2022 Community Greenhouse Gas Emissions Inventory

Seattle

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Dear Friends and Partners,

As we evolve our work to meet the urgency of the climate crisis, I have deep appreciation for Seattle's history of innovation and collaboration between government, community, and private sectors. Our latest greenhouse gas emissions inventory for 2022 offers both a reflection of our progress and a clear-eyed view of the challenges ahead.

Seattle, like many cities across the country, conducts regular greenhouse gas emissions inventories to measure the scope and scale of our climate pollution and help identify where the opportunities are for the greatest future impact. While emissions rose modestly in 2022 compared to the pandemic-induced decrease in 2020, they remain below pre-pandemic levels. At the same time, Seattle's population grew 2% and our economy grew 22%.

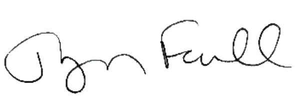
Seattle has long been a leader in climate action, but the climate crisis requires swift and aggressive action. We must continue to phase out fossil fuels from the buildings and transportation sectors while reconciling the inequitable impacts of climate change. We must prioritize low-income and communities of color, who bear the brunt of the harm from the climate crisis, by continuing to invest in green jobs, affordable clean energy, and healthier, more resilient neighborhoods.

Cities, counties, states, and regions have always been the engines of progress. Seattle and our neighbors are determined to meet this moment. Initiatives like our electrification of transportation, energy-efficient retrofitting of buildings and households for families at all income levels, and the expansion of urban green spaces show what's possible when we lead with purpose and collaboration.

Over the past few years, the City has implemented and expanded several significant policies and programs to reduce emissions from buildings, making their results not yet reflected in the 2022 GHG inventory. The Building Emission Performance Standards (BEPS) and the expanded residential and business Clean Heat Program are projected to reduce building emissions a combined 35% by 2050.

We're inspired by the steps we've taken under the One Seattle Climate Justice Agenda. With the continued support of community partners and the resilience of our residents, I'm confident we can forge a path to a more just, sustainable future.

Sincerely,



Jessyn Farrell, Director
Seattle Office of Sustainability & Environment

Introduction and Context

The Role of a Greenhouse Gas Inventory in Equity-Centered Climate Action

Tracking greenhouse gas (GHG) emissions across the buildings, transportation, industrial, and waste sectors helps the City develop effective programs and policies designed to reduce climate impacts. This GHG emissions inventory reports on the sources and magnitude of Seattle's core GHG emissions and provides short- and long-term trends so the City of Seattle and its residents are better able to take informed actions to combat the climate crisis.

Seattle's climate leadership has resulted in progressive energy efficiency policies and a robust public transit network which has in turn helped achieve one of the lowest per-capita emissions rates relative to North American peer cities. Our early climate investments started us off in the right direction to reduce emissions, however, as our population and economy continue to grow, we need a greater degree of reductions primarily from eliminating fossil fuel use through electrifying our buildings and vehicles to achieve our climate goals.

Centering Climate Justice

Climate change is a racial justice issue at its core. Seattle's increasing consumption of fossil gas harms our Black, Indigenous, and People of Color (BIPOC) communities who unequally bear the burden of climate change, air pollution, and environmental degradation. While this GHG inventory provides a broad understanding of how our emissions are trending, it is not detailed enough in scope or depth to use as the primary source for making decisions that center racial equity. To address this gap, the City developed the One Seattle Climate Portal in 2022 to house more frequent and granular indicators of emissions in our neighborhoods.

Research indicates that BIPOC communities in the U.S are more concerned than whites about climate change[1], yet historically, environmental decisions on policy, communications and programming have been made by those with race and class privilege. It is therefore imperative that we center this context and prioritize partnering with BIPOC communities to shape equitable climate policy for the City when analyzing the results of this inventory.

ICLEI and Scope of Emissions

The International Council for Local Environmental Initiatives (ICLEI) – Local Governments for Sustainability is an international organization of local and regional government organizations that have made a commitment to sustainable development. The ICLEI's USA program was founded in 1991 and created the Cities for Climate Protection, the world's first and largest program supporting cities in climate action planning to reduce GHG emissions measurably and systematically.[2] This GHG inventory follows the national standards set forth by ICLEI – Local Governments for Sustainability USA as outlined in their "U.S. Community Protocol for Accounting and Reporting of Greenhouse Gas Emissions", which outlines methodology for

[1] https://climatecommunication.yale.edu/publications/race-and-climate-change/
[2] http://icleiusa.org/about-us/who-we-are/

community-scale GHG emission inventories. These standards make it easier for the city to compare its emissions with other cities and past inventories.[3]

The emission sources covered in the "core emissions inventory" correspond to ICLEI's "local government significant influence" framework. The "expanded emissions inventory" correspond to ICLEI's "community-wide activities" framework and include GHG emissions released within community boundaries and due to community activities, such as energy consumption and waste disposal.

Core Emissions

Sector	Subsector(s)	Categories
Buildings	Residential	Heating Oil, Puget Sound Energy, Seattle City Light
	Commercial	CenTrio Steam, Heating Oil, Puget Sound Energy, Seattle City Light, UW Steam
Transportation	Road: Passenger	Buses, Cars, Light-Duty Trucks
	Road: Trucks	Medium- & Heavy-Duty Trucks
Waste	Residential, Commercial, Self-Haul	All waste materials
Offsets	Residential, Commercial	Seattle City Light

Table 1: 'Core Emissions' categories delineated by sector and subsector

Core emissions include the transportation, buildings, and waste sectors as well as GHG offsets. Core emissions sources are those the city can most directly and significantly impact. Most of the City's climate policies and programs are aimed at reducing our core emissions.

[3]ICLEI, Greenhouse Gas Protocols, *U.S. Community Protocol*. http://icleiusa.org/ghg-protocols/

Expanded Emissions

Sector	Subsector(s)	Categories
Buildings	Residential	Yard Equipment
	Commercial	Commercial Equipment
Industry	Energy Use	Industrial Equipment, Heating Oil, Puget Sound Energy, Seattle City Light, King County Wastewater Treatment
	Fugitive Gasses	Gas Infrastructure Leaks, (Sulfur Hexafluoride) SF6 from Switchgear
	Process	Cement, Glass, Steel
Transportation	Air	King County Airport (KCA), Sea-Tac Airport (SEA)
	Marine	Hotelling, Pleasure Craft, State Ferries, Other Boat Traffic
	Rail	Freight Rail, Passenger Rail
Waste	Construction & Demolition	All waste materials
	Wastewater	Fugitive Emissions
Sequestration	Commercial, Residential, Self-Haul	Waste materials with high carbon content[4]
Offsets	Industrial	Seattle City Light

Table 2: 'Expanded Emissions' categories delineated by sector and subsector

Expanded emissions include all core emission sectors as well as additional sectors, subsectors, and categories. The table below identifies the sectors, subsectors, and categories included under core emissions and additional ones included under expanded emissions.

Consumption-based Emissions

Consumption-based inventories account for the emissions associated with the goods and services consumed within the community, no matter where they are produced. This includes embodied emissions associated with production, transportation, use, and disposal of goods, food, and services consumed. Consumption-based emissions inventories help communities understand how consumption of goods and services by their community contributes as a root driver of GHG emissions on a global scale.

For example, while the core and expanded inventories capture the emissions generated by a car while it is being driven in Seattle, they do not capture the emissions generated elsewhere in sourcing the raw materials or assembling the vehicle in a factory. Such emissions likely occurred outside the U.S. or inside this country, but outside of Seattle.

[4] Specific high-carbon content materials such as wood scraps and lumber unfortunately still make it into our landfills. Their sequestration of carbon is represented as negative emissions in this category.

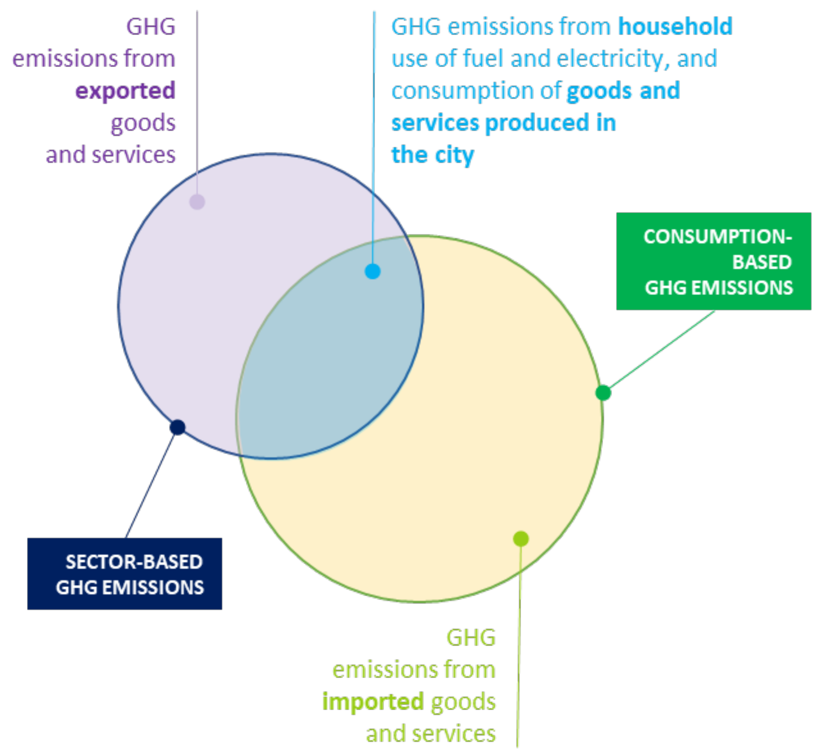


Figure 1: Comparison showing the scale of sector-based emissions versus consumption-based emissions..[5]

Figure 1 compares the scope of sector-based, or geographic, and the consumption-based GHG inventories. Consumption-based emissions can be over twice as much as the geographic-based emissions that this report covers.

In 2022 Seattle partnered with King County on the County's consumption-based emissions inventory (CBEI) analysis update for calendar year 2019, which estimates the greenhouse gas (GHG) emissions associated with all the goods and services consumed within the community, no matter where they are produced (including the extraction of raw materials, manufacturing, and global transportation). This inventory looks at all of the emissions associated with the food we eat, the things we buy, how we travel, and the homes we live in. The CBEI analysis – also available on Seattle's inventory page – shows that in 2019, the typical Seattle household was responsible for roughly 33 metric tons of carbon dioxide equivalent annually (mtCO_2e), or about 16 mtCO_2e per person. For context, 33 mtCO_2e is equivalent to 7 gasoline-powered passenger vehicles driven for one year. With 343,988 households in the city, this is a total of roughly 11 million mtCO_2e in 2019 attributable to residents of Seattle.

[5] C40 Cities Report: Consumption-Based GHG Emissions of C40 Cities. Page 8.

To advance Seattle's vision of zero waste[6], we support and promote policies and practices that create a circular economy and reduce Seattle waste and carbon pollution as rapidly as possible (e.g., food waste prevention and food rescue, building deconstruction and building materials salvage, promotion of reuse and repair). That's why Seattle is increasingly focusing on waste prevention strategies and metrics in solid waste programs and policies. To prevent waste, which is proven to lead to best results in terms of reducing pollution and resource use, Seattle is looking "upstream" at how products and packaging are made for opportunities to prevent or reduce waste from the start. The consumption-based emissions inventory could potentially provide a baseline for measuring the impacts of waste prevention efforts and information about how to reduce our consumption-related climate impacts.

What is a circular economy?

A circular economy aims to ensure that materials and products keep cycling through new uses and seeks to stop waste from being produced in the first place. The circular economy includes actions such as buying and using less, making and buying products that last longer, designing products and systems for reuse and remanufacture, repair, sharing, donating, or re-selling items so others can use them.

Data Source Considerations

The data collected and analyzed to create this inventory consists of varying levels of accuracy and granularity. Some data sources, like building energy use, provide a much more accurate measure of emissions since they rely on measured data. Other sources, like roadway vehicle miles traveled (VMT), rely on modeled data to estimate the resulting emissions, which requires back- and forecasting to derive emission estimates for non-model years. Ideally, all emissions sources would be measured values, but this is not always possible with some emission categories.

Further, methodologies for existing sources can change over time, resulting in material changes to emissions. For example, emissions from road transportation in this inventory for *all years* are significantly lower than what was reported in prior inventories because of a calculation that was overrepresenting Seattle's share of VMT from a regional model. For these reasons it is also prudent not to compare data from one year's report to a prior year's report; it is best to use the most recent report even for prior years' data since this is always the most up to date.

As we evaluate emissions trends with an eye towards future policy development, it is important to keep in mind the certainty – or uncertainty – of individual data elements. Additionally, it is important to continuously evaluate methodology and data sources to increase the certainty and granularity of the report over time.

[6] https://www.seattle.gov/utilities/about/plans/solid-waste/zero-waste

Table 3: 'Core Emissions' Level of Granularity and Certainty

Sector	Category	Data source(s)	Level of certainty	Level of granularity
Core Emissions				
Buildings	**Electricity and Fossil Gas**	Building energy use from City Light and PSE	**High** – exactly what buildings consume, so we are certain about their corresponding emissions	**High** – annual data rolled up by sector (commercial, residential) by Census tract
	Steam	Fuel use from CenTrio and the University of Washington	**High** – exactly what buildings consume, so we are certain about their corresponding emissions	**Low** – annual data, not temporal or spatial
	Heating Oil	EIA and Census data	**Low** – estimates based on regional and national data, and not actual consumption data	**Low** – annual data, not temporal or spatial
Transportation	**Cars and Trucks**	PSRC's SoundCast 2018 model for vehicle miles traveled (VMT) & estimated emissions	**Low**/**Med** – 2018 modeled data forecasted and back-casted to all inventory years using WSDOT regional urban and rural interstate VMT	**High** – data sorted by Census tracts by passenger vehicles and medium/heavy duty trucks
Waste	**Waste**	SPU waste reports on tonnage and waste composition by sector	**Med**/**High** – measured information direct from SPU samples and surveys.	**High** – over 40 different waste stream types, but not spatial or temporal

Table 4: 'Expanded Emissions' Level of Granularity and Certainty

Sector	Emissions Category	Data source(s)	Level of certainty	Level of granularity
Expanded Emissions				
Industry	**Steel, cement, and glass production**	EPA's large emitters database (self-reported)	Med – self-reported emissions, but measurements during testing period are not always indicative of annual operations	Med/High – annual data for each large emitter, but not temporal
	Electricity and Fossil Gas	Building energy use from utilities (Seattle City Light and Puget Sound Energy)	High – exactly what buildings consume, so we are certain about their corresponding emissions	High – annual data rolled up by sector (commercial, residential) by Census tract
Transportation	**Air**	Fuel consumption at airports scaled by population	Low – scaling jet fuel consumption by population of Seattle vs. larger region results in a crude estimate	Low – annual fuel consumption in gallons, with no additional detail
	Marine	Combination of NONROAD model, Puget Sound Maritime Inventory	Very Low – data from Washington State Ferries is accurate since it is based on fuel usage. Other sources such as NONROAD data is modeled after EPA MOVES 2014, rather than the more up-to-date EPA MOVES3.	Med – some granularity with types of marine traffic (pleasure craft, ferries etc.)
	Rail	Gallons of fuel, ridership miles from Amtrak, Sound Transit	Med – amount of fuel used per gallon is estimated for Amtrak but reported for Sound Transit.	Med – annual data, not temporal
Building	**Non-road equipment**	NONROAD modeled data, updated in 2014.	Low – older modeled data, not measured consumption. Relies on scaling by population	Med – some granularity with motor and fuel types.

Seattle's Climate Goals

Seattle remains committed to the emissions reduction targets established through a Council Resolution in 2011, which aims to achieve a 58% emissions reduction by 2030 and net zero carbon by 2050. Seattle's Climate Action Plan in 2013, along with a 2018 Climate Action Strategy, identify focused actions that would reduce emissions on transportation and building sectors. Seattle has further cemented its leadership as a city that centers equity in climate progress through Seattle's Green New Deal and directs a portion of JumpStart Payroll Tax Revenue to support policies and programs that create clean energy jobs and advance an equitable transition from fossil fuels.

Over the past few years, Seattle has worked to advance the directives issued in the Green New Deal Executive Order (EO-2020-01), which calls for all City departments to work together with the Green New Deal Oversight Board (Oversight Board) to advance the goals set forth by the Green New Deal Resolution and Ordinance. In 2021, the City released a Climate Impact Actions report to identify the top ten actions Seattle could take in order to achieve expeditious reductions in emissions. Recommended actions fall under three broad categories: building a framework to center community needs; reducing emissions from the transportation sector; and reducing emissions from buildings. The Oversight Board has made budget recommendations to the Mayor's Proposed Budgets for 2022- 2023, 2024, and 2025-2026 to shape the direction of Seattle's climate justice work.

Seattle stays committed to accelerating and deepening climate investments and changing how we design and implement policies to meet the scale of the climate crisis. In 2022, Mayor Bruce Harrell put forth the One Seattle Climate Justice Agenda framework, which prioritizes targeted investments and community-driven policies that support building a green economy, ensuring a just transition from fossil fuels, and building community health and climate resilience.

Post-Pandemic Return to a New Normal

Seattle's prior emissions inventory reflected the realities of a city grappling with the first year of the COVID-19 pandemic. The unprecedented nature of change that the pandemic brought through its stay-at-home orders and business closures lead to the single largest decrease in emissions recorded since the baseline year of 2008. That decrease would prove to be temporary as 2022 emissions numbers have rebounded to near pre-pandemic levels. As more Seattle residents returned to work, VMT began to tick back up, and data sources indicate that this upward trend is set to continue for 2023 as well. Building energy use also increased as businesses started to open back up and tourists returned to the region. Both VMT and commercial building energy use will likely continue to trend upwards with Seattle's largest employers ramping up a return to office for their workers.

Core Emissions Changes from 2020 - 2022: Key Findings

Summary

In 2022, emissions across Seattle's three core sectors rose by around 4% after a pandemic-induced dip in 2020, although they haven't returned to pre-pandemic levels. 2022 emissions are 11.8% lower than the baseline year of 2008, with population increasing 26% during the same period. The City needs a further 46.2% of reductions in the next eight years – roughly 5.75% annually – to hit its 2030 interim target of a 58% reduction in core emissions.

Buildings Sector (6% increase)

Emissions from commercial and residential buildings account for around a third of Seattle's core emissions. Virtually all emissions in our buildings come from burning fossil gas. In 2022 these sources accounted for around 1.1 million mtCO_2e, which was about 5% higher than 2020 and around 7% lower than 2008. The primary driver for the increase from 2020 to 2022 was because of a 6% increase in commercial and residential fossil gas use. It is difficult to say what the cause for this increase was with a high degree of certainty. The exact cause of this rise is uncertain, but several factors likely played a role. Seattle experienced 15% hotter summers and 13% colder winters compared to 2020, increasing energy demand for heating and cooling. Additionally, efforts to improve ventilation may have heightened HVAC energy use. However, these increases were likely offset to some extent by low occupancy rates in commercial buildings and hotels, though these are now trending upward. This variability makes it difficult to predict which direction building sector emissions will trend in the future.

