Virginia Greenhouse Gas Inventory – 2018

Virginia Department of Environmental Quality

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Summary and Overview

This report summarizes results of the economy-wide greenhouse gas (GHG) inventory carried out by the Virginia Department of Environmental Quality (DEQ), and includes sector-specific analyses and methodologies.

Released from a broad range of human activities, GHGs are gases that trap heat in the atmosphere, and include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (HFCs and SF_6). Solar radiation in the lower atmosphere acts like a greenhouse, preventing heat from escaping and contributing to global warming. To manage the risk of climate change, track progress, and identify opportunities, and as required by law, DEQ collects information on many types of pollutants, including GHGs. This information is included in the GHG inventory, which is updated every 4 years. DEQ's 2021 GHG inventory uses 2018 data, the most recent data available.

With the passage of Senate Bill 1282 Greenhouse gas emissions inventory; regulations by the General Assembly in 2021, DEQ will develop an enhanced inventory process for future inventories. The enhanced inventory will allow DEQ to gather more detailed data to supplement the default data in SIT that is currently the primary source of data. Enhanced inventory updates will occur every four years at minimum. Future inventories will be used to track progress of the Commonwealth's emissions reduction efforts, with the end goal of carbon neutrality by 2045.

During the 2018 reporting period, approximately 141 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) were emitted in the Commonwealth, approximately 18 percent less than was emitted in 2005. CO_2e is the standard way of describing GHGs so that they can be compared because different gases can have different global warming potentials. For example, a ton of methane emissions will cause at least 25 times the amount of warming as a ton of CO_2, and can be described as 25 tons of CO_2e. Approximately 52 $MMTCO_2e$ were sequestered by agriculture, soil and trees during this period, resulting in net emissions of 89 $MMTCO_2e$. The current inventory used the U.S. Environmental Protection Agency's (EPA) State Inventory Tool (SIT) to calculate Virginia's economy-wide emissions. Figure 1 depicts emissions by source.

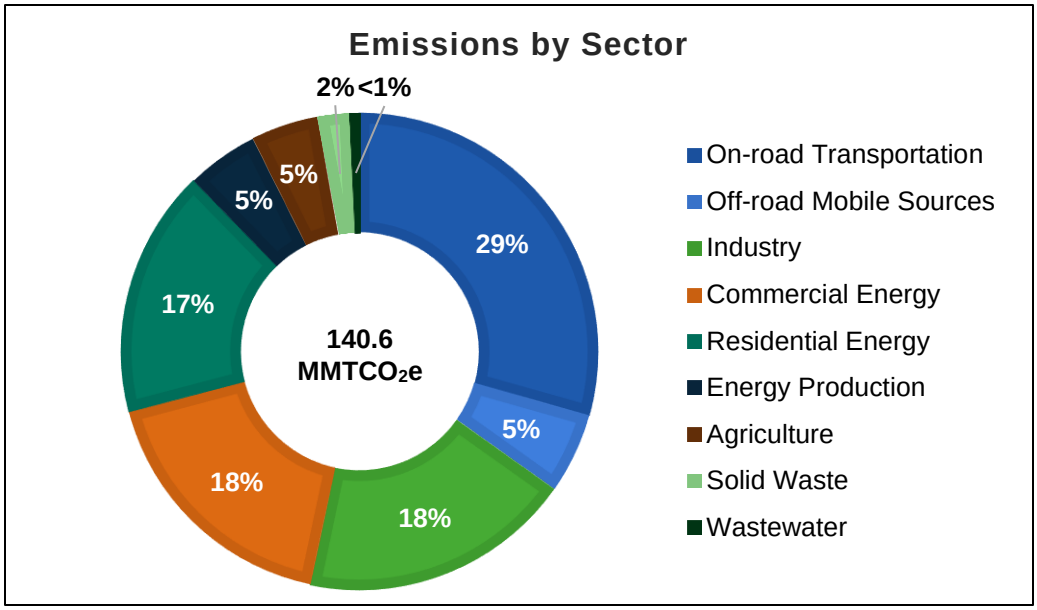

Figure 1. Sources of GHG emissions

Methodology

SIT, which was used to develop the inventory, is composed of 11 sector-specific modules:

- Agriculture
- Combustion of fossil fuels (CO_2 only)
- Coal mining
- Electricity consumption
- Industrial processes
- Land use, land use change, and forestry
- Mobile combustion (transportation)
- Natural gas and oil
- Solid waste
- Stationary combustion (CH_4 and N_2O)
- Wastewater

SIT modules contain default data for individual states, which users can select or supply their own data. DEQ used default data for most sectors, but supplemented the mobile combustion, natural gas and oil and solid waste modules. Data for these modules came from a variety of sources including: Virginia Department of Transportation (VDOT), U.S. Energy Information Administration (EIA), U.S. Office of Pipeline Safety (OPS), and DEQ.

