad vehicles such as dirt bikes, are included in the inventory and forecast for the residential, commercial, and industrial (RCI) sectors. Table C-6 shows how EIA divides gasoline and diesel fuel consumption between the transportation, commercial, and industrial sectors.

Table C-6. EIA Classification of Gasoline and Diesel Consumption

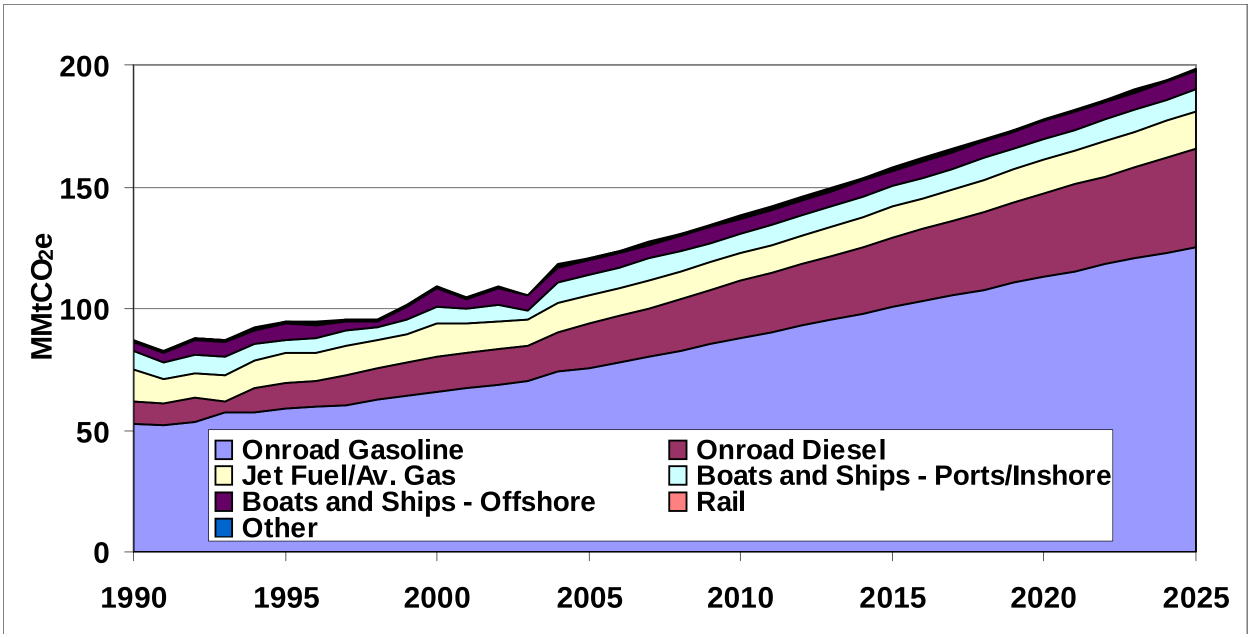
Sector	Gasoline Consumption	Diesel Consumption
Transportation	Highway vehicles, marine	Vessel bunkering, military use, railroad, highway vehicles
Commercial	Public non-highway, miscellaneous use	Commercial use for space heating, water heating, and cooking
Industrial	Agricultural use, construction, industrial and commercial use	Industrial use, agricultural use, oil company use, off-highway vehicles

Results

As shown in Figure C-1 and in Table C-7, onroad gasoline consumption accounts for the largest share of transportation GHG emissions. Emissions from onroad gasoline vehicles increased by about 44% from 1990 to 2005, accounting for 63% of total transportation emissions in 2005. GHG emissions from onroad diesel fuel consumption increased by 88% from 1990 to 2005, and by 2005 accounted for 15% of GHG emissions from the transportation sector. Emissions from boats and ships increased by 35% from 1990 to 2005 to account for 12% of transportation emissions in 2005. . Emissions from aviation decreased by 13% from 1990 to 2005 to account for 9% of transportation emissions in 2005. Emissions from all other categories combined (locomotives, natural gas, liquefied petroleum gas (LPG), and oxidation of lubricants) contributed about 1% of total transportation emissions in 2005.

GHG emissions from onroad gasoline consumption are projected to increase by about 66%, and emissions from onroad diesel consumption are expected to increase by 123% between 2005 and 2025. Aviation emissions are projected to increase by 33% from 2005 to 2025, while marine emissions are projected to increase by 11% from 2005 to 2025.

