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CHELAN COUNTY

Community Greenhouse Gas Inventory

Calendar Year 2023

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Contents

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This Chelan County community greenhouse gas inventory was conducted by Parametrix. Grace Thirkill, Claudia Denton, and Suzy Godber of Parametrix provided data-gathering assistance and facilitated the use of Climate Metrix, a proprietary greenhouse gas inventory tool, to conduct the analysis. They are the primary authors of this report.

Data Collection

Also, a special thank you to additional staff and agencies providing data and guidance, including Chelan County Public Utility District No.1 (PUD), Cascade Natural Gas, Chelan County, City of Chelan, Lake Chelan Airport, Link Transit, Montana-Dakota Utilities Company, and Waste Management.

Glossary of Terms

GHG

Short for greenhouse gases. Emissions of greenhouse gases are the cause of current climate change. An inventory of GHGs measures gases in units of CO_2e (carbon dioxide equivalent). 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 and communities 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 the gas 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 28, meaning one ton has 28 times the effect of one ton of carbon dioxide (IPCC AR5 values).

Consumption-Based Emissions

Emissions from consumption and purchase of goods and services, 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.

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 (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 also known as **local emissions**. This type of inventory follows a set protocol (GPC) determining what is included in each sector. Mainly, sector-based emissions include emissions from building energy and vehicles along with local sources of GHGs from waste, uncontrolled loss of industrial and refrigerant gases, and agriculture. Note that emissions from household consumption of goods and services are not included in sector-based inventories. Standard sectors include:

- **Building Energy:** emissions from energy used or produced in a fixed location, e.g. electricity, natural gas, propane, and fuel oil. The GPC term is stationary energy.
- **Transportation:** emissions from vehicles and mobile equipment. The GPC term is mobile energy.

- **Waste:** solid waste emissions and wastewater treatment emissions.
- **Industrial Process and Product Use (IPPU):** refrigerants and other fugitive gases from industrial processes.
- **Agriculture, Forestry and Land Use (AFLU):** emissions from agriculture (e.g. animal waste and agricultural inputs) and community land use change (e.g. development of forest or grasslands). *While this category includes emissions from wildfires, wildfire emissions are split out from AFLU in this report for valuable context.*

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.

Market-based Electricity Emissions Accounting

Refers to the GHG intensity of electricity contracts with local utilities and other contracts, representing the impacts of electricity use based on specific energy purchases. Contrast with Location-based Electricity Emissions Accounting.

MT

Short for Metric Ton (~2,200 lbs.). This is a common unit by international standards.

MT CO_2e

Metric tons of carbon dioxide equivalent (MT CO_2e) is 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. This is the unit of measure used for all GHG emissions are reported in for in this inventory.

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 a geographic boundary (scope 1), from electricity and shared energy generation serving the community (scope 2), and emissions that occur outside the boundary, but that are driven by activity within the boundary (scope 3).

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

Executive Summary

Chelan County's community GHG inventory estimates the GHG emissions associated with the geographic boundaries of the County. This report represents the community's carbon footprint, and it provides a baseline for future GHG emissions tracking. This inventory can be used to better understand how different sectors impact emissions. The inventory will help provide context to evaluate future mitigation strategies and to inform further investment in community-level climate mitigation work and regional efforts with public agencies, utilities, nonprofit partners, and the business community.

This inventory follows the internationally recognized *Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC)* and includes all significant sources of GHG emissions from activities occurring within Chelan County's geographic boundary (local emissions). In addition, this inventory also accounts for consumption-based emissions, which are emissions associated with all goods and services that are consumed by residents, regardless of where those goods were produced. Categories of consumption-based emissions include purchased goods, food, fuel, and air travel. The emissions categories presented in this report align with those required under the GPC framework. Data confidence varies; where possible, activity data was obtained directly from utilities, which is considered highly accurate; in other cases, estimates were downscaled from statewide data. Additional details on data sources and emissions factors are provided in the Protocols, Methodology, and Data Used section. Estimates are rounded to the nearest 1,000.

Summary of Findings

Chelan County's 2023 Community GHG emissions combined local and consumption-based emissions totaled 3,453,000 MT CO_2e. With a population of 79,997, this equates to 43.2 MT CO_2e per capita.

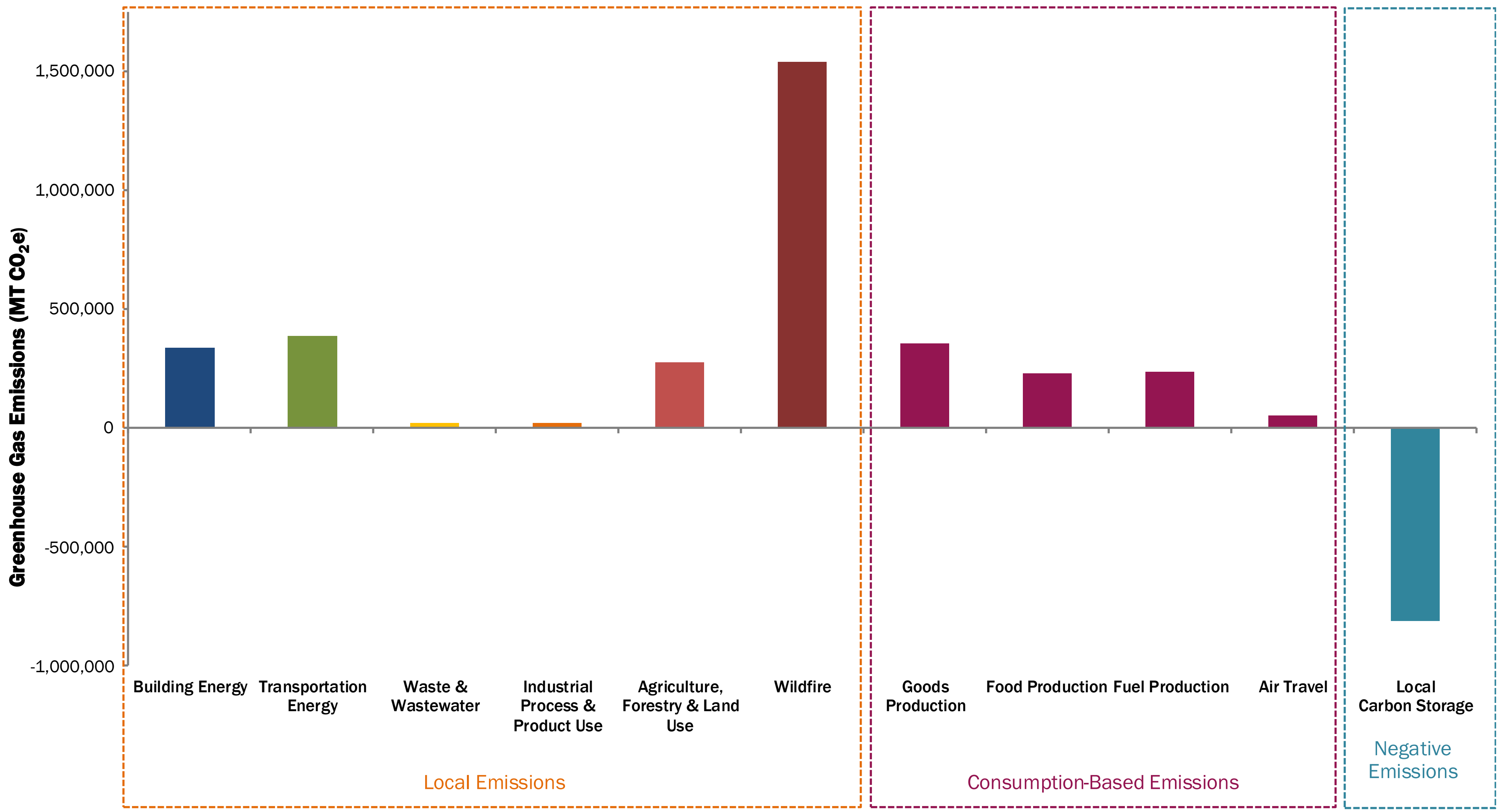
Local emissions include emissions from activities occurring within Chelan County's geographic boundary and include building energy; transportation energy; waste and wastewater; industrial process and product use; agriculture, forestry, and land use; and wildfire. Key findings include:

- Local emissions totaled 2,581,000 MT CO_2e, about 32.3 MT CO_2e per capita.
- Forest carbon loss due to specifically wildfires were the largest source of local emissions. A separate study that informs this is provided in Appendix C.
- Transportation and building energy were the second and third largest respectively.

Consumption-based emissions include emissions generated outside of the community during the production of goods, food, fuel, and service products purchased and consumed by Chelan County residents. Key findings include:

- Consumption-based GHG emissions totaled 873,000 MT CO_2e, about 10.9 MT CO_2e per capita.
- Goods production was the largest source of consumption-based emissions, followed by fuel production and food production.

Figure 1 below provides a comprehensive summary of Chelan County's total greenhouse gas emissions for the year 2023, offering an overview of the distribution and relative contributions of different sources and sectors within the County's overall emissions profile.