Results produced from SIT generated ten sector source categories plus sequestration from land use, as shown in the list above. DEQ used the detailed results from SIT to generate eight alternative sector categories to represent the results in a more easily understandable format, as depicted in Figure 1, and shown below. Results by SIT category, power sector emissions and data sources can be found in the appendix.

The following sections provide sector-specific details on 2018 GHG emissions. It should be noted that most tables of results will include a breakdown of individual GHGs (CO_2, CH_4, N_2O, and others) in addition to total CO_2e. Note that the results from some SIT modules only report CO_2e, not individual gases. Therefore, CO_2e values will be higher than the sum of individual gases in many of the following sections. It should also be noted that negative values represent emissions that have been avoided or sequestered.

Transportation

The transportation sector, which consists of both on-road and off-road mobile sources as identified in Table 1 below, was the Commonwealth's highest emitter in 2018. Emissions from all transportation sources were 48.93 $MMTCO_2e$, which comprised approximately 35% of total emissions. On-road and off-road mobile source emissions were 41.28 $MMTCO_2e$ and 7.65 $MMTCO_2e$, respectively, which comprised about 29% and 6% of total emissions, respectively. Transportation emissions include CO_2, CH_4, and N_2O from on-road and off-road fuels, electricity used for light rail and vehicle lubricants. Table 1 depicts the sources of all transportation emissions by vehicle type. Table 2 depicts the sources of CO_2 emissions by fuel type. Figure 2 depicts the sources of emissions by vehicle type, grouped into on-road and off-road.

Vehicle Type	On- or off-road	Fuels Included	CO_2	CH_4	N_2O	Total
Light Duty	On	Gas, Diesel, CNG, LPG	28.042	0.0551	0.3076	28.405
Heavy Duty	On	Gas, Diesel, CNG, LPG, LNG	12.719	0.0034	0.0290	12.751
Bus	On	CNG	0.0340	0.0018	0.0019	0.0377
Motorcycle	On	Gasoline	0.0876	0.0014	0.0016	0.0906
Aviation	Off	Jet Fuel, Aviation Gasoline	4.1982	0.0034	0.0384	4.2399
Boat	Off	Gas, Diesel, Residual Fuel Oil	0.6226	0.0011	0.0047	0.6284
Rail	Off	Diesel	0.8255	0.0018	0.0069	0.8342
Tractor	Off	Gasoline, Diesel	0.2051	0.0008	0.0017	0.2076
Construction	Off	Gasoline, Diesel	1.0209	0.0014	0.0076	1.0300
Utility	Off	Gasoline, Diesel	0.3963	0.0006	0.0030	0.3999
Other	N/A	Lubricants, Electricity	0.3103	N/A	N/A	0.3103

Table 1. Transportation emissions by vehicle type ($MMTCO_2e$)

Fuel Type	$MMTCO_2$
Gasoline	29.9768
Diesel	13.8193
Jet Fuel	4.16994
Aviation Gasoline	0.02824
Residual Fuel Oil	0.12175
CNG	0.03473
LPG	0.00063
LNG	0.00004
Electricity	0.07006
Lubricants	0.24026

Table 2. Transportation CO_2 emissions by fuel type ($MMTCO_2$)

