2017 COMMUNITY GREENHOUSE GAS INVENTORY

Prepared by Good Company and ESA
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GLOSSARY OF TERMS

GHG

Short for Greenhouse Gases. Emission of Greenhouse Gases are the cause of current Climate Change. An inventory of GHGs measures gases in units of CO_2e. A GHG inventory is also known as a carbon footprint.

GHGP/GPC/Protocol

This type of inventory follows a set protocol, the GHG Protocol (GHGP) standard for cities known as Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC). This protocol determines what is included within a set boundary and categorizes emissions by sector. See Sector-based inventory for more information.

GWP

Short for Global Warming Potential. This refers to the potency of emissions to trap heat in the atmosphere. Carbon Dioxide has a GWP of 1, and other GHG gases are more potent and expressed as a multiple of Carbon Dioxide. For example, Methane has a GWP of 34, meaning one molecule of it has 34 times the effect of one molecule of Carbon Dioxide.

Imported Emissions (Other Scope 3)

Imported Emissions, also known as Other Scope 3 Emissions per GPC protocol, include emissions from upstream fuel production and household consumption, such as food, household goods, and air travel.

IPCC AR5

The United Nations Intergovernmental Panel on Climate Change (IPCC) releases Assessment Reports providing an overview of the state of knowledge concerning climate change science. The fifth report, AR5, is the most recent version released in 2014.

KWh

Short for kilowatt hour. Kilowatt hours are a standard unit for electricity consumption, and a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.

Sector-based Greenhouse Gas Inventory (i.e., Local Emissions)

This refers to preparing an inventory that is broken down by various sectors of the community that have common GHG characteristics. In this report, sector-based emissions are called **local emissions**. This type of inventory follows a set protocol (GPC) determining what is included in each sector, as discussed in Section IV Methodology Overview. Mainly, sector-based emissions include emissions from building energy and vehicles along with local sources of GHGs from waste (regardless of landfill site) and uncontrolled loss of methane and refrigerant gases. Note that emissions from

household consumption of goods and services are not included in sector-based inventories. The sectors applicable to this inventory are discussed on page 8 and include:

Stationary Energy: emissions from energy used or produced in a fixed location, e.g. electricity, natural gas, heating fuel oil (mainly building energy).

Transportation: emissions from vehicles and mobile equipment.

Process Emissions & Product Use: refrigerants and other fugitive gases from industrial processes and natural gas transportation.

Waste: landfilled waste emissions and wastewater treatment emissions.

Location-based Electricity Emissions Accounting

Refers to GHG intensity of the regional electricity grid, representing the average impacts of electricity use and efficiency efforts across the region. Contrast with Market-based Electricity Emissions Accounting. See discussion on Page 16.

Market-based Electricity Emissions Accounting

Refers to the GHG intensity of electricity contracts with local utilities, in the case Snohomish County Public Utility District. Contrast with Location-based Electricity Emissions Accounting. See discussion on Page 16.

MT

Short for Metric Ton (~2,200 lbs.). International standards call for metric tons as the typical standardized unit.

MT CO_2e

Metric Tons of Carbon Dioxide equivalent – a unit of measure. Most greenhouse gases are more potent in warming the atmosphere than carbon dioxide. In order to calculate and compare emissions easily, all gases are calculated and combined into a carbon dioxide equivalent, typically measured in metric tons.

Scope (as in Scope 1, Scope 2, Scope 3)

Scopes are one method to define the source of emissions. Scope categories distinguish between emissions that occur within the City's geographic boundaries (scope 1), from electricity generation serving the community (scope 2), and emissions that occur outside the City's boundaries, but that are driven by activity within the boundaries (scope 3). Scopes are discussed on pages 19 and 20 and are another way to frame emissions included in other inventory methods.

Therm

Common reporting unit of natural gas that represents 100,000 British thermal units. A therm is roughly equivalent to 100 cubic feet of natural gas.

I. EXECUTIVE SUMMARY

The City of Edmonds commissioned a Community Greenhouse Gas (GHG) Inventory to better understand local sources of GHG emissions to inform development of a Community Climate Action Plan (CAP). The inventory follows the Global Protocol for Community-Scale GHG Inventories, an internationally recognized community GHG inventory protocol[1] and accounts for all significant sources of GHG emissions driven by activities taking place within the City's geographic boundary.

Edmonds 2017 Community GHG Emissions in this report are presented using two types of inventory boundaries – 1) Local Emissions, and 2) Imported Emissions. Emissions are measured in metric tons of carbon dioxide equivalent (MT CO_2e).

LOCAL EMISSIONS (SECTOR-BASED)

Edmonds Local Emissions are presented in Figure 1 using a "sectors" view. The sectors are defined by GHG inventory protocol and meant to group emissions to align with common community planning bodies and programmatic resources. These emissions total about 300,000 MT CO_2e, or 7.2 MT CO_2e per Edmonds resident. These emissions are equivalent to 65,000 gasoline-powered cars driving for 1 year.

Figure 1: Edmonds 2017 Local Emissions

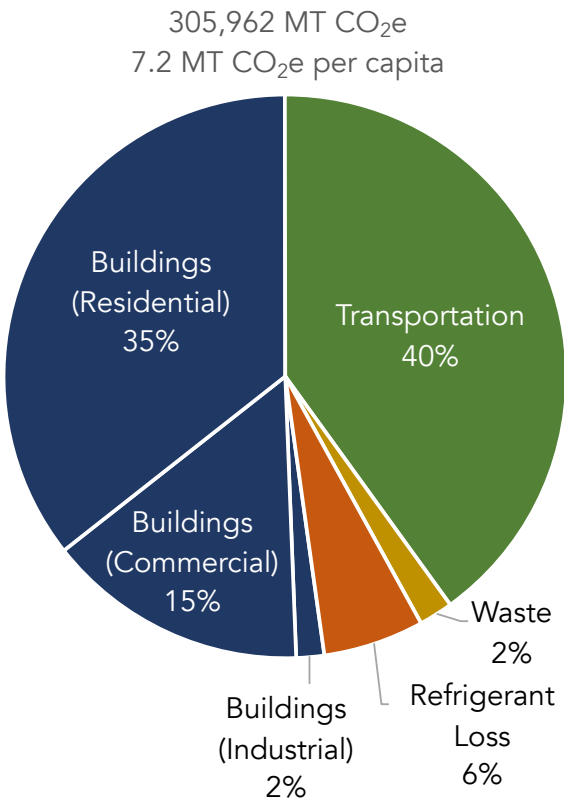


Figure 1 provides the details of Edmonds' Local Emissions. The largest sources include residential and commercial energy use by **Buildings** (52% of total) and local passenger and freight **Transportation** (40%). Smaller local sources of emissions include **Refrigerant Loss** from buildings and vehicles (6%) and landfilled **Waste** – solid waste landfill disposal and waste water treatment (2%).

As can be seen, the residential sector dominates as a source of **Buildings** emissions and emission in the building sector. Building emissions are about equally split between natural gas and electricity. Transportation is dominated by passenger vehicles and to a lesser extent, commercial vehicles. Smaller sectors include product use (uncontrolled refrigerant loss), and waste (landfilled solid waste and wastewater).

[1] Greenhouse Gas Protocol – Global Protocol for Community-Scale Greenhouse Gas Inventories and ICLEI's U.S. Community Greenhouse Gas Protocol

Imported Emissions

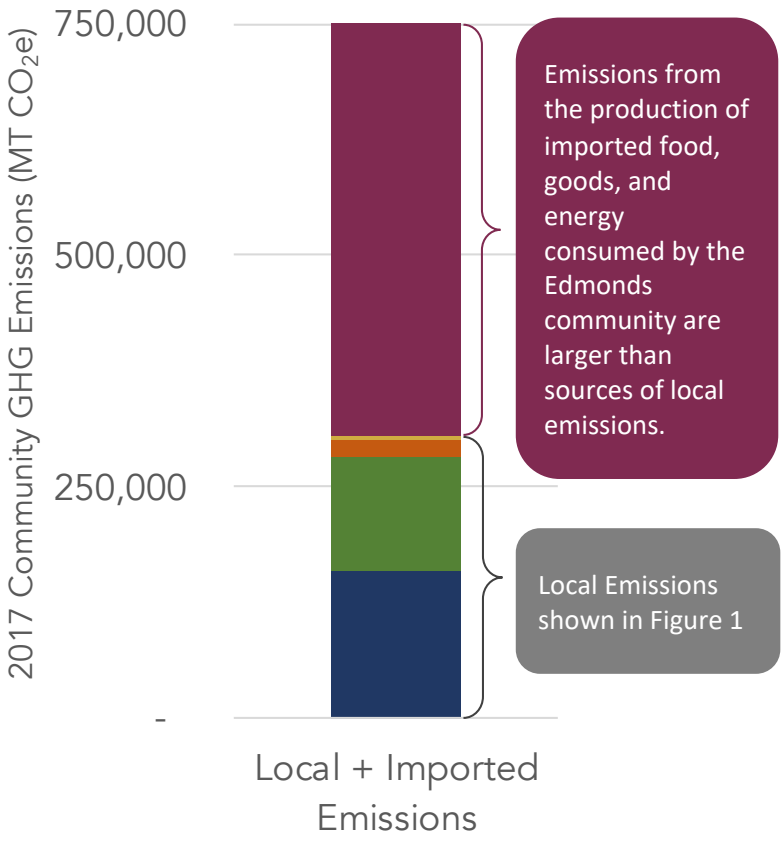
In addition to Local Emissions, shopping by Edmonds households also generates community emissions, referred to in this report as **Imported Emissions**. These emissions are generated outside of Edmonds to produce the goods, food and services imported and consumed in Edmonds. **Imported Emissions** are larger in scale than Edmonds Local Emissions (see the **magenta** stack in Figure 2). Figure 3 shows that the largest sources of Imported Emissions include those from the production of goods – such as furniture, clothing, and building materials; food – a large component of which is from meat products; production of fuels[2]; and air travel[3].

