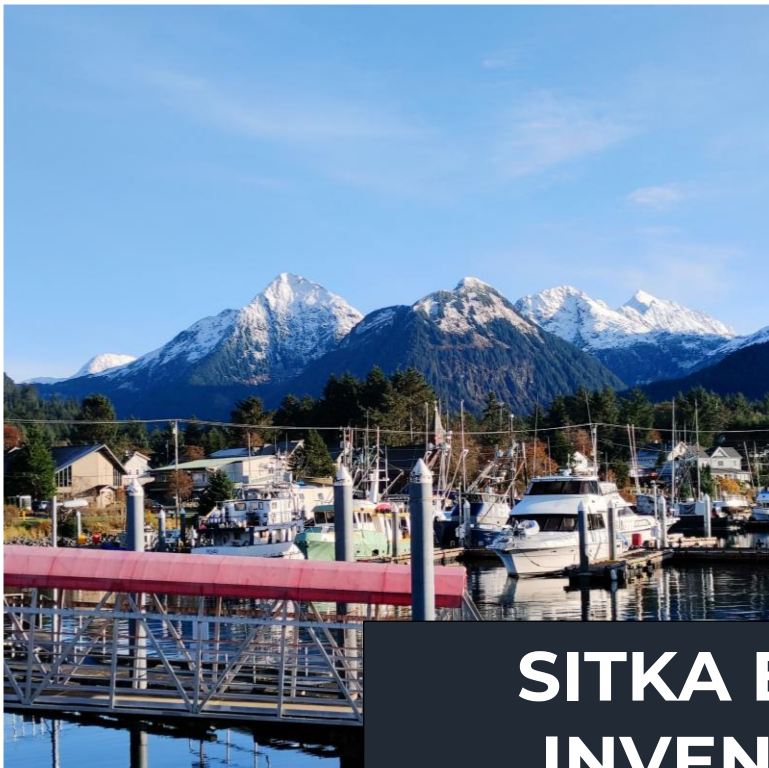
PNNL-37965

A City and Borough of Sitka Project

SITKA COMMUNITY RENEWABLE ENERGY STRATEGY

SCRES



SITKA ENERGY INVENTORY – TECHNICAL REPORT

Baseline year: 2023

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EXECUTIVE SUMMARY

The City and Borough of Sitka was chosen for an Energy Technology Innovation Partnership Project award starting in fall 2023, the third cohort of the program. The scope of the following work was driven by the city as well as the city-appointed Sustainability Commission. The community asked for a method to track its reliance on imported fuel sources as well as the emissions associated with the combustion of those fuels and other processes in Sitka. Since Sitka is an island, barging in fuel is expensive: Sitka has a higher diesel and gasoline cost compared to the national average, yet the electricity cost is close to the national average with Sitka's two hydropower dams providing baseload power. Understanding how much fuel each sector consumes can help target opportunities to reduce their fuel consumption and thus costs. Reducing energy consumption or transferring energy dependency from diesel to electricity can help reduce costs and increase security for different sectors across Sitka.

The Pacific Northwest National Laboratory (PNNL) provided research and methodology consistent with this request. This project is a communitywide inventory, requiring methods to estimate the fuel usage and emissions from various industries. For each estimate, PNNL presents methodologies that can be repeated by the community in future years to understand how the city's emissions are changing.

Based on the analysis, for all three emission scopes, Sitka produced approximately **84,346 metric tons of carbon dioxide equivalent (MTCO$_2$e)** in 2023. The sectors analyzed include electricity, ground transportation, recreational and charter boats, commercial fishing, residential and commercial heating, waste and wastewater, air travel, cruise ships, and shipping. Figures ES-1 and Tables ES-1 and ES-2 show the total amount of emissions produced by Sitka in 2023 by end use, with scope 1 and 3 sectors indicated in green and yellow, respectively. Scope 1 emissions refer to GHG emissions from sources located within the city boundary, while scope 3 emissions refer to emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

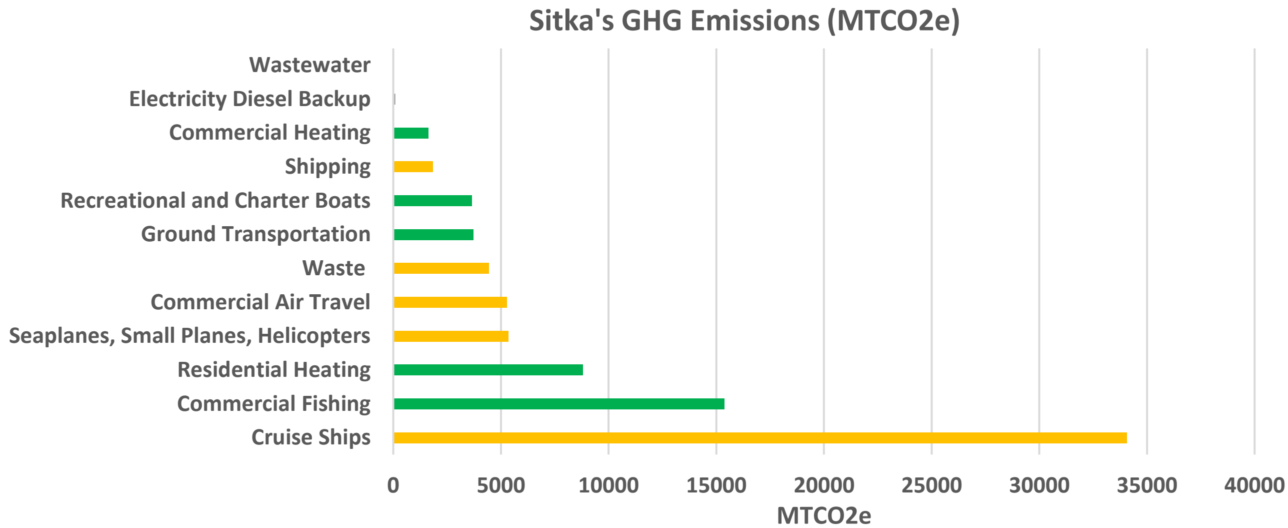

Figure ES-11. Total emissions produced by Sitka in 2023

Table ES-1. Sitka's Scope 1 End Use, Separated by Category

Scope 1 End Use	$MTCO_2e$	Percent of Total Emissions
Electricity	102	<1%
Buildings	10,448	12%
Ground Transportation	3,727	4%
Marine Activity	19,043	23%
Wastewater Treatment	9	<1%
Total Scope 1 Emissions	**33,328**	**40%**

Table ES-2. Sitka's Scope 3 End Use, Separated by Category

Scope 3 End Use	$MTCO_2e$	Percent of Total Emissions
Solid Waste Disposal	4,440	5%
Air Travel	10,645	13%
Shipping	1,854	2%
Cruise Ships	34,072	40%
Total Scope 3 Emissions	**51,011**	**60%**

A City and Borough of Sitka Project
SITKA COMMUNITY RENEWABLE ENERGY STRATEGY SCRES

2023 Greenhouse Gas Inventory – Technical Report

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ACKNOWLEDGMENTS

This report was written by Andrea Mott, Ali Trueworthy, and Molly Grear from Pacific Northwest National Laboratory, with contributions from community members Bri Gabel and Erik de Jong. Thank you to the Sustainability Commission, the Sitka Sentinel, the Alaska Longline Fishermen's Association, Chandler Kemp from Kempy Energetics, and all who have provided feedback on this inventory.

Suggested Citation: Mott, A., A. Trueworthy, M. Grear, B. Gabel, and E. de Jong. 2025. Sitka Greenhouse Gas Inventory Technical Report. Sitka Community Renewable Energy Strategy. Sitka, AK.

INTRODUCTION

This greenhouse gas (GHG) inventory was prepared at the request of the City and Borough of Sitka (CBS) under the Energy Technology Innovation Partnership Project (ETIPP). ETIPP is a U.S. Department of Energy program focused on aiding coastal, remote, and island communities that are interested in creating a more reliable, affordable, and efficient energy system. The goal of this inventory is to provide a GHG emissions baseline for the full community of Sitka. This can help the municipality track progress toward its energy independence goals as well as identify the policy mechanisms that could be implemented to reduce emissions.

This inventory aims to understand how much energy each sector consumes. Identifying the largest consumers of fuel can help target areas to reduce energy consumption, and therefore, energy costs. On average, Sitka has a higher diesel cost than the national average due to the additional costs of shipping fuel to the island. Sitka also has a lower to average electricity cost compared to the national average due to their hydropower electricity generation[1]. Identifying ways to transfer fuel dependency from diesel to electricity can help reduce costs for different sectors across Sitka.

Also, as an island, Sitka is dependent on shipment of fuel for their energy needs. Understanding how much energy each sector consumes highlights dependencies on fuel shipments, and can generate opportunities to increase their energy security. For example, transferring sectors that are highly dependent on the shipment of fuel to using the onsite hydroelectric electricity generation can increase their energy resiliency to external events.

CBS partnered with the Pacific Northwest National Laboratory (PNNL) through the ETIPP program. PNNL sought input from the Sitka Sustainability Commission, and other community groups, to ensure they made acceptable assumptions and used the best data available.

WHAT IS A GREENHOUSE GAS INVENTORY?

A GHG inventory tracks the GHG emissions of a certain group, city, county, or region. GHGs are gases that trap heat in the Earth's atmosphere. Solar radiation from the Sun warms the Earth's surface, which in turn releases heat back into the atmosphere. Some of that heat leaves the atmosphere and dissipates into space, but some is absorbed and reemitted by certain gases in the atmosphere—trapping the heat in the atmosphere. This is known as the "greenhouse effect," and those gases, known as greenhouse gases, include carbon dioxide (CO_2), methane (CH_4),

[1] City and Borough of Sitka, Alaska, Sitka's Energy Today. https://www.cityofsitka.com/departments/SitkaCommunityRenewableEnergyStrategy/SitkasEnergyToday

nitrous oxide (N_2O), and fluorinated gases.[2] The GHG inventory considers human activities associated with GHG emissions and estimates the quantity of emissions from those activities.

HOW TO READ THIS DOCUMENT

This document covers the technical methodology used to inventory Sitka's GHG emissions and the results of that inventory applied to the year 2023. The primary audience for this report is CBS staff who will continue to inventory GHG emissions in Sitka using this report as a baseline. For the reader primarily interested in the results of the inventory, those can be found in the section titled "CBS Greenhouse Gas Emissions Totals." At the end of this document, there are summary sheets that show the emission results by sector and list the assumptions made to obtain those results. For readers looking for more detail, the methodology section and appendices include detailed description the calculations used to arrive at these estimates. There are several appendices that directly address questions that surfaced during the public comment period for an early draft of this report.

BASELINE RESULTS

Based on the analysis, Sitka produced approximately **84,346 metric tons of carbon dioxide equivalent (MTCO_2e)** in 2023. The sectors analyzed include electricity, ground transportation, recreational and charter boats, commercial fishing, residential and commercial heating, waste and wastewater, air travel, cruise ships, and shipping. Table 1 shows the total amount of energy consumed and emissions produced by Sitka in 2023 by end use, with scope 1 and 3 sectors are indicated in green and yellow, respectively. Scope 1 emissions refer to GHG emissions from sources located within the city boundary, while scope 3 emissions refer to emissions that occur outside the city boundary as a result of activities taking place within the city boundary. These results are elaborated on in the Results section of this report.

Table 12. Total emissions produced by Sitka in 2023

Scope	Emission Source	Fuel Consumed (gallons)	Emissions (MTCO_2e)	% Total Emissions
3	**Cruise ships**	3.3 Mgal diesel	34,072	40%
1	**Commercial fishing**	1.4 Mgal diesel 120 kgal gasoline	15,376	18%
1	**Residential heating**	790 kgal fuel oil	8,808	10%
3	**Seaplanes, small planes, helicopters**	526 kgal jet fuel	5,359	6%
3	**Commercial air travel**	542 kgal jet fuel	5,286	6%

[2] U.S. Environmental Protection Agency (EPA) Overview of Greenhouse Gases. https://www.epa.gov/ghgemissions/overview-greenhouse-gases.

Scope	Emission Source	Fuel Consumed (gallons)	Emissions ($MTCO_2e$)	% Total Emissions
3	**Waste**	N/A	4,440	5%
1	**Ground transportation**	743 kgal gasoline 80.7 kgal diesel	3,727	4%
1	**Recreational and charter boats**	403 kgal gasoline	3,667	4%
3	**Shipping**	181 kgal diesel	1,854	2%
1	**Commercial heating**	150 kgal fuel oil	1,640	2%
1	**Electricity backup**	9.9 kgal diesel	102	<1%
1	**Wastewater**	N/A	9	<1%
	Total Emissions		**84,339**	

METHODOLOGY

This section details the general methodology used to calculate the GHG emissions for the community of Sitka, following guidance from the Greenhouse Gas Protocol for Cities.[3] The GHG Protocol supplies the most widely used GHG standards and guidance to governments, cities, and corporations for tracking their GHGs to best support progress toward community emissions goals. Inventory methods across cities can range significantly, depending on data availability and quality.