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Introduction

The Our Valley Our Future Post-Carbon Economy Initiative, led by the community-based organization Our Valley Our Future (OVOF), is working to help the Wenatchee Valley transition toward a sustainable, low-carbon economy. Its goals include reducing greenhouse gas (GHG) emissions, advancing renewable energy, and strengthening climate resilience.

This Greenhouse Gas (GHG) Inventory Report is a collaborative effort of Sustainable NCW, Chelan County, and OVOF. It provides a baseline assessment of the community's current emissions profile, offering essential data to guide development of sustainability initiatives. By identifying major sources of emissions and enabling progress tracking over time, the report supports collective action to lower the region's carbon footprint and move toward a more sustainable and resilient future.

To ensure clarity and transparency, the report is organized into the following sections:

- **Protocols, Methodology, and Data Used:** Outlines the approaches, tools, and emissions factors used to prepare Chelan County's 2023 GHG inventory, including both local and consumption-based emissions.
- **Inventory Results – Total Emissions:** Summarizes overall emissions for 2023, combining local and consumption-based results.
- **Inventory Results – Local Emissions:** Provides an overview of local GHG emissions for 2023.
- **Inventory Results – Detailed Results by Local Sector:** Breaks down local GHG emissions in greater detail by sector and source.
- **Inventory Results – Consumption-Based Emissions:** Summarizes emissions linked to goods and services consumed in 2023.
- **Appendix A – Detailed Emissions Breakdown:** Detailed table of all emissions results.
- **Appendix B – Electricity Accounting:** Overview of market-based versus location-based electricity accounting.
- **Appendix C – Chelan County Wildfire Emissions:** Chelan County Wildfire Emissions Report (2016–2024), used in estimating wildfire-related emissions.

Protocols, Methodology, and Data Used

Protocols and Methodologies

This GHG inventory adheres to established protocols and methodologies to ensure accuracy, transparency, and replicability. This inventory follows Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) 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 U.S. Community Protocol for guidance on calculation of consumption-based emissions (i.e., Other Scope 3).

Parametrix's carbon calculator tool *Climate Metrix – Community* was used for GHG emissions calculations. Activity data are documented in the Inventory Audit Trail. *Climate Metrix – Community* is an Excel-based calculator that documents all activity data, emissions factors, and emissions calculations used in the inventory. The audit trail catalogs all data and resource files used to complete the inventory. These resources are highly detailed and will allow those conducting future inventories to replicate the methods used in this inventory.

GHG emissions presented in this report are represented in metric tons of carbon dioxide equivalent (MT CO_2e). The gases considered in the analysis are consistent with protocol and include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), chlorofluorocarbons (CFCs), sulfur hexafluoride (SF_6), and perfluorocarbons (PFCs) per the Kyoto Protocol. All GHG calculations use 100-year global warming potentials as defined in the International Panel on Climate Change's Fifth Assessment Report (IPCC AR5).

Local and Consumption-Based Emissions Categories

Chelan County's GHG inventory reports both local and consumption-based emissions. **Local emissions** (also referred to as sector-based emissions) are generated from local sources within the community, such as vehicles and buildings. Local emissions are most often under the community's direct control. Per GPC protocol, this GHG inventory includes the following local emissions sources:

- **Building Energy:** Residential, commercial, and industrial buildings are major sources of GHG emissions, primarily from natural gas combustion and electricity generation using fossil fuels. In Chelan County, electricity is largely supplied by hydropower, about 80% of the grid mix from Chelan County PUD, which contributes low emissions. This category also includes small amounts of other combusted fuels and estimates of methane released from natural gas lost during local distribution. The emissions in this report reflect market-based accounting. For more information on this accounting method, see Appendix B.
- **Transportation Energy:** This category includes emissions from gasoline, diesel, electricity used by passenger vehicles, rail, and transit. Aviation gasoline and jet fuel dispensed at Lake Chelan airport are also included. Waterborne transportation data was not available.
- **Waste & Wastewater:** Landfilling organic matter (such as food scraps and paper) produces methane, a potent greenhouse gas. The treatment of wastewater from both centralized

treatment and septic systems also produces GHG emissions including nitrous oxide and methane generation.

- **Industrial Process & Product Use (refrigerants):** Refrigerant emissions come from building and transportation cooling systems such as air conditioners and refrigerators. Refrigerants are powerful global warming gases. Therefore, relatively small losses have a larger climate impact.
- **Agriculture, Forestry, & Land Use (AFLU):** These emissions come from agricultural activity (e.g., animal waste and agricultural inputs), forestry (any activities that cut down trees), and community land use change (e.g., development for homes or infrastructure).
- **Wildfire (part of AFLU):** Wildfire emissions are part of the AFLU category per GPC protocol. For this inventory, wildfire is placed in its own category for context and presentation purposes, since the emissions here are very large and of particular interest to Chelan County. For this inventory, a more granular study of wildfire emissions was conducted and available for review in Appendix C.

Chelan County's 2023 GHG inventory goes beyond GPC requirements by including analysis of additional **consumption-based emissions** which are emissions associated with all goods and services that are consumed by residents, regardless of where those goods were produced. This includes lifecycle emissions from purchased goods and food (e.g., materials extraction, production, and transportation of purchased goods, fuels, and food) as well as emissions from services used by residents (e.g., air travel outside the community) that occur outside of the geographic boundary of the County. These emissions are accounted for in other communities' local emissions. However, better understanding consumption-based emissions is useful because they are substantial, driven by local demand, and can be reduced by decreasing or changing consumption habits. Sources of consumption-based emissions include the following:

- Goods**:** These emissions are from extracting, manufacturing, and transporting raw materials into final products such as building materials, cars, furniture, and clothing.
- Food & Beverage**:** These emissions are from agriculture (energy for irrigation, production of fertilizers, methane emissions from livestock, etc.) and transportation of raw materials and finished products. Categories include produce, cereals, dairy, meat, and others.
- Upstream Fuel Production**:** Process and energy emissions from the extraction and production of fuel products (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, and diesel (not available for propane and fuel oil). These emissions are separate from those that are generated when the fuel is used in your car or house.
- Air Travel**:** Emissions associated with air travel by the community (regardless of the airport's location).

Data Sources and Emissions Factors

This section outlines the data sources and emissions factors used in the inventory. Table 2 summarizes the included emissions sources along with their corresponding data sources, activity data, emissions factors, and data quality. Some estimates are more precise than others, reflecting differences in data availability and quality. Data quality definitions provided by GPC are defined in Table 1 and used in Table 2.

Table 1: Data Quality Assessment Definitions

Data Quality	Activity Data	Emissions Factor
High	Detailed activity data	Specific emissions factors
Medium	Modeled activity data using robust assumptions	More general emissions factors
Low	Highly-modeled or uncertain activity data	Default emissions factors

Table 2: Data Sources and Emissions Factors

Sector	Emissions Source	Activity Data	Data Source	Emissions Factor	Data Quality
Building Energy	Electricity (kWh)	County-Wide consumption provided directly by utility by sector (residential, commercial, industrial).	Chelan PUD (includes data for BPA irrigation)	1) Market-Based: Utility-specific emissions factors from and Washington Department of Ecology 2) Location Based: EPA Emissions & Generation Resource Integrated Database (eGRID)	High
Building Energy	Natural gas (therms)	County-Wide consumption provided directly by utility by sector (residential, commercial, industrial).	Montana-Dakota Utilities Co.	U.S. Department of Energy and EPA GHG Emissions Factor Hub constants	High
Building Energy	Other fuels (gallons)	Gallons of fuel oil and propane, separated by residential and commercial. Downscaled by population from state-level data.	U.S. Energy Information Administration State Energy Consumption Estimates	U.S. Department of Energy and EPA GHG Emissions Factor Hub constants	Medium
Transportation	Passenger Cars (gallons)	Estimated fuel gallons are calculated from total vehicle miles traveled in Chelan County, adjusted based on Washington State data for travel activity by vehicle type and functional class, and incorporating average fuel efficiency for each vehicle type	WSDOT VMT and travel activity data prepared for FHWA Highway Performance Monitoring System	Using U.S. Department of Energy and EPA GHG Emissions Factor Hub constants	Medium