The emission calculations for the buildings sector rely on actual measured electricity and fossil gas usage reported by City Light and PSE, resulting in a high level of certainty.

Transportation Sector (4% increase)

Emissions from light vehicles, medium and heavy trucks have typically accounted for around 60% of Seattle's core emissions. In 2022 these sources emitted around 1.7 million mtCO_2e, which was just under 4% higher than 2020 and about 14% lower than our baseline year of 2008. The primary driver for the 4% increase from 2020 is due to vehicle miles traveled (VMT) increasing by 8.8%. This increase was expected from 2020 to 2022 and tracks with an increase in economic activity, workers returning to the office, and increased tourist activity. Vehicles on the road have also increased their fuel efficiency on average; in addition to 3.4% of VMT in King County being taken in EVs[7], BEV registrations have nearly doubled in the county from 2020 to 2022[8]. These factors are likely to have contributed towards mitigating the emissions increase and will prove to be crucial for future years; data from 2023 is already indicating a further 5% annual increase in VMT. Transit ridership has also been gradually increasing since the low-point of the pandemic.

[7] https://www.replicahq.com/?popup_name=Mapping+EV+VMT+by+county

[8] https://wsdot.wa.gov/about/data/gray-notebook/gnbhome/environment/electricvehicles/electricvehicles.htm

Passenger and truck calculations are based on VMT data modeled by Puget Sound Regional Council (PSRC) for the whole region, prior to scaling to model Seattle VMT. However, there is uncertainty with these values as the underlying model uses a base year of 2018 which is then scaled to inventory years using a ratio of regional VMT from urban highways in the inventory year relative to 2018. This may cause the data to not fully account for interurban travel levels as it is based on highway VMT and not local VMT on Seattle roadways.

Waste Sector (7% increase)

Emissions from landfilled waste account for around 2% of Seattle's 2022 core emissions, with the primary source of emissions being material that should have been recycled or composted rather than disposed in the garbage. In 2022, landfilled recyclable and compostable materials contributed to around 69,00 mtCO2e in emissions, which was almost 7% higher than 2020 but 31% lower than 2008. The primary driver of the emissions increase since 2020 was a 41% increase in emissions from self-hauled waste, which is believed to be due to increased disposal of high landfill methane-producing materials, such as paper, food, and yard waste. Although disposed tonnage from the commercial sector returned to near pre-pandemic levels in 2022 after hitting a low in 2020, emissions from the commercial sector stayed roughly steady due to relatively lower levels of food waste in the commercial garbage stream.

Emissions Overview

Core GHG Emissions

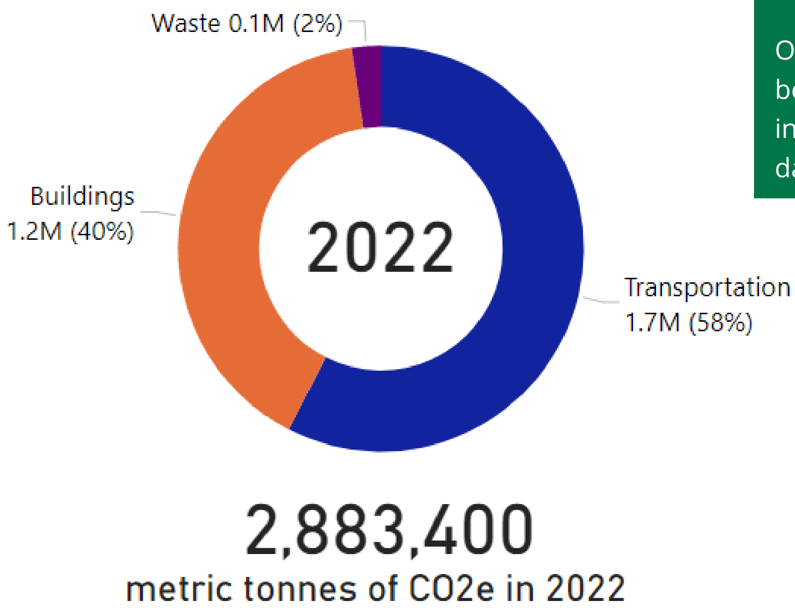


Figure 2: Seattle's core GHG emissions by sector in 2022.

Online Data Dashboard

Our GHG Inventory webpage has been updated for 2022 with interactive dashboards to view the data. Explore the data online here.

Figure 2 above depicts the relative contribution of the transportation, buildings, and waste sectors to city-wide emissions in the year 2022. In the transportation sector, passenger vehicles and commercial trucks contribute to the city's core GHG emissions. Passenger vehicles include single- and high-occupancy vehicles, motorcycles, light trucks, and buses. Commercial trucks include light-, medium-, and heavy-duty commercial trucks. In the building sector, emissions are tracked for residential and commercial buildings. Residential buildings include single- and multi-family residential units (excluding common spaces such as lobbies, hallways etc.). Commercial buildings include small, medium, and large businesses. Waste sector emissions primarily cover emissions from organics disposed in landfills.

In 2022, these three sectors contributed around 2.9 million mtCO_2e, which is about 4.6% higher than 2020 emissions. The transportation sector accounted for 58% of all core emissions, continuing to be the largest source of core sector emissions in Seattle. This still constitutes a drop in relative contribution from previous years (roughly 62% for inventory years between 2005 and 2018). COVID-19 decreased travel, and subsequently emissions, across all subsectors in 2020, and while these numbers have risen in 2022 they haven't returned to pre-pandemic levels. Therefore, the share of emissions from building sources in 2022 have risen to 40% of all core emissions from 36% in 2018, primarily due to a corresponding decrease in transportation sector emissions.

Table 5: Seattle's core emissions by category in 2022, the prior inventory year (2020), and baseline year (2008).

Core GHG Emissions Summary Table

Category (mt CO2e)	2008	2020	2022	% change from 2008	% change from 2020
Buildings	**1,274,000**	**1,130,000**	**1,197,000**	**-6.1%**	**5.9%**
Commercial	**685,000**	**620,000**	**670,000**	**-2.1%**	**8.2%**
CenTrio Steam	92,000	63,000	69,000	-24.6%	9.0%
Heating Oil	8,000	1,000	1,000	-92.0%	-45.7%
PSE	413,000	433,000	464,000	12.2%	7.1%
Seattle City Light	87,000	40,000	51,000	-41.2%	29.2%
UW Steam	85,000	82,000	86,000	0.8%	4.2%
Residential	**589,000**	**510,000**	**526,000**	**-10.7%**	**3.1%**
Heating Oil	109,000	61,000	48,000	-55.6%	-20.6%
PSE	432,000	425,000	446,000	3.3%	4.8%
Seattle City Light	49,000	24,000	32,000	-34.2%	33.0%
Offsets	**(149,000)**	**(77,000)**	**(97,000)**	**-34.8%**	**26.4%**
Transportation	**2,003,000**	**1,654,000**	**1,715,000**	**-14.4%**	**3.7%**
Road: Passenger	**1,734,000**	**1,412,000**	**1,460,000**	**-15.8%**	**3.4%**
Buses	61,000	52,000	45,000	-25.2%	-12.4%
Cars & Light Duty Trucks	1,673,000	1,360,000	1,415,000	-15.4%	4.0%
Road: Trucks	**269,000**	**242,000**	**255,000**	**-5.4%**	**5.3%**
Medium & Heavy Duty	269,000	242,000	255,000	-5.4%	5.3%
Waste	**101,225**	**65,276**	**69,812**	**-31.0%**	**6.9%**
Commercial	**52,629**	**27,978**	**27,885**	**-47.0%**	**-0.3%**
Residential	**38,671**	**29,947**	**31,561**	**-18.4%**	**5.4%**
Selfhaul	**9,926**	**7,351**	**10,366**	**4.4%**	**41.0%**
Total (mtCO2e)	**3,229,225**	**2,772,276**	**2,884,812**	**-10.7%**	**4.0%**
Population	**593,588**	**735,157**	**749,256**	**26.2%**	**1.9%**
Per Capita Emissions (mtCO2e/person)	**5.44**	**3.77**	**3.85**	**-30.7%**	**2.1%**

A summary of core GHG emissions for 2008, 2020, and 2022 is outlined in **Table 5** above. The rounded emissions values are reported for all core sectors and subsectors. All values are rounded to the nearest thousand metric tonnes (mt) of CO_2e, except for the waste sector as these estimates frequently total less than a thousand $mtCO_2e$. A per-capita emissions value is provided to normalize the data.

Expanded GHG Emissions

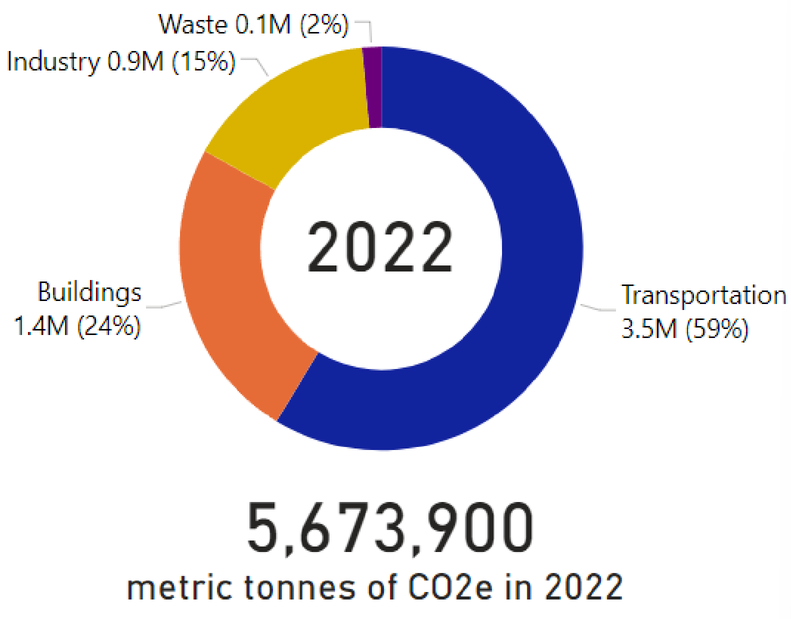


Figure 3: Seattle's expanded GHG emissions by sector in 2020.

A majority of Seattle's expanded GHG emissions stem from the transportation and industry sectors, which includes freight transportation and air travel. In 2022, the transportation sector accounted for 59% of the expanded GHG emissions in Seattle, while 24% stemmed from the buildings sector, 15% from the industry sector, and 2% from the waste sector.[9] Emissions from road transportation (1.7 million mtCO_2e), air travel (1.5 million mtCO_2e), and industry (1 million mtCO_2e) are the three highest contributors to expanded GHG emissions. Emissions from air travel experienced a 50% increase from 2020 numbers.

A summary of expanded GHG emissions for 2008, 2020, and 2022 is outlined in **Table 6** below. The rounded emissions values are reported for all core and expanded sectors and subsectors. All values are rounded to the nearest thousand mtCO_2e, expect for the waste sector as these estimates frequently total less than a thousand mtCO_2e. A per-capita emissions value is provided to normalize the data.

[9] It is important to note that our this geographic-based emissions inventory only measures lifetime emissions that would be emitted by waste disposed during 2022. Consumption-based emission inventories more accurately account for the impacts of purchasing of goods and services by measuring the embodied emissions associated with production, transportation, use, and disposal of goods, food, and services consumed.

Table 6:Seattle's expanded emissions by category in 2022, the prior inventory year (2020), and baseline year (2008).

Expanded GHG Emissions Summary Table					
Category (mt CO2e)	2008	2020	2022	% change from 2008	% change from 2020
Buildings	1,432,000	1,347,000	1,441,000	0.7%	7.0%
Commercial	825,000	817,000	895,000	8.5%	9.6%
CenTrio Steam	92,000	63,000	69,000	-24.6%	9.0%
Equipment	140,000	197,000	225,000	60.5%	14.0%
Heating Oil	8,000	1,000	1,000	-92.0%	-45.7%
PSE	413,000	433,000	464,000	12.2%	7.1%
Seattle City Light	87,000	40,000	51,000	-41.2%	29.2%
UW Steam	85,000	82,000	86,000	0.8%	4.2%
Residential	607,000	530,000	546,000	-10.0%	3.1%
Heating Oil	109,000	61,000	48,000	-55.6%	-20.6%
PSE	432,000	425,000	446,000	3.3%	4.8%
Seattle City Light	49,000	24,000	32,000	-34.2%	33.0%
Yard Equipment	17,000	20,000	20,000	15.2%	1.9%
Industry	1,357,000	963,000	912,000	-32.8%	-5.2%
Energy Use	511,000	507,000	517,000	1.1%	1.8%
Equipment	214,000	211,000	232,000	8.5%	9.8%
Heating Oil	36,000	18,000	11,000	-69.9%	-39.4%
PSE	246,000	271,000	265,000	7.9%	-2.1%
Seattle City Light	15,000	7,000	9,000	-43.8%	19.4%
Fugitive Gases	24,000	21,000	25,000	6.7%	21.4%
Process	822,000	434,000	370,000	-55.0%	-14.7%
Offsets	(164,000)	(84,000)	(106,000)	-35.6%	25.8%
Sequestration	(187,000)	(173,000)	(140,000)	-25.3%	-19.3%
Transportation	3,532,000	2,861,000	3,475,000	-1.6%	21.5%
Air	1,302,000	1,000,000	1,535,000	17.9%	53.5%
Marine	179,000	180,000	196,000	9.4%	9.1%
Rail	48,000	27,000	29,000	-39.3%	7.3%
Road: Passenger	1,734,000	1,412,000	1,460,000	-15.8%	3.4%
Road: Trucks	269,000	242,000	255,000	-5.4%	5.3%
Waste	128,900	89,200	92,100	-28.5%	3.3%
Commercial	52,600	28,000	27,900	-47.0%	-0.3%
Construction & Demolition	12,900	8,400	4,100	-68.1%	-50.9%
Residential	38,700	29,900	31,600	-18.4%	5.4%
Selfhaul	9,900	7,400	10,400	4.4%	41.0%
Wastewater	14,700	15,500	18,200	23.6%	17.2%
Total (mtCO2e)	6,098,900	5,003,200	5,674,100	-6.9%	13.4%
Population	593,588	735,157	749,256	26.2%	1.9%
Per Capita Emissions (mtCO2e/person)	10.27	6.80	7.57	-26.3%	11.3%

GDP, Population, and Emissions

Since 2008, Seattle's gross domestic product (GDP) and population have grown dramatically in unison with one another, as is seen in **Figure 4.** 2022 in particular saw a steep increase in the City's GDP – almost 84% over 2008 – while population grew more modestly to 26% over 2008 levels.

Core emissions have consistently stayed below 2008's baseline levels through 2022. 2020 showed the largest decrease in emissions relative to the 2008 base year due to the pandemic, but some of those reductions have been reversed in 2022.

Expanded GHG emissions decreased inversely with GDP and population growth prior to 2012; however, since the economic boom in 2012, expanded GHG emissions steadily increased along with GDP and economic growth. 2018 expanded GHG emissions were 0.2% greater than 2008 GHG emission levels, but since then expanded emissions have continued to trend below 2008 levels.

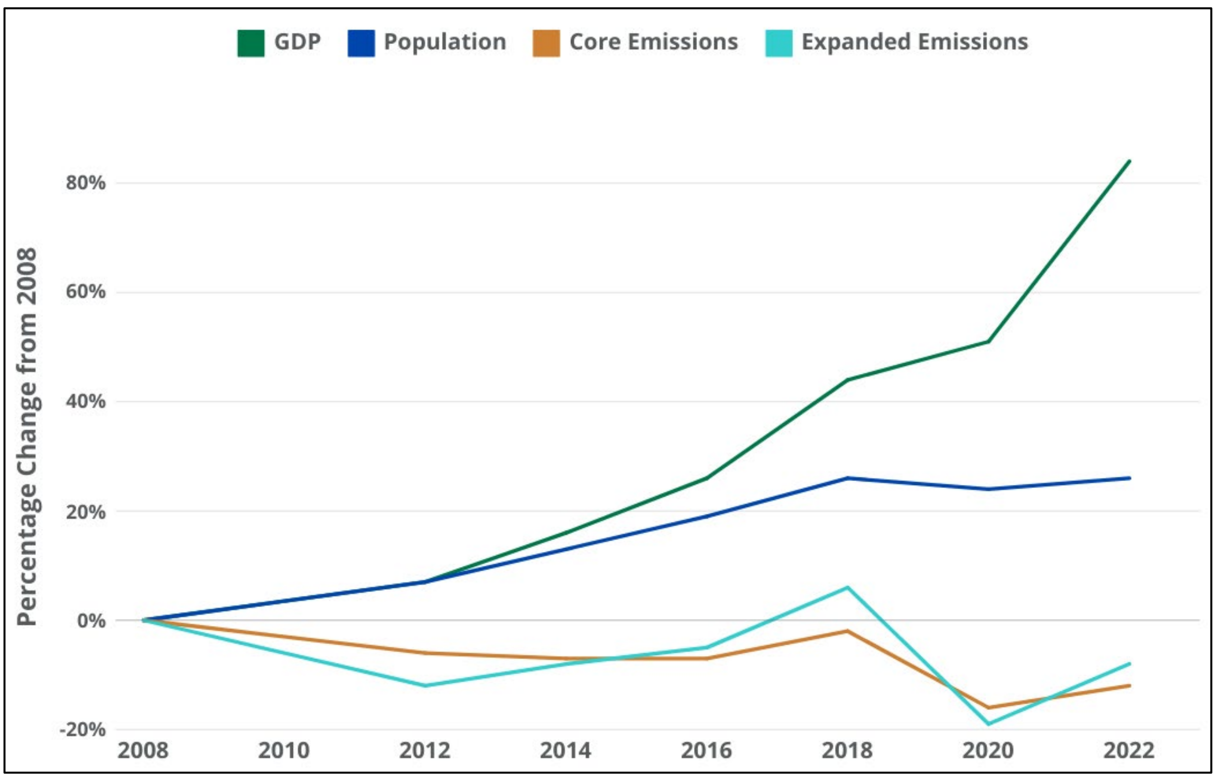


Figure 4: Percent difference from 2008 for GDP, population, and emissions in Seattle from 2008 to 2022.

Detailed Emissions

Transportation Emissions

In the transportation sector, core emissions decreased around 14..4% since 2008 – from 2 million mtCO_2e in 2008 to 1.71 million mtCO_2e in 2022 (**Figure 5**). Road transportation has been the largest contributor of emissions since Seattle started tracking emissions in 1990. Total emissions in this sector increased through 2008; however, they have been decreasing since 2008 due to improvements in vehicle fuel economy and changes in VMT. 2020 Saw a steep decline in emissions from road transportation due to pandemic-induced lockdowns, but VMT and their consequent emissions have rebounded in 2022 from 2020 levels.