The baseline year for this inventory is 2023 based on the start of this analysis, but many data sources are from previous or future years because of availability of data during the development timeline. This report references the best available data at the time of writing. Values can be updated as better data become available at an interval determined by the community. Two forms of data were used to estimate emissions: fuel import data and activity data.

- **Fuel Import Data**: Fuel import data come from the U.S. Army Corps of Engineers (USACE) 2022 Cargo Report[4] for Sitka Harbor. The Cargo Report is a record of all shipments in and out of the city, including fuels, which are divided into categories of gasoline, kerosene, distillate fuel oil, residual fuel oil, hydrocarbons and petrol gases, and petroleum products not elsewhere counted (NEC). If the fuel burned is assumed to be the same as the amount of fuel imported, the emissions from burning fuels could be estimated using only the Cargo Report. However, because of both fluctuations in the Cargo Report data from year to year and some issues with data quality (discussed in detail in Appendix A.6), a combination of Cargo Report data and activity data is used instead.
- **Activity Data:** Activity data can be used to estimate the frequency of certain emissions-related activities in Sitka. Emissions are calculated from the ground up by estimating how often certain activities take place and what levels of emissions are caused by those activities. Activity data come from a variety of sources with a variety of uncertainties, which are discussed in each of the forthcoming sections. These activity data allow emissions in Sitka to be categorized by sector and subsector. Dividing fuel and emissions into finer-resolution categories helps determine which policy mechanisms or community actions can have the highest impact in terms of reducing emissions. Policy mechanisms can include incentivizing building energy efficiency measures and electrifying vehicles, buildings, or boats. For example, understanding the emissions tied to heating residential

[3] GHG Protocol for Cities. https://ghgprotocol.org/ghg-protocol-cities.

[4] 5-Year Cargo Report. 2022. https://ndc.ops.usace.army.mil/wcsc/webpub/#/report-landing/year/2021/region/4/location/4808.

housing can determine the emissions impact of incentivizing home electrification measures.

Emissions are calculated by multiplying activity data (such as gallons of fuel consumed) by an emission factor (emissions per activity unit). Emission factors are from EPA's GHG Factor Hub[5] and converted to metric tons of CO_2 equivalent ($MTCO_2e$). This incorporates emissions from CO_2, CH_4, and N_2O.

The reported results primarily reflect the activity data methodology. Fuel import data was mainly used to validate that the assumptions were reasonable. Once emissions from both the fuel import and activity data are calculated, they are compared. Because both fuel import data and activity data have limitations, comparing the two forms of data helps improve estimates. The best available data was sought and used throughout the process of conducting this inventory. Assumptions were updated iteratively with help from knowledgeable members of the Sitka community. Each time assumptions were updated, the estimates from activity data were verified with estimates from fuel import data. Additionally, the total amount of gasoline was compared using gas station sales tax, and the total sales were generally consistent with the USACE Cargo Report. Where there were limited activity data—for recreational fishing vessels and for seaplanes, small planes, and helicopter trips—Cargo Report data were used.

It should be noted that assumptions in GHG reports are common, especially for harder-to-track sectors, such as marine and air travel. When finer-resolution or more accurate data become available, this inventory should be updated accordingly.

The following sections describe the ground-up calculations made using activity data, categorized by sector and scope.

[5] EPA Emissions Factors: https://www.epa.gov/system/files/documents/2024-02/ghg-emission-factors-hub-2024.pdf.

INVENTORY SCOPE

GHG emissions are commonly classified into three scopes, which are used to help categorize and track emissions. The GHG Protocol for Cities defines those scopes as shown in Table 2, which is adopted from the GHG Protocol Corporate Standard. The GHG Protocol allows reporting of GHG emissions in various formats depending on the purpose and audience, which have been adopted to align with the community of Sitka's feedback.

Table 2. Definitions of Scopes for Cities' GHG Emissions from the GHG Protocol for Cities[6]

Scope	Definition
Scope 1	GHG emissions from sources located within the city boundary.
Scope 2	GHG emissions occurring due to the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary.

The city commission defined the purview of this inventory to include all Scope 1 emissions (electricity generation, stationary fuel combustion, transportation, wastewater) as well as selected Scope 3 emissions (air travel, waste, shipping, cruise ships) that could be calculated and helpful for the municipality. Scope 2 emissions are not relevant to Sitka because their electricity is generated locally within the municipality.

According to direction from the Sitka Sustainability Commission, this inventory does not include carbon sequestration (e.g., the trees removing CO_2 from the atmosphere) or nonanthropogenic emissions from decomposition or other natural processes. This inventory also does not include fugitive emissions from refrigerants (see Appendix A.4).

In this report, the term "Sitka" is used to indicate the community at large; "CBS" to indicate the local municipality, including the municipally owned utility; and "Sitka Sustainability Commission" to indicate the group of local community members appointed to a city board to advise CBS on matters of sustainability.

[6] GHG Protocol, Global Warming Potential values: https://ghgprotocol.org/sites/default/files/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_0.pdf.

SCOPE 1 EMISSIONS

Scope 1 emissions are emissions that occur within Sitka's boundaries. These include emissions from electricity generation, buildings, ground transportation, marine activity, and wastewater treatment. The following sections detail the methodology used to calculate these Scope 1 emissions, summarized in Table 3.

Table 3. Sitka's Scope 1 End Use, Separated by Category

Scope 1 End Use	$MTCO_2e$	Percent of Total Emissions
Electricity	102	<1%
Buildings	10,448	12%
Ground Transportation	3,734	4%
Marine Activity	19,043	23%
Wastewater Treatment	9	<1%
Total Scope 1 Emissions	**33,328**	**40%**

ELECTRICITY GENERATION

Sitka's electricity is generated from hydropower, so there are no emissions associated with its primary electricity generation. Sitka occasionally uses diesel for backup power. In 2023, CBS provided data indicating 9,975 gallons of diesel fuel were used for backup power and mandatory periodic generator testing, resulting in emissions of 102 $MTCO_2e$. Given the small percentage of emissions related to this source compared to other sectors (<0.1%), shown over the past 6 years in Figure 1, variations from year-to-year are assumed to be insignificant. Any longer-duration failures or outages of the dams resulting in diesel being burned for electricity would lead to increased emissions from this source.

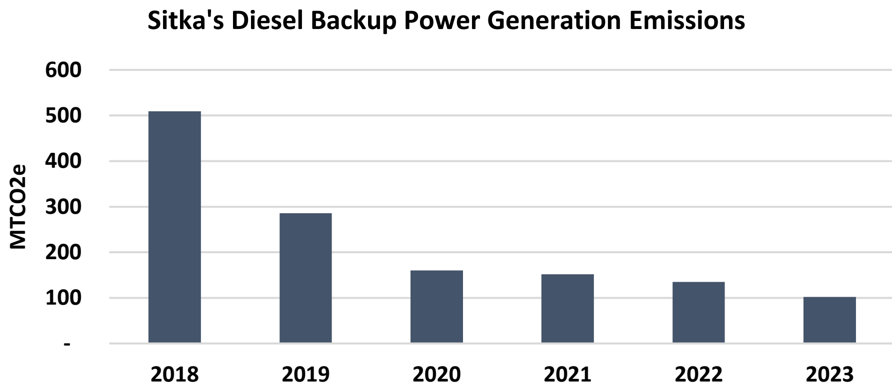

Figure 1. Diesel backup power generation emissions from 2018 to 2023

Although assuming hydropower is an emissions-free electricity source is considered standard practice, it should be noted that there is some uncertainty around the emissions associated with hydropower because of decomposition of organic materials in reservoirs. While this assumption may need to be updated in a future iteration as new science and research becomes available, it is currently standard practice to assume hydropower emissions are zero, especially when compared to other fuel generation sources.

BUILDING HEATING

Buildings have emissions associated with their energy used operating the buildings. Because Sitka's electricity generation is supplied from hydropower, which has no emissions associated with its generation, the building emissions in Sitka are solely from any combustion that occurs for space heating, domestic hot water (DHW), and cooking. Space heating can be provided from multiple sources such as fuel oil (furnaces and boilers), electricity (electric resistance heaters, such as baseboards and wall heaters, and heat pumps), and wood (stoves, boilers). Each of these heating systems have a variety of efficiencies. Electric heat pumps are increasingly common in Sitka, which are highly efficient. DHW and cooking systems can be electric or not.

Because there is not energy data for every building's space heating, DHW, and cooking needs, their associated emissions are estimated based on square footage, electricity utility bills, state-level energy intensity estimates, and fuel source across buildings.

RESIDENTIAL BUILDING HEATING

To calculate the amount of energy consumed by residential buildings, information on square footage, heating fuel type, and average heating energy used per household for Sitka's homes was collected. The 2017 Sitka Borough Housing Assessment[7] states Sitka has 3,513 occupied homes. The U.S. Energy Information Administration's (EIA's) Residential Energy Consumption Survey (RECS) dashboard[8] estimates the average space heating and DHW consumption by state. The average of the RECS's Alaska and Washington state averages value of 76 million British thermal units (MMBtu; 56 MMBtu for space heating + 20 MMBtu for hot water) per household is used to avoid overestimating Sitka's residential heating because Sitka is more temperate than the majority of Alaska. With this information, the following formula is used to estimate the total amount of energy used for residential heating to be 266,988 MMBtu/yr:

$$\#\ occupied\ houses\ \times \frac{avg\ heating\ energy}{house} = total\ residential\ heating\ energy$$

To calculate the emissions associated with residential heating, it was necessary to determine the fuel source used in the buildings. Space heating is a seasonal electricity use, meaning that homes that heat with electricity will have higher electricity consumption in the winter. Homes heating with fuel oil would not appear in the electric bill. Therefore, if the average electricity use in the summer months is 50% or more over the winter months, that home likely uses electric heating.

Therefore, to estimate the portion of homes heated by electricity, electricity consumption data provided by CBS for every account in Sitka was used. The electric utility bills data was processed using an R script, with the following logic: If the average electricity consumption over the summer months (June, July, August) was 50% lower than the winter months (November, December, January), the building was most likely heated by electricity. If houses are not heated by electricity, they are predominantly heated by fuel oil and a small percentage by wood. Applying this logic resulted in estimations that 57% of residential buildings use electric heating, 41% use fuel oil, and 2% use wood for heating. This results in 8,808 $MTCO_2e$ from residential space heating and DHW consumption per year.

Some houses' monthly electricity data may be influenced by changes in occupancy (e.g., decrease of energy one month from traveling out of town), but it can be assumed that these fluctuations even out across the large number of households. Many houses in Sitka also have multiple heating sources (e.g., baseboards plus radiators, or dual-fuel heat pumps), and some houses that use primarily non-electric heating may also use a small amount of electric heating (e.g., space heaters). This is also assumed to balance out over the large number of households. If houses are extremely well insulated or have highly efficient heat pumps, it also may not be

[7] Sitka Borough 2017 Alaska Housing Assessment: https://www.ahfc.us/application/files/1215/1510/4582/Final_-_Sitka_Borough_Summary.pdf.

[8] Residential Energy Consumption Survey (RECS) Dashboard, 2020. https://experience.arcgis.com/experience/cbf6875974554a74823232f84f563253?src=%E2%80%B9%20Consumption%20%20%20%20%20%20Residential%20Energy%20Consumption%20Survey%20(RECS)-b1.

flagged as electric heating. Future work could improve estimates by conducting studies on specific residential heating systems types across Sitka.

Figure 2 shows an example of a single household electricity use which uses electric heating. In this example, the winter months (December, January, February) have an average of 254 kilowatt-hours (kWh)/month, compared to the summer months (June, July, August), which have an average of 76 kWh/month. This fluctuation in energy use is best explained by the decrease in electric heating over the summer months in this household. Since the seasonal variation is greater than 50%, this house would be flagged as electric heating.