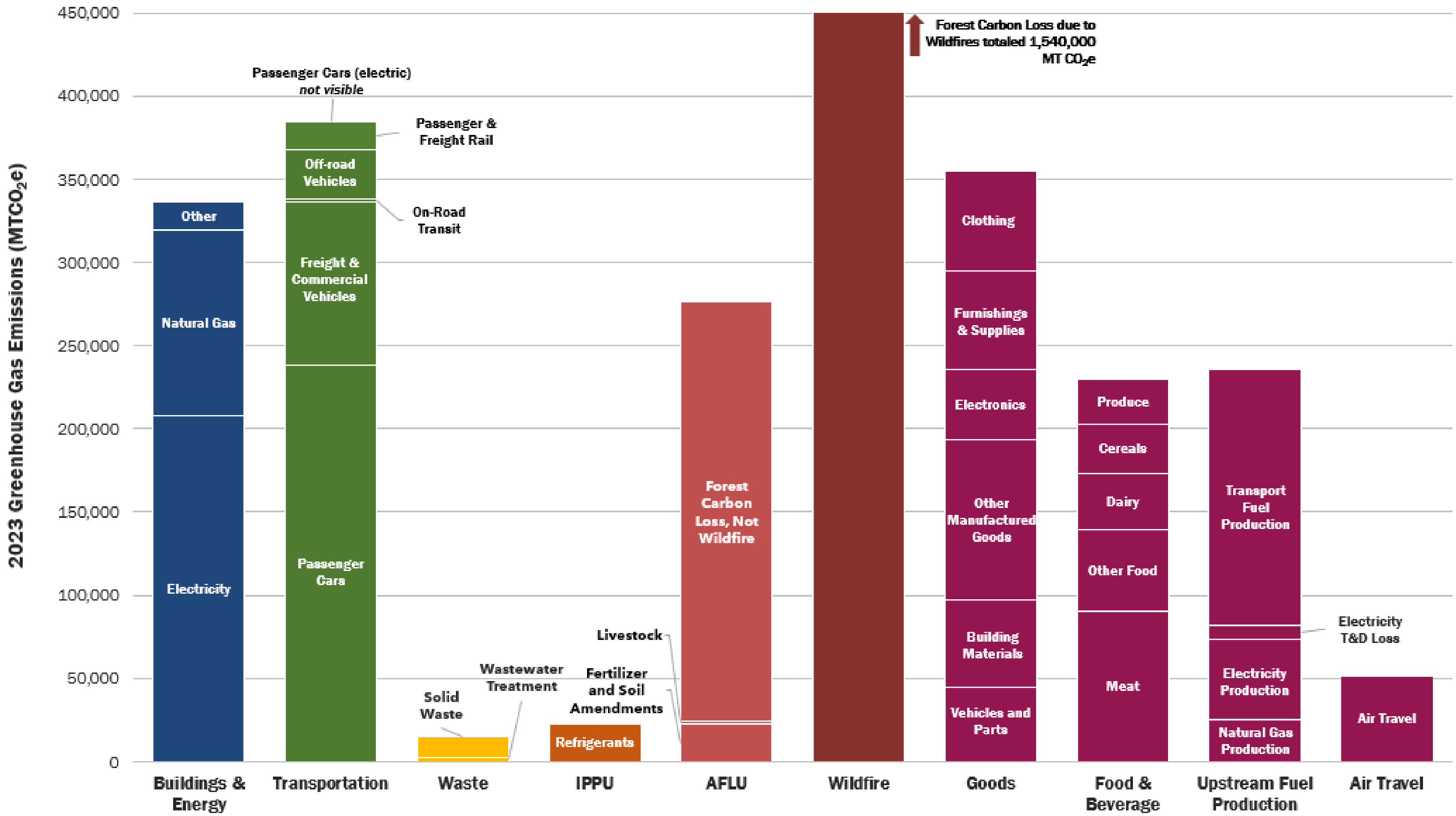
	Passenger Cars (electric)	Identified count of vehicle registration in Chelan County. Estimated kWh based on average miles driven.	DMV registration data, estimated annual miles per EV	1) Market-Based: Utility-specific emissions factors from and Washington Department of Ecology 2) Location Based: EPA Emissions & Generation Resource Integrated Database (eGRID)	Medium
	Freight & Commercial Vehicles (gallons)	Estimated fuel gallons are calculated from total vehicle miles traveled in Chelan County, adjusted based on Washington State data for travel activity by vehicle type and functional class, and incorporating average fuel efficiency for each vehicle type	WSDOT VMT and travel activity data prepared for FHWA Highway Performance Monitoring System	Using U.S. Department of Energy and EPA GHG Emissions Factor Hub constants	Medium
	Off-Road Vehicles (MT CO_2e)	Emissions pulled from Washington State GHG Inventory, downscaled by population	Washington State GHG Inventory	Data already in MT CO_2e and downscaled by Chelan County population	Medium
	On-Road Transit (gallons)	Gallons of both gasoline and diesel use from Link Transit, downscaled for Chelan County by service territory land area	National Transit Database	Using U.S. Department of Energy and EPA GHG Emissions Factor Hub constants	Medium
	Passenger & Freight Rail (MT CO_2e)	Emissions pulled from Washington State GHG Inventory, downscaled by railroad length	Washington State GHG Inventory	Data already in MT CO_2e and downscaled by railroad length	Medium
	Aviation Fuel (gallons)	Gallons of fuel provided directly from Lake Chelan Airport	Lake Chelan Airport (Cashmere contacted but does not have fueling station)	Using U.S. Department of Energy and EPA GHG Emissions Factor Hub constants	High
Waste & Wastewater	Solid Waste (tons)	Tons of solid waste for County and destination landfills (Wenatchee, Dryden, and Chelan Transfer Stations)	Waste Management	EPA FLIGHT, Emissions per ton of waste at destination landfill (Greater Wenatchee Landfill)	High
	Wastewater Treatment (MT CO_2e)	Estimated based on EPA community inventory tool using wastewater service population and facility characteristics	EPA Community GHG Inventory Tool	Results already in MT CO_2e	Low

	Septic	Population served by septic	EPA Community GHG Inventory Tool	Available in the EPA Community GHG Inventory Tool	Medium
IPPU	Refrigerants (MT CO_2e)	Emissions pulled from Washington State GHG Inventory, downscaled by population	Washington State GHG Inventory	Data already in MT CO_2e	Medium
AFLU	Livestock (livestock population)	Number of dairy cows, beef cows, sheep, goats, swine, horses, and poultry	USDA Census of Agriculture	ICLEI US Protocol	Medium
	Fertilizer and Soil Amendments	Number of acres of harvested cropland, proportion of total agricultural soil emissions from state-level inventories	USDA Census of Agriculture, EPA estimated GHG Inventory	Data already in MT CO_2e and downscaled from state level data	Medium
	Forest Carbon Loss (hectares)	Tree cover loss in 2023 due to all other drivers (excluding wildfires)	Global Forest Watch	Data already in MT CO_2e and downscaled by county level data	Medium
Wildfire	Forest Carbon Loss (acres burned)	LANDFIRE fuelbed data; forest biomass data; fuel moisture data; wildfire perimeter and attribute data; burn severity data; First Order Fire Effects Model default fuelbed input values	USDA Forest Service; Fire Environment Mapping System; WA DNR	2022 EPA State Inventory Tool (SIT) in its Natural and Working Lands (NWL) inventory	Medium
Consumption-Based Emissions	Goods Production	American community survey household income distribution	U.S. Census American Community Survey	UC Berkeley CoolClimate Calculator	Low
	Food Production	American community survey household income distribution	U.S. Census American Community Survey	UC Berkeley CoolClimate Calculator	Low
	Upstream Energy (fuel use)	Activity data for gasoline, diesel, natural gas, and electricity use is described above	Data sources for electricity, natural gas, and all fuel use.	Life-cycle emissions factors for the various transportation fuel types and electricity production are provided by Ecology's Clean Fuel Standard Program carbon intensity scores, EPA eGRID data, OR-GREET	High
	Air Travel	American community survey household income distribution	U.S. Census American Community Survey	UC Berkeley CoolClimate Calculator	Low

Inventory Results – Total Emissions

Local and consumption-based emissions combine for a total of **3,453,000 MT CO_2e** (shown below in Figure 2), or **43.2 MT CO_2e per resident.**

