Alaska Greenhouse Gas Emissions Inventory

1990-2020

Alaska Department of Environmental Conservation
Division of Air Quality

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1 Table of Contents

Table of Figures

Acronyms

DEC	Alaska Department of Environmental Conservation
AEA	Alaska Energy Authority
CCS	Center for Climate Strategies
CH_4	Methane
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
GHGRR	Greenhouse Gas Reporting Rule
GWP	Global Warming Potential
HFC	Hydrofluorocarbons
MOVES	Motor Vehicle Emission Simulator
MMT	Million Metric Tons
MSW	Municipal Solid Waste
MT	Metric Tons
N_20	Nitrous oxide
ODS	Ozone depleting substance
PCE	Power Cost Equalization (Program)
PFC	Perfluorocarbons
SF_6	Sulfur hexafluoride
SIT	State GHG Inventory Tool
TPY	Tons per year
T&D	Transmission and Distribution
USFS	U.S. Forest Service
USGS	U.S. Geological Survey
U.S.	United States

I. Summary

This report focuses on Alaska's greenhouse gas (GHG) emissions from anthropogenic (human-caused) sources, as well as from natural sources such as wildfires. It considers the last thirty years of emissions generated within the state using available data from several sources, including federal and state emissions databases. This report also considers recent information (2018) on emissions reservoirs, also referred to as carbon sinks or carbon sequestration.

Estimates of natural carbon emissions and sinks are calculated using statewide vegetative data generated by the U.S. Geological Survey (USGS). The inclusion of USGS data is a new change from the previous emission estimation approach, which used only default calculations run using sequestration capacity on U.S. Forest Service lands in Southeast and Southcentral Alaska. The USGS data is based on statewide vegetation studies and estimated capacity of state natural environments constituting 97.9% of total state lands.[1]

The report utilizes the Environmental Protection Agency's (EPA) State Inventory Tool (SIT), which contains default emissions data for all sectors through 2019. Data for 2020 was derived in part from the Energy Information Administration (EIA), the EPA, and other state and federal sources.

The SIT calculates emissions across all economic sectors for the six Kyoto Protocol pollutants based on individual state inputs. DEC also utilized data generated by the EPA Facility-Level Emissions Database (FLIGHT). This was done to analyze large facility contributions to statewide emissions over the four years of available data since 2015. Many of the most important industrial and electrical installations in the state submit carbon dioxide equivalent (CO_2e) statistics to the EPA under the Greenhouse Gas Reporting Rule (GHGRR).[2] This data can be found in the EPA FLIGHT.

Gross emissions from oil and gas have decreased between 1990 and 2020 mainly due to the decline in crude oil production and refining. Natural gas emissions are relatively equivalent to previous reports with a slight increase from 2017 to 2020. Gross emissions from electrical generation have increased by 3% between 1990 and 2019, from 2.61 to 2.67 million metric tons (MMT) of CO_2e as calculated by the SIT CO_2 from Fossil Fuel Combustion (CO_2FFC) module.[3] Total state emissions as calculated by the SIT tool are 33.70 MMT for the year 2019.

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[1] Yujie He, Helene Genet, A David McGuire, Qianlai Zhuang, Bruce K. Wylie, and Yujin Zhang, "Alaska Carbon Balance," In*, Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, U.S. Geological Survey Professional Paper 1826, ed. Zhiliang Zhu and A. David McGuire, (Reston, Virginia: U.S. Geological Survey, 2016), p. 189.

[2] Mandatory Reporting of Greenhouse Gases (40 CFR part 98)

[3] Gross emissions from electrical generation taken from EPA State Inventory Tool (SIT) calculations on electrical emissions.

i. Background

Alaska's first statewide GHG inventory was drafted by the Center for Climate Strategies (CCS) in 2007. The report analyzed GHG emissions from 1990, 2000, and 2005, and projected emissions out to 2025. DEC then examined GHG emissions from stationary sources operating under Title V operating permits and in January 2008 issued a report of these findings. The final version of the CCS report was completed in July 2009 and included two appendices from DEC documenting additional analysis of emissions from stationary sources and the aviation sector.

In March 2015, DEC issued a GHG emissions inventory report that included the EPA emission factor changes and emission estimates with data from the years 1990 through 2010. This GHG Emission Inventory Report did not directly compare its results to the previous CCS 2009 report because of slight methodological changes and changes in emission factor values. Some of the differences between the CCS 2009 and DEC 2015 reports may appear as large percentage changes but are small quantity changes. Nonetheless, the results of both inventories indicated a similar overall picture; both inventories show the same industries as being the highest emitters and the same overall GHG emission trends through the years.

The 2015 GHG emissions inventory was published in 2018 and included data on all major sectors of the state economy, as well as carbon sinks and wildfire contributions to the state GHG footprint.

This report (2016 to 2020) similarly covers all sources of GHG emissions in the state of Alaska and includes data from the SIT for 1990 through 2020. At the time this emission inventory was prepared, not all sectors had updated emissions for 2020 due to data reporting and updating schedules for EPA. Those sectors which lack updated 2020 figures have data through 2019 and are noted in the overview as lacking the final year data.

Figure one presented below shows the state's yearly profile as produced in a stacked chart from 1990 through 2019. 2020 data was left out of the stacked chart due to the incomplete status of emissions figures in the SIT. Figure two shows the state's yearly profile as a pie chart, with petroleum and natural gas extraction refining taking up nearly 60% of yearly direct GHG emissions.

Figure 1 Alaska Gross CO2 Emissions by Sector, 1990-2019

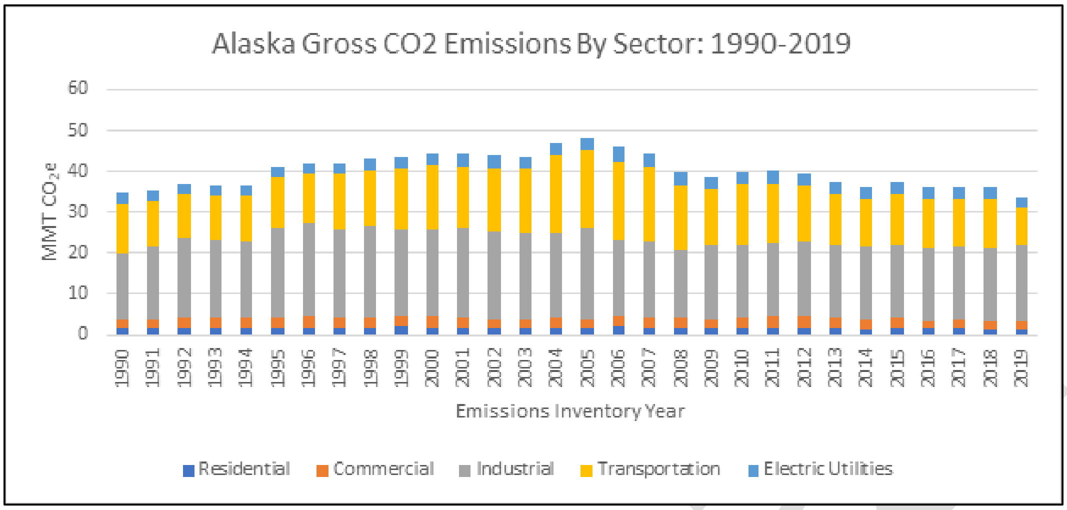
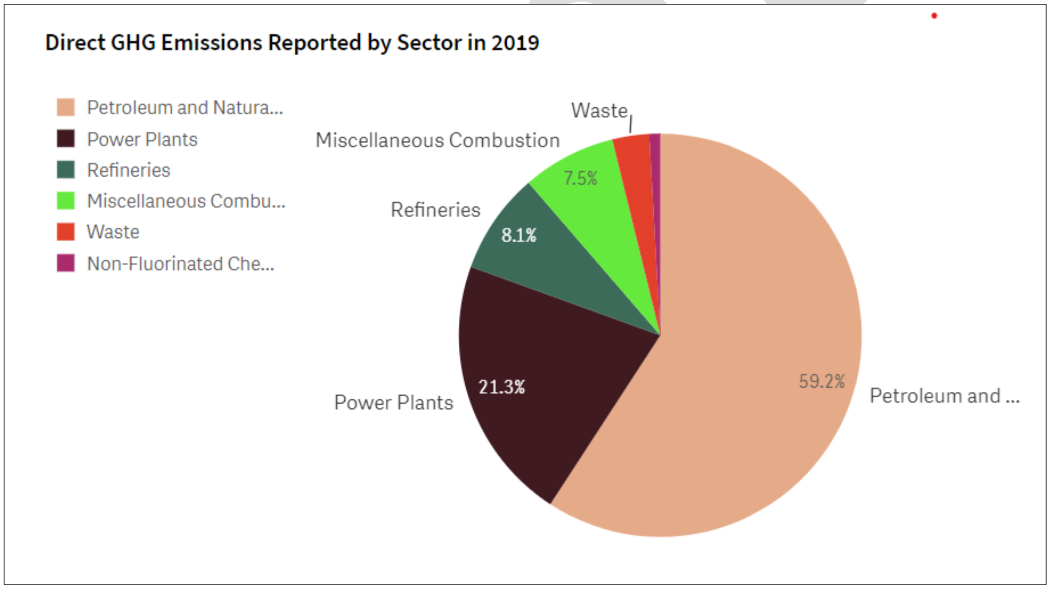


Figure 2 EIA GHG Emissions by Sector



II. Sector Emissions: State by State Comparison

As of 2020, 59.2% of Alaska's emissions are generated by industrial activity which includes the state's extensive oil and gas industry. Adding in refineries, the percentage of state emissions rises to 67.3%. The second largest sector of emissions, power plants, was responsible for 21.3% of the state's total GHG footprint for the year. Both Wyoming and North Dakota, mountain West states with similar economic and settlement patterns as Alaska, have energy consumption profiles which mirror Alaska's at a 55% average for their state's industry which remains oil and gas driven. Louisiana, by comparison, has a significantly higher footprint of its O&G industry at 72% total state energy consumption.[4]

This inventory report is structured as follows:

SIT emissions are presented first, as these encompass both the facility level stationary emissions as well as the non-point emissions totals generated using fuel consumption and other data. This is followed by a brief comparison with FLIGHT emissions to illustrate differences between statewide and facility-specific emissions.

FLIGHT data is presented in a separate section following SIT-generated data. This is done to allow FLIGHT data to be examined on its own, as FLIGHT and SIT data do not always align and in some instances show significant divergence. Analysis will be minimal, but divergent data will be communicated to EPA to inquire as to reasons for differences in SIT and FLIGHT data. In addition, GHG emissions estimated in the transportation section, railroad subsection, were calculated using fuel use data submitted to DEC for triennial National Emissions Inventory (NEI) reporting. This data is kept in the SIT-generated section for ease of reading and comparison with other SIT generated transportation sections (on-road, off-road, etc.).

i. Greenhouse Gases

The six Kyoto Protocol GHGs (Kyoto GHGs), as well as the global warming potential (GWP) associated with each GHG, are addressed in Figure 1. The Kyoto Protocol was enacted on December 11, 1997. It is an international agreement linked to the United Nations Framework Convention on Climate Change that establishes emission reduction targets using registry systems, reporting, compliance systems, and adaptation.[5] This international framework was updated with voluntary emissions reductions under the 2015 Paris Climate Accords, of which the United States (U.S.) was a participant in diplomatic negotiations. The nation is a signatory on both accords, though neither have been formally adopted by the U.S. Senate under Constitutionally outlined treaty ratification requirements.[6] [7]

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[4] Louisiana's specific industrial footprint is 71.9%, which includes O&G and the oil refining sectors. Like Alaska, Louisiana's GDP is reliant on oil and gas extraction though with a heavier emphasis on natural gas exports due to the state's location in the Gulf of Mexico. Wyoming and North Dakota are more comparable in terms of both geography and demographics. For more information on Louisiana's energy profile, please see the state's EIA website available at: https://www.eia.gov/state/?sid=LA#tabs-2

[5] For more information, please see: "Kyoto Protocol to the United Nations Framework Convention on Climate Change," Agreed to in 3rd Session in Kyoto, Japan, 1-10 December 1997, *United Nations Framework Convention on Climate* Change, available at: https://unfccc.int/sites/default/files/resource/docs/cop3/l07a01.pdf (Accessed 12/6/2021).

[6] For more information, see: "The Paris Agreement. United Nations Climate Change," Available at: https://unfccc.int/process-and-meetings/the-paris-agreement/the-paris-agreement (Accessed 11/15/2021).

[7] New reduction targets have been established as part of negotiations at the Conference of Parties (COP) 26 Conference in Glasgow, Scotland and are awaiting Senate treaty ratification. The overall goal of the Sino-American agreement, which was part of the COP 26 negotiations, is to limit global warming to the Kyoto Protocols 1.5-degree Celsius target by the year 2100. As of the publication of this report (2023), the draft Sino-American Agreement also has yet to be ratified by the U.S. Senate.

GHG emissions are presented using a common metric, CO_2e (carbon dioxide equivalency), which incorporates the relative contribution of each individual GHG to the global average radiative forcing on a GWP weighted basis. CO_2e is a useful metric that allows other GHGs to be quantified and compared to the amount of CO_2 that would produce a similar impact. (Figure 1). The GWP compares the atmospheric warming ability of a compound relative to carbon dioxide. For example, this comparison means that one pound of methane (CH_4) warms the atmosphere as much as 25 pounds of CO_2.

ii. Kyoto Greenhouse Gases

Each Kyoto GHG (Figure 2) is listed with their GWP. The GWP is defined as a unit of measure that allows comparisons of the global warming impacts of different gases. The larger the GWP, the more that a given gas warms the Earth compared to CO_2 over that time period (usually 100 years is used).[8]

Figure 3 Global Warming Potential of Greenhouse Gases

Greenhouse Gas	Common Sources and Uses	Global Warming Potential
Carbon dioxide (CO_2)	Combustion	1
Methane (CH_4)	Combustion, decomposition	25
Nitrous oxide (N_2O)	Combustion	298
Sulfur hexafluoride (SF_6)	Electrical insulator	22,800
Hydrofluorocarbons (HFC)	Refrigerants	12-14,800
Perfluorocarbons (PFC)	Semiconductors, medical uses	7,390-17,700

iii. Purpose of Stationary Sources Inventory

In addition to the statewide emissions analysis, this report provides an analysis of the GHG emissions from major Alaska facilities reported directly to the EPA under the GHGRR. This emissions data is submitted to the EPA FLIGHT. The analysis of major stationary sources provides additional insight into major emitters in Alaska. Stationary sources are typically larger industrial facilities operating in Alaska and are subject to state air quality permit requirements. As of the writing of this report, data is available to the general public via the EPA FLIGHT database and is updated through December 31, 2020 for all statewide sources. Data for 2020 and 2021 was not included in this report.

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[8] The United Nations Framework Convention on Climate Change (UNFCCC) calls for the stabilization of greenhouse gas (GHG) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The Kyoto Protocol to the Convention commits its parties to binding targets based on as a 'basket' of six GHGs, including carbon-dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6).

DEC used this data to compare stationary source emissions against sector and statewide reported fuel use in the SIT. Doing so allows for a direct calculation of large stationary source contributions to statewide estimated GHG totals.[9]

iv. Federal Greenhouse Gas Reporting Rule (GHGRR)

In 2010, the EPA implemented the federal Greenhouse Gas Reporting Rule (GHGRR). This rule requires facilities emitting more than 25,000 metric tons (MT) of CO_2e to report their emissions to the EPA annually. Summaries of the information reported are available to the public on the EPA FLIGHT website.[10]

Using the EPA data provides several advantages for Alaska when evaluating emissions from large facilities:

- **Consistency –** Facilities are required to report emissions under the federal GHGRR according to protocols established by the EPA. This requirement ensures that reporting is consistent from year to year and that all facilities are reporting emissions in the same way.
- **Comprehensiveness –** The EPA GHG Reporting Tool is set up to record GHG emissions by sector. Fuel quantities reported to the EPA may not include all the GHG emissions emitted from a facility.
- **Frequency –** Under the GHGRR, emitters are required to report emissions annually.
- **Automation –** The EPA uses a web-based system to collect and report GHG emissions data. Much of the analysis is automated.

This report includes a summary of the emissions reported to the EPA in addition to the SIT modules results.

Using these totals allows for a closer examination of facility-level and sector contributions to total statewide GHG emissions. It also allows for analysis of SIT data inclusivity in the event of discrepancies between SIT and FLIGHT datasets where FLIGHT data showed higher emissions results than SIT modules.

v. Sector Descriptions

This inventory reports emissions according to eight sectors which have been updated with the most recent data available:

- **Industrial** emissions are those emitted during industrial production and include direct emissions that are produced at the facility and indirect emissions that occur off site but are associated with the facility's use of energy. Because Alaska has a limited manufacturing sector, this sector includes all emissions from the state's oil

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[9] For more information, see the following: "FLIGHT – 2021 Greenhouse Gas Emissions from Large Facilities," *U.S. EPA*, August 7, 2021, available at: https://ghgdata.epa.gov/ghgp/main.do?site_preference=normal (Accessed 12/6/2021).

[10] FLIGHT – 2021 Greenhouse Gas Emissions from Large Facilities, *EPA*, available at: https://ghgdata.epa.gov/ghgp/main.do?site_preference=normal (Accessed 12/6/2021).

and gas sector. This includes emissions from fuel burned at a facility to produce electricity used solely at that facility. This category also includes fugitive emissions from the oil and gas industry. Emissions from crude oil refineries are included in this category, along with the state's limited chemical manufacturing industry, and seafood processing.

- **Transportation** includes emissions from cars, ships, planes, trains, and other mobile equipment.

- **Residential and Commercial** emissions include fuel combustion at homes and commercial buildings, mostly to generate heat. For example, home and hot water heating or building heat in office buildings.

- **Electrical Generation** includes the emissions from fuels combusted to produce electricity provided to the grid. The grid may be the rail belt grid or small local grids providing electricity to one community.

- **Waste decomposition** can give off methane, such as when waste food decomposes anaerobically.

- **Agriculture** produces GHGs from several mechanisms; examples include fertilizer converting to nitrous oxide and decomposition from agricultural waste that produces methane.

- **Emission Sinks**, or emission reservoirs, are areas in which carbon is removed from the atmosphere and sequestered. Methane and nitrous oxide emissions that result from wildfires are subtracted from the emission sinks.

Additional information regarding emissions for each updated sector is included in the Alaska specific sector results.

vi. Projections

Previous inventories utilized economic trend analysis, paired with emissions data, to forward project potential emissions scenarios based on realistic assumptions. For this inventory, the recent COVID-19 pandemic and the statewide oil and gas recession which started in 2014 may have generated significant economic headwinds. The oil and gas-driven statewide recession started in 2014 and has generated job losses and economic contractions that were, prior to 2020, easier to project with trend analysis.

The ongoing COVID-19 pandemic has added an additional layer of difficulties to predicting future emissions as disruptions have been general and widespread. It is possible that these changes may result in longer term changes in statewide emissions and economic output after the end of pandemic-driven activity changes such as travel restrictions and supply chain issues. The effects of the oil and gas recession and pandemic are not fully realized in state data except for population loss.

Because of these challenges, DEC did not calculate updated projections for future emissions scenarios.

vii. Methodology

The EPA SIT is available for states to prepare GHG emission inventories. The SIT develops the inventory in a top-down fashion, applying emission factors to statewide activity data (e.g., gallons of fuel used). The tool consists of a set of Excel workbooks, referred to as modules, with one workbook for each emission category. (See Figure 3)

SIT spreadsheets include applicable formulas, emission factors, conversion factors, and global warming potentials embedded within them. The modules include relevant state-level default data provided by a variety of federal agencies. The user may choose to use the default data or to supply data from other sources. The tool calculates emissions across all sectors for all six Kyoto GHGs.

This revised inventory is based on the June 1, 2021, version of the SIT which includes data through December 31, 2019, and partial 2020 data. Additional available data sets collected by DEC supplemented tool defaults. The 2020 data was added manually based on availability.[11]

As SIT modules mature, the key components (i.e., the coefficients, emission factors, formulas, and conversion factors) change nationally and by state because of better insight, familiarity, accurateness, and proficiency. As a result of recent updates, the current SIT modules for GHG emissions may differ from previously calculated GHG emissions. Any comparison from this GHG emissions inventory (2016 through 2020 data) report to prior reports should keep the emission factor changes in mind.

Figure 4 SIT Sector Modules and GHG Components

Module	Description	Gases
Agriculture	Emissions from agricultural activities	CH_4, N_2O
Coal	Emissions from coal mining and abandoned coalmines	CH_4
Electricity Consumption	Electricity emissions are based on electricity consumed in State[12]	CH_4, N_2O
Fossil Fuel Combustion	Emissions from the combustion of fossil fuels – includes fuels combusted across all sectors. Other gases produced are addressed by sector	CO_2

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[11] All relevant state data has been taken from EIA databases on fuel and energy consumption for EGU Sector. Oil and gas calculations used EIA, Pipeline Hazardous Materials Safety Administration, Alaska Oil and Gas Conservation Commission (AOGCC), and other key databases to generate emissions data for the period under review.

Module	Description	Gases
Industrial Processes	Emissions from industrial processes	all Kyoto GHGs
Land Use, Land Use Change, Forestry	Emissions from forestry practices include the effects of changes in land uses on carbon sinks	CH_4, N_2O, CO_2
Mobile Combustion	Non-CO_2 emissions from mobile sources	CH_4, N_2O
Natural Gas and Oil	Emissions from production and transmission of natural gas and oil	CH_4, N_2O
Solid Waste	Emissions from solid waste disposal	CH_4, N_2O, CO_2
Stationary Combustion	Non-CO_2 emissions from stationary combustion	CH_4, N_2O
Wastewater	Emissions from wastewater and treatment	CH_4, N_2O

viii. State Adjustments to Inventory Tool

The GHG Inventory uses several sets of publicly available data to generate emissions activity results for years not included in the SIT. At present, the SIT lacks all updated default information for the 2020 inventory year which requires manual input of the recent available data.

Edits to the SIT defaults are made when applicable data is available. A list of data sources is included in Appendix A.

All fuel consumed by rural electrical generators is included in statewide emissions under electrical consumption.

III. Results

SIT results will be presented on a sector basis as they are found in the SIT. The first two categories (Electrical Generation and Oil and Gas) are among the largest sectors of emissions and economic output in the state. Data for electrical generation is taken directly from SIT results, while oil and gas results also include inputs from outside sources like federal reporting databases. Other major sectors (mining, transportation, etc.) contain some amount of data from external sources or triennial National Emissions Inventory (NEI) data to assist in filling in emissions calculations gaps that might exist in the SIT data. Residential and commercial GHGs, along with the landfill section, contain no external data and are based entirely on SIT data.

Data gathered from the FLIGHT system can be found near the end of the results section as a stand-alone dataset. FLIGHT data does not always align with information found in the SIT, and no immediate explanation can be identified. To avoid reader confusion, this data was separated out from SIT-generated totals. Charts and graphs in the FLIGHT section are for individual sources, rather than the amalgamated totals found in the SIT. DEC will communicate all discrepancies between datasets to the EPA to enable future improvements to the SIT.

Land Use and Change totals can be found at the end of the results section. This is new data and is no longer reliant on generic figures that were found in the SIT in previous reports. Sequestration totals were taken from a new USGS report published in 2017 after the completion of the last Alaska GHG Inventory. See Section 1.18.1 for a full description of the USGS report.

i. Alaska Sector Results and Analysis

i. Alaska Per Capita Emissions

According to the EIA and based on total energy-related CO_2 emissions for 2020, EIA ranked Alaska 41st in emissions amongst states. On a per capita basis, Alaska ranks fourth highest in the nation, and second for total energy expenditures.[13] This has not changed since 2015, and EIA comments that, "Alaska's total energy consumption is among the 10 lowest states, but its per capita energy consumption is the 4th-highest in part because of its small population, harsh winters, and energy-intensive industries".[14] [15]

The state's total yearly CO_2 emissions rank 41st out of the fifty states and Puerto Rico with 35.2 million tons recorded for 2019. This is far behind Texas (701.9 MMT) and California (363 MMT), the states with the highest populations and largest state economies in the United States.