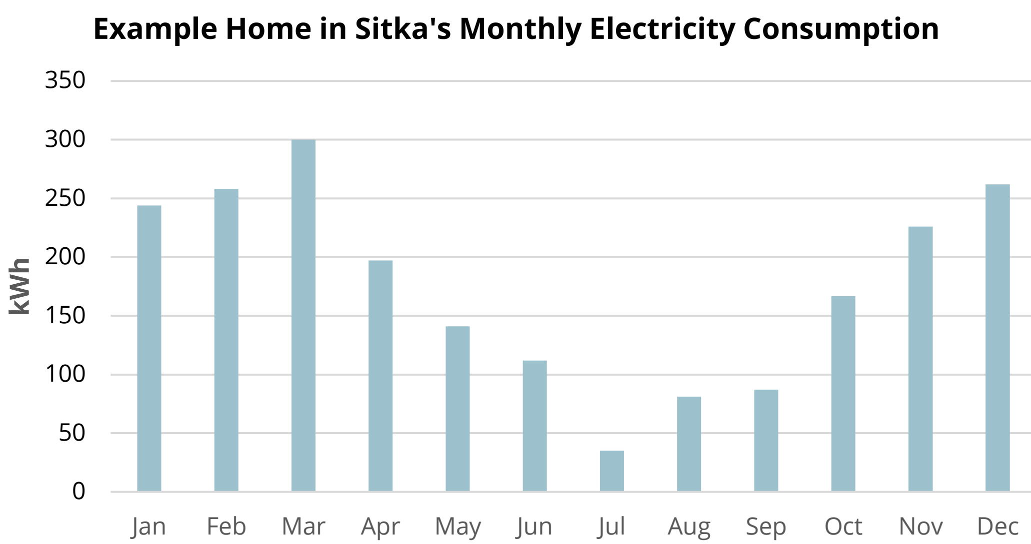

Figure 2. Monthly electric bills from a Sitkan residence, showing electric heating due to seasonal variation

It was also assumed that if the winter utility bills are greater than summer utility bills by 50%, the houses are heated by electricity. Assuming a threshold of 70%, this results in 47% of the residential heating is electric. If a 30% threshold is assumed, this results in 68% of residential heating is electric. Therefore, it can confidently be said that at least 47% of residential heating is electric. Since this threshold would most likely be higher, a 50% threshold is assumed. This range is shown in Table 4 with their corresponding impact on emissions.

Table 4: Impact of Threshold of Winter vs Summer Utility Bills on Emissions

% Winter Utility Bills Higher than Summer Utility Bills Assumption	% Residential Heating Assumed to be Electric	Resulting Residential GHG Emissions
30%	68%	10,526 MTCO2e

50%	57%	8,299 MTCO2e
70%	47%	6,073 MTCO2e

An alternative method of estimating the percentage of electric heating would be to use the American Community Survey, which is conducted by the U.S. Census Bureau on 5-year averages for Sitka, based on a random survey. The American Community Survey's most recent estimate is from 2019 to 2023 and indicates 41% of Sitka's household heating is electric. However, this is based on a 5-year average, contains some questionable data (such as some houses being reliant on utility gas, which does not exist in Sitka), and does not align with the actual electric utility bills for residents across Sitka. Therefore, the method described previously was used. In addition, a community survey done in SCRES asked respondents how they heated their homes, revealing 43% of respondents indicated electric heating. This was not used because more data was available in the utility bills. However, the SCRES survey indicated that 2% of wood stoves were used for heating, which is used for lack of additional wood related data.

COMMERCIAL BUILDINGS HEATING

For commercial buildings, Sitka's 2024 Commercial and Industrial Square Footage data, which shows a footprint of 2.3 million square feet (SF) for Sitka's commercial and industrial buildings, was used. This analysis combines commercial and industrial buildings because Sitka does not have a large industrial footprint. It is assumed that 25% of these buildings' square footage is not space conditioned (heated or cooled), because of either unoccupancy (especially seasonal) or use as warehouses or storage buildings. The EIA estimates commercial buildings use, on average, 25 kBtu/SF for space heating.[9] The following equation was used to calculate the total commercial space heating energy consumption of 42,418 MMBtu:

$$total\ SF\ of\ commercial\ buildings\ \times percent\ heated\ \times \frac{avg\ heating\ energy}{SF} = total\ commercial\ heating\ energy$$

Sitka's building utility bills were used to determine which commercial buildings' heating systems were electric, following the same methodology used for residential heating but for the commercial utility bills. This resulted in 49% of occupied commercial buildings that use electric heating and 51% that use fuel oil. DHW is included in this assumption because the buildings'

[9] U.S. Energy Information Administration (EIA), *Heating U.S. commercial buildings is most energy intensive in cold climates*, September 2023. https://www.eia.gov/todayinenergy/detail.php?id=60301#:~:text=U.S.%20commercial%20buildings%20in%20cold,heating%20in%20each%20climate%20zone.

heating is predominately electric. This results in 1,640 $MTCO_2e$ of emissions from commercial buildings per year.

GROUND TRANSPORTATION

Because Sitka is on an island, on-road transportation emissions include the fuel combustion emissions that occur from vehicles within the CBS boundary. According to the Alaska Department of Motor Vehicles, Sitka currently has 8,274 vehicles with engines (categorized by vehicle class in Table 5). The breakdown of electric vehicles (EVs) compared to conventional internal combustion engines vehicles is shown in Table 6. It should be noted that the number of EVs has increased by 54% since 2022, placing Sitka at around 24 EVs per 1,000 people. For comparison, California has 30 EVs per 1,000 people.

Table 5. Vehicles With Engines in Sitka Categorized Based on VIN in 2024

Vehicle Category*	Quantity	Percentage
Class 1	7,335	88.7%
Class 2	797	9.6%
Class 3+	27	0.3%
Motorcycles/ATV	115	1.4%

**Class 1 and 2 are light-duty vehicles. Class 3+ are medium-duty vehicles.*

Table 6. EVs Compared to Non-EVs Based on VIN in 2024

Vehicle Category	Quantity	Percentage
EVs	195	2.4%
Plug-in hybrid electric vehicles (PHEVs)	14	0.2%
Conventional	8,065	97.5%

Not all vehicles are driven regularly, and electric vehicles produce zero emissions in Sitka because the electricity is supplied by hydropower. Based on data from the Alaska Department of Transportation Traffic Analysis and Data Application website[10], 60–70% of the vehicles in Sitka are driven daily. There are 7,335 Class 1 vehicles registered as internal combustion engine vehicles and it is assumed that 70% are driven regularly (resulting in 5,135 regularly driven vehicles). According to a CBS survey from 2022 asking where people lived and commuted in Sitka with 466 valid responses, the average is 4 daily miles. The average fuel efficiency for cars in the

[10] Alaska Department of Transportation Traffic Analysis and Data Application website: https://alaskatrafficdata.drakewell.com/publicmultinodemap.asp

United States is 24 miles per gallon.[11] Because of the lack of long-distance driving in Sitka, the fuel efficiency is estimated to be slightly lower than the U.S. average at 20 miles per gallon. This results in total gas vehicle emissions of 3,168 $MTCO_2e$ in 2024. 70% of the registered 824 Class 2 and 3 vehicles (trucks, vans, or recreational vehicles) are assumed to be regularly driven and rely on diesel. Assuming these vehicles get 15 miles per gallon based on CBS pickup truck efficiency data and also travel 4 miles per day, this results in 551 $MTCO_2e$. For motorcycles and ATVs, it is assumed that 70% of the 115 vehicles are active, drive 4 miles per day, and are used only 80 days per year, with an average fuel efficiency of 30 miles per gallon, resulting in 8 $MTCO_2e$. When emissions from all vehicle types are combined, this results in total vehicle emissions of 3,727 $MTCO_2e$ in 2024.

MARINE ACTIVITY

Marine activity includes commercial fishing, recreational fishing and boating, and charter boats. Shipping is discussed in more detail in the Scope 3 Emissions section.

COMMERCIAL FISHING

Fuel use in commercial fishing was investigated using the State of Alaska Commercial Fisheries Entry Commission (CFEC) Public Search Application and the calculated averages of tracked fuel usage from Sitka fishermen and fuel usage estimates. Fuel usage was estimated based on vessel efficiency, data from the VFEAT analysis tool, and data reported by Kempy Energetics.[12,13]

The commercial fishing industry is estimated to consume an annual 1,393,760 gallons of diesel and 124,619 gallons of gas, resulting in 15,376 $MTCO_2e$. The full details and assumptions in this analysis are presented in Appendix A.1.

RECREATIONAL BOATS

Recreational boats include all boats that are not for commercial fishing or charter boats. This report assumes that there are approximately 1,500 active recreational boats based on boating registrations, taking an average of 30-mile trips, 3 times per month, 6 months per year, with an average fuel efficiency of 3 miles per gallon (which is approximately the fuel efficiently of a 20-ft recreational aluminum Hewescraft). This results in an estimated emissions of 2,856 $MTCO_2e$ per year.

[11] U.S. DOE, Alternative Fuels Data Center: https://afdc.energy.gov/data/10310.
[12] CFEC: https://www.cfec.state.ak.us/plook/#permits.
[13] https://kempyenergetics.com/white-paper/white-paper-example-1/.

CHARTER BOATS

Charter boats are popular in Sitka, especially during the tourism season. The charter boat logbook, provided by Sitka Area Management via the Division of Sport Fish (part of Alaska Department of Fish and Game), documents 7,920 charter boat trips taken in 2023 from 142 active vessels. Detailed annual data are presented in Appendix A.3. These are the number of trips that ended in Sitka and do not include private fishing trips, which are included in recreational boating. Charter boats primarily run on gasoline based on input from the Sitkan community and charter boat industry, although some diesel charter boats exist. Because no further information regarding charter boats (such as size of boat and length of trip) is available, each trip was assumed to go 25 miles, with an average conservative fuel efficiency of 2.5 miles per gallon, consuming a total of 79,200 gallons of gasoline, based on validation from the Sitka community members. This results in 811 $MTCO_2e$ per year from charter boats.

WASTEWATER TREATMENT

Wastewater generates N_2O emissions from the biological processes used during treatment. Wastewater treatment emissions are calculated based on the total population served and type of treatment, using the federal GHG wastewater reporting methodology and corresponding emission factor.[14] Sitka's population is 8,380 people with more than 610,800 tourists throughout the summer season. This value is taken from Sitka cruise ship schedule and actual tourist or seasonal numbers may be higher. Assuming each tourist spends an average of 10 hours per day in Sitka, this equates to roughly an additional 697 people regularly contributing to wastewater per year. Because Sitka's wastewater treatment plant is without nitrification or denitrification processes, the emissions factor of 0.009 grams of N_2O/person/day is used. Assuming daily use for 9,076 people, this results in wastewater treatment emissions of 8.7 $MTCO_2e$. Although wastewater contributes a miniscule amount of GHG emissions, it is included for completeness.

[14] Federal Greenhouse Gas Accounting and Reporting Guidance, Council on Environmental Quality, 2016: https://www.sustainability.gov/pdfs/federal_ghg%20accounting_reporting-guidance.pdf.

SCOPE 2 EMISSIONS

Scope 2 emissions are indirect emissions associated with energy that is generated outside of Sitka's boundaries but consumed within Sitka's boundaries. Most commonly, Scope 2 emissions are from greenhouse gases that are burned in power plants outside the boundaries of an area but supply electricity via the grid connection. Because Sitka generates all electricity locally and is not connected to a larger grid network with additional loads, there are no Scope 2 emissions.

SCOPE 3 EMISSIONS

Scope 3 emissions are indirect emissions that occur outside of Sitka as a result of activities taking place within the boundary. Because Sitka is an island, certain scope 3 emissions were included to more accurately reflect the community. In collaboration with the Sustainability Commission, solid waste, air travel, shipping, and cruise ships are included. The following sections detail the methodology used to calculate these Scope 3 emissions, summarized in Table 7.

Table 7. Sitka's Scope 1 End Use, Separated by Category

Scope 3 End Use	$MTCO_2e$	Percent of Total Emissions
Solid Waste Disposal	4,440	5%
Air Travel	10,645	12%
Shipping	1,854	2%
Cruise Ships	34,072	40%
Total Scope 3 Emissions	**51,011**	**60%**

SOLID WASTE DISPOSAL

Municipal solid waste (MSW) from Sitka is shipped to Washington state. Waste disposal generates emissions from the decomposition of organic waste, generating methane and CO_2. According to Republic Services 2023 Summary, Sitka shipped 7,618 short tons of waste to Seattle in 2023. Using EPA's average mixed MSW emission factor, this produces 4,418 $MTCO_2e$.

Sitka also ships 240 short tons of recycling, which does not include glass or metals, which produces 22 $MTCO_2e$. Glass and metals recycling occurs within Sitka but results in a negligible amount of emissions because of the relatively small quantity of material and the low emissions factor for glass and metals recycling. Although recycling produces minimal emissions, it is still include it in the total emissions of solid waste disposal.

The emissions from shipping solid waste are counted under shipping emissions. Given the weight of waste shipped, emissions from shipping solid waste account for approximately 7% of shipping emissions. Note solid waste data are from 2023, whereas data for shipping are from 2022. However, we can assume the ratio can be assumed to be similar from year to year.

AIR TRAVEL

Because Sitka is on an island, air travel is the primary mode of transportation to anywhere outside the city. This inventory includes emissions from aviation fuel combustion occurring within the city boundary and from portions of one-way transboundary journeys outside the city boundary (e.g., a flight to New York that has a layover in Seattle). Sitka has multiple types of flights: commercial, personal, general aviation (e.g., medical, coastguard), and cargo.