Figure 2: Full Breakdown of Chelan County's 2023 Emissions Sources



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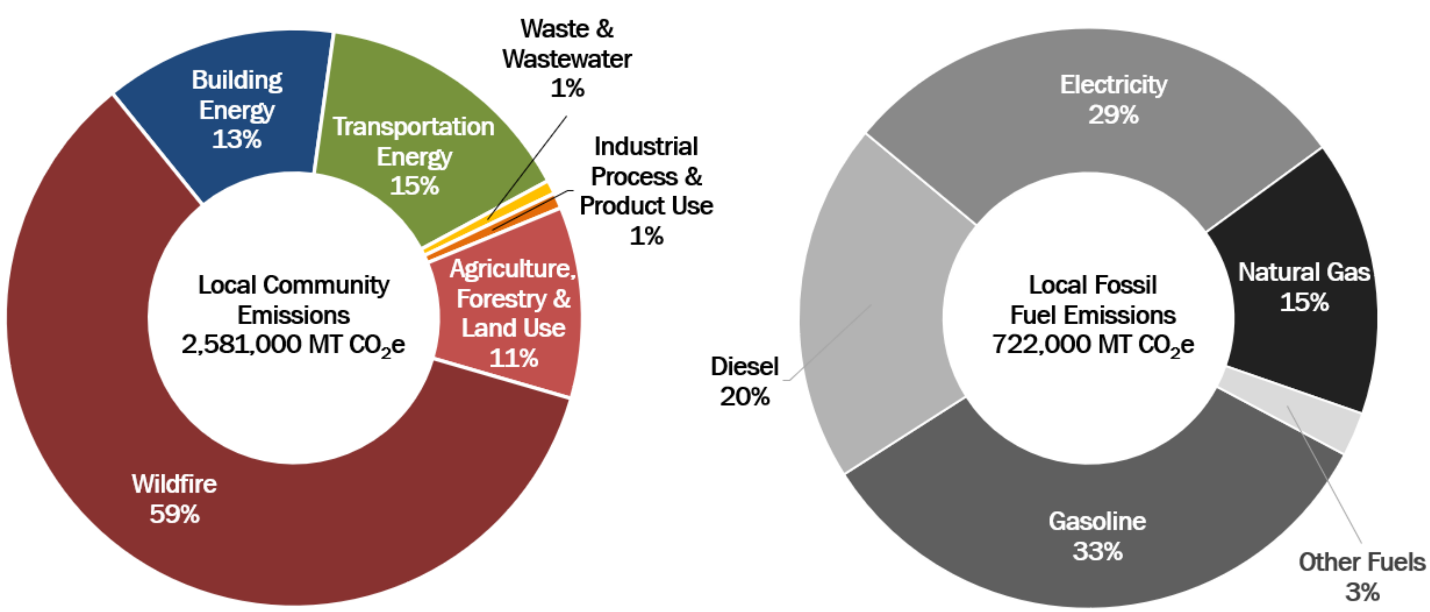
Inventory Results – Local Emissions

Protocols refer to **local emissions** as sector-based emissions that are generated from local sources within the community, such as vehicles and buildings. These emissions are generated close to home and are most often under the community's **direct control**. The Chelan County community generated **nearly 2,581,000 MT CO_2e** of local emissions which averages about 32.3 MT CO_2e per resident.

Chelan County's local emissions are shown on the left side of Figure 3 (below) and primarily come from **wildfire,** with other larger sources including **building energy**, **transportation energy**, and **agriculture, land use, and forestry**. Smaller sources of emissions for Chelan County include **industrial process and product use** as well as **waste and wastewater**. The right side of Figure 3 details fossil fuel use across all categories of local emissions. Note that all emissions from buildings energy and transportation energy are from fossil fuels (32% of local emissions). However, not all building or transportation energy sources contribute to emissions. Electricity generated from zero-carbon sources, such as hydropower, does not contribute to the County's emissions; biogenic fuels, such as renewable diesel and biodiesel, contribute minimal emissions. If hydropower did not encompass 80% of the grid mix for Chelan County PUD, the emissions from electricity would be much higher.

Wildfire; agriculture, land use, and forestry; industrial process and product use; and **waste and wastewater** sources all produce non-energy emissions. These emissions include, but are not limited to, greenhouse gases from carbon emitted from wildfire and forest loss, waste processing and water treatment, methane from livestock, and high-global warming potential (GWP) gases, such as refrigerants. The emissions from these non-fossil sources are further discussed in the corresponding sector sections.

Figure 3: 2023 Local Community Emissions and Fossil Fuel Emissions Details



Parametrix

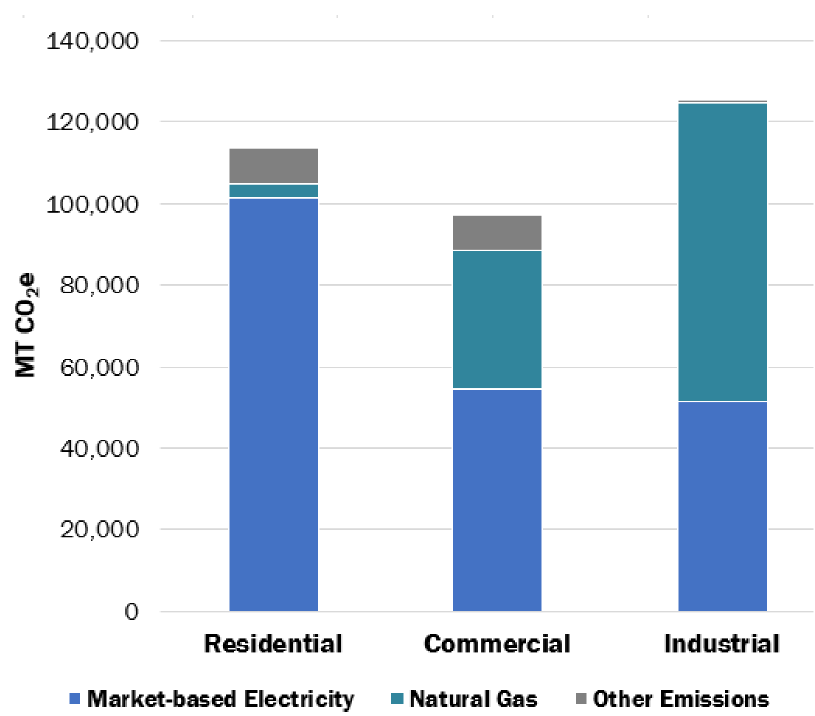
Inventory Results – Detailed Results by Local Sector

Building Energy

Energy used in buildings is Chelan County's third largest source of local GHG emissions, accounting for 13% of local emissions. These emissions come from a mix of electricity, natural gas use, and other stationary combusted fuels, and they result in 337,000 MT CO_2e.[1] The market-based electricity accounting method uses utility-specific factors and accounts for the use of renewable energy, i.e. hydropower, in the community as well as voluntary community participation in utility-sponsored green power programs.

By energy type, electricity had the largest impact (47% of total building emissions) with natural gas following (25% of total building emissions). Although about 80% of electricity is sourced from hydropower from Chelan PUD, about 20% is from unspecified sources and those emissions are what are predominantly reflected. Appendix B: Electricity Accounting section further discusses the use of market-based emissions factors. There is limited access to natural gas in the county, but natural gas has more emissions per unit of energy compared to electricity. The combustion of other fuels, including propane and fuel oil, were a combined smaller source of emissions (4%). Figure 4 shows emissions by subsector and energy type. Fugitive natural gas escaping from local distribution systems was reported by Montana-Dakota Utilities Co. and accounts for 0.3% of total building emissions and is included in natural gas emissions.

Figure 4: Building Energy Emissions by Source



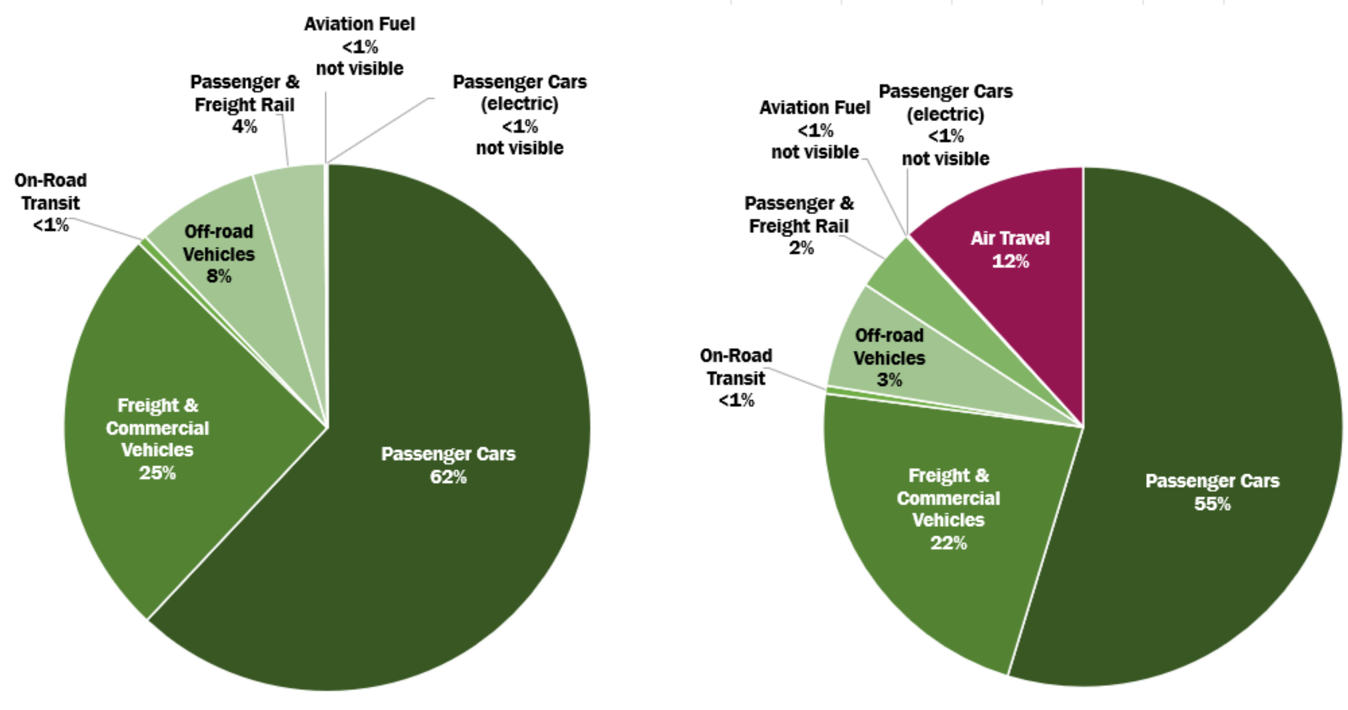
[1] All emissions estimates use market-based accounting for electricity unless otherwise noted. Market-based electric accounting totals 336,816 MT CO_2e, while location-based accounting totals 680,966 MT CO_2e. See Appendix B: for information about market-based versus location-based accounting.