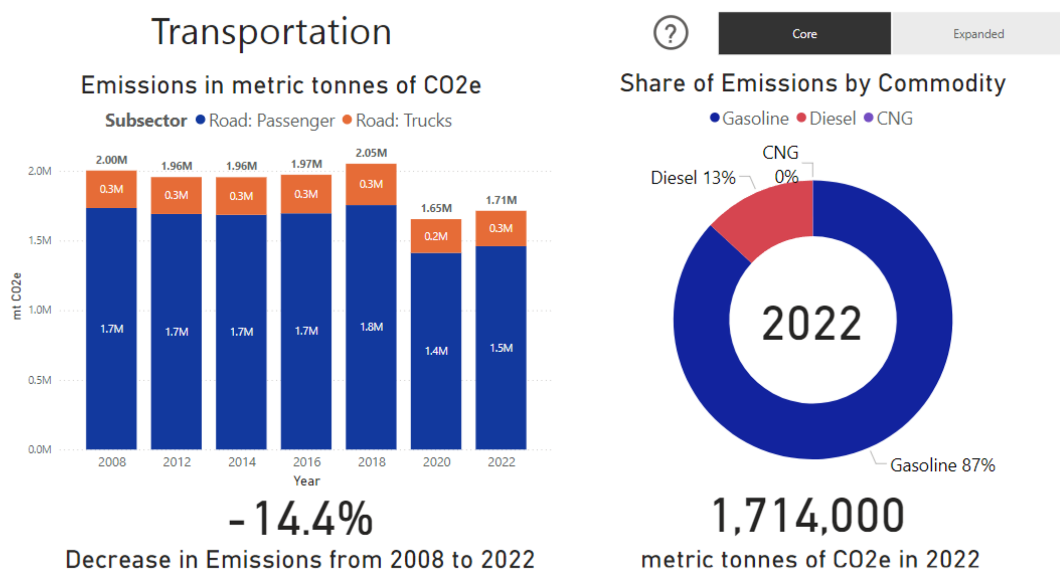


Figure 5: Core transportation emissions by subsector and commodity.

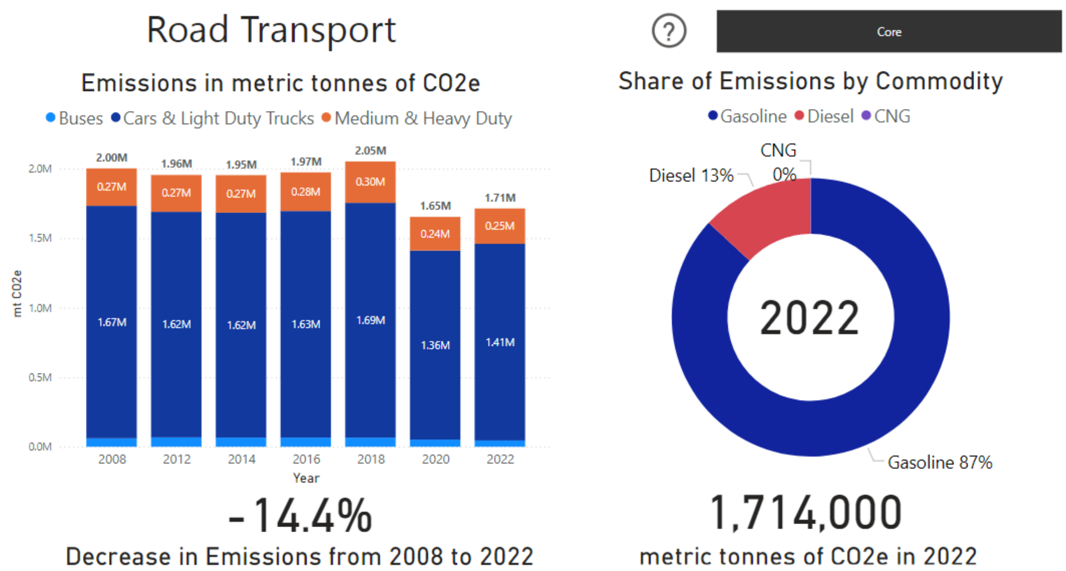


Figure 6: Core Road transportation emissions by category and commodity.

It is important to note that the methodology for calculating road transportation emissions is based on modeled data (See **Appendix D1: Road Transportation**), which carries a higher level of uncertainty compared to emissions from the building sector that are based on measured energy consumption. Additionally, emissions from road transportation in this inventory for *all years* are significantly lower than what was reported in prior inventories because of a calculation that was overrepresenting Seattle's share of VMT from a regional model.

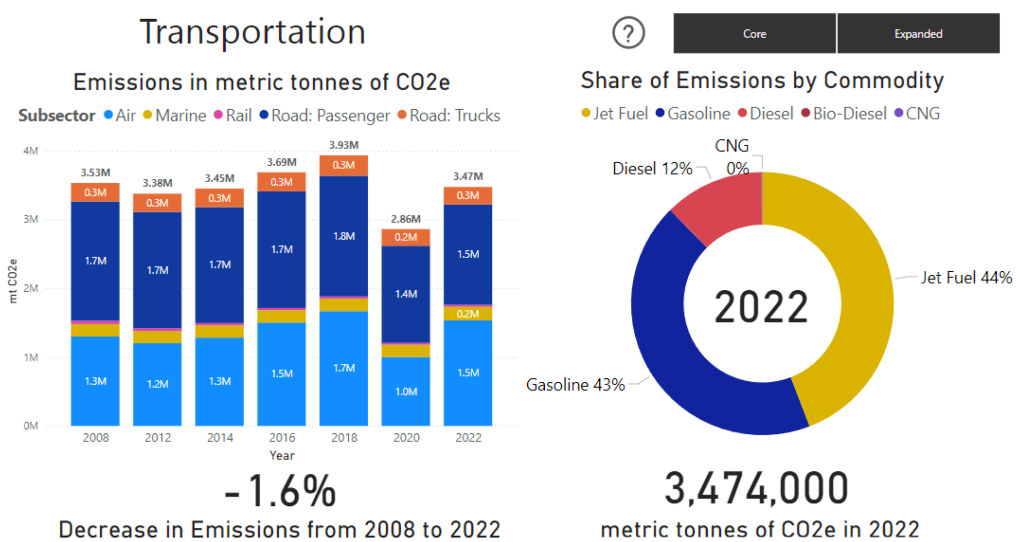


Figure 7: Expanded transportation emissions by category and commodity.

As seen in **Figure 7**, expanded transportation GHG emissions are just 1.6% lower than 2008 levels. The increase in expanded transportation emissions can primarily be attributed to a 50%

increase in air travel from 2020 to 2022. Emissions increases from marine and rail – both around 10% – were modest in comparison.

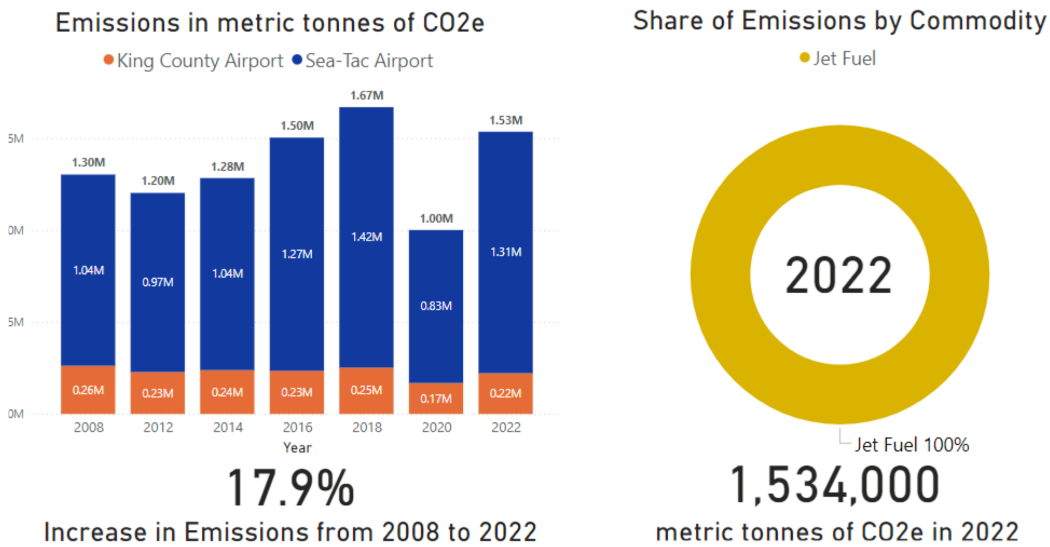


Figure 8: Expanded air transportation emissions by airport and commodity.

Figure 8 displays air transportation emissions having increased by almost 18% - from 1.3 million mtCO_2e in 2008 to 1.5 million mtCO_2e in 2022. While this figure is still below the 1.67 million mtCO_2e recorded in 2018, it surpasses the 1 million mtCO_2e reported in 2020 and remains higher than 2016 levels, suggesting a trend that could see emissions returning to or exceeding pre-pandemic levels.

Building Emissions

In the building sector, core GHG emissions have decreased by 6.1% since 2008 – from 1.27 million mtCO_2e to 1.19 million mtCO_2e in 2022, as seen in **Figure 9**.

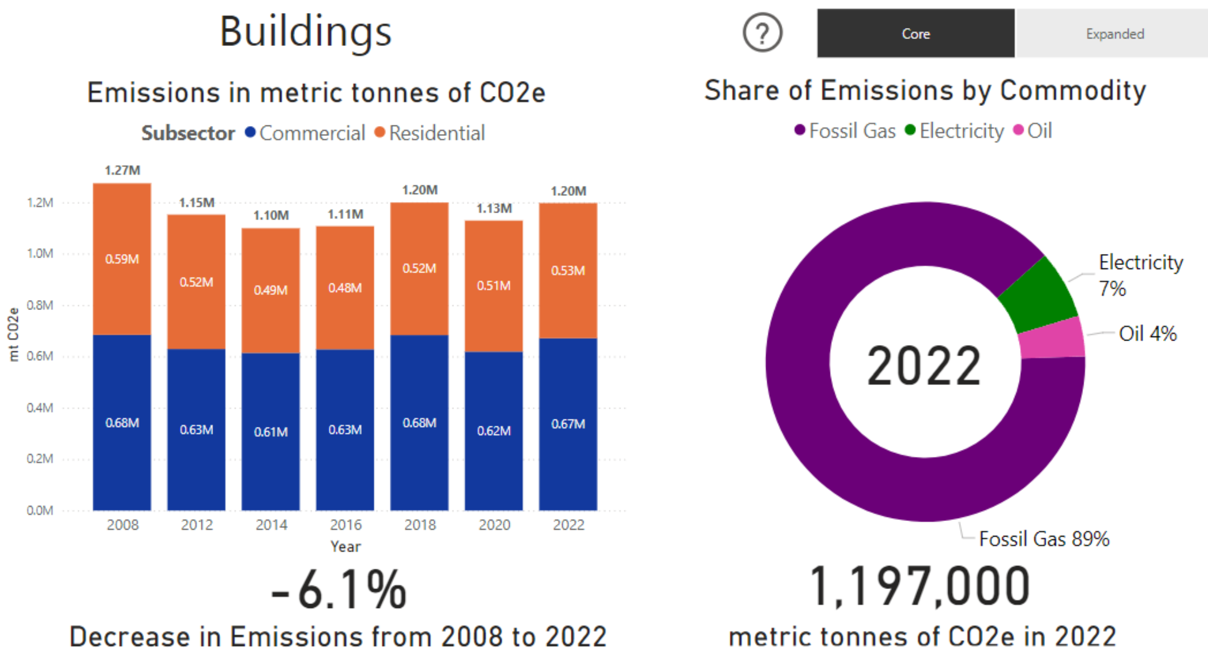


Figure 9: Core buildings emissions by subsector and commodity.

Expanded building sector emissions have increased by just under 1% since 2008 – from 1.43 million mtCO_2e in 2008 to 1.44 million mtCO_2e in 2022 per **Figure 10**.

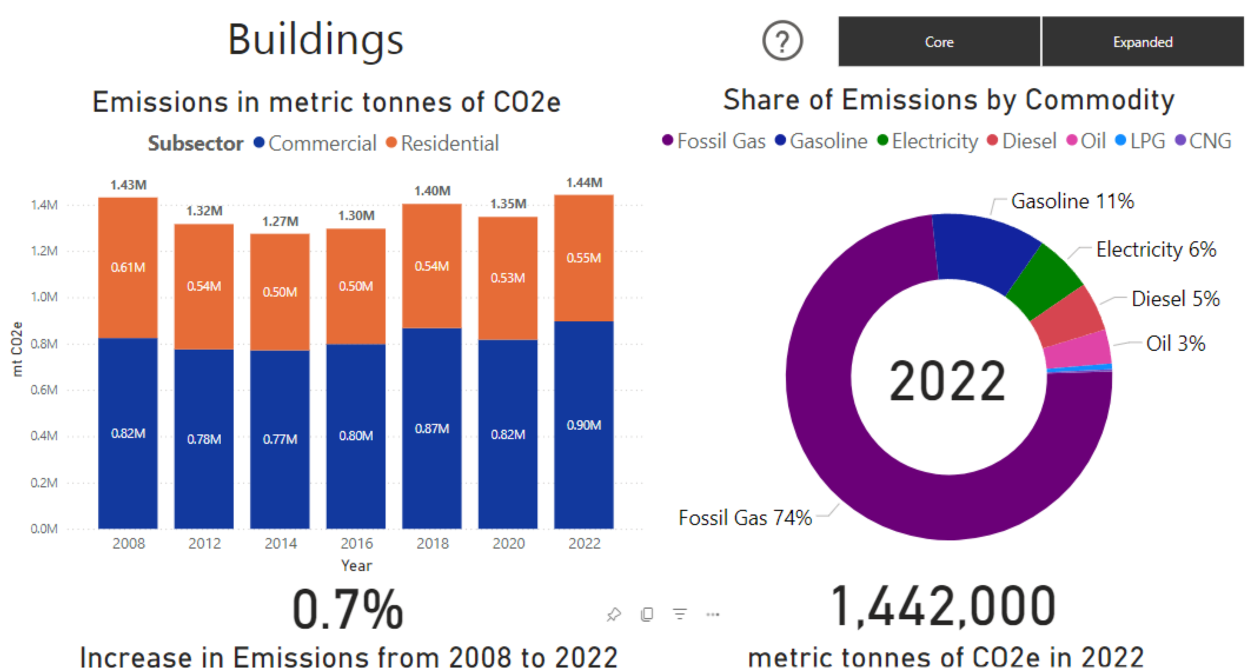


Figure 10: Expanded buildings emissions by subsector and commodity.

About 90% of the electricity that City Light provides to consumers in Seattle comes from low-carbon hydroelectric dams. City Light purchases high-quality carbon offsets equal to the greenhouse gas emissions resulting from all aspects of City Light's operations, including those created by fossil fuels included in the mix of power the utility buys, employees' travel, and the trucks and other equipment used in its operations. Because of variation in hydroelectricity production from year to year, City Light's external power purchases and the consequent amount of emissions from electricity and carbon offsets purchases varies annually. Therefore, there are significant annual fluctuations in the pre-offset emissions attributable to our electricity use, even if electricity consumption is trending down.

In 2022, electricity, while continuing to be the largest source of *energy* for Seattle's buildings (55%), is responsible for only 7% of *emissions* in this sector, before offsets. **Figure 11** compares the difference between energy usage and emissions between electricity, fossil gas, and oil to highlight the key advantage of electricity as an energy source.

While fossil gas and oil are currently responsible for 89% and 4% respectively of building emissions, they only account for 45% of the total energy consumed. Commercial GHG emissions from fossil gas increased by 6.9% between 2020 and 2022. Over the same period, residential GHG emissions from fossil gas increased by about 4.8%. There are various factors that could have contributed to fluctuations in energy use in 2022. This inventory year experienced 15% more cooling degree-days and 13% more heating degree-days compared to 2020. Additionally, as the City recovered from a pandemic, rebounding commercial and hotel occupancies coupled with increased ventilation requirements could have driven up energy consumption in 2022.

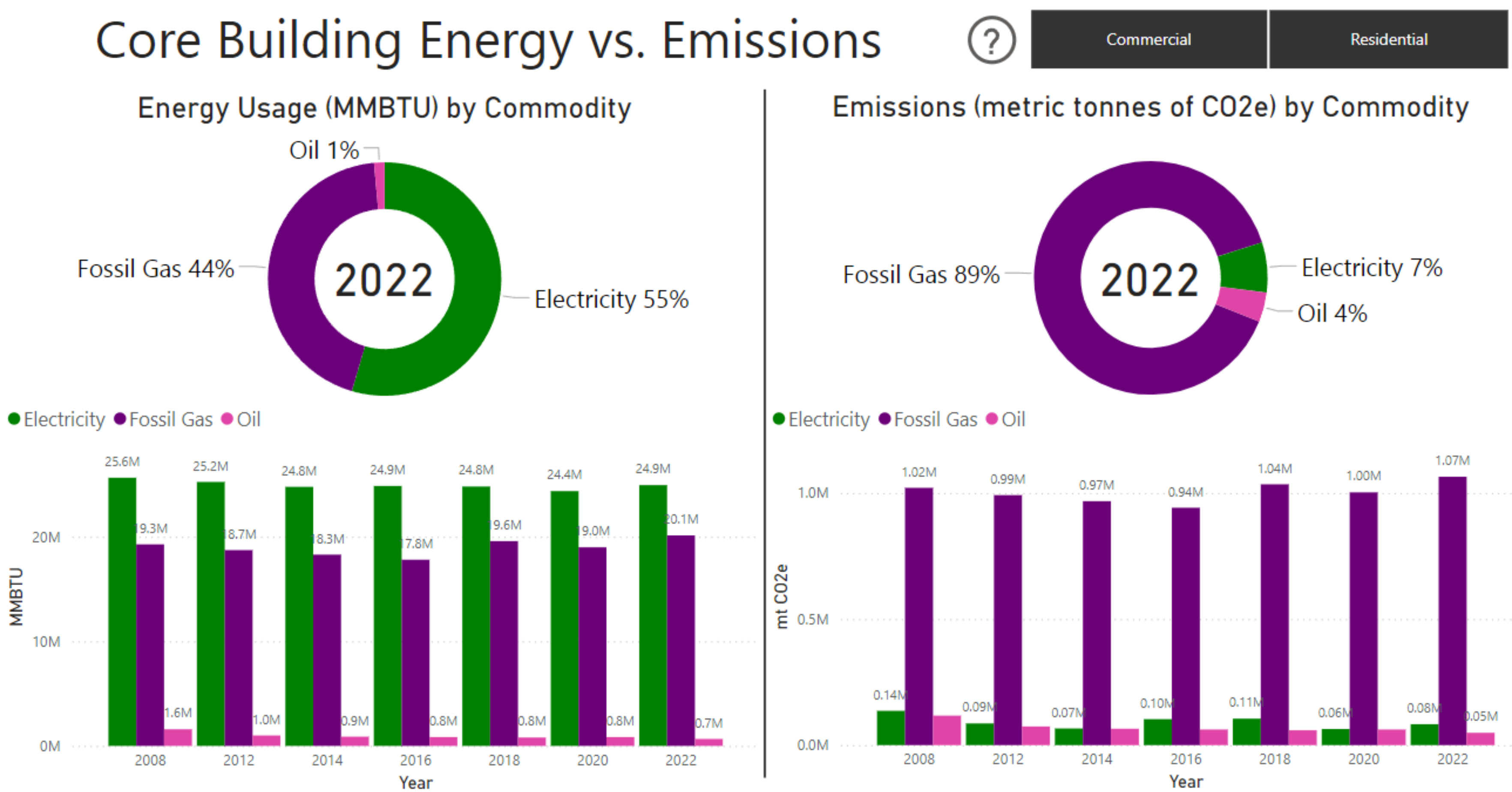


Figure 11: Core Buildings: Energy vs Emissions from Fuel Source

Residential Building Emissions

See **Appendix D5: Residential Building Energy** for more information on methodology for the Residential Building Sector.