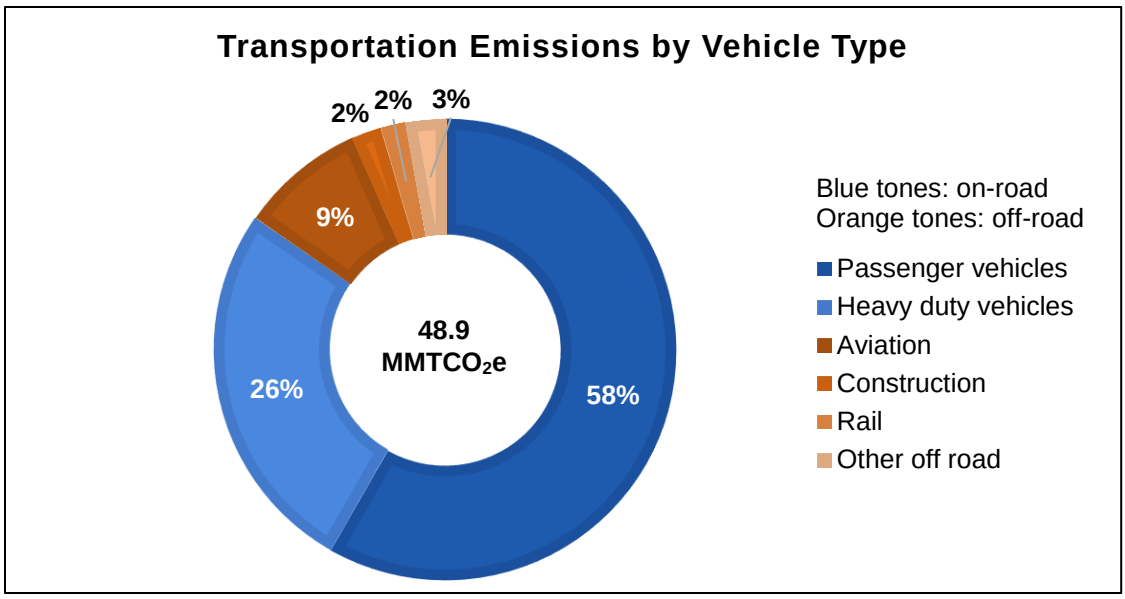

Figure 2. Transportation emissions by vehicle type, grouped by on-road and off-road ($MMTCO_2e$)

Industry

Industry was the second largest source of GHGs in the Commonwealth. Emissions from industry totaled 26.03 $MMTCO_2e$, approximately 18 percent off all GHG emissions in 2018. Sources of industrial emissions are stationary combustion of fossil fuels, electricity use and process emissions. Table 3 depicts the breakdown of industrial emissions by source. Table 4 displays the breakdown of process emissions by industry.

Source	CO_2	CH_4	N_2O	HFCs, PFCs, NF_3, SF_6	Total
Stationary Combustion	11.186	0.0578	0.0956	N/A	11.339
Electricity Use	6.2611	N/A	N/A	N/A	6.2611
Process Emissions	3.8641	N/A	N/A	4.5625	8.4266

Table 3. Industrial emissions by source ($MMTCO_2e$)

Industry	CO_2	HFCs, PFCs, NF_3, SF_6	Total
Cement	0.8102	N/A	0.8102
Lime	0.9726	N/A	0.9726
Limestone & Dolomite	0.2122	N/A	0.2122
Soda Ash	0.0524	N/A	0.0524
Iron & Steel	0.8169	N/A	0.8169
Ammonia	0.9957	N/A	0.9957
Urea	0.0040	N/A	0.0040
ODS	N/A	4.3681	4.3681
Semiconductor	N/A	0.0699	0.0699
Electric T&D	N/A	0.1245	0.1245

Table 4. Process emissions by industry ($MMTCO_2e$)

Commercial Energy

Commercial energy, the third largest source of GHG emissions, is composed of electricity use and stationary combustion of fossil fuels by commercial entities. Commercial energy emissions totaled 24.72 $MMTCO_2e$, which was approximately 18 percent of total emissions in 2018. Table 5 displays detailed emissions from the commercial sector.

Source	CO_2	CH_4	N_2O	Total
Electricity Use	18.429	N/A	N/A	18.429
Stationary Combustion	6.2505	0.0315	0.0099	6.2919

Table 5. Commercial emissions by source ($MMTCO_2e$)

Residential Energy

Residential energy is composed of electricity use and stationary combustion of fossil fuels by residential buildings. Residential energy emissions totaled 23.66 $MMTCO_2e$, which was approximately 17 percent of total emissions in 2018. Table 6 displays detailed emissions from the residential sector.

Source	CO_2	CH_4	N_2O	Total
Electricity Use	16.911	N/A	N/A	16.911
Stationary Combustion	6.6107	0.1140	0.0222	6.7469

Table 6. Residential emissions by source ($MMTCO_2e$)

Energy Production

Energy production is composed of emissions from coal mining and the production, transmission, and distribution of natural gas and oil. Energy production emissions totaled 6.85 $MMTCO_2e$, which was approximately 5 percent of all emissions in 2018. Table 7 depicts emissions by sector. Table 8 displays detailed coal mining emissions. Table 9 displays detailed natural gas and oil emissions.