Figure C-1. Transportation Gross GHG Emissions by Fuel, 1990-2025



Source: CCS calculations based on approach described in text.

Table C-7. Gross GHG Emissions from Transportation ($MMtCO_2e$)

Source	**1990**	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
Onroad Gasoline	52.39	58.90	66.00	75.52	87.89	100.57	113.25	125.51
Automobiles	*33.81*	*33.56*	*36.68*	*40.86*	*48.14*	*55.54*	*62.79*	*69.72*
Light-Duty Trucks	*16.86*	*23.57*	*27.60*	*32.76*	*37.73*	*42.85*	*48.01*	*53.02*
Heavy-Duty Trucks/Buses	*1.62*	*1.67*	*1.62*	*1.78*	*1.88*	*2.03*	*2.26*	*2.57*
Motorcycles	*0.09*	*0.10*	*0.11*	*0.12*	*0.14*	*0.16*	*0.18*	*0.20*
Onroad Diesel	9.63	10.92	13.85	18.10	23.25	28.55	34.03	40.31
Automobiles	*0.27*	*0.21*	*0.19*	*0.18*	*0.23*	*0.32*	*0.44*	*0.63*
Light-Duty Trucks	*0.44*	*0.62*	*0.84*	*0.99*	*1.31*	*1.80*	*2.47*	*3.56*
Heavy-Duty Trucks/Buses	*8.92*	*10.09*	*12.82*	*16.93*	*21.70*	*26.44*	*31.12*	*36.11*
Jet Fuel/Aviation Gas	13.10	11.49	14.34	11.37	11.58	12.59	13.73	15.11
Boats and Ships - Ports/Inshore	7.12	5.91	6.89	8.92	8.00	8.37	8.74	9.12
Boats and Ships - Offshore	3.88	6.63	7.42	5.89	6.25	6.61	6.97	7.33
Rail	0.31	0.68	0.28	0.57	0.57	0.57	0.57	0.57
Other	0.39	0.36	0.40	0.38	0.41	0.43	0.46	0.49
Total	**86.81**	**94.89**	**109.19**	**120.75**	**137.94**	**157.69**	**177.75**	**198.44**

Key Uncertainties

Uncertainties in Onroad Fuel Consumption

A major uncertainty in this analysis is the conversion of the projected VMT to fuel consumption. These are based on first allocating Florida's total VMT by vehicle type using national vehicle type growth projections from AEO2007 modeling, which may not reflect Florida conditions. The conversion of the VMT data to fuel consumption also includes national assumptions regarding fuel economy by vehicle type. Due to the large tourist industry in Florida, and the associated use of rental cars with the tourist industry, the Florida fleet may have a higher average fuel economy than the national fleet due to the use of relatively new vehicles in the rental car industry. If this is the case, then the onroad emissions growth may be overestimated for Florida. The Florida Department of Environmental Protection is in the process of obtaining and processing vehicle registration data for Florida. The GHG emission projections may be revised once these data are available so that the GHG projections use a more realistic estimate of fleet turnover in Florida.
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Energy Independence and Security Act of 2007

The reference case projections documented here do not include the corporate average fuel economy (CAFÉ) or biofuels provisions (or any other provisions) of the Energy Independence and Security Act of 2007. Increases in vehicle fuel economy resulting from this act would lead to reduced CO_2 emissions from onroad vehicles. Reductions attributable to the CAFÉ and biofuels provisions of this Act will be separately quantified at a later date.

Uncertainties in Aviation Fuel Consumption

The jet fuel and aviation gasoline fuel consumption from EIA is actually fuel *purchased* in the State, and therefore, includes fuel consumed during state-to-state flights and international flights. The fuel consumption associated with international air flights should not be included in the State inventory; however, data were not available to subtract this consumption from total jet fuel estimates. Another uncertainty associated with aviation emissions is the use of general aviation forecasts to project aviation gasoline consumption. General aviation aircraft consume both jet fuel and aviation gasoline, but fuel specific data were not available.

Uncertainties in Marine Fuel Consumption

There are several assumptions that introduce uncertainty into the estimates of commercial marine fuel consumption. These assumptions include:

- 75% of marine diesel and 25% of residual fuel is consumed in port; and
- The proportion of freight tonnage at ports in Florida to the total national freight tonnage reflects the proportion of national marine fuel that is consumed in Florida.