See **Appendix D7: Residential & Commercial Building Equipment** for more information on methodology for estimating emissions from equipment for the Residential Building Sector.

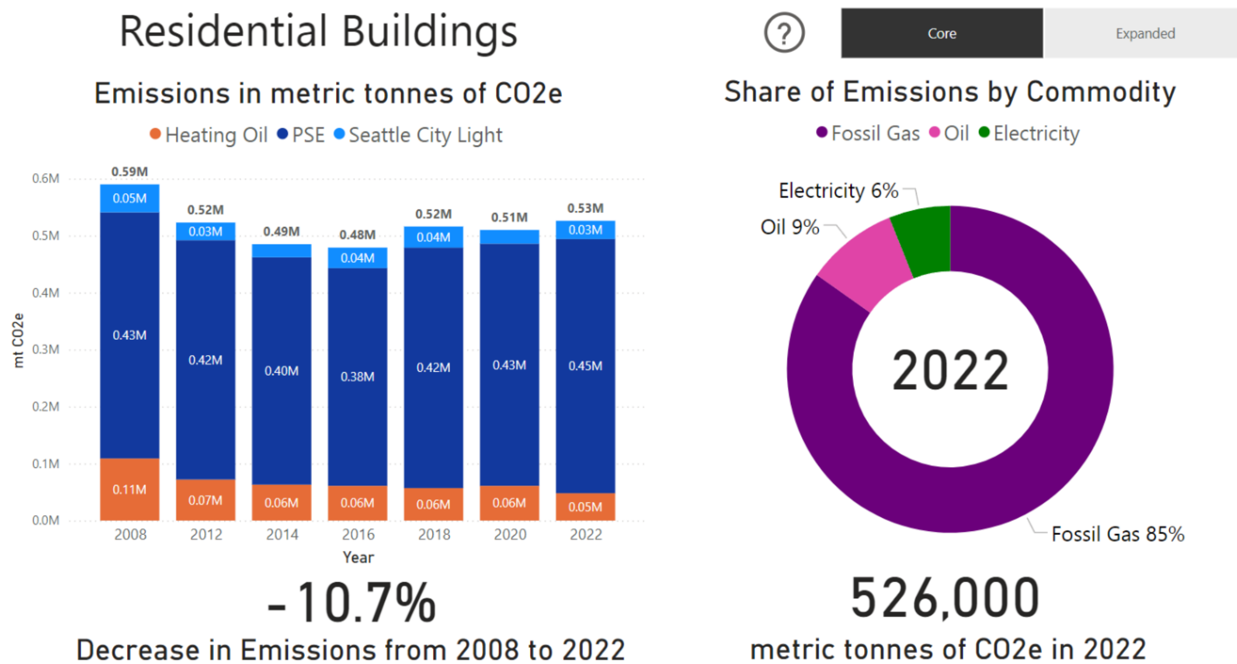


Figure 12: Core residential building emissions by source and commodity.

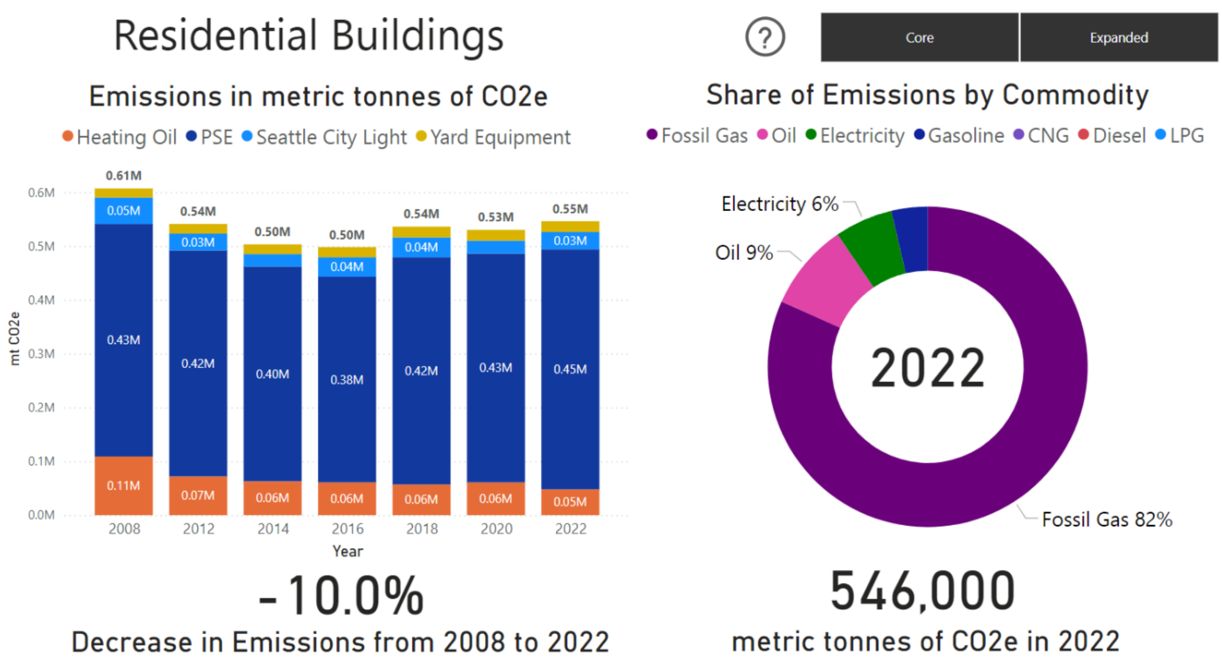


Figure 13: Expanded residential building emissions by source and commodity.

Commercial Building Emissions

See **Appendix D6: Commercial Building Energy** for more information on methodology for the Residential Building Sector.

See **Appendix D7: Residential & Commercial Building Equipment** for more information on methodology for estimating emissions from equipment for the Commercial Building Sector.

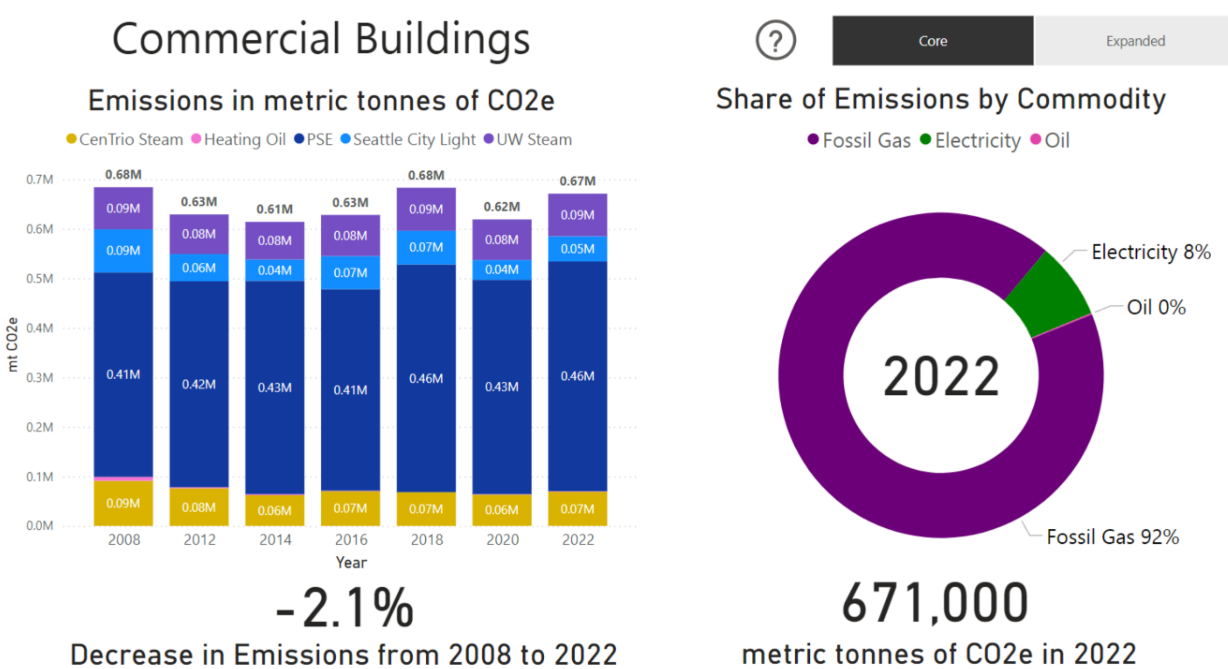


Figure 14: Core commercial building emissions by source and commodity.

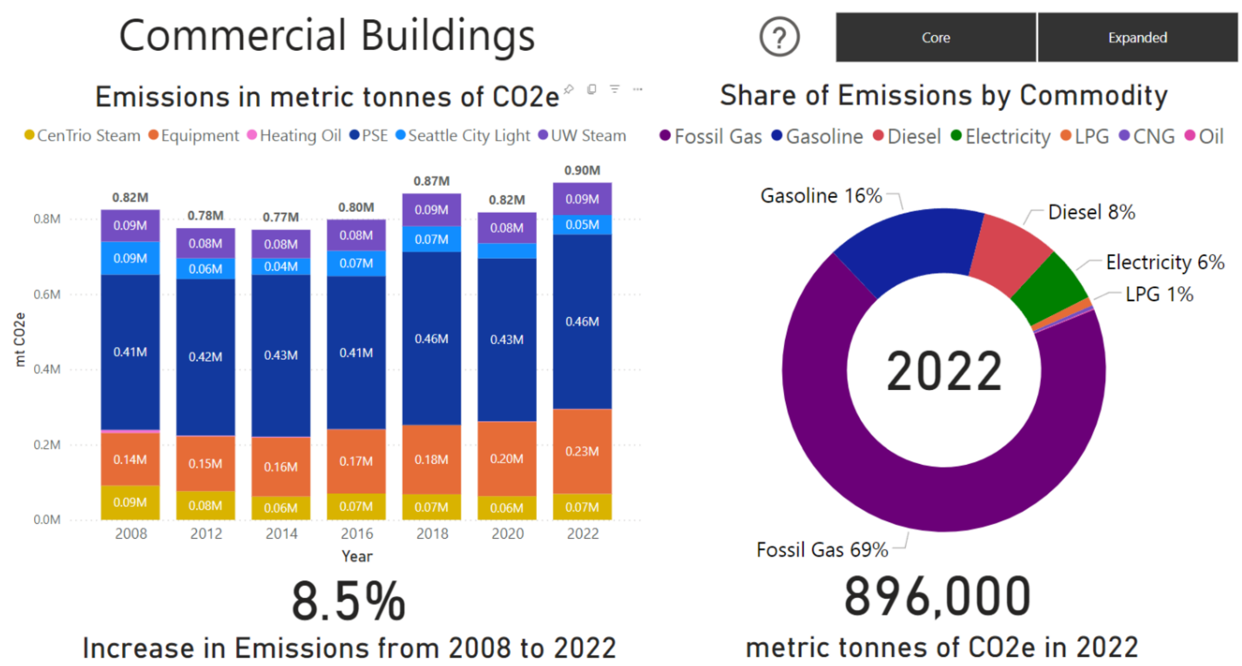


Figure 15: Expanded commercial building emissions by source and commodity.

Industry Emissions

Industry-related emissions decreased 32% since 2008 – from 1.36 million mtCO_2e in 2008 to 0.91 million mtCO_2e in 2022 (**Figure 16**), largely due to a reduction in cement emissions.

Since 2008, cement-related emissions decreased by more than half. Emissions from cement production in Seattle stem from the Ash Grove Cement Company's plant in the Duwamish River Valley. These emissions were also about 9% lower than in 2020.

Meanwhile, emissions from fossil gas usage (including gas infrastructure leaks) increased 8% since 2008, from 0.27 million mtCO_2e in 2008 to 0.29 million mtCO_2e in 2022. Emissions from steel production have decreased 24.5% since 2008, with 43 thousand mtCO_2e emitted in 2022.

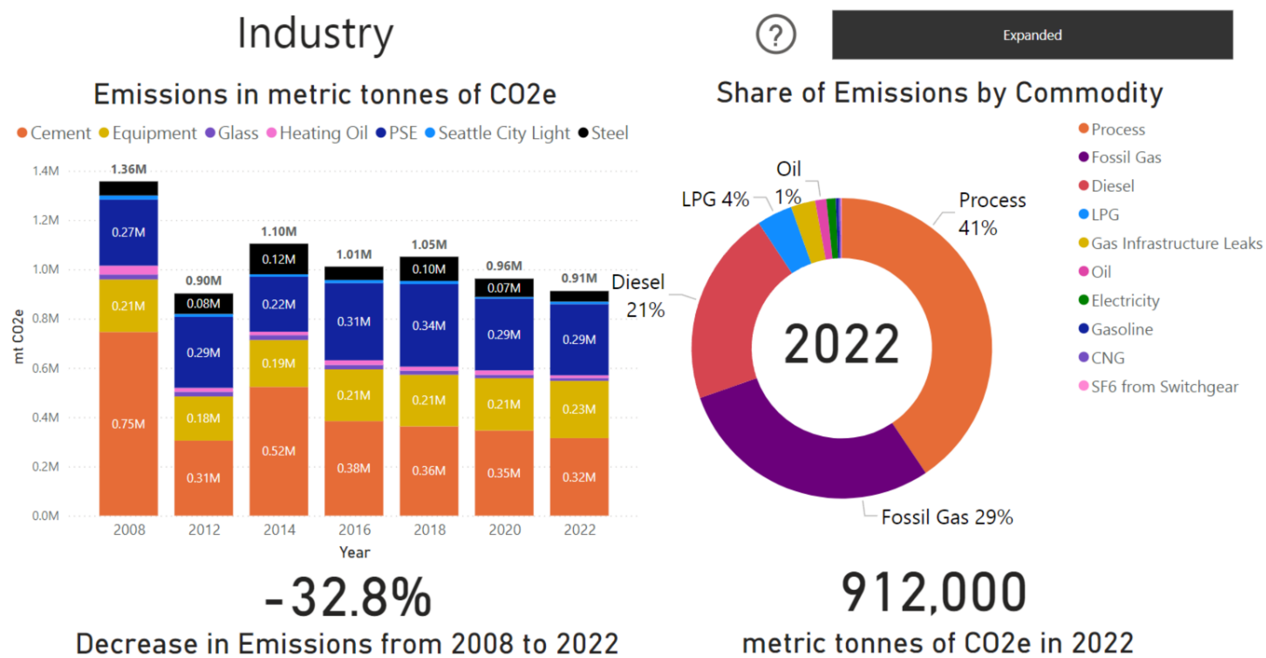


Figure 16: Industrial sector emissions by source and commodity.

See **Appendix D9: Industry** for more information on methodology for the Industry Sector.

Waste Emissions

In the waste sector, core emissions derived from the commercial, residential, and self-haul subsectors have decreased 31% from 100.7 thousand $mtCO_2e$ in 2008 to 69.4 thousand $mtCO_2e$ in 2022 (**Figure 17**). Expanded emissions, including the core subsectors as well as wastewater and construction & demolition, have decreased 28.5% from 2008 to 2022, or from 128.3 thousand $mtCO_2e$ to 91.6 thousand $mtCO_2e$ (**Figure 18**). The reduction in waste emissions is due to more waste being diverted to the appropriate stream as well as more waste being prevented in the first place.

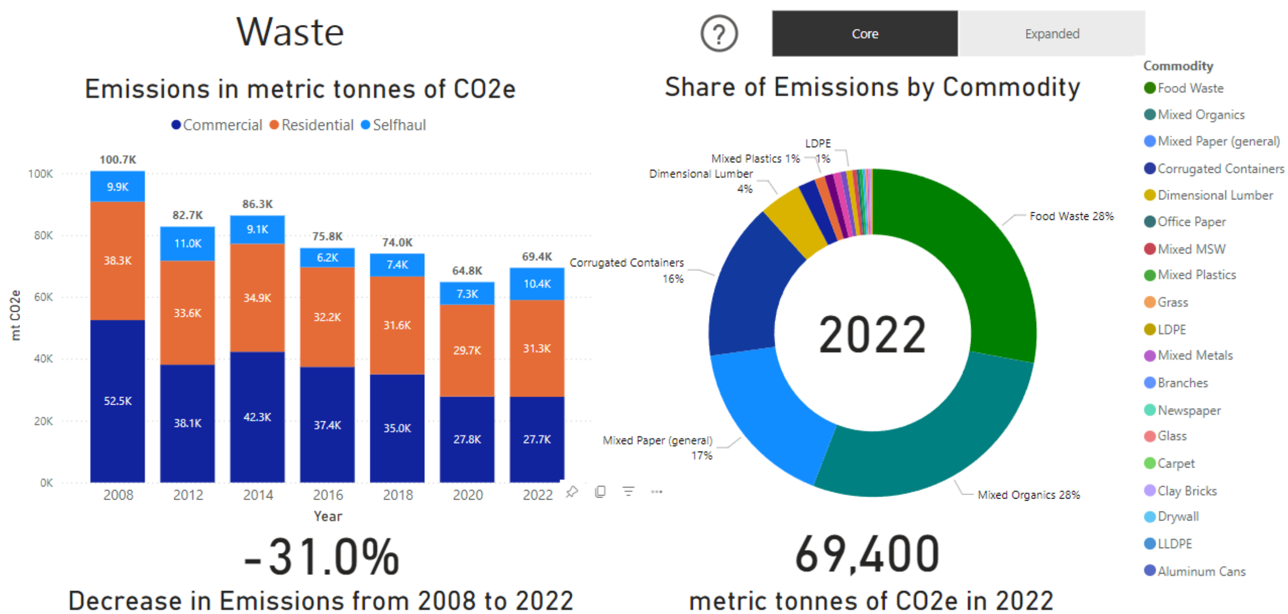


Figure 17: Core waste emissions by subsector and material type.