Sector	CH_4
Coal Mining	4.5513
Natural Gas & Oil	2.3010

Table 7. Energy production emissions by sector ($MMTCO_2e$)

Mine Type	CH_4
Active	3.3545
Abandoned – Vented	0.1483
Abandoned – Sealed	0.6857
Abandoned – Flooded	0.3627

Table 8. Coal mining emissions by mine type ($MMTCO_2e$)

Sector	Activity	CH_4
Natural Gas	**Production**	0.81570
	Transmission	0.62943
	Distribution	0.85587
Oil	**Production**	0.00004

Table 9. Natural gas and oil emissions by activity ($MMTCO_2e$)

Agriculture

Agriculture emissions come from a variety of agricultural practices, including fertilization, livestock management and residue burning. Agriculture emissions totaled 6.42 $MMTCO_2e$, which was approximately 4 percent of all emissions in 2018. Table 10 displays agriculture emissions by source.

Source	CO_2	CH_4	N_2O	Total
Liming	0.1676	N/A	N/A	0.1676
Urea Fertilization	0.0231	N/A	N/A	0.0231
Enteric Fermentation	N/A	2.6039	N/A	2.6039
Manure Management	N/A	0.4668	0.2924	0.7592
Agricultural Residue Burning	N/A	0.0005	0.0004	0.0009
Soils	N/A	N/A	2.8685	2.8685

Table 10. Agriculture emissions by source ($MMTCO_2e$)

Solid Waste

Solid waste emissions are composed of emissions associated with decomposition in landfills and emissions from waste incineration. Solid waste emissions totaled 3.03 $MMTCO_2e$, which was approximately 2 percent of all emissions in 2018. Table 11 displays emissions from landfills. Table 12 displays emissions from waste incineration.

Source	CH_4
Potential CH_4 **(Waste Generation)**	7.6343
Avoided CH_4 **(Flaring & Landfill Gas to Energy)**	-5.3896
Oxidation	-0.2245
Net Emissions	2.0202

Table 11. Emissions from landfills ($MMTCO_2e$)

Waste Type	CO_2	CH_4	N_2O	Total
Plastic	0.6499	N/A	N/A	0.6499
Synthetic Rubber	0.0975	N/A	N/A	0.0975
Synthetic Fibers	0.2423	N/A	N/A	0.2423
Unspecified	N/A	0.0006	0.0174	0.0180

Table 12. Emissions from waste incineration by waste type ($MMTCO_2e$)

Wastewater

Wastewater emissions come from processes used by municipal and industrial wastewater treatment facilities and their effluent water discharge. Wastewater emissions totaled 0.95 $MMTCO_2e$, which was less than 1 percent of total emissions in 2018. Table 13 displays wastewater emissions by facility type.

Facility Type	CH_4	N_2O	Total
Municipal	0.6807	0.2550	0.9357
Industrial	0.0159	N/A	0.0159

Table 13. Wastewater emissions by facility type ($MMTCO_2e$)

Land Use and Forestry

The land use and forestry sector accounts for sequestration of carbon by vegetation and other land uses. This sequestration of carbon offsets emissions from other sectors. In 2018, approximately 51.76 $MMTCO_2e$ was sequestered and offset by land use and forestry. Economy-wide emissions without considering land use and forestry were 140.60 $MMTCO_2e$. When factoring in the land use and forestry sector, net economy-wide emissions were 88.84 $MMTCO_2e$ in 2018. Table 14 provides a breakdown of sources of sequestration.

Source	$MMTCO_2e$
Forestry	-47.335
Urban Trees	-2.6940
Landfilled Yard Trimmings & Food Scraps	-0.2301
N_2O from Settlement Soils	0.0382
Agricultural Soil Carbon Flux	-1.5340
Net Emissions	-51.755

Table 14. Carbon sequestered from land use and forestry ($MMTCO_2e$)

Appendix

This appendix contains additional details not included in the main portion of the inventory report. Figure 3 depicts emissions broken down by the default SIT sectors. Figure 4 depicts emissions broken down by fuel type. Power sector emissions are reported in Figure 5 and Table 15. Power sector emissions differ from electricity consumption emissions because consumption includes electricity imported from other states, as well as emissions associated with the end-use of the electricity, such as indirect emissions from heating. Table 16 provides details on data inputs and sources of this data.

