2018 Community Greenhouse Gas Emissions Inventory

Seattle

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Updated Jan 2021 with minor error corrections to population figures in Tables 1 and 2.

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Dear Friends and Partners,

2020 has been a year of reckoning in many ways. We are in the midst of a massive global health crisis and the devastating economic impacts that have resulted from our efforts to contain COVID-19. Across the nation people have taken to the streets to fight for racial justice – demanding that their voices be heard and governments respond. Climate change brought us the most damaging western wildfire season in recent history, including dangerous smoke that smothered our region for weeks, along with a record-breaking hurricane season where tropical cyclones formed and accelerated in intensity at a record rate. Both resulted in millions of dollars in damage and loss of life that is disproportionately borne by Black, Indigenous, and People of Color (BIPOC) communities.

Our social, economic, and health crisis are intertwined, and climate change is the threat multiplier in all cases. **We cannot solve our problems in a singular fashion and we cannot heal our communities and our planet without accounting for climate change**. Government at all levels must take bold action now to help slow down the rate of climate change.

Like many large cities, Seattle conducts GHG emissions inventories to better understand the scope and scale of our climate pollution and help identify where the challenges and opportunities are for the greatest impact. This most recent inventory includes data up through 2018 and is a sobering wake up call for us. We continue to be far away from our goals and have started trending in the wrong direction. Seattle's core GHG emissions have increased 1.1% since our last report, and emissions from the building sector increased over 8%. It is urgent that we take action now to accelerate the pace of future emissions reductions.

Even more troubling is the knowledge that the health, environmental, and economic burdens of climate change are unfairly borne by our BIPOC neighbors. In Seattle's South Park neighborhood, home to a majority of BIPOC residents, life expectancy is a full 13 years shorter than Seattle's Laurelhurst neighborhood, a predominantly white, wealthy neighborhood.[1] BIPOC residents also have higher rates of asthma and other cardiovascular and pulmonary conditions that are known to be caused by hazardous air pollution. We must not accept these disparities as something we are powerless to address.

This report shows us where our shortcomings are, and where we must focus as a City to best heal and fight the climate crisis. Fossil fuel extraction and consumption is the single-largest contributor to climate change, harmful air pollution, and environmental degradation, approximately two-thirds of which come from transportation. If we are to realize a city where every resident has the opportunity to thrive, we need to transition away from fossil fuels. We must embrace solutions that disrupt the status quo when it comes to building construction and management, as well as new transportation policies that prioritize transit and the electrification of vehicles that move people, goods, and services throughout our City.

We're ready to do the hard work and are counting on your support.

Sincerely,

Jessica Finn Coven, Director
Seattle Office of Sustainability & Environment

[1] Gould L., Cummings BJ. *Duwamish Valley Cumulative Health Impacts Analysis.* Seattle WA: Just Health Action and Duwamish River Cleanup Coalition/Technical Advisory Group. March 2013. (pg 38)

Introduction and Context

The Role of an Inventory in Equity-Centered Climate Action

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

Seattle's historical climate leadership has resulted in progressive energy efficiency policies and a robust public transit network which in turn has helped us achieve one of the lowest per-capita emissions rates compared to North American peer cities. What this shows is that our climate actions started us off in the right direction. However, as our population and economy continue to grow, we need a greater degree of reductions to achieve our climate goals. Subsequent climate emissions reductions will have to come primarily from eliminating fossil fuel use through electrifying our buildings and vehicles.

While this inventory provides us 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. Climate change is a racial justice issue. Seattle's increasing consumption of fossil gas is harming our Black, Indigenous, or People of Color (BIPOC) communities who unequally bear the burden of climate change, air pollution, and environmental degradation.

BIPOC communities in the U.S are more concerned than whites about climate change[2], yet historically, environmental decisions on policy, communications and programming have been siloed and within a vacuum made by those with race and class privilege. It is therefore imperative that we center this context when analyzing the results of this inventory and prioritize partnering with BIPOC communities to shape equitable climate policy for the City.

ICLEI and Scope of Emissions

The Local Governments for Sustainability (ICLEI), is an international organization of local governments and national and regional local government organizations that have made a commitment to sustainable development. The ICLEI USA's 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 greenhouse gas emissions measurably and systematically.[3] This greenhouse gas inventory follows the national standards set forth by ICLEI USA for a community-scale GHG emissions inventory. These standards make it easier for the City of Seattle to compare our emissions with other cities and past inventories.[4]

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

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

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

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.

Core Emissions

Sectors	Subsectors	Categories
Transportation	Road: Passenger and Trucks	Buses, Cars, Light/Medium/Heavy Duty Trucks
Buildings	Residential, Commercial	Seattle City Light, Puget Sound Energy, Enwave Steam, UW Steam, Heating Oil
Waste	Residential, Commercial, Self-haul	All waste materials
Offsets	Residential, Commercial	Seattle City Light

Expanded Emissions

Sectors	Subsectors	Categories
Transportation	Marine, Rail, Air	Hotelling, Pleasure Craft, Other Boat Traffic, Freight & Passenger Rail, State Ferries, King County Airport, Sea-Tac Airport
Buildings	Residential, Commercial	Yard Equipment, Commercial Equipment
Industry	Energy Use, Fugitive Gases, Process	Industrial Equipment, Seattle City Light, Puget Sound Energy, Heating Oil, Steel, Glass, Cement
Waste	Construction & Demolition, Wastewater	All waste materials, Fugitive Gases from Wastewater
Sequestration[5]	Residential, Commercial, Self-haul	All waste materials
Offsets	Industrial	Seattle City Light

[5] 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.

Data Source Considerations

The data collected and analyzed to create this inventory vary greatly in their accuracy and granularity. Some data sources – measured building energy use, for example – provide a much more accurate resulting picture of emissions, whereas other sources like modeled road transportation VMT (vehicle miles traveled) might not account for the rapid rise to prominence of transportation network companies (TNCs) like Uber and Lyft, thereby presenting an incomplete emissions picture. As we evaluate emissions trends with an eye towards future policy development, it is important to keep in the mind of level of certainty we have with the data.

Emissions Category	Data source(s)	Level of certainty	Level of granularity
Core Emissions			
Buildings – Electricity & Fossil Gas	Building energy use from utilities (SCL and PSE)	**High** – exactly what buildings consume, so we are certain about their corresponding emissions	**Low**/**Med** – annual data rolled up by sector (commercial, residential)
Buildings – Steam	Fuel use from Enwave as of 2018	**High** – exactly what buildings consume, so we are certain about their corresponding emissions	**Low** – annual data, not temporal or spatial
Buildings – Fuel 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
Road Transport	2014 PSRC data model on vehicle miles traveled; fuel estimates by vehicle class	**Low**/**Med** – older modeled data that is scaled to current year using regional VMT estimates	**Low**/**Med** – data sorted by vehicle type but not temporal or spatial
Waste	SPU waste reports on tonnage and composition	**Med**/**High** – measured information direct from SPU samples and surveys	**High** – over 40 different waste stream types, but not spatial or temporal

Emissions Category	Data source(s)	Level of certainty	Level of granularity
Expanded Emissions			
Industrial Processes (steel, cement, 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
Air Transport	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
Rail Transport	Gallons of fuel, ridership miles from Amtrak, SoundTransit	**Med** – amount of fuel used per gallon is estimated for Amtrak but reported for SoundTransit.	**Med** – annual data, not temporal
Marine Transport	Combination of NONROAD model, Puget Sound Maritime Inventory	**Med** – data from Washington State Ferries is accurate since it is based on fuel usage. Other sources such as NONROAD data is modeled	**Med** – some granularity with types of marine traffic (pleasure craft, ferries etc.)
Non-road equipment	NONROAD modeled data, last updated in 2014 and scaled by population	**Low** – older modeled data, not measured consumption	**Med** – some granularity with types of motors and fuels

Seattle's Climate Reduction Goals and Mayor's Strategy

The Seattle 2013 Climate Action Plan aims to achieve a 58% emissions reduction by 2030 and net zero carbon by 2050. Mayor Jenny Durkan's 2018 Climate Action Strategy builds on the Climate Action Plan with some focused actions that would reduce emissions on transportation and building sectors. It does this by focusing on providing price signals that reflect the true cost of driving, incentivizing shared and

electric transportation choices, expanding charging infrastructure, and incentivizing efficient and emissions reductions in buildings.[6] Highlights from the Mayor's Strategy include:

Reducing Transportation Emissions

- Improving mobility through traffic congestion pricing
- Electric vehicle readiness for new construction ordinance
- Charging station network map & strategy
- Rideshare and taxi fleet electrification
- Green Fleet Action Plan update

GHG Emissions Assessment

- Assess GHG Emissions Impact of City decisions

Reducing Building Emissions

- Washington State tiered residential energy code
- Provide incentives for energy efficiency and emissions reductions in buildings
- Performance standards for existing commercial and multifamily buildings
- Improve municipal building energy efficiency and reduce carbon emissions 40 percent by 2025
- Oil to electric heat pump conversions in homes

The City is currently addressing both energy efficiency and building emissions through strong energy codes, incentives, and through energy benchmarking and mandatory tune-ups in existing buildings. We are seeing the positive impact of these policies on participating buildings in reduced energy use and GHG emissions. Continued action is being pursued through the following initiatives:

- *Clean Heat Program:* In partnership with the Office of Housing (OH) and Seattle City Light (SCL), the City is implementing a program to fully fund the transition from oil to clean electricity for low-income households. A tax on oil which will support the program will be delayed until September 2021, but existing funding available to OH can support approximately 25 homes through 2021.

- *Seattle Energy Code:* The first step in addressing building-related emissions is to stop increasing emissions from fossil gas in new construction. The proposed update to the Seattle Energy Code would require clean electric heating and hot water systems in new commercial and multifamily buildings.

- *Performance Standards for Existing Buildings:* Existing buildings need to be transitioned off fossil gas to have any significant emissions reductions. Consistent with the Mayor's 2018 Climate Action Strategy and building on the State's new energy performance standards which begin in 2026, OSE is developing GHG emissions standards for Seattle's existing buildings. OSE is developing a plan for technical and financial assistance to help owners improve their buildings, prioritizing those serving BIPOC communities, and identifying how the policy can provide BIPOC workers with career pathways into the clean energy field. Note: this policy is currently in development and not been publicly released. It is considered critical in order to reduce our current building emissions trends.

[6] http://www.seattle.gov/environment/climate-change/climate-planning/climate-action-plan

Many transportation efforts that maximize efficiency and reduce vehicle miles traveled are managed by Seattle's Department of Transportation (SDOT), including but not limited to the renewal of the Seattle Transit Benefit District, transit-only lanes, and the Bicycle Master Plan. In addition to these actions it is imperative that we decarbonize the transportation sector to meet our climate goals and strive to fund a more equitable public transportation system. Supportive citywide transportation initiatives include:

- *Congestion Pricing:* The City is seeking to engage community in a conversation to consider what is needed to build a more equitable transportation system, decrease traffic, reduce climate pollution, and ensure stable, progressive revenue for transit. The City has heard from community members that the Seattle needs a more robust and equitable public transportation system, particularly for people with lower incomes and BIPOC communities who have been displaced from the city core. We have also heard that traffic is getting worse, stalling our buses and making other transit modes less desirable. With input from and coordination with local partners and community members, the City hopes to explore new revenue sources that are stable and progressive; and design an equitable revenue and investment proposal that maximizes benefits to BIPOC communities.

- *Transportation Electrification:* Decarbonization of transportation is critical to meet climate goals. Even with significant reductions in vehicle miles traveled, nearly all cars, buses and trucks will need to be electrified with City Light's carbon free electricity for Seattle to be carbon neutral by 2050. As such, the City is planning for a future where everything that moves people, goods, and services in and around the City is electrified. OSE, City Light and SDOT, in partnership with other city departments, have led a citywide effort to map out a draft blueprint for Seattle to pursue and accelerate actions, policies and technologies necessary to electrify transportation at scale. This strategy establishes aggressive goals for 2030 and lays out several actions related to infrastructure, policy, mobility and workforce development that will be taken over the next two years that will move us towards the 2030 goals.

Core Emissions Changes from 2016 - 2018: Key Findings

Buildings Sector (8.1% increase)

Emissions in the buildings sector increased drastically between 2016 and 2018. The major factors contributing to the increase in building emissions are new buildings with fossil gas heating, colder winters, warmer summers, and a growing population and workforce. The emissions 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 (2.4% decrease)

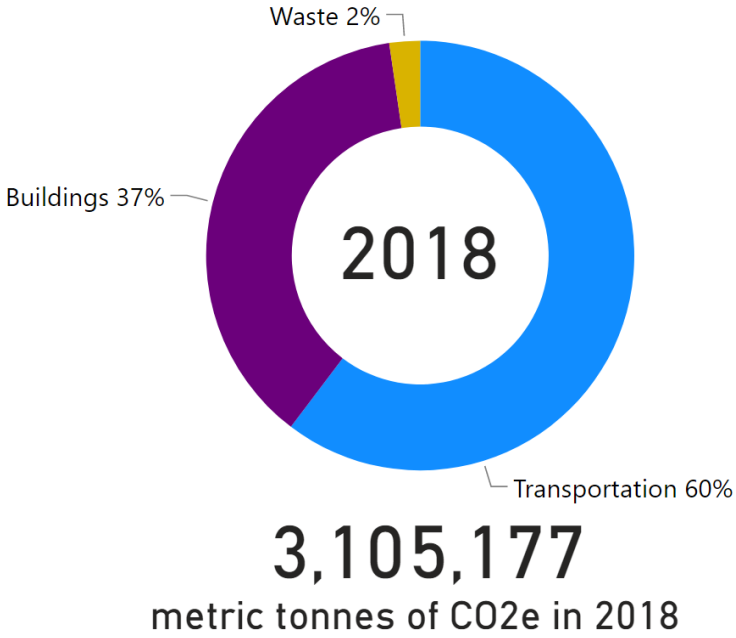
Lower passenger vehicle miles traveled (VMT) per resident and more efficient vehicles resulted in a decrease in transportation emissions. Transportation sector calculations are based on VMT data that is modeled for the whole region by PSRC and scaled for Seattle's purposes. However, there is uncertainty with these figures because the underlying data model uses a base year of 2014 which is then scaled to future years using regional VMT figures. This may mean that the data is not accounting for recent urban transportation trends such as increases in VMT from TNCs.