Imported Emissions are presented distinctly from Local Emissions because local sources of emissions are commonly required reporting by inventory protocols and voluntary GHG reporting bodies (e.g., Compact of Mayors or Carbon Disclosure Project) and are often the basis for setting community climate goals.

The reasons for the focus on local emissions include; 1) these emissions sources, like cars, are commonly "owned" by the community, 2) inventory data is available and emissions calculations are more accurate compared to currently available sources used to estimate imported emissions. In contrast Imported Emissions are typically not required, are more difficult to influence on a local level, and rely on more generalized data.

That said – Imported emissions are large in scale, and have local opportunities for action with existing technology. For example, consumers may choose to travel long distances by air, by train or boat or purchase offsets to reduce this source of emissions. Additional local action is presented later in the report.

Figure 2: Comparison of Local to Imported Emissions



[2] These are emissions from energy used and various process emissions that occur during production and transport of energy products prior to combustion in Edmonds. Combustion emissions are accounted for in Local Emissions.
[3] Air travel is grouped with Imported Emissions because all flights taken by Edmonds residents depart from airports outside of City of Edmonds. It also reflects the fact that air travel emissions are calculated using the same method as other sources of Imported Emissions from household consumption.

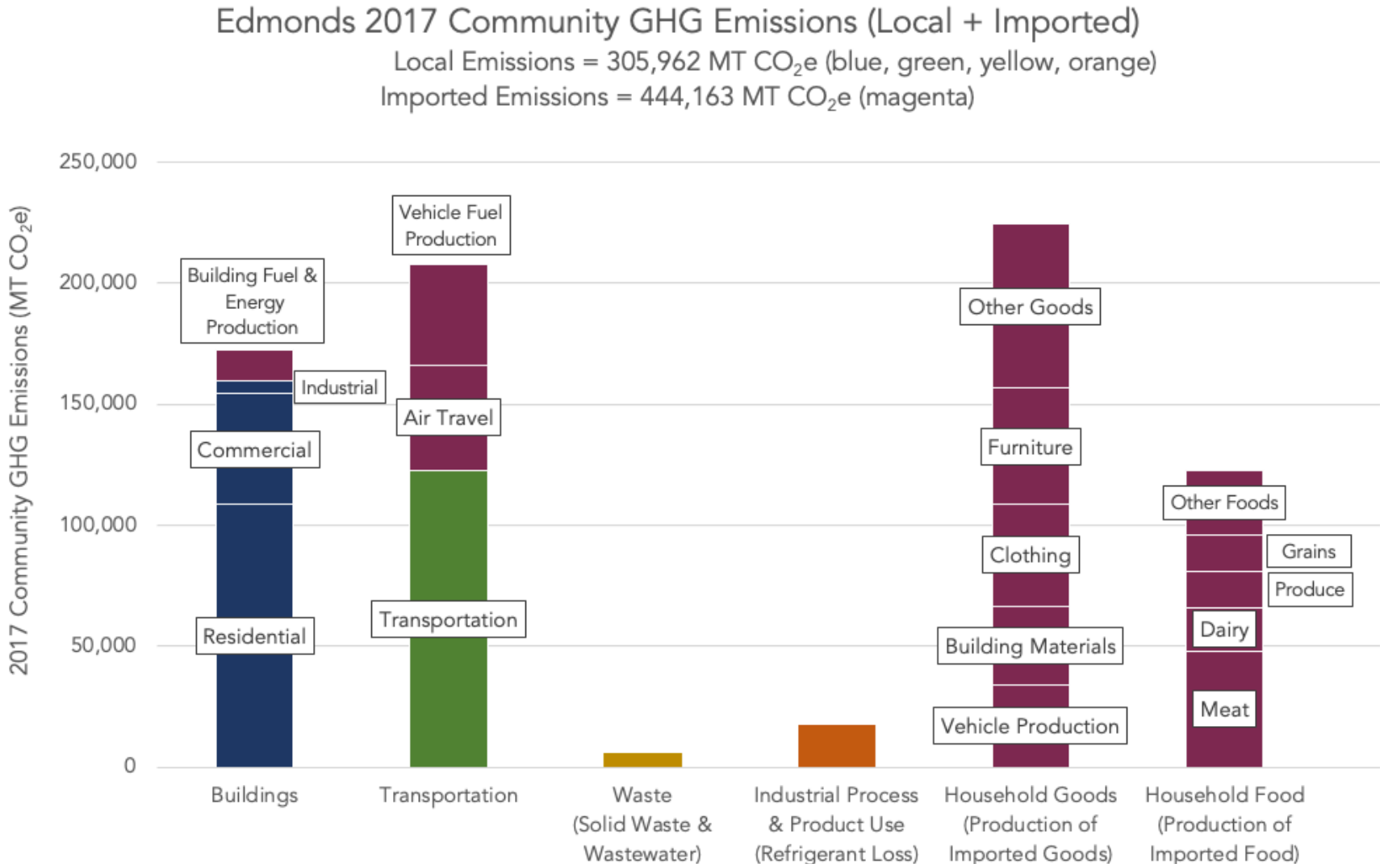


Figure 3: Detailed summary and sense-of-scale emissions comparison for Edmonds Local and Imported emissions sources.

Note 1: Graph presents location-based electricity accounting emissions (regional power mix). Market-based electricity accounting is included in Figures 7 & 9.

Note 2: "Other Goods" include electronics, toys, personal care products, cleaning products, printed reading materials, paper, office and medical supplies, etc.

II. INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC), the United Nations body that regularly convenes climate scientists, has identified human activity as the primary cause of the climate change that has occurred over the past few decades which is accelerating in recent years. Consensus statements from the IPCC suggest that human-caused greenhouse gas emissions (GHGs) must be reduced significantly – perhaps more than 50% globally, and by 90% in wealthier nations that are the largest emitters – by mid-century in order to avoid the worst potential climate impacts on human economies and societies. The most common international goal to mitigate the worst climate impacts, is to limit global average temperature increases to no more than 2°C (3.6°F) relative to temperatures at the start of the industrial revolution. As of 2018, we've already passed the halfway point: average temperatures have increased by more than 1°C (1.8°F) since the industrial revolution and are on track to increase to 1.5°C (2.7°F) by 2040.

It's with this understanding and urgency that the City of Edmonds commissioned this community greenhouse gas (GHG) inventory. A GHG inventory quantifies the GHG emissions associated with a specific boundary – such as the geographic boundary of a community or operational control within an organization – for a specific period of time such as a fiscal or calendar year. Edmonds' 2017 Community GHG Inventory is based on City of Edmonds' geographic boundary; uses data for calendar year 2017 (with exceptions noted in Appendix A) and includes the following emissions sources:

Stationary Energy use by residential, commercial, and industrial buildings and facilities represents a large source of community emissions. These emissions come from "smokestack" during combustion of natural gas and fuels for water and building heat, and to generate electricity for use in Edmonds.

Transportation energy, and particularly on-road vehicle transportation, of passengers and freight also represents a large fraction of community emissions. Like stationary energy, transportation emissions are generated at the tailpipe as well as upstream during production of fuels.

Process Emissions & Product Use (Refrigerant Loss) of refrigerants are lost from transportation and building cooling systems. Refrigerants are powerful global warming gases. Therefore, relatively small losses have a large climate impact. Likewise, a fraction of natural gas is lost during local distribution.

Waste disposal in landfills and wastewater treatment produces methane, most of which is collected and used for energy, but a fraction leaks out to the atmosphere having a negative climate impact.