Transportation

Transportation emissions are the second-largest source of local emissions for Chelan County, totaling 385,000 MT CO_2e (15% of local emissions). On-road passenger vehicles were the leading source of local transportation emissions (62%). These emissions originate from gasoline, primarily used by passenger vehicles. This category also includes the small amount of electricity used by electric vehicles (<1%). Diesel, primarily used by on-road freight and commercial vehicles, comes as next-highest at 25%. The next-largest category is off-road vehicles, which can come from construction, farming, landscaping, or other non-road vehicles and mobile equipment, and account for 8% of total emissions. Transit and rail accounted for 4% of local transportation emissions. Aviation fuel used by Lake Chelan Airport accounted for less than 1% of local transportation emissions. Waterborne transportation emissions from sources like local ferries at Lake Chelan were not available.

Many residents travel by airplane, whether within the Chelan County boundary or not (for example, traveling by air from SeaTac Airport), and this additional air travel is part of the community's consumption-based emissions. As is shown on the right side of Figure 5, emissions from non-local air travel (magenta) are a significant source of emissions in addition to local transportation emissions (green). Air travel emissions are estimated at about 51,000 MT CO_2e.

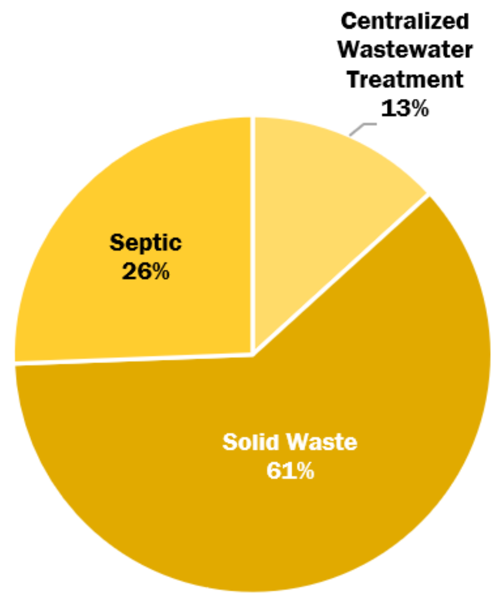
Figure 5: Transportation Emissions Breakdown
Left: Chelan County's transportation emissions, excluding non-local air travel.
Right: Chelan County's transportation emissions, including consumption-based emissions from non-local air travel.



Waste & Wastewater

Waste and wastewater treatment emissions are Chelan County's smallest source of emissions and total about 20,000 MT CO_2e, 1% of local emissions. Figure 6 illustrates the breakdown of emissions from both solid waste and wastewater, which come from non-energy sources.

Figure 6: Waste & Wastewater Emissions Breakdown



Chelan County's solid waste emissions are estimated to total 12,000 MT CO_2e. Chelan County has no landfills that handle municipal waste within its geographic boundaries. Waste was landfilled at Waste Management's Greater Wenatchee Regional Landfill in Douglas County. The proportion of methane emissions associated with the waste generated by the Chelan County community are accounted here, even though these emissions occur outside of the Chelan County limits, since the waste reflected here is generated by Chelan County residents.

Wastewater is processed by multiple jurisdictions, including the Cities of Wenatchee, Cashmere, Entiat, Chelan, Leavenworth, and Chelan PUD. All these facilities are included in the analysis. Total wastewater process emissions are estimated to total 3,000 MT CO_2e. Additionally, there are an estimated 18,600 people served by septic systems within the County. Septic systems are more GHG intensive than centralized wastewater treatment because of the different treatment processes. Emissions from septic systems are estimated to total 5,000 MT CO_2e.

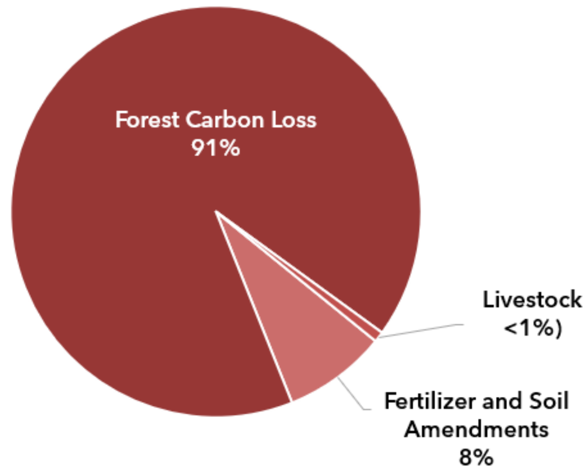
Industrial Process & Product Use

Industrial Process and Product Use (IPPU) emissions are Chelan County's second smallest source of local emissions, estimated to be 23,000 MT CO_2e, 1% of local emissions. IPPU emissions are non-energy sources of emissions and come from unintentional leaks or discharges of gases from equipment or facilities. They come from refrigeration systems (air conditioning, refrigerators, freezers) or specialized industrial gases — chlorofluorocarbons (CFCs), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), nitrogen trifluoride (NF_3) — and have a large climate impact, up to 23,500 times the global warming potential of an equivalent weight of CO_2 depending on the gas.

Fugitive loss of refrigerants from residential and commercial buildings and vehicle air conditioning and refrigeration equipment are the only source of Chelan County's IPPU emissions.

Agriculture, Forestry, and Land Use

Figure 7: AFLU Emissions Breakdown



Agriculture, forestry, and land use (AFLU) emissions are 11% of Chelan County's local emissions and total 276,000 MT CO_2e (excluding wildfire emissions – see below). As shown in Figure 7, the largest contribution to AFLU emissions was from forest carbon loss, as estimated by satellite analysis of tree coverage, which includes loss from deforestation (hard commodities, permanent agriculture, and infrastructure development) and drivers of temporary disturbances (logging and other natural disturbances). Chelan County lost 570 hectares of tree coverage in 2023, and emissions totaled 252,000 MT CO_2e.

The application of fertilizer and soil amendments to orchards and cropland is a significantly smaller source of emissions in this category, and total 22,000 MT CO_2e. Additionally, livestock emissions total 2,000 MT CO_2e. A variety of livestock are raised within the county, and these emissions come from enteric fermentation (digestive process) by ruminant animals (animals with more than one stomach) and manure management.

Wildfire

Wildfire emissions account for approximately 59% of Chelan County's total local emissions, by far the largest single source, totaling about 1,540,000 MT CO_2e. When forests are burned by wildfire, they release the carbon stored in trees and vegetation into the atmosphere as CO_2, significantly contributing to climate change. Because wildfire activity fluctuates widely from year to year, these emissions represent a snapshot in time and are difficult to predict or control.

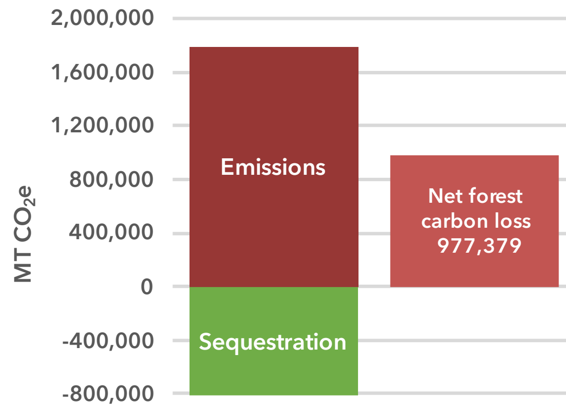
In the Pacific Northwest especially, forest loss from wildfire is the leading source of land-based emissions. A detailed analysis of wildfire emissions in Chelan County from 2016 to 2024 is available in Appendix C. Over this period, annual emissions have varied greatly depending on fire size, severity, and vegetation density. The average annual emissions for this time period are estimated at 1,440,000 MT CO_2e, with several years, including 2023, exceeding 1,500,000 MT CO_2e. In contrast, years with smaller fires, such as 2016 and 2020, saw much lower emissions.

To illustrate the impact, wildfire emissions from 2021 alone are equivalent to the annual emissions of over 385,000 gas-powered cars or the electricity use of more than 340,000 homes. This far exceeds the 276,000 MT CO_2e emitted through other forms of forest carbon loss measured in this inventory, including deforestation activities and natural disturbances, underscoring the outsized climate impact of severe wildfire seasons.