Waste Sector (9.4% decrease)

The major factors contributing to the reduction in waste emissions are less waste disposal and more composting and recycling. While this decrease is commendable, waste emissions account for just 2.2% of total core emissions. Waste sector emissions calculations are based on SPU's Solid Waste and Waste Composition reports for the commercial, residential, and self-haul categories.

Emissions Overview

Core GHG Emissions



Online Data Dashboard

Our GHG Inventory webpage has been updated for 2018 with interactive dashboards to view the data. Explore the data online here.

Figure 1:Seattle's core GHG emissions by sector in 2018.

Figure 1 above depicts the relative contribution of the transportation, buildings, and waste sectors to city-wide emissions. The relative contribution of these three emissions categories has remained relatively consistent since 1990, though the share attributed to buildings declined from about 40% in 1990 and 2008 to about 36% in 2016. Due to the large increase in building sector emissions in 2018, these now make up 37% of Seattle's total core emissions.

In the transportation sector we track both passenger vehicles and commercial trucks. Passenger vehicles include single- and high-occupancy cars, motorcycles, light trucks, and buses. Commercial trucks include light, medium, and heavy commercial trucks. In the building sector we track emissions from 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.

Table 1: Seattle's core emissions by category in 2018, the prior inventory year (2016) and baseline year (2008).

	2008	2016	2018	% change from 2008	% change from 2016
Population	**593,588**	**704,352**	**744,955**	**25.5%**	**5.8%**
Buildings	**1,274,000**	**1,109,000**	**1,199,000**	**-5.9%**	**8.1%**
Commercial	**684,000**	**628,000**	**683,000**	**-0.1%**	**8.8%**
Enwave Steam	91,000	70,000	68,000	-25.3%	-2.9%
Heating Oil	8,000	1,000	-	-100.0%	-100.0%
PSE	413,000	408,000	460,000	11.4%	12.7%
Seattle City Light	87,000	67,000	68,000	-21.8%	1.5%
UW Steam	85,000	82,000	87,000	2.4%	6.1%
Residential	**590,000**	**481,000**	**516,000**	**-12.5%**	**7.3%**
Heating Oil	109,000	63,000	57,000	-47.7%	-9.5%
PSE	432,000	382,000	422,000	-2.3%	10.5%
Seattle City Light	49,000	36,000	37,000	-24.5%	2.8%
Offsets	**(136,000)**	**(103,000)**	**(105,000)**	**-22.8%**	**1.9%**
Transportation	**2,001,000**	**1,985,000**	**1,937,000**	**-3.2%**	**-2.4%**
Road: Passenger	**1,712,000**	**1,687,000**	**1,640,000**	**-4.2%**	**-2.8%**
Buses	60,000	65,000	65,000	8.3%	0.0%
Cars & Light Duty Trucks	1,652,000	1,622,000	1,575,000	-4.7%	-2.9%
Road: Trucks	**289,000**	**298,000**	**297,000**	**2.8%**	**-0.3%**
Medium & Heavy Duty	289,000	298,000	297,000	2.8%	-0.3%
Waste	**96,000**	**77,000**	**70,000**	**-27.1%**	**-9.1%**
Commercial	**51,000**	**37,000**	**34,000**	**-33.3%**	**-8.1%**
Residential	**37,000**	**31,000**	**30,000**	**-18.9%**	**-3.2%**
Selfhaul	**8,000**	**9,000**	**6,000**	**-25.0%**	**-33.3%**
Total	**3,235,000**	**3,068,000**	**3,101,000**	**-4.1%**	**1.1%**
Per Capita Emissions	**5.4**	**4.4**	**4.2**	**-23.6%**	**-4.4%**

Expanded GHG Emissions

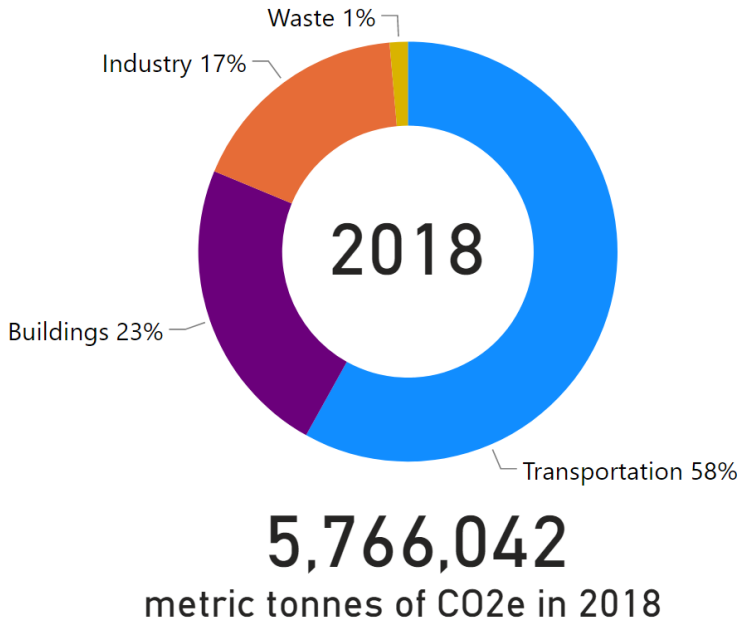


Figure 2: Seattle's expanded GHG emissions by sector in 2018.

Fifty eight percent of Seattle's Expanded GHG emissions come from transportation, 24% from buildings, 17% industry, and 1% from the waste sector. Air transport and the industrial sector together comprise of the two largest sources of expanded emissions, at around 1.3 million mt CO_2e and 1 million mt CO_2e respectively. Emissions from air transport in particular have risen over 40% since 2008 and over 9% just between 2016 and 2018.

Table 2: Seattle's expanded emissions by category in 2018, the prior inventory year (2016) and baseline year (2008).

	2008	2016	2018	% change from 2008	% change from 2016
Population	**593,588**	**704,352**	**744,955**	**25.5%**	**5.8%**
Buildings	**1,431,000**	**1,298,000**	**1,404,000**	**-1.9%**	**8.2%**
Commercial	**824,000**	**798,000**	**868,000**	**5.3%**	**8.8%**
Enwave Steam	91,000	70,000	68,000	-25.3%	-2.9%
Equipment	140,000	170,000	185,000	32.1%	8.8%
Heating Oil	8,000	1,000	-	-100.0%	-100.0%
PSE	413,000	408,000	460,000	11.4%	12.7%
Seattle City Light	87,000	67,000	68,000	-21.8%	1.5%
UW Steam	85,000	82,000	87,000	2.4%	6.1%
Residential	**607,000**	**500,000**	**536,000**	**-11.7%**	**7.2%**
Heating Oil	109,000	63,000	57,000	-47.7%	-9.5%
PSE	432,000	382,000	422,000	-2.3%	10.5%
Seattle City Light	49,000	36,000	37,000	-24.5%	2.8%
Yard Equipment	17,000	19,000	20,000	17.6%	5.3%
Industry	**1,357,000**	**1,012,000**	**1,052,000**	**-22.5%**	**4.0%**
Energy Use	**510,000**	**536,000**	**552,000**	**8.2%**	**3.0%**
Equipment	213,000	210,000	210,000	-1.4%	0.0%
Heating Oil	36,000	19,000	16,000	-55.6%	-15.8%
PSE	246,000	296,000	314,000	27.6%	6.1%
Seattle City Light	15,000	11,000	12,000	-20.0%	9.1%
Fugitive Gases	**24,000**	**20,000**	**22,000**	**-8.3%**	**10.0%**
Process	**823,000**	**456,000**	**478,000**	**-41.9%**	**4.8%**
Offsets	**(151,000)**	**(114,000)**	**(117,000)**	**-22.5%**	**2.6%**
Sequestration	**(195,000)**	**(153,000)**	**(173,000)**	**-11.3%**	**13.1%**
Transportation	**3,200,000**	**3,450,000**	**3,519,000**	**10.0%**	**2.0%**
Air	**972,000**	**1,253,000**	**1,369,000**	**40.8%**	**9.3%**
Marine	**179,000**	**180,000**	**180,000**	**0.6%**	**0.0%**
Rail	**48,000**	**32,000**	**33,000**	**-31.3%**	**3.1%**
Road: Passenger	**1,712,000**	**1,687,000**	**1,640,000**	**-4.2%**	**-2.8%**
Road: Trucks	**289,000**	**298,000**	**297,000**	**2.8%**	**-0.3%**
Waste	**109,000**	**89,000**	**79,000**	**-27.5%**	**-11.2%**
Commercial	**51,000**	**37,000**	**34,000**	**-33.3%**	**-8.1%**
Construction & Demolition	**11,000**	**10,000**	**6,000**	**-45.5%**	**-40.0%**
Residential	**37,000**	**31,000**	**30,000**	**-18.9%**	**-3.2%**
Selfhaul	**8,000**	**9,000**	**6,000**	**-25.0%**	**-33.3%**
Wastewater	**2,000**	**2,000**	**3,000**	**50.0%**	**50.0%**
Total	**5,751,000**	**5,582,000**	**5,764,000**	**0.2%**	**3.3%**
Per Capita Emissions	**9.7**	**7.9**	**7.7**	**-20.1%**	**-2.4%**

GDP, Population, and Emissions

Since 2008, Seattle Gross Domestic Product (GDP) and population have grown dramatically in unison with one another. GDP increased 41.4% from 2008 to 2018. Population increased 25.5% from 2008 to 2018. Core emissions have continually decreased inversely with GDP and population growth until 2018. 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 are 0.2% greater than 2008 GHG emission levels.

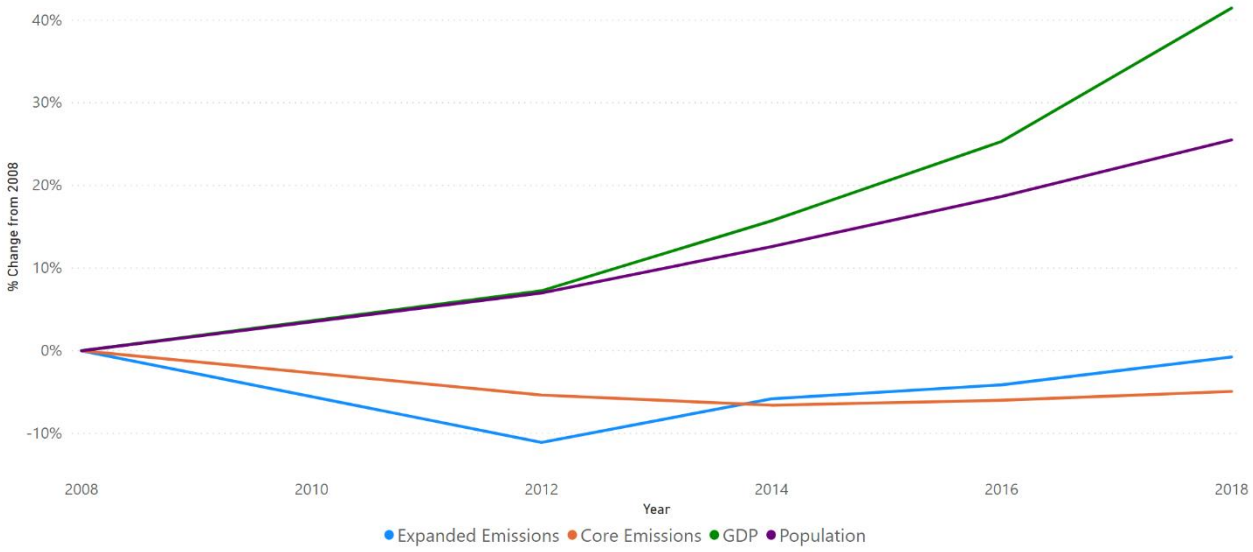


Figure 3: GDP, population and emissions trends in Seattle from 2008 to 2018.

Detailed Emissions

Per Capita Core GHG Emissions Drivers

Per capita emissions have continued to decrease since 2008 demonstrating that we are achieving efficiencies in energy use and vehicle fuel consumption. Core per capita GHG emissions decreased from 5.5 $mtCO_2e$ per resident in 2016 to 4.2 $mtCO_2e$ per resident in 2018. The waterfall (Figure 4) shows the various factors contributing to the overall decrease in per capita emissions. The greatest reductions in per capita GHG emissions can be attributed to more efficient passenger vehicles, lower passenger vehicle travel, and warmer weather.