Imported Emissions that are generated outside of the community during the production of goods, food, fuels and service products consumed by residents of Edmonds.

III. INVENTORY BOUNDARIES

The Edmonds' 2017 Community Greenhouse Gas Inventory presented in this report is based on calendar year 2017 data for the City of Edmonds' geographic boundary. This inventory considers all seven Kyoto gases, but only four are relevant for Edmonds – carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and hydrofluorocarbons (HFC).

Edmonds' inventory follows Greenhouse Gas Protocol's *Global Protocol for Community-Scale Greenhouse Gas Emissions (GPC).*[4] The GPC focuses on and requires inventory reporting on sources of Local Emissions (i.e., Sector-based emissions). The inventory goal beyond GPC requirements to include Imported Emissions (i.e., Other Scope 3 Emissions) to inform community climate action planning on a known, large emissions source often excluded from inventories. For additional details on Methodology – see section *VI. Methodology Overview*.

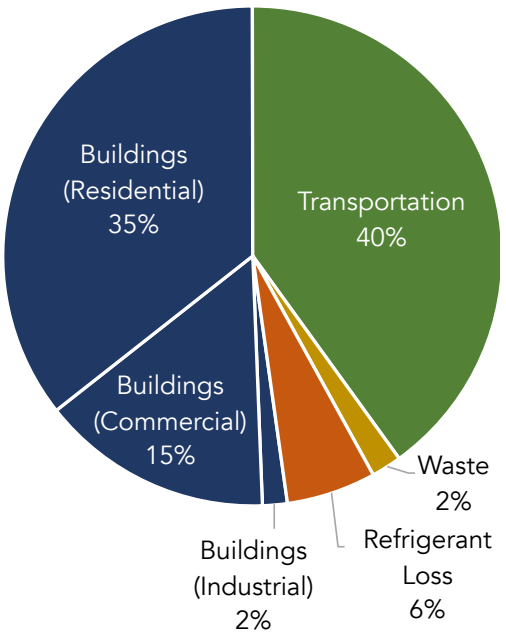
IV. INVENTORY RESULTS

LOCAL EMISSIONS (SECTOR-BASED)

The Edmonds community generated 305,962 MT CO_2e of Local, Sector-based emissions. This quantity of GHGs is equivalent to 65,000 passenger cars annual emissions, or the carbon sequestered *annually* by over 350,000 acres of average U.S. forest – a land area about 30 times the size of the City of Edmonds.

Edmonds' local emissions[5] are shown in **4** and come primarily from building electricity use and combustion of natural gas in (blue segments) as well as gasoline and diesel combustion in vehicles to transport people and goods (green segment). Emissions from waste include landfill disposal of community solid waste and wastewater treatment (yellow). Emissions from local product use include refrigerant gas loss from buildings and vehicles,

Figure 4: Edmonds 2017 Community GHG Emissions (Local, Sector-based Emissions)



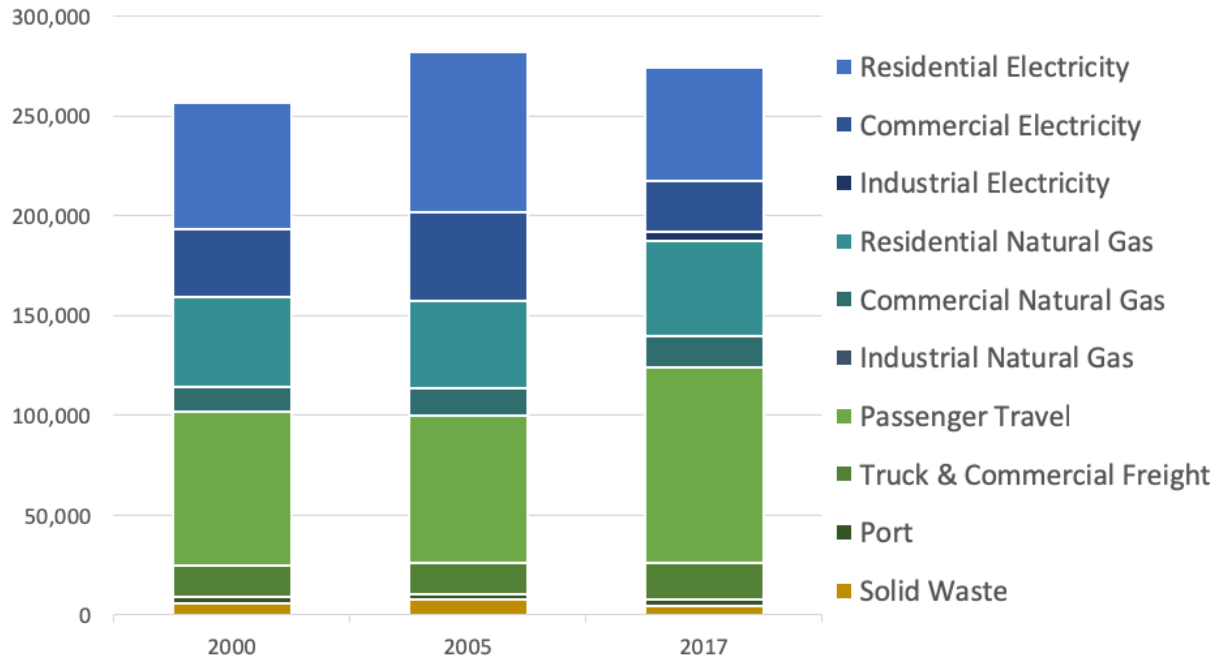
[4] GPC has become the recommended or required standard for international reporting to Carbon Disclosure Project's Cities Survey and the Global Covenant of Mayors for Climate & Energy. While Edmonds does not currently participate in these endeavors currently – Edmonds' inventory has been conducted to allow for adoption in the future. GPC may be downloaded at https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities.

[5] Sector-based emissions inventories (or in-geographic boundary inventories) include local emissions, within the City's boundaries, from energy use by homes, businesses, and vehicles as well as emissions from landfilling solid waste and wastewater treatment.

and natural gas loss from the local distribution system (orange). Note that all emissions from buildings and transportation are from fossil fuels; only waste and refrigerants (Industrial Process & Product Use sector) are non-fossil fuel emissions.

Edmonds inventoried Local Emissions for data years 2000 and 2005 in 2009.[6] Figure 5 compares these to 2017 emissions for various emissions sources. During this period, the population of Edmonds increased about 7%, from 39,459 to 42,209[7]. These comparisons are limited to only the emissions sources included in Edmonds 2000 and 2005 inventories.[8] As can be seen, electricity related emissions have decreased in the residential and commercial sectors. Industrial electricity emissions have increased, but the scale of the increase is small compared to other sources of Stationary Energy emissions. Natural gas emissions have increased in all sectors. This increase is attributed to population increase as well as differences in heating needs during the calendar years. The largest driver of Edmonds emissions increases is related to emissions from on-road transportation which have increased 27% between 2000 and 2017.

Figure 5: Comparison of Edmonds' available historical emissions (reported in MT CO_2e).



[6] Report downloaded November 2018 at http://www.edmondswa.gov/greenhouse-gas-inventory.html. The report is all that remains of this work completed in 2009 for inventory year's 2000 and 2005. The ICLEI tool used to calculate emissions is no longer supported or available and no related data files are available on the City's server. Therefore, it is challenging to compare and contrast year-over-year differences, particularly related to the transportation modeling performed for previous inventories.

[7] The previous inventory was prepared after the last annexation in Edmonds, therefore no adjustment was necessary for comparison of total or per capita GHG calculations. Population data is from the U.S. Census and ACS.

[8] **Figure 5** and Figure 7: only data that was available for all three years was compared, i.e. the change in total electricity, natural gas, passenger travel, truck freight and commercial services, port, and solid waste emissions, in order to make a comparable evaluation. Stationary Energy other fuels, wastewater energy use, multiple transportation components, multiple waste components, and industrial process and product use were not included.

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Imported Emissions

In addition to accounting for Local Emissions, Edmonds' inventory also considers **Imported Emissions,** which are generated outside of Edmonds to produce the imported goods, food, and services consumed by Edmonds households. Edmonds Imported Emissions total 444,163 MT CO_2e. This quantity of GHGs is equivalent to 95,000 passenger vehicles annual emissions, or the carbon sequestered *annually* by over 500,000 acres of average U.S. forest – a land area about 40 times the size of the City of Edmonds. Figure 6 compares the scale of Local, sector-based emissions to Imported Emissions from household consumption of goods, food, air travel, and production and transport of the fuels combusted in Edmonds.