On a per capita basis at the end of 2019, Alaska's emissions were ranked fourth in the nation behind North Dakota, Louisiana, and Wyoming. This is the same EIA ranking that the state held in 2015. With the state's lower populations, per capita emissions are higher than the national average. Alaska's total electrical generation for 2019 was 547,000 MW, placing

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[13] Energy-Related Carbon Dioxide Emissions at the State Level, 2000-2018 Quick Facts," *U.S. EIA*, March 2, 2021, available at: https://www.eia.gov/environment/emissions/state/ (Accessed 12/6/2021).

[14] EIA: Alaska: State Profile and Energy Estimates, 2021, available at: https://www.eia.gov/state/?sid=AK#tabs-1 (Accessed 11/15/2021).

[15] Alaska's Per Capita emissions profile is high due to several circumstances: The state's low population, its Arctic environment, and the presence of a large and developed oil and natural gas industry. Alaska's Arctic and sub-Arctic environments require residents to utilize a comparatively high amount of both energy and fuel to heat and maintain their homes during the long and harsh winter months. Between October and April, much of the state is exposed to below freezing temperatures and significant snowfall along with extended periods of low sunlight. This requires homeowners to use more energy both for heating and home lighting purposes. Much of the state's home heating involves the burning of fossil fuels, either natural gas, diesel, or fuel oil, to heat dwellings, businesses, and other public spaces and ensure interior spaces do not fall below comfort levels. Lastly, the state has a well-developed and mature oil and natural gas industry in both the North Slope and Cook Inlet which provides fossil fuel energy resources for interior markets and is exported to the contiguous United States. This results in a comparatively higher GHG profile per capita for state residents compared to other states with similar population and economic profiles.

the state 49th out of 50 states and Puerto Rico, ahead of only the District of Columbia (22 MW) and Vermont (191 MW).[16]

The EIA calculations for per capita emissions take into consideration local infrastructure and environmental conditions, which for Alaska are unique compared to the contiguous United States. The state's Arctic environment generates long and harsh winters, and its economy is reliant on oil and natural gas extraction, both of which explain the state's large per capita emissions footprint. EIA also notes that the state has a large diesel-fired electrical microgrid network in rural communities. The state ranks second behind Hawaii for total power generated by petroleum (petroleum distillate/diesel).[17][18]

Alaska's GHG 2020 emissions comprise about 0.66% of nationwide GHG emissions. Using currently available data, global anthropogenic GHG emissions account for 36.44 billion tons per year (TPY) with Alaska contributing 0.000092672% of CO_2e to these global emissions.[19][20]

ii. Electrical Generation Emissions

Emissions from electrical generating units in the state of Alaska occur throughout the state from a variety of sources. Emissions calculations generated by the SIT for this sector are for all fuel types: coal, natural gas, and petroleum distillate (diesel). The SIT tool generates emissions totals for each fuel type on a statewide basis rather than by each power plant. For information on a per-facility basis, see FLIGHT totals in this report.

1. Electrical Generation GHG Emissions SIT Results

Emissions are presented in millions of metric tons of CO_2 equivalency (MMT CO_2e); this includes CO_2, CH_4, and other greenhouses gases. Although the results from the SIT allow for extended trend analysis, it does not allow for a more localized examination of borough or census area emissions. All emissions figures in the SIT are a statewide only result and data for facilities are grouped under sectors.

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[16] "Alaska: State Profile and Energy Estimates," U.S. EIA, January 21, 2021, available at: https://www.eia.gov/state/?sid=AK (Accessed 12/6/2021).

[17] Ibid.

[18] As discussed in Footnote 21, the state's per capita emissions footprint is a result of circumstances which include Alaska's Arctic and sub-Arctic environments, harsh winters, low population, and its mature oil and natural gas industries. However, the state is ranked 49th of 50 states for electrical generation and is ahead of Vermont and the District of Columbia.

[19] EIA: Rankings: Total Carbon Dioxide Emissions, 2018. Available at: https://www.eia.gov/state/rankings/?sid=AK#series/226 (Accessed 11/15/2021).

[20] Data on global CO_2e emissions derived from the following website: The World in Data. CO2 Emissions. 2021. Available at: https://ourworldindata.org/co2-emissions (Accessed 11/15/2021).

2. Electrical Generation SIT Results and Trend Analysis

Figure 5 SIT EGU Emissions by Fuel Type, 1990-2019

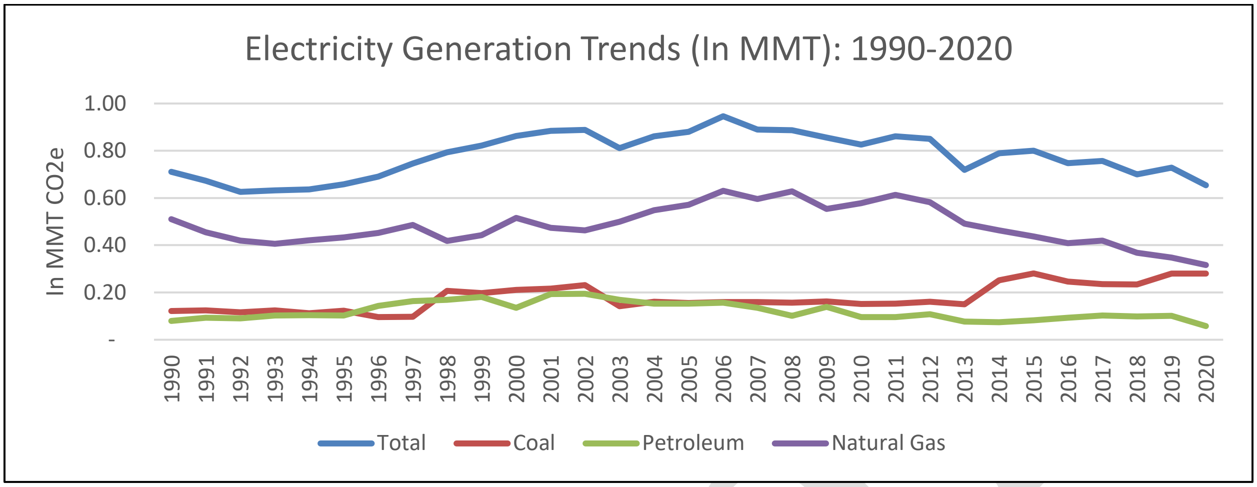
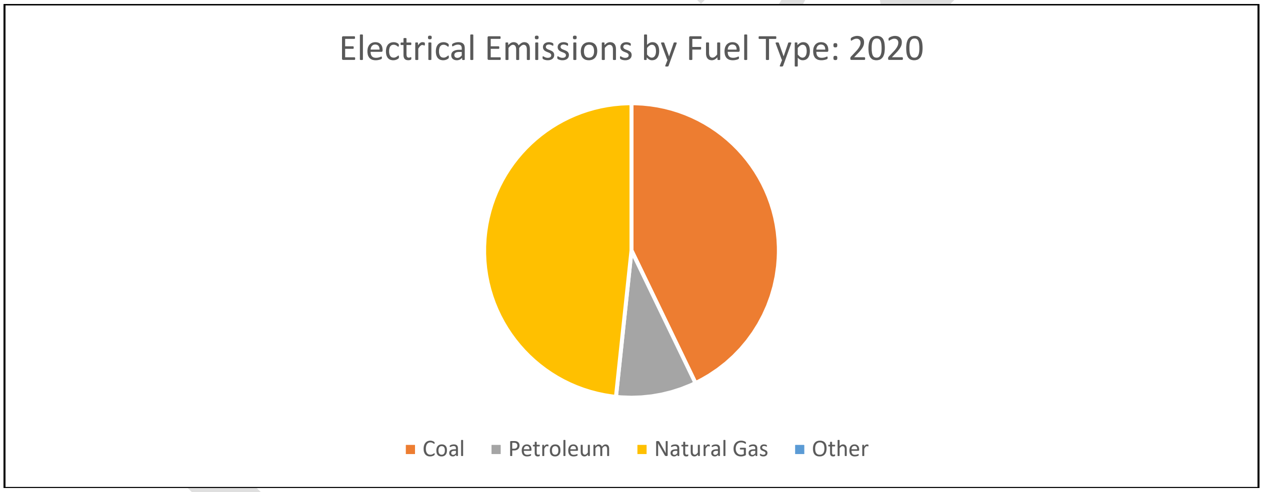


Figure 6 Electrical Emissions by Fuel Type, 2020



Statewide emissions expressed in CO_2e from 1990 through 2020 show a continued plateauing and slow decline of three of the four fuel combustion types and generation forms with some slight variations in yearly fuel and emissions results. Coal combustion is shown increasing from 2013. Petroleum distillate (diesel) has declined slightly over the last two years of the reporting period. Natural gas electrical emissions showed a continual decline since their peak in 2012.

Since 1990, total emissions have declined according to the SIT since the peak in the mid-2000s. Natural gas emissions peaked in the early 2010s, while coal has risen above its starting point in 1990. Petroleum distillate has been on a long-term decline by SIT calculations compared to its starting point as well.

Statewide fuel consumption for electricity generation in 2020 – as shown in figure 6 – was split between natural gas, coal, and a smaller percentage generated by petroleum distillate. The small wedge of petroleum distillate represents rural Alaska power generation. Natural gas and coal are geographically distinct, with natural gas in Southcentral Alaska and coal in Interior Alaska.

iii. Alaska Oil and Gas Emissions

The oil and gas sector is the largest industry in Alaska. In 2019, EIA ranked Alaska as the sixth largest producer of crude oil and the 12th largest producer of natural gas in the country.[21]

The SIT module for Natural Gas and Oil Systems calculates CH_4 and CO_2e emissions from all phases of natural gas systems (including production, transmission, venting and flaring, and distribution) and petroleum systems (production, refining, and transport). This section addresses the change in emissions since 2015. FLIGHT data can be found in the stand-alone section located before the Land Use and Change section at the end of this report.

1. Natural Gas Consumption

EIA reports that about 78% of Alaska's natural gas consumption occurs in the natural gas and crude oil production process.[22] Greenhouse gas emissions resulting from the oil and gas industry's use of natural gas for power generation is included in the electric power discussion of this report (p. 43).

2. Natural Gas and Oil Production

The EIA states that Alaska ranks third in the nation (after Texas and Pennsylvania) in natural gas gross withdrawals. But without the ability to bring the gas to market, 90% is reinjected into oil reservoirs. This helps maintain crude oil production rates. Reinjected gases are not included in natural gas production figures of this report.

Natural gas production in the SIT includes entries for natural gas wells onshore and from marine wells in the Gulf of Mexico. In Alaska, the marine petroleum platforms and offshore wells are included in the state's total number of wells and not segregated by location.

EIA defines natural gas wells as those, "…completed to produce natural gas from one or more gas zones or reservoirs." These do not include wells drilled for crude oil where natural gas deposits are also located and produced along with oil. EIA data includes the number of gas wells and gas condensate. It does not include wells that generate both natural gas and petroleum, which are more common in Alaska. Oil wells that produce natural gas are included in the petroleum production module. The Alaska Oil and Gas Conservation Commission (AOGCC) identifies "gas liquids" as a type of well which differs

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[21] "Primary Energy Production Estimates in Physical Units Ranked by State, *U.S. EIA*, available at: https://www.eia.gov/state/seds/sep_prod/pdf/P4.pdf (Accessed 12/6/2021).

[22] EIA energy profile for the State of Alaska, available at: https://www.eia.gov/state/print.php?sid=AK

from what is available within the SIT. To maintain consistency with previous years, Alaska selected the EPA toolkit default for well numbers. This decision allowed for the comparison of current production volumes to previous years.

Greenhouse gas emissions from oil are created by oil production, refining, and transportation.

Natural gas production rates have showed a steady increase since 1990. By comparison, petroleum production has shown a steady decline over the same three decades.[23] [24]

Figure 7 Alaska Natural Gas Withdrawals (MMscf)

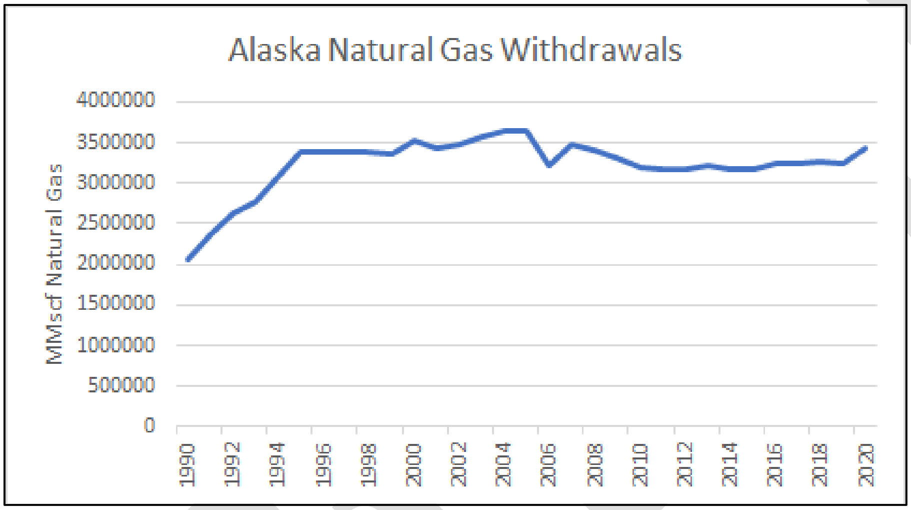
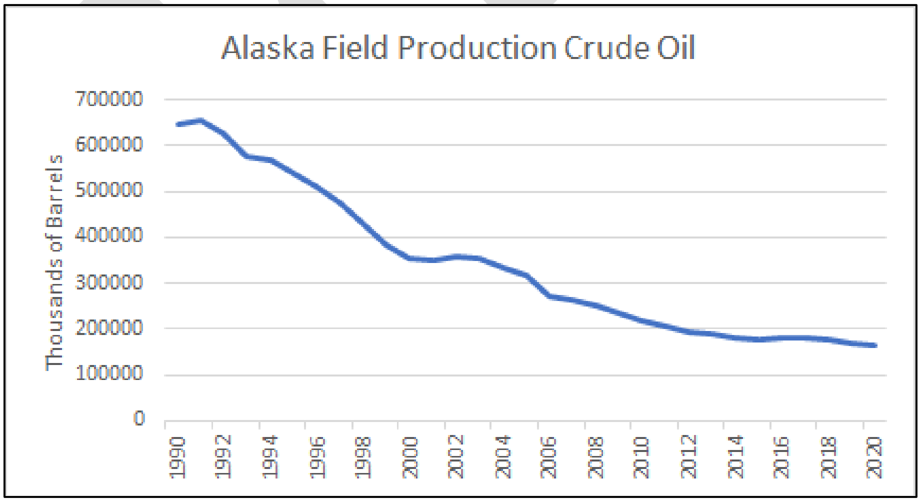


Figure 8 Alaska Field Production: Crude Oil, 1990-2020



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[23] "Alaska Natural Gas Gross Withdrawals," *U.S. EIA*, 11/30/2021, available at: https://www.eia.gov/dnav/ng/hist/n9010ak2A.htm (Accessed 12/6/2021).

[24] Ibid.

The Natural Gas and Oil Systems module calculates CH_4 and CO_2e emissions from all phases of natural gas systems (including production, transmission, venting and flaring, and distribution) and petroleum systems (including production, refining, and transport).[25] Data used in the SIT is primarily obtained from the State of Alaska, EIA, PHMSA and the EPA. Like production volumes CO_2e emissions from oil production have continued to decline while those from gas production, transmission, and distribution have remained relatively the same with some increase occurring from 2017 to 2019 (Figure 9).

Since the publication of the State of Alaska 2015 GHG report, CO_2e emissions from oil production has declined by 0.49 MT (Figure 9). Emissions from natural gas production, transmission, and distribution has remained steady with a small increase in gas production from 2017 to 2019, followed by a decrease in 2020 amounting to a total reduction of 0.12 MT CO_2e (Figure 10).[26]

Figure 9 Oil and Gas CO_2e Emissions, 1990-2020

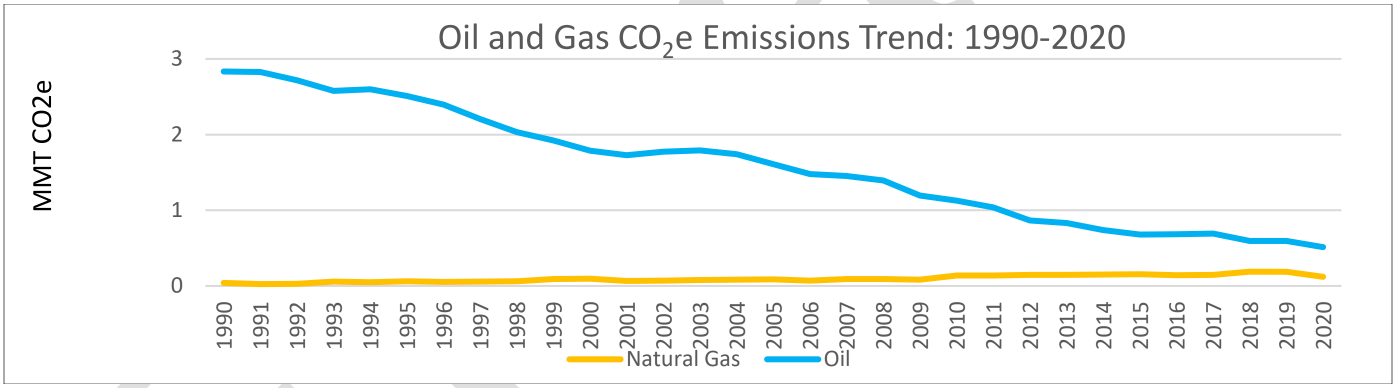
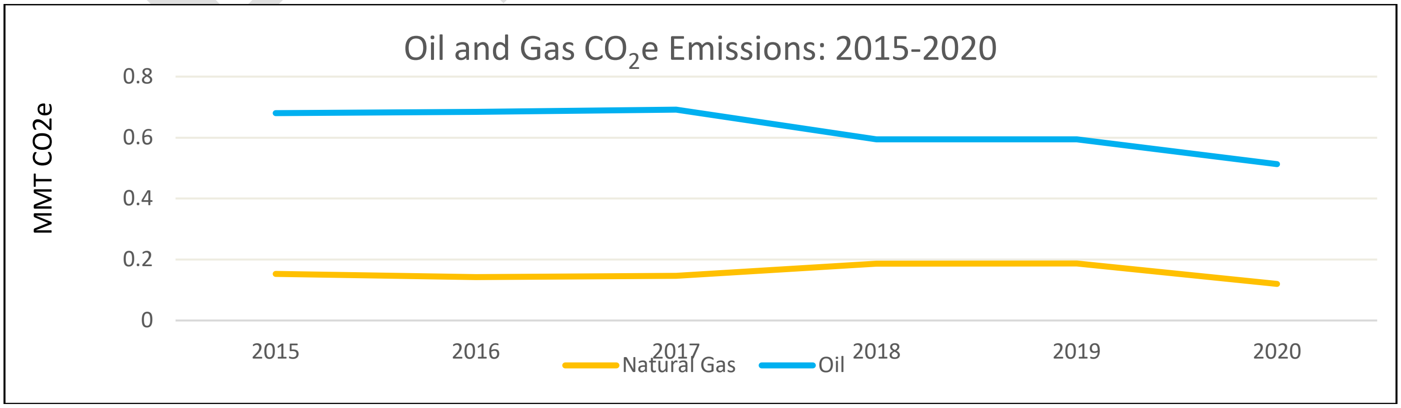


Figure 10 Oil and Gas CO_2e Emissions, 2015-2020



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[25] Please note that flaring is restricted by AOGCC regulations, and natural gas flaring must be reported to the AOGCC if it is longer than one-hour. Below one-hour of flaring, events are not reported to AOGCC and must therefore be estimated based on operator data.

[26] "State of Alaska Greenhouse Gas Report, 2010-2015," *Alaska Department of Environmental Conservation*, 2018, available at: https://dec.alaska.gov/air/anpms/projects-reports/greenhouse-gas-inventory (Accessed 12/7/2021).

Since 1990, oil and gas CH_4 emission parallel CO_2e trends (Figure 11). In the last five years, CH_4 emissions from oil production have declined by 0.325 MMT and natural gas production emissions has decreased 0.134 MMT following a small increase from 2017-2019.

Figure 11 Oil and Gas CH_4 Emissions, 1990-2020

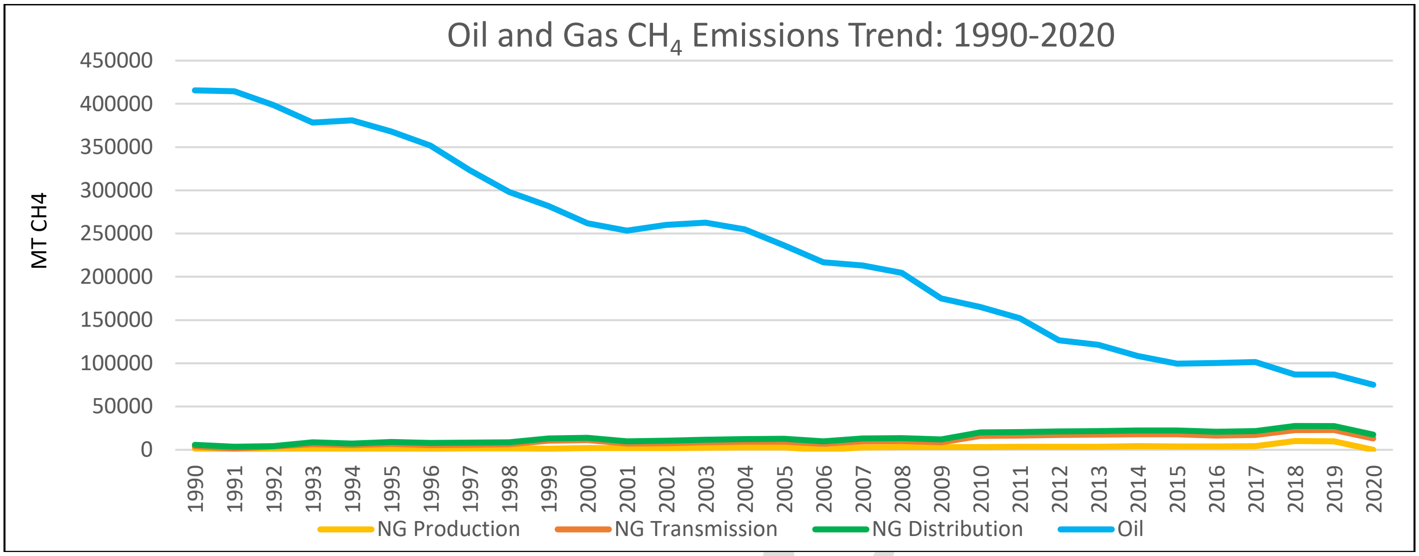
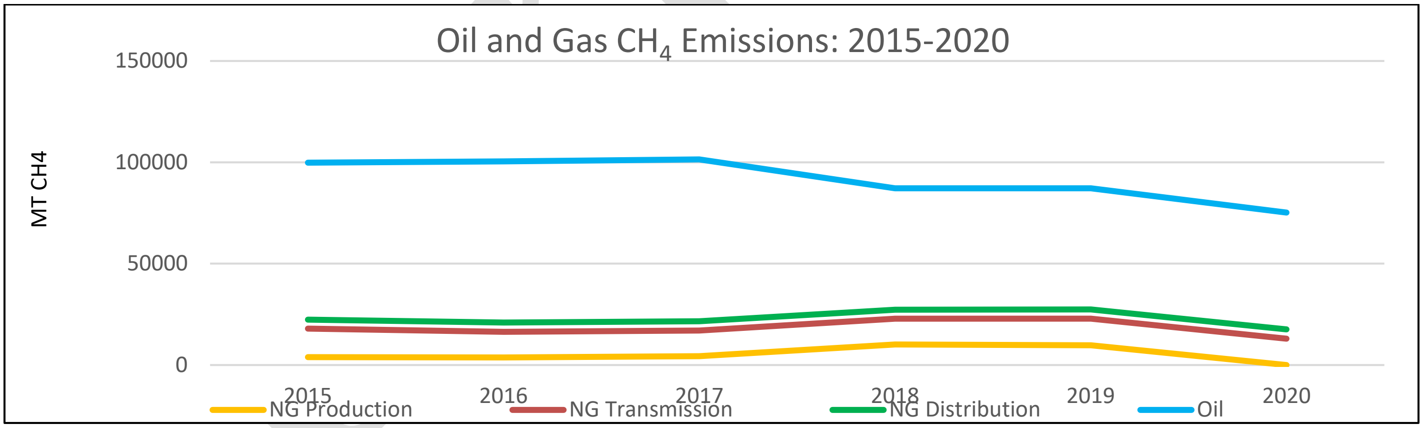


Figure 12 Oil and Gas CH_4 Emissions, 2015-2020



Transmission and distribution CH_4 emissions reflect the trend in natural gas production with a slight increase from 2017 to 2019.