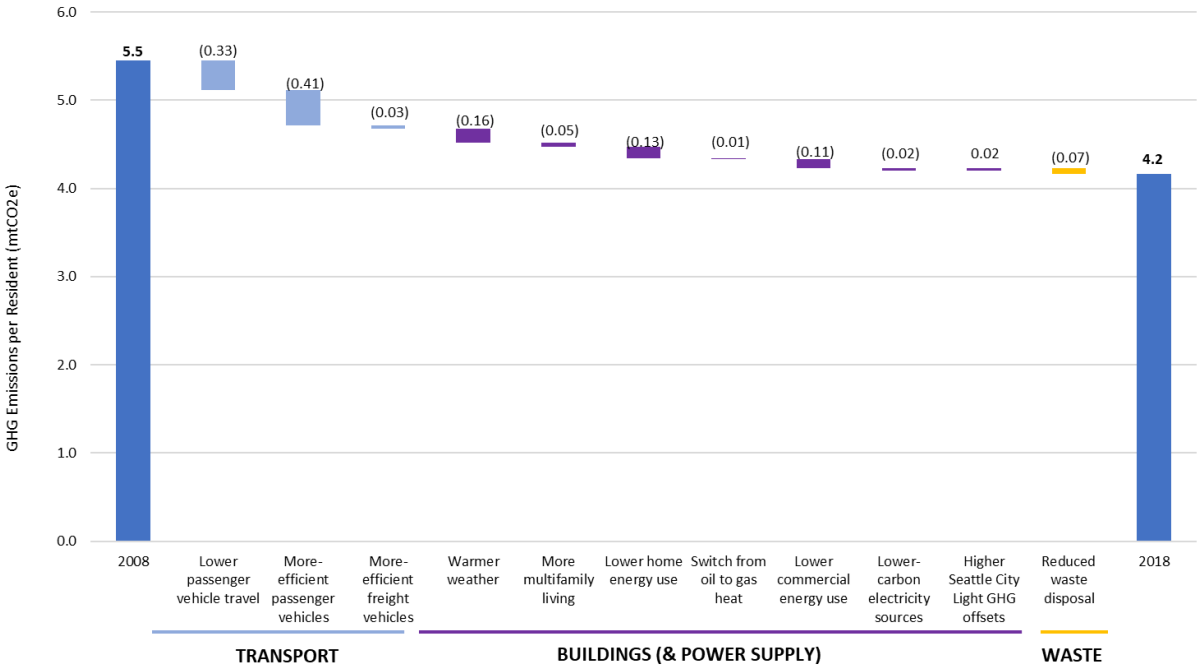


Figure 4: Factors contributing to a change in per capita core emissions between 2008 and 2018.

Overall Expanded GHG Emissions Drivers

The expanded (excluding sequestration) GHG emissions for Seattle stayed relatively the same – about 5.94 million $mtCO_2e$ – between 2008 and 2018.

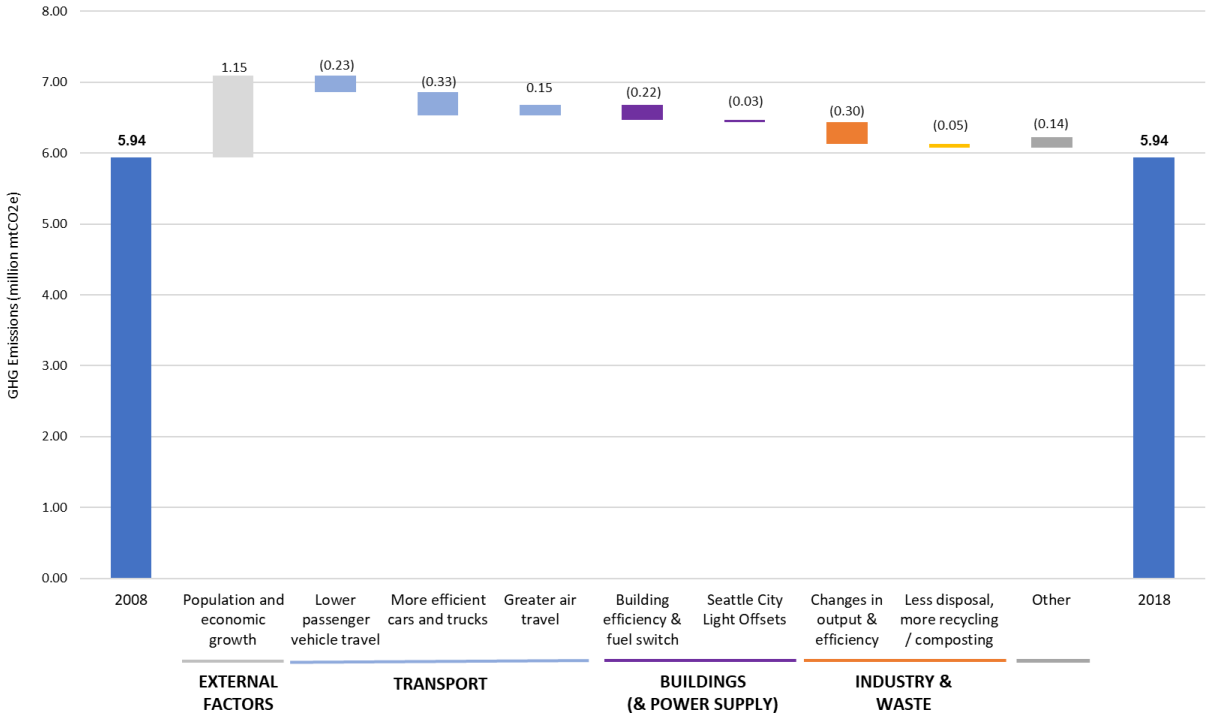


Figure 5: Factors contributing to changes in overall expanded emissions between 2008 and 2018.

Figure 5 above shows that the greatest contributors to GHG emission increases in Seattle came from population, economic growth, and greater air travel. Population and economic growth alone contributed 840,000 $mtCO_2e$ between 2008 and 2018.

Transportation Emissions

In the transportation sector, core emissions decreased around 3% since 2008 – from 2 million $mtCO_2e$ in 2008 to 1.94 million $mtCO_2e$ in 2018. Road transportation has been the largest category 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 changes in the fuel economy of vehicles and changes in miles traveled. Advances in vehicle technology have increased the average fuel economy for cars and light-duty trucks (including SUVs) in Seattle from about 20 miles per gallon of fuel in 2008 to about 23.6 miles per gallon in 2018.

It is important to note that while the methodology for calculating road transportation emissions has remained consistent, it is still based on modeled data (see the Methodology section on Road Transportation for more details), which carries a higher level of uncertainty compared to emissions from the building sector which are based on actual measured energy consumption.

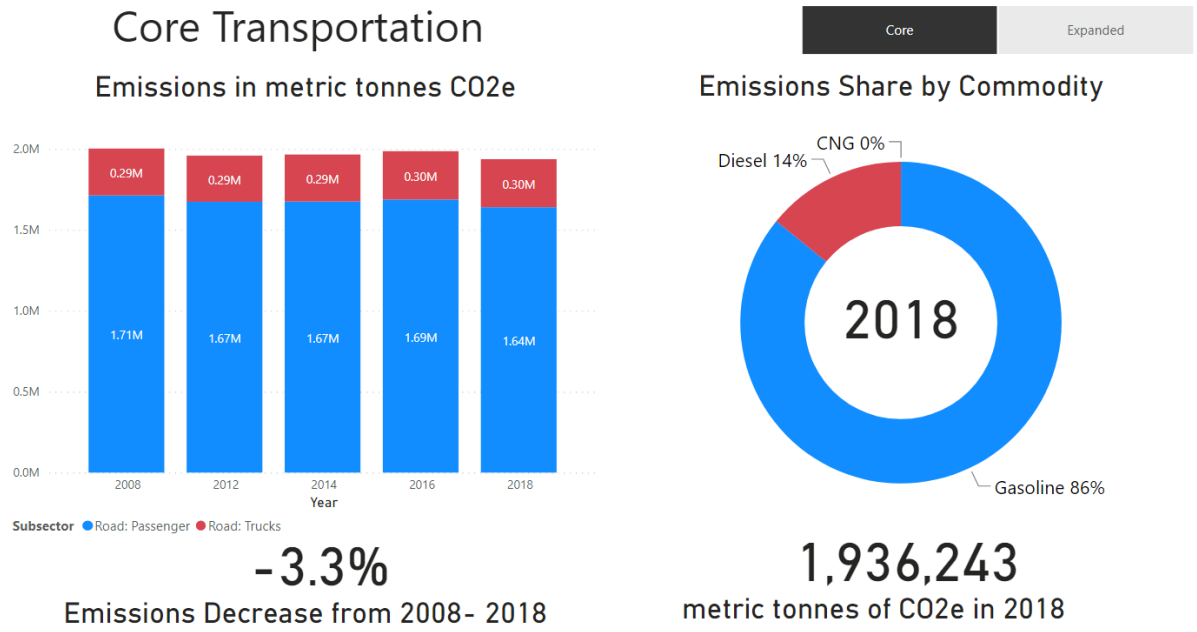


Figure 6: Core road transportation emissions by vehicle category and fuel type.

Expanded GHG emissions increased almost 10% since 2008, with most of the increase attributed to greater air travel. Air transport emissions increased by 40% from 972 thousand $mtCO_2e$ to 1.37 million $mtCO_2e$ in 2018.

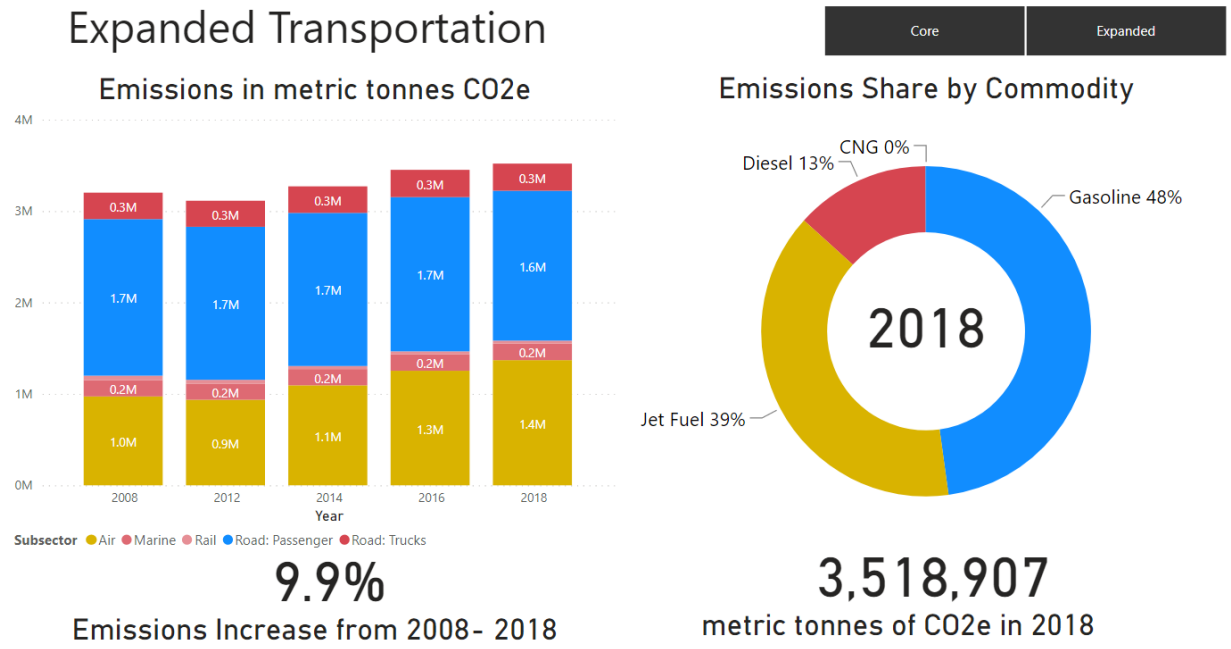


Figure 7: Expanded transportation emissions by category and fuel type.

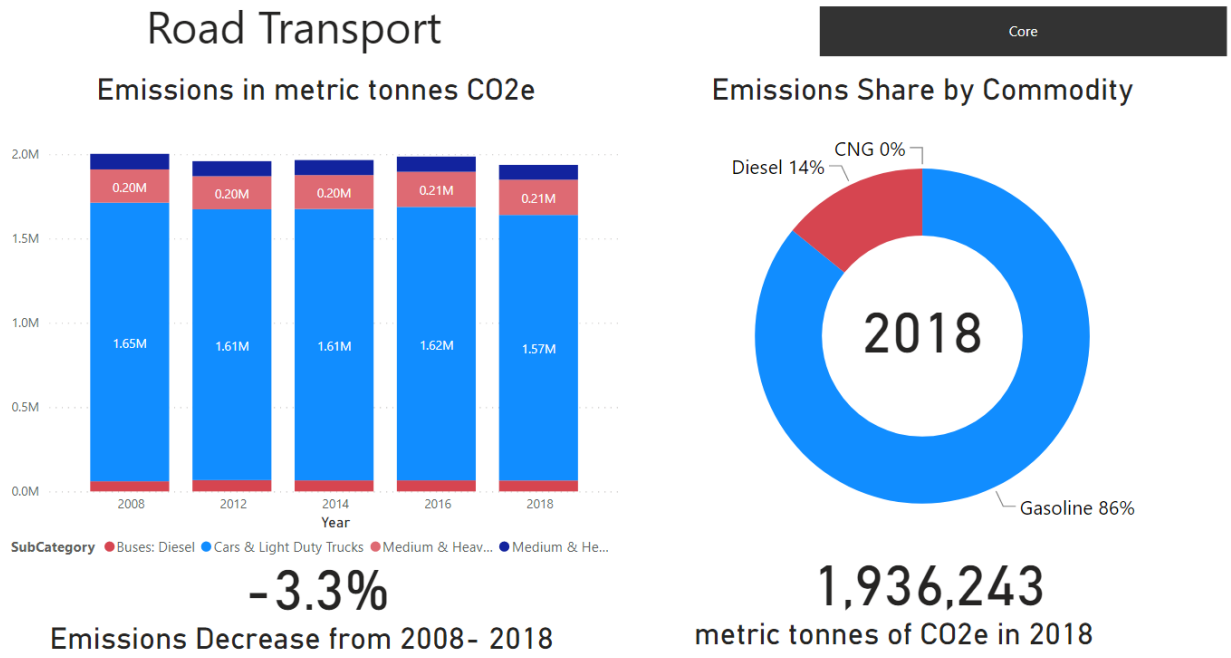


Figure 8: Expanded road transportation emissions by vehicle category and fuel type.