Within goods, the largest purchasing categories include furniture, meat, clothing, and building materials. Within food, the largest purchasing category is meats and specifically beef and lamb products. Air travel from flights taken by Edmonds residents that depart from airports outside of Edmonds are a significant slice of Edmonds' Imported Emissions. The final significant slice is Imported Emissions from upstream fuel production. These are emissions from energy used and various process emissions that occur during production and transport of energy products combusted in Edmonds and accounted for in Edmonds Local Emissions.

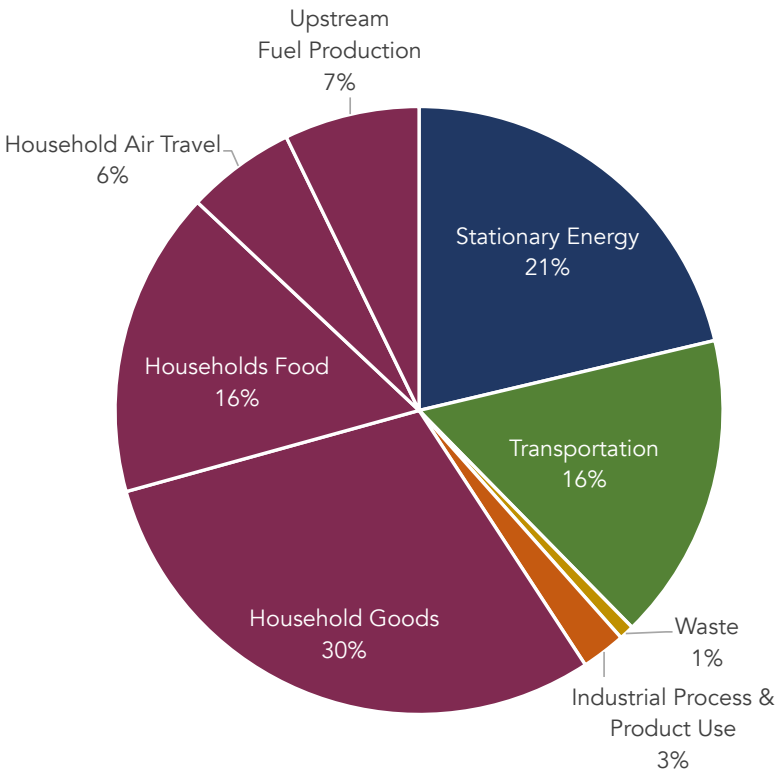

Figure 6: Comparison of Local Emissions to Imported Emissions.

Emissions Sector / Sub-Sector	2000 (MT CO_2e)	2005 (MT CO_2e)	2017 (MT CO_2e)	% Change since 2000	Per capita (2017)
Local Emissions: Stationary Energy (Building	**154,865**	**182,511**	**159,773**	3%	3.8
Residential Buildings					
Electricity (Location-Based)	63,575	80,328	56,764	-11%	1.3
Electricity (Market-Based)	*15,727*	*14,478*	*3,039*	*-81%*	*0.1*
Natural Gas	44,884	43,926	47,440	6%	1.1
Other Fuels	NE	NE	4,312		0.1
Commercial Buildings and Facilities					
Electricity (Location-Based)	33,686	44,624	25,362	-25%	0.6
Electricity (Market-Based)	*8,073*	*8,043*	*1,893*	*-77%*	*0.0*
Natural Gas	12,557	13,559	15,682	25%	0.4
Other Fuels	NE	NE	4,738		0.1
Industrial Facilities					
Electricity (Location-Based)	150	0	4,821	3109%	0.1
Electricity (Market-Based)	*36*	*0*	*261*	*625%*	*0.0*
Natural Gas	13	74	73	459%	0.0
Wastewater energy use	NE	NE	583		0.0
Local Emissions: Transportation	**96,169**	**91,953**	**122,585**	**27%**	**2.9**
Passenger Travel	77,510	73,614	98,121	27%	2.3
Ferry (info. only - not part of total)	*NE*	*NE*	*28,180*		0.7
Truck Freight	15,427	15,398	10,779	18%	0.3
Commercial Services			7,478		0.2
Port	3,232	2,941	3,332	3%	0.1
Rail - Passenger & Freight	NE	NE	1,608		0.0
Transit	NE	NE	854		0.0
Off Road	NE	NE	412		0.0
Local Emissions: Waste	**5,784**	**7,699**	**5,962**	**3%**	**0.1**
Solid Waste	5,784	7,699	4,343	-25%	0.1
Composted Organics			404		0.0
Wastewater (Incineration of solids)			541		0.0
Wastewater (Effluent)			674		0.0
Local Emissions: Industrial Process and Product Use			**17,642**		**0.4**
Product Use (refrigerants)			17,339		0.4
Fugitive Emissions from Natural Gas Systems			303		0.0
Local Emissions: Agriculture, Forestry, and Land Use					
Livestock			*NO*		
Land			*NE*		
Other Agriculture			*NO*		
Imported Emissions: Other Scope 3 Sources	**NE**	**NE**	**444,163**		**10.5**
Household Consumption					
Goods			224,363		5.3
Food			122,313		2.9
Services - Air Travel			43,513		1.0
Upstream Energy Production					
Transportation Fuels			41,323		1.0
Natural Gas			2,605		0.1
Electricity (location-based)			10,046		0.2
Electricity (market-based)			540		0.0
Local Emissions (location-based electric)	256,818	282,163	305,962	7%	7.2
Local Emissions (market-based electric)	183,243	179,732	169,336	5%	4.0
Local (location-based) + Imported Emissions			750,125		17.8
Local (market-based) + Imported Emissions			613,499		14.5

NE = Emissions occur but are not reported or estimated - see justification in exclusions
NO = Activity or process does not occur within City

Figure 7: Summary Table of Edmonds 2017 Community GHG Emissions.
**See page 14 for a discussion of location-based and market-based electricity accounting emissions.*

DETAILED RESULTS FOR SIGNIFICANT EMISSIONS

Stationary Energy (Buildings)

Electricity and natural gas use by the residential and commercial sectors are a large source of local emissions. Edmonds residents' homes have more than double the impact of commercial businesses. Industrial energy is small by comparison. By energy type, electricity had the largest impact (54% of total building energy); followed by natural gas (40%); and other fuels (6%). **Figure 8** shows stationary energy emissions broken down by sub-sector and energy type.

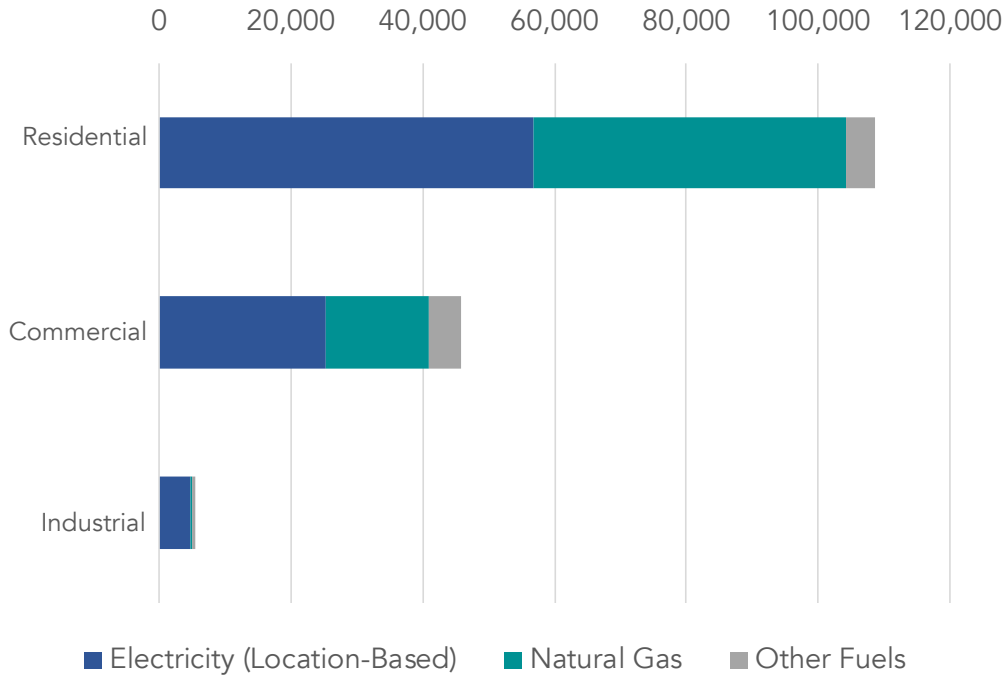

Figure 8: Comparison of stationary energy use, by sub-sector and energy type, using location-based electricity accounting.