3. Flaring and Venting

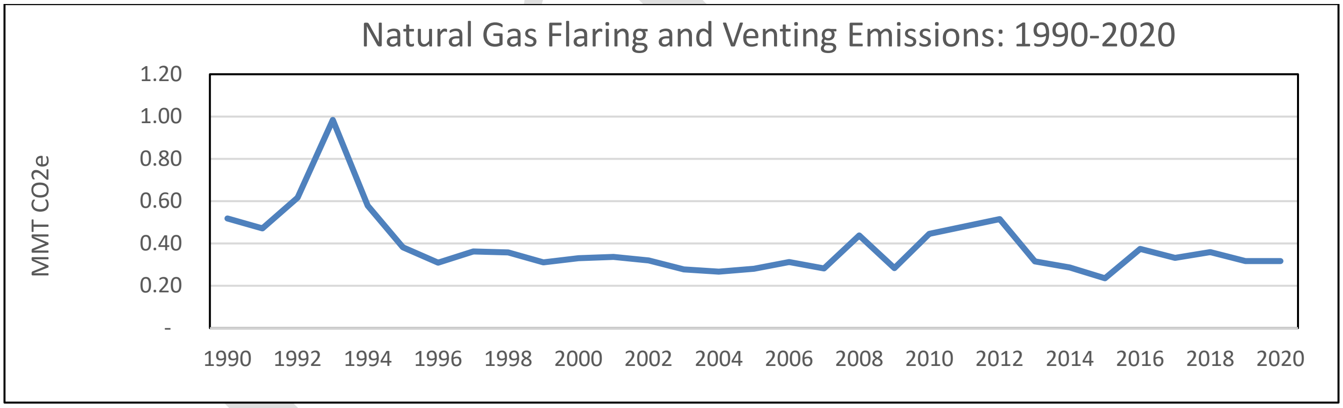
Emissions from venting and flaring are calculated from crude oil and natural gas exploration, production, processing, transportation, and storage operations. The SIT assumes that 20% of the emissions are vented and 80% are flared, and the emissions are calculated based on a national emission factor of 54.71. The EIA obtains venting and flaring volumes from the AOGCC. Under Alaska Administrative Code (AAC), 20 AAC 25.235, gas flaring is prohibited and is considered a waste of a state resource except in the case of emergency or system testing or routine oil field practices. Under this regulation, operators must report any release of gas (other than incidental de minimis venting) for any incident that exceeds one hour. The result of the flaring and venting of gas is reflected in Figure 13.

In Title V permit applications emission units that release less than 3,750 TPY of CO_2e are deemed insignificant and are not included in a Title V operating permit application for ongoing monitoring.[27] Depending on the volume, some flared and vented emission units are reported in annual or triennial emission reports and emission fee billing.

In a review of emission fee reports received in 2020, flared and vented emission volumes were different than those reported to AOGCC. In 2020, 1,259,815.75 MMscf (131,021,020.00 million British thermal units) of flared and vented emissions were reported. Using the calculation for venting and flaring provided in EPA publications, with an emission factor of 54.71, a total of 55.104 MMT CO_2e were emitted. This is a significant difference from SIT calculations.

Emission Calculations: Emissions (MMT CO_2e) = Activity Data (BBtu) x Emission Factor (MT CO_2/BBtu) x % flared ÷106 (MT/MMT)

Figure 13 Oil and Gas Flaring and Venting Emissions, 1990-2020



Comparing the SIT results with the FLIGHT data there are differences in volumes due to SIT calculation methodology verses FLIGHT reporting requirements. Both show a downward trend of emissions. As stated earlier in the report, the SIT was used for consistency. However, it may be useful to update the SIT to be more applicable to Alaska facilities and emissions in the future.

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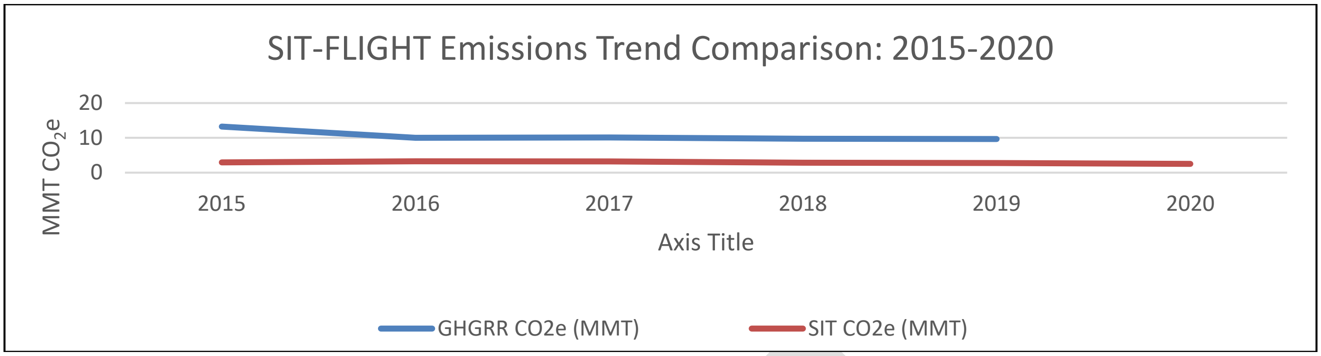
[27] 18 AAC 50.326(e)(15)

Figure 14 Comparison of EPA SIT and FLIGHT CO$_2$e Emissions, 2015-2020



iv. Mining Emissions: Coal, Gold, Zinc, and Abandoned Mines

Mining in Alaska has historically been a significant industry since the territorial period. During the first half of the 20th Century, gold and coal mining dominated the state's mining sector with dozens of large and small mines operating throughout the state. Currently, operable mines in the state include the Red Dog Mine, a large zinc mine located near Kotzebue, and the Healy Coal Mine near Denali National Park. Healy is the primary source of coal for the network of coal-fired power plants located in city of Fairbanks. Other mines include the Kensington and Greens Creek gold mines near Juneau. For more information on individual mines, see Section VII.7, p. 51 for mines reporting to the FLIGHT system.

The EPA SIT mining module produces emissions data for all GHGs, including CH$_4$ emissions. This also includes abandoned gold and coal mines, of which there are forty-five which have been registered with the Alaska Department of Natural Resources, Division of Mining. These abandoned mines have also undergone reclamation to clean up environmental damage from active operations in the last century.

The federal Bureau of Land Management (BLM) has jurisdiction over abandoned mines located on those lands managed by the federal government. BLM does not maintain a list of abandoned mines in usable format like the Division of Mining. Information on the BLM website only covers abatement and clean-up actions at the Red Devil Mine in the middle Kuskokwim River. As a result, BLM managed abandoned mines were excluded from these calculations.

Several of the gold mines operated at the turn of the century were located close enough to coal deposits to provide the mines with a fuel source for steam engines. After closure, the coal mines would be responsible for more of the methane emissions than the gold mines. Using the DNR Division of Mining, Land and Water data, the average year of closure for these older abandoned mines in the state was 1941.

1. Mining Sector SIT Results: Abandoned and Active Mines

Abandoned mine emissions calculated by the SIT show a downward trend since 1990. Emissions have fallen from 25,000 tons of CH$_4$ in 1990 to 11,813 tons in 2020.

Figure 15 SIT Coal Mine Emissions, 1990-2020

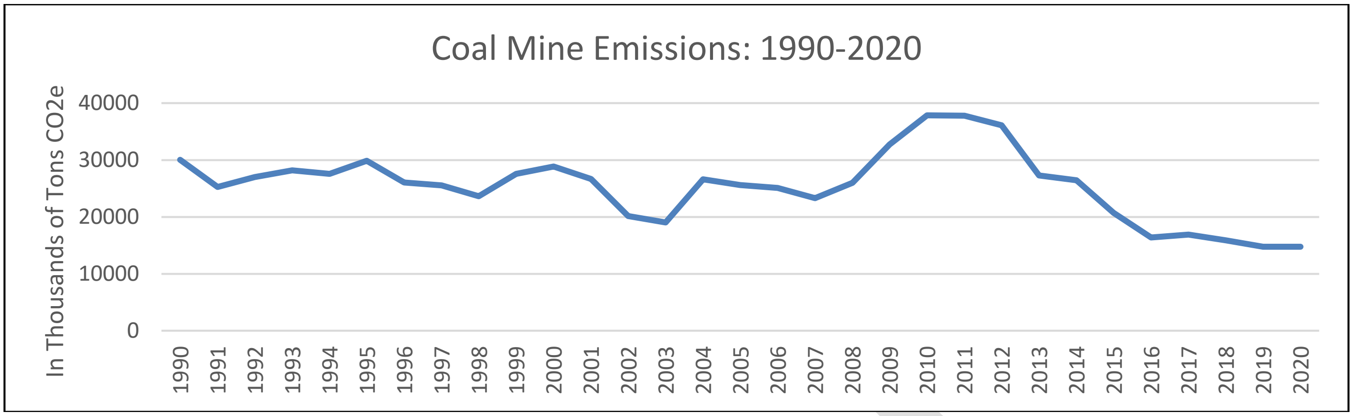
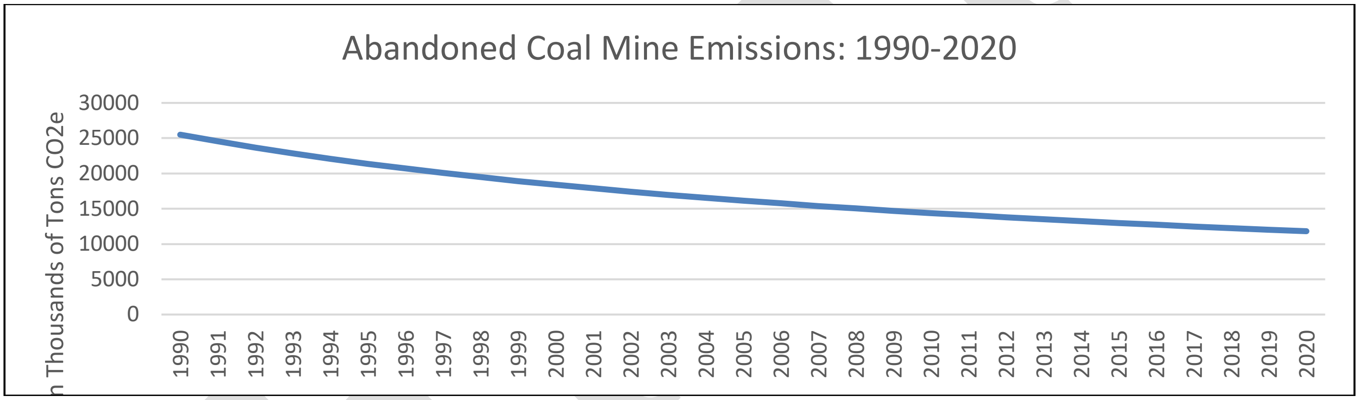
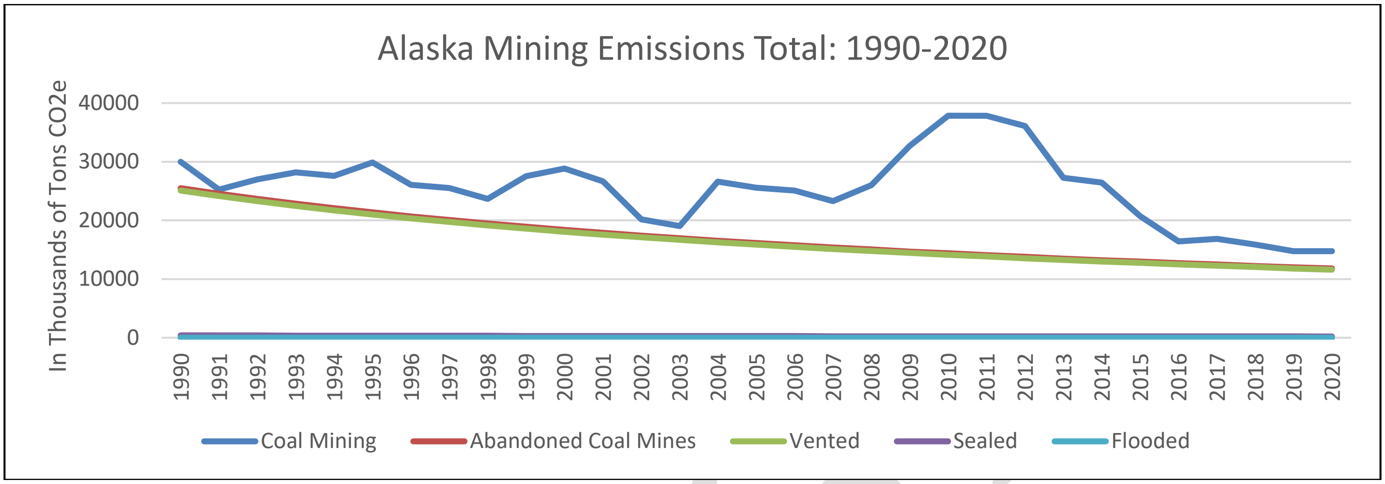


Figure 16 SIT Abandoned Coal Mine Emissions Trend, 1990-2020



Active coal mine emissions decreased by 16,000 tons of CH_4 since 1990, though there was an increase between 2008 and 2014 which coincided with the most active period of coal exports to markets in East Asia. With the closure of export markets abroad, Alaska's coal mining industry has relied on available markets in-state. These are largely in the Interior where fuel choices are limited, and facilities still rely on coal for power generation and heating.

Figure 17 Alaska Mining Emissions Total, 1990-2020



v. Transportation

Transportation emissions are generated by burning fuel in motor vehicles like cars and trucks, personal use all-terrain vehicles and snow machines, marine vessels, aircraft, construction, construction equipment, and other motorized equipment. Greenhouse gas emissions like CO_2e are proportional to the amount of fuel consumed, while emissions of CH_4 and N_2O depends on the type of equipment and fuel type.

Emissions calculations are derived from two spreadsheets used in the EPA SIT tool: The CO_2FFC Module, and the Mobile Sources Module. Both modules produce emissions calculations needed to complete statewide calculations: The CO_2FFC module generates total statewide carbon dioxide emissions from statewide mobile and stationary sources, while the mobile sources module produces methane and nitrous oxide emissions results. Charts will be presented using data from both, and summaries with a combination of both sets of data will be noted as such.

Using the last full year of emissions data available in the CO_2FFC module (2019), statewide transportation emissions were 12.21 MMT CO_2e, with an additional 90,000 tons of methane and nitrous oxides emitted that year. Aircraft and marine traffic made up large amounts of the emissions totals calculated in the transportation module, while the CO_2FFC module does not provide differentiation between the different transportation types. CO_2FFC data is presented in terms of fuel consumed. This includes all forms of petroleum and natural gas burned in the state for transportation purposes. Personal vehicles such as aircraft and marine vessels all use diesel or another type of petroleum distillate. Coal is no longer used by any transportation source in Alaska as a fuel source.[28]

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[28] DEC has been in communication with EPA on the issue of fuel loading and consumption of the state's aviation and marine industries. Ted Stevens Anchorage International Airport serves as a refueling hub for trans-Pacific air cargo flights traveling between East Asia and North America. In addition, several large international marine shipping routes cross Alaska waters. This includes the Great Northern Circle Route, one of the busiest marine cargo routes in the world which runs to the north and south of the Aleutian Islands. DEC

1. Transportation – Categories and Emissions Changes

On and off-road emissions categories in Alaska are smaller compared to states of similar size in the contiguous United States. This is a result of a smaller overall population than other geographically large states.

The three largest categories of transportation emissions in the state are aviation (commercial and personal), marine, and on-road vehicle traffic. Alaska's aviation industry is widespread and is used in communities large and small throughout the state. Major air hubs operate in Anchorage (Ted Stevens-Anchorage International Airport), Fairbanks (Fairbanks International Airport), Juneau, and Ketchikan. Regional hubs are scattered throughout the state, and most communities have small airports for light aircraft access year-round. Ted Stevens-Anchorage International Airport is a major cargo hub for trans-Pacific air freight. Fairbanks functions as the cargo and passenger hub for Interior Alaska. Both Anchorage and Fairbanks have active military air bases.[29]

Alaska has a large and active marine industry which connects large and small communities to trans-Pacific trade routes and markets in the contiguous United States. In addition to cargo vessels, the state is an active destination for the international cruise industry during spring and summer months. The state has historically and continues to have an active and well-established fishing industry which operates year-round in large and small coastal communities in the Gulf of Alaska, Bering Sea, and North Pacific Ocean. In addition to domestic marine traffic, the state also has significant amounts of international traffic as well. Vessels traversing federal or state waters using international shipping routes are not included in the SIT and are not represented in this report.[30]

Railroad traffic in the state is limited to a single Class 2 railway, the Alaska Railway (AKRR) between Seward and Fairbanks. A smaller Class-3 railway, the White Pass and Yukon Railway (WPYRR), operates between Skagway and Carcross in the Yukon Territory, Canada. State port infrastructure is extensive, with cargo and passenger vessels utilizing ports across all areas.

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has conversed with EPA on emissions attribution for marine and aviation traffic during both triennial NEI processes, as well as regulatory projects like the recent Regional Haze Plan submitted in August 2022. However, if any potentially misattributed international air emissions from international fuel loading or over-flights were included in the SIT model, DEC cannot single them out at present due to the emissions modeling structure.

[29] Although these bases have an active military aviation presence, these emissions are not included in the SIT at present. As a state agency, DEC can request but does not have the regulatory authority to require submission of aviation fuel consumption by local military installations.

[30] As mentioned in the previous footnote, the state has been in conversation with the EPA on emissions attribution for international maritime traffic passing through Alaska state waters. DEC has voiced these concerns to the agency during the last two NEI cycles in 2017 and 2020, as data review identified issues with international emissions attribution being assigned to boroughs and census areas without major port access in remote parts of Western Alaska. Because of the way that the SIT calculates emissions, DEC cannot exclude any of these misattributed emissions at present if they were included in SIT runs.

Aircraft traffic is extensive, with heavy passenger and cargo traffic and a fleet of single and two-engine light aircraft operating in urban and rural areas.

The most limited transportation category is on-road passenger vehicle and interstate truck traffic. State on-road highway activity occurs only on the Alaska Highway between the Kenai Peninsula, Fairbanks, and the Alcan Highway border crossing into the Yukon Territory. Remote communities outside of the 'Railbelt and Roadbelt' areas of the state have limited intercity road connections. Many residents in Western and Northern Alaska supplement this limited highway capacity with more extensive off-road vehicle traffic, along with personal marine and aviation traffic. In the state dust survey conducted in 2016, a few communities identify 90% off road vehicle use except for trucks used for firewood, trash, and community services.[31]

2. Transportation – SIT Emissions Calculation By Vehicle-Type

The categories of vehicle emissions are grouped together as follows:

- **Highway vehicles:** Emissions from highway vehicles are calculated in the SIT mobile combustion module. The tool uses Vehicle Miles Traveled (VMT) averages produced by the Alaska Department of Transportation, along with data on average vehicle age to produce a total statewide profile of emissions. Miles driven are distributed by vehicle age and emissions are then calculated. The age of the vehicle is directly related to the technology by model year, which is separated out into the following categories: advanced, moderate, uncontrolled, non-catalyst, oxidation catalyst, early 3-way catalyst, 3-way, and low emissions vehicle.

- **All-Electric and Hybrid Highway Vehicles:** In the last decade, new categories of hybrid vehicles have also been released which use both lithium ion batteries and high efficiency engines to reduce vehicle emissions profiles. It is likely that numbers of these vehicles will increase in the next decade. There are also increasing numbers of all-electric vehicles which have no emissions profile which would be calculated in this tool.

- **Aircraft:** The calculation of aviation emissions relies upon the quantity and type of fuel purchased in Alaska. Jet fuel (kerosene) is the primary fuel used by aircraft and commercial operators in Alaska and is the primary contributor to air pollution and GHG emissions from this category.

  In addition, small numbers of light aircraft continue to burn aviation gasoline (AvGas) in rural Alaska. The fuel is primarily used for older single or twin-engine, piston-powered aircraft. It has been replaced by jet fuel for use in newer turboprop aircraft. These older aircraft are more prevalent in Alaska. Small numbers of older

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[31] Alaska DEC has conducted four rounds of surveys in rural Alaska to gauge public interest in road dust issues in the years 2007, 2010, 2011, and 2016, along with assisting on the publication of the Rural Dust Toolkit. "2010 and 2016 Rural Alaska Dust Surveys," *Alaska Department of Environmental Conservation*, 2016, available at: https://dec.alaska.gov/air/anpms/communities/pm10-rural (Accessed 12/7/2021).

multi-engine piston aircraft (DC-3s and DC-4s, C-46s, etc.) are still in regular use as well, connecting rural hub communities to Anchorage and Fairbanks. These aircraft are less efficient in fuel combustion than newer aircraft and have substantially larger emissions profiles in take-off and landing and cruise cycles.

Unlike the previous report, DEC did not have the time or resources to supplement EPA emissions data with its own aviation inventory.

- **Marine:** State fuel sales to this industry are limited to low-sulfur diesel or ultra-low sulfur diesel as mandated by International Maritime Organization (IMO) regulations in place since January 1, 2020. These regulations do not control or limit GHG emissions from ocean-going or coastal marine vessels and act primarily as an air and environmental pollution control mechanism.
- **Railroad:** For GHG emissions calculation purposes, all emissions from the AKRR are captured in the EPA SIT tool. Those emissions from the (WPYRR) which occur in the vicinity of Skagway on the American side of the border are also included.

3. Transportation – Results

a. On-Road Vehicle Emissions Trends, 1990-2018

Over the three decades of vehicle data, emissions from gasoline highway vehicles have remained consistent with a slight increase to over two million TPY of CO_2e as of the last year of data in 2018. Passenger vehicle emissions have also increased to over 1.33 million TPY since 1990. This trend, mirrors gross on-road vehicle total emissions which rebounded from a short period of decline in 2014.

Emissions analysis highlight the major on-road categories of gasoline highway, passenger car, light-duty truck, and diesel highway emissions. Other categories of on-road vehicles are minor and well below the half-million to one-million TPY range shown in major categories. Figure 18 shows a summary of all statewide on-road vehicle emissions combined back to 1990.