Local Carbon Storage

Carbon dioxide removals from tree growth, known as sequestration, are also included separately. When calculated as a “net forest carbon loss”, the sequestration from forest growth is subtracted from total emissions of forest lost, as shown in Figure 8. This figure is calculated specifically for 2023, but these emissions can change significantly. Although forests can regrow with proper management, it takes decades for them to absorb the same amount of carbon they released. In the meantime, that carbon remains in the atmosphere, intensifying climate change.

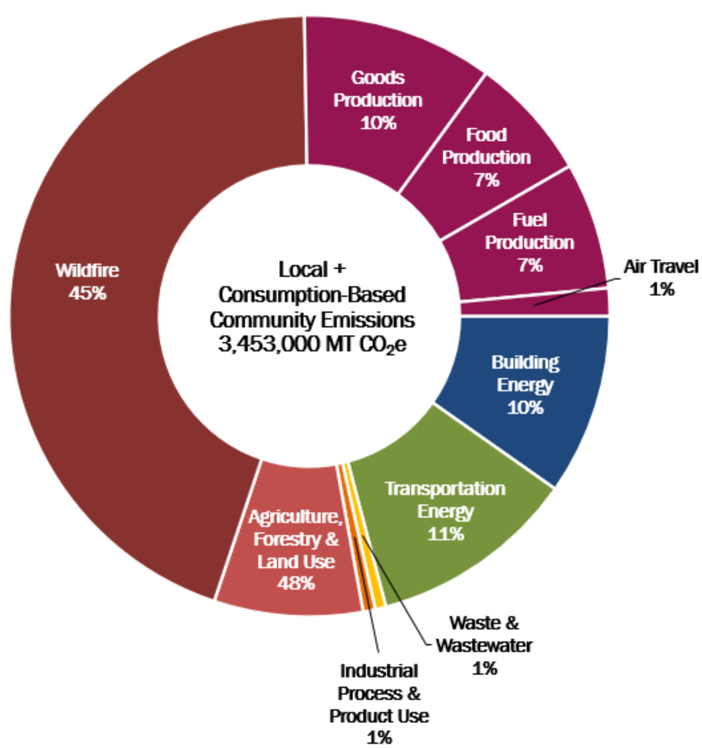
Figure 8: *Net Forest Carbon Loss Emissions*



Inventory Results – Consumption-Based Emissions

Chelan County’s consumption-based emissions were estimated at 873,000 MT CO_2e and make up 25% of total emissions when combined with local emissions (Figure 9). Consumption-based emissions are referred to as “Other Scope 3” in GPC protocol. While reporting these emissions is typically optional due to measurement challenges, they are included here because the data exists to estimate them, they represent significant sources of emissions, and opportunity exists to reduce them. Consumption-based emissions are GHG emissions associated with the production of goods and services purchased and consumed by residents within the County, regardless of where those goods and services are produced. By including what residents consume locally that is produced elsewhere, consumption emissions provide complementary perspective that can reveal the broader environmental impact of a community’s consumption. These consumption-based emissions will be captured in another community’s local emissions accounting.

Figure 9: *2023 Local and Consumption-Based Emissions*



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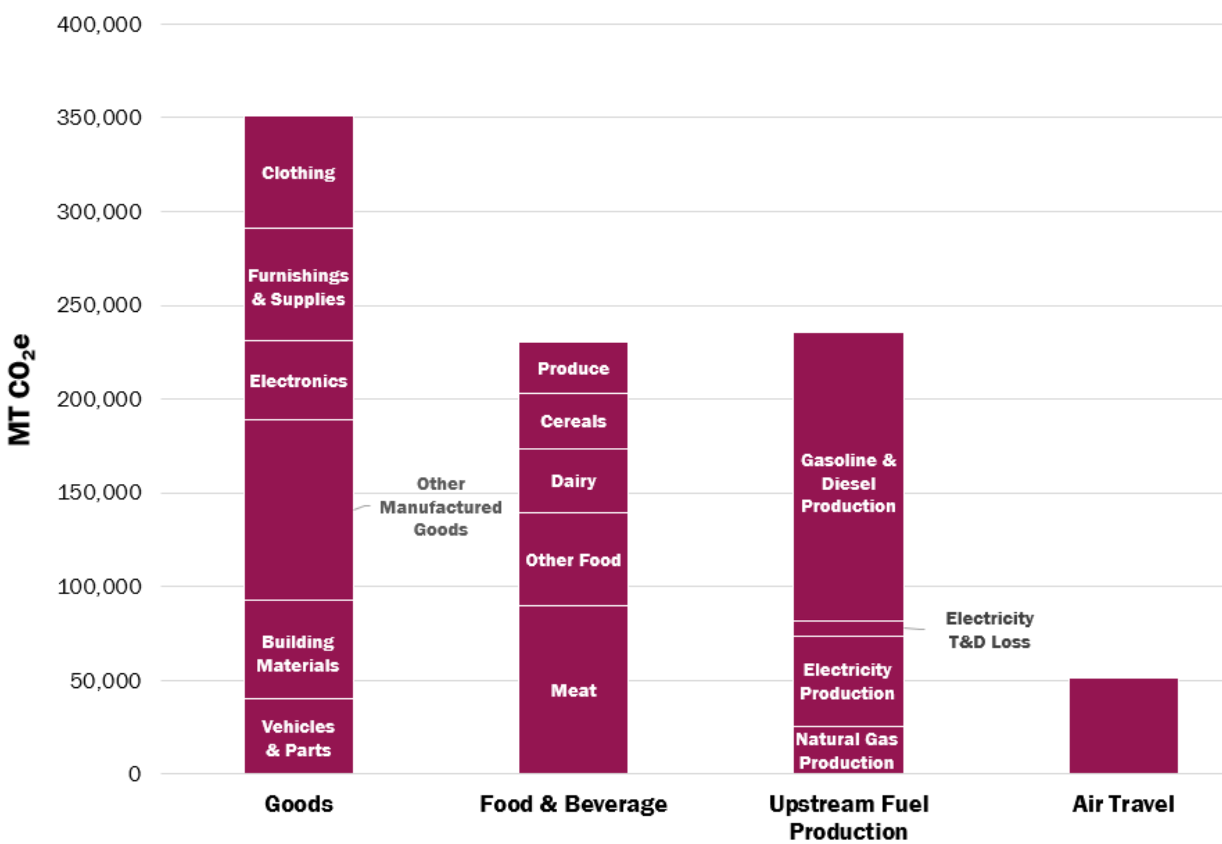
These emissions are hard to control since they are based on personal choice, but the community can support reducing these emissions through public education on the impacts of consumption and presenting opportunities to refuse, reuse, repair and recycle. That said, these emissions are included in the inventory because they are large, they are caused by local demand, and opportunities exist to reduce these emissions locally by reducing consumption.

As shown in Figure 10, the largest source was consumption of goods, with major contributors including other manufactured goods, clothing, furnishings and supplies, building materials, vehicles and parts. The second largest source was upstream fuel production, mainly from gasoline and diesel, which is tied closely to tailpipe passenger and freight transportation. Another large source was food and beverage consumption, where the largest contributor was meat consumption. Air travel by Chelan County residents also contributed to emissions. Note that these air travel emissions are from air travel trips taken by residents regardless of airport location.

Figure 10: Breakdown of Consumption-Based Emissions



Appendix A:
Detailed Emissions Breakdown

Detailed Emissions Breakdown

Table 3 below provides detailed emissions breakdowns for all categories for both market-based and location-based accounting. The figures represented in this report are market-based accounting. Details on the difference between market-based and location-based accounting are provided in Appendix B.

Table 3: Detailed Emissions Breakdown

Emissions Sector / Sub-Sector	2023 Emissions (MT CO_2e)		Per capita (MT CO_2e)	
	*Market-based	Location-based	*Market-based	Location-based
Building Energy	**336,816**	**680,966**	**4.2**	**8.5**
Residential Buildings				
Electricity	101,307	267,206	1.3	3.3
Natural Gas	3,700		0.0	
Other Fuels	8,622		0.1	
Commercial Buildings				
Electricity	54,630	144,091	0.7	1.8
Natural Gas	33,703		0.4	
Other Fuels	8,736		0.1	
Industrial Facilities				
Electricity	51,352	135,445	0.6	1.7
Natural Gas	73,528		0.9	
Fugitive Emissions from Natural Gas Systems	962		0.01	
Wastewater Treatment Energy	276	4,973	0.003	0.06
Transportation	**384,993**	**385,867**	**4.8**	**4.8**
On-Road Passenger Vehicles				
Gasoline Vehicles	238,650		3.0	
Electric Vehicles	414	1,091	0.01	0.01
On-Road Freight & Commercial Vehicles	97,539		1.2	
On-Road Transit	2,138	2,335	0.03	0.03
Off-Road Vehicles and Equipment	29,069		0.4	
Passenger and Freight Rail	17,012		0.2	
Aviation Fuel	172		0.002	
Waste & Wastewater	**20,076**		**0.3**	
Solid Waste Disposal	12,278		0.2	
Wastewater Treatment & Septic Systems	7,798		0.1	
Industrial Process & Product Use	**22,526**		**0.3**	
Refrigerants (Product Use)	22,526		0.3	
Agriculture, Forestry, and Land Use	**276,335**		**3.45**	
Forest Carbon Loss	251,611		3.1	
Fertilizer & Soil Amendments	22,458		0.3	
Livestock	2,266		0.0	
Wildfire	**1,539,768**		**19.25**	
Forest Carbon Loss Due to Wildfire	1,539,768		19.2	
Consumption-Based Emissions	**872,585**	**966,619**	**10.9**	**12.1**
Household Consumption				
Goods	355,375		4.4	
Food	230,175		2.9	
Upstream Energy Production	235,739	329,773	2.9	4.1
Air Travel	51,296		0.6	
Negative Emissions (Sequestration & Offsets)	**-814,000**		**-10.2**	
Local Carbon Storage	-814,000		-10.2	
Local Emissions	**2,580,515**	**2,925,539**	**32.3**	**36.6**
Consumption-Based Emissions	**872,585**	**966,619**	**10.9**	**12.1**
Local + Consumption	**3,453,100**	**3,892,158**	**43.2**	**48.7**