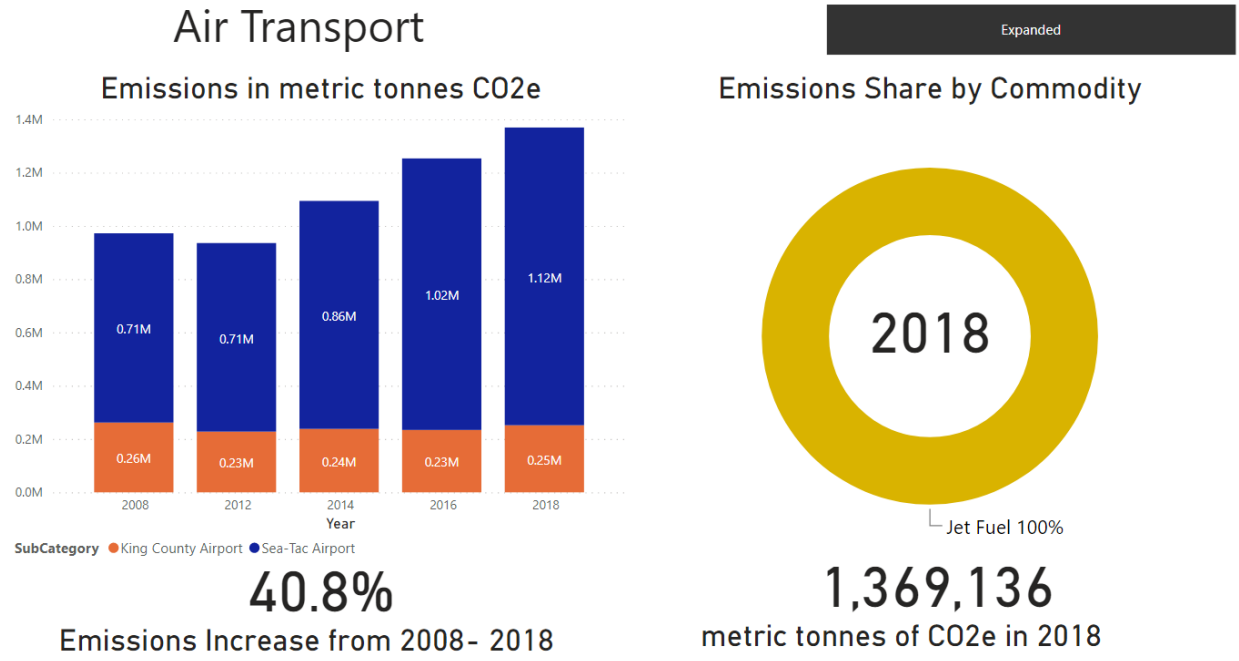


Figure 9: Air transportation emissions by source.

Buildings Emissions

In the buildings sector, core GHG emissions decreased 5.9% since 2008 – from 1.27 million $mtCO_2e$ to 1.19 million $mtCO_2e$ in 2018. Expanded building sector emissions decreased 1.9% since 2008 – from 1.43 million $mtCO_2e$ in 2008 to 1.40 million $mtCO_2e$ in 2018. However, both core and expanded building sector emissions increased by about 8% between 2016 and 2018, primarily as a result of an increase in fossil gas use.

About 90% of the electricity that Seattle City Light (SCL) provides to consumers in Seattle comes from low-carbon hydroelectric dams. SCL purchases high-quality local carbon offsets equal to the greenhouse gas emissions resulting from all other aspects of SCL'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, SCL's external power purchases and the consequent amount of carbon offsets purchases varies annually. This is why there are significant annual fluctuations in the pre-offset emissions attributable to our electricity use, even if electricity consumption is trending down. Electricity, while continuing to be the largest source of energy for Seattle's buildings (54%), is responsible for only 9% of emissions in this sector before offsets. Fossil gas is currently responsible for 86% of building sector emissions, none of which are offset.

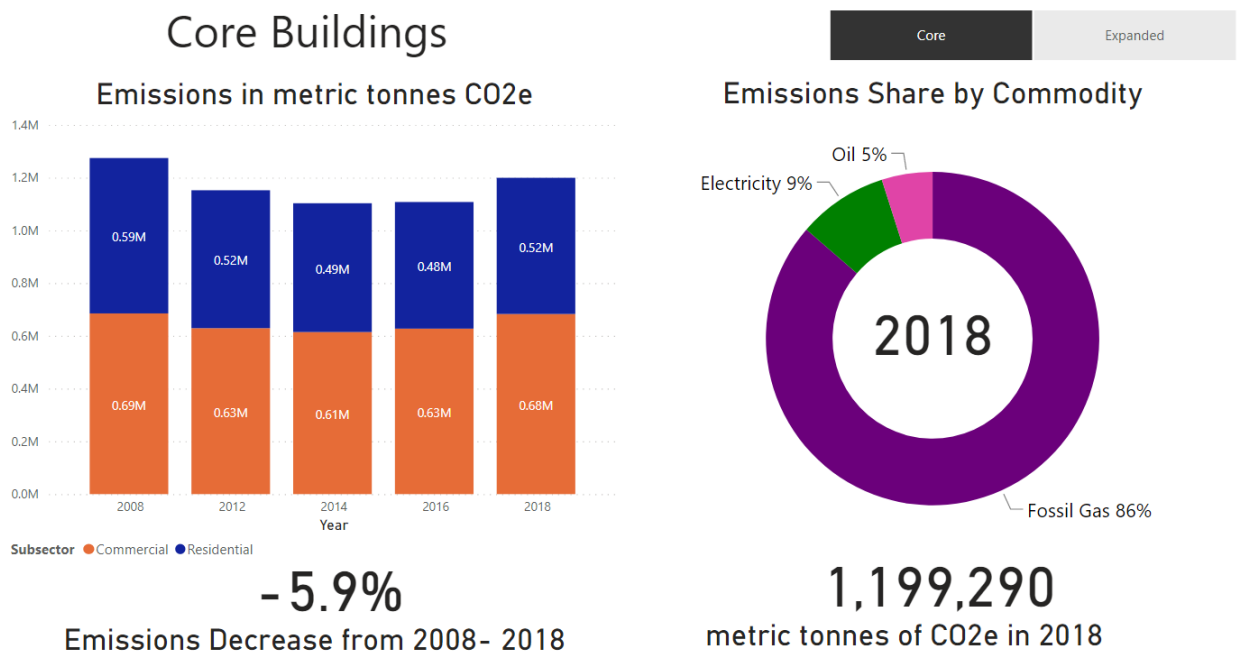


Figure 10: Core buildings emissions by subsector and fuel type.

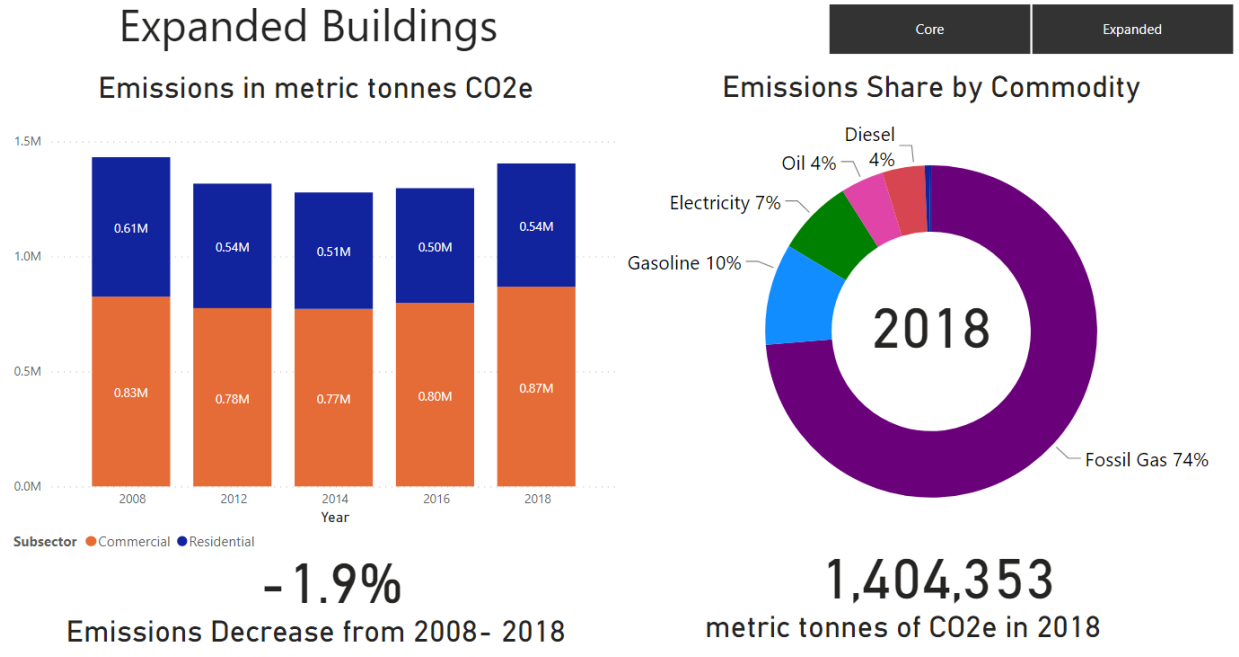


Figure 11: Expanded buildings emissions by subsector and fuel type.

Residential GHG emissions from PSE fossil gas decreased by about 2.2% between 2008 and 2018. In comparison, the commercial GHG emissions from fossil gas has increased by 4% over the same period.

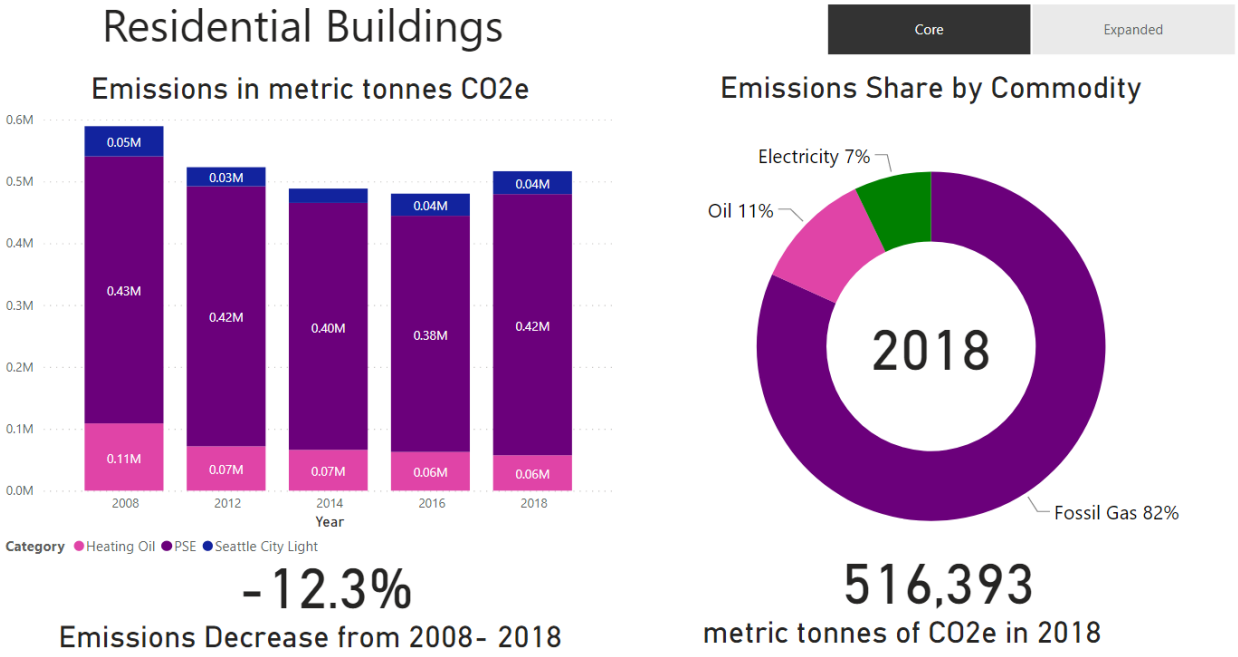


Figure 12: Core residential building emissions by source and fuel type.

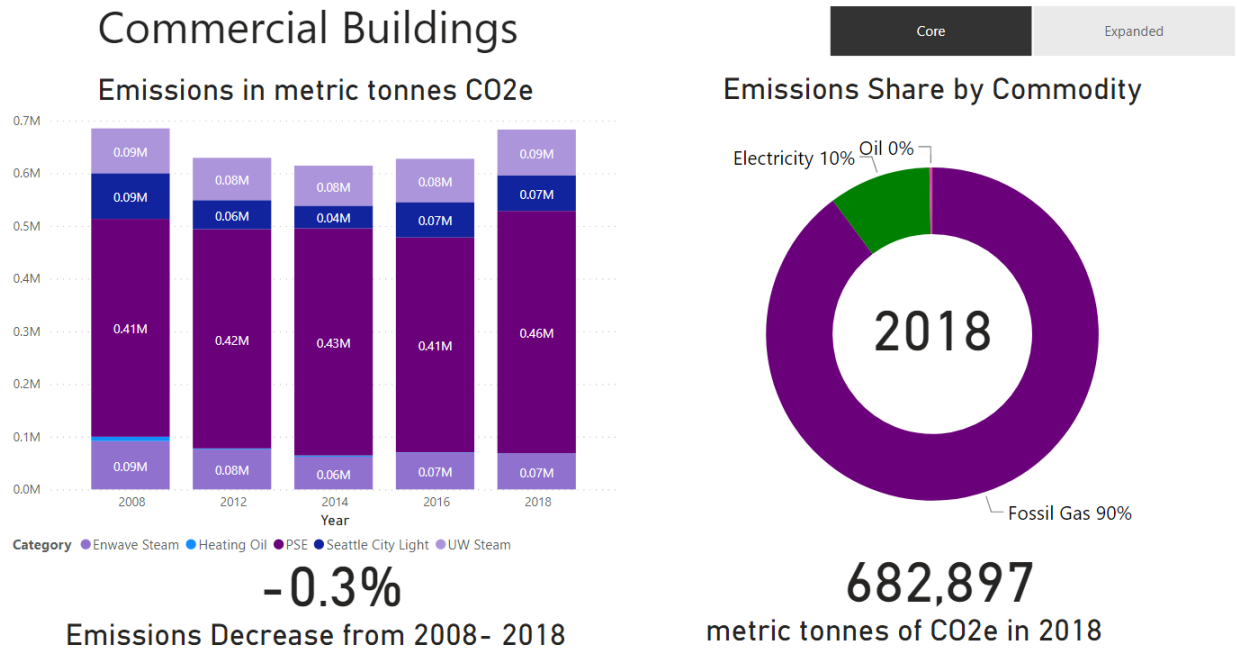


Figure 13: Core commercial building emissions by source and fuel type.