SEAPLANES, HELICOPTERS, AND SMALL PERSONAL PLANES

The 5-Year Cargo Report shows Sitka imported 658,000 gallons of kerosene in 2022, which, in its highly refined form, is a type of jet fuel. This jet fuel is used for smaller, more local air travel such as seaplanes, small personal planes, and helicopters used for coastguard or medical evacuation. Emissions from burning this jet fuel are 5,359 $MTCO_2e$. However, Rocky Guiterrez Airport does some portion of refueling on-site, meaning some portion of this fuel imported goes toward refueling commercial planes at the airport. on-site refueling jet fuel numbers from Alaska Airlines were not available, so we estimate 20% of the kerosene shipped to Sitka goes toward commercial air travel.

$$Seaplanes, Small\ Planes, and\ Helicopoter\ Emissions\ = 80\% \times Cargo\ Report's\ Kerosene\ Emissions$$

COMMERCIAL AIR TRAVEL

Based on feedback from Sitka community members, most planes that stop at Sitka's Rocky Gutierrez Airport do not refuel on-site. Assumptions had to be made because annual fuel data from planes do not exist. According to the Bureau of Transportation Statistics T-100 Segment Data for 2023,[15] Sitka's Rocky Gutierrez Airport had 40,586 passenger-miles (number of passengers and the distance they have flown in thousands, for flight segments originating from and arriving to Sitka) in 2023. From this, the air travel emissions can be calculated using the commonly used passenger-miles-based method. Most flights are assumed to be classified as "medium haul" (such as to Seattle, or ~850 miles) and therefore use EPA's "Air Travel – Medium Haul" emission factor (0.130 $MTCO_2e$/passenger-mile). This is a common method for estimating air travel emissions in GHG inventories when actual data are not available. This results in a total of 5,286 $MTCO_2e$ from commercial air travel. Combining commercial air travel, seaplanes, small planes, and helicopters, Sitka's total air travel emissions are estimated to be 10,645 $MTCO_2e$ per year.

[15] Bureau of Transportation Statistics: https://www.transtats.bts.gov/Data_Elements.aspx?Qn6n=H.

$$Commerical\ Air\ Travel\ Emissions = passenger.miles\ x \frac{MTCO2e}{passenger.miles}$$

FUTURE AIR TRAVEL WORK

Currently, cargo plane data are not broken out in this calculation. These data can be added with more information from Alaska Airlines on the breakdown of cargo and commercial flights, along with any refueling data. The Federal Aviation Agency (FAA) data provided by the Sitka Rocky Gutierrez Airport shows in 2023 there were 1,812 commercial flights, 9,860 seaplane flights, 1,325 military flights, and 10,342 general aviation flights—resulting in a total of 23,339 flights (Table 8). "General aviation flights" refer to flights by pilots flying their own or rented aircraft, training flights, private cargo, and recreational flights. The seaplane flights include commercial passenger flights servicing fewer than 60 people on the plane from Sitka Rocky Gutierrez Airport and A29 Seaplane Base (float planes, which are Alaska seaplanes and float planes for hire). These data are included in case additional information becomes available regarding refueling and air travel in Sitka.

Table 8. 2023 FAA Data on Flights by Type

Type of Flight	Number of Flights in 2023
Commercial	1,812
Seaplane	9,860
Military	1,325
General aviation	10,342
Total flights leaving Sitka	**23,339**

Apart from 2020, Sitka's commercial travel has been steadily increasing since 2002, as shown in Figure 3 .

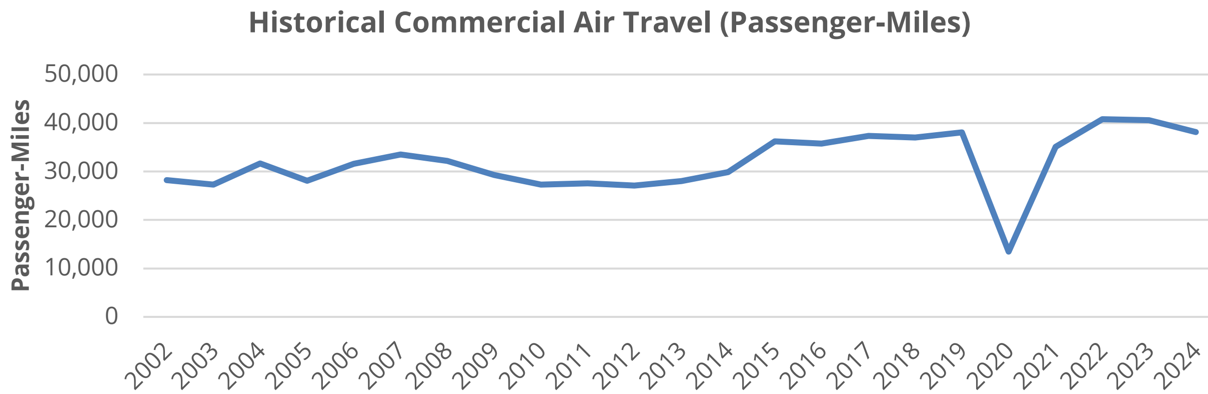

Figure 3. Air travel in revenue passenger-miles from 2002 to 2024

SHIPPING

Sitka is very dependent on marine shipping, whose emissions are considered Scope 3 and are not always included in GHG inventories because of the difficulties estimating shipping emissions. Defining boundaries is important for estimating shipping emissions. According to the 2022 Cargo Report, Sitka ships and receives 117,658 short tons of material via barges. A barge can carry 1 ton of cargo about 650 miles with 1 gallon of fuel.[16] Assuming a barge travels to and from Seattle, including stops in Ketchikan and Petersburg (which is a common shipping route), the distance traveled is approximately 1,000 miles. Actual shipping distances may be greater. This results in approximately 181,000 gallons of diesel fuel consumed by the barges, or 1,850 $MTCO_2e$.

To improve estimates of shipping emissions, data from official records, manifests, or surveys can be used to determine the apportionment of emissions to Sitka from the overall shipping companies. It should be noted that barge transport is more efficient than other forms of shipping, such as trains, trucks, or planes. According to the Cargo Report, of the materials shipped, approximately 57% are received (shipped into Sitka) and 42% are shipped out of Sitka. Fish accounts for approximately 63% of outbound shipments. Groceries were the largest single category of imports, comprising approximately 20% of imported tonnage in 2022. Plane cargo shipping could be added to this inventory when data become available.

[16] Texas A&M Transportation Institute, *A modal Comparison of Domestic Freight Transportation Effects on the General Public: 2001–2014.* 2017. https://nationalwaterwaysfoundation.org/file/31/final%20tti%20report%202001-2014%20approved.pdf.

CRUISE SHIPS

Revenue from cruise ships and their passengers account for a large portion of Sitka's economic activity. Cruise ships do not draw power from Sitka's port, and they do not refuel in Sitka; however, they burn fuels while in port in Sitka. Although this combustion happens within Sitka's boundaries, it is standard practice in GHG reporting to count emissions from intercity or international trips as Scope 3 emissions. Only GHG emissions are reported for cruise ships, not nitrogen oxides (NOx), sulfur oxides (SOx), and fine particulate matter ($PM_{2.5}$) emissions, which are the gases responsible for air pollutants associated with cruise ships.[17]

The 2024 cruise ship schedule is used to determine the number of cruise ships visiting Sitka annually. In 2024, there were 39 cruise ships with 328 scheduled trips to Sitka, with a total duration of 333 ship days (one ship can stay for multiple days during multiple visits). It should be noted that cancelled ship visits or unplanned visits are not considered in this calculation. The scope of cruise ship emissions is defined to include just the number of emissions they produce while within Sitka's boundary: transiting to and from the port and while docked. This is to better understand the emissions produced within Sitka's boundary. Using historical AIS data (Automatic Identification System, which tracks ships), an average 4-hour maneuver time—which is the time to approach Sitka, tie to the dock, and leave—is calculated. The cruise ship schedule is used to calculate the average stay per boat in Sitka at 9 hours. Hotel load is assumed to be 29% of total installed power and low speed moving and maneuvering is assumed to be 25% of total installed power. These percentages are chosen after consulting with a captain of medium to large size cruise ships. This results in a total diesel consumption of 3.3 MGal and 34,072 $MTCO_2e$ generated per year.

CRUISE-SHIP-RELATED GROUND TRANSPORTATION EMISSIONS

According to Harrigan Centennial Hall, there are 100 permits for small passenger vans or buses to load/unload tourists. Large buses are used to move tourists from the docks to Harrigan Centennial Hall. Smaller buses are also used by tour companies. The 2024 cruise ship schedule includes the number of passengers each ship can carry. Assuming the ships are at full capacity, 610,818 cruise ship tourists spend a day in Sitka per year. Assuming each cruise ship tourist is transported via van or bus for an average of 20 miles per day, this results in 464 $MTCO_2e$ per year from diesel. This is a subset of the already considered emissions from trucks and buses in the ground transportation section, based on the assumption that each of these vehicles is registered with the Alaska Department of Motor Vehicles. This means emissions from tourist

[17] F. Murena, L. Mocerino, F. Quaranta, and D. Toscano. 2018. "Impact on air quality of cruise ship emissions in Naples, Italy." *Atmospheric Environment*, Volume 187, pages 70–83, ISSN 1352-2310. https://doi.org/10.1016/j.atmosenv.2018.05.056.

ground transportation is not an *addition to* the previously counted ground transportation emissions but rather a *portion of* those emissions.

CITY AND BOROUGH OF SITKA GREENHOUSE GAS EMISSIONS TOTALS

Based on this analysis, for all three scopes, Sitka produced approximately **84,346 $MTCO_2e$** in 2023. The sectors analyzed include electricity, ground transportation, recreational and charter boats, commercial fishing, residential and commercial heating, waste and wastewater, air travel, cruise ships, and shipping. Cruise ships and shipping emissions are often not included in GHG inventories because of their difficulty to calculate and limited ability to mitigate but are included here because of their large impact on Sitka's economy and air pollution. Figure 4, Table 9, and Table 10 show the end uses by scope. Green is used to denote Scope 1; yellow is used to denote Scope 3.

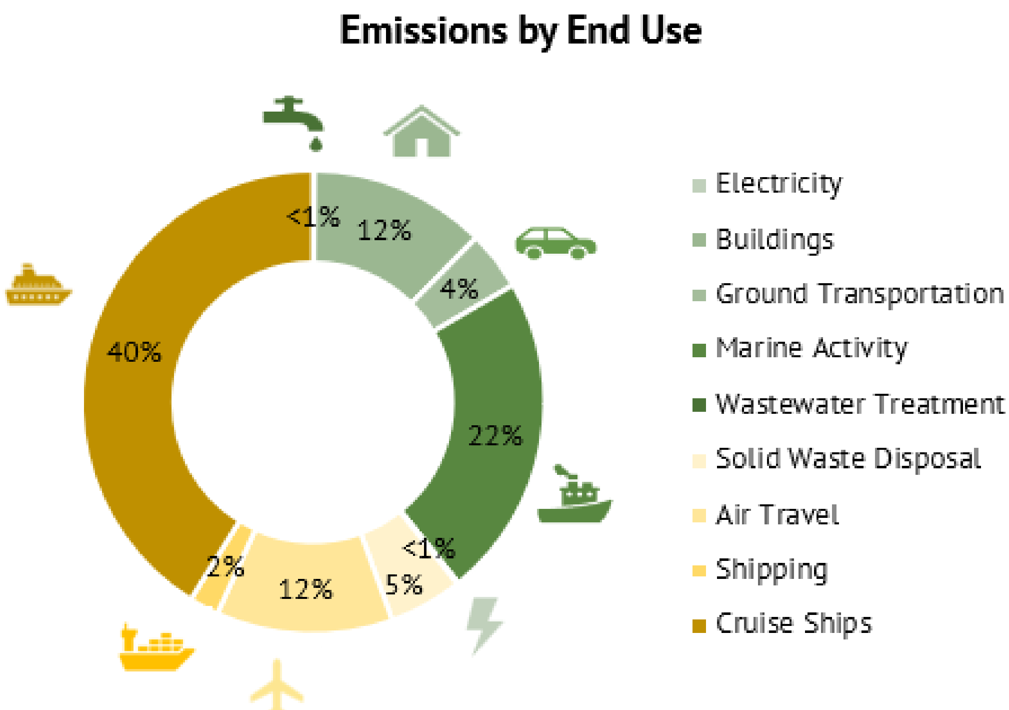

Figure 4. Sitka's emissions by end use, separated by category

Table 9. Sitka's Scope 1 End Use, Separated by Category

Scope 1 End Use	$MTCO_2e$	Percent
Electricity	102	<1%
Buildings	10,448	12%
Ground Transportation	3,734	4%
Marine Activity	19,043	23%
Wastewater Treatment	9	<1%
Total Scope 1 Emissions	**33,328**	**40%**

Table 10. Sitka's Scope 3 End Use, Separated by Category

Scope 3 End Use	$MTCO_2e$	Percent
Solid Waste Disposal	4,440	5%
Air Travel	10,645	12%
Shipping	1,854	2%
Cruise Ships	34,072	40%
Total Scope 3 Emissions	**51,011**	**60%**

Figure 5 show Sitka's GHG emissions by end use in finer detail, revealing the largest end uses of emissions are cruise ships (40%) and commercial fishing (18%). Table 11 also conveys the fuel consumption tied to each end use.