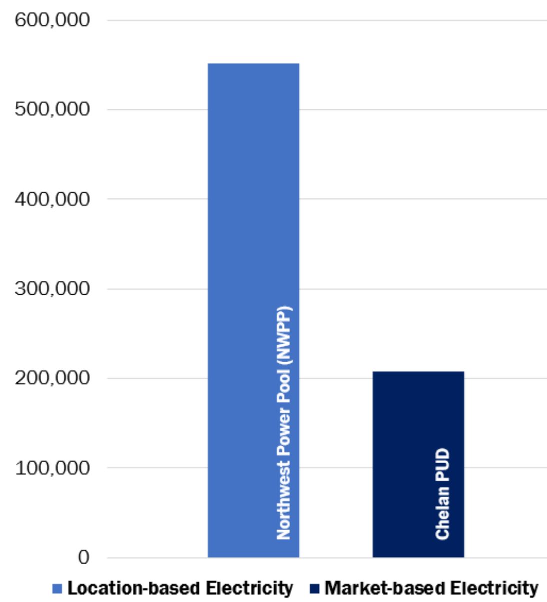
Appendix B:
Electricity Accounting

Electricity Accounting

Activity data was collected directly from Chelan PUD. Data provided was split by residential, commercial, and industrial. The GPC and Scope 2 guidance requires that communities report electricity emissions using two accounting methods: market-based and location-based.[2] **Market-based accounting** is based on the GHG intensity of electricity contracts with local utilities and is used in most of the figures presented in this report as the GPC protocols' recommended methodology to track progress toward goals over time. Market-based accounting captures the emissions savings from the 80% hydroelectric grid mix supplied by Chelan PUD. The remaining emissions reflect the other fossil sources. **Location-based accounting** is calculated using the regional electricity grid's (Northwest Power Pool) GHG intensity and represents the average impacts of electricity use and efficiency efforts for the region. Figure 11 displays electricity emissions using both accounting methods.

- **Market-based method** (or utility-specific) represents emissions specific to the utility and considers community purchase of Renewable Energy Certificates (such a program is not available at Chelan PUD, but they do offer credit for those generating excess solar to feed the grid). 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. It also highlights benefits 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 11: Electricity Emissions (MT CO_2e) Using Both Accounting Methods



- **Location-based method** (or regional grid) multiplies an organization's electricity use by the average emissions intensity of a specific regional electricity grid that is published by the Environmental Protection Agency (eGRID 2023).[3] Note that over time, there may be differences in emissions results for inventory years due to the use of an updated eGRID emissions factor (typically released every 1 to 2 years). Location-based electricity accounting offers a means of assessing the average impact of electricity use on the regional electricity grid.

[2] For details, visit http://www.ghgprotocol.org/scope_2_guidance.

[3] Http://www.epa.gov/system/files/documents/2025-1/egrid2023_summary_tables_rev1.pdf

Appendix C:

Chelan County
Wildfire Emissions

COUNTY OF CHELAN

Chelan County Wildfire Emissions 2016-2024

AUGUST 2025

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Introduction and Purpose

To complement Chelan County's Community Greenhouse Gas (GHG) Inventory, this analysis quantifies wildfire-related emissions from 2016 through 2024. As wildfires across the West have intensified in frequency and severity, their contribution to atmospheric GHGs has grown—often reversing the carbon storage and sequestration benefits of forests and other natural and working lands.

Understanding wildfire emissions is increasingly important for regional climate action planning, forest health policy, and land management decisions. High-severity wildfires release large volumes of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), eroding the long-term climate mitigation value of forests and rangelands. These dynamics are relevant not only to GHG accounting but also to active management strategies such as forest thinning, prescribed fire, and biomass utilization—all of which aim to reduce catastrophic fire risk while preserving or enhancing long-term carbon outcomes. This work aligns with emerging efforts across the Western U.S. to bring wildfire emissions into the scope of natural climate solutions, and to support a more accurate accounting of how forests and fuels contribute to—and are impacted by—climate change.

Results Overview

Wildfire emissions in Chelan County have varied significantly year to year, driven primarily by fire size, severity, and the density of vegetation within burned areas. From 2016 to 2024, average annual wildfire emissions are estimated at approximately 1.44 million metric tons of CO_2-equivalent (CO_2e), with 2018 and 2022 both surpassing 2.2 million MT CO_2e. By contrast, lighter fire years like 2016 and 2020 resulted in substantially lower emissions. To put this in perspective, wildfire emissions from 2021 alone are equivalent to the annual emissions from over 385,000 gas-powered cars or the electricity use of more than 340,000 homes—underscoring the significant climate impact of high-intensity fire seasons.

On average, wildfires in the study period emitted approximately 62.6 MT CO_2e per acre burned, though this varied widely. High-intensity fires such as Jack Creek, Nason Ridge, and Airplane Lake produced emissions intensities of 100–150 MT CO_2e/acre due to dense, overstocked fuels and significant canopy consumption. In contrast, fires like Red Apple burned through lighter fuels and grassy foothills, producing far lower emissions per acre. Collectively, these findings underscore how differences in fuel density, vegetation type, and fire severity strongly influence wildfire emissions and their contribution to countywide GHG totals. Notably, emissions from Chelan County wildfires in 2021 alone offset roughly 7.3% of all forest carbon sequestration statewide in that year, highlighting the scale of impact from a severe fire season. Detailed results, including year-by-year and fire-by-fire emissions estimates, are provided in accompanying tables and charts throughout this memo (see Figures 1–4).

Emissions Methodologies in Flux

Our analytical team engaged Washington State Department of Ecology (Ecology) and WA Department of Natural Resources (DNR) at the front of this task with the intent of aligning our methodology with theirs for consistency and ease of future analysis. However, Ecology is still in the process of updating the wildfire emissions methodology and DNR confirmed with us that Ecology is the best point of contact to manage Washington wildfire emissions calculations and approach. California Air Resources Board (CARB) is a nationally recognized resource for estimating wildfire emissions. As of this analysis, CARB (like Ecology) is in the process of updating its wildfire emissions methodology, but a finalized version has not yet been published. The Washington State Department of Ecology currently uses the 2022 EPA State Inventory Tool (SIT) in its Natural and Working Lands (NWL) inventory, which relies on default combustion factors and aggregated data on acreage burned provided by DNR. Ecology is expected to adopt a more refined method in 2025 or 2026.

Our Study Approach

This analysis builds on the foundational wildfire emissions estimation framework developed by the CARB, with several refinements to increase local specificity for Chelan County. While CARB's methodology—centered on the First Order Fire Effects Model (FOFEM)—remains a national reference point, our approach incorporates additional spatially resolved inputs and more nuanced fire behavior parameters to improve the accuracy of county-scale emissions estimates.

Our team's approach integrates FOFEM's batch processing functionality within a custom Python-based geospatial data pipeline. This enables automated generation of input fuel profiles—referred to as "plots"—for each wildfire based on:

- Localized vegetation and fuel characteristics
- TreeMap-derived biomass estimates
- Fire behavior and severity (from Monitoring Trends in Burn Severity, or MTBS)
- Fuel moisture levels (via Fire Environment Mapping System, or FEMS)
- Seasonal timing of ignition

Each unique plot represents a specific combination of fire-relevant conditions and serves as a modeling unit in FOFEM. The model simulates fire effects for each plot and outputs emissions by combustion phase (flaming and smoldering) and fuel class (e.g., surface fuels, large woody debris, duff).

The result is a more mechanistic and spatially tailored GHG inventory that calculates emissions of CO_2, CH_4, and N_2O for each wildfire footprint. This level of resolution allows us to move beyond default fuel load assumptions and generic emission factors, producing results that better reflect the diversity of ecosystems, fire behavior, and fuel conditions across Chelan County.