Since 2007, SPU has developed annual reports to monitor waste prevention, waste diversion, and progress made towards the City's solid waste goals.[10] SPU's emphasis on proper waste diversion and prevention has led to a continued decrease in emissions through reduced tonnage and less-emitting emission factors. SPU now also publishes quarterly municipal solid waste reports through an online dashboard.

This inventory also relies on SPU's waste composition studies to determine the share of emissions by material type in the waste stream. Since the 2020 inventory the residential waste composition study has not been updated so the material share of emissions remains at the same ratio, which consequently means that the 5.4% increase in residential waste emissions from 2020 to 2022 was a direct result of increased residential waste tonnage. A 2022 update to the commercial waste composition study showed that plastics constituted an additional four percentage points of the waste stream vs. the prior study in 2016, while organics constituted five fewer percentage points. Commercial sector waste emissions stayed relatively the same between 2020 and 2022. Self-haul emissions rose by 41% over the same timeframe which is

[10] SPU's Annual *Waste Prevention & Recycling Reports*.

believed to be due to increased disposal of high landfill methane-producing materials, such as paper, food, and yard waste.

A general decline in waste disposal has remained relatively consistent over the years for the various subsectors in the core and expanded emissions (**Figure 18**); however, the 'Commercial' (47% decrease) and 'Construction & Demolition' (68.1% decrease) subsectors experienced the highest decline in emissions between 2008 and 2022. Wastewater and self-haul emissions experienced a growth since 2008 by 23.6% and 4.4% respectively.

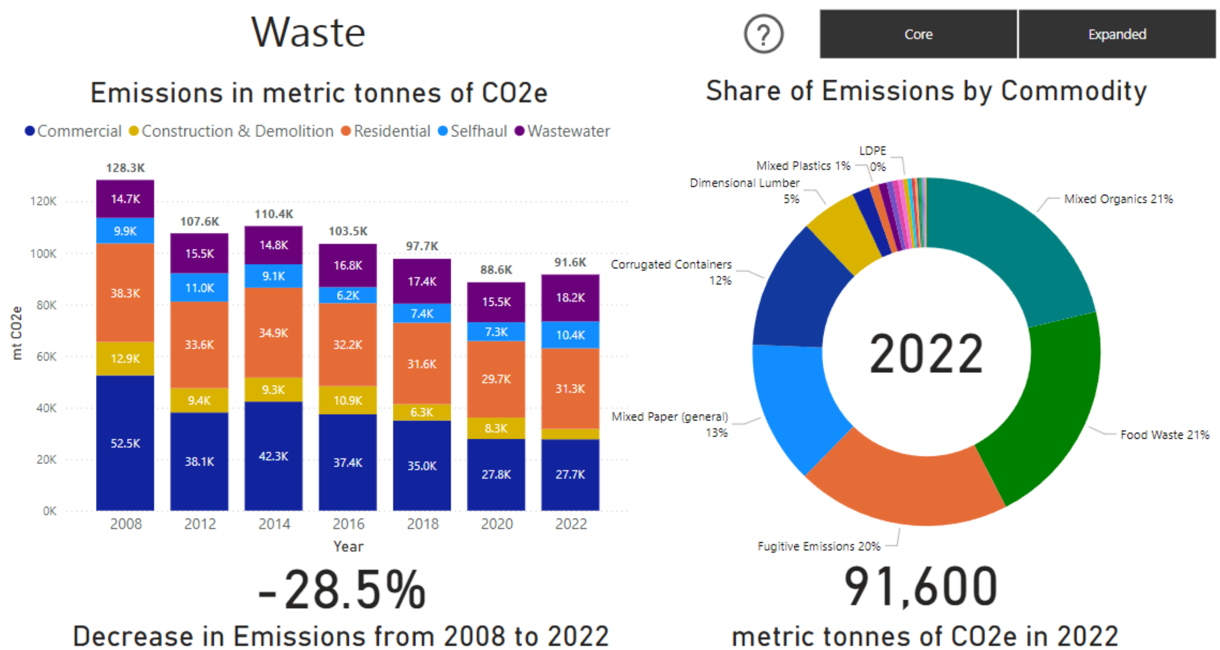


Figure 18: Expanded waste emissions by commodity and stream.

See Appendix D8: Waste & Wastewater for more information on methodology for the Waste Sector.

Sequestration and Offset Emissions

There are two sources of negative emissions in the city's GHG inventory: sequestration and offsets. Waste materials composed of organic matter stored in landfills are considered negative emissions in the inventory as they are removed from the atmosphere when they are buried. This sequestration of high-carbon materials leads to a substantial decrease in emissions.

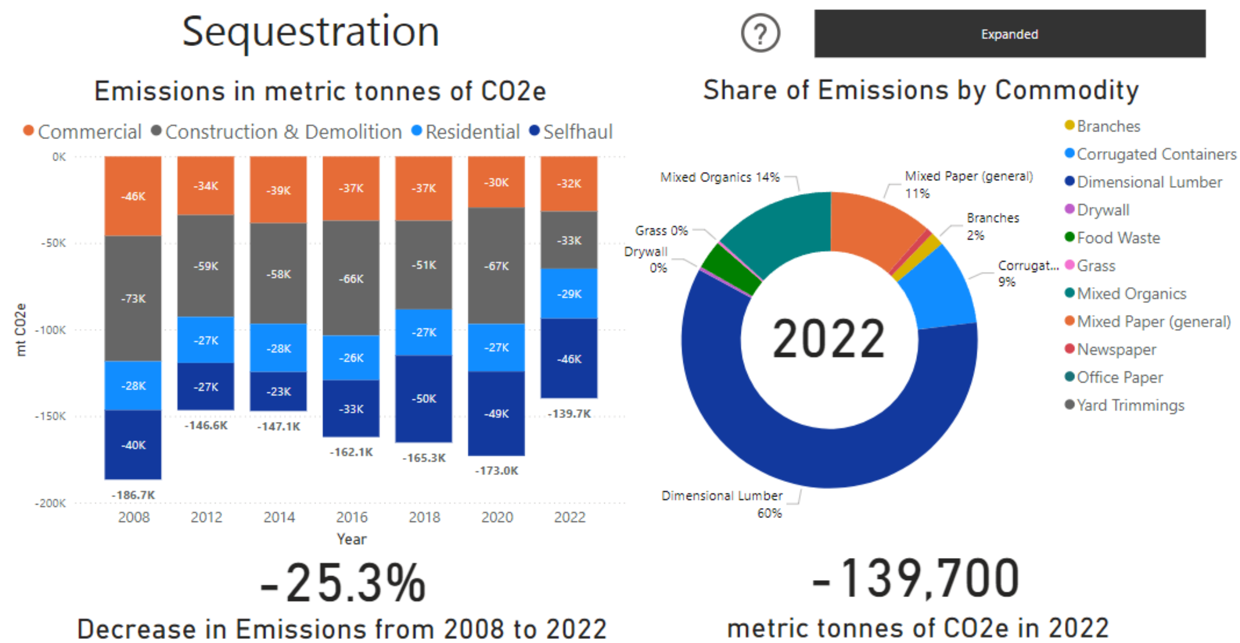


Figure 19: Sequestered emissions by category and commodity.

Additionally, carbon offsets purchased by an agency to counteract certain sources of emissions contribute to the inventory. City Light and KCWTD are the two agencies that have offset data reported in the inventory.

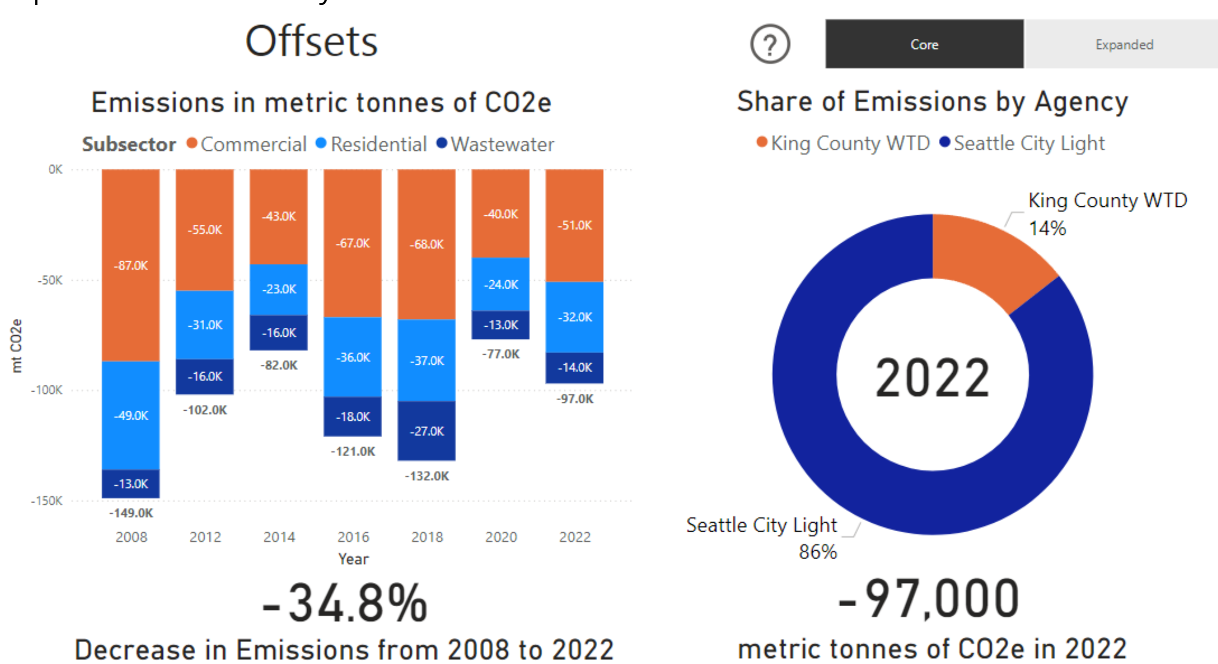


Figure 20: Emissions offset by sector and agency.

Visit [this website] for more information on Carbon Offsets , and [this page] for more details on City Light's environmental stewardship strategy.

Appendix

Appendix A: Detailed Emissions Inventory Tables

Emissions Category	2008	2012	2014	2016	2018	2020	2022
Buildings	**1,431,000**	**1,316,000**	**1,274,000**	**1,296,000**	**1,403,000**	**1,347,000**	**1,442,000**
Commercial	**824,000**	**775,000**	**771,000**	**798,000**	**867,000**	**817,000**	**896,000**
CenTrio Steam	91,000	76,000	62,000	70,000	68,000	63,000	69,000
Fossil Gas	91,000	76,000	62,000	70,000	67,000	63,000	69,000
Oil	0	0	0	0	1,000	0	0
Equipment	140,000	146,000	157,000	170,000	184,000	198,000	225,000
CNG	2,000	2,000	2,000	2,000	3,000	3,000	3,000
Diesel	39,000	45,000	49,000	53,000	57,000	62,000	70,000
Gasoline	95,000	94,000	101,000	109,000	118,000	126,000	144,000
LPG	4,000	5,000	5,000	6,000	6,000	7,000	8,000
Heating Oil	8,000	2,000	2,000	1,000	0	1,000	1,000
Oil	8,000	2,000	2,000	1,000	0	1,000	1,000
PSE	413,000	416,000	431,000	407,000	460,000	433,000	464,000
Fossil Gas	413,000	416,000	431,000	407,000	460,000	433,000	464,000
Seattle City Light	87,000	55,000	43,000	67,000	68,000	40,000	51,000
Electricity	87,000	55,000	43,000	67,000	68,000	40,000	51,000
UW Steam	85,000	80,000	76,000	83,000	87,000	82,000	86,000
Fossil Gas	85,000	80,000	76,000	83,000	86,000	82,000	86,000
Oil	0	0	0	0	1,000	0	0
Residential	**607,000**	**541,000**	**503,000**	**498,000**	**536,000**	**530,000**	**546,000**
Heating Oil	109,000	72,000	63,000	61,000	57,000	61,000	48,000
Oil	109,000	72,000	63,000	61,000	57,000	61,000	48,000
PSE	432,000	420,000	399,000	382,000	422,000	425,000	446,000
Fossil Gas	432,000	420,000	399,000	382,000	422,000	425,000	446,000
Seattle City Light	49,000	31,000	23,000	36,000	37,000	24,000	32,000
Electricity	49,000	31,000	23,000	36,000	37,000	24,000	32,000
Yard Equipment	17,000	18,000	18,000	19,000	20,000	20,000	20,000
CNG	0	0	0	0	0	0	0
Diesel	0	0	0	0	0	0	0
Gasoline	17,000	18,000	18,000	19,000	20,000	20,000	20,000
LPG	0	0	0	0	0	0	0
Industry	**1,357,000**	**902,000**	**1,104,000**	**1,011,000**	**1,051,000**	**962,000**	**912,000**
Energy Use	**510,000**	**475,000**	**419,000**	**536,000**	**551,000**	**508,000**	**517,000**
Equipment	213,000	179,000	190,000	210,000	209,000	212,000	232,000
CNG	2,000	2,000	2,000	2,000	2,000	2,000	2,000
Diesel	172,000	149,000	157,000	174,000	173,000	175,000	192,000
Gasoline	6,000	3,000	3,000	3,000	3,000	3,000	3,000
LPG	33,000	25,000	28,000	31,000	31,000	32,000	35,000
Heating Oil	36,000	16,000	14,000	19,000	16,000	18,000	11,000
Oil	36,000	16,000	14,000	19,000	16,000	18,000	11,000

Emissions Category	**2008**	**2012**	**2014**	**2016**	**2018**	**2020**	**2022**
PSE	246,000	270,000	207,000	296,000	314,000	271,000	265,000
Fossil Gas	246,000	270,000	207,000	296,000	314,000	271,000	265,000
Seattle City Light	15,000	10,000	8,000	11,000	12,000	7,000	9,000
Electricity	15,000	10,000	8,000	11,000	12,000	7,000	9,000
Fugitive Gases	**24,000**	**20,000**	**18,000**	**19,000**	**22,000**	**20,000**	**25,000**
PSE	22,000	18,000	16,000	17,000	21,000	20,000	24,000
Gas Infrastructure Leaks	22,000	18,000	16,000	17,000	21,000	20,000	24,000
Seattle City Light	2,000	2,000	2,000	2,000	1,000	0	1,000
SF6 from Switchgear	2,000	2,000	2,000	2,000	1,000	0	1,000
Process	**823,000**	**407,000**	**667,000**	**456,000**	**478,000**	**434,000**	**370,000**
Cement	746,000	305,000	523,000	384,000	363,000	346,000	315,000
Process	746,000	305,000	523,000	384,000	363,000	346,000	315,000
Glass	20,000	19,000	20,000	18,000	17,000	14,000	12,000
Process	20,000	19,000	20,000	18,000	17,000	14,000	12,000
Steel	57,000	83,000	124,000	54,000	98,000	74,000	43,000
Process	57,000	83,000	124,000	54,000	98,000	74,000	43,000
Offsets	**-164,000**	**-112,000**	**-90,000**	**-132,000**	**-144,000**	**-84,000**	**-106,000**
Commercial	**-87,000**	**-55,000**	**-43,000**	**-67,000**	**-68,000**	**-40,000**	**-51,000**
Seattle City Light	-87,000	-55,000	-43,000	-67,000	-68,000	-40,000	-51,000
Electricity	-87,000	-55,000	-43,000	-67,000	-68,000	-40,000	-51,000
Industrial	**-15,000**	**-10,000**	**-8,000**	**-11,000**	**-12,000**	**-7,000**	**-9,000**
Seattle City Light	-15,000	-10,000	-8,000	-11,000	-12,000	-7,000	-9,000
Electricity	-15,000	-10,000	-8,000	-11,000	-12,000	-7,000	-9,000
Residential	**-49,000**	**-31,000**	**-23,000**	**-36,000**	**-37,000**	**-24,000**	**-32,000**
Seattle City Light	-49,000	-31,000	-23,000	-36,000	-37,000	-24,000	-32,000
Electricity	-49,000	-31,000	-23,000	-36,000	-37,000	-24,000	-32,000
Wastewater	**-13,000**	**-16,000**	**-16,000**	**-18,000**	**-27,000**	**-13,000**	**-14,000**
King County WTD	-13,000	-16,000	-16,000	-18,000	-27,000	-13,000	-14,000
Electricity	-13,000	-16,000	-16,000	-18,000	-27,000	-13,000	-14,000
Sequestration	**-185,000**	**-144,000**	**-146,000**	**-160,000**	**-165,000**	**-170,000**	**-139,000**
Commercial	**-45,000**	**-32,000**	**-39,000**	**-36,000**	**-36,000**	**-29,000**	**-31,000**
Construction Materials	-12,000	-9,000	-10,000	-12,000	-12,000	-9,000	-9,000
Dimensional Lumber	-12,000	-9,000	-10,000	-12,000	-12,000	-9,000	-9,000
Drywall	0	0	0	0	0	0	0
Food Waste	-5,000	-3,000	-4,000	-3,000	-3,000	-2,000	-2,000
Food Waste	-5,000	-3,000	-4,000	-3,000	-3,000	-2,000	-2,000
Mixed Materials	-6,000	-5,000	-6,000	-7,000	-7,000	-6,000	-6,000
Mixed Organics	-6,000	-5,000	-6,000	-7,000	-7,000	-6,000	-6,000
Paper	-21,000	-15,000	-19,000	-13,000	-13,000	-11,000	-14,000
Corrugated Containers	-7,000	-1,000	-3,000	-4,000	-4,000	-3,000	-7,000
Mixed Paper (general)	-11,000	-12,000	-13,000	-8,000	-8,000	-7,000	-7,000
Newspaper	-3,000	-2,000	-3,000	-1,000	-1,000	-1,000	0
Office Paper	0	0	0	0	0	0	0
Yard Trimmings	-1,000	0	0	-1,000	-1,000	-1,000	0