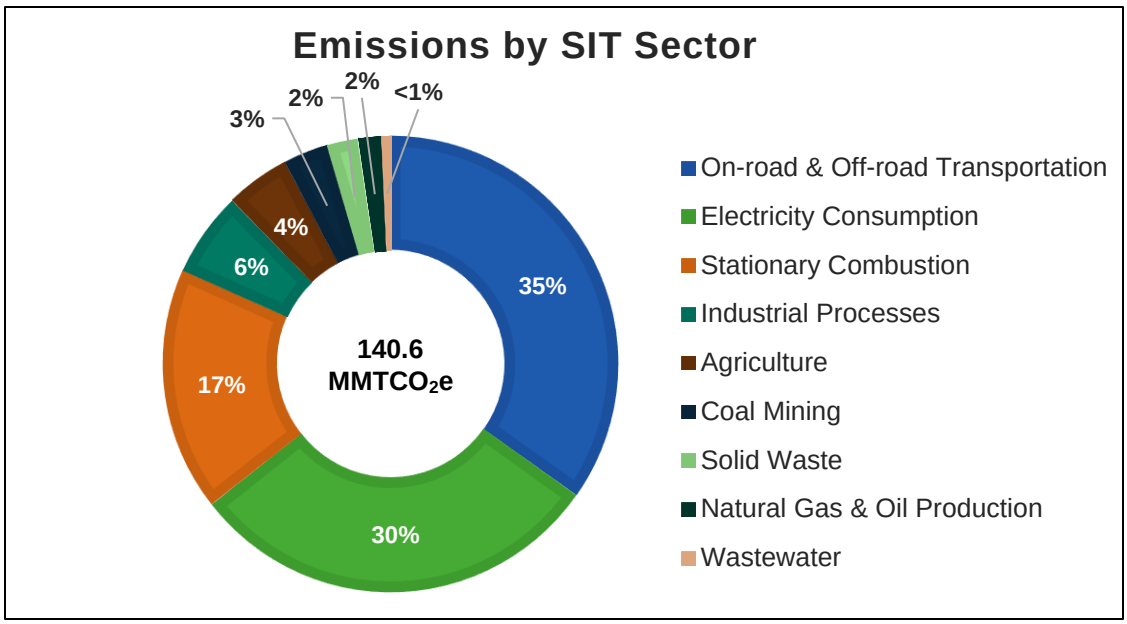

Figure 3. Emissions by SIT categories

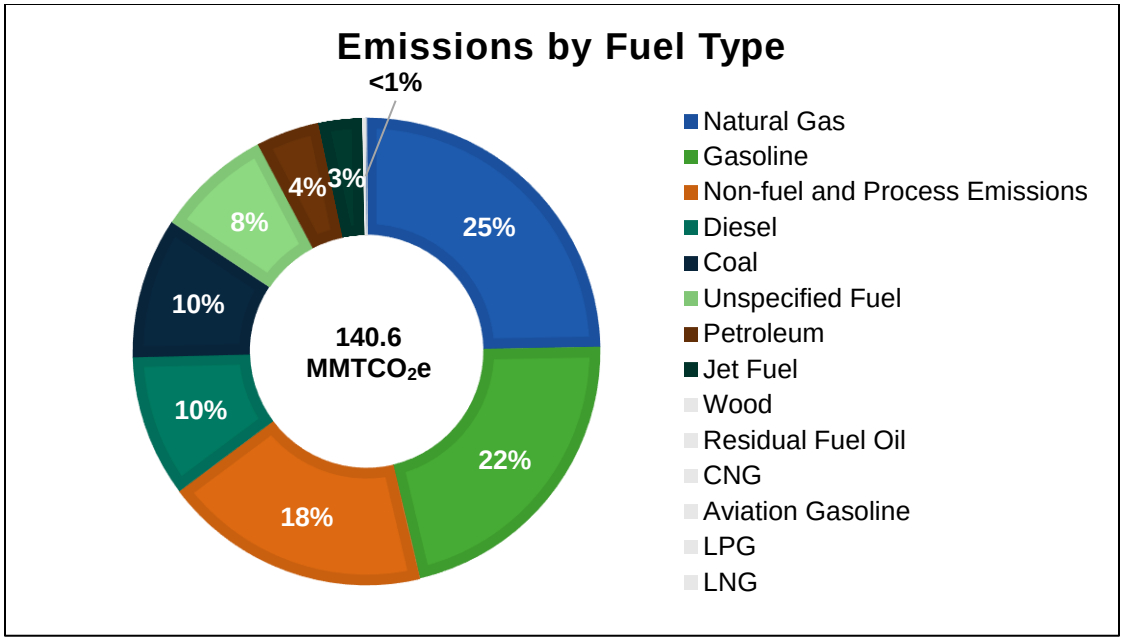

Figure 4. Emissions by fuel type. Note that wood, residual fuel oil, CNG, aviation gasoline, LPG and LNG are shown in white due to their small individual and cumulative share of the total (cumulatively less than 1% of total)