Figure 18 Total Statewide On-Road Vehicle Emissions, Trend, 1990-2018

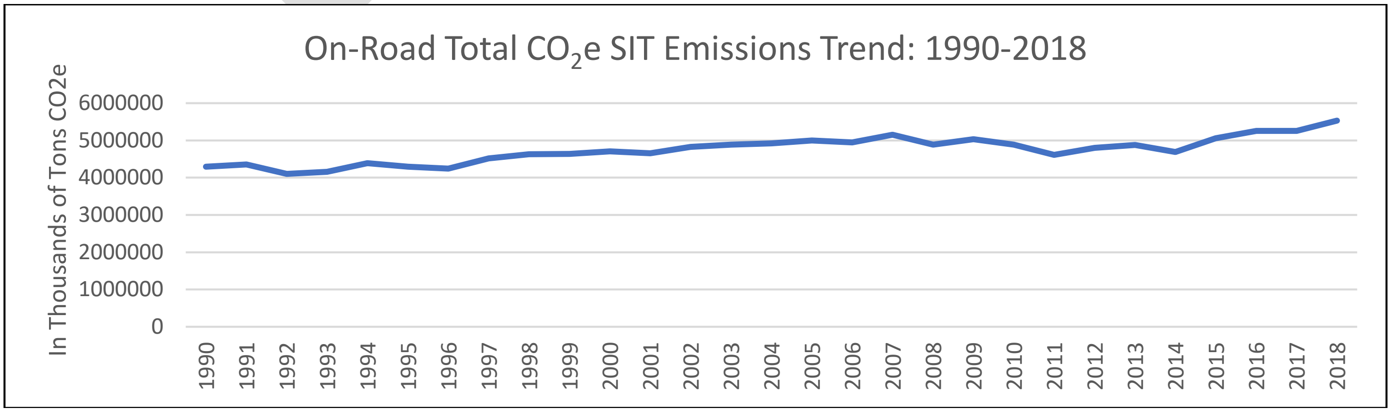
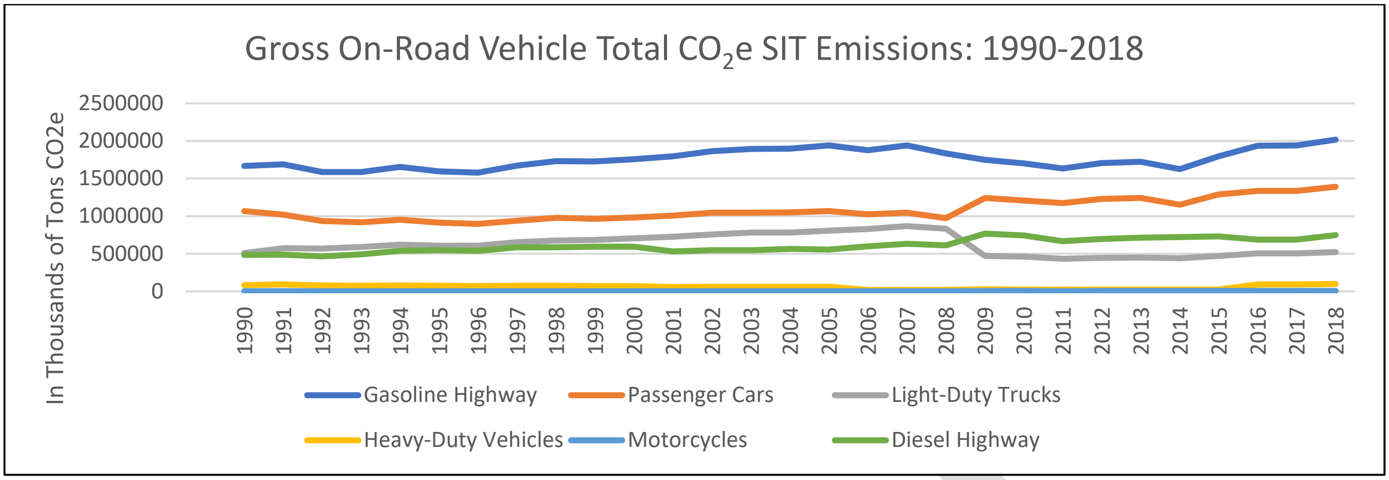


Figure 19 On-Road Vehicle Emissions, 1990-2018



b. Passenger Vehicle and Gasoline Highway Total Emissions Trends, 1990-2018

Passenger vehicle and gasoline highway emissions have rebounded from declines which took place in the last two decades. Emissions rebounded in the last four years of the analysis period and rose above the prior emissions peak in 2008. Emissions reached 2.01 MMT CO2e per year by 2018. Passenger vehicle emissions followed a more direct increase following a single year decrease in 2008. By 2018, passenger vehicle emissions reached 1.4 MMT per year CO2e, an increase of 400,000 tons since 2000.

Although the state population has fallen to roughly 730,000 from 750,000 in the early 2010s, passenger and gasoline highway vehicle emissions increased.

Figure 18 Gasoline Highway Vehicle Emissions, 1990-2018

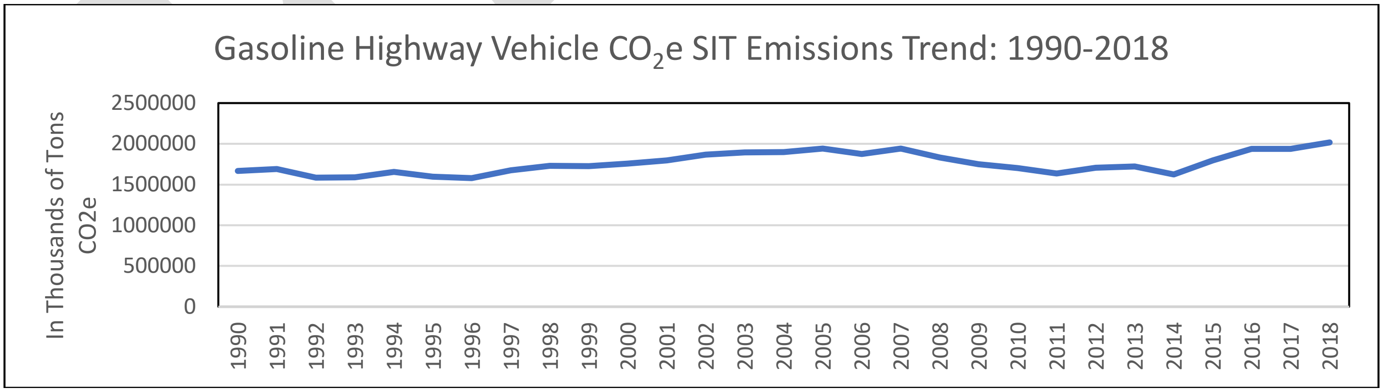
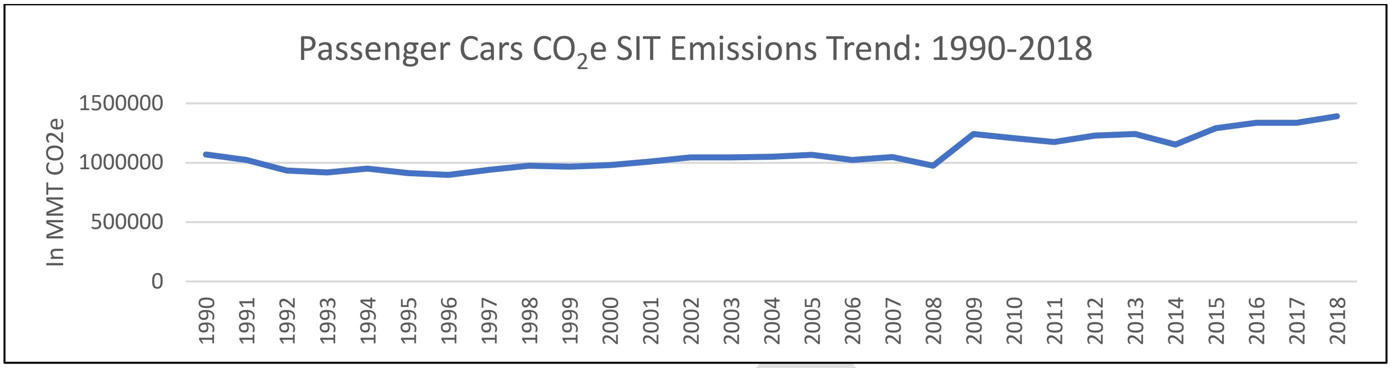


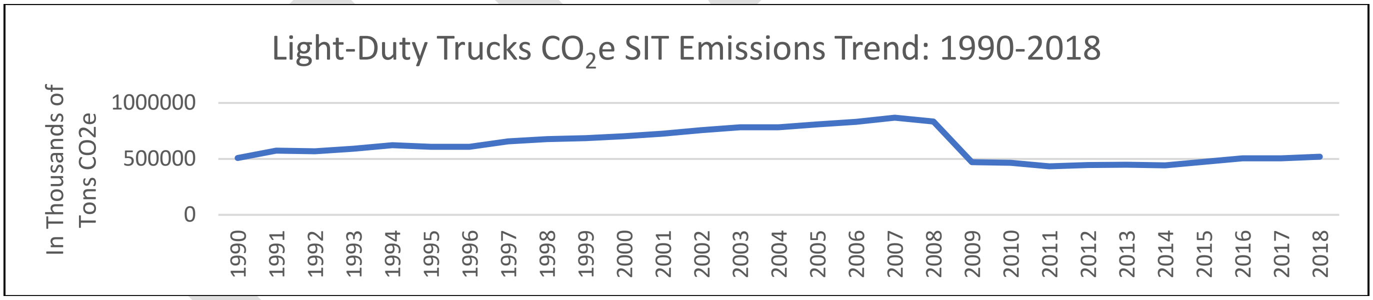
Figure 19 Statewide Passenger Vehicle CO₂e Emissions, 1990-2018



c. Light-Duty Trucks (SUVs and Pick-Up Truck) CO₂e Emissions Trend, 1990-2018

Emissions generated by light-duty trucks, which include SUVs and personal pick-up trucks, showed a significant decline at the end of the 2000s from 834,000 to 471,000 tons. This decline coincides with both the onset of the national recession as well as the beginning of the low-sulfur diesel and engine efficiency regulations, also known as CAFE (Corporate Average Fuel Economy) standards. Emissions plateaued at roughly 470,000 tons until 2014 and then rose to a half-million tons per year by the end of the available data in 2018.

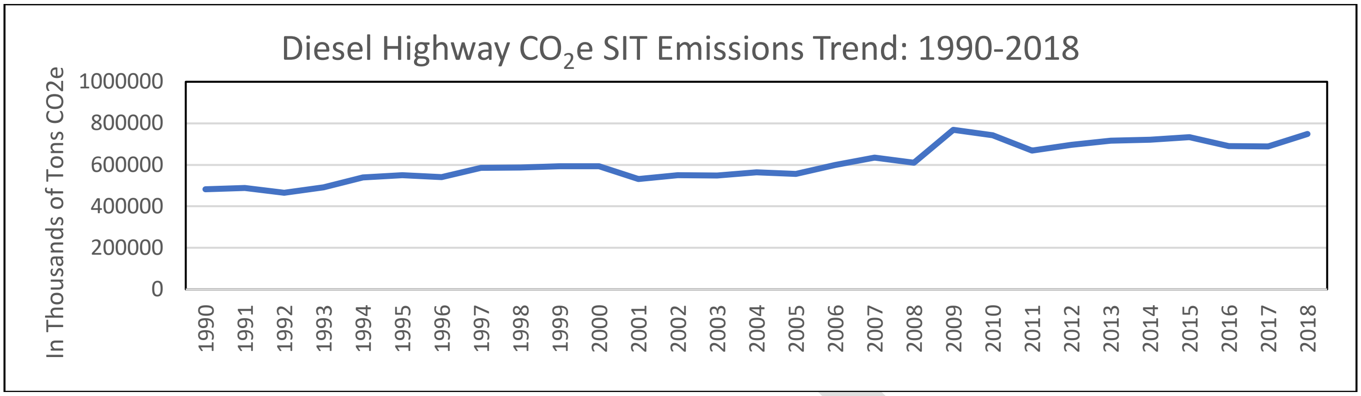
Figure 20 Light Duty Pick-Up Truck Emissions, 1990-2018



d. Diesel Highway Emissions Trend, 1990-2018

Diesel highway vehicle emissions trends have been on an upward trend since 1990 with only a handful of slight yearly reductions. Yearly emissions as of the end of the analysis period were just below 800,000 TPY of CO₂e, an increase of almost 300,000 TPY since 2000.

Figure 21 Diesel Highway Emissions Trend, 1990-2018



e. Gross Off-Road Vehicle Emissions Trend, 1990-2018

State off-road vehicle emissions, including aviation and marine sources, peaked in the mid to late 2000s and fell off during the recession. Aviation and marine vessel emissions rose in the 2010-2015 period. In this review period emissions from these transportation sources continued with a slight decline. The decline in emissions appears to coincide with the recession, the use of higher-efficiency engines, and phasing out of bunker fuel for ocean-going vessels; but this causation is only speculative.

Figure 22 Total Off-Road Vehicle Emissions, 1990-2018

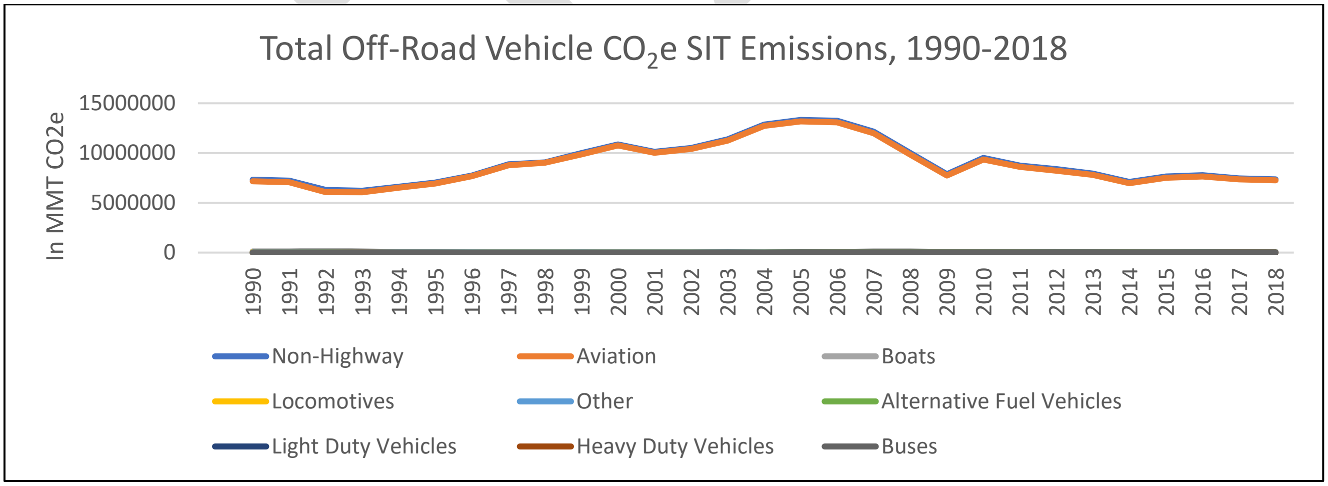
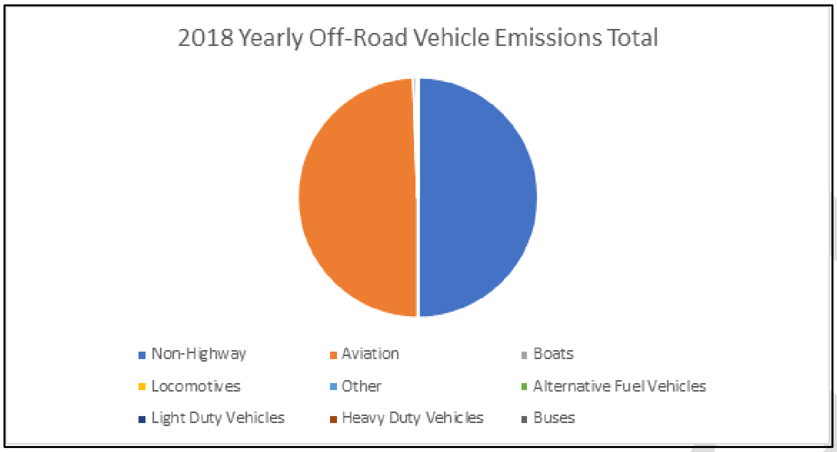


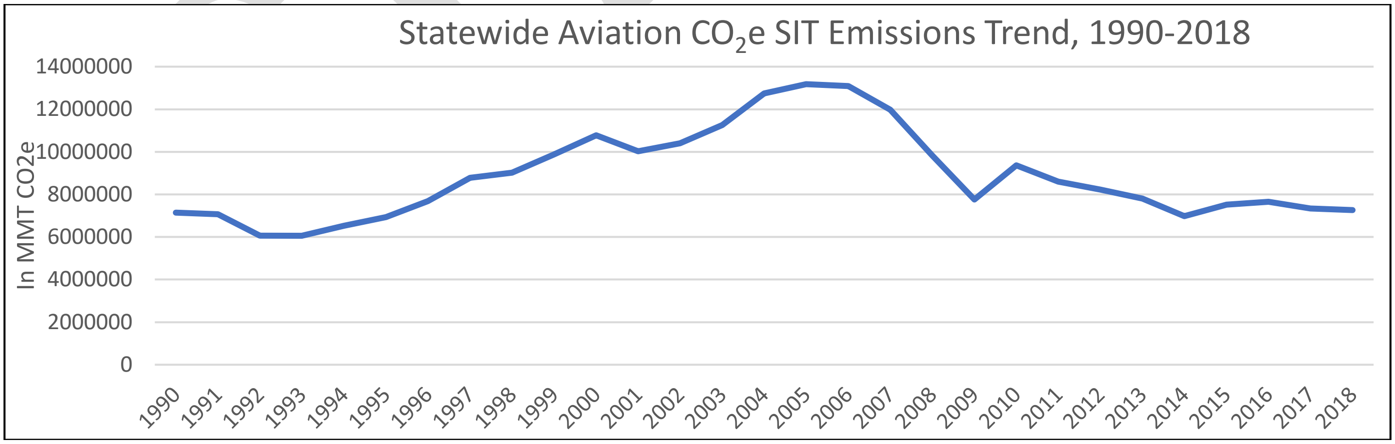
Figure 23 Yearly Off-Road Vehicle Emissions Total, 2018



f. Aviation Emissions Trend, 1990-2018

State aviation emissions peaked mid-decade in the 2000s at slightly below 14 million TPY of CO_2e and declined starting in 2007 and 2008 to below ten million tons. Emissions continued declining to below 8 million tons from 2014 through the end of the period in 2018. These results include emissions from large cargo and passenger aircraft, as well as smaller single and twin-engine piston aircraft.

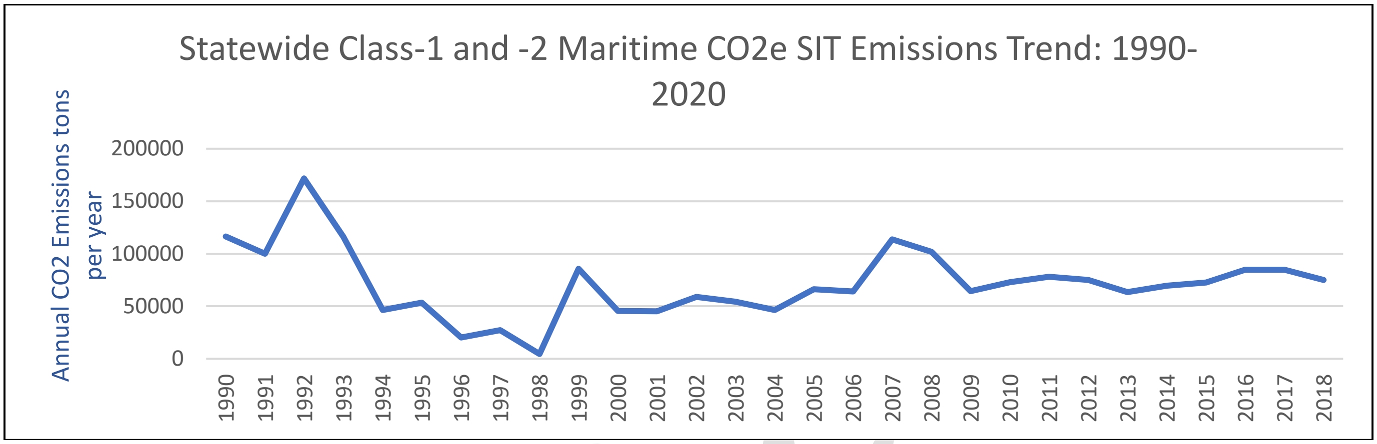
Figure 24 Statewide Aviation Emissions, 1990-2018



g. Maritime Emissions Trend, 1990-2018

Alaska maritime CO_2e emissions peaked in the early 1990s and rapidly declined to below 50,000 TPY by the end of the decade. From 2000 onward to the end of the available data in 2018, recorded state maritime emissions remained stable around 85,000 TPY CO_2e. As explained in the introduction, the SIT does not allow for differentiation or more granular analysis. As a result, the results produced and graphed only show maritime emissions without any labeling of what class vessel produced these emissions. Comparing this data against available emissions results from the triennial NEI, it is possible that this this is only composed of Class-1 and Class-2 vessel traffic. Class-3 traffic, comprised of large oceangoing cargo and cruise vessels, generate significantly more pollution than is shown in this dataset.

Figure 25 Class-1 and -2 Marine CO_2e Emissions, 1990-2018



h. Locomotive Emissions Trend, 1990-2018

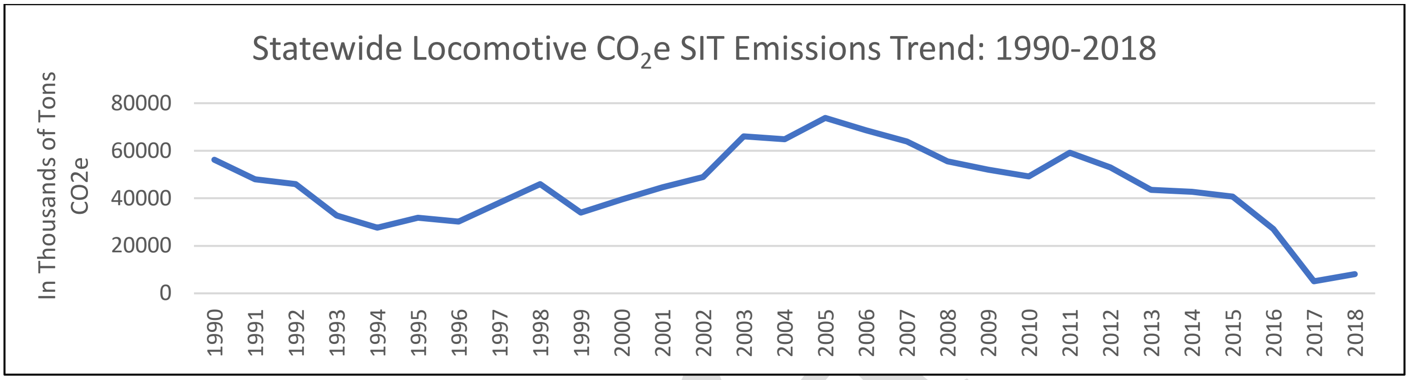
Two railways are in operation in the state of Alaska at present: the Class-2 Alaska Railroad (AKRR) and Class-3 White Pass and Yukon Railroad (WPYRR). Combined total statewide locomotive emissions peaked in the mid-2000s above 70,000 TPY CO_2e and fell off to around 10,000 TPY by the end of the analysis period. According to the EPA National GHG emissions report, emissions data was generated by historic fuel usage per carload for Class-II and -III railroads.

Both the AKRR and WPYRR burn petroleum distillate (diesel) for their locomotives. The WPYRR maintains a small fleet of locomotives for use on special tourism-designated trips that use bunker fuel. These are retrofitted steam engines which originally burned coal and have been rebuilt to use bunker fuel. Bunker fuel has a substantially higher GHG emissions profile than petroleum distillate-fired locomotives. This higher GHG profile was not represented in the SIT for the WPYRR. However, it is a relatively small railway and has a minimal footprint compared to the AKRR.

Neither the AKRR nor WPYRR data are represented in the FLIGHT dataset as these are not stationary permitted facilities. DEC does have access to triennial NEI data, which includes a fuel consumption report submitted by both railways. The consumption report includes a calculation of Criteria Air Pollutants, as well as CO_2e. These totals were pulled and compared against those totals generated in the EPA SIT.

The AKRR reported in the 2020 NEI that their CO_2e emissions were 27,310 tons, a 20,000-ton difference from the EPA SIT figures. The 2017 NEI report from the WPYRR showed a yearly total of 10,200 tons of CO_2e. Using the 2020 AKRR and 2017 WPYRR CO_2e totals, state railway traffic produced a total of 37,200 tons compared to the 7,000 tons produced in the EPA SIT. The NEI totals are the actual GHG profile for the state as these are based on reported fuel consumption.

Figure 26 Statewide Railroad Emissions, 1990-2018[32]



i. Statewide Comparative Non-Road Emissions Trend, 1990-2018

Due to issues with statistical estimates noted in previous sections, only state aviation emissions reflect a realistic emissions profile for activity. DEC will report emissions changes required to the EPA for marine and locomotive inventories to ensure accurate inventories can be generated in the future. Charts below are generated with and without aviation emissions to show the relative influence and size of statewide aviation emissions. The final two chart demonstrates the total share of each category of emissions overall in the first and last years of available data (1990 and 2018). This is done to illustrate the relative stability of these emissions sources since the first year with emissions data in 1990.

j. Comparative Statewide Aviation, Maritime, and Locomotive Emissions, 1990-2018

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[32] Statewide railroad emissions taken from EPA SIT tool; AKRR and WPYRR data reported to DEC as part of 2017 and 2020 NEI.