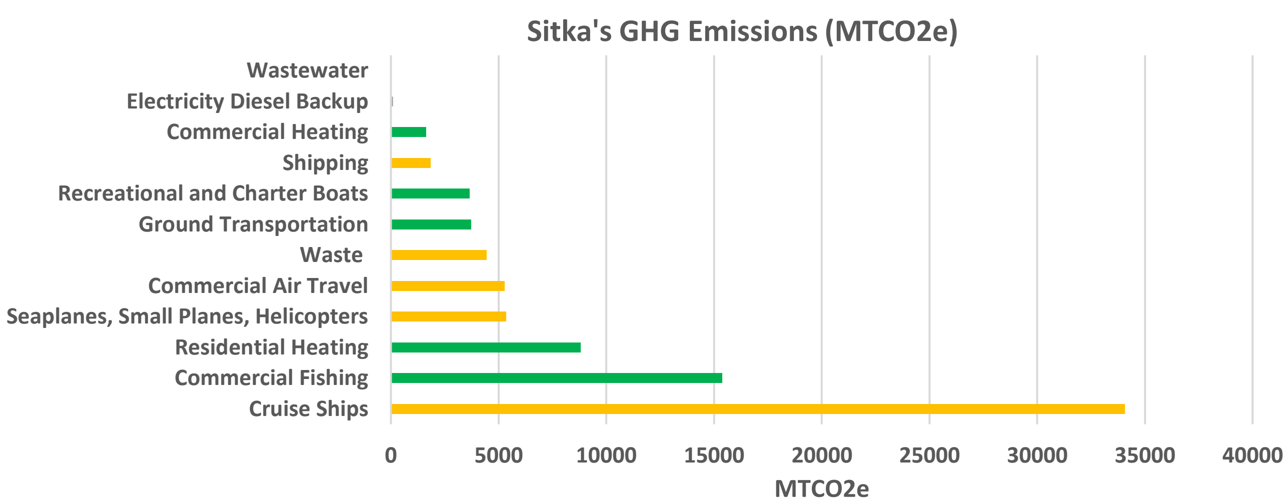

Figure 5. Sitka's emissions by source

Table 11. Sitka's Emissions and Fuel Consumed

Scope	Emission Source	Fuel Consumed (gallons)	Emissions ($MTCO_2e$)	% Total Emissions
3	**Cruise ships**	3.3 Mgal diesel	34,072	40%
1	**Commercial fishing**	1.4 Mgal diesel 120 kgal gasoline	15,376	18%
1	**Residential heating**	790 kgal fuel oil	8,808	10%
3	**Seaplanes, small planes, helicopters**	526 kgal jet fuel	5,359	6%
3	**Commercial air travel**	542 kgal jet fuel	5,286	6%
3	**Waste**	N/A	4,440	5%
1	**Ground transportation**	743 kgal gasoline 80.7 kgal diesel	3,727	4%
1	**Recreational and charter boats**	403 kgal gasoline	3,667	4%
3	**Shipping**	181 kgal diesel	1,854	2%
1	**Commercial heating**	150 kgal fuel oil	1,640	2%
1	**Electricity backup**	9.9 kgal diesel	102	<1%
1	**Wastewater**	N/A	9	<1%
	Total Emissions		**84,339**	

These emissions can be grouped by sector: transportation, buildings, industry, and waste. Industry is the largest emissions sector, accounting for 60% of Sitka's emissions, as shown in Figure 6, comprising the two largest end uses: commercial fishing and cruise ship emissions. It should be noted that while commercial fishing and cruise ships could also be considered transportation, they are a large portion of Sitka's economic sector. The second highest sector is transportation, which comprises ground-based, marine, and air travel, including seaplanes, commercial planes, small planes, recreational and commercial boats, cars, and buses. It is unsurprising that transportation is a large component of Sitka's emissions because people are required to fly or boat to arrive in or leave Sitka. Buildings account for 12% of emissions (residential and commercial building heating), and waste accounts for 5% of Sitka's emissions, which includes the emissions associated with solid waste disposal, wastewater, and recycling.

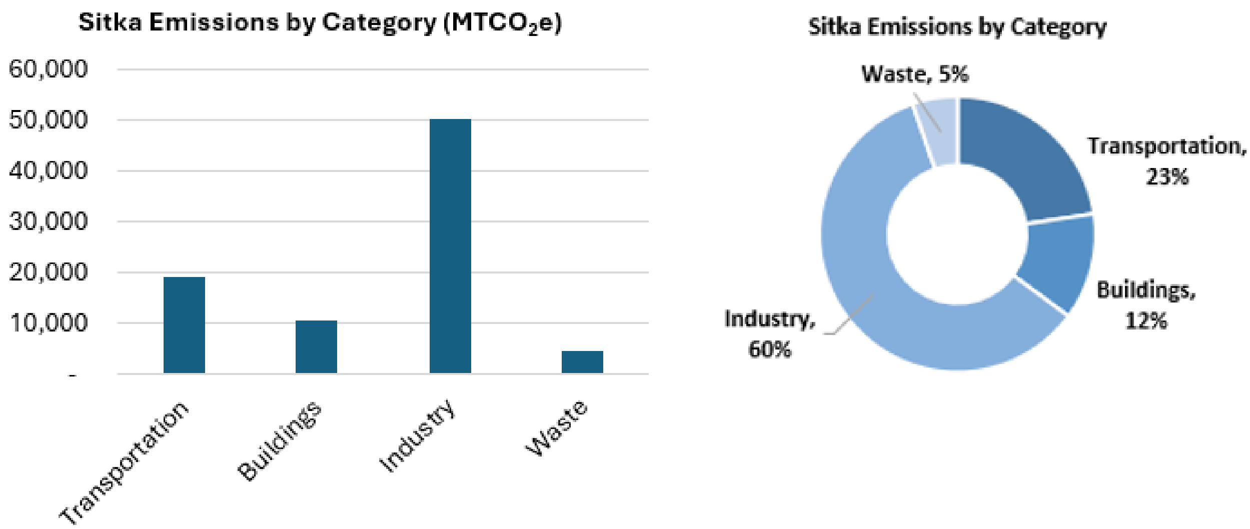

Figure 6. Sitka's emissions by category (MTCO₂e)

Figure 7 displays Sitka's emissions by source. Distillate fuel oil (also known as diesel) is the largest portion at 76%. The largest portion of distillate fuel oil comes from commercial fishing, followed by residential and commercial buildings. Jet fuel is the second highest source of emissions at 13% and gasoline at 10%.

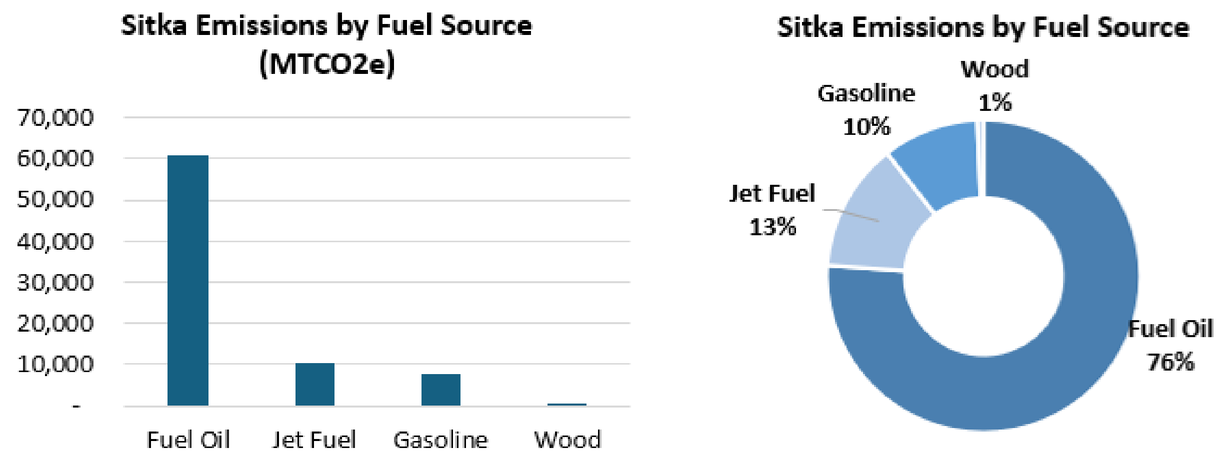

Figure 7. Sitka's emissions by fuel source

Sankey diagrams can be used to show the flow of energy from fuel source to end use. Figure 8 helps visualize the correlation of emissions source and end use, showing the interconnection of emission source (e.g., fuel) to end use to general category.

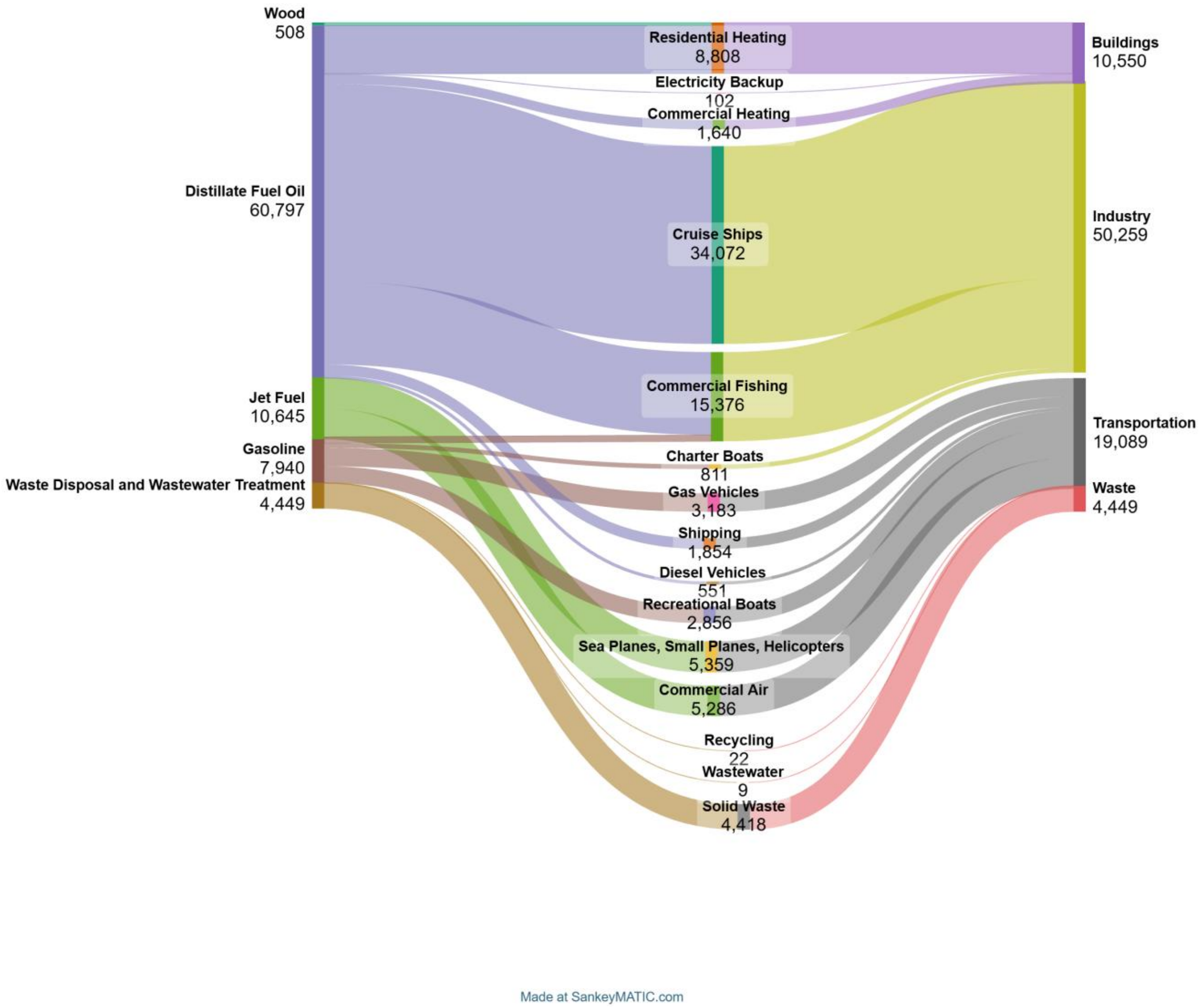

Figure 8. Sankey diagram of Sitka's emissions by source, end use, and category (MTCO₂e). Graphic created at https://sankeymatic.com.

APPENDIX A – METHODOLOGY

This appendix provides additional information on the methodology used to generate this report.

A.1 DETAILED COMMERCIAL FISHING ESTIMATES

This analysis aims to quantify the emissions of all fishing vessels that are home ported in Sitka, Alaska. Although some additional fishing vessels may come into Sitka Sound or other nearby areas to fish, some of Sitka's vessels leave the nearby area to fish. Claiming the emissions from Sitka's registered boats is an estimate for the emissions that are related to Sitka's economic activity. This analysis estimates the total number of gallons of fuel consumed by the fleet of active vessels registered in Sitka.