Emissions Category	2008	2012	2014	2016	2018	2020	2022
Branches	-1,000	0	0	-1,000	-1,000	-1,000	0
Grass	0	0	0	0	0	0	0
Construction & Demolition	**-72,000**	**-59,000**	**-58,000**	**-66,000**	**-52,000**	**-67,000**	**-33,000**
Construction Materials	-68,000	-56,000	-55,000	-63,000	-49,000	-64,000	-31,000
Dimensional Lumber	-68,000	-56,000	-55,000	-63,000	-49,000	-64,000	-31,000
Mixed Materials	0	0	0	0	0	0	0
Mixed Organics	0	0	0	0	0	0	0
Paper	-2,000	-2,000	-2,000	-2,000	-2,000	-2,000	-2,000
Corrugated Containers	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000
Mixed Paper (general)	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000
Yard Trimmings	-2,000	-1,000	-1,000	-1,000	-1,000	-1,000	0
Branches	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000	0
Grass	0	0	0	0	0	0	0
Yard Trimmings	-1,000	0	0	0	0	0	0
Residential	**-29,000**	**-26,000**	**-27,000**	**-25,000**	**-27,000**	**-26,000**	**-29,000**
Construction Materials	-3,000	-4,000	-3,000	-2,000	-3,000	-4,000	-4,000
Dimensional Lumber	-3,000	-4,000	-3,000	-2,000	-3,000	-4,000	-4,000
Drywall	0	0	0	0	0	0	0
Food Waste	-4,000	-3,000	-3,000	-3,000	-3,000	-2,000	-2,000
Food Waste	-4,000	-3,000	-3,000	-3,000	-3,000	-2,000	-2,000
Mixed Materials	-10,000	-10,000	-10,000	-9,000	-10,000	-11,000	-12,000
Mixed Organics	-10,000	-10,000	-10,000	-9,000	-10,000	-11,000	-12,000
Paper	-11,000	-8,000	-11,000	-11,000	-11,000	-9,000	-11,000
Corrugated Containers	-2,000	-1,000	-1,000	-1,000	-1,000	-3,000	-3,000
Mixed Paper (general)	-7,000	-6,000	-7,000	-7,000	-7,000	-6,000	-7,000
Newspaper	-2,000	-1,000	-3,000	-3,000	-3,000	0	-1,000
Office Paper	0	0	0	0	0	0	0
Yard Trimmings	-1,000	-1,000	0	0	0	0	0
Branches	-1,000	-1,000	0	0	0	0	0
Grass	0	0	0	0	0	0	0
Selfhaul	**-39,000**	**-27,000**	**-22,000**	**-33,000**	**-50,000**	**-48,000**	**-46,000**
Construction Materials	-35,000	-19,000	-16,000	-30,000	-47,000	-45,000	-39,000
Dimensional Lumber	-35,000	-19,000	-16,000	-30,000	-47,000	-45,000	-39,000
Drywall	0	0	0	0	0	0	0
Food Waste	0	0	0	0	0	0	0
Food Waste	0	0	0	0	0	0	0
Mixed Materials	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000
Mixed Organics	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000
Paper	-3,000	-7,000	-5,000	-2,000	-2,000	-2,000	-5,000
Corrugated Containers	-1,000	-1,000	-1,000	-1,000	-1,000	-1,000	-3,000
Mixed Paper (general)	-2,000	-5,000	-4,000	-1,000	-1,000	-1,000	-2,000
Newspaper	0	-1,000	0	0	0	0	0
Office Paper	0	0	0	0	0	0	0
Yard Trimmings	0	0	0	0	0	0	-1,000

Emissions Category	2008	2012	2014	2016	2018	2020	2022
Branches	0	0	0	0	0	0	-1,000
Grass	0	0	0	0	0	0	0
Transportation	**3,532,000**	**3,376,000**	**3,450,000**	**3,687,000**	**3,934,000**	**2,861,000**	**3,474,000**
Air	**1,302,000**	**1,202,000**	**1,283,000**	**1,502,000**	**1,668,000**	**1,000,000**	**1,534,000**
King County Airport	262,000	228,000	238,000	234,000	252,000	168,000	221,000
Jet Fuel	262,000	228,000	238,000	234,000	252,000	168,000	221,000
Sea-Tac Airport	1,040,000	974,000	1,045,000	1,268,000	1,416,000	832,000	1,313,000
Jet Fuel	1,040,000	974,000	1,045,000	1,268,000	1,416,000	832,000	1,313,000
Marine	**179,000**	**176,000**	**179,000**	**180,000**	**181,000**	**180,000**	**197,000**
Hotelling	53,000	43,000	37,000	36,000	36,000	36,000	21,000
Diesel	53,000	43,000	37,000	36,000	36,000	36,000	21,000
Other Boat Traffic	59,000	62,000	76,000	74,000	74,000	85,000	118,000
Diesel	59,000	62,000	76,000	74,000	74,000	85,000	118,000
Pleasure Craft	32,000	30,000	25,000	26,000	26,000	26,000	26,000
Diesel	6,000	6,000	6,000	6,000	6,000	6,000	6,000
Gasoline	26,000	24,000	19,000	20,000	20,000	20,000	20,000
State Ferries	35,000	41,000	41,000	44,000	45,000	33,000	32,000
Bio-Diesel	0	1,000	2,000	2,000	2,000	3,000	3,000
Diesel	35,000	40,000	39,000	42,000	43,000	30,000	29,000
Rail	**48,000**	**42,000**	**33,000**	**32,000**	**33,000**	**27,000**	**29,000**
Rail - Freight	41,000	34,000	24,000	23,000	23,000	23,000	23,000
Diesel	41,000	34,000	24,000	23,000	23,000	23,000	23,000
Rail - Passenger	7,000	8,000	9,000	9,000	10,000	4,000	6,000
Diesel	7,000	8,000	9,000	9,000	10,000	4,000	6,000
Road: Passenger	**1,734,000**	**1,691,000**	**1,685,000**	**1,696,000**	**1,755,000**	**1,412,000**	**1,460,000**
Buses	61,000	68,000	66,000	65,000	66,000	52,000	45,000
CNG	1,000	1,000	1,000	0	1,000	1,000	1,000
Diesel	60,000	67,000	65,000	65,000	65,000	51,000	44,000
Cars & Light Duty Trucks	1,673,000	1,623,000	1,619,000	1,631,000	1,689,000	1,360,000	1,415,000
Gasoline	1,673,000	1,623,000	1,619,000	1,631,000	1,689,000	1,360,000	1,415,000
Road: Trucks	**269,000**	**265,000**	**270,000**	**277,000**	**297,000**	**242,000**	**254,000**
Medium & Heavy Duty	269,000	265,000	270,000	277,000	297,000	242,000	254,000
Diesel	190,000	189,000	194,000	201,000	211,000	171,000	180,000
Gasoline	79,000	76,000	76,000	76,000	86,000	71,000	74,000
Waste	**128,300**	**107,600**	**110,400**	**103,500**	**97,700**	**88,600**	**91,600**
Commercial	**52,500**	**38,100**	**42,300**	**37,400**	**35,000**	**27,800**	**27,700**
Construction Materials	1,000	700	700	900	700	500	500
Asphalt Concrete	0	0	0	0	0	0	0
Asphalt Shingles	0	0	0	0	0	0	0
Carpet	0	0	0	0	0	0	0
Clay Bricks	0	0	0	0	0	0	0
Concrete	100	0	0	0	0	0	0
Dimensional Lumber	900	700	700	900	700	500	500
Drywall	0	0	0	0	0	0	0

Emissions Category	2008	2012	2014	2016	2018	2020	2022
Fiberglass Insulation	0	0	0	0	0	0	0
Electronics	100	400	0	0	0	0	0
CRT Displays	0	0	0	0	0	0	0
Mixed Electronics	100	400	0	0	0	0	0
Portable Electronic Devices	0	0	0	0	0	0	0
Food Waste	22,900	16,400	17,100	13,900	13,300	10,600	8,800
Food Waste	22,900	16,400	17,100	13,900	13,300	10,600	8,800
Glass	100	100	100	100	100	100	100
Glass	100	100	100	100	100	100	100
Metals	300	100	100	200	100	100	200
Aluminum Cans	0	0	0	0	0	0	0
Mixed Metals	300	100	100	200	100	100	200
Steel Cans	0	0	0	0	0	0	0
Mixed Materials	7,200	6,400	6,900	8,600	7,900	6,300	6,200
Mixed MSW	700	700	500	500	300	200	300
Mixed Organics	6,500	5,700	6,400	8,100	7,600	6,100	5,900
Paper	19,100	13,300	16,400	12,300	11,900	9,400	11,100
Corrugated Containers	6,400	600	3,100	3,800	3,700	2,900	5,900
Mixed Paper (general)	8,900	9,700	10,200	6,600	6,400	5,100	5,100
Newspaper	700	600	600	300	300	200	100
Office Paper	3,100	2,400	2,500	1,600	1,500	1,200	0
Plastics	900	400	700	900	500	400	500
HDPE	0	0	0	0	0	0	0
LDPE	400	100	400	500	300	200	200
Mixed Plastics	500	300	300	400	200	200	300
PET	0	0	0	0	0	0	0
Tires	0	0	0	0	0	0	0
Tires	0	0	0	0	0	0	0
Yard Trimmings	900	300	300	500	500	400	300
Branches	400	0	0	200	200	200	100
Grass	500	300	300	300	300	200	200
Construction & Demolition	**12,900**	**9,400**	**9,300**	**10,900**	**6,300**	**8,300**	**4,000**
Construction Materials	7,700	5,900	5,800	6,700	3,700	4,900	2,400
Asphalt Concrete	100	0	0	0	0	0	0
Asphalt Shingles	1,100	500	500	600	300	400	200
Clay Bricks	400	400	400	500	200	300	100
Concrete	100	0	0	0	0	0	0
Dimensional Lumber	5,100	4,200	4,100	4,700	2,800	3,700	1,800
Drywall	900	800	800	900	400	500	300
Fiberglass Insulation	0	0	0	0	0	0	0
Electronics	0	0	0	0	0	0	0
CRT Displays	0	0	0	0	0	0	0
Mixed Electronics	0	0	0	0	0	0	0

Emissions Category	2008	2012	2014	2016	2018	2020	2022
Portable Electronic Devices	0	0	0	0	0	0	0
Glass	0	100	100	100	0	100	0
Glass	0	100	100	100	0	100	0
Metals	300	100	100	200	100	100	0
Mixed Metals	300	100	100	200	100	100	0
Mixed Materials	1,900	1,200	1,200	1,300	700	900	400
Mixed MSW	1,800	900	900	1,000	500	600	300
Mixed Organics	100	300	300	300	200	300	100
Paper	1,800	1,600	1,600	1,900	1,400	1,800	900
Corrugated Containers	1,000	800	800	900	700	900	400
Mixed Paper (general)	800	800	800	1,000	700	900	500
Plastics	300	200	200	300	100	200	100
Mixed Plastics	300	200	200	300	100	200	100
Tires	0	0	0	0	0	0	0
Tires	0	0	0	0	0	0	0
Yard Trimmings	900	300	300	400	300	300	200
Branches	400	200	200	200	200	200	100
Grass	200	100	100	200	100	100	100
Yard Trimmings	300	0	0	0	0	0	0
Residential	**38,300**	**33,600**	**34,900**	**32,200**	**31,600**	**29,700**	**31,300**
Construction Materials	300	300	300	200	100	200	200
Asphalt Concrete	0	0	0	0	0	0	0
Asphalt Shingles	0	0	0	0	0	0	0
Carpet	100	0	100	0	0	0	0
Clay Bricks	0	0	0	0	0	0	0
Concrete	0	0	0	0	0	0	0
Dimensional Lumber	200	300	200	200	100	200	200
Drywall	0	0	0	0	0	0	0
Fiberglass Insulation	0	0	0	0	0	0	0
Electronics	100	0	0	0	0	0	0
CRT Displays	0	0	0	0	0	0	0
Mixed Electronics	100	0	0	0	0	0	0
Portable Electronic Devices	0	0	0	0	0	0	0
Food Waste	17,400	13,600	13,600	12,600	12,400	9,200	9,700
Food Waste	17,400	13,600	13,600	12,600	12,400	9,200	9,700
Glass	100	100	100	100	100	100	100
Glass	100	100	100	100	100	100	100
Metals	100	200	100	100	100	100	100
Aluminum Cans	0	0	0	0	0	0	0
Mixed Metals	100	200	100	100	100	100	100
Steel Cans	0	0	0	0	0	0	0
Mixed Materials	10,800	11,200	11,100	10,300	10,000	11,900	12,500

Emissions Category	2008	2012	2014	2016	2018	2020	2022
Mixed MSW	200	200	100	100	100	200	200
Mixed Organics	10,600	11,000	11,000	10,200	9,900	11,700	12,300
Paper	8,300	7,200	8,900	8,100	8,300	7,500	7,900
Corrugated Containers	1,600	1,300	1,000	900	900	2,300	2,400
Mixed Paper (general)	5,300	4,700	5,800	5,300	5,400	5,000	5,300
Newspaper	500	300	700	600	600	100	100
Office Paper	900	900	1,400	1,300	1,400	100	100
Plastics	600	400	500	500	300	500	500
HDPE	0	0	0	0	0	0	0
LDPE	300	200	300	300	200	200	200
LLDPE	0	0	0	0	0	100	100
Mixed Plastics	300	200	200	200	100	200	200
PET	0	0	0	0	0	0	0
PLA	0	0	0	0	0	0	0
PP	0	0	0	0	0	0	0
Tires	0	0	0	0	0	0	0
Tires	0	0	0	0	0	0	0
Yard Trimmings	600	600	300	300	300	200	300
Branches	200	300	100	100	100	100	200
Grass	400	300	200	200	200	100	100
Selfhaul	**9,900**	**11,000**	**9,100**	**6,200**	**7,400**	**7,300**	**10,400**
Construction Materials	3,400	1,900	1,600	2,800	3,000	2,900	2,700
Asphalt Concrete	0	0	0	0	0	0	0
Asphalt Shingles	100	0	0	0	0	0	100
Carpet	200	100	100	200	100	100	100
Clay Bricks	100	0	0	100	100	100	100
Concrete	200	100	100	100	0	0	100
Dimensional Lumber	2,600	1,500	1,200	2,300	2,700	2,600	2,200
Drywall	200	200	200	100	100	100	100
Fiberglass Insulation	0	0	0	0	0	0	0
Electronics	0	0	0	0	0	0	100
CRT Displays	0	0	0	0	0	0	0
Mixed Electronics	0	0	0	0	0	0	100
Portable Electronic Devices	0	0	0	0	0	0	0
Food Waste	800	1,400	1,200	500	700	700	900
Food Waste	800	1,400	1,200	500	700	700	900
Glass	100	100	100	0	0	0	100
Glass	100	100	100	0	0	0	100
Metals	200	100	100	200	200	200	200
Aluminum Cans	0	0	0	0	0	0	0
Mixed Metals	200	100	100	200	200	200	200
Steel Cans	0	0	0	0	0	0	0
Mixed Materials	2,200	1,700	1,400	1,100	1,300	1,300	1,900

Emissions Category	2008	2012	2014	2016	2018	2020	2022
Mixed MSW	800	600	500	500	500	500	700
Mixed Organics	1,400	1,100	900	600	800	800	1,200
Paper	2,700	5,200	4,400	1,300	1,900	1,900	3,900
Corrugated Containers	1,300	700	600	800	1,200	1,200	2,500
Mixed Paper (general)	1,300	3,600	3,000	500	700	700	1,300
Newspaper	0	100	100	0	0	0	0
Office Paper	100	800	700	0	0	0	100
Plastics	200	300	100	200	200	200	200
HDPE	0	0	0	0	0	0	0
LDPE	0	100	0	0	0	0	0
Mixed Plastics	200	200	100	200	200	200	200
PET	0	0	0	0	0	0	0
Tires	0	0	0	0	0	0	0
Tires	0	0	0	0	0	0	0
Yard Trimmings	300	300	200	100	100	100	400
Branches	100	0	0	0	0	0	300
Grass	200	300	200	100	100	100	100
Wastewater	**14,700**	**15,500**	**14,800**	**16,800**	**17,400**	**15,500**	**18,200**
Fugitive	14,700	15,500	14,800	16,800	17,400	15,500	18,200
Fugitive Emissions	14,700	15,500	14,800	16,800	17,400	15,500	18,200
Grand Total	**6,099,300**	**5,445,600**	**5,702,400**	**5,805,500**	**6,176,700**	**5,004,600**	**5,674,600**

Appendix B: Data Model Change

In 2018, the Seattle GHG inventory transitioned from an Excel-based model to an Excel and Power BI model to improve the efficiency and replicability for future greenhouse gas inventories. Doing this also allows the city to display connected, flexible, and interactive online dashboards on a website. All of the transition base values are now compiled in an Excel workbook called <CityofSeattleEmissionsInputMaster>.

B1: Emissions Calculations

All the numbers needed for the GHG calculations are pulled in from the <CityofSeattleEmissionsInputMaster> Excel workbook, and the calculations are automatically performed using DAX code in calculated columns and measures in Power BI instead of in an Excel workbook as previous years have done.

The GHG calculation methodology for this 2022 inventory remains effectively the same as the 2020 GHG inventory. However, the methodology changed in a few instances to improve accuracy or to retroactively update calculations.

See **Appendix D1.1**: Road Transportation, Light-, Medium-, and Heavy-Duty Vehicles, for revised road transportation methodology based on updated outputs from PSRC's SoundCast 2018 Model.

See **Appendix D2.3**: Air Transportation Uncertainty for details on an adjustment to how fuel consumed at SeaTac was allocated to Seattle passengers.

See **Appendix D5.3**: Residential Building Energy, Direct Fuel Use (Heating Oil) and **Appendix D6.2.2**: Commercial Building Energy, Petroleum for details on data adjustments to account for a deprecated fuel sale data source.

Appendix C: Source Documentation

The formal inventory is a dataset consisting of electronic files. This set of files is not available to download but can be requested via email through the staff contact listed on OSE's GHG Inventory webpage. The data files are divided into the following categories:

C1: Index file

A single index file, <Community-Dataset-Index.xlsx>, lists names, descriptions, and sources of all other files in the inventory.

C2: Source files

These files range from categories YR-00 to YR-80. Within each category, files are denoted by the file number that follows the category (i.e. 20-10-XX). The files are organized by category in the following format, with 'YR' indicating the 2-digit year the inventory file corresponds to:

YR-00 Inventory

YR-10 Transportation

YR-20 Buildings

YR-40 Industry

YR-50 Waste

YR-60 Electricity

YR-70 Demographics

YR-80 Reference

As source files are superseded by newer files, the previous versions are archived, and the new information incorporated. In addition, some source files from prior inventory work in Seattle are referenced in <CityofSeattleEmissionsInputMaster.xlsx>. These source files are provided in comments and source notes in the format 14-XX-XX (*2014 Seattle Community Greenhouse Gas Inventory*), 12-XX-XX (*2012 Seattle Community Greenhouse Gas Inventory*), 08-XX-XX (*2008 Seattle Community Greenhouse Gas Inventory*) or 05-XX-XX (*2005 Inventory of Seattle Greenhouse Gas Emissions: Community & Corporate*) and are maintained by the City of Seattle Office of Sustainability & Environment (OSE).