Figure 27 Comparative Aviation, Marine, and Railroad Emissions, 1990-2018

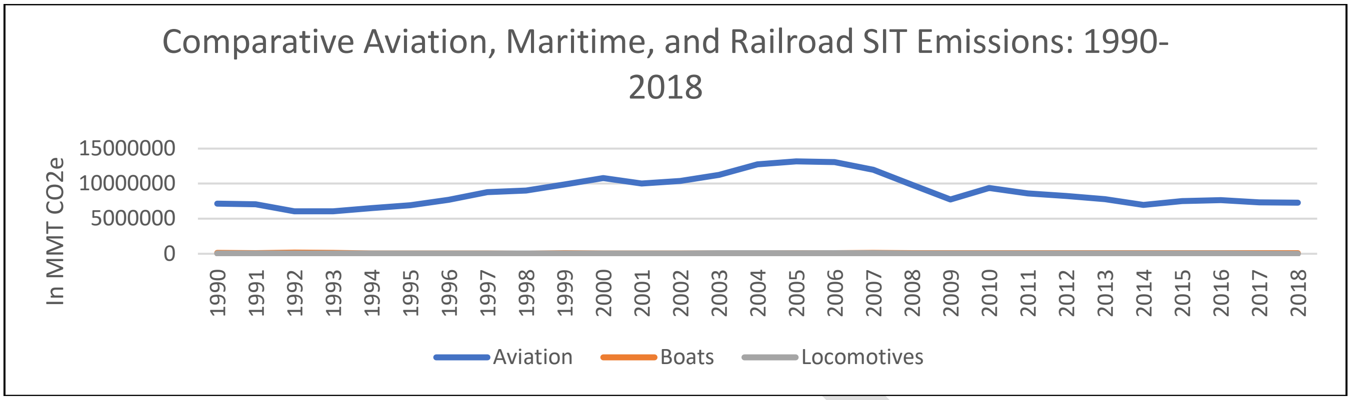


Figure 28 Comparative Maritime, Locomotive, and Farm Equipment Emissions, 1990-2018

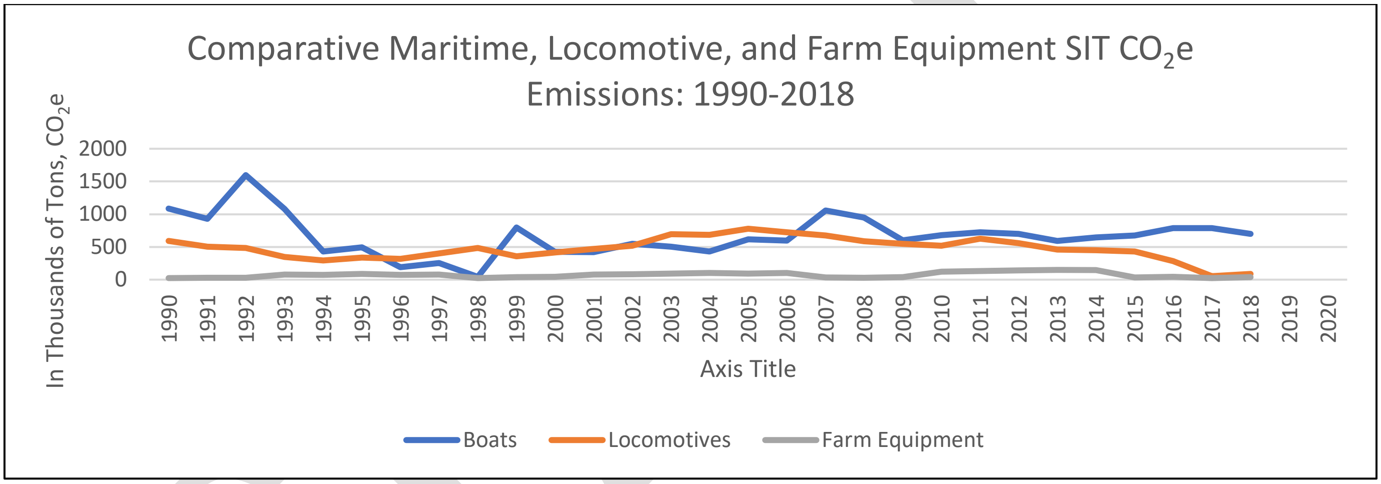


Figure 29 Alaska Off-Road Emissions Share by Source Category, 1990

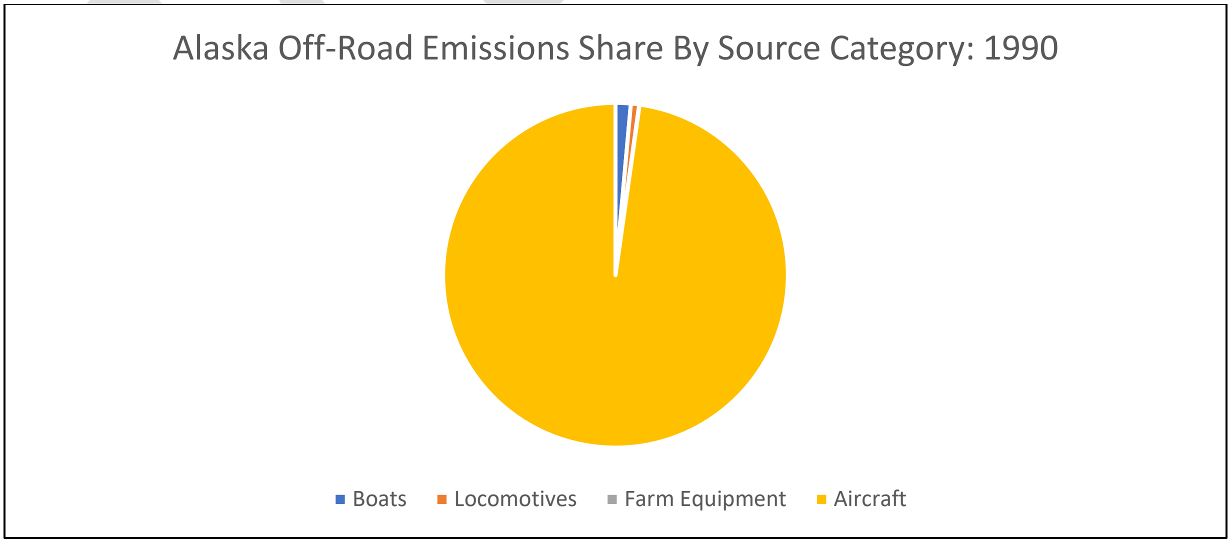
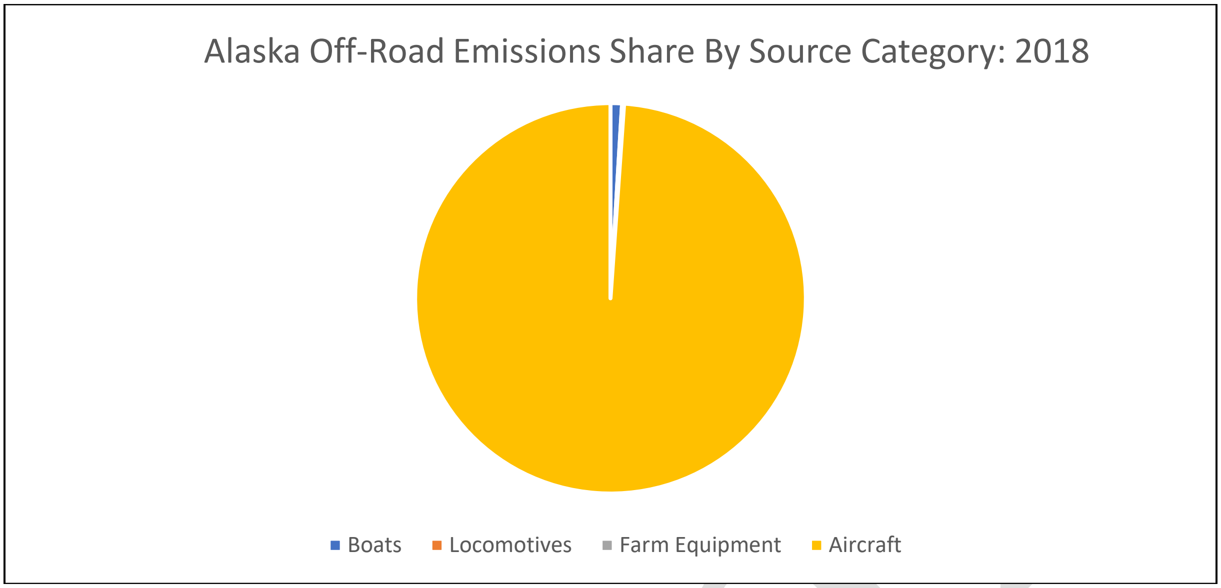


Figure 30 Alaska Off-Road Emissions Share by Source Category, 2018



vi. Residential and Commercial GHG Emissions

Residential and commercial GHG inventories are generated by the CO_2FFC module and are presented in terms of MMT per year by fuel combustion type. Residential consumption of coal has not been recorded since 2007, while commercial consumption in businesses (likely for heating) has continued.

1. Residential Greenhouse Gas Emissions

Statewide residential emissions have remained flat since 2013 when they fell from the previous year's 1.76 MMT to 1.56 MMT of CO_2e. The major source of household emissions has been from natural gas, which is a major source of heating and cooking for houses, condominiums, and apartments in Southcentral Alaska. Household natural gas emissions peaked in 2012 at 1.15 MMT. Emissions have almost returned to their 2012 levels as of 2020, with emissions calculated at 1.14 MMT. Emissions rose 200,000 tons between 2019 and 2020, indicating a significant jump in residential natural gas use compared to the prior eight years. Overall, emissions have risen by 430,000 tons of CO_2e since 1990 as the state's population has gone up by 181,000 during the same period.

Figure 31 Statewide Residential Emissions, 1990-2020

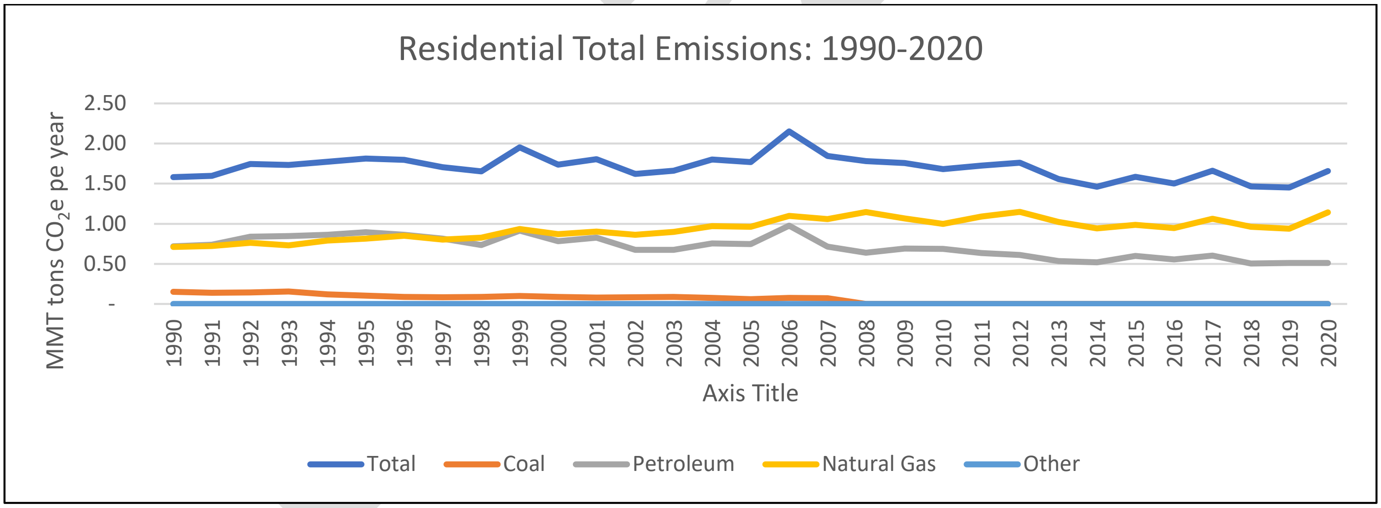


Figure 32 Residential CO_2e Emissions by Fuel Type, 2020

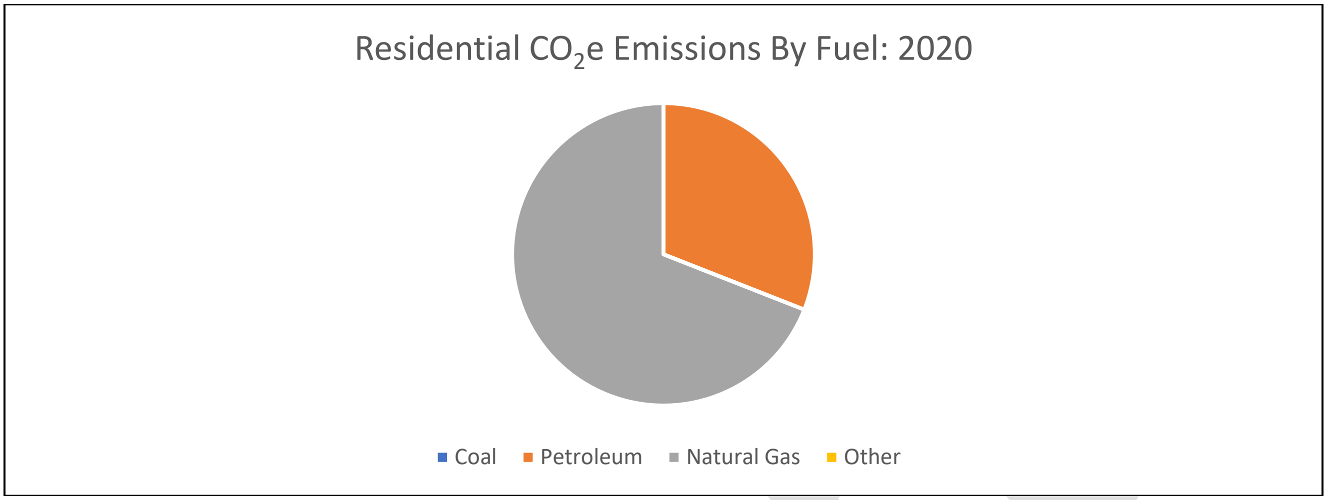
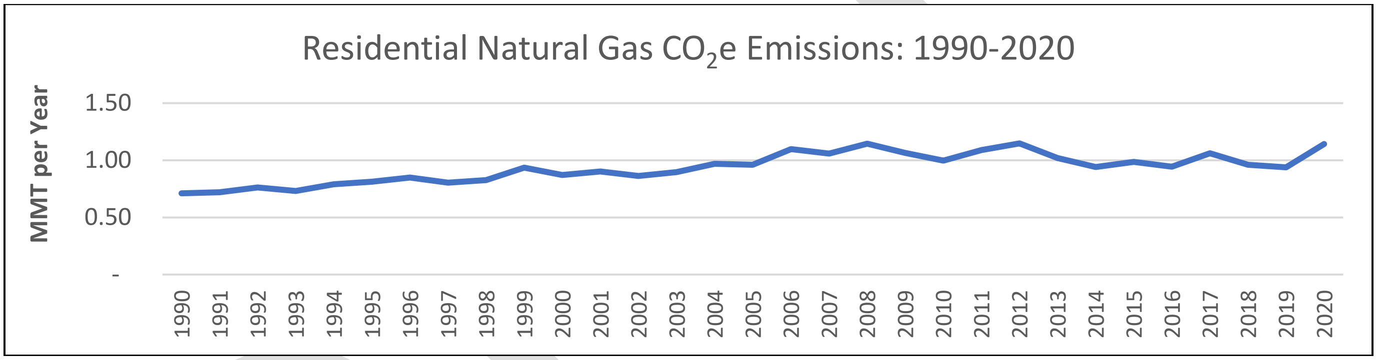


Figure 33 Residential Natural Gas CO_2e Emissions, 1990-2020



2. Commercial Greenhouse Gas Emissions

Commercial emissions over the three decades of available data have fallen since their peak in 2011 of 2.79 MMT CO_2e to 2.03 MMT CO_2e in 2019, the last full year of inventory data. This follows the same general trend of the state economy, where output fell along with the oil and gas recession which set in during the same time. State natural gas commercial emissions plateaued from 2018-2020 at 750,000 tons CO_2e.

Figure 34 Commercial CO2e Emissions by Fuel Type, 1990-2020

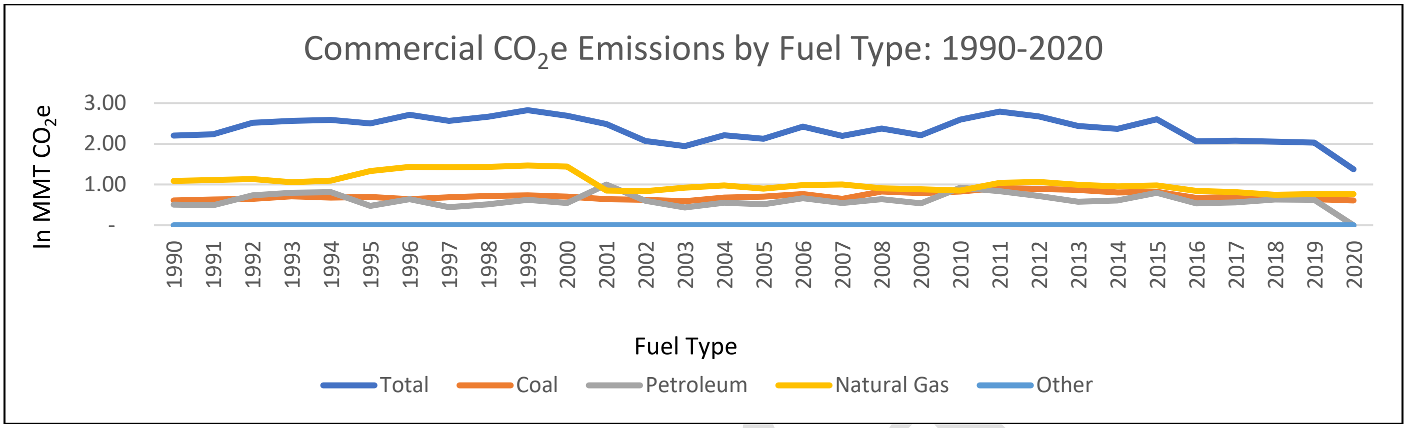


Figure 35 Commercial CO2e Emissions by Fuel Type, 2019

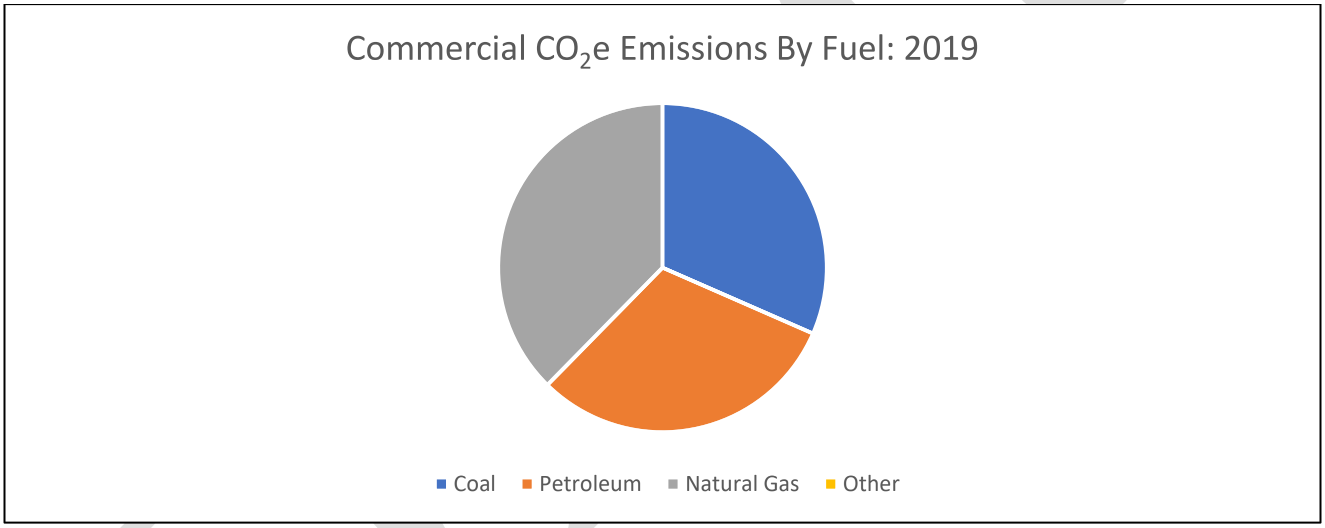
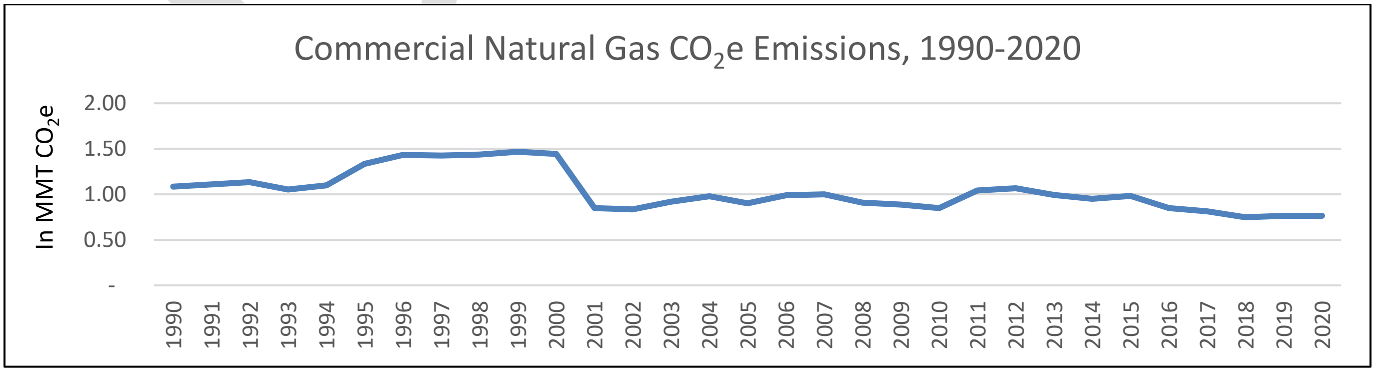


Figure 36 Commercial Natural Gas CO2e Emissions, 1990-2020

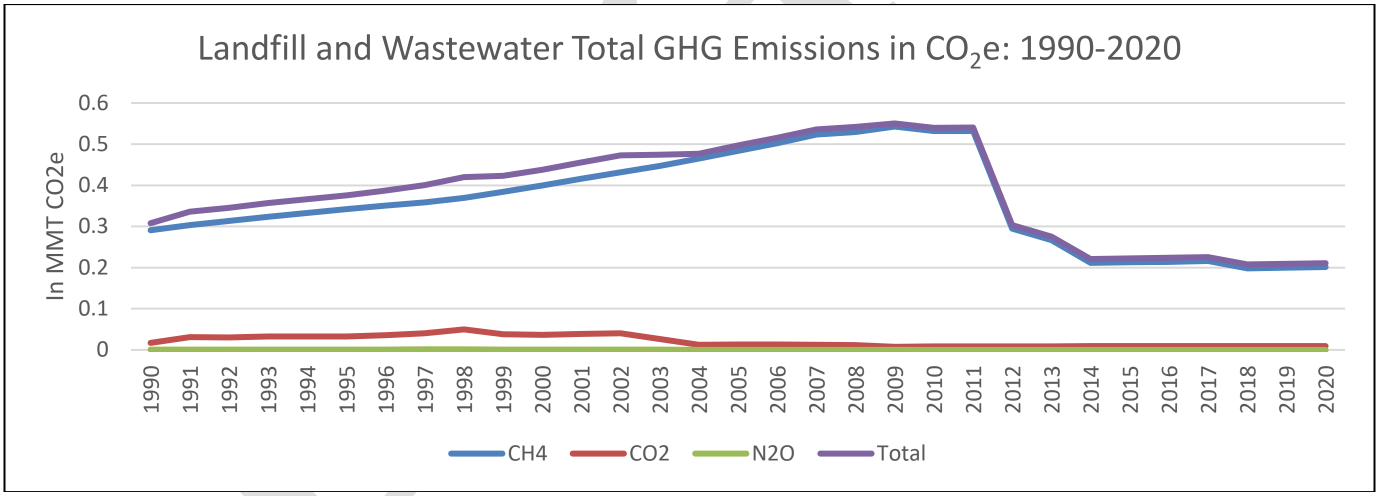


vii. Waste Disposal GHG Emissions

1. Landfill and Wastewater Emissions

Waste disposal generates GHG emissions, primarily CH_4 from decomposition. The waste sector contains emissions from landfills, waste combustion (waste incinerators), and emissions generated by wastewater facilities (public systems). A variety of factors can influence GHG generation, including population; time that waste is in landfills; and the proportion of plastics, synthetic rubber, and synthetic fibers in discarded materials. Consistent with the 2015 Alaska GHG inventory report, waste emissions constitute 1% of statewide emissions. Municipal solid waste generated 21,000 tons per year of GHG emissions in 2020, which is a reduction of 30,000 tons per year from 2012 emissions. Wastewater systems represented in the GHG module for Alaska would be large municipal processing systems, including Anchorage and Fairbanks, as well as Southeast Alaska communities like Juneau or Sitka. Rural landfills are likely not included in these emissions estimates.[33]

Figure 37 Landfill and Wastewater GHG Emissions, 1990-2020



2. Landfill and Wastewater CH_4 Emissions

Landfill and Wastewater emissions produced 60,000 tons of CH_4 in 2020, with a 10-year average of 60,058 tons from 2010 through 2019. It is unclear by EPA guidance whether large and small landfill and wastewater systems are included in the SIT, or if the generated totals are only the larger facilities in Southeast and Southcentral Alaska.