The Community Inventory Protocol (GPC) requires that communities report electricity emissions using the location-based electricity accounting method (navy blue bar on **Figure 9, next page**). ***Location-based electricity accounting emissions*** are calculated using the regional electricity grid's GHG intensity and represent the average impacts of electricity use and efficiency efforts. The Location-based electricity accounting method has been used in graphics up to this point in the report. The GPC also recommends that communities calculate ***Market-based electricity accounting*** *for sensitivity analysis* which is based on the GHG intensity of electricity contracts with local utilities.[9] This is a very significant distinction for Edmonds' as

[9] Market-based electricity accounting is commonly used for target and goal tracking and is useful to assess and manage GHGs associated with electricity generation and supply. Location-based electricity accounting offers a means of assessing the average impacts of electricity use on the regional electricity grid. It also highlights benefits

market-based electricity accounting emissions are much smaller than location-based electricity accounting emissions. Snohomish PUD's electricity generation from Bonneville Power Administration are largely served by low-GHG hydroelectric and nuclear power. The market-based electricity accounting method also accounts for community participation in utility green power programs. In 2017, Snohomish PUD's customers voluntarily purchased Renewable Energy Credits (RECs) from SPUD equal to about 1% of demand, which further decreases Edmonds' market-based electricity accounting emissions.

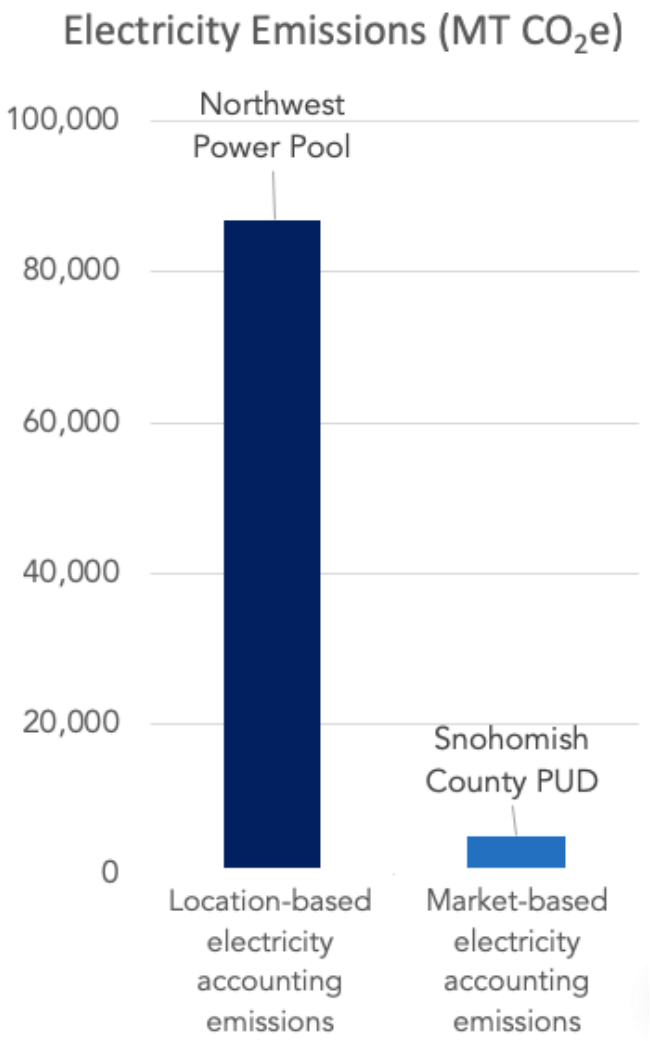

Figure 9: Comparison of Edmonds' 2017 electricity emissions (MT CO_2e).

These findings have implications for Edmonds Climate Action Plan. Market-based electricity accounting emissions show that Edmonds existing electricity supply contracts are already very low-GHG and therefore climate action planning does not need to focus on utility-scale electricity supply. Edmonds is very fortunate as this is the starting place for most other communities. This fortune allows Edmonds to focus on other action areas such as fuel switching vehicles and natural gas heating systems to SPUD's low-GHG electricity. The large caveat to these findings is that BPA electricity generation is a finite resource. So, while Edmonds focuses on fuel switching to electricity, this increased electricity use should be balanced with additional energy efficiency programs or ensuring that additional electricity demand is supplied with new renewable electricity generation so as to not increase overall community electricity use. While Edmonds is already supplied with low-carbon BPA electricity contracts, Edmonds may choose to go further, and pursue a 100% renewable energy goal from new generation sources. This action would serve to further reduce GHGs as any low-carbon BPA electricity not consumed in Edmonds, is available to displace electricity from more GHG-intensive sources elsewhere.

for energy efficiency actions, particularly in communities served by utilities with very low GHG electricity. That is, the less electricity used in the community, the more low-GHG electricity there is available for export to communities with more GHG intensive electricity sources.

Figure 10 and **Figure 11** present community energy consumption in *units of energy* instead of GHG emissions as have been presented in previous graphics. Total community electricity use decreased by 7% between 2000 and 2017. For 2017, 65% of electricity was consumed by the residential sector, 29% by the commercial sector[10], and 6% by the industrial sector.

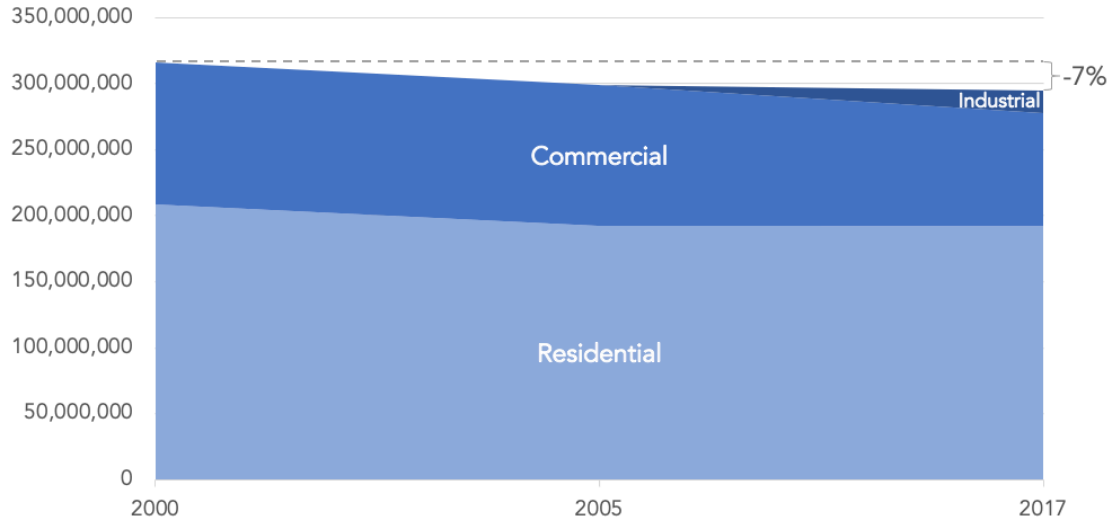

Figure 10: Edmonds electricity use (in kWh), by sector. Decrease of 7%, 2000-2017.

Total community natural gas use increased by 10% between 2000 and 2017 (see **Figure 11**). For 2017, 75% of natural gas was consumed by the residential sector, nearly 25% by the commercial sector. About 0.1% was consumed by the industrial sector, not visible in the graph.

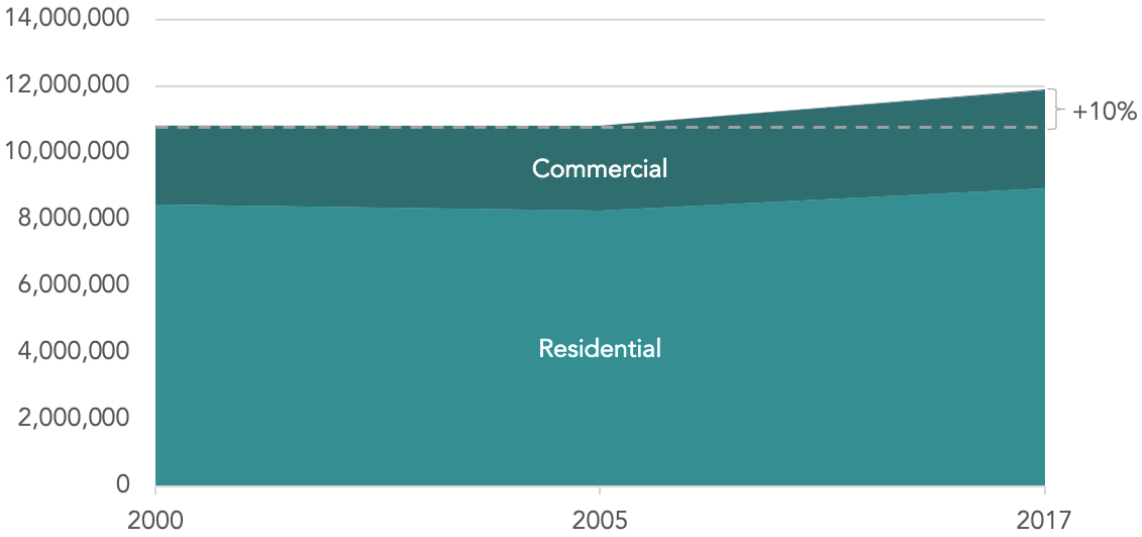

Figure 11: Edmonds natural gas use (in therms), by sector. Increase of 10%, 2000-2017.Edmonds natural gas use (in therms), by sector. Percent (%) change, 2000 to 2017.