Appendix D: Methodology & Source Notes

D1: Road Transportation

D1.1 Light-, Medium-, and Heavy-Duty Vehicles

ICLEI[11] recommends different protocols for estimating emissions from the transportation sector for self-reported inventories (SRI). TR.1 *Emissions from Passenger Vehicles* recommends methodology and equations for estimating emissions from passenger vehicles. Table TR.1.1, *Descriptions of Input Data Conditions*, details methodology for estimating emissions from passenger vehicles ordered by preference.

***Table TR.1.1* Descriptions of Input Data Conditions**
You may choose different combinations of input data conditions across columns, but not within each column. The input data conditions in each column are presented in order of preference.

Travel Activity (T)	**Emissions or Energy (E)**	**Local Adjustments for vehicle efficiency and fuel type (L)**
For Recommended Method: Model data of all travel originating or terminating within the jurisdictional boundaries of a community, from: **(T1)** an activity-based* regional travel demand model with trip origin and destination data **(T2)** a trip-based travel demand model with trip origin and destination data (four step models) **For Alternate Method Only:** **(T3)** An estimate of VMT within the community from a travel demand model (cordon method), with model calibrated to observed traffic counts within the community; **(T4)** an estimate of VMT within the community from a source other than a travel demand model (see equation TR.1.B.1 below)	**For All Methods:** Output of CO_2, N_2O, and CH_4 for each or the aggregate of all traffic analysis zones within the community from: **(E1)** a fully-integrated modal emissions model (vehicle hours operating for each vehicle specific power bins), such as U.S. EPA MOVES (see Table TR.1.2 for details); **(E2)** a vehicle-mile-traveled (VMT)-based emissions model using VMT and speed outputs from the travel model, such as EMFAC or MOBILE **(E3)** Any post-processing method which relies on aggregated methods of vehicle activity, such as emissions per mile or assumed fuel efficiency (including equations TR.1.B.1 and TR.1.B.2)	**For All Methods:** **(L1)** Adjustments within the model for vehicle mix based on known data on vehicle registrations per community or traffic analysis zone; **(L2)** Post-processing adjustments based on known-data on vehicle registrations per community or traffic analysis zone; **(L3)** Adjustments based on known county-wide or regional average data (includes use of EMFAC county sub-area for California users); **(L4)** Adjustments based on known statewide average data **(L5)** No adjustments, use national averages (model default)

* 'Activity-based' in this context refers to the way in which travel demand is modeled, and is unrelated to the distinction made in this protocol between activities and sources.

Figure 21: ICLEI: Table TR.1.1 Descriptions of Input Data Conditions[11]

D1.1.1 Light-Duty Vehicles

Travel Activity (T) is derived from the T1 methodology, which uses an activity-based regional travel demand model with trip origin and destination data courtesy of PSRC's SoundCast 2018 model[12]. Emissions or Energy (E) is most similar to the E1 methodology. PSRC uses MOVES

[11] ICLEI's U.S. Community Protocol, Appendix D Transportation and Other Mobile Emission Activities and Sources
[12] Puget Sound Regional Council, Activity-Based Travel Model: SoundCast 2018

every few years to generate emissions rates per mile that vary based on speed, roadway type, time of day, and vehicle type. They represent a fleet of vehicles in the region using data on registration by vehicle type and anticipated fleet change according to federal and state laws (like EPA's CAFE standards). This output therefore also enables us to follow the L1 methodology for local adjustments pertaining vehicle efficiency and fuel type.

Following the T1 methodology for light-duty vehicles, PSRC generated an output from the SoundCast 2018 model to estimate VMT by origin and destination per Census tract in Seattle for roadway emissions.[13]. SoundCast models the travel behavior of individuals and households in the Puget Sound area based on a daily activity pattern derived from sociodemographic and land-use data for the base year of 2018. Trips from origins, and destinations, are compiled and the resulting VMT is calculated based on the Manhattan distance, or distance along the street network, to the destination, or origin. This process is known as an origin-destination pair approach and is recommended per ICLEI[11] for community-scale inventories.

Commute and non-commute VMTs were summarized at the Census tract-level per origin and destination and then averaged to obtain a citywide estimate for an average weekday in the model year. This method counts the entire length of a trip if it's origin or destination resides in a Census tract within the city limits of Seattle. This includes VMT outside the city if it begins or ends within the geographic boundary, but omits trips that both begin and end outside the city, even if they pass through (e.g. on I-5). VMT outside the city limits are included as the City could influence individual travel choices through infrastructure and policy implementation when the origin or destination resides within the city limits. It was at this calculation step that an error was discovered in prior inventory years; non-commute trips were being double counted in the calculations for average weekday and annual VMTs, resulting in an over-estimation of VMTs occurring in Seattle. This error was duly fixed for the 2022 inventory.

VMTs for an average weekday are then grown by the number of days in a year (365.25 days) as recommended per ICLEI[11]*, TR.1.B.1 VMT Estimate from Passenger Vehicles*. PSRC uses an annual adjustment factor of 300 to model yearly estimates from daily outputs within their model, since travel patterns are significantly different between weekdays and weekends. The adjustment factor of 365.25 remains in use as it is recommended by ICLEI[11].

D1.1.2 Medium- and Heavy-Duty Vehicles

For medium and heavy-duty vehicles, the T3 methodology was used which incorporated the SoundCast 2018 model to derive VMT that passes through each Census tract regardless of if the origin or destination was in Seattle. VMT and total daily tons of CO2 were summarized by PSRC at the Census tract-level for medium-duty and heavy-duty vehicles.[14]. The T1 methodology used for light-duty vehicle emissions could not be replicated due to difficulties in accurately modeling truck traffic.

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[13] PSRC SoundCast 2018, Origin/destination model output for cars and light-duty trucks. 20-11-05.

[14] PSRC SoundCast 2018, Intertract VMT model output for medium and heavy-duty trucks. 20-11-06.

Like the methodology for light-duty vehicles, Emissions or Energy (E) is derived from the E1 methodology. Local adjustments for vehicle efficiency and fuel type (L) are derived from L1.

As mentioned earlier in the light-duty methodology, VMT for an average weekday are then grown by the number of days in a year (365.25 days), as recommended per ICLEI[11]. This methodology should be reviewed to estimate roadway emissions more accurately.

D1.1.3 Non-Model Year VMT Adjustments

To estimate VMT for inventory years that are not model years, a percentage of local vehicle activity relative to the base year of 2018 was used to forecast and back-cast values. PSRC included forecasted values for 2020 and 2022 in their modeled output file, while back-casting for 2008 through 2016 was post-processed separately. The same process remains consistent for light-, medium-, and heavy-duty vehicles. The Washington State Department of Transportation (WSDOT) reports yearly urban VMT on state highways in King County[15], which is used to estimate past and future citywide VMTs. WSDOT uses a consistent methodology from year to year for these roads, which carry about half of the VMT in King County. Therefore, this was judged to be a purer signal of yearly changes in VMT than data provided to the federal Highway Performance Management System (HPMS) by WSDOT. The WSDOT data provided to the HPMS for state highway VMT are supplemented with sampled data from local roads, which has higher uncertainty and a non-standard methodology over time.

D1.1.4 Emissions

To calculate fuel consumption for years 2008 to 2016, annual VMT per class were multiplied by their respective fuel economies derived from PSRC modeling for King County. PSRC provided vehicle fuel efficiency estimates for King County by vehicle class (cars, light trucks, etc.) for 2005 through 2020**Error! Bookmark not defined.**. For each vehicle category in PSRC's VMT model results (i.e. p assenger vehicles, commercial trucks), a composite fuel economy figure was calculated using a weighted average based on the VMT of the vehicle classes in that category based on PSRC's estimated fleet makeup. Finally, annual fuel consumption was multiplied by energy intensities for fuel-specific (gasoline or diesel) carbon contents from the US EPA's national GHG inventory[17]. This methodology only applies for years 2008 to 2016, since PSRC has been directly providing Seattle emissions figures for 2018 and later.

D1.2 King County Metro and Sound Transit Busses

ICLEI's TR.4, *Emissions from Transit*[11] details methodology for estimating emissions from busses. Emissions from non-electric buses were calculated based on King County Metro (KCM)[16] diesel usage and Sound Transit[16] diesel and compressed natural gas (CNG) usage as reported in the '*2022 Fuel and Energy'* data table from the Federal Transit Administration's (FTA) National Transit Database (NTD). Diesel was converted to CO_2e using energy intensities from the US EPA's national GHG inventory[17].

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[15] WSDOT, Annual mileage and travel information. *State Highway Vehicles Miles Traveled*.

[16] KCM – NTD ID: 00001, Mode: MB, TOS: DO; Sound Transit – NTD ID: 00040, Mode: CB, TOS: DO.

[17] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 2020*, Annex 2, Emissions from fossil fuel combustion

CNG is reported in diesel-gallon equivalents (DGE)[18] in '*2022 Fuel and Energy*' and must be converted to pounds or standard cubic feet[19] (scf) of CNG before applying the emission factor for pounds of CNG to emissions. Since CNG exists in a gaseous state, the volume fluctuates depending on the temperature and pressure. To compensate, CNG measurements rely on the volume of CNG in scf or on the weight of CNG.

Finally, bus fuel use was then scaled based on an estimated ratio of miles traveled on routes serving the city of Seattle for both KCM and Sound Transit.

D1.3 Uncertainty & Data Needs

Uncertainty exists in the estimates of VMT as the methodology relies on modeled VMT data from PSRC's 2018 SoundCast model. While scaling modeled VMT using county-wide annual VMT values for past and future years, county numbers may not have fully captured the impact of factors such as lockdowns or the rise of ride-sharing and the gig economy. An updated data source that relies on aggregated GPS data might more accurately represent changes in VMT specific to Seattle. Additionally, SDOT provides motor vehicle volumes at 20 locations throughout the city to create a monthly control factor[20]. These factors can adjust VMT based on measured monthly data specific to the city. Basing the control factor off SDOT maintained roads, rather than highways, may give a more accurate factor for VMT experienced within the city limits for non-model years.

D2: Air Transportation

ICLEI[11] recommends different protocols for estimating emissions from the air transportation sector for self-reported inventories (SRI). Equation TR.6.B1.1, *CO_2e Emissions from Aircraft*, details methodology for estimating emissions from air travel that relies on dispensed jet fuel and aviation gas (AVGAS) volumes. TR.6.D, *Attribution of Air Travel Emissions to your Community*, details methodology to assign a portion of the total emissions to a community.

D2.1 Sea-Tac International Airport

The Port of Seattle provides data through direct correspondence for total jet fuel dispensed at the Sea-Tac Airport (SEA). The percentage of emissions attributed to Seattle was estimated through a comparison of population in the city and the greater Puget Sound region. Using Equation TR.6.D.1, *Attribution of Emissions from Air Travel to your Community*[21], emissions for Seattle from SEA were estimated.

D2.2 King County International Airport

King County International Airport (KCIA) provided data directly to OSE for jet fuel and aviation gas distributed in 2020. All resulting emissions are attributed to Seattle to account for roughly

[18] DGE refers to the amount of volume in diesel equivalent to the amount of energy in the volume of CNG. This conversion is for energy content purposes and is not a perfect proxy for emissions.
[19] One standard cubic foot is equal to the volume of one cubic foot at standard pressure (1 ATM) and temperature (20 degrees C).
[20] Seattle Department of Transportation, *2021 Traffic Report*, p. 8.
[21] ICLEI US Protocol Append D - Transportation and Other Mobile Emissions Activities and Sources.

half of emissions associated with air travel to and from KCIA (since presumably fuel associated with inbound flights would be approximately equal to fuel associated with outbound flights, assuming similar origins and destinations). The KCIA emissions do not include fuel for aircraft operated by Boeing, which are fueled at a separate facility and for which fuel use data is not available for all inventory years.

D2.3 Uncertainty

Uncertainty in air travel emissions from SEA attributed to Seattle is relatively high. Even though fuel usage at the airport is documented, the method for attributing emissions to Seattle assumes that passenger travel for household and business travel is identical (per resident and employee, respectively) across the region, despite demographic differences (e.g., in income, or in type of employment). Due to COVID-19, the enplaning passenger survey (EPS) at SEA, which provided data on the origin and destination of passengers, was paused in Q1 of 2020. This created uncertainty in the percentage of passengers attributed to Seattle in 2020, which saw atypical flight travel patterns due to COVID-19. Beginning in 2022, this calculation was adjusted for all years to use an origin-destination share of SeaTac's trips attributable to King County, which was then multiplied by the ratio of Seattle's population to King County. The resulting percentages are about four to five points higher than values in prior inventories.

By contrast, uncertainty in emissions at KCIA is relatively low as it is based directly on fuel usage data.

D2.4 Data Needs

More recent data for the number of passengers traveling to and from Seattle is needed to improve the accuracy of the city's attributed emissions percentage. This can be improved if SEA resumes their EPS efforts on a quarterly or yearly basis.

D3: Rail Transportation

D3.1 Rail – Passenger

Passenger rail emissions result from the Amtrak Cascades train that stops in Seattle as it travels between Portland, Oregon and Vancouver, British Columbia. The average number of gallons of diesel fuel per passenger-miles was estimated based on national consumption data from the Bureau of Transportation Statistics (BTS) Table 4-27.[22]. The table reports an aggregate of energy intensity (Btu/revenues passenger-mile) for diesel and electric energy consumed by rail at the national level, which is then converted to diesel gallon equivalents (DGE) per revenue passenger-mile to estimate fuel intensity.

National average fuel use per mile was scaled by the number of riders on the Cascade route as reported by WSDOT in the *Amtrak Cascades: 2022 Performance Data Report*. Consistent with the origin-destination pair methodology employed for vehicle trips, only half of the emissions associated with trips that begin or end in Seattle are attributed to the city's emissions totals.

[22] BTS. Table 4-27: 'Energy Intensity of Amtrak Services (loss-adjusted conversion factors)'

Using the NTD's *2022 Fuel and Energy* data table, emissions from Sound Transit's Sounder commuter rail service[23] were estimated based on diesel usage reported for Sound Transit.

The city is a major destination for commuters on the Sounder, but the route also serves areas outside of the city limits. To compensate for outside trips, half of the emissions associated with the Sounder were assigned to Seattle. This is consistent with the origin-destination pair methodology employed to estimate other types of transport emissions in this inventory.

D3.2 Rail – Freight

Freight rail emissions were taken directly from the Puget Sound Maritime Air Forum *2016 Puget Sound Maritime Air Emissions Inventory (PSMAEI)*. Estimates of locomotive related emissions associated with the Port of Seattle[24] and the Northwest Seaport Alliance (NWSA) North Harbor[25] were extracted. These include emissions arising from locomotive activity moving into or out of the ports, emissions while idling at the ports, and emissions from the trains as they travel in the greater Puget Sound region while traveling to or from the ports. Emissions for prior years were recalculated to use this same definition and were scaled to each inventory reporting year (e.g. 2014) from the closest year in which a Puget Sound Maritime Emissions Inventory was conducted (e.g., 2016) using the tonnage of cargo handled at the Seattle ports as reported in the PSMAEI.

D3.3 Uncertainties

Uncertainty in freight emissions is high due to the reliance on the PSMAEI, which is released every five years. Since freight rail emissions are scaled by tonnage of cargo at Seattle ports, which is reported on in the PSMAEI, the values post-2016 do not differ as the value used to scale remains the same due to lack of updated data.

D4: Marine Transportation

D4.1 Pleasure Craft

Marine pleasure craft emissions for 2014 were obtained from the Washington Department of Ecology's *2014 Comprehensive Inventory*. This inventory calculated emissions using the EPA MOVES 2014a NONROAD model for King County. Equipment types included in the inventory's pleasure craft emissions are 'Inboard/Sterndrive', 'Outboards', and 'Personal Water Craft' for diesel and gasoline engines.

The inventory inputs identical values for King County estimates during non-modelled inventory years after 2014. This was done as emissions from pleasure craft likely have a non-linear relationship with GDP, population, employment, and other sociodemographic indicators. Therefore, forecasting emissions from the model year to non-model years would likely increase uncertainty in the reported estimate.

[23] NTD ID: 00040, Mode: CR, TOS: PT

[24] *2016 PSMAEI* Table 9.56, '2016 Port of Seattle Maritime-related Emissions within the Airshed, tpy'

[25] *2016 PSMAEI* Table 9.46, '2016 NWSA North Harbor Maritime-related Emissions within the Airshed, tpy and %'

King County modeled emissions were then scaled by the ratio of Seattle's population to King County's population to estimate the share of emissions likely attributed to Seattle. This leads to a minimal variation between reported values for inventory years between 2014 and 2020. The EPA released the MOVES 3 NONROAD model in 2020 but estimates from this model have yet to be incorporated into the city's inventory.

D4.2 State Ferries

Emissions from state ferries attributable to Seattle were calculated using fuel cost, gallons, and route data from Washington State Ferries' Fiscal Year 2023 Route Statements (**22-12-02b**).

D4.3 Other Ship and Boat Traffic

Emissions for all ships and boats other than the Washington State Ferries and recreational boats were based on the Puget Sound Maritime Air Forum's *2016 Puget Sound Maritime Air Emissions Inventory* (PSMAEI). These other types of vessels include large container ships, bulk cargo ships, and tankers as well as cruise ships, which collectively are called "Ocean Going Vessels", or OGVs. The emissions associated with these OGVs that are included in Seattle's inventory are for energy use when the ships are secured at berth at each port, termed "hoteling", as well as energy used during maneuvering of the vessels while entering and leaving port. All estimates for OGV hoteling and maneuvering emissions are taken from the PSMAEI and were calculated as the sum of those from NWSA's North Harbor and Port of Seattle[24].

Other types of boats considered include tugboats, towboats, fishing vessels, and any other government or commercial vessel besides the ferries and recreational boats considered above, collectively called "harbor craft." Estimates for these emissions were adapted from those reported for King County[26], all of which were assumed to be attributable to Seattle, since the two ports included in the PSMAEI – Port of Seattle and the NWSA's North Harbor – are both in Seattle. The estimate from Table 4.5[26] was reduced by an estimate in PSMAEI for recreational vessels[24], and this inventory's estimate for ferries[27] was further deducted. This leaves an estimate for harbor vessels in the city without ferries and recreational boats.

D4.4 Uncertainty

Uncertainty in emissions data for Washington State Ferries is relatively low, as they are based on fuel usage reports. By contrast, other sources, such as pleasure craft emissions, exhibit high uncertainty as they rely on modeled data that is difficult to forecast accurately.

The Puget Sound Maritime Air Forum releases a PSMAEI every five-years with the previous report being released in 2016. Many of the values in the Marine Transportation sector were grown from the *2016 PSMAEI* report using a ratio of total tonnage relative to 2016 delivered through the NWSA. Total tonnage for the inventory was inputted for years prior to 2016 from values reported in the PSMAEI.