Information on Sitka-registered vessels was collected by downloading Alaska's commercial fishing database for 2023.[18] This database contains both permits for various fisheries and vessels registered for commercial fishing. For the commercial fisheries in Alaska, this database contains additional data that may be useful for determining fuel consumption per year, including the year built, the hull type, the type of gear present on the boat, the dimensions, tonnage, engine type, and horsepower. Of the registered vessels in 2023, 71% were diesel engines, 28% gas, and 1% left the engine data field blank. Generally, gas-powered vessels are hand trollers or hand pickers, with a few power trollers or longliners; there are also some vessels registered as tenders that are reported as gas powered.

The total number of vessels operating out of Sitka in 2023 was 510. Some of these vessels were likely inactive for the year. This is assumed to be about 5% and that this percentage is even across the types of fisheries and boats. This percentage of inactive vessels can be changed in the Excel tool. From there, an estimate of the fisheries each vessel participates in for how many days per year and generally where they fish is required. Based on the types of gear present on each vessel, we made a general rule for how to quantify the fisheries each vessel participates in. The gear types we considered are as follows:

- Purse seine or ring net gear
- Gillnet gear
- Troll gear (power troll, mechanical jig, dinglebar)
- Longline gear
- Hand troll gear
- Pot gear

[18] https://www.cfec.state.ak.us/plook/#permits.

- Tenders
- Diving and handpicked.

Because most boats have multiple types of gear, it must be assumed that some vessels fish multiple fisheries. Any vessel that has only one type of gear is assumed to fish only in that fishery. In addition, all vessels that have seine or gillnet gear are assumed to fish using that gear because it is more specialized. For vessels with troll and longline gear, only 50% of vessels with that gear in addition to other gear is estimated because the troll and longline gear may sometimes be used for sport fishing or previous years' fisheries. Similarly, vessels that have hand gear as well as other gear types are assumed to not hand troll because the hand gear is likely just a recreational activity. Vessels that are labeled as tenders are assumed to operate as tenders at least some of the time and excluded from the counts of data with a single type of gear, but the tender vessels can be assumed to fish other fisheries if they contain multiple types of gear. These assumptions are summarized in Table A-1.

Table A-1. Assumptions for Estimating the Number of Vessels Operating in Each Fishery

Gear	Vessel Activity	Gear Code	Count With Only This Gear and Are Not a Tender	Count That Contains This Gear and Other Gear (can be a tender)	Estimated Number of Vessels Fishing in This Method	Notes
Purse seine, ring net	Fishing	01, 10	34	55	85	Assume 95% of vessels that have seine gear fish using that gear
Gillnet	Fishing	03, 04	12	23	33	Assume 95% of vessels that have gillnet gear fish using that gear
Troll and mechanical jigs	Fishing	15, 25, 26	102	281	237	Assume 95% of vessels that have only this gear, plus 50% of vessels that contain this gear
Longline	Fishing	06	13	215	120	Assume 95% of vessels that have only this gear, plus 50% of vessels that contain this gear
Hand troll	Fishing	05	41	85	39	Assume 95% of vessels that have only this gear but none of the vessels that have other gear
Diving or handpicking	Fishing	11, 12	14	65	33	Assume 95% of vessels that have only this gear and 30% of vessels that have other gear
Pot gear	Fishing	09	4	103	76	Assume 95% of vessels that have only this gear and 70% of vessels that have other gear
Tender	Tender packer	N/A	52		49	Assume 95% of vessels that are tenders operate as tenders

Next, the distance to the fishing areas for each fishery was estimated as well as the number of round trips to the fishing areas (Table A-2). These distances are variable based on individual fisherman as well as the type of fish being caught. In directly measuring vessel efficiency, Kempy Energetics reported vessels operating as longline and trollers with an approximate efficiency of 2.5 miles per gallon (MPG); this efficiency can change significantly based on the mode of operation (such as transiting or fishing). Smaller vessels such as diving, hand picking, and hand trollers are assumed to have higher efficiency. As vessels adopt more efficient practices or take other efficiency measures, the MPG could be updated to reflect this change in future iterations of the inventory.

Table A-2. Estimated Number of Round Trips by Fishing Type

Fishing Type	Estimated Number of Vessels Fishing in This Method	Approximate One-Way Distance to Fishing Areas (miles)	Number of Round Trips to Fishing Ground	Estimated Miles	MPG	Estimated Yearly Fuel Usage per Boat (gallons)
Purse seine, ring net	85	125	30	7,500	2	3,750
Gillnet	33	100	20	4,000	2	2,000
Troll and mechanical jigs	237	150	15	4,500	2.5	1,800
Longline	120	150	10	3,000	2.5	1,200
Hand troll	39	25	30	1,500	5	300
Diving or handpicking	33	25	30	1,500	5	300
Pot gear	76	25	30	1,500	4	375
Tender	49	150	50	15,000	1.5	10,000

To double check these assumptions, Data from Kempy Energetics was used to double check these assumptions. They collected a series of data from the FVEAT tool where fishermen provided estimates of their annual fuel consumption or completed the tool to estimate their fuel usage. Table A-3 shows the estimates and average estimates for each fishing method.

Table A-3. Estimates and Average Estimates of Commercial Fishing Fuel From Fishermen

Fishing Type	Annual Gallons of Fuel Estimates From Fishermen	Average
Purse seine, ring net	7800, 6171, 1232, 3837	4760
Gillnet	600, 1490, 1716, 1721, 1615	1428
Troll and mechanical jigs	2900, 1850, 980, 2270, 3269, 2183, 1140, 1571, 620, 1228, 2320, 105, 368	1600
Longline	3000, 642, 1123, 382, 1404, 101, 105, 2320, 631	1079
Hand troll	N/A	N/A
Diving or handpicking	519, 302	410
Pot gear	314	314

Finally, these two methods were compared. Generally, both assumptions resulted in the same order of magnitude for the annual gallons of fuel per vessel, with differences in both positive and negative directions (Table A-4).

Table A-4. Self-Reported vs. Calculated Estimated in Commercial Fishing Fuel

Fishing Type	Self-Reported Estimates (gallons)	Calculated Estimates (gallons)	Percent Difference
Purse seine, ring net	4,760	3,750	21%
Gillnet	1,428	2,000	-40%
Troll and mechanical jigs	1,600	1,800	-12%
Longline	1,079	1,200	-11%
Hand troll	N/A	300	No comparison
Diving or handpicking	410.5	300	27%
Pot gear	314	375	-19%
Tender	10,852	10,000	8%

To make a final estimate of the total gallons of fuel consumed by the commercial fishing industry, the number of gallons between the two estimates was averaged, then the percentage of the vessels powered by gas and diesel was estimated as reported by the vessel database (Table A-5).

Table A-5. Calculated Gallons of Diesel and Gasoline by Fishing Type

Fishing Type	Gallons of Fuel From Average of Two Estimates	Percentage Gas	Gallons Diesel	Gallons Gasoline
Purse seine, ring net	36,1675	0%	361,675	0
Gillnet	56,569	0%	56,569	0
Troll and mechanical jigs	402,936	10%	362,643	40,294
Longline	136,720	10%	123,048	13,672
Hand troll	11,700	50%	5,850	5,850
Diving or handpicking	11,723	50%	5,862	5,862
Pot gear	26,182	30%	18,327	7,854
Tender	510,874	10%	459,787	51,087
		TOTALS	**1,393,760**	**124,619**

A.2 ACTIVE CHARTER VESSELS IN SITKA

Table A-6 shows the number of active charter vessels annually in Sitka, which is tracked in a logbook accumulated by the Division of Sport and Fish in Anchorage. In the table, "Active Vessels" means vessels that ended a trip in Sitka proper at some point during the year, and "Number of Trips" means the total trips that ended in Sitka.

Table A-6. Number of Active Charter Vessels That Ended a Trip in Sitka Proper 2006–2023

Year	Number of Active Vessels	Number of Trips
2006	207	11,094
2007	199	10,888
2008	202	10,529
2009	172	7,040
2010	156	7,296
2011	151	7,211
2012	153	7,039
2013	146	6,713
2014	144	7,555
2015	142	8,008

Year	Number of Active Vessels	Number of Trips
2016	151	8,011
2017	164	8,401
2018	153	7,989
2019	159	8,020
2020	112	4,100
2021	128	7,685
2022	145	8,311
2023	142	7,920

A.3 REFRIGERANT EMISSIONS

Refrigerants are fluorinated gases. Many residential and industrial technologies use refrigerants, including refrigerators, air conditioners, industrial ice producers, and data centers. There are both direct (Scope 1) and indirect (Scope 3) emissions from refrigerants. Ideally, a refrigerant is contained within the technology where it exists. The process of converting a refrigerant from a liquid to a gas and back to a liquid is what produces the cooling effect. However, technologies using refrigerants are prone to leakage or improper disposal, which leads to the refrigerants being released into the atmosphere. This leakage is the main source of direct emissions and is therefore extremely difficult to quantify and track. Even the small volume of direct emissions that are released accounts for approximately 1% of U.S. emissions.[19] Indirect emissions from refrigerants are about 2 times as high as direct emissions, and they come from the high energy costs of producing refrigerants. Refrigerants, in theory, can be collected from machinery and reused; however, this does not often happen because the costs of recovery outweigh the potential revenue.

Refrigerant emissions are not accounted for in this inventory, primarily because of the difficulty and uncertainty of quantifying those emissions. That said, the seafood processing industry is a major user of refrigerants and any steps taken to make seafood processing more efficient or prevent refrigerant leakage in the industry could lead to decreased emissions. The shipping of goods that require refrigeration is another major source of refrigerant emissions. After fishing vessels, refrigerated bulk carriers are responsible for the highest amount of refrigerant

[19] U.S. EPA. Inventory of U.S. Greenhouse Gas Emissions and Sinks. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

emissions for refrigeration (but not for air conditioning) compared to other ships.[20] In 2018, refrigerated containers accounted for 18.2 million $MTCO_2e$ worldwide.

A.4 THE ROLE OF THE TONGASS NATIONAL FOREST

This inventory does not consider carbon that is naturally sequestered by trees and other plants around Sitka. This carbon sequestration, though substantial (the Tongass stores the most carbon of any U.S. national forest[21]), is part of a natural carbon cycle that includes many other exchanges of carbon between land, water, and the atmosphere.

Although various policies and practices have established ways to quantify and credit individuals or organizations for reforestation or forest protection, these methods of crediting are not standard in GHG inventories. This is especially true when the land in question is not managed or designed intentionally for carbon sequestration. In short, the city of Sitka is not credited for what the trees do.

A.5 USING THE USACE CARGO REPORT

Due to the fluctuations in the Cargo Report data, this inventory relies primarily on activity data. However, Cargo Report data is used for validation of assumptions and filling in gaps for sectors without adequate activity data (e.g. air travel). Data from the USACE's Cargo Report from 2022 for the port labeled "Sitka Harbor" is used. Because of some changes in how the cargo data are reported as of 2021, the 5-Year Cargo Report data required some interpretations. Justification is provided for 1) why "Sitka Harbor" was used vs. "Sitka Ports and Harbors" or a combination of the two, 2) why the year 2022 was used, and 3) why the chosen standard was selected for comparing calculations from activity data to fuel imports data.

1. In 2021, USACE began reporting data for "Sitka Harbor" and "Sitka Ports and Harbors," as opposed to just "Sitka Ports and Harbors" prior to 2021. What counted under "Sitka Ports and Harbors" prior to 2021, became counted under "Sitka Harbor" in 2021 and 2022. What became "Sitka Ports and Harbors" in 2021 and 2022 is believed to be a subset of what is counted under "Sitka Harbor." The new "Sitka Ports and Harbors" counts only the

[20] International Marine Organization, Fourth Greenhouse Gas Study 2020. Fourth Greenhouse Gas Study 2020.

[21] Barrett, Tara M. 2014. Storage and flux of carbon in live trees, snags, and logs in the Chugach and Tongass national forests. Gen. Tech. Rep. PNW-GTR-889. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 44 p. https://research.fs.usda.gov/treesearch/45431.

docks, ports, and harbors within the jurisdiction of the Sitka Ports and Harbors Commission. These assumptions are supported by the following evidence:

   a. The port called "Sitka Harbor" (2022, 2021) and the port called "Sitka Ports and Harbors" prior to 2021 are described in the same way on the USACE website: "Section Included: From the Alaska Lumber & Pulp Co. Mill in Silverbay on the south to Starrigavan Bay on the north including the Sitka Central Waterfront and Japonski Island. Controlling Depth: 22 feet at mllw in western channel and 10 feet in small boat basin. Project Depth: 22 feet in western channel; 10 feet in small boat basin and approach channel. All depths refer to mllw." (Note: mllw = mean lower low water.)

   b. The port called "Sitka Ports and Harbors" in 2021 and 2022 includes "Section Included: From the southern point of Crescent Harbor to the southern point of the Sitka Airport runway, then north and east along the coast of Alice, Charcoal, and Japonski Island, thence west along the breakwater, then following the western coast of Baranof Island to the point of completion," which is the same language used to describe the jurisdiction of the Sitka Ports and Harbors Commission in Sitka's General Code.[22]

   c. These descriptions indicate there could be imports coming in between Starrigavan Bay and the northernmost point of Baranof Island. However, there are only four USACE navigation units in that area: St. John Baptist Bay, Salmonberry Cove, Kalinin Bay, and Katlian Bay[23]; none of these areas has infrastructure for importing goods.

   d. Looking at the years 2016–2020, the data published under "Sitka Ports and Harbors" match the data in the 5-Year Cargo Report from 2022 "Sitka Harbor."