Industry Emissions

Industry emissions decreased 22.6% since 2008- from 1.36 million mtCO2e in 2008 to 1.05 million mtCO2e in 2018. This decrease in process emissions was largely due to reduction in cement process emissions which was halved since 2008. Meanwhile fossil gas use has increased 24.9% since 2008 from .27 to .33 million mtCO2e.

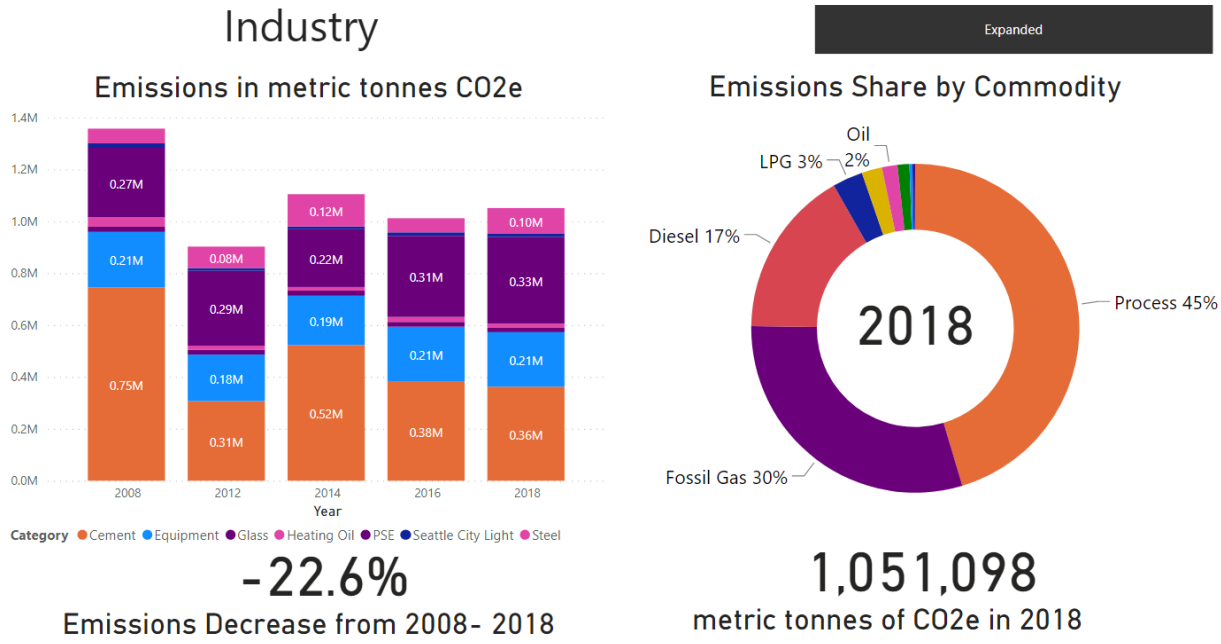


Figure 14: Industrial sector emissions by source and fuel type.

Waste Emissions

In the waste sector, core emissions decreased 25.6% since 2008- from 100 thousand $mtCO_2e$ to 74.42 thousand $mtCO_2e$ in 2018. Expanded GHG emissions decreased 26.5% since 2008- from 115,675 $mtCO_2e$ in 2008 to 84,958 $mtCO_2e$ in 2018. The waste emissions decrease is due to less waste disposal and more composting and recycling. This decline in waste disposal has remained consistent over the years for the residential, commercial, self-haul, and construction & demolition subsectors.

One important thing to note is that our GHG emissions inventory only records gross emissions in order to follow the ICLEI GHG Accounting protocol. As a result, the benefits of waste diversion such as composting and recycling are not considered, and our inventory may underestimate the GHG emissions reductions in the waste sector due to these diversion programs. Recycling and composting may reduce life cycle GHG emissions not accounted for in this inventory by reducing the need for extraction of raw materials. The consumption-based inventory more accurately measures the full lifecycle GHG emissions of materials consumed by the Seattle community than this geographic-based emissions inventory.[7] The geographic-based inventory only measures the lifetime GHG emissions that would be emitted by waste disposed of during the year of the report.

[7] See Appendix section on consumption-based emissions.

Landfills create GHG emissions through the decomposition process of organic materials through aerobic and anaerobic bacteria. Aerobic bacteria initially break down organic matter and release CO_2, and anaerobic bacteria further break them down once oxygen has been depleted. The fermentation process produces a biogas that consists of 50 percent carbon dioxide and methane. This inventory counts only non-biogenic CO_2 emissions (biogenic meaning organic materials), and thus, this inventory may undercount the emissions from the waste sector.[8]

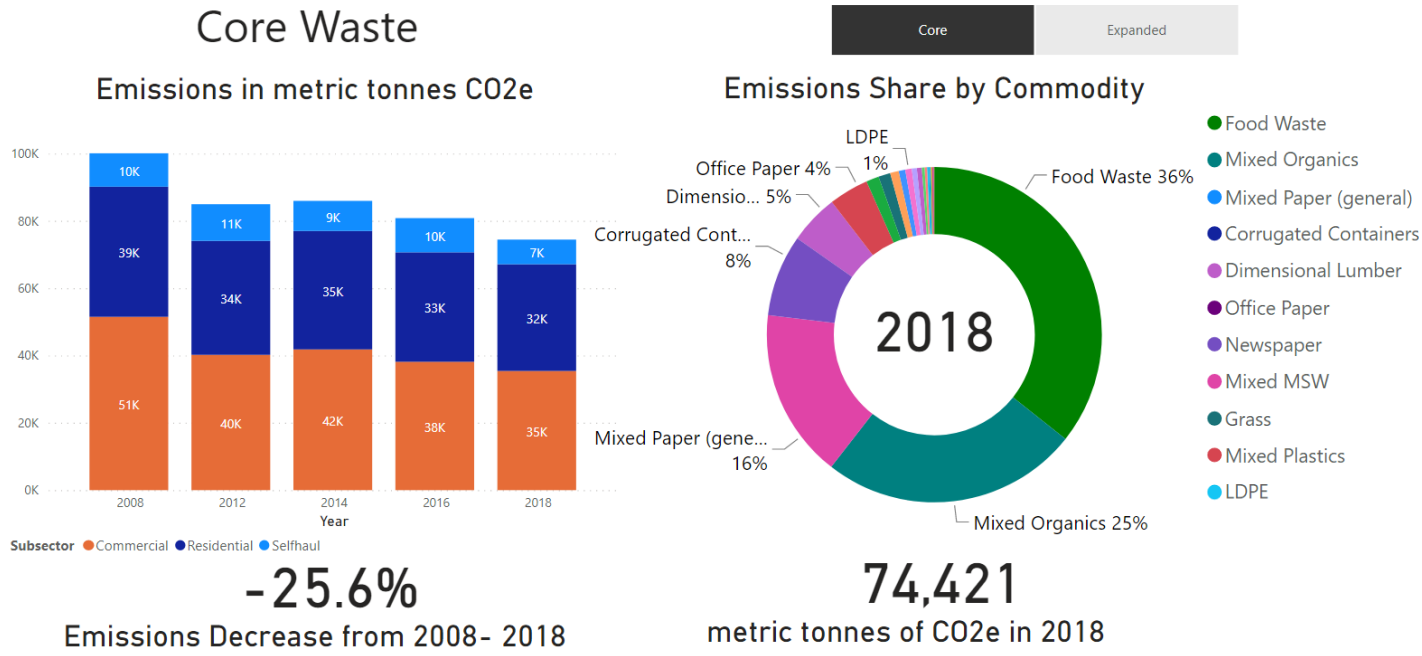


Figure 15: Core waste emissions by sub-sector and material type.

[8] ICLEI Community Protocol Appendix E- Solid Waste

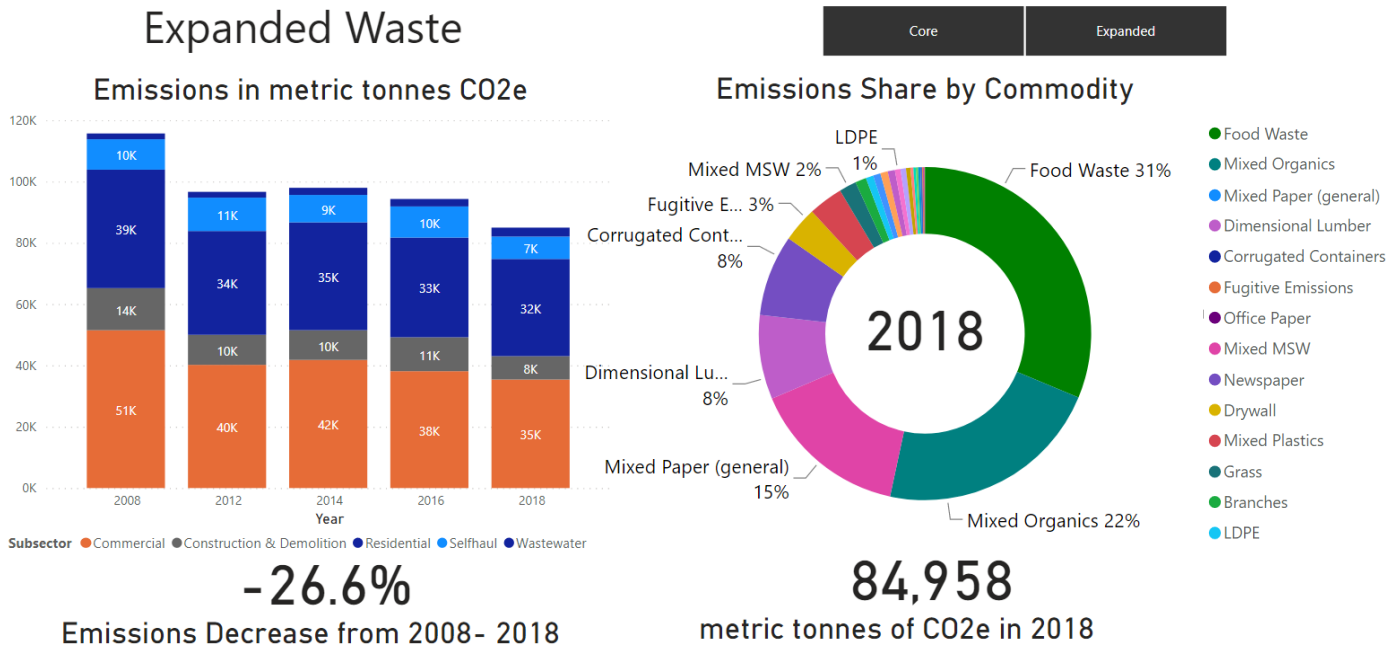


Figure 16: Expanded waste emissions by sub-sector and material type.

Appendices

Consumption-based Emissions

A consumption-based inventory accounts for the GHG emissions associated with the goods and services consumed within the community. 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 by their community contributes as a root driver of greenhouse gas emissions on a global scale. While the City does not typically conduct a full-fledged consumption-based inventory, this section contains a preliminary estimate based on already existing information such as King County's consumption-based inventory and U.C. Berkeley's CoolClimate Calculator.