[10] Note that street lights accounted for 1% in 2017 (not available separately for previous years) and is included in commercial use in the graph.

Transportation

On-road transportation of passengers is Edmonds' leading source of transportation-related Local, sector-based emissions. See **Figure 12** (left hand side). These emissions originate from residential-owned passenger cars and trucks, which primarily use E10 gasoline or B5 diesel. The next largest category is heavy-duty freight vehicles operating within the boundary which represent 9% of transportation-related emissions. The next category, commercial service vehicles, include local freight, restaurant delivery, and service providers such as electricians, plumbers, etc. These categories are trailed by emissions from port, rail, transit, and off-road (land-based) sources.

Air travel is not considered a source of Local emissions for Edmonds as there are no airports within the City's boundary. With Edmonds inventory, air travel services consumed by Edmonds residents for flights departing outside Edmonds are included as part of Edmonds **Imported emissions** from household consumption. As is shown in Figure 12 (right), GHGs from air travel services are large sources of emissions compared to Edmonds Local transportation emissions.

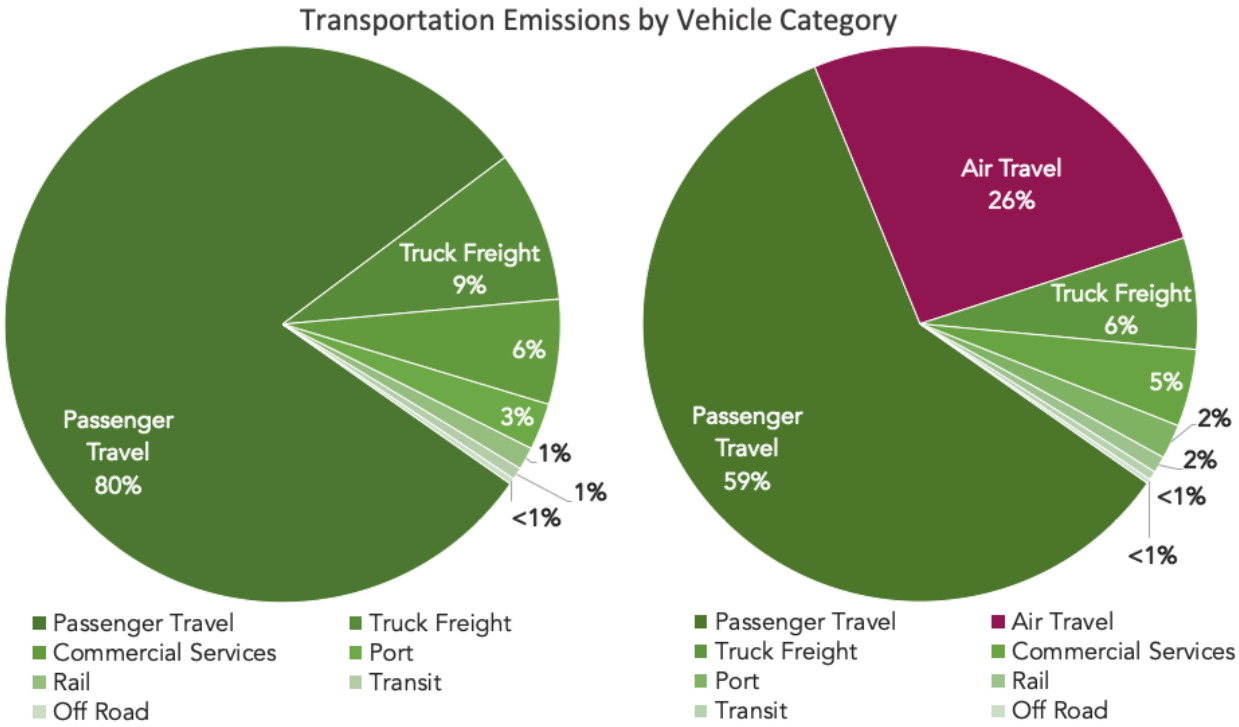

Figure 12: Distribution of transportation emissions by vehicle category, comparing sector-based emissions (left) and sector-based with scope 3 air travel (right, with magenta).

Information only item: Ferry services between Edmonds and Kingston combust a significant amount of diesel fuel which generates 28,180 MT CO_2e – nearly three times the amount of truck freight emissions. Because ferry passengers do not all live and/or work in Edmonds, and passenger origin data is unavailable, this item is excluded from Edmonds community GHG totals.

Imported Emissions (Other Scope 3 Emissions)

Edmonds' inventory goes beyond GPC protocol requirements to known large sources of Imported Emissions. The following Imported Emissions categories are considered.

Household Goods: Emissions from extraction, manufacture, and transportation of raw materials into final products such as building materials, automobile, furniture, clothing, and other goods.

Household Food: Emissions from agriculture (energy for irrigation, production of fertilizers, methane emissions from livestock, etc.), transportation of raw materials, and finished products emissions. Categories included are grains, dairy, meat, produce, and other foods.

Energy (Fuel Production): Process and energy emissions from the extraction and production into usable fuel products (e.g. electricity from household outlets, gasoline pumped into cars, natural gas combusted by furnaces, etc.). These upstream emissions are considered at the community-scale for electricity, natural gas, gasoline, diesel, propane, and fuel oil.

Figure 13 compares Local emissions only to **Imported Emissions**. As can be seen, the scale of **Imported Emissions**, as a category is significantly larger than Edmonds' local emissions. Figure 3 provides more detail and shows that the largest sources of these emissions include goods and furniture, meat and dairy, transportation fuels and air travel, clothing, and food.

These imported sources of emissions are not currently required reporting in the GPC protocol, due to limitations related to accurately accounting for these emissions over time at the community scale.[11] While these accounting limitations are an issue at present, the scale of consumption-based emissions is large enough to warrant inclusion in community

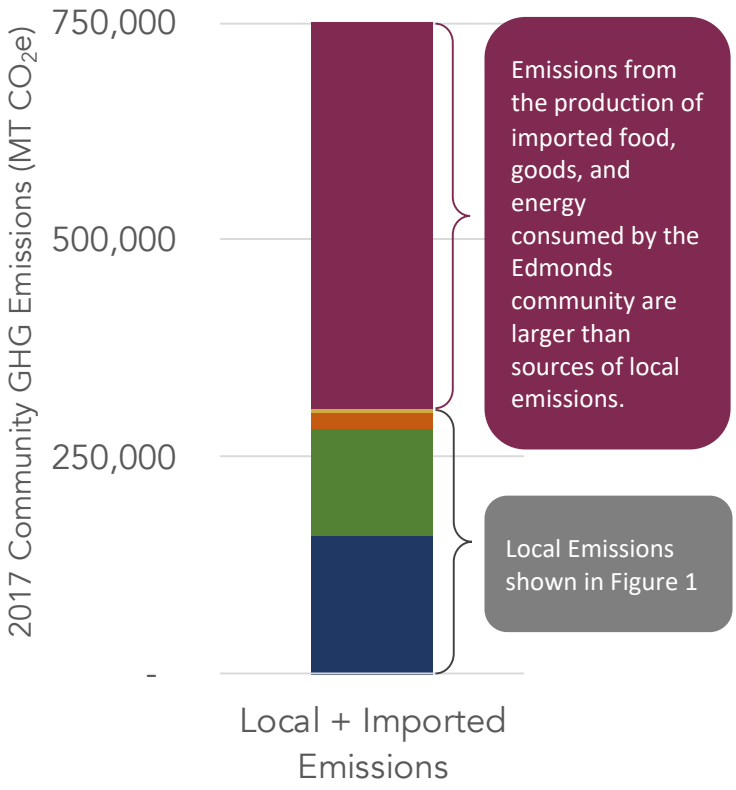

Figure 13: Comparison of Local to Imported Emissions

[11] The GPC authors, C40 Cities, and Oregon Department of Environmental Quality are all currently working to develop tools that will allow for more accurate community tracking of these emissions in the future.

climate action plans. In fact, communities have already begun incorporating action to reduce these sources of emissions. Examples of best practice actions currently being implemented by communities to address these emissions include:

- Programs that reduce edible food waste
- Programs that shift diets towards low-GHG food types
- Whole building reuse or recovery and reuse of building materials
- Repair and buying used for clothing, furniture, and electronics
- Recycling programs and purchase of products with recycled content

When considering consumption-based emissions, it's important to highlight the relationship between income and emissions for certain categories of consumption. Not surprisingly, households with larger annual incomes will typically consume more and therefore generate disproportionately more GHGs than households with smaller incomes.