The state does not have a uniform system of landfills and wastewater processing, unlike the contiguous United States. The state's rural wastewater systems are not standardized. Some

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[33] It is unclear how potential landfill methane flares might be included in this modeling, as the Anchorage Municipality operates both a methane flare as well as a gas collection system. Moving forward, DEC will coordinate with EPA to ensure that both landfill gas flaring and gas collection systems are accurately modeled in the SIT for Alaska. In addition, it is also unclear how (or if) the large network of unpermitted municipal landfills in rural Alaska is included in this emissions total. This is another point which DEC will communicate to EPA for future GHG inventory calculations.

communities utilize underground sewage lagoons, while others use above ground lagoons which can freeze over in the winter months. This creates difficulties in calculating emissions. In addition, there are several communities with small enough populations that inspections are infrequent and wastewater systems may be co-located with landfills. These landfills and wastewater systems are small enough to not require annual emissions reporting or air emissions permits under Alaska law.

viii. Agriculture

1. Overview

Alaska has limited commercial agriculture. There is small scale barley and wheat production in Interior Alaska and vegetable and livestock production in the Matanuska-Susitna Valley, Delta Junction, and the Copper River basin. Unlike the contiguous United States, Alaska's environment is not suitable for large-scale industrial agrobusiness at present. The sector has not grown to a size which would generate a larger total GHG emissions footprint than the state's fishing, mining, or oil and gas sectors.

GHG emissions include updated livestock and crop acreage data from the USDA and the DNR, Division of Agriculture. SIT default figures do not include some of the smaller farms located throughout the Matanuska-Susitna Valley and Interior Alaska. These farms report agricultural activity, including crop burning and livestock, to the Alaska Department of Natural Resources, Division of Agriculture.

Crop and livestock production generate GHG emissions through decomposition and other biological processes. Emissions from the agricultural sector include those generated by enteric fermentation, manure management, agricultural soils, and agricultural residue burning (crop burning).

Enteric fermentation is produced by animals, such as cattle, sheep, goats, swine, horses, and other animals that have a large fore-stomach, or rumen. Enteric fermentation takes place in the digestive system of the animals and is the main contributor of methane (CH_4) from ruminant animals. There are also substantial populations of non-livestock ruminants, such as moose and caribou, which reside throughout the state and are not included in this inventory.

Manure management emissions are calculated by multiplying the agricultural animal population by the typical animal mass and the average volatile solids produced. The state did not include data on the non-livestock population in these calculations. Methane production and nitrous oxide production from manure is based on the volatile solids. Agricultural soils from plant residues, legumes, plant fertilizers, and animals are calculated. Agriculture emissions from residues, legumes, and histosols are minimal. The only applicable residue calculations for Alaska are barley and oats. Agricultural residue burning relates to the crop residue produced and subsequently burned.

Statewide agricultural emissions increased slightly since 1990. Yearly agricultural emissions in 2020 were calculated as 109,000 tons total GHGs (CO_2e, CH_4, etc.), an increase of 50,000 tons since 1990. Almost all this increase was generated by a roughly 50,000-ton increase in emissions from enteric fermentation from livestock. As of 1990, enteric fermentation made up some 17,000 tons of GHGs, while in 2020 it constituted 67,000 tons. By comparison, ag soils have increased by 7,000 tons from 28,000 tons in 1990 to 35,000 in 2020.

Even with this doubling of yearly GHG emissions, the state's agricultural sector is less than one percent of statewide totals. Emissions from mechanized agricultural equipment, such as combines or tractors, are included in the off-road mobile emissions category.

Projecting into the next decade, it is possible that this footprint may increase as more lands are opened to agriculture in Interior Alaska.[34] Parallel trends are occurring in Russian Siberia as climate change-driven permafrost thaw is opening up new areas to organized agricultural operations, though the soil is of lower quality than traditional areas in the Russian bread basket in European Russia.[35] State planners should consider including agricultural emissions in triennial reporting to the EPA for NEI purposes and generating GHG figures. This would allow for yearly, or triennial, emissions tracking and would eliminate the time spent identifying databases with livestock and agricultural statistics to generate emissions figures for this report.

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[34] See below citation from the Center for Strategic and International Studies regarding climate driven agricultural frontiers and the potential growth of Alaskan interior agriculture through the end of the century.

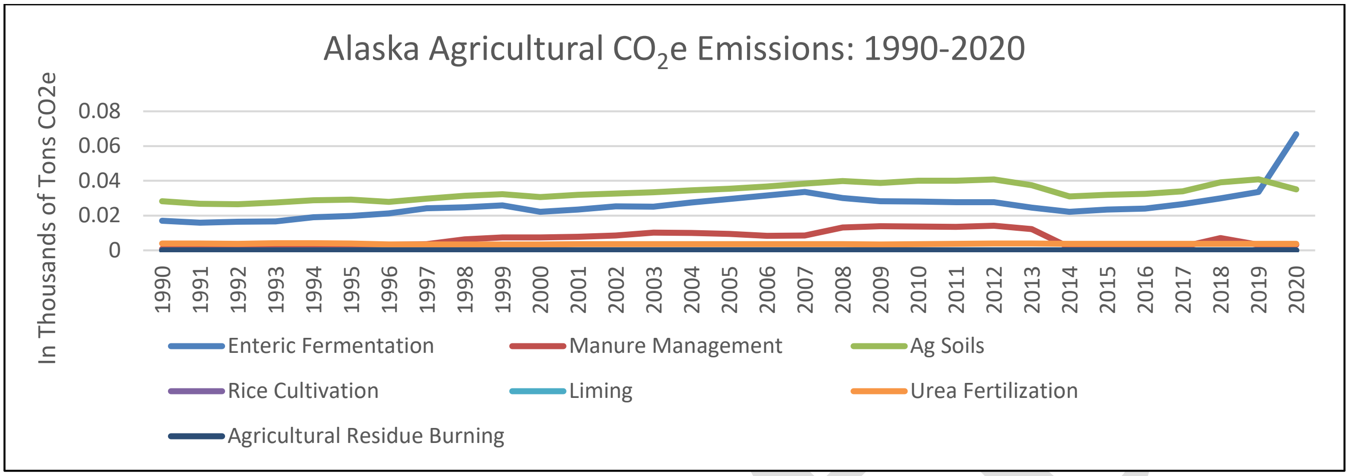
[35] The Washington, DC-based thinktank the Center for Strategic and International Studies (CSIS) conducted an extensive study of the impacts of climate change on Russia, including on the nation's agricultural sector, in January 2021. The report demonstrated several ongoing trends in the Russian Far East and Siberia which parallel environmental and infrastructure challenges and impacts being felt across Alaska. For agriculture the challenges include shifting rainfall patterns, droughts, and agricultural decline in areas traditionally known as being breadbaskets for state-run agriculture in Russia and the former Soviet Union. At the same time, areas across the Russian Far East and Siberia which were formerly permafrost-dominant have shown significant thawing, opening larger areas of land to large-scale industrial agriculture and development.

The opening of new lands for agriculture in areas formerly inhospitable to organized agriculture is common across Siberia and the Russian Far East. These areas are known as 'Climate-driven agricultural frontiers.' By the newest models, large sections of the Alaska interior, along with northern Ontario, Quebec, the Yukon Territory, and other areas of Canada and the US Rocky Mountain Western states will become agricultural frontiers with increased suitability for crops and organized agriculture. Soil quality, however, is varied based on the areas in question and former environmental conditions. This is a trend which will continue through the century across the northern latitudes, including Alaska.

For more information on the CSIS study of Russia and climate change, see: https://www.csis.org/analysis/climate-change-will-reshape-russia .

For more information and modeling of climate-driven agricultural frontiers, see the following article: Lee Hannah et al., "The environmental consequences of climate-driven agricultural frontiers," PLoS ONE, Iss. 15, Article 2 (2020), available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0228305 (Accessed 7/18/2022).

Figure 38 Alaska Agricultural GHG Emissions, 1990-2020



ix. Alaska FLIGHT Facility Level Totals

1. Overview

Facility level emissions data is another approach for understanding and comprehending state emissions profiles. Since the GHGRR was implemented in 2010, large facilities have been required to submit yearly emissions data to the EPA FLIGHT system. These facility-level emissions should align with available data in the SIT, as facility data is included in the SIT toolkit. In most instances for statewide yearly data, FLIGHT data did not align with sector emissions generated by the SIT. No immediate explanation was available for these data discrepancies. In many instances, FLIGHT data is higher than SIT totals.

For Alaska totals, these facilities are the largest emitters in the state and represent key pieces of state-level infrastructure. FLIGHT facilities generate a significant amount of statewide emissions, as well as yearly statewide economic activity. FLIGHT emissions were not collected for every sector as some, such as household or transportation emissions, are not available. For those sectors with large stationary source emissions generation, like electrical generation or mining, facility totals have been included for the half-decade.

The following sectors have FLIGHT data which will be presented: Electrical Generation, Landfills, and Mining. All other sectors represented by SIT data do not have available source data.

2. Electrical Generating Sector FLIGHT Totals

Alaska electrical sector facility emissions are grouped by fuel type, with natural gas and coal the largest fossil fuel powered electrical generating units. A small number of diesel-fired generators are also included in FLIGHT totals and are presented as well. Most diesel-fired generators large enough to be included in FLIGHT reporting are in Western and Southwestern Alaska, with back-up generators in Southeast Alaska included. Natural gas and coal-fired generators are in Southcentral and Interior Alaska, with some natural gas generators located in the North Slope Borough. Coal-fired electrical generators are only located in Interior Alaska, where there are no natural gas pipelines presently.

3. Natural Gas Emissions Trends: 1990-2020

Between 2016 and 2020, average natural gas-fired power plant emissions in the FLIGHT system were calculated at 1.546 MMT CO_2e. The first two years of the period (2016-18) showed higher overall annual emissions than the last two (2018-2020). Emissions in 2018 and 2019 were below 1.4 MMT and fell further in 2020 to 1.16 MMT CO_2e from natural gas-fired power plants in the state. As most of the natural gas-fired electrical generators are in Southcentral Alaska, these emissions reductions may be due to local population declines, better energy efficiency in power generation, the integration of the regional power grid and activation of renewable energy sources in the region (Bradley Lake Hydropower Station, Fire Island Wind Farm, etc.), or upgrades to facilities.

SIT data shows the state producing under 1 MMT of GHG emissions from power plants back to 1990. Statewide emissions averages for the last thirty years were 482,229 tons of GHGs according to SIT data. This is 34% of the 2019 FLIGHT total, a large undercount of emissions. SIT data for 2019 showed a statewide total of 347,269 tons of GHG emissions, 24% of EIA emissions for that year.

Charts below show FLIGHT emissions trends by facility for the period covered in this report. Natural gas facility emissions reported to the FLIGHT database remained consistent through the period. A significant change in reported emissions came from the Nikiski Co-Generating Station. Facility emissions dropped from a half-million tons of CO_2e in 2016 to a consistent 200,000 tons of CO_2e from 2017 through 2020. Emissions from the Hank Nikkels Plant dropped as well from above 300,000 tons of CO_2e in 2016 to under 100,000 tons through 2020.

Figure 39 Natural Gas EGU Facility Emissions, 2016-2020

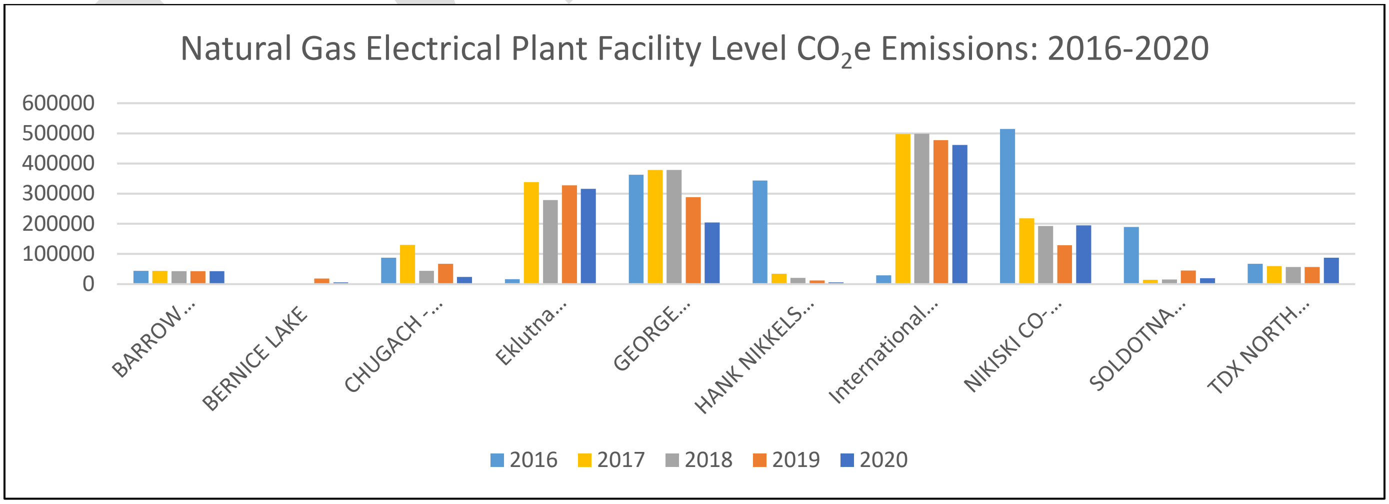
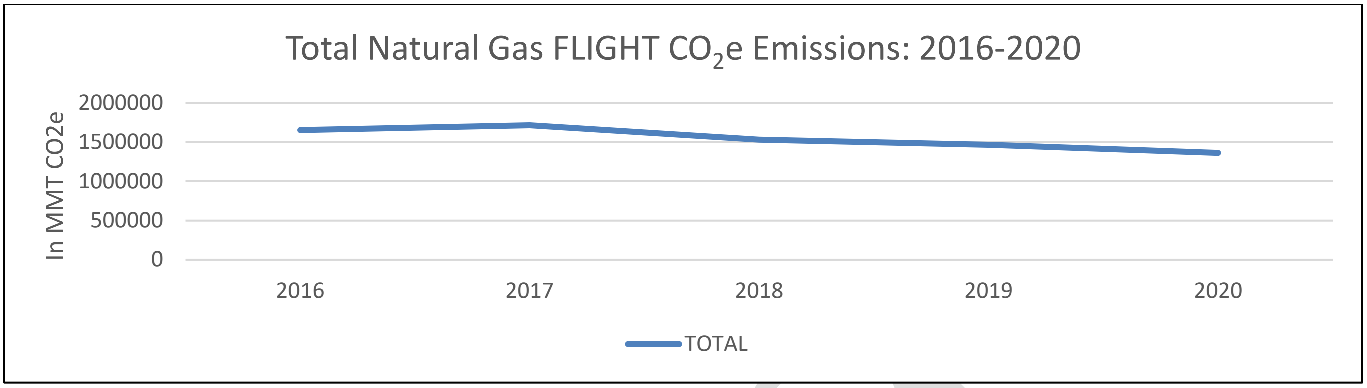


Figure 40 Alaska Natural Gas EGU Facility Emissions Total, 2016-2020



4. Coal Emissions Trends: 1990-2020

Emissions from coal-fired electrical units increased 0.86 MMT CO$_2$e in 2018 to 1.03 MMT in 2019. Of the three major fossil fuels burned for electrical generation in the state, only coal has demonstrated any increase in usage over the last five years. Emissions have increased by nearly a half-million tons of CO$_2$e since 2013, and by 0.27 MMT since 2018. While emissions from coal-fired electrical generators have risen overall, total statewide electrical generation emissions have declined to 2.40 MMT CO$_2$e from 3.07 MMT in 2018 which is a reduction of 0.67 MMT CO$_2$e between 2018 and 2020.

All coal fired facilities are in the Fairbanks North Star Borough and the Denali Borough. No natural gas pipeline exists at present to bring gas from Cook Inlet or the North Slope gas fields to the Fairbanks market. This limits Fairbanks facilities to coal, which is accessible via the Healy coal mine near Denali National Park, or petroleum distillate (diesel) from the Nikiski refinery which must be shipped north on rail tanker cars.

By comparison, the SIT calculated average yearly emissions of 177,318 tons of GHGs from state coal fired EGUs between 1990 and 2020. Over the last five years of the decade, SIT emissions were calculated at a yearly average of roughly 260,000 tons, a reduction of 75% facility-level emissions totals. For FLIGHT and SIT data results, there is a significant difference between the emissions results, with SIT results showing much lower yearly emissions than comparable FLIGHT results. This trend is demonstrated in coal and natural gas EGU results. Over the thirty years of available data in the SIT, no year produced an emissions total of more than 270,000 tons from coal-fired electrical plants.

Using the FLIGHT dataset as the actual statewide emissions total, coal fired EGUs are the only category showing an upward trend through the last decade. This is represented in the chart as resulting from increased emissions at the Healy Power Plant. Facility emissions doubled from 300,000 tons CO$_2$e to just under 600,000 tons CO$_2$e between 2017 and 2020.

Figure 41 Coal-Fired EGU Facility Emissions, 2016-2020

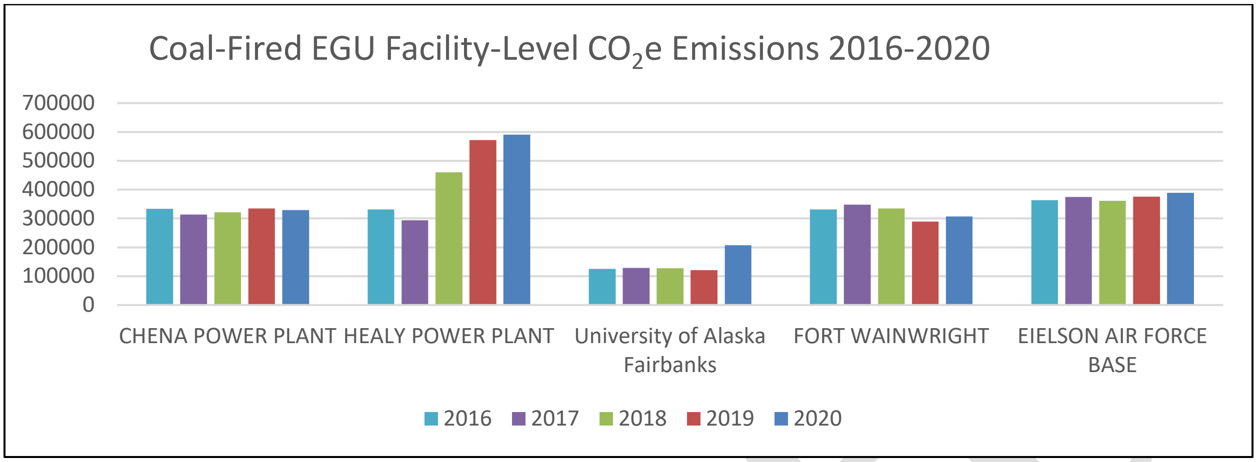
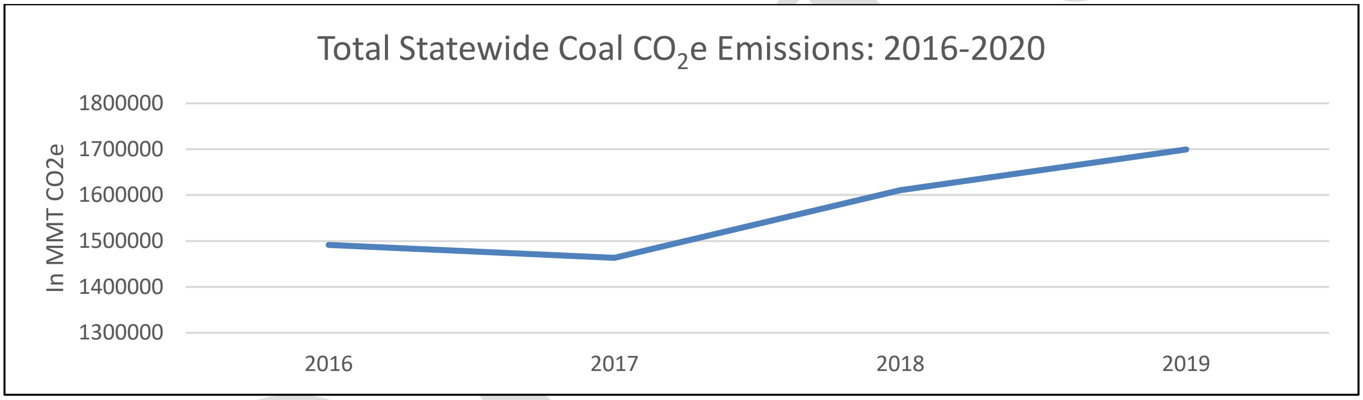


Figure 42 Alaska Coal-fired EGU Facility Emissions Total, 2016-2020



a. Petroleum Distillate (Diesel) Emission Trends: 1990-2020

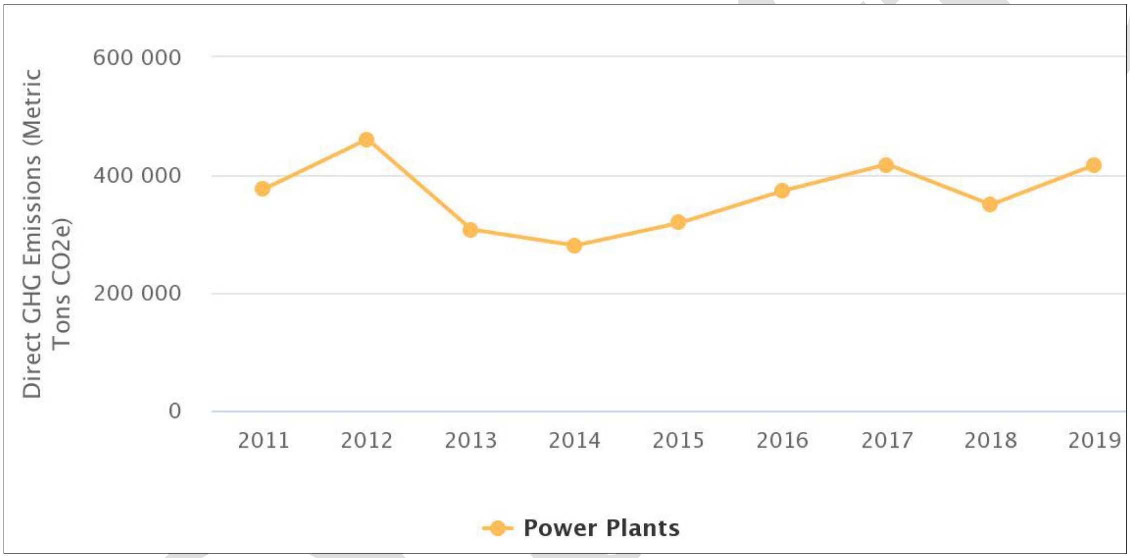
Petroleum distillate (diesel) is the primary fuel used for electrical generation in rural Alaska due to distance and availability of other fuels. By FLIGHT data, diesel-fired electrical generation trends have remained stable through the current period, with no significant changes recorded. SIT data showed similar results, with yearly data over the last decade remaining at or below 100,000 TPY of emissions from all statewide diesel-fired electrical generators. The average yearly emissions of diesel-fired generators by SIT data since 1990 was 120,837 tons.

b. Petroleum Distillate-Fired Electrical Generation Emissions

Rural Alaska is home to the largest number of microgrids in North America, with many communities and private industries generating their own on-site power due to infrastructure limitations. This is due to the lack of a statewide power generation and distribution infrastructure. Most small, rural communities and industries utilize diesel-fired generators to provide electricity to residents and industrial sites. This is largely due to the availability of diesel as the most common form of petroleum fuel in Western and Southwestern Alaska. In some instances, industrial power generators also serve as community power generators as well. These are generally smaller communities with economies based around the fishing industry.