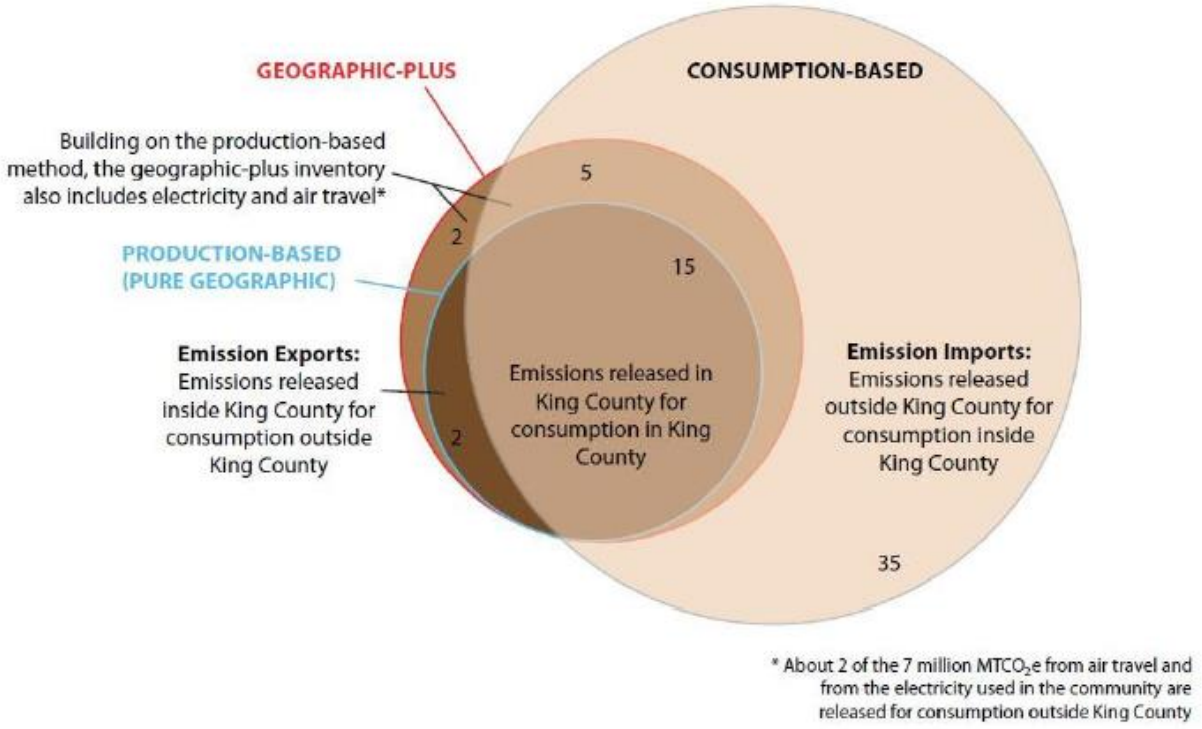


Figure 17: Comparison of King County, Washington GHG Inventories. The numbers in the circles indicate emissions in $mtCO_2e$.[9]

Figure 3 compares the scope of the community-wide or "geographic-plus" and the consumption-based GHG inventory in King County. The consumption-based inventory captures additional and different ways that Seattle residents contribute to the climate crisis.

Consumption-based reporting relies on assembling data on activities and GHG-intensity estimates for those activities. For an estimate of Seattle's consumption-based inventory we utilize the CoolClimate Calculator which is a consumption-based carbon footprint model developed by U.C. Berkley. It provides an instantaneous estimate of average household carbon footprints for essentially every populated zip code, city, county, and state in the United States. This model assumes 22 miles per gallon per

[9] ICLEI U.S. Community Protocol Appendix I

vehicle and average U.S. diets for each household. The CoolClimate Calculator is only populated with consumption data for calendar year 2008 which is a big flaw as consumer consumption has likely changed dramatically within the past decade.[10] Additionally, the Calculator does not account for Seattle's local electricity grid being carbon neutral. Other methods for estimated consumption-based emissions utilize more expensive and time-consuming household collection survey or customized economic models.

To estimate household consumption-based emissions for Seattle, the average carbon footprint was taken for each good category. The calculator estimates total household average emissions to be 46.43 $mtCO_2e$. Multiplying this number by the number of Seattle households (323,446 households, obtained from the 2018 5-year American Community Survey) gives us an estimate for total consumption-based emissions in Seattle of 15 million $mtCO_2e$.

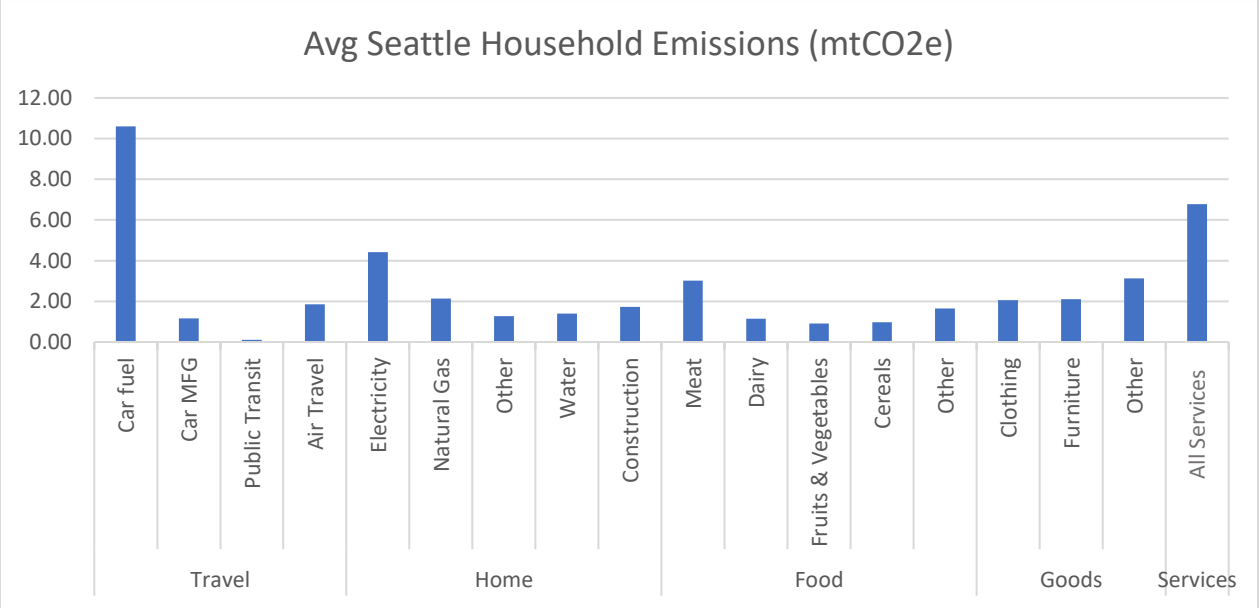


Figure 18: Average Seattle Household Emissions by Category. Note that the emissions associated with Electricity is likely inaccurate in this estimate since it does not account for our carbon-neutral grid.

[10] https://pubs.acs.org/doi/suppl/10.1021/es4034364

Data Model Change

The Seattle GHG inventory has 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 <CityInputEmissionsMaster>.

Emissions Calculations – All of 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 2018 inventory remains the same as the 2016 GHG inventory.

Source Documentation

The formal inventory is a dataset consisting of electronic files. These data files are divided into the following categories:

Index file – A single index file, <Community dataset index 2018.xlsx>, lists names, descriptions, and sources of all other files in the inventory.

Source files – These files are numbered 18-00-00 to 18-80-00. The files are organized by category in the following format, with 'YR' indicating the 2-digit year that the inventory files correspond 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

In addition, some source files from prior inventory work in Seattle are referenced in <CityofSeattleEmissionsInputMaster>. 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).

Methodology & Source Notes

Road Transportation

This inventory employs a method that counts emissions from all trips that occur entirely within Seattle, half of trips that either begin or end in the city, and no trips that both begin and end outside the city (even if they pass through the city, e.g. on I-5), known as an origin-destination pair approach. This is an increasingly common way of counting GHG emissions in community-scale inventories and was recommended in ICLEI's U.S. Community Protocol.

Road transportation emissions were predominately calculated from daily average vehicle miles traveled (VMT) modeling results provided by PSRC for cars (single-occupancy vehicles and carpools) and trucks (medium and heavy duty). To estimate VMT for 2018, PSRC's modeled VMT results for 2014 **(18-11-05)** were scaled by a ratio of 2014 total VMT on state highways in urban King County to that from 2018 provided by the Washington State Department of Transportation (**18-11-09**). WSDOT uses a consistent methodology from year to year for these roads, which carry about half of total VMT in King County and which were therefore judged to be a purer signal of changes in VMT from year to year than data provided by WSDOT to the federal Highway Performance Management System (HPMS), for which WSDOT data on state highways are supplemented with sampled data for local roads but for which uncertainty is higher and methods have changed over time.

In order to calculate emissions, annual VMT were multiplied by emissions factors derived from modeling by PSRC for King County. PSRC provided estimates of vehicle fuel efficiency for Seattle by vehicle class (cars, light trucks, etc.) for 2005 through 2018. For each vehicle category in PSRC's VMT model results (i.e. passenger 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. Finally, annual VMT were multiplied by energy intensities derived as above and fuel-specific (gasoline or diesel) carbon contents from the US EPA's national GHG inventory **(18-80-01)**. The methodology for fuel economy calculation is a simplified version of the approach taken in prior years. Previously calculated fuel economy figures have consequently been updated in the inventory.

Emissions from non-electric buses were calculated based on fuel usage for King County Metro and Sound Transit as reported to the National Transit Database **(18-11-13)**. Fuel use was scaled based on the percentage of Metro and Sound Transit miles of travel on routes serving the city of Seattle (approximately 12 million miles for routes serving Seattle out of 15 million total miles for all Sound Transit routes) **(18-11-14)**.

Uncertainty exists both in the estimates of vehicle travel (VMT) and vehicle fuel efficiency, the two primary drivers of road transport GHG emissions. Sources of uncertainty for VMT include that in PSRC's underlying model and in the scaling method used to scale PSRC's 2014 model results to 2016, 2018 and prior years based on data from WSDOT.

Air Transportation

Sea-Tac International Airport: The Port of Seattle provided data for total jet fuel distributed to aircraft at Sea-Tac Airport (**18-14-06**). The fraction of emissions attributable to Seattle was estimated through a comparison of population in the city compared to the greater Puget Sound region, from which Sea-Tac draws the majority of its passengers.

King County International Airport: King County International Airport (KCIA) provided data for jet fuel and aviation gas distributions in 2018 **(18-14-08)**. All resulting emissions are attributed to Seattle, to account for roughly 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). This approach is consistent with the origin-destination pair approach taken for road travel to and from Seattle. 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.

Uncertainty in emissions from air travel via Sea-Tac attributed to Seattle is relatively high, because even as fuel usage at the airport is well known, 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). By contrast, uncertainty in emissions at King County international airport is relatively low, as it is based directly on fuel usage data.

Rail Transportation

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 mile was estimated based on national data **(18-13-01)**. National average fuel use per mile was scaled by the number of riders on the Cascade route, as reported by Amtrak **(18-13-02)**. 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. Emissions from Sound Transit Sounder light rail service were estimated based on light rail fuel usage reported by Sound Transit **(18-11-13)**. Because the Sounder rail services areas outside of Seattle and because the city is a major destination for commuters that use the service, half of the emissions associated with Sounder fuel use were assigned to Seattle. This is consistent with the origin-destination pair methodology employed to estimate other types of transport emissions in this inventory.

Rail - Freight: Freight rail emissions were taken directly from the 2016 Puget Sound Maritime Air Emissions Inventory (**16-80-03**), estimates of locomotive related emissions associated with the Port of Seattle (Table 9.56) and the Northwest Seaport Alliance North Harbor (Table 9.49), both in Seattle. 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 Maritime Air Emissions inventories.

Marine Transportation

Pleasure Craft: Marine pleasure craft emissions for 2018 were obtained directly from NONROAD modeling results for King County (**14-40-02**). Modeled emissions from 2018 were scaled by the Seattle fraction of King County population. The NONROAD model has not been updated for 2018, so data used for 2018 before scaling with population is identical to what was used in 2014 and 2016.

Other Ship and Boat Traffic: Emissions for 2018 for all ships and boats other than the Washington State Ferries and recreational boats (see descriptions above) were based on the 2016 Puget Sound Maritime Air Emissions Inventory (**16-80-03**). 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 Maritime Air Emissions Inventory, and were calculated as the sum of those from Northwest Seaport Alliance's North Harbor (Table 9.46) and Port of Seattle (Table 9.56) in the primary source (**16-80-03**). 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 (**16-80-03**, Table 4.5), all of which were assumed to be attributable to Seattle, since the two ports included in the Maritime Air Emissions Inventory – Port of Seattle and the Northwest Seaport Alliance North Harbor – are both in Seattle. The estimate from Table 4.5 was reduced by that source's estimate for recreational vessels (from Table 9.56), and then this Seattle inventory's estimate for ferries (as described above) was further deducted to leave just an estimate for harbor vessels other than ferries and recreational boats.

Uncertainty in emissions data for Washington State Ferries is relatively low, as they are based on fuel usage statistics. By contrast, uncertainties for other sources are relatively high as they are based on model output that in some cases (e.g., for pleasure craft) scale national data to Seattle.

Residential Building Energy

When needed, fuel-specific emissions factors (gCO_2/L) from the US EPA's national GHG inventory (**18-80-01**) were used.

Electricity: Seattle City Light (SCL) provided residential building electricity consumption within Seattle for 2018. Utility emission factors (tCO_2/MWh) remained the same, and in the absence of a 2018 emissions factor, the 2017 factor was used **(18-60-04)**. The SCL emission rate was multiplied by residential electricity consumption to obtain total emissions.

Direct Fuel Use (Fossil Gas): Puget Sound Energy (PSE) provided 2018 fossil gas use by Seattle residences **(18-20-02)**.

Direct Fuel Use: (Heating Oil): Seattle residential oil use was estimated from 2018 Washington State distillate fuel oil and kerosene sales by end-use, which is reported by the U.S. Energy Information Administration **(18-40-03)** and scaled to Seattle by the ratio of Seattle homes with oil heat to Washington State homes with oil heat as reported for 2018 by the U.S. Census Bureau American Fact Finder database **(18-20-01)**. Seattle's heating oil usage was also scaled by the ratio of heating degree days in Seattle to the population-weighted statewide average number of heating degree days **(18-20-04, 18-20-08)**. This scaling is necessary because heating demand in Seattle is somewhat less than the statewide average, which includes areas with colder winter temperatures.

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

Commercial Building Energy

Electricity: Seattle City Light (SCL) provided commercial building electricity consumption within Seattle for 2018. Utility emission factors (tCO_2/MWh) remained the same, and in the absence of a 2018 emissions factor, the 2017 factor was used **(18-60-04)**. The SCL emission rate was multiplied by residential electricity consumption to obtain total emissions.

Direct Fuel Use (Fossil Gas): Puget Sound Energy (PSE) provided 2018 fossil gas use by Seattle businesses **(18-20-02)**. 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.