Figure 14 highlights this relationship. The four colored bars represent different household income tiers. As can be seen, household income significantly influences emissions for the consumption of material goods and air travel as basic needs are met and more discretionary income is available. This, however, is not the case when it comes to food as people and households consume about the same quantity and composition of food.

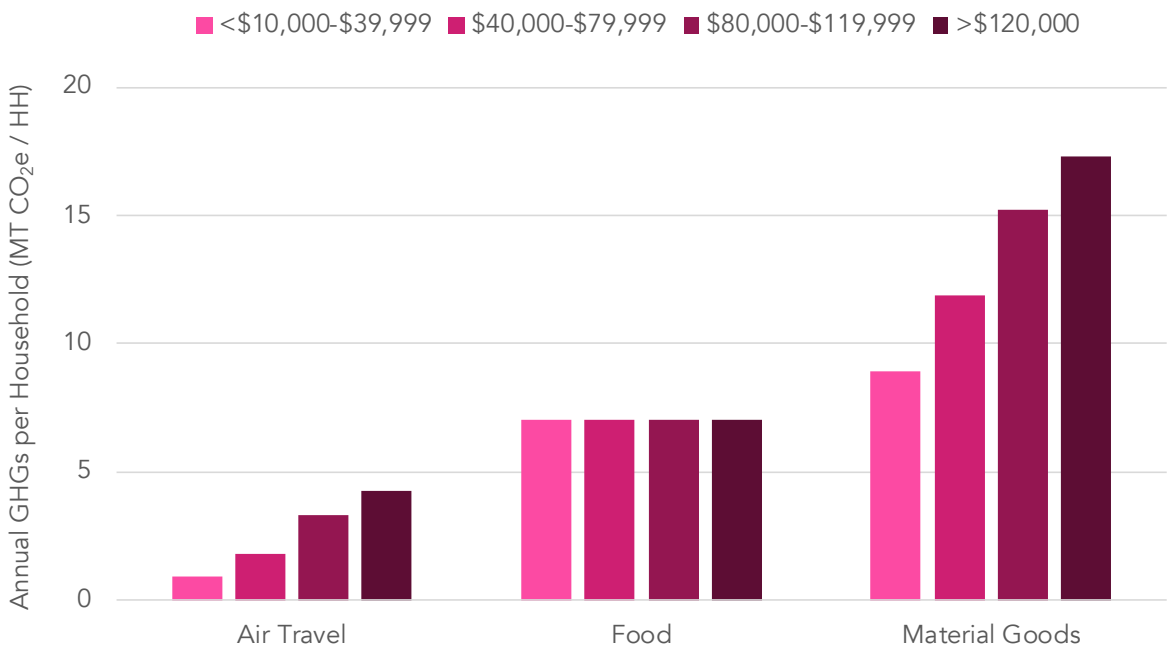

Figure 14: Comparison of household (HH) income tiers and emissions for purchase types.

VI. METHODOLOGY OVERVIEW

Protocols and Tools

This inventory follows Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories by Greenhouse Gas Protocol (GHGP). This inventory also follows GHGP's Scope 2 Guidance for location-based and market-based electricity accounting emissions and ICLEI's US Community Protocol for guidance on calculation of Imported Emissions (i.e., Other Scope 3 as defined by GPC protocol).

ICLEI's ClearPath Community-Scale emissions management software was used for the majority of emissions calculations. Emissions calculations outside of ClearPath are documented in the CY 2017 GHG Inventory Audit Trail. The Audit Trail catalogs all data, calculation, and resource files used to complete the inventory. This Audit Trail clearly documents all data sources and methods for replication in future inventories.

All community GHG emissions presented in this report are represented in metric tons of carbon dioxide equivalent (MT CO_2e). Quantities of individual GHGs are accounted for in the ICLEI's ClearPath carbon calculator and include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), Chlorofluorocarbons (CFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6) per the Kyoto Protocol. All GHG calculations use 100-year global warming potentials (GWP) as defined in the International Panel on Climate Change's 5th Assessment Report (IPCC AR5).

For those knowledgeable about the GHG Inventory Protocol, Figure 15 compares GPC emissions sources included in Edmonds inventory; notes when a GPC emissions source did not occur, or are not included; and the emissions Scope category for each emissions source. GHG inventory accounting classify emissions by three Scope categories, which are defined below. For those interested in greater detail on Scope, see the GPC for details.

Scope 1	GHG emissions from sources located within the city boundary.
Scope 2	GHG emissions occurring as a consequence of the use of grid-supplied electricity within the City's geographic boundary.
Scope 3	All other GHG emissions that occur outside the city boundary as a result of activities taking places within the City's geographic boundary.

Figure 15: Description of community inventory GHG Scope accounting categories.

Emissions Sector / Sub-Sector	Included in Edmonds Inventory	Scope 1	Scope 2	Scope 3
Stationary Energy				
Residential Buildings	•	✓	✓	
Commercial Buildings and Facilities	•	✓	✓	
Industrial Facilities	•	✓	✓	
Energy Generation Supplied to the Grid	•	✓		
Transportation				
On-Road Passenger and Commercial Vehicles	•	✓		
On-Road Freight Vehicles	•	✓		
On-Road Transit Vehicles	•	✓		
Off-Road Vehicles and Equipment	•	✓		
Waterborn Navigation	•	✓		
Waste				
Solid Waste Generated in City	•			✓
Wastewater Generated in City	•	✓		
Biological Treatment of Waste Generated in City	*NO*			✓
Incineration of Waste Generated in City	•	✓		
Industrial Process and Product Use				
Product Use (refrigerants)	•	✓		
Fugitive Emissions from Natural Gas Systems	•	✓		
Industrial Processes	*NO*	✓		
Agriculture, Forestry, and Land Use				
Livestock	*NO*	✓		
Land	*NE*	✓		
Other Agriculture	*NO*	✓		
Other Scope 3 Emissions Sources				
Household Consumption	•			✓
Upstream Energy Production	•			✓

NE = Emissions occur but are not reported or estimated - see justification in exclusions
NO = Activity or process does not occur within City

Figure 16: Crosswalk of emission and Scope categories.

Summary of Inventory Exclusions

Emissions Sector / Sub-Sector	Justification for Exclusion
Agriculture, Forestry, and Land Use	No significant activity identified within City. The City could consider including land-use change emissions if future greenspace development.
Livestock	No significant activity identified within City.
Fugitive Emissions from Coal Production	No activity identified within City.
Industrial Processes	No significant activity identified within City, per EPA FLIGHT database.
Industrial propane and fuel oil	Based on the relatively small emissions from industrial electricity and natural gas use – use of these fuels expected to be small and therefore were not estimated.

Figure 17: Description of community inventory GHG Scope accounting categories.

Data Collection

Good Company worked with Shane Hope, Project Manager for the City of Edmonds to collect the 2017 data required to calculate emissions. City staff along with other local and regional government staff as well as private businesses that serve the Edmonds community graciously provided time, data and expertise. Data and emissions factors are described in Appendix A. Detailed data records are available to City staff in the form of the inventory Audit Trail, which are organized raw data and calculation files used in the inventory with a Table of Contents. Data is also documented in the inventory within the ClearPath carbon calculator input fields. These resources are highly detailed and will allow for those conducting future inventories to fully understand and replicate the methods used in the 2017 inventory. Similar resources are not available for Edmonds 2000 and 2005 inventories conducted in 2009. Good Company did not conduct these inventories and were unable to track down audit trail files or emissions calculations in the course of our 2017 work.

Two data models were used in the course of Edmonds community inventory to estimate primary data using methods and guidance provided in ICLEI's US Community GHG Protocol. These include:

- Puget Sound Regional Council's Trip-based Travel Model. This model was used by PSRC on behalf of the City of Edmonds to provide inventory data on vehicle-miles traveled within the City of Edmonds geographic boundaries. This data is downscaled per capita for Edmonds based on County-level data. PSRC also provided an "on-road" factor which is an emissions factor specific to the County that represents the average emissions per VMT. This factor is calculated by PSRC using EPA's On-Road Model. This data is used in the Transportation sector of Edmonds Local Emissions.
- Cool Climate Network's, Household Calculator. This model was used by Good Company to estimate Edmonds Imported Emissions related to household consumption of goods, food, and air travel.

See Appendix A for additional information on data and emissions factors used in this inventory.