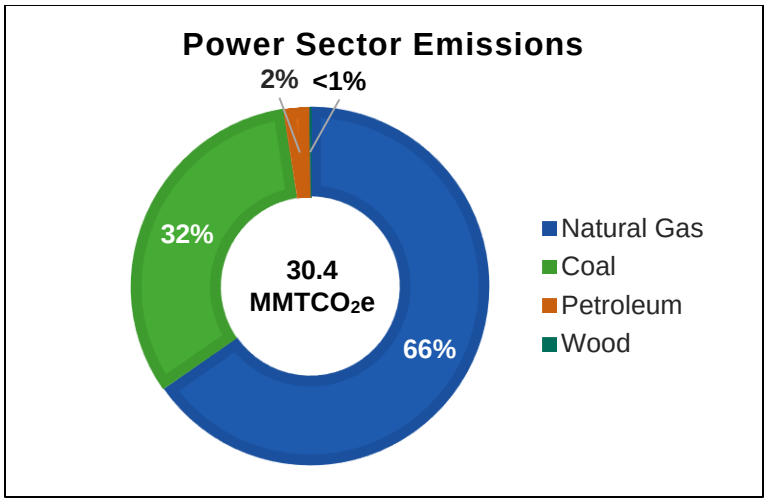

Figure 5. Power sector emissions by fuel type

GHG Type	$MMTCO_2e$
CO_2	30.2992
CH_4	0.02774
N_2O	0.08358
Total CO_2e	30.4106

Table 15. Power sector emissions by GHG

Inventory Data Inputs & Sources

Sector	Data Input	Default Data Sources	Supplemental Data Sources
On-road Transportation	Vehicle Miles Traveled (VMT)	Federal Highway Administration (FHWA)	None
	Annual mileage accumulation	Environmental Protection Agency (EPA)	None
	Emissions control technologies	EPA	None
	Age distribution of vehicles	EPA	Supplemented with DEQ data
	Emissions factors	EPA	None
Off-road Transportation	Aviation fuel consumption and activity	Energy Information Administration (EIA)	None
	Boat fuel consumption	FHWA and EPA	None
	Locomotive activity	EIA	None
	Agriculture, construction, and other off-road gasoline consumption	FHWA	None
	Other off-road activity	EPA	None
	Emissions factors	EIA and Intergovernmental Panel on Climate Change (IPCC)	None
Residential, Commercial, and Industrial Energy	Electricity consumption	EIA	None
	Stationary combustion	EIA	None
Industrial Processes	Iron and steel production	American Iron and Steel Institute (AISI)	None
	Cement and lime production	United States Geological Survey (USGS)	Supplemented with EPA GHG Reporting Program (GHGRP)
	Semiconductor and ozone depleting substances (ODS) substitutes national emissions	EPA	None
	Soda ash production and consumption	EPA	None
	Limestone and dolomite consumption	EPA	None
	Ammonia production and urea consumption	USGS	Supplemented with EPA GHGRP
	Electric power SF_6 consumption	EPA	None
	Emissions factors	IPCC and EPA	None
Agriculture	Livestock population	US Department of Agriculture (USDA)	None
	Crop production	USDA	None
	Crop area burned	EPA	None
	Manure management data	EPA	None

Sector	Data Input	Default Data Sources	Supplemental Data Sources
	Urea and fertilizer consumption	Association of American Plant Food Control Officials (AAPFCO) and The Fertilizer Institute	None
	Liming application	USGS	None
Coal	Abandoned and underground mines	EPA	None
	Coal production	EIA	None
	Ventilation systems data	EPA	None
Solid Waste	Methane flared or recovered	EPA	None
	Solid waste quantity	EPA	Supplemented with DEQ data
Natural Gas and Oil	Pipeline data	US Department of Transportation (DOT)	None
	Natural gas production	EIA	None
Wastewater	Population	US Census	None
	Industrial wastewater treatment	EPA	None
Land Use and Forestry	Settlement soils data	AAPFCO and The Fertilizer Institute	None
	Landfilled yard trimmings and food scraps	EPA	None
	Forest carbon flux	US Forest Service (USFS)	None
	Urban tree coverage	USFS	Supplemented with research paper
	Agricultural soil carbon flux	EPA	None

Table 16. SIT data inputs and sources of data