Diesel generators are also used as back-ups for hydropower stations in Southeastern Alaska. Although most generators have significant electrical generating capacity, they are used infrequently and only in a peaking or support function for the larger hydropower stations in the area. In addition, petroleum distillate is used for energy generation in the Fairbanks North Star Borough at the North Pole Power Plant.

Figure 43 EGU Diesel Facility Emissions Total, 2011-2019



c. Comparison Between FLIGHT Emissions and SIT Totals

FLIGHT facilities in Alaska make up a large share of total statewide electrical emissions and are responsible for 95.5% of average statewide electrical emissions. Due to the incomplete nature of 2019 emissions in the SIT tool, it is likely that these values could change once default data is available for the SIT after final EPA validation of EIA data.

Except for the North Pole Power Plant, all other diesel-fired FLIGHT facilities have stable emissions at or below 50,000 TPY of GHG emissions. When combined, the GHG total is roughly 100,000 TPY, with is around one-third of the emissions generated by the North Pole Power Plant on a yearly basis.

d. FLIGHT-SIT Coal-Fired Emissions Comparison

FLIGHT reporting facilities made up 92% of total statewide emissions (1.2 MMT CO_2e) against statewide coal emissions total (1.3 MMT CO_2e) during the reporting period in the

SIT. The three FLIGHT reporting facilities that use coal (Chena Power Plant, Healy Power Plant, and the Fort Wainwright CHPP) are all located in Interior Alaska. Fuel choices are limited in the Interior, and a replacement for coal in the form of natural gas is expanding via trucking from Cook Inlet. Coal has fallen out of use in the rest of the State, where it has been replaced with either natural gas (Southcentral Alaska) or was not heavily used to begin with (Southeast, Western, and Northern Alaska).

e. FLIGHT-SIT Natural Gas-fired Emissions Comparison

Natural gas-fired electrical emissions from FLIGHT facilities constituted 100% of statewide electrical emissions reported in the SIT tool for 2019. Total FLIGHT facility emissions constituted a total share of 116% of statewide natural gas-fired electrical emissions. At present, EIA fuel consumption figures for 2019 are not in their finalized form and may be updated when available. Using the last full validated year of emissions (2018), FLIGHT facilities constituted a 97% share of statewide natural gas electrical emissions.

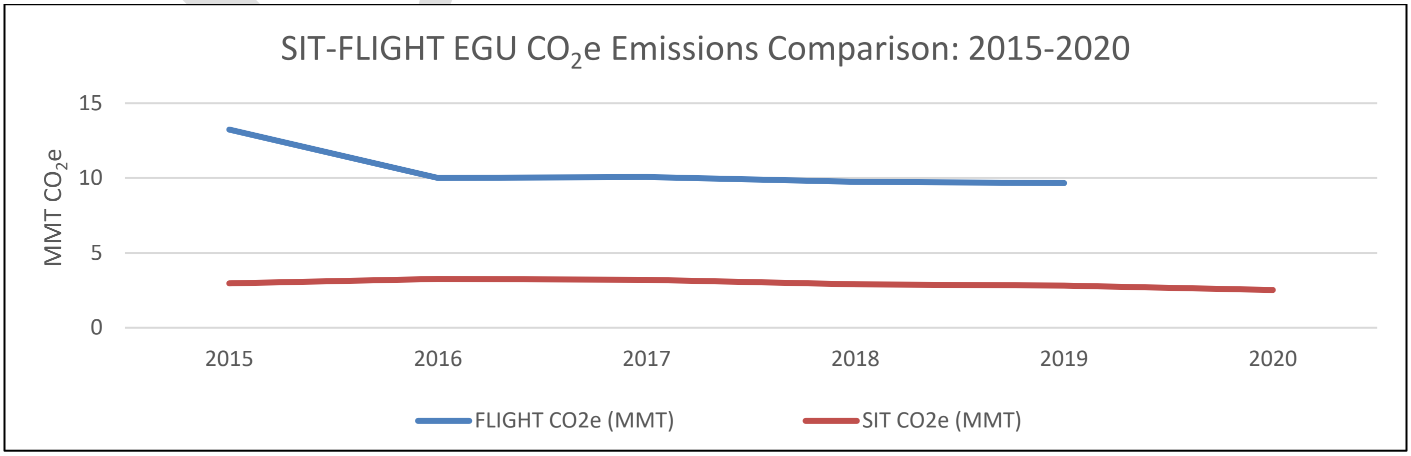
f. FLIGHT-SIT Petroleum Distillate (Diesel) Emissions Comparison

Data reported in the FLIGHT system for diesel generators calculated at 112% of statewide totals in the SIT. This indicates that FLIGHT reporting facilities produced more emissions than those produced using SIT data alone.

5. Oil and Gas Facility-Level Emissions

In 2015, one facility was excused from reporting and in 2019, 38 oil and gas facilities (including refineries) reported emissions to the FLIGHT system. Out of those, 12 were excused from reporting emissions. This may account for the reduction of emissions since 2015. Comparing the SIT results with the FLIGHT data there are difference in volumes due to SIT calculation methodology verses FLIGHT reporting requirements. However, both show a downward trend of emissions.

Figure 44 SIT-FLIGHT CO₂e Emissions Comparison, 2015-2020



6. Landfill Facility-Level Emissions

Landfills reporting to the FLIGHT system include active facilities, such as the Anchorage Regional Landfill, which service major municipal regions. It also includes inactive or shuttered facilities, like the now closed municipal landfill located under Merrill Field in central Anchorage. It does not include landfills located in rural Alaska which are rated Class III facilities. These primarily serve communities under 500 residents and are not included in statewide FLIGHT reporting.

a. FLIGHT Waste Facility Emissions

FLIGHT emissions peaked in 2017, with 887,000 tons of GHGs emitted from all reporting facilities. The facility with the highest reporting emissions from the FLIGHT database was the Anchorage Regional Landfill, with 632,000 tons of total GHGs, including CH_4 and CO_2e, emitted in 2017. These facilities showed 50% fewer emissions the following year.. It is possible that this cut in GHG emissions at the Anchorage Regional Landfill is a direct result of landfill gas capture system upgrades that were completed and brought online in 2018. A similar system is in place at the Juneau Capital Landfill, although that facility services a smaller population than the Anchorage Regional Landfill.

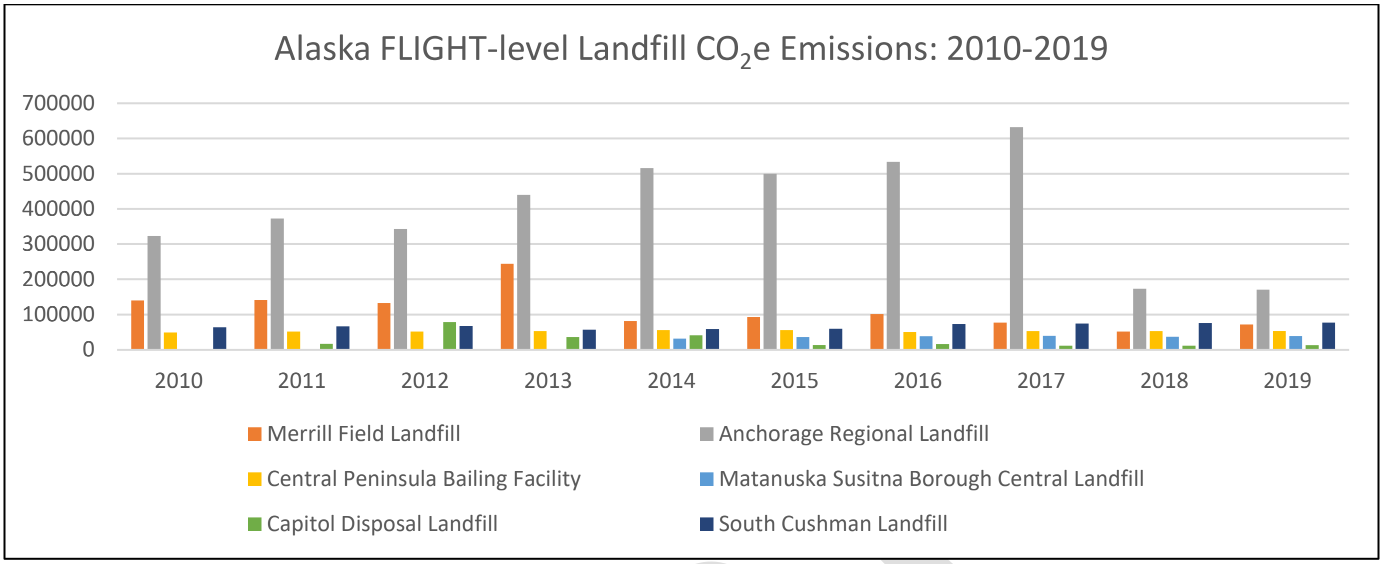
GHG emissions for all other landfills in the state were similar across the three-year reporting window (2016-2019) where Anchorage Regional Landfill's emissions decreased by 50% between 2017 and 2018. The only facility in this period that increased emissions was the Merrill Field Landfill, which has been closed since the late 1980s. Emissions at the Merrill Field Landfill rose by nearly 20,000 tons, from 54,000 to 72,000 tons CH_4 between 2018 and 2019. This increase is nearly 70,000 tons CH_4 below 2010 reported emissions of 139,852 tons. There is no immediate explanation for the increase in CH_4 emissions from the Merrill Field Landfill at present.

b. Landfills - FLIGHT and GHG SIT Comparison

FLIGHT emissions for the years 2011-2019 showed a yearly average of 680,000 tons of total GHGs (CO_2e, CH_4) from reporting facilities. By comparison, the SIT produced an annual average of 34,900 tons of total GHGs per year; 5% of the FLIGHT emissions for the same period. It is unclear where this data discrepancy comes from at present. This will be communicated to the EPA along with other instances of misaligned SIT and FLIGHT datasets.

Examining the FLIGHT data, the Matanuska Susitna Borough Central Landfill and Capitol Disposal Landfill in Juneau produced annual average emissions like the SIT Landfill module. The Anchorage landfills (Anchorage Regional Landfill and Merrill Field Landfill [closed since 1989]) produced 400,000 and 113,600 TPY of GHGs. With these two emissions profiles in the FLIGHT data, it is unclear whether facilities have been included in SIT data.

Figure 45 Alaska Landfill Facility Emissions, 2010-2019



7. Mining Facility-Level Emissions

Due to emissions reporting limits under the FLIGHT system, only three mines submit yearly emissions. All other facilities in the state are too small to report under the GHGRR.

a. Mining Sector FLIGHT Facility-Level Results

Three mines report to the FLIGHT system at present: Red Dog Mine (zinc), Hecla Greens Creek Mine near Juneau (gold), and the Kensington Mine near Juneau (gold). All three are either zinc or precious metals mines. Total statewide facility CO_2e emissions increased from 192,732 tons in 2011 to 230,243 tons in 2020, an increase of roughly 38,000 tons, or 16.5%, over the nine-year period where all three mines reported to the FLIGHT system.

The Red Dog Mine maintained the largest footprint in the state, with an average of 146,822 tons of GHGs (CH_4, CO_2e) between 2011 and 2020. Hecla Greens Creek and the Kensington Mine reported an emissions footprint of 18,600 and 33,500 tons each on average.[36]Emissions from the Healy Coal Mine were too small to require reporting to FLIGHT systems under the GHGRR. The data for Hecla Greens Creek Mine emissions were not available for 2018 or 2018 in the FLIGHT database. The explanation provided stated, “Facility discontinued reporting for a valid reason.”

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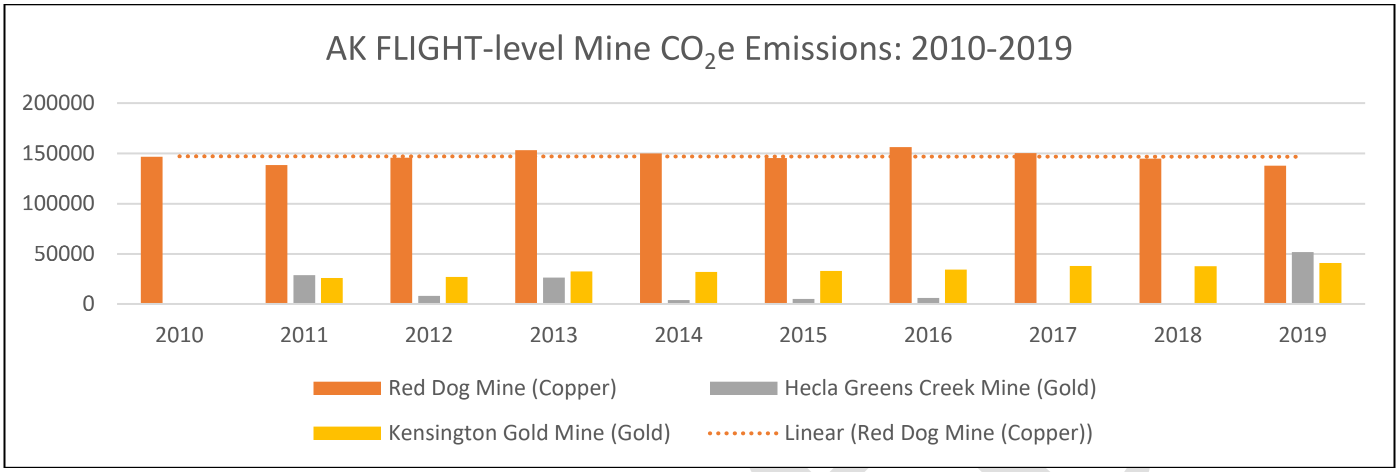
[36] Both Hecla Greens Creek and Kensington Mines receive power from the local hydroelectric power stations in Juneau. These emissions are the result of on-site fuel consumption and mine operations.

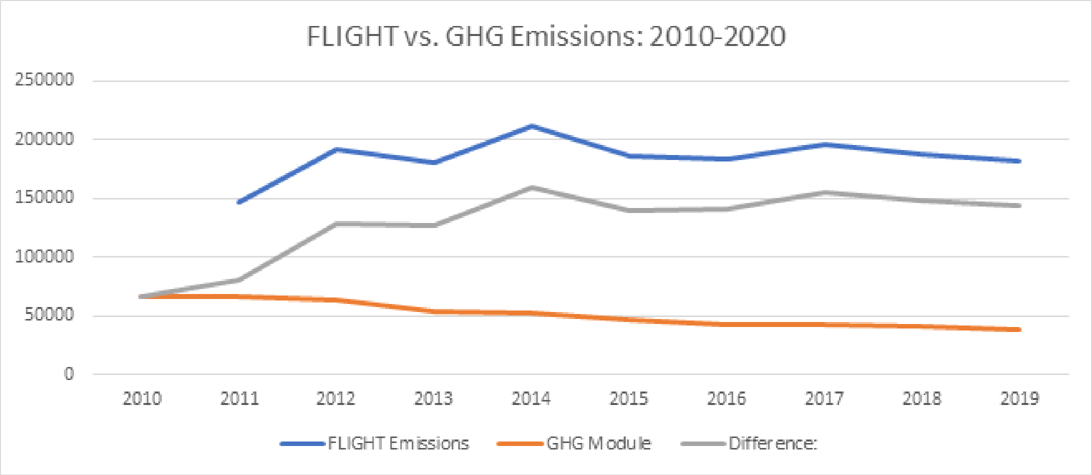
Figure 46 Alaska Mine Facility Emissions, 2010-2019



b. Mining Sector FLIGHT vs. GHG Module Emissions Comparison

FLIGHT facility emissions reported on average 190,000 tons per year as compared to 60,000 tons generated by the SIT mining module. This leaves a gap of 130,000 tons of emissions between the two reports. As the tool uses an aggregated total for state-level emissions, it is unclear where the reporting gap may be located. This discrepancy in emissions totals will be communicated to EPA.

Figure 47 FLIGHT-SIT Mine Emissions Comparison, 2010-2019



x. Land Use, Land-Use Change

1. Overview

The land use and change SIT module calculates vegetation loss and gains. Vegetation is essential for the absorption of CO_2 or “sequestration” of carbon. When vegetated areas absorb carbon, they are also referred to as a “carbon sink.” These areas can be forests, riparian (river) systems, lakes, tundra, or grasslands.

These factors are relatively stable over time but can be impacted by such events as wildfires which can vary greatly in acreage and emissions between years. Wildfire emissions were excluded from the emissions inventory on the basis that these gases would be absorbed by more productive recolonized vegetation. However, in addition to CO_2, wildfires also produce N_2O and CH_4 which are less readily incorporated into new plant growth. CH_4 contributes 25 times the carbon change potential of CO_2 and N_2O contributes 298 times the global climate change potential of CO_2.

Carbon emissions and sequestration from forest management and land use-change are dependent on the following factors: Limiting of agricultural soils, landfilled yard trimmings and food scraps, forest carbon flux, acreage of urban trees, forest fires, N_2O released from settlement soils, and urea fertilization. Carbon flux is defined as the amount of carbon exchanged between Earth’s carbon sinks. Forest carbon flux includes above ground and below ground biomass, dead wood, litter, and soil organic carbons. Forest carbon flux can also be represented by the total carbon storage.[37] [38]

2. Emissions Sinks – U.S. Forest Service Alaska Calculations

Unlike the 2010-2015 GHG report, the state of Alaska has chosen to use a new set of calculations using USGS research, rather than the previous inputs. The SIT and the national

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[37] Another category of emissions sinks which has been discussed recently is oil and gas well sequestration. This is tied to a new category of technology known as “Carbon Capture, Utilization, and Storage” (CCUS), which uses air filtration and other techniques to remove Carbon Dioxide and other GHGs from both the ambient air as well as from stationary sources like power plants and oil and gas refineries. The state of Alaska has begun exploring the use of abandoned oil and gas wells in Cook Inlet as potential future GHG sequestration sites. However, it should be noted that this technology is still very new and is still in the laboratory and initial field-testing stages. The state and federal governments are working on including this sequestration capacity in both the Willow EIS and Alaska LNG EIS to calculate potential future GHG and climate impacts of these projects.

[38] The Department of Energy has produced carbon intensity studies of Alaska North Slope oil and gas in its supplemental EIS’s for both Willow and AK LNG. For more information on carbon intensity, please see the following links:
Willow Master Development Plan Final Environmental Impact Study:
https://eplanning.blm.gov/public_projects/109410/200258032/20063228/250069410/Vol%201_Willow%20Draft%20Supplemental%20EIS_July%202022.pdf
Alaska LNG Project Final Environmental Impact Study:
https://www.energy.gov/nepa/articles/doeeis-0512-s1-final-supplemental-environmental-impact-statement-january-6-2023

GHG report include a per capita forest sequestration estimate which both use U.S. Forest Service (USFS)-managed land in Southeast and Southcentral Alaska. This is only a small portion of total state sequestration capacity and only represents a portion of available sequestration capacity. [39]

The land area managed by the USFS is small compared to those lands managed by other state and federal agencies in total. In total, there are only two national forests managed by USFS in the state of Alaska: The Tongass National Forest and Chugach National Forest. The Tongass National Forest covers parts of the Alexander Archipelago in Southeast Alaska and includes large old-growth forest stands. The Chugach National Forest is in Southcentral Alaska around Prince William Sound and includes parts of the Kenai Peninsula. While these are large forests, they do not represent a significant portion of the state's vegetation or sequestration capacity.

This sequestration capacity built into in the SIT has been used in previous statewide GHG Inventories. This included the last inventory published in 2018. Due to the limited calculations, this calculation left much of the state's vegetation out of the final figures. As a result, DEC has chosen to use the newer USGS study as the basis for the state's carbon sequestration calculations.

3. Emissions Sinks – USGS Report Review

DEC chose to use the data from the USGS report because it includes most of the state vegetative zones. This report contains full calculations of sequestration in tons of CO_2e, as opposed to acres of vegetation or other figures which require additional intermediary steps. It also provides calculations for each of the state's vegetative zones in terms of carbon sequestration capacity along with aquatic ecosystem sequestration. The sequestration factors for each primary vegetation type provides for more accurate calculations for Alaska habitat types.

The USGS report generates sequestration capacity for 97.9% of the state's lands and ecosystems, including tundra, shrubland, upland and lowland forests, wetlands, and other vegetations.[40] This sequestration capacity is estimated based on two time periods: A historical period and a projection period. The historical period is estimated based on state data (including climate and land use) from 1950 through 2009. This historical period covers roughly the first two decades of the state GHG Inventory (1990-2010). The second period, or the projection period, covers the years 2010 through 2099 and includes projections for sequestration.

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[39] A final category of emissions sinks which were not included in this study is seaweed and kelp, which have been proposed as potential avenues of carbon sequestration for future consideration. These are still very new options for the state to explore. But, there is not yet enough available data to make a statement regarding potential seaweed or kelp growth sites, or estimated carbon sequestration capacity for these locations. DEC will include these and other sequestration routes in future GHG Inventory studies, along with carbon sequestration estimates along with currently available USGS carbon sequestration data.

[40] A. David McGuire, Helene Genet, Yujie He, et al., "Chapter 9: Alaska Carbon Balance," part of *Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, ed. Zhiliang Zhu and A. David McGuire, U.S. Geological Survey: Reston, VA, 2016, p. 189.

DEC is using the conservative baseline estimates in the USGS report, rather than the more aggressive sequestration estimates included in the report. This allows state planners to return to these sequestration figures in future reports and adjust upward if needed.

The USGS report is considered by DEC to be the preferable approach to statewide carbon sequestration calculations for several reasons. This report provides a full calculation of the amount of carbon stored currently in ecosystems such as tundra, wetlands, and forests. It also provides an estimate of the capacity of each ecosystem to sequester carbon on a yearly basis. This is crucial for analysis as it allows planners to keep track of the rate of growth or loss of each ecosystem for carbon sequestration.

This report also provides a valuable estimate of the rate of GHG flux within Alaska ecosystems. Due to the state location in northern and Arctic latitudes, the various natural systems and regional ecosystems are more vulnerable to the impacts of climate change. These impacts can include warming and ambient temperature increases, increasing coastal and interior storm intensity, expansion or contraction of sensitive vegetation types, and spring and summer permafrost thawing. This sensitivity in sub-Arctic and Arctic ecosystems are well-documented within the scientific literature.[41]

Changes like these can generate direct impacts on state sequestration capacity. Climate forcing events, including the ongoing permafrost thaw and subsequent CH_4 release, directly impact how state GHG flux must be calculated. Reports like this will be important in coming years for comprehending state carbon sequestration capacity transformations.

The following sections provide an overview of each of the surveyed ecosystems in the USGS study, along with each of their estimated carbon stocks or sequestration in teragrams per year. A summary reading of the total state capacity, identified in the report as "Upland and Wetland Ecosystems," is located at the end of the section along with sequestration charts for both the Historical Period (1950-2009) and the Projection Period (2010-2099).

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[41] For more information on Arctic and Subarctic climate sensitivity, see the following articles and chapters:
Manfried Bolter and Felix Muller, "Resilience in polar ecosystems: From drivers to impacts and changes," *Polar Science*, Vol. 10 (2016, pp. 52-59, available at: https://reader.elsevier.com/reader/sd/pii/S1873965215300116?token=B422E4D70BC2A91D21DE7BD49AF9BBBF8F735652E93B3658ED0944E0B0FD0B35C20F118E2850697B52F46AD3E28E3701&originRegion=us-east-1&originCreation=20220203200919 (Accessed 2/3/2022).
Sofia Ribeiro, Audrey Limoges, Thomas Davidson et. al, "Vulnerability of North Water ecosystem to climate change," *Nature Communications*, Vol. 12, July 22, 2021, available at: https://www.nature.com/articles/s41467-021-24742-0.pdf (Accessed 2/3/2022).
Anisimov, O.A., D.G. Vaughan, T.V. Callaghan, C. Furgal, H. Marchant, T.D. Prowse, H. Vilhjálmsson and J.E. Walsh, 2007: Polar regions (Arctic and Antarctic). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, 653-685, available at: https://www.ipcc.ch/site/assets/uploads/2018/02/ar4-wg2-chapter15-1.pdf (Accessed 2/3/2022).