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[26] *2016 PSMAEI* Table 4.5, '2016 Total Study Area Commercial Harbor and Government Vessel Emissions by County and Regional Clean Air Agency, tpy'
[27] Seattle's *GHG Inventory Report*, Transportation: Marine: State Ferries

D4.5 Data Needs

Incorporating the results for Seattle from the EPA MOVES3 NONROAD model will increase certainty in the data by adding an additional yearly estimate for the MOVES3's model year – 2020.

D5: Residential Building Energy

Fuel-specific emissions factors (gCO_2/L) from the US EPA's national GHG inventory[28] were utilized in calculating emissions from residential buildings.

D5.1 Electricity

City Light provided residential building electricity consumption (GWH) within Seattle for all inventory years through personal communication with OSE. City Light also provided emission factors (Mg of CO_2/MWh) from electricity generation for each inventory year through direct communication. The City Light emission rate was multiplied by residential electricity consumption to obtain total emissions. The most recent emissions factor currently available as of this inventory's publishing is 2021, which was applied to 2022 energy use.

D5.2 Direct Fuel Use (Fossil Gas)

PSE provided data through direct correspondence for the total count of residential customers and total natural gas dispensed (therms) for each inventory year.

D5.3 Direct Fuel Use (Heating Oil)

Seattle residential oil use was estimated from Washington State distillate fuel oil and kerosene sales by end-use, which is reported by the U.S. Energy Information Administration (EIA)[29] and scaled to Seattle by the ratio of Seattle homes with oil heat to Washington State homes with oil heat as reported by the U.S. Census Bureau[30] EIA's sales data was however deprecated in 2022, with the last year of available data being 2020. Therefore a linear forecasting calculation (from 2008 to 2020) was used to estimate fuel oil and kerosene sales by end-use for 2022.

Seattle's heating oil usage was also scaled by the ratio of heating degree days (HDD) in Seattle to the population-weighted statewide average number of HDD[31]. This scaling is necessary because heating demand in Seattle is somewhat less than the statewide average, which includes areas with colder winter temperatures.

D5.4 Uncertainty

Uncertainty in electricity and fossil gas emissions is quite low since it is based directly on utility data. Uncertainty in residential oil use emissions is relatively high since it is scaled from statewide data. In all categories, uncertainty is high in the categorization of energy use between

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[28] EPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks 2020*, Annex 2, Emissions from fossil fuel combustion

[29] EIA *Distillate Fuel Oil and Kerosene Seles by End Use*, pet_cons_821use_dcu_SWA_a.xls

[30] U.S. Census Data: DP04: SELECTED HOUSING CHARACTERISTICS 2020 ACS 5-year

[31] Seattle: KSEA Station; HDD 65 deg F; Washington, population-weighted HDD: NOAA Weighted HDDs in Washington

different classes of users, such as commercial, residential, and industrial. This split is based on utility rate class, which involves some mixing of sources between categories.

D5.5 Data Needs

Data for residential buildings that burn heating oil needs a more accurate estimate for Seattle based on regional data, rather than ratioing a statewide estimate.

D6: Commercial Building Energy

Fuel-specific emissions factors (gCO_2/L) from the US EPA's national GHG inventory[281] were utilized in calculating emissions from commercial buildings.

D6.1 Electricity

City Light provided commercial building electricity consumption (GWH) within Seattle for all inventory years through personal communication with OSE. City Light also provided emission factors (Mg of CO_2/MWh) from electricity generation for each inventory year through direct communication. The City Light emission rate was multiplied by commercial electricity consumption to obtain total emissions.

D6.2 Direct Fuel Use

D6.2.1 Fossil Gas

PSE provided data through direct correspondence for the total count of Seattle commercial businesses and total natural gas dispensed (therms) for each inventory year. Fossil gas use at steam plants and for commercial equipment use as CNG are assumed to be included in PSE's reported commercial sector fossil gas totals but are subtracted from the total reported by PSE and given separately for the purposes of this inventory.

D6.2.2 Petroleum

Seattle commercial building oil use was estimated using Washington State Distillate Fuel Oil and Kerosene sales by end-use, which is reported by the U.S. EIA.[32], prorated by the ratio of Seattle to Washington State commercial employment.[33]**.** EIA's sales data was however deprecated in 2022, with the last year of available data being 2020. Therefore a linear forecasting calculation (from 2008 to 2020) was used to estimate fuel oil and kerosene sales by end-use for 2022.

D6.3 Steam

Emissions from fossil gas for steam production was sourced directly from CenTrio (formerly Emwave) through OSE's District Energy Greenhouse Gas Emissions Reporting Form. UW's fossil gas use for steam production was also shared with OSE through direct communication.

D6.4 Uncertainties

Uncertainties in commercial building emissions estimates are similar to residential buildings: low uncertainty for fossil gas and electricity; high uncertainty for oil use.

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[32] EIA *Distillate Fuel Oil and Kerosene Seles by End Use*, pet_cons_821use_dcu_SWA_a.xls
[33] PSRC *2020 Covered Employment Estimates by Jurisdiction*

D6.5 Data Needs
Data for commercial buildings that burn petroleum needs a more accurate estimate based on regional data, rather than ratioing a statewide estimate of fuel sold.

D7: Residential & Commercial Building Equipment

D7.1 Residential Yard Equipment (Petroleum)
King County yard equipment emissions in 2014 were estimated by the Washington Department of Ecology using EPA's NONROAD 2014a model. This data was then grown using a ratio of King County population in the inventory year to King County population in the 2014 model year.

Emissions by petroleum type were tabulated **(14-40-02)**, prorated for Seattle by the ratio of Seattle to King County population **(16-70-11).** The NONROAD model has not been updated with 2020 data from the EPA NONROAD MOVES3 model, so data used for 2020 before scaling with population is identical to what was used in 2014.

D7.2 Commercial Equipment (Fossil Gas and Petroleum)
Emissions from commercial equipment powered by CNG and petroleum fuel in King County were estimated by the Washington Department of Ecology using EPA's NONROAD 2014a model. This data was then grown using a ratio of King County population in the inventory year to King County population in the 2014 model year. Emissions were tabulated by fuel type and sector **(14-40-02)**, then scaled to Seattle by the ratio of Seattle to King County commercial employment **(18-70-11).** The NONROAD model has not been updated with 2020 data from the EPA MOVES3 NONROAD model, so data used for 2020 before scaling with population is identical to what was used in 2014.

D7.3 Uncertainty
Uncertainty is high for residential and commercial equipment since it is based on a national model that has not been updated for the inventory since 2014.

D7.4 Data Needs
The EPA MOVES3 NONROAD model needs implemented in the inventory to increase accuracy of reported values.

D8: Waste & Wastewater

D8.1 Waste Management
Material-based estimates of solid waste hauled and landfilled in each inventory year were calculated based on waste composition studies developed by Seattle Public Utilities (SPU).[34] for construction and demolition, self-haul, residential, and commercial waste generated within Seattle. The most recent waste composition study for the respective waste stream was then applied to the reported annual tonnage to obtain an estimate of tonnage per material for each sector, which was then compiled in **22-50-07**. Emission factors for landfilling and carbon

[34] SPU Solid Waste Composition Studies. *Residential Waste Composition; Commercial and Self-Haul Waste Streams Composition; Construction, Demolition, and Land Clearing Waste Composition.*

sequestration by category of solid waste were taken from EPA's WARM model (**18-50-09**) and compiled in **22-50-07**.

Emissions were calculated in Power Bi based on the emission factors and carbon sequestration of the material as well as the emissions associated with hauling the material to the landfill facilities. Transportation emissions associated with hauling waste were based on EPA's default assumption of emissions associated with 20 miles of travel plus additional emissions associated with 234 miles of travel by class-1 freight rail to landfill facilities in Arlington, OR (average distance of 254 miles from Seattle).

D8.2 Wastewater Treatment

Wastewater treatment emissions for 2022 were provided via email by the King County Wastewater Treatment Division (KCWTD) for the West Point, South, Brightwater, Carnation, and Vashon treatment plants. In 2020, KCWTD's changed their reporting process for wastewater emissions to account for fugitive emissions more accurately per the 2019 IPCC Guidelines. KCWTD provided a summed emission total for all treatment sites for previous years. When data for inventory years was not present, a linear interpolation derived emission values for missing years.

The new methodology included CH_4 and N_2O emissions from the wastewater treatment process and removed the emissions from the incomplete combustion of CH_4 from flares as detailed in **Table 7.**

Table 7: KCWTD Revised Methodology per 2019 IPCC Guidelines

Source	**Description**	**2019 IPCC Guidelines**
Biogas scrubber water	Methane released (CH_4 slip) when scrubber water is discharged in the primary effluent distribution channel	-
Incomplete combustion in flares	Release of methane (CH_4) due to combustion efficiency < 100%	Removed
N_2O (aeration)	Nitrous oxide (N_2O) produced during the wastewater treatment process	Revised
Digestion Cover Gap CH_4	Release of methane (CH_4) due to gap in digester covers	-
CH_4 from receiving water body	Release of methane (CH_4) in receiving water bodies	Added
N_2O from receiving water body	Release of nitrous oxide (N_2O) in receiving water bodies	Added

D8.3 Uncertainty

Uncertainty in waste management emissions include estimates of methane release based on waste composition and methane release collection efficiencies over time (including for the future, which would affect methane emissions from waste generated in 2022). There is some uncertainty in both values, although the impact on total Seattle emissions is likely to be relatively small due to the miniscule overall contribution of this source. Wastewater treatment uncertainty includes methane capture rate, which is likely uncertain, although applied to a small portion of emissions.

D8.4 Data Needs

Due to SPU's periodic reporting of updated waste composition studies and annual total tonnage, there are no outstanding data needs from this sector.

D9: Industry

As a part of the EPA's Greenhouse Gas Reporting Program (GHGRP), the EPA requires mandatory reporting for commercial and industrial facilities that emit over 25,000 $mtCO_2e$ annually[35]. This reporting from the EPA is the source for some of the categories outlined in the Industry Sector.

Of the six EPA Large Emitters Industrial Facilities, four (Ardagh Glass, Ash Grove Cement, NuCor Steel, and CertainTeed Gypsum) are located in the Duwamish Valley. The other two not within the Duwamish valley are the University of Washington in the University District and CenTrio Steam in downtown.

Due to a history of industrial-related pollution, the Duwamish Valley has been designated a EPA superfund site and the surrounding areas remain disproportionately exposed to higher health risks. Seattle's Duwamish Valley Program (DVP) was created to address inequities in the Duwamish Valley through principals designed for environmental justice and equitable outcomes[36].

9.1 Cement

A majority of industrial emissions stem from the creation of cement, which is made by heating a mixture of limestone, clay, and several other materials to create a mixture vital for construction and urban development. Process emissions from cement are released in one of two ways: from the energy needed to heat the mixture and from the chemical reaction of limestone ($CaCO_3$) to lime (CaO) when the mixture is heated[37]. Recently, the U.S. cement industry has faced restricted growth due to closed or idle plants, underutilized capacity, and relatively inexpensive imports[38].

9.2 Steel & Glass

Emissions for both Steel and Glass are self-reported in EPA's Large Emitters Database for 2010 through 2022. Steel emissions are from Seattle's predominant manufacturer, Nucor (an electric arc furnace that produces crude steel). Glass operations emissions are from manufacturing at Seattle's Ardagh Glass (formerly Saint-Gobain Containers).

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[35] EPA FLIGHT, Facility Level GHG Emissions Data

[36] Seattle's Duwamish Valley Program, *Duwamish Valley Action Plan*, June 2018.

[37] IPCC, Industrial Process Sector, *CO2 Emissions from Cement Production*

[38] U.S. Geological Survey, *Mineral Commodity Summaries: Cement*, January 2022.

9.3 Fugitive SF_6 Emissions
City Light provided provisional fugitive SF_6 emissions for 2022 via internal communication.

9.4 Fugitive Methane Emissions
Fugitive methane emissions were taken from PSE's *2022 Greenhouse Gas Inventory* and PSE's *Natural Gas Utility Operating Statistics* report.

9.5 Uncertainty
Uncertainty is relatively high for all categories of process and fugitive emissions, particularly for steel production. There is significant variability in reported process emissions between years, much of which can be attributed to the emission testing methodology. Nucor manufactures several different grades of steel with unique chemistries – each of which affects emission levels – in varying quantities throughout the year. Since process emission testing occurs over a three-day period every year, the chemistry of the scrap being tested is not consistent and is likely not representative of the annual aggregate chemistry of Nucor's steel output. Additionally, Nucor's total output changes depending on the market condition.

Appendix E: Tracking Metrics

Metric Category	2008	2012	2014	2016	2018	2020	2022
Employment							
Employment	436,943	441,043	469,907	508,264	548,468	587,781	670,001
Population							
Population	593,588	635,063	668,342	704,352	744,955	735,157	749,256
Buildings: Residential & Commercial							
Building Emissions per resident (MT CO2e/resident)	2.15	1.81	1.65	1.57	1.61	1.54	1.60
Buildings Emissions (MT CO2e)	1,274,257	1,152,079	1,099,691	1,106,428	1,200,145	1,129,884	1,196,562
Commercial Electricity (MMBtu)	16,426,275	16,195,285	16,089,965	16,214,747	16,017,614	15,139,720	15,324,906
Commercial Emissions (MT CO2e)	685,118	629,230	614,492	627,436	683,329	619,678	670,409
Commercial emissions per employee (MT CO2e/employee)	1.57	1.43	1.31	1.23	1.25	1.05	1.00
Commercial emissions per resident (MT CO2e/resident)	1.15	0.99	0.92	0.89	0.92	0.84	0.89
Commercial energy per employee (MMBtu/employee)	63.33	61.25	57.19	52.75	50.40	44.41	40.35
Commercial Energy Use (MMBtu)	27,672,290	27,014,228	26,873,319	26,809,590	27,641,358	26,105,369	27,034,915
Commercial Fossil gas (MMBtu)	11,125,978	10,795,743	10,752,903	10,584,413	11,597,827	10,947,121	11,699,239
Commercial GHG intensity of energy (kg CO2e/MMBtu)	24.76	23.29	22.87	23.40	24.72	23.74	24.80
Commercial Heating oil (MMBtu)	120,038	23,200	30,451	10,430	25,917	18,528	10,770
Cooling degree days (CDD)	195.00	181.00	372.00	291.00	411.00	428.90	494.90
Energy use per capita per heat demand (GJ per capita per 1000 HDD)	6.27	5.96	6.47	6.20	5.80	5.46	4.89
Heating degree days (HDD)	5,062	4,738	3,948	3,827	4,065	4,505	5,109
Residential Electricity (MMBtu)	9,221,131	9,048,915	8,687,005	8,645,691	8,790,445	9,229,291	9,615,108
Residential Emissions (MT CO2e)	589,139	522,849	485,199	478,992	516,817	510,207	526,153
Residential emissions per resident (MT CO2e/resident)	0.99	0.82	0.73	0.68	0.69	0.69	0.70
Residential energy per resident (MMBtu/resident)	31.74	28.26	25.55	23.71	23.56	24.62	24.96
Residential Energy use (MMBtu)	18,841,311	17,948,088	17,077,941	16,699,192	17,550,683	18,097,594	18,702,025
Residential Fossil gas (MMBtu)	8,148,439	7,927,928	7,539,972	7,220,722	7,985,580	8,045,041	8,432,626
Residential GHG intensity of energy (kg CO2e/MMBtu)	31.27	29.13	28.41	28.68	29.45	28.19	28.13
Residential Heating oil (MMBtu)	1,471,740	971,245	850,964	832,780	774,659	823,262	654,290

Metric Category	2008	2012	2014	2016	2018	2020	2022
Total Buildings GHG intensity of energy (kg CO2e/MMBtu)	56.03	52.42	51.28	52.09	54.17	51.93	52.93
Total energy per degree day (MMBtu/DD)	8,847.94	9,140.54	10,173.90	10,565.51	10,096.52	8,959.58	8,161.48
Total energy use (residential + commercial) (MMBtu)	46,513,601	44,962,315	43,951,260	43,508,782	45,192,041	44,202,963	45,736,940
Transportation							
Emissions per mile (kgCO2e/VMT)	0.49	0.48	0.45	0.44	0.44	0.43	0.41
Freight emissions per person (MT CO2e/resident)	0.45	0.42	0.40	0.39	0.40	0.33	0.34
Freight truck emissions per mile (kgCO2e/VMT)	1.03	1.02	1.00	0.98	1.03	1.02	0.98
Freight Truck VMT (miles)	260,986,760	260,016,132	268,634,819	282,620,955	288,895,572	237,899,373	258,855,985
Freight Truck VMT/person (miles/resident)	439.68	409.43	401.94	401.25	387.80	323.60	345.48
Passenger emissions per mile (kgCO2e/VMT)	0.45	0.44	0.42	0.40	0.41	0.40	0.38
Passenger emissions per person (MT CO2e/resident)	2.92	2.66	2.52	2.41	2.36	1.92	1.95
Passenger VMT (miles)	3,863,722,736	3,849,921,650	4,026,978,273	4,235,706,512	4,330,675,875	3,571,760,230	3,875,151,593
Passenger VMT/person (miles/resident)	6,509.10	6,062.27	6,025.33	6,013.62	5,813.34	4,858.50	5,172.00
Road Emissions (MT CO2e)	2,002,996	1,955,669	1,954,369	1,974,336	2,053,053	1,653,962	1,714,811
Road Emissions per person (MT CO2e/resident)	3.37	3.08	2.92	2.80	2.76	2.25	2.29
VMT (miles)	4,124,709,496	4,109,937,783	4,295,613,093	4,518,327,468	4,619,571,447	3,809,659,602	4,134,007,578
VMT per resident (miles/resident)	6,948.78	6,471.70	6,427.27	6,414.87	6,201.14	5,182.10	5,517.48
Waste Management							
Emissions per ton disposed (MT CO2e/ton)	0.80	0.75	0.77	0.74	0.69	0.54	0.55
Nonresidential waste (tons)	267,676	204,562	197,304	203,844	238,836	207,211	233,085
Nonresidential Waste Emissions per resident (MT CO2e/resident)	0.11	0.08	0.08	0.06	0.06	0.05	0.05
Nonresidential waste per resident (tons/employee)	0.61	0.46	0.42	0.40	0.44	0.35	0.35
Residential waste (tons)	127,219	111,420	112,211	103,735	107,485	119,903	126,365
Residential Waste Emissions per resident (MT CO2e/resident)	0.07	0.05	0.05	0.05	0.04	0.04	0.04
Residential waste per resident (tons/resident)	0.21	0.18	0.17	0.15	0.14	0.16	0.17
Waste Emissions (MT CO2e)	101,225	83,317	86,941	76,409	74,461	65,276	69,812
Waste Emissions per resident (MT CO2e/resident)	0.17	0.13	0.13	0.11	0.10	0.09	0.09