Summary of Inventory Sensitivities

There is some degree of uncertainty in Edmonds community inventory results, as there are in all most GHG inventory results. This uncertainty stems from a variety of sources that can include lack of available data sources and the need to estimate sources of primary data. Uncertainty can also stem from a lack of publically available emissions factors used to calculate emissions from activity data.

The relative scale of uncertainty can be used to inform the reading of the results. It can also helpful in planning the approach to future inventory and reporting efforts, including

prioritization of additional data gathering. The relative scale of uncertainty may also be useful to inform goal setting and prioritization of climate actions.

In general, Local emissions typically trend towards lower uncertainty and have mid-to-low emissions, while Imported emissions trend toward higher uncertainty and also have larger scale emissions.

The majority of Local, sector-based emissions are very accurate in terms of primary inventory data, emissions factors, and calculation methodology. Specifically:

- Highly accurate sources of community emissions include: natural gas combustion, electricity use, and solid waste treatment.
- Moderately accuracy sources include PSRCs transportation model. PSRCs model and County-level data is assumed to be highly accurate at the County level. County-level data is downscaled to estimate Edmonds emissions instead of being based on Edmonds specific data and therefore this source is considered moderately accurate.
- The low accuracy source is refrigerants. This data is estimated from the U.S. GHG inventory. The State of Washington does not currently report on this emissions source in its inventory, which would allow for a more accurate estimate.

For Imported Emissions:

- Moderate accuracy is assumed for upstream fuel emissions. These calcualtions are based on primary data from utilities, which is considered highly accurate (same sources used for Local Emissions). This data is combined with estimates of upstream fleet fuel emissions from EPAs AFLEET Tool. This tool is based on deep research from Argonne National Laboratory.
- Moderate accuracy is also assigned to household consumption. The Cool Climate Network's Household Calculator represents the state-of-the-art for calculating these emissions. The Calculator uses county-level U.S. consumer survey data combined with known emissions rates in over 400 economic sectors to estimate the emissions.

Suggestions for Future Inventories

- **Increase the frequency of community inventories.** The gap between this inventory and the previous inventory was almost 10 years. In that amount of time memories fade, files are purged from servers, and staff change organizational rolls. We've sought to address the loss of memory and files in the 2017 inventory by providing detailed inventory documentation and calculations. That said – an inventory frequency of 2 – 5 years is common.
- **Work closely with PSRC on transportation modeling and collect local data.** PSRC suggested that City of Edmonds collect more data on traffic counts and conduct local trip surveys.
- **Household Consumption Data and Methodology:** These emissions were estimated using the Cool Climate Network's, Household Calculator as described in ICLEI's U.S. Community GHG Inventory Protocol. This method does not provide a long-term means to accurately track these emissions. That said – a variety of entities are actively working

on addressing this issue, including C40 Cities and the Urban Sustainability Director's Network. The City of Edmonds will want to review available tools and methodologies available in the future.

- **Work with local vendors to collection more accurate refrigerant data:** Establish a process to collect more accurate, local refrigerant data. Invite cooling equipment vendors and services to join the Climate Action Planning process with a primary goal of establishing voluntary, anonymous data collection methods.

APPENDIX A: SUMMARY OF DATA AND EMISSIONS FACTORS

Description of Data and Emissions Factors	
Population information was obtained from the US census Bureau. Per capita GHG emissions were obtained by diving the 2017 Local Emissions by the 2017 estimated population.	
Emissions Category	**Category Description**
Stationary Energy (Buildings)	
Residential Energy	*These categories include direct emissions from natural gas, fuel oil, and propane combustion by the residential, commercial, and industrial sectors within the City's geographic boundaries. Also includes the indirect emissions from grid electricity use by the same sectors for the same geographic boundaries.*
Commercial Energy	
Industrial Energy	
Electricity and natural gas data provided by utilities and considered highly accurate. Fuel oil and propane use estimated using state-level per capita fuel usage data and Edmonds annual population. Emissions factors for natural gas, fuel oil, and propane are programmed into ICLEI's ClearPath and are considered highly accurate. Electricity location-based emissions factors are taken from EPA eGRID 2016 data for the Northwest Power Pool (NWPP) sub-region. Market-based electricity accounting emissions factors; green power program participation; and residential and commercial PV solar generation are provided by Snohomish Public Utility District.	
Transportation	
On-Road Energy	*Direct emissions from gasoline and diesel for passenger & freight transportation.*
Total on-road vehicle miles traveled, and VMT splits for on-road vehicles types and greenhouse gas emissions on-road factors are provided by Puget Sound Regional Council (PSRC) and are considered moderately accurate. Values for City of Edmonds are downscaled using population from County-level modeling. Emissions factors for fuel types are based on EPA's MOVES model, which is used by PSRC to calculate the on-road factor previously mentioned.	
Transit	*Direct emissions from gasoline and diesel for passenger transit transportation.*
Fuel volume data provided by Community Transit staff and is considered highly accurate. Default fuel emissions factors are programmed into ClearPath.	
Water Transportation	*Direct emissions from gasoline and diesel for ferry and port activity.*
Fuel volume data provided by Washington Dept. of Transportation (WSDOT) and Port of Edmonds staff. WSDOT data is considered moderate accurate and Port data is considered highly accurate.	
Rail - Passenger & Freight	*Direct emissions from gasoline and diesel for passenger and freight transportation.*
Rail emissions for Snohomish County, as reported in the Puget Sound Clean Air Agency Greenhouse Gas Emissions Inventory, down-scaled by population to the Edmonds community.	
Off Road	*Direct emissions from gasoline and diesel for off-road vehicles such as construction equipment, etc.*
Off road emissions for Snohomish County, as reported in the Puget Sound Clean Air Agency Greenhouse Gas Emissions Inventory, down-scaled by population to the Edmonds community.	
Industrial Process and Product Use	
Refrigerant Loss	*Fugitive loss of refrigerants from building and vehicle air conditioning systems.*

Actual data on refrigerant loss is not available at the local level. National-level data from the US 2016 GHG Inventory which is down-scaled by population to estimate emissions for Edmonds. The data source and methodology used here is considered low accuracy. This estimate is included to provide sense of scale and to not leave out a known, significant source of community emissions.	
Natural gas fugitive emissions	*Fugitive loss of natural gas during the local product distribution.*
Default value of 0.3% from EDF User Guide for Natural Gas Leakage Rate Modeling Tool (default in ClearPath).	
Waste	
Landfill Solid Waste	*Fugitive methane emissions from mixed solid waste generated in the community and disposed of at outside the City.*
City of Edmonds solid waste staff collected 2017 weight data from local solid waste haulers and is considered highly accurate. Self-haul data is not available and represents a data gap, but Edmonds staff do not believe self-haul to represent a significant fraction of community waste quantities. Waste composition data (2009) is provided by Snohomish County staff and is considered moderately accurate due to age of data. Composition data is used by ClearPath to calculate the solid waste emissions factor. Methane GWP is based on AR5, 100-year GWP values. Solid waste values for 2000 and 2005 are taken from Edmonds Inventory report and are input into ClearPath to update emissions results with current calculation methodology and best practice.	
Composting Organic Waste	*Fugitive methane and nitrous oxide emissions from composting of organic wastes (wood, yard debris, and food). It should be noted that while composting does produce emissions, they are significantly less than if the same material were landfilled. Also, land-application of compost increases soil carbon sequestration. That benefit is not currently accounted for in GPC methodology.*
City of Edmonds staff provided 2017 compost weight which are considered highly accurate. Default composting emissions factors are programmed into ClearPath.	
Effluent Discharge	*Fugitive nitrous oxide emissions from discharge of treated effluent (wastewater).*
Emissions are calculated using Edmonds' population and ClearPath methodology & emissions factors.	
Biosolids Incineration	*Direct emissions from the combustion of biosolids (wastewater).*
City of Edmonds staff provided 2017 biosolids weight and heat contents. ClearPath methodology and default emissions factors are used.	
Other Scope 3	
Goods	*Upstream energy and process emissions raw material extraction, manufacturing, and out-of-state transportation of goods.*
Food	*Upstream energy and process emissions from the growing, processing and transportation of foods.*
Accurate data on quantities and suppliers for the goods and food consumed by Edmonds community households is not readily available. Therefore, the Cool Climate Carbon Calculator and US Census Bureau data on distribution of households by household income were used to estimate emissions.	
Energy (Fuel Production)	*Upstream energy and process emission from the production and distribution of natural gas, gasoline, diesel and electricity consumed either directly or indirectly by the Community.*
Data for gasoline, diesel, natural gas and electricity use is same as previously described. Direct and lifecycle emissions factors for the various energy types are provided by EPA's AFLEET tool. Emissions are calculated in Excel outside of ClearPath and entered into ClearPath as an emissions total.	

Figure 18: Inventory summary of data and emissions factors.