Direct Fuel Use: (Petroleum): Seattle commercial building oil use was estimated using 2018 Washington State Distillate Fuel Oil and Kerosene sales by end-use, which is reported by the U.S. Energy Information Administration **(18-40-03)**, prorated by the ratio of Seattle to Washington State commercial employment **(18-70-11).**

Steam: Emissions from fossil gas for steam production was sourced directly from Emwave **(18-40).**

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

Residential & Commercial Building Equipment

Residential Yard Equipment (Petroleum): King County yard equipment emissions in 2018 were estimated by the Washington Department of Ecology using EPA's NONROAD model, and relevant model output was provided **(14-40-01)**. 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 for 2018, so data used for 2018 before scaling with population is identical to what was used in 2014.

Commercial Equipment (Fossil Gas and Petroleum): Emissions from equipment powered by compressed fossil gas (CNG) and petroleum fuel in King County were estimated by the Washington Department of Ecology using EPA's NONROAD model and relevant model output was provided **(18-40-01)**. Emissions were tabulated by fuel type and sector **(18-40-02)**, then scaled to Seattle by the ratio of Seattle to King County commercial employment **(18-70-11).** The NONROAD model has not been updated for 2018, so data used for 2018 before scaling with employment is identical to what was used in 2014.

Uncertainty is high for residential and commercial equipment, since it is based on a national model.

Waste & Wastewater

Waste management: Quantities of solid waste hauled and landfilled in each inventory year were calculated based on quantities of waste collection reported in Seattle Public Utilities waste composition studies (**18-50-10**) and compiled in **18-50-07**. Emissions factors for landfilling and carbon sequestration by category of solid waste were taken from EPA's WARM model (**18-50-09**) and emissions were calculated in **18-50-08**. Emissions associated with transporting waste to landfill facilities 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, WA (average distance of 254 miles from Seattle).

Wastewater Treatment: Wastewater treatment emissions for 2018 were provided by the King County Wastewater Treatment Division **(18-50-01)**. These include both stationary CH_4 emissions and process N_2O emissions.

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 2012). There is some uncertainty in both of these values, although the impact on total Seattle emissions is likely to be relatively small due to the small overall contribution of this source. Wastewater treatment uncertainty includes methane capture rate, which is likely uncertain, although applied to a very small level of emissions.

Industry

Steel & Glass: Emissions for both Steel and Glass are self-reported in EPA's Large Emitters Database for 2010 to 2018 (**18-40**). 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).

Fugitive SF_6 emissions: Seattle City Light (SCL) provided provisional fugitive SF_6 emissions for 2018 **(18-60-05)**, which were converted to CO_2-equivalent emission based on the 100-year global warming potential of SF_6 (22,800) from the IPCC Fourth Assessment Report.

Fugitive methane emissions: Fugitive methane emissions were taken from PSE's 2018 Greenhouse Gas Inventory **(18-40-11)**. This data source represents a change in methodology from previous years, and moves from an accurate yet resource-intensive process to a simpler and more reliable estimate from PSE.

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

Detailed Emissions Inventory Tables

Emissions Category	2008	2012	2014	2016	2018
Transportation	**3,200,000**	**3,112,000**	**3,269,000**	**3,450,000**	**3,519,000**
Air	**972,000**	**936,000**	**1,093,000**	**1,253,000**	**1,369,000**
King County Airport	262,000	228,000	238,000	234,000	252,000
Jet Fuel	262,000	228,000	238,000	234,000	252,000
Sea-Tac Airport	710,000	708,000	855,000	1,019,000	1,117,000
Jet Fuel	710,000	708,000	855,000	1,019,000	1,117,000
Marine	**179,000**	**176,000**	**179,000**	**180,000**	**180,000**

Emissions Category	2008	2012	2014	2016	2018
Hotelling	53,000	43,000	37,000	36,000	36,000
Diesel	53,000	43,000	37,000	36,000	36,000
Other Boat Traffic	59,000	62,000	76,000	74,000	73,000
Diesel	59,000	62,000	76,000	74,000	73,000
Pleasure Craft	32,000	30,000	25,000	26,000	26,000
Diesel	6,000	6,000	6,000	6,000	6,000
Gasoline	26,000	24,000	19,000	20,000	20,000
State Ferries	35,000	41,000	41,000	44,000	45,000
Bio-Diesel		1,000	2,000	2,000	2,000
Diesel	35,000	40,000	39,000	42,000	43,000
Rail	**48,000**	**42,000**	**33,000**	**32,000**	**33,000**
Rail - Freight	41,000	34,000	24,000	23,000	23,000
Diesel	41,000	34,000	24,000	23,000	23,000
Rail - Passenger	7,000	8,000	9,000	9,000	10,000
Diesel	7,000	8,000	9,000	9,000	10,000
Road: Passenger	**1,712,000**	**1,673,000**	**1,674,000**	**1,687,000**	**1,640,000**
Buses	60,000	67,000	65,000	65,000	65,000
CNG	0	0	0	0	0
Diesel	60,000	67,000	65,000	65,000	65,000
Cars & Light Duty Trucks	1,652,000	1,606,000	1,609,000	1,622,000	1,575,000
Gasoline	1,652,000	1,606,000	1,609,000	1,622,000	1,575,000
Road: Trucks	**289,000**	**285,000**	**290,000**	**298,000**	**297,000**
Medium & Heavy Duty	289,000	285,000	290,000	298,000	297,000
Diesel	197,000	196,000	201,000	208,000	209,000
Gasoline	92,000	89,000	89,000	90,000	88,000
Buildings	**1,431,000**	**1,316,000**	**1,277,000**	**1,298,000**	**1,404,000**
Commercial	**824,000**	**775,000**	**771,000**	**798,000**	**868,000**
Enwave Steam	91,000	76,000	62,000	70,000	68,000
Fossil Gas	91,000	76,000	62,000	70,000	67,000
Oil	0	0	0	0	1,000
Equipment	140,000	146,000	157,000	170,000	185,000
CNG	2,000	2,000	2,000	2,000	3,000
Diesel	39,000	45,000	49,000	53,000	58,000
Gasoline	95,000	94,000	101,000	109,000	118,000
LPG	4,000	5,000	5,000	6,000	6,000
Heating Oil	8,000	2,000	2,000	1,000	0
Oil	8,000	2,000	2,000	1,000	0
PSE	413,000	416,000	431,000	408,000	460,000
Fossil Gas	413,000	416,000	431,000	408,000	460,000
Seattle City Light	87,000	55,000	43,000	67,000	68,000
Electricity	87,000	55,000	43,000	67,000	68,000
UW Steam	85,000	80,000	76,000	82,000	87,000

Emissions Category	2008	2012	2014	2016	2018
Fossil Gas	85,000	80,000	76,000	82,000	86,000
Oil	0	0	0	0	1,000
Residential	**607,000**	**541,000**	**506,000**	**500,000**	**536,000**
Heating Oil	109,000	72,000	66,000	63,000	57,000
Oil	109,000	72,000	66,000	63,000	57,000
PSE	432,000	420,000	399,000	382,000	422,000
Fossil Gas	432,000	420,000	399,000	382,000	422,000
Seattle City Light	49,000	31,000	23,000	36,000	37,000
Electricity	49,000	31,000	23,000	36,000	37,000
Yard Equipment	17,000	18,000	18,000	19,000	20,000
CNG	0	0	0	0	0
Diesel	0	0	0	0	0
Gasoline	17,000	18,000	18,000	19,000	20,000
LPG	0	0	0	0	0
Industry	**1,357,000**	**903,000**	**1,105,000**	**1,012,000**	**1,052,000**
Energy Use	**510,000**	**475,000**	**419,000**	**536,000**	**552,000**
Equipment	213,000	179,000	190,000	210,000	210,000
CNG	2,000	2,000	2,000	2,000	2,000
Diesel	172,000	149,000	157,000	174,000	174,000
Gasoline	6,000	3,000	3,000	3,000	3,000
LPG	33,000	25,000	28,000	31,000	31,000
Heating Oil	36,000	16,000	14,000	19,000	16,000
Oil	36,000	16,000	14,000	19,000	16,000
PSE	246,000	270,000	207,000	296,000	314,000
Fossil Gas	246,000	270,000	207,000	296,000	314,000
Seattle City Light	15,000	10,000	8,000	11,000	12,000
Electricity	15,000	10,000	8,000	11,000	12,000
Fugitive Gases	**24,000**	**19,000**	**19,000**	**20,000**	**22,000**
PSE	22,000	18,000	16,000	17,000	21,000
Gas Infrastructure Leaks	22,000	18,000	16,000	17,000	21,000
Seattle City Light	2,000	1,000	3,000	3,000	1,000
SF6 from Switchgear	2,000	1,000	3,000	3,000	1,000
Process	**823,000**	**409,000**	**667,000**	**456,000**	**478,000**
Cement	746,000	307,000	523,000	384,000	363,000
Process	746,000	307,000	523,000	384,000	363,000
Glass	20,000	19,000	20,000	18,000	17,000
Process	20,000	19,000	20,000	18,000	17,000
Steel	57,000	83,000	124,000	54,000	98,000
Process	57,000	83,000	124,000	54,000	98,000
Waste	**109,000**	**90,000**	**91,000**	**89,000**	**79,000**
Commercial	**51,000**	**38,000**	**39,000**	**37,000**	**34,000**
Construction Materials	1,000	1,000	1,000	1,000	1,000

Emissions Category	2008	2012	2014	2016	2018
Asphalt Concrete				0	0
Asphalt Shingles	0	0	0	0	0
Carpet	0	0	0	0	0
Clay Bricks	0	0	0	0	0
Concrete	0	0	0	0	0
Dimensional Lumber	1,000	1,000	1,000	1,000	1,000
Drywall	0	0	0	0	0
Fiberglass Insulation	0	0	0	0	0
Electronics	0	0	0	0	0
CRT Displays	0	0	0	0	0
Mixed Electronics	0	0	0	0	0
Portable Electronic Devices		0	0	0	0
Food Waste	26,000	16,000	17,000	14,000	13,000
Food Waste	26,000	16,000	17,000	14,000	13,000
Glass	0	0	0	0	0
Glass	0	0	0	0	0
Metals	0	0	0	0	0
Aluminum Cans	0	0	0	0	0
Mixed Metals	0	0	0	0	0
Steel Cans	0	0	0	0	0
Mixed Materials	5,000	7,000	7,000	9,000	8,000
Mixed MSW	1,000	0	0	1,000	0
Mixed Organics	4,000	7,000	7,000	8,000	8,000
Paper	18,000	14,000	14,000	13,000	12,000
Corrugated Containers	7,000	3,000	3,000	4,000	4,000
Mixed Paper (general)	7,000	8,000	8,000	7,000	6,000
Newspaper	0	1,000	1,000	0	0
Office Paper	4,000	2,000	2,000	2,000	2,000
Plastics	1,000	0	0	0	0
HDPE	0	0	0	0	0
LDPE	0	0	0	0	0
Mixed Plastics	1,000	0	0	0	0
PET	0	0	0	0	0
Tires	0	0	0	0	0
Tires	0	0	0	0	0
Yard Trimmings	0	0	0	0	0
Branches	0	0	0	0	0
Grass	0	0	0	0	0
Construction & Demolition	**11,000**	**9,000**	**9,000**	**10,000**	**6,000**
Construction Materials	8,000	6,000	6,000	7,000	3,000
Asphalt Concrete	0	0	0	0	0

Emissions Category	2008	2012	2014	2016	2018
Asphalt Shingles	1,000	1,000	1,000	1,000	0
Clay Bricks	0	0	0	0	0
Concrete	0	0	0	0	0
Dimensional Lumber	6,000	4,000	4,000	5,000	3,000
Drywall	1,000	1,000	1,000	1,000	0
Fiberglass Insulation	0	0	0	0	0
Electronics	0	0	0	0	0
CRT Displays	0	0	0	0	0
Mixed Electronics	0	0	0	0	0
Portable Electronic Devices	0	0	0	0	0
Glass	0	0	0	0	0
Glass	0	0	0	0	0
Metals	0	0	0	0	0
Mixed Metals	0	0	0	0	0
Mixed Materials	1,000	1,000	1,000	1,000	1,000
Mixed MSW	1,000	1,000	1,000	1,000	1,000
Mixed Organics	0	0	0	0	0
Paper	2,000	2,000	2,000	2,000	2,000
Corrugated Containers	1,000	1,000	1,000	1,000	1,000
Mixed Paper (general)	1,000	1,000	1,000	1,000	1,000
Plastics	0	0	0	0	0
Mixed Plastics	0	0	0	0	0
Tires	0	0	0	0	0
Tires	0	0	0	0	0
Yard Trimmings	0	0	0	0	0
Branches	0	0	0	0	0
Yard Trimmings	0	0	0	0	0
Residential	**37,000**	**32,000**	**34,000**	**31,000**	**30,000**
Construction Materials	0	0	0	0	0
Asphalt Shingles	0	0	0	0	0
Carpet	0	0	0	0	0
Clay Bricks	0	0	0	0	0
Concrete	0	0	0	0	0
Dimensional Lumber	0	0	0	0	0
Drywall	0	0	0	0	0
Fiberglass Insulation	0	0	0	0	0
Electronics	0	0	0	0	0
CRT Displays	0	0	0	0	0
Mixed Electronics	0	0	0	0	0
Portable Electronic Devices		0	0	0	0