Analysis of the sum of the state's sequestration capacity is located at the end of this section along with comparisons of carbon emissions from other U.S. states against current Alaska sequestration capacity in all zones of vegetation.

4. Southeast Alaska Coastal Forest Region

a. Overview of Vegetative Zone

This encompasses much of the area originally included in the SIT, which is much of the Tongass National Forest. According to the USGS study, the coastal rainforests of Southeast Alaska have some of the highest carbon stocks in the world, including dissolved organic and inorganic carbon processed via a lateral loss vector.[42] Calculations of carbon density in Southeast Alaska by USGS reached an estimate of 30 kilograms of carbon per square meter.[43] Carbon stocks in the Tongass National Forest are estimated at 2.8 petagrams (gigatons), plus or minus 0.5 petagrams.[44] This is an estimate which is applied to both the historical and projection periods.

5. Alaska Coastal Forests

a. Overview

This section covers all coastal forests in Southeast and Southcentral Alaska, along with forests located on Kodiak Island. This includes parts of Southeast Alaska which were included in the previous set of calculations. The USGS report provides calculations from 2004 onward, rather than an estimate back to the 1950 baseline used in other estimates. As this is labeled the historical inventory, it should be applied back to the 1950 baseline period. According to estimates, coastal Alaska forests have a carbon sequestration capacity of roughly 1000 teragrams, or one gigaton of carbon, for the period 2015-2020.[45]

6. Soil Carbon and Permafrost

a. Overview

This section presents information on stored carbon located in arctic and boreal forest ecosystems, along with estimated carbon stocks in permafrost soils. According to recent studies cited in this report, northern permafrost areas (North America, Europe, and Asia) contain roughly 1,300 petagrams (1300 gigatons) of organic soil. Of these, 800 petagrams

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[42] David V. D'Amore, Francis E. Biles, S. Mark Nay, and T. Scott Rupp, "Chapter 4: Watershed Carbon Budgets in the Southeastern Alaska Coastal Forest Region," part of *Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, ed. Zhiliang Zhu and A. David McGuire, U.S. Geological Survey: Reston, VA, 2016, p. 77.

[43] Ibid.

[44] David D'Amore et al., "Ch. 4: Watershed Carbon Budget in Southeastern Alaskan Coastal Forest Region," 77.

[45] Xiaoping Zhou, Svetlana Schroder, A. David McGuire, and Zhiliang Zhu, "Chapter 5: Forest Inventory0Based Analysis and Projections of Forest Carbon Stocks and Changes in Alaskan Coastal Forests," part of *Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, ed. Zhiliang Zhu and A. David McGuire, U.S. Geological Survey: Reston, VA, 2016, p. 95.

are in permanently frozen (permafrost) soils in Arctic latitudes.[46] This is nearly four times the amount of carbon released by all anthropogenic sources (fossil fuel burning, land use, etc.) since the start of the Industrial Revolution in 1750, estimated at 240 petagrams, With warming trends that have started since 2014, thaw of these area will be irreversible and the release of these frozen carbon stocks (permafrost carbon feedback) have not been accounted for in IPCC climate modeling.[47]

7. Upland Alaska Ecosystems

a. Overview

The areas designated upland ecosystems include arctic and boreal permafrost regions, which corresponds with much of Interior and Northern Alaska. During the historical period estimates, these regions of the state were estimated to sequester 5.01 teragrams of CO_2e per year, or five billion kilograms of CO_2e.[48] The chapter noted that the northern boreal had significant carbon losses (emissions) from wildfires since the 1950 baseline year, including large wildfire years in 2004 and 2005.[49] Furthermore, the study noted that environmental disturbances such as wildfires, "…would be a strong determinant of the future spatial and temporal variability of carbon dynamics, particularly in the [Northwest Boreal]."[50]

8. Lowland Alaska Ecosystems

a. Overview

Lowland wetland ecosystems in the state account for 177,069 square kilometers, 12 percent of total state land area.[51] These areas have historically been a source of CH_4 and CO_2e emissions. During the historical period (1950-2009) they are estimated to have released an average of 27.93 teragrams (27.93 billion kilograms) of CO_2e per year into the atmosphere. By the end of the projection period (2090-2100), estimates of CO_2e emissions from wetland areas of the state range between 37 and 90 teragrams (37-90 billion kilograms) of CO_2e. These ecosystems have been shown to be potentially sensitive to anthropogenic climate change, which could result in significant changes to CO_2e emissions.[52] These ecosystems also sequester large amounts of carbon. During the

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[46] Bruce Wylie, Neal J. Pastick, Kristopher D. Johnson, Norman Bliss, and Helene Genet, "Chapter 3: Soil Carbon and Permafrost Estimates and Susceptibility to Climate Change in Alaska," part of *Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, ed. Zhiliang Zhu and A. David McGuire, U.S. Geological Survey: Reston, VA, 2016, p. 53.

[47] Ibid.

[48] Helene Genet, Yujie He, A. David McGuire, Qianlia Zhuang, Yujin Zhang, Frances Biles, David D'Amore, Xiaoping Zhu, and Kristopher Johnson, "Chapter 6: Terrestrial Carbon Modeling: Baseline and Projections in Upland Ecosystems," part of *Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, ed. Zhiliang Zhu and A. David McGuire, U.S. Geological Survey: Reston, VA, 2016, p. 105.

[49] Ibid.

[50] Ibid.

[51] Helene Genet, Yujie He, A. David McGuire, Qianlai Zhuang, Bruce Wylie, and Yujin Zhang, "Chapter 7: Terrestrial Carbon Modeling: Baseline and Projections in Lowland Ecosystems of Alaska," part of *Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, ed. Zhiliang Zhu and A. David McGuire, U.S. Geological Survey: Reston, VA, 2016, p. 133.

[52] Ibid.

historical period, lowland and upland ecosystems sequestered an average of 3.7 teragrams (3.7 billion kilograms) of CO_2e per year.[53]

9. Alaska Inland Aquatic Systems

a. Overview

The system of freshwater inland aquatic ecosystems in the state account for 60,000 square kilometers, or 3.5 percent of total state area.[54] These ecosystems include riparian and lacustrine systems which were responsible for sequestering 41.2 teragrams (41.2 billion tons) of CO_2e per year during the historical period.[55] Carbon sequestration totals were not shown to change for the projection period.[56] Both aquatic systems are important parts of the carbon cycle and are responsible for delivery of carbon down-river to aquatic and terrestrial ecosystems, as well as more distant oceanic ecosystems.[57]

10. Alaska Upland and Wetland Sequestration

a. Overview

This umbrella category consists of the full 97.9% of state lands included in the USGS study, 1.475 million square kilometers. It includes a synthesis of results from the upland, wetland, and inland aquatic ecosystems. Total carbon sequestration from all three ecosystems during the Historical Period (1950-2009) was estimated at 3.7 teragrams (3.7 billion tons) of carbon per year, with variability in sequestration among the three sub-categories.[58] For the Projection Period (2010-2099), carbon sequestration capacity for all three categories was estimated to increase significantly to a yearly average between 18.2 and 34.4 teragrams per year.[59]

For future projection purposes, DEC has selected the low estimate of 18.2 teragrams per year. This was done in keeping with the conservative approach that the agency has taken in other estimates in this report. Because of the 16 teragram difference between the two averages, taking the lowest estimate also allows future reports to increase the yearly sequestration capacity as needed using findings from any future USGS studies.

Based on the 18.2 teragram increase over the 90-year time period, an increase of 10% was calculated for the 2010-2019 time period. This increase brings sequestration capacity to 4.07 teragrams (4.07 billion tons), an increase of 18.5 million tons per year over the

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[53] A. David McGuire et. Al., "Chapter 9: Alaska Carbon Balance," p. 189.

[54] Sarah Stackpoole, David Butman, David Chow, Kris Verdin, Ben Gaglioti, and Robert Striegl, "Chapter 8: Carbon Burial, Transport, and Emission in Inland Aquatic Ecosystems in Alaska," part of *Baseline and Projected Future Carbon Storage and Greenhouse-Gas Fluxes in Ecosystems of Alaska*, ed. Zhiliang Zhu and A. David McGuire, U.S. Geological Survey: Reston, VA, 2016, p. 159.

[55] Sarah Stackpoole, et. Al., "Chapter 8: Carbon Burial, Transport, and Emission in Inland Aquatic Ecosystems in Alaska," p. 159.

[56] Ibid.

[57] Ibid.

[58] A. David McGuire et. Al., "Chapter 9: Alaska Carbon Balance," p. 189.

[59] Ibid.

decade. This increase was factored into the charts used to demonstrate state sequestration capacity. Figures are presented below with all statewide emissions and sequestration figured into totals.

11. Alaska Net Carbon Sequestration Results

Figure 48 Alaska Historical Net Carbon Sequestration, 1990-2009

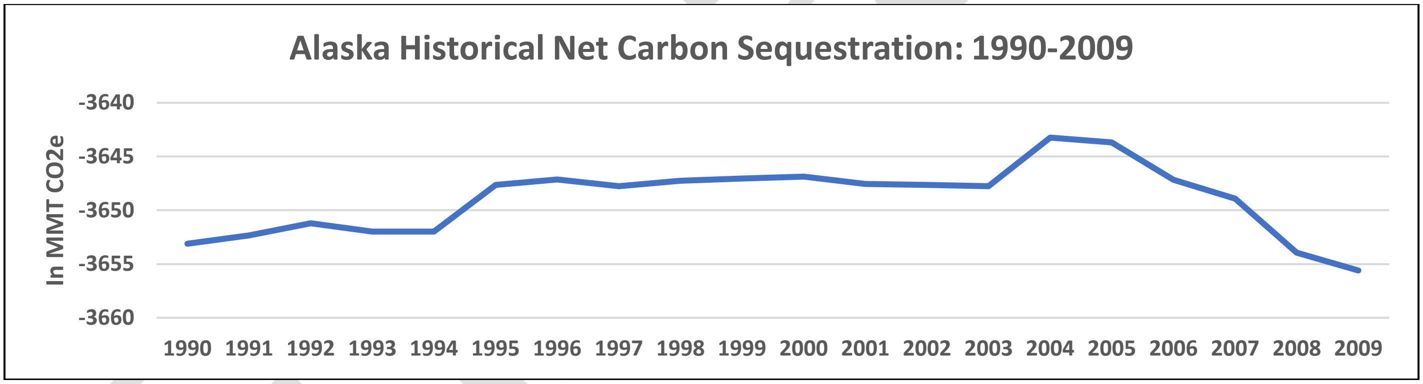


Figure 49 Alaska Net Carbon Sequestration Projection: 2010-2020

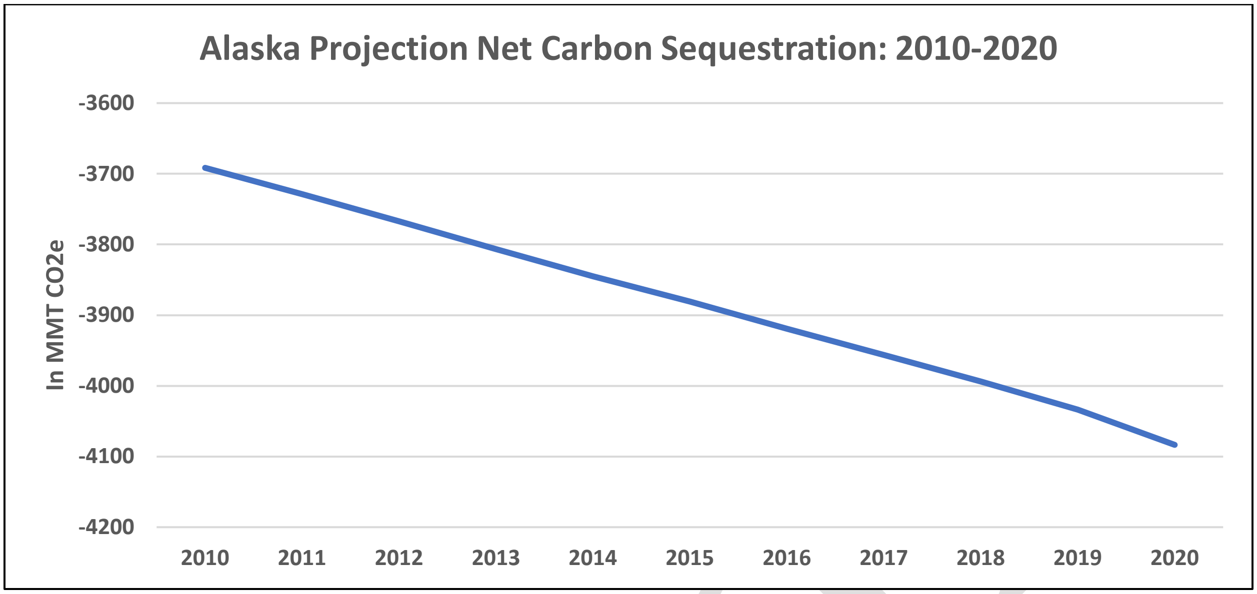
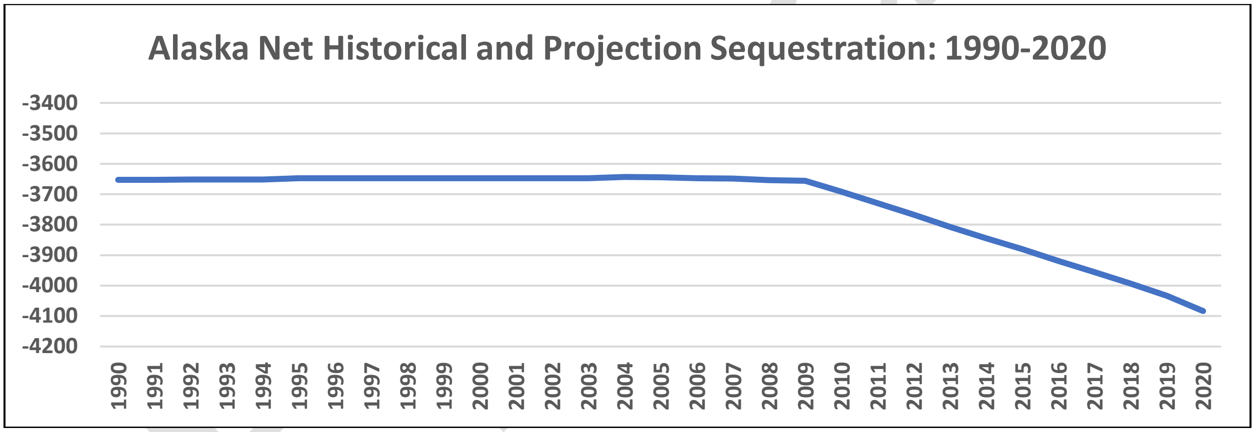


Figure 50 Alaska Net Historical and Projection Carbon Sequestration, 1990-2020



12. Land Use/Change Sequestration Results

Alaska sequestration capacity has remained significantly higher than state emissions totals since 1990. Between 1990 and 2020, the state produced yearly emissions on average of 46.96 MMT of GHGs (CO_2e, CH_4, etc.) against an average yearly sequestration capacity of 3.778 billion tons of CO_2e. Combined, state emissions remained in the negative for the last thirty years as calculated by the SIT. Using these results, Alaska was a net carbon sink rather than a source of GHG emissions from anthropogenic sources.

From the 1990 through 2009 baseline period, state anthropogenic emissions remained within a small range of yearly totals. Sequestration capacity increased from 2010 through 2020, with net sequestration calculated at 4.083 billion tons in 2020 after subtracting anthropogenic sources. According to USGS results, the state added 18 million tons per year of new sequestration capacity through vegetation growth.

These calculations do not include carbon flux from natural sources. Such sources include Permafrost Carbon Feedback (PCF), which is still being estimated and refined by government and academic research programs. Once a more accurate estimate of PCF is determined in terms of GHG tonnage per year, DEC will investigate using these calculations in the SIT to better estimate total statewide GHG emissions. In addition, state planners will keep track of IPCC reports to monitor for the inclusion of PCF. Once these are more accurately calculated, DEC planners may consider including them in Alaska yearly results.[60]

Natural carbon flux is not a controllable source of GHG emissions for the state. Any estimate of PCF emissions or natural carbon flux should not be considered the same as a controllable anthropogenic source. Another source of carbon flux along with PCF is state wildfire emissions. This will be discussed in a separate section of the Land Use/Change analysis.

13. Wildfire and State Atmospheric Carbon Flux

During the past 30 years (1990-2020), the zones of activity, intensity, and intervals between major fire years have all increased. This is likely the result of climate change, which has placed stressors on other parts of state natural and economic processes.[61] Intervals between major wildfire years have shrunk from once every decade to roughly once every five years, a fifty percent increase in the number and size of major wildfires in under 30 years. The number of wildfire seasons burning over a million acres has increased fifty percent over the same thirty-year timespan.[62]

Since 2010, there have been four years with wildfire seasons over one million acres and two years (2015, 2019) with wildfire activity over two million acres. Since 2000, the largest

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[60] For the most updated information on PCF and GHG emissions/carbon emissions and global climate goals, please see the following articles: Susan Natali et. Al., "Permafrost carbon feedback threatens global climate goals," PNAS, Vol. 118, No. 21, May 17, 2021, available at: https://www.pnas.org/doi/10.1073/pnas.2100163118 (Accessed 7/18/2022);
Erin Flanagan, "The global carbon budget and permafrost feedback loops in the Arctic," *The Arctic Institute*, February 25, 2021, available at: https://www.thearcticinstitute.org/global-carbon-budget-permafrost-feedback-loops-arctic/ (Accessed 7/18/2022);
Andrew MacDougall, "Estimated effect of the permafrost carbon feedback on the zero emissions commitment to climate change," Biogeosciences, Vol. 18, 4937-4952, 2021, available at: https://bg.copernicus.org/articles/18/4937/2021/bg-18-4937-2021.pdf (Accessed 7/18/2022); and
Jordan Wilkerson, "How much worse will thawing permafrost make climate change?" *Scientific American*, August 11, 2021, available at: https://www.scientificamerican.com/article/how-much-worse-will-thawing-arctic-permafrost-make-climate-change/ (Accessed 7/18/2022).

[61] For more detailed information about climate change in Alaska, see: R. Thoman and J.E. Walsh, "Alaska's Changing Environment: Documenting Alaska's Physical and Biological Changes Through Observation," International Arctic Research Center: University of Alaska Fairbanks, 2019, available at: https://uaf-iarc.org/wp-content/uploads/2019/08/Alaskas-Changing-Environment_2019_WEB.pdf (Accessed 12/6/2021).

[62] R. Thoman and J.E. Walsh, "Alaska's Changing Environment," p. 3.

wildfire year in the state was 2015, with a total of 5.15 million acres burned, roughly double the 2019 wildfire total of 2.62 million acres.[63]

As shown in the following chart, state wildfire acreage and gross wildfire numbers have been on the increase over the last thirty years.

Figure 51 Total Alaska Wildfire Acreage by Year, 1990-2020[64]

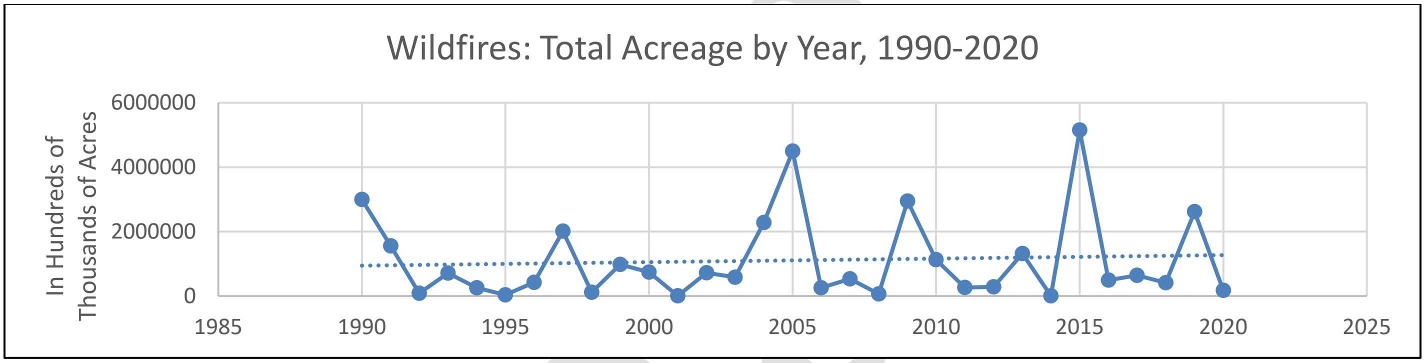
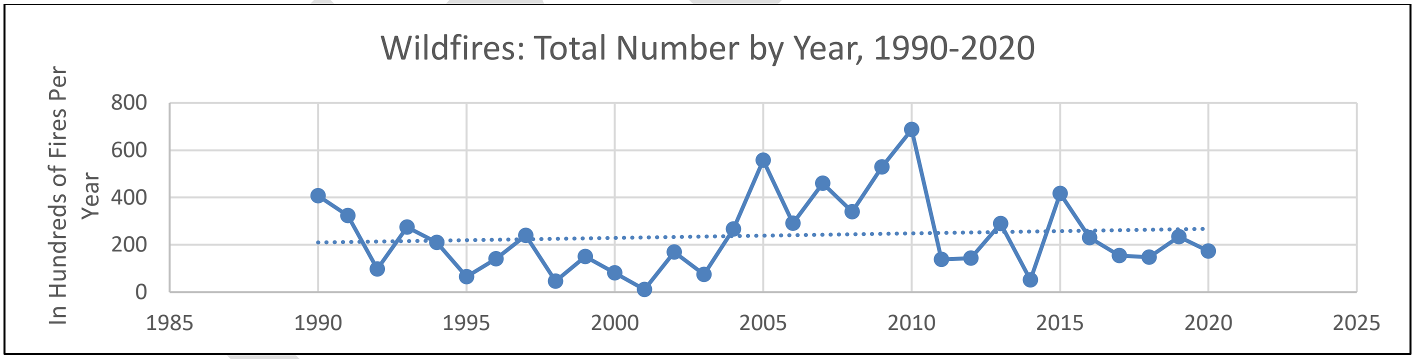


Figure 52 Alaska Total Wildfire Numbers by Year, 1990-2020



14. Wildfire Increase and Long-Term Implications for Sequestration Capacity

The gap between state anthropogenic emissions and carbon sequestration capacity is wide. Because the state has such a small emissions footprint compared to its total sequestration capacity, natural sources of GHG emissions including wildfires should be studied carefully. The primary challenge for state planners is in calculating this footprint as it is currently, as well as working with scientific groups to provide models for future wildfire growth.

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[63] 2015 and 2019 Alaska Wildfire Emissions Inventories, Alaska Department of Environmental Conservation, available at: https://dec.alaska.gov/air/anpms/projects-reports/fire-emission-inventory/ (Accessed 11/30/2021).

[64] Alaska Wildfire acreage and numbers derived from information taken from the Alaska Wildfire Emissions Reports (2005-2020), published by the Alaska Department of Environmental Conservation. Data from 1990-2004 taken from fire statistics gathered on the Alaska Interagency Coordination Center (AICC) Website. Alaska Wildfire Emissions Inventories available at: : https://dec.alaska.gov/air/anpms/projects-reports/fire-emission-inventory/. AICC website available at: https://fire.ak.blm.gov/ .

Together with PCF, wildfire emissions are the largest category of uncontrollable natural emissions in the state.

At present, the yearly Alaska wildfire report does not include CO_2e emissions from wild or prescribed fires. It does, however, calculate CH_4. Because the state does not include CO_2e estimates in its yearly wildfire report, it needs to rely on EPA and scientific estimates produced sometimes years after the wildfire year. Building trend models would involve identifying and inserting emissions factors into the state's wildfire calculation tool to produce estimates.

The long-term implications of the growth in acreage and intensity of wildfire seasons is mixed. Since 2000, there has been an observed expansion of wildfire activity into the Yukon-Kuskokwim Delta Area in Western Alaska and into parts of Southwestern Alaska. This includes areas near Lake Iliamna, as well as forests near Dillingham and Bethel which had infrequent wildfires prior to this 20-year window of time. This has come while state sequestration capacity has increased from vegetation growth according to the USGS Alaska sequestration report.