2. 2022 data is used for two reasons:

   a. It was the most recent year for which data was available during the curation of this inventory.

   b. The 2022 data have the least fuel in the category of "Petro Products NEC," meaning it was not necessary to "guess" whether those fuels are gasoline, diesel, and so on.

3. The following acceptable ranges are assumed for determining if the estimates from activity data align with the estimates from the imported fuel data (Table A-7). In general, wide ranges are applied because of the variability in the cargo report data, considering

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[22] Sitka's General Code 13.05.030 https://sitka.municipal.codes/SGC/13.05.030.

[23] USACE Complete Dock List from Navigation and Civil Works Decision Support (NDC) Library. https://ndclibrary.sec.usace.army.mil/resource/b625649b-4c33-46a2-fadf-d263f02ebf63.

data from 2002 to 2022 but favoring more recent data. There are several forms of variability in the data that impact decisions about acceptable ranges:

a. There is wide variation in the total amount of fuels imported per year. Figure A-3 shows the net imports of fuels (receipts minus shipments). From this figure, it can be assumed that not all fuels imported in a certain year are used in that year and some industries import over cycles longer than a calendar year. The total net fuel imports between 2002 and 2022 range from 11,308 gal in 2008 to 52,637 gal in 2015. The average import over those years was 25,785. However, before centering the acceptable range around this average, potential changes in fuel use over time must be considered.

b. From Figure A-4, peaks in imports happen about every 4 years. To smooth these peaks and consider changes to fuel imports over time, a 4-year moving average is calculated. Each data point represents the average of the year labeled and the 3 years prior. For instance, the data point for 2022 is the average of all net fuel imports from 2019 to 2022. The 4-year moving average of the total fuels imported into Sitka from 2005 until 2022 shows a slight downward trend in fuel imports. For this reason, the acceptable range of total fuels is shifted downward from the 21-year average.

c. As shown in Figure A-4, there is also a high variability in gasoline, diesel, and Petro. Products NEC. It appears during the time frame of 2015–2020, some amount of both diesel and gasoline were counted in the Petro. Products NEC category. This poses a challenge for estimating the acceptable ranges for individual fuels. As with the numbers for total fuels, a range around the average is formed, this time excluding data from 2015 to 2020, then the range is shifted downward to more closely reflect recent data.

d. Kerosene began to be counted in 2015.

e. The ranges are defined through this semi-systematic method, as opposed to using a more rigid statistical method, is because a rigid methodology is both unnecessary and it tends to imply a certain meaning or certainty to data that, in this case, does not accurately reflect reality.

Table A-7. Acceptable Ranges for Fuel Import Estimates

Fuel	2022 Net Import (short tons)	Average (years counted in average; short tons)	Acceptable Low Range (short tons)	Acceptable High Range (short tons)	Acceptable Range (gallons)	Acceptable Range ($MTCO_2e$)
Gasoline	5,942	12,829	5,000	13,000	1.6–4.3 million	14,000–38,000

		(2002–2015)				
Kerosene	2,197	1,289 (2015–2022)	700	2,500	0.2–0.8 million	2,100–7,600
Distillate fuel	10,265	14,125 (2002–2015)	9,000	15,000	2.5–4.2 million	23,000–38,000
All fuel	18,438	25,785 (2002–2022)	14,500	27,200	N/A	N/A

For each fuel listed in the first column, we note the net import of that fuel in 2022, the average net import over the years noted, and the minimum and maximum of our acceptable range in short tons. The final two columns show range converted to gallons and $MTCO_2e$ and rounded to two significant figures. If our estimation of the fuel used is within the range, we consider it acceptable. To determine if the total fuels are in range, we convert back to short tons.

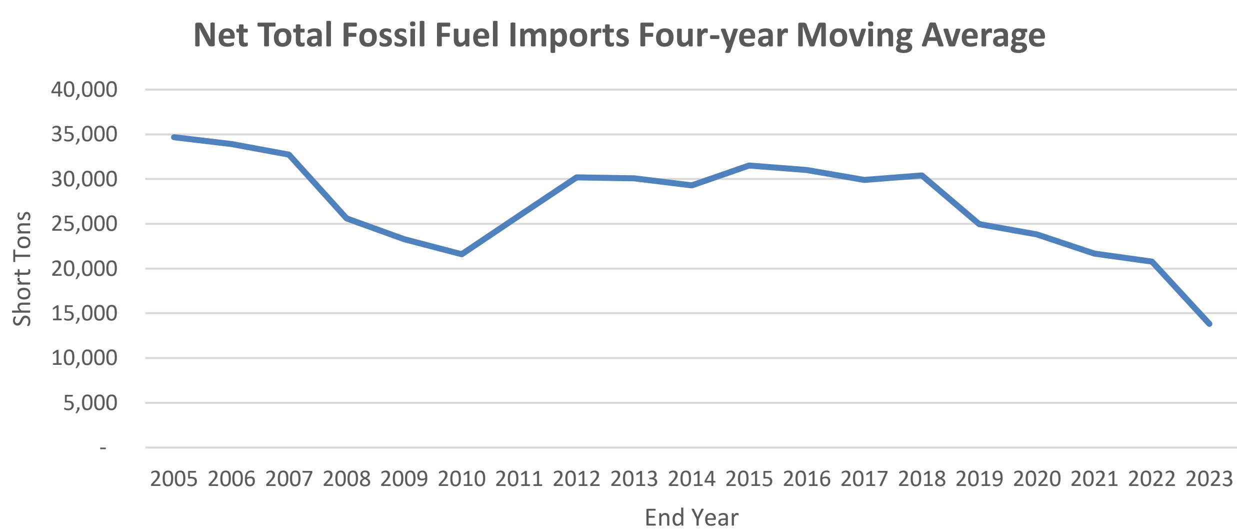


Figure A-1. A 4-year moving average of the net total fuel imports into Sitka, where the point above 2022 represents the average from 2019 to 2022, the point above 2021 represents the average from 2018 to 2021, and so forth

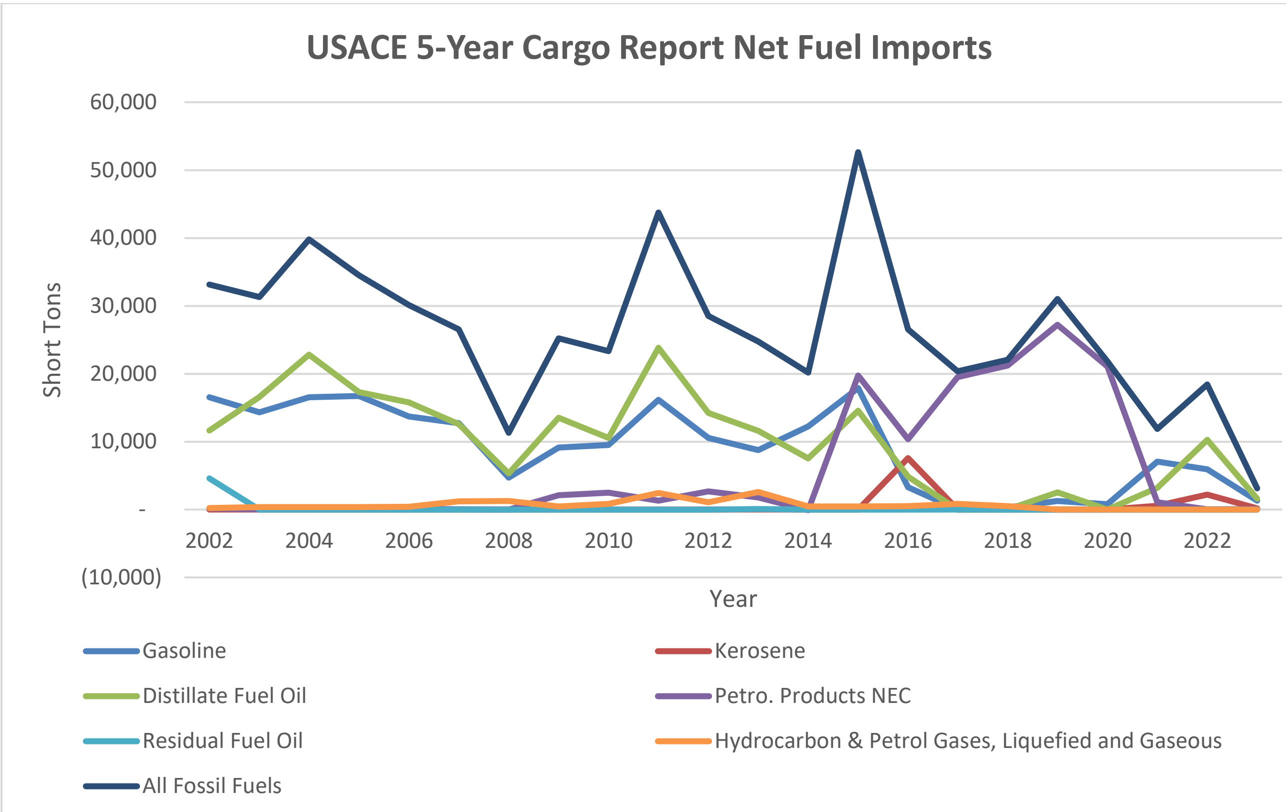


Figure A-2. Net fuel imports into Sitka 2002–2022 based on USACE cargo reports

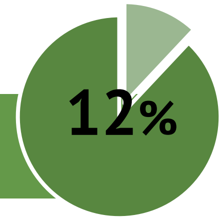
APPENDIX B – SUMMARY TABLES BY SCOPE

On each summary page, a confidence level on a scale of 1–4 is provided, with 4 being the most confident. However, the scale should not be considered linear; rather, each number has a unique meaning, shown in Table B-1 (and included on each summary page). The confidence levels are unitless. In the summary tables, scope 1 is indicated in green and scope 3 is indicated in yellow.

Table B-1. Confidence Levels for Summaries

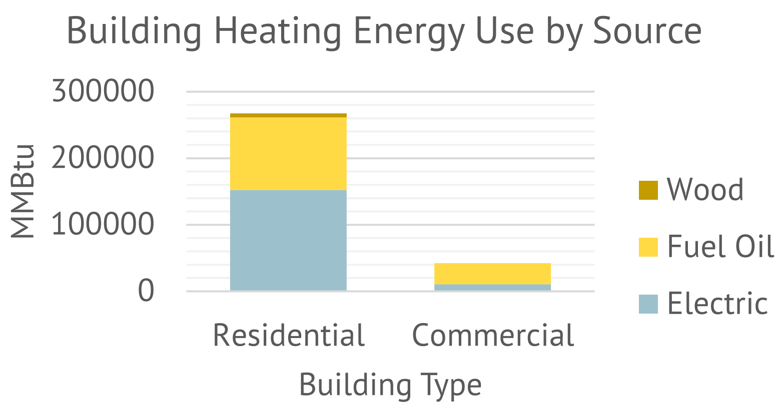
4	Confident in values. Values may need to be updated in future iterations of the inventory.
3	Additional, better, or more local data could improve estimate, but the overall impact would likely be small. Estimate is still technically justified with general understanding.
2	Additional local data could improve not only the estimate but also our method of calculation so the inventory is better able to account for efficiency improvements or other changes.
1	More or better data could improve estimates, and the overall impact could be meaningful.

Building Emissions



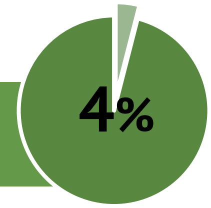
Building emissions come from the combustion of fuels for space heating, water heating, and cooking.