Emissions Category	2008	2012	2014	2016	2018
Food Waste	17,000	14,000	14,000	13,000	12,000
Food Waste	17,000	14,000	14,000	13,000	12,000
Glass	0	0	0	0	0
Glass	0	0	0	0	0
Metals	0	0	0	0	0
Aluminum Cans	0	0	0	0	0
Mixed Metals	0	0	0	0	0
Steel Cans	0	0	0	0	0
Mixed Materials	11,000	11,000	11,000	10,000	10,000
Mixed MSW	0	0	0	0	0
Mixed Organics	11,000	11,000	11,000	10,000	10,000
Paper	9,000	7,000	9,000	8,000	8,000
Corrugated Containers	2,000	1,000	1,000	1,000	1,000
Mixed Paper (general)	5,000	5,000	6,000	5,000	5,000
Newspaper	1,000	0	1,000	1,000	1,000
Office Paper	1,000	1,000	1,000	1,000	1,000
Plastics	0	0	0	0	0
HDPE	0	0	0	0	0
LDPE	0	0	0	0	0
Mixed Plastics	0	0	0	0	0
PET	0	0	0	0	0
Tires	0	0	0	0	0
Tires	0	0	0	0	0
Yard Trimmings	0	0	0	0	0
Branches	0	0	0	0	0
Grass	0	0	0	0	0
Self-haul	**8,000**	**9,000**	**7,000**	**9,000**	**6,000**
Construction Materials	3,000	1,000	1,000	1,000	3,000
Asphalt Concrete					0
Asphalt Shingles	0	0	0	0	0
Carpet	0	0	0	0	0
Clay Bricks	0	0	0	0	0
Concrete	0	0	0	0	0
Dimensional Lumber	3,000	1,000	1,000	1,000	3,000
Drywall	0	0	0	0	0
Fiberglass Insulation	0	0	0	0	0
Electronics	0	0	0	0	0
CRT Displays	0	0	0	0	0
Mixed Electronics	0	0	0	0	0
Portable Electronic Devices		0	0	0	0
Food Waste	1,000	1,000	1,000	1,000	1,000

Emissions Category	2008	2012	2014	2016	2018
Food Waste	1,000	1,000	1,000	1,000	1,000
Glass	0	0	0	0	0
Glass	0	0	0	0	0
Metals	0	0	0	0	0
Aluminum Cans	0	0	0	0	0
Mixed Metals	0	0	0	0	0
Steel Cans	0	0	0	0	0
Mixed Materials	2,000	2,000	1,000	2,000	1,000
Mixed MSW	1,000	1,000	0	1,000	0
Mixed Organics	1,000	1,000	1,000	1,000	1,000
Paper	2,000	5,000	4,000	5,000	1,000
Corrugated Containers	1,000	1,000	1,000	1,000	1,000
Mixed Paper (general)	1,000	3,000	2,000	3,000	0
Newspaper	0	0	0	0	0
Office Paper	0	1,000	1,000	1,000	0
Plastics	0	0	0	0	0
HDPE	0	0	0	0	0
LDPE	0	0	0	0	0
Mixed Plastics	0	0	0	0	0
PET	0	0	0	0	0
Tires	0	0	0	0	0
Tires	0	0	0	0	0
Yard Trimmings	0	0	0	0	0
Branches	0	0	0	0	0
Grass	0	0	0	0	0
Wastewater	**2,000**	**2,000**	**2,000**	**2,000**	**3,000**
Fugitive	2,000	2,000	2,000	2,000	3,000
Fugitive Emissions	2,000	2,000	2,000	2,000	3,000
Offsets	**-151,000**	**-96,000**	**-74,000**	**-114,000**	**-117,000**
Commercial	**-87,000**	**-55,000**	**-43,000**	**-67,000**	**-68,000**
Seattle City Light	-87,000	-55,000	-43,000	-67,000	-68,000
Electricity	-87,000	-55,000	-43,000	-67,000	-68,000
Industrial	**-15,000**	**-10,000**	**-8,000**	**-11,000**	**-12,000**
Seattle City Light	-15,000	-10,000	-8,000	-11,000	-12,000
Electricity	-15,000	-10,000	-8,000	-11,000	-12,000
Residential	**-49,000**	**-31,000**	**-23,000**	**-36,000**	**-37,000**
Seattle City Light	-49,000	-31,000	-23,000	-36,000	-37,000
Electricity	-49,000	-31,000	-23,000	-36,000	-37,000
Sequestration	**-195,000**	**-145,000**	**-144,000**	**-153,000**	**-173,000**
Commercial	**-44,000**	**-33,000**	**-37,000**	**-37,000**	**-36,000**
Construction Materials	-16,000	-9,000	-10,000	-12,000	-12,000
Dimensional Lumber	-15,000	-9,000	-10,000	-12,000	-12,000

Emissions Category	2008	2012	2014	2016	2018
Drywall	-1,000	0	0	0	0
Food Waste	-6,000	-3,000	-4,000	-3,000	-3,000
Food Waste	-6,000	-3,000	-4,000	-3,000	-3,000
Mixed Materials	-4,000	-6,000	-7,000	-8,000	-7,000
Mixed Organics	-4,000	-6,000	-7,000	-8,000	-7,000
Paper	-18,000	-15,000	-16,000	-13,000	-13,000
Corrugated Containers	-7,000	-3,000	-3,000	-4,000	-4,000
Mixed Paper (general)	-9,000	-10,000	-10,000	-8,000	-8,000
Newspaper	-1,000	-2,000	-3,000	-1,000	-1,000
Office Paper	-1,000	0	0	0	0
Yard Trimmings	0	0	0	-1,000	-1,000
Branches	0	0	0	-1,000	-1,000
Grass	0	0	0	0	0
Construction & Demolition	**-83,000**	**-60,000**	**-59,000**	**-67,000**	**-61,000**
Construction Materials	-79,000	-57,000	-56,000	-64,000	-58,000
Dimensional Lumber	-79,000	-57,000	-56,000	-64,000	-58,000
Mixed Materials	0	0	0	0	0
Mixed Organics	0	0	0	0	0
Paper	-2,000	-2,000	-2,000	-2,000	-2,000
Corrugated Containers	-1,000	-1,000	-1,000	-1,000	-1,000
Mixed Paper (general)	-1,000	-1,000	-1,000	-1,000	-1,000
Yard Trimmings	-2,000	-1,000	-1,000	-1,000	-1,000
Branches	-1,000	-1,000	-1,000	-1,000	-1,000
Yard Trimmings	-1,000	0	0	0	0
Residential	**-29,000**	**-26,000**	**-27,000**	**-25,000**	**-27,000**
Construction Materials	-3,000	-4,000	-3,000	-2,000	-3,000
Dimensional Lumber	-3,000	-4,000	-3,000	-2,000	-3,000
Drywall	0	0	0	0	0
Food Waste	-4,000	-3,000	-3,000	-3,000	-3,000
Food Waste	-4,000	-3,000	-3,000	-3,000	-3,000
Mixed Materials	-10,000	-10,000	-10,000	-9,000	-10,000
Mixed Organics	-10,000	-10,000	-10,000	-9,000	-10,000
Paper	-11,000	-8,000	-11,000	-11,000	-11,000
Corrugated Containers	-2,000	-1,000	-1,000	-1,000	-1,000
Mixed Paper (general)	-7,000	-6,000	-7,000	-7,000	-7,000
Newspaper	-2,000	-1,000	-3,000	-3,000	-3,000
Office Paper	0	0	0	0	0
Yard Trimmings	-1,000	-1,000	0	0	0
Branches	-1,000	-1,000	0	0	0
Grass	0	0	0	0	0
Self-haul	**-39,000**	**-26,000**	**-21,000**	**-24,000**	**-49,000**
Construction Materials	-35,000	-19,000	-16,000	-18,000	-47,000

Emissions Category	2008	2012	2014	2016	2018
Dimensional Lumber	-35,000	-19,000	-16,000	-18,000	-47,000
Drywall	0	0	0	0	0
Food Waste	0	0	0	0	0
Food Waste	0	0	0	0	0
Mixed Materials	-1,000	-1,000	-1,000	-1,000	-1,000
Mixed Organics	-1,000	-1,000	-1,000	-1,000	-1,000
Paper	-3,000	-6,000	-4,000	-5,000	-1,000
Corrugated Containers	-1,000	-1,000	-1,000	-1,000	-1,000
Mixed Paper (general)	-2,000	-4,000	-3,000	-3,000	0
Newspaper	0	-1,000	0	-1,000	0
Office Paper	0	0	0	0	0
Yard Trimmings	0	0	0	0	0
Branches	0	0	0	0	0
Grass	0	0	0	0	0
Grand Total	**5,751,000**	**5,180,000**	**5,524,000**	**5,582,000**	**5,764,000**

Tracking Metrics

Metric by Category	2008	2012	2014	2016	2018
Employment					
Employment	436,943.00	441,043.00	469,907.00	508,264.00	552,210.00
Population					
Population	593,588.00	635,063.00	668,342.00	704,352.00	744,955.00
Buildings: Residential & Commercial					
Building Emissions per resident (MT CO2e/resident)	2.15	1.81	1.65	1.57	1.61
Buildings Emissions (MT CO2e)	1,274,256.64	1,152,079.22	1,102,817.17	1,107,529.34	1,199,290.04
Commercial Electricity (MMBtu)	16,426,274.56	16,195,284.93	16,089,964.71	16,214,746.78	15,917,456.40
Commercial Emissions (MT CO2e)	685,118.03	629,230.05	614,491.84	627,435.79	682,896.88
Commercial emissions per employee (MT CO2e/employee)	1.57	1.43	1.31	1.23	1.24
Commercial emissions per resident (MT CO2e/resident)	1.15	0.99	0.92	0.89	0.92
Commercial energy per employee (MMBtu/employee)	63.33	61.25	57.19	52.75	49.87
Commercial Energy Use (MMBtu)	27,672,290.31	27,014,227.54	26,873,318.96	26,809,589.77	27,539,316.94
Commercial Fossil gas (MMBtu)	11,125,977.83	10,795,743.00	10,752,903.24	10,584,413.20	11,597,498.24
Commercial GHG intensity of energy (kg CO2e/MMBtu)	24.76	23.29	22.87	23.40	24.80
Commercial Heating oil (MMBtu)	120,037.93	23,199.61	30,451.01	10,429.79	24,362.30
Cooling degree days (CDD)	195.00	181.00	372.00	291.00	411.00
Energy use per capita per heat demand (GJ per capita per 1000 HDD)	6.27	5.96	6.49	6.20	5.76
Heating degree days (HDD)	5,062.00	4,738.00	3,948.00	3,827.00	4,065.00
Residential Electricity (MMBtu)	9,221,131.36	9,048,915.38	8,687,005.38	8,645,690.73	8,690,914.45
Residential Emissions (MT CO2e)	589,138.61	522,849.16	488,325.33	480,093.54	516,393.16
Residential emissions per resident (MT CO2e/resident)	0.99	0.82	0.73	0.68	0.69
Residential energy per resident (MMBtu/resident)	31.74	28.26	25.62	23.73	23.43
Residential Energy use (MMBtu)	18,841,311.06	17,948,087.61	17,120,242.37	16,714,095.76	17,451,152.76
Residential Fossil gas (MMBtu)	8,148,439.30	7,927,927.60	7,539,972.20	7,220,721.80	7,985,579.50
Residential GHG intensity of energy (kg CO2e/MMBtu)	31.27	29.13	28.52	28.72	29.59
Residential Heating oil (MMBtu)	1,471,740.40	971,244.63	893,264.79	847,683.23	774,658.81
Total Buildings GHG intensity of energy (kg CO2e/MMBtu)	56.03	52.42	51.39	52.13	54.39

Total energy per degree day (MMBtu/DD)	8,847.94	9,140.54	10,183.69	10,569.13	10,051.49
Total energy use (residential + commercial) (MMBtu)	46,513,601.37	44,962,315.15	43,993,561.33	43,523,685.53	44,990,469.70
Transportation					
Emissions per mile (kgCO2e/VMT)	0.49	0.48	0.46	0.44	0.42
Freight emissions per person (MT CO2e/resident)	0.49	0.45	0.43	0.42	0.40
Freight truck emissions per mile (kgCO2e/VMT)	1.00	0.98	0.97	0.95	0.92
Freight Truck VMT (miles)	290,727,741.64	289,646,506.06	299,247,344.55	314,827,282.03	321,816,928.94
Freight Truck VMT/person (miles/resident)	489.78	456.09	447.75	446.97	432.00
Passenger emissions per mile (kgCO2e/VMT)	0.45	0.44	0.42	0.40	0.38
Passenger emissions per person (MT CO2e/resident)	2.88	2.63	2.51	2.40	2.20
Passenger VMT (miles)	3,802,558,693.60	3,788,985,083.46	3,964,021,873.11	4,169,472,348.28	4,262,979,882.22
Passenger VMT/person (miles/resident)	6,406.06	5,966.31	5,931.13	5,919.59	5,722.47
Road Emissions (MT CO2e)	2,001,828.96	1,958,297.86	1,965,037.34	1,985,517.21	1,936,242.93
Road Emissions per person (MT CO2e/resident)	3.37	3.08	2.94	2.82	2.60
VMT (miles)	4,093,286,435.24	4,078,631,589.52	4,263,269,217.66	4,484,299,630.31	4,584,796,811.15
VMT per resident (miles/resident)	6,895.84	6,422.40	6,378.87	6,366.56	6,154.46
Waste Management					
Emissions per ton disposed (MT CO2e/ton)	0.79	0.76	0.77	0.78	0.69
Nonresidential waste (tons)	267,588.00	204,563.00	197,304.66	204,554.20	239,033.80
Nonresidential waste per resident (tons/employee)	0.61	0.46	0.42	0.40	0.43
Residential waste (tons)	127,160.00	111,402.00	112,234.00	103,732.30	107,481.17
Residential waste per resident (tons/resident)	0.21	0.18	0.17	0.15	0.14
Waste Emissions (MT CO2e)	100,058.22	84,934.28	85,924.71	80,802.20	74,420.79
Waste Emissions per resident (MT CO2e/resident)	0.17	0.13	0.13	0.11	0.10