In addition to biomass and fuel moisture inputs, this method incorporates burn severity data from the Monitoring Trends in Burn Severity (MTBS) program, which is converted into crown fire ratios for improved modeling of canopy consumption. This enables a more accurate representation of emissions from high-intensity fires, which are common across forested areas in the county.

Together, this approach represents a significant improvement in local emissions estimation fidelity—producing defensible results that support long-term GHG accounting, climate action planning, and consistency with evolving state and federal inventory protocols.

Result Details

Wildfire emissions have averaged ~1.44 million MT CO_2e/year since 2016, with 2018 and 2022 approaching or exceeding two and a quarter million metric tons. Emissions vary widely from year to year based on annual fire activity, but emissions have exceeded 1 million MT CO_2e in all years except 2016, 2019, and 2020.

In aggregate, these results represent approximately 62.6 MT CO_2e per acre burned, though the results vary widely based on the input factors, particularly fuel load. For example, the Jack Creek fire saw substantial crown scorch in remote and densely forested mountain valleys, and emissions are estimated to be close to 150 MTCO2e/acre (see Figure 3). The Nason and Airplane Lake fires exceed this emissions intensity, largely due to the density of fuels within those perimeters. By contrast, the Red Apple fire burned through grassy foothills, producing an estimated 15.5 MT CO_2e/acre.

Year	Total CO_2e (MT)	Burned Acres
2016	203,188	3,208
2017	1,358,454	21,911
2018	2,337,321	42,691
2020	355,021	10,326
2021	1,651,517	35,708
2022	2,212,198	19,359
2023	1,539,768	8,860
2024	1,858,539	41,846
Grand Total	**11,516,007**	**183,909**

Figure 1. Annual Wildfire Emissions Table, 2016-2024
Table showing yearly GHG emissions from wildfires in Chelan County. Emissions vary widely with fire activity.

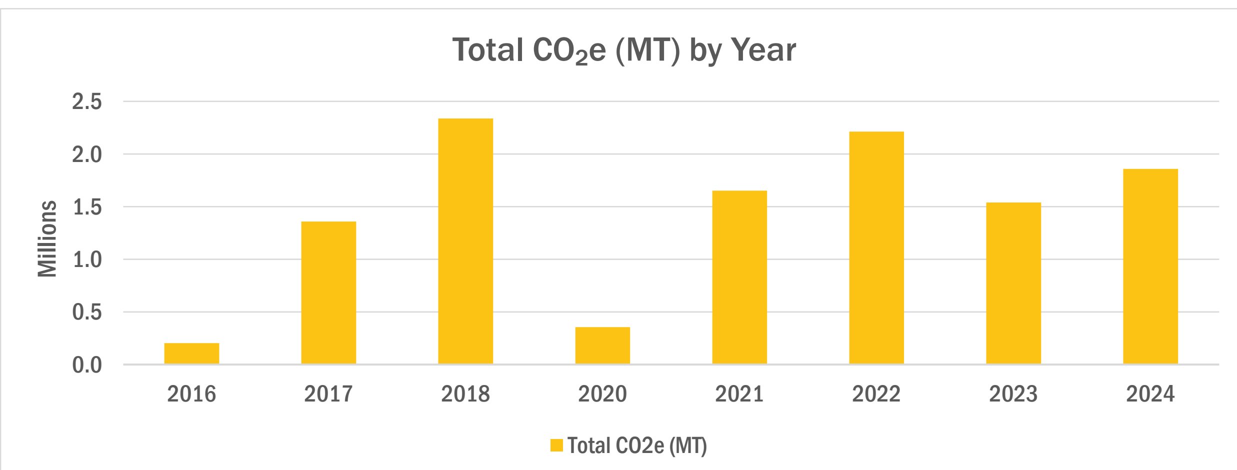


Figure 2. Emissions Trend by Year
Line chart illustrating how wildfire emissions fluctuate annually based on fire severity and acreage burned.

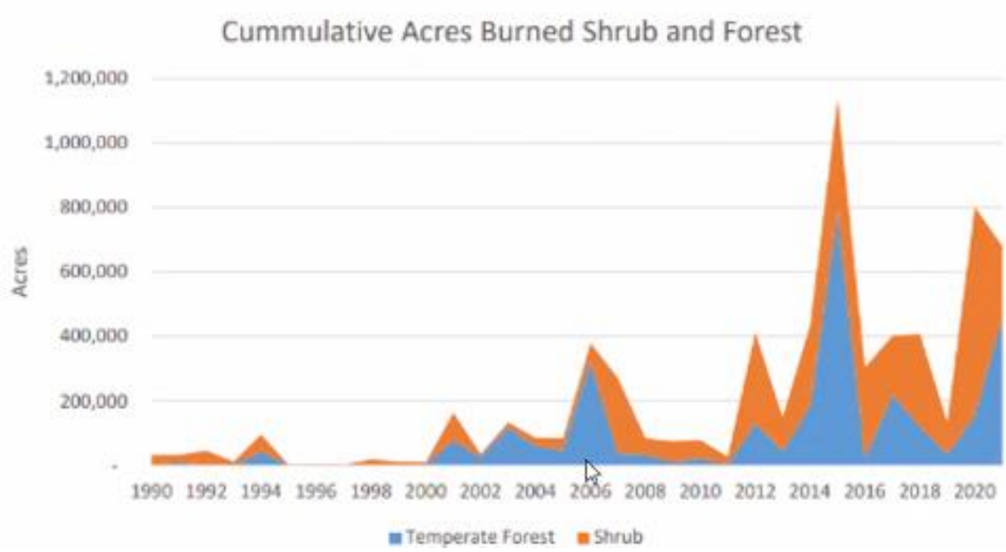
Year and Fire Name	Total CO_2e (MT)	Burned Acres	Average MT CO_2e/acre
2016	**203,188**	**3,208**	**63**
BUCK CREEK	203,188	3,208	63
2017	**1,358,454**	**21,911**	**62**
JACK CREEK	654,096	4,444	147
SPARTAN	217,943	8,729	25
UNO PEAK	486,415	8,738	56
2018	**2,337,321**	**42,691**	**55**
COUGAR CREEK	2,302,905	41,401	56
ROCKY REACH	34,415	1,290	27
2020	**355,021**	**10,326**	**34**
APPLE ACRES	161,636	5,754	28
CHIKAMIN	162,199	1,607	101
COLOCKUM	31,186	2,965	11
2021	**1,651,517**	**35,708**	**46**
NASON	280,792	1,317	213
RED APPLE	190,663	12,276	16
TWENTYFIVE MILE	1,180,062	22,115	53
2022	**2,212,198**	**19,359**	**114**
MINNOW RIDGE	606,796	5,131	118
STAYMAN	23,729	3,118	8
WHITE RIVER-IRVING PEAK	1,581,673	11,110	142
2023	**1,539,768**	**8,860**	**174**
AIRPLANE LAKE	1,373,401	6,955	197
BLUE LAKE	103,795	1,072	97
DOME PEAK	62,573	833	75
2024	**1,858,539**	**41,846**	**44**
PIONEER	1,834,811	38,729	47
STAYMAN	23,729	3,118	8
Grand Total	**11,516,007**	**183,909**	**63**

Figure 3.3 Emissions by Fire and Year
Breakdown of emissions by individual fire. Highlights which fires drove the highest emissions in each year.

Interestingly, 2020 saw statewide net emissions from land use change (meaning wildfire and land us change was higher in Washington than annual carbon sequestration), largely due to estimated wildfire emissions, but those fires primarily occurred elsewhere, as Chelan County saw less fire activity that year compared to the average over the study period. 2019 saw no wildfires larger than 1,000 acres. Emissions from Chelan County wildfires for 2021 (1.65 million MT CO_2e) are roughly equivalent to 7.3% of all forest carbon sequestration for Washington State in that year, and average annual emissions over the analysis period from 2016 - 2024 (1.44 million MTCO2e) offset approximately 6.4% of annual forest carbon sequestration, estimated as the average carbon sequestration from WA forests across all years reported in Figure 4 below.

Figure 4. WA Statewide Emission from Land Use, Land Use Change and Forestry ($MTCO_2e$)
Washington State-level comparison of carbon flux from land use. Provides statewide context for Chelan County's wildfire emissions alongside forest carbon sequestration statewide. Note: Forest fire emissions impacts are highlighted in the table below, and include CO_2, CH_4, and N_2O emissions reported as $MTCO_2e$. The top line shows overall sequestration (negative value) but that number has been decreasing as forest fires have increased. Excerpted from WA State GHG Inventory, 1990-2021.

	1990	2000	2005	2010	2015	2019	2020	2021
Total	**(22.4)**	**(19.4)**	**(19.7)**	**(20.4)**	**6.1**	**(19.7)**	**4.1**	**(4.3)**
Forest carbon flux	(22.3)	(18.3)	(21.0)	(22.8)	(24.5)	(22.7)	(22.3)	(21.8)
Forest land remaining Forest land	*(22.8)*	*(18.9)*	*(21.5)*	*(23.4)*	*(25.3)*	*(23.5)*	*(23.1)*	*(22.6)*
Other land converted to forest