End Use	$MTCO_2e$	% of Buildings Emissions	% of Total Emissions
Residential	8,808	77%	10%
Commercial	1,640	22%	2%
Total buildings	10,550*	100%	12%
*Includes emissions from backup diesel generators			



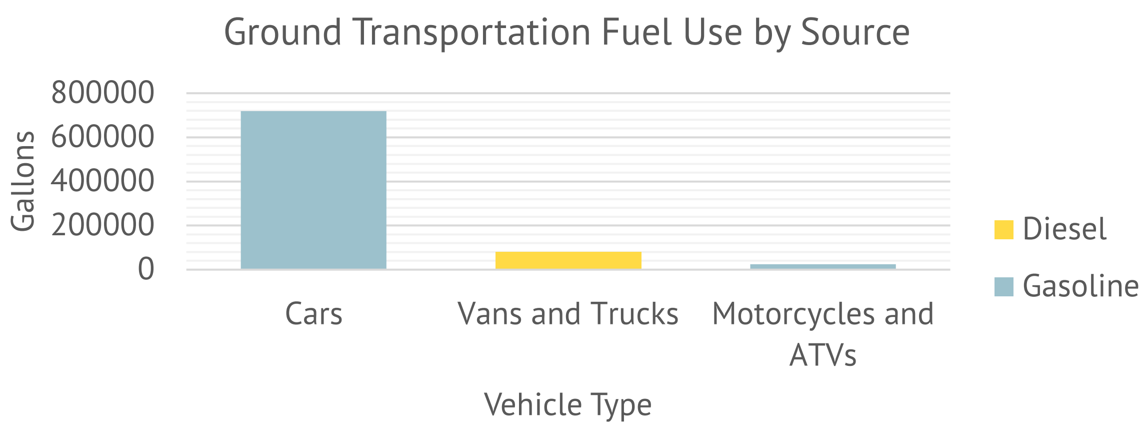
Input Parameter	Input	Source	Confidence
Residential Buildings			
Number of occupied houses	3,513	2017 Sitka Borough Housing Assessment	4
Average fuel use per household for heating and hot water	76 MMBtu/ house	U.S. Energy Information Administration's (EIA's) Residential Energy Consumption Survey (RECS) Dashboard, average between Alaska and Washington estimates	2
Residential Heat Source			
Percent electric heating	57%	Utility bill analysis	3
Percent fuel oil heating	41%		3
Percent wood heating	2%		3
Commercial Buildings			
Total commercial building square footage	2.3 million SF	Sitka's 2024 Commercial and Industrial Square Footage data	4
Percentage of building footage that is space conditioned	75%	Assumed based on use	3
Average fuel use per square foot (SF) for space heating in commercial buildings	25 kBtu/SF	EIA Commercial Buildings Energy Survey	2
Commercial Heat Source			
Percent electric heating	25%	Utility bill analysis	3
Percent fuel oil heating	75%		3

Ground Transportation Emissions



Ground transportation emissions come from the combustion of fuels in motor vehicles.

End Use	$MTCO_2e$	% of Ground Transportation emissions	% of Total Emissions
Cars	3,168	85%	3%
Vans and trucks	551	15%	<1%
Motorcycles and ATVs	8	<1%	<1%
Total ground transportation	3,737	100%	4%



Input Parameter	Input	Source	Confidence
Resident Ground Transportation			
Number of vehicles with engines	7,335 Class 1 824 Class 2 and 3 115 motorcycle/ATV	Alaska Department of Motor Vehicles	4
Percentage of registered vehicles that are active	70%	Assumed using Alaska Department of Transportation Traffic Analysis and Data Application website	4
Average miles driven per day per vehicle	4 miles/day	Calculated average vehicles traveled per day using 2022 CBS survey on commuting.	4
Number of active days per year	350 days (Class 1) 350 days (Class 2&3) 80 days (ATV)	Assumption	3
Average fuel efficiency	20 MPG (Class 1) 20 MPG (Class 2&3) 30 MPG (ATV)	Adjusted from U.S. average fuel efficiency of 24 MPG considering Sitka's lack of highway driving	2
Tourist Ground Transportation			

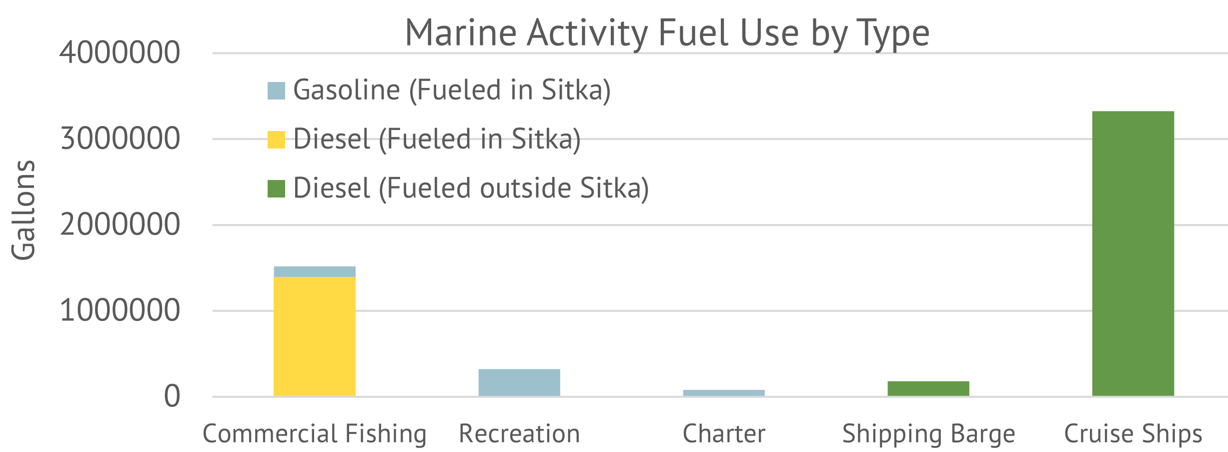
12%	Percentage of total ground transportation emissions attributed to tour buses carrying passengers between the cruise ship terminal and destinations in Sitka. These buses run on diesel and are counted within the Class 2 and 3 diesel vans and trucks category.

Personal & Industrial Marine Emissions

65%

Marine activity emissions come from the combustion of fuels in oceangoing vessels.

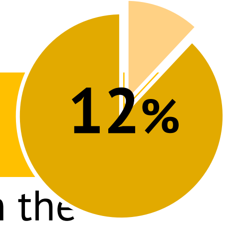
End Use	$MTCO_2e$	% of Marine Activity Emissions	% of Total Emissions
Commercial fishing	15,376	28%	18%
Recreational fishing and boating	2,856	5%	3%
Charter	811	1%	<1%
Barge shipping	1,854	3%	2%
Cruise ships	34,072	62%	40%
Total marine activities	54,969	100%	65%



Input Parameter	Input	Source	Confidence
Commercial Fishing			
Number of registered vessels	510 vessels	State of AK's commercial fishing database	4
Percentage of vessels inactive	5%	Assumption	3
Fuel use of vessels	Varies by vessel type	Detailed in Appendices	2
Recreational Boats			
Number of boats	1500 boats	Assumptions	2
Miles traveled	540 miles/ year/boat		3
Fuel efficiency	3 miles/gallon		2
Charter Boats			
Number of trips (2023)	7,920 trips/yr	Charter boat logbook by Sitka Area Management, Division of Sport Fish	4
Number of miles per trip	25 miles	Assumption	3
Miles per gallon	2.5 miles/gallon	Assumption	2
Barge Shipping*			
Tons of materiel shipped	117,658 tons	USACE Cargo Report (2022)	4
Shipping distance	1,000 miles	One-way Seattle to Sitka by sea	3
Capacity of 1 gallon fuel	650 miles/ton-gallon	Texas A&M Transportation Institute	3
Cruise ships*			
Gallons of diesel burned	3,325,968 gallons	Summation of fuel use by each cruise ship that made port in Sitka in 2024.	4

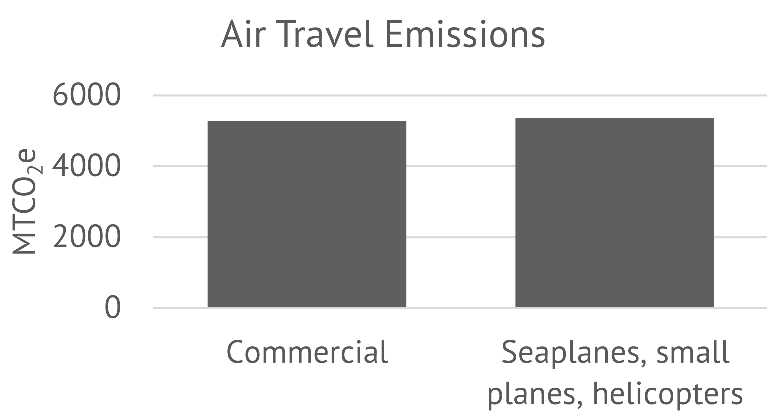
*Note: barge shipping and cruise ships are further elaborated on in their own section, but included here for comparison across marine sectors.

Air Travel Emissions



Air travel emissions come from aviation fuel combustion within the city boundaries and from portions of one-way transboundary journeys.

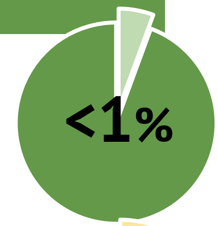
End Use	$MTCO_2e$	% of Air Travel Emissions	% of Total Emissions
Commercial flights	5,286	50%	6%
Seaplanes, small planes, helicopters	5,359	50%	6%
Total air travel	10,645	100%	12%



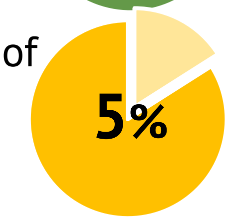
Input Parameter	Input	Source	Confidence
Commercial Flights			
Revenue passenger miles	40,586 passenger-miles	Bureau of Transportation Statistics T-100 Segment data, selecting for Sitka's airport and passenger-miles.	4
Emissions factor	0.130 $MTCO_2e$/passenger-mile	EPA Air Travel - Medium Haul Emissions Factor	3
Seaplanes, Small Planes, and Helicopters			
Total kerosene imported (2022)	657,784 gallons	USACE 2022 Cargo Report	2
Percent of imported kerosene used in seaplanes, small planes, and helicopters	80%	Assumption	1

Wastewater and Waste Emissions

Wastewater emissions come from methane and nitrous oxide released during anaerobic processes associated with treating wastewater.



Solid waste disposal emissions come from the decomposition of organic matter in landfills.



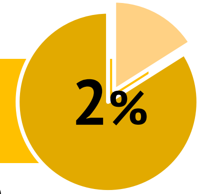
End Use	$MTCO_2e$	% of Waste and Wastewater Emissions	% of Total Emissions
Wastewater	9	<1%	<1%
Solid waste	4,418	99%	5%
Recycling	22	<1%	<1%
Total waste	4,449	100%	5%

Input Parameter	Input	Source	Confidence
Wastewater			
Sitka population	8,380 people		4
Tourist population equivalent	694 people	Cruise ship schedule	3
Emissions factor	0.009 grams/person/day	EPA Emissions Factor	4*
Waste^			
Solid waste shipped	7,618 short tons	Republic Services 2023 Summary	4
Mixed municipal solid waste emissions factor	0.58 $MTCO_2e$/short ton	EPA Emissions Factor	4
Recycling shipped	240 short tons	Republic Services 2023 Summary	4
Recycling emissions factor	0.09 $MTCO_2e$/short ton	EPA Recycling Emissions Factor	4

*Scientific understanding of emissions associated with wastewater treatment plants is evolving. Using this emissions factor is still considered best practice under federal greenhouse gas reporting guidelines.

^Transportation emissions for solid waste and recycling are included with shipping emissions.

Shipping Emissions

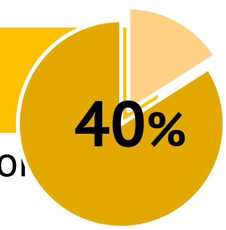


Shipping emissions come from the combustion of fuels used to transport goods and materials to and from Sitka.

End Use	Gallons of Diesel	$MTCO_2e$	% of Total Emissions
Shipping	181 kgal	1,854	2%

Input Parameter	Input	Source	Confidence
Shipping			
Tons of material shipped and received	117,658 short tons	USACE Cargo Report	4
Distance traveled	1,000 miles	Assumed, Seattle to Sitka, one-way	3
Ton-miles per gallon	650 miles/1 ton-1gal	Texas A&M Transportation, "A Model Comparison of Domestic Freight Transportation Effects on the General Public: 2001-2014". January 2017.	3
Diesel consumed for 1 ton shipped	1.54 gallons/ton		4

Cruise Ship Emissions



Cruise ship emissions come from the combustion of fuels used for cruise ships entering, docking, and leaving Sitka.

End Use	Gallons of Diesel	$MTCO_2e$	% of Total Emissions
Cruise ship	3,300 kgal	34,072	40%

Input Parameter	Input	Source	Confidence
Cruise ships			
Hotel load	29% of total installed power	Verified with local captain of cruise ship and boating community	3
Maneuver time (time to approach Sitka, tie and untie from dock, and leave Sitka. Starting count when line Biorka/Cape Edgecomb is crossed.	4 hrs	Data from historical AIS (Automatic Identification System) data, which track ships	3
Low speed and maneuvering load	25% of total installed power	Verified with local captain of cruise ship and boating community	3
Installed power of cruise ship	[Ranges based on ship]	Alaska cruise ship schedule and desk research.	4
Hours cruise ship in port	9 hrs (average)	Derived from cruise ship schedule	4

4	Confident in values, but values will need to be updated in future iterations of the inventory.
3	Additional, better, or more local data could improve estimate, but the overall impact would likely be small. Estimate is still technically justified with general understanding.
2	Additional local data could improve not only the estimate but also the method of calculation so the inventory is better able to account for efficiency improvements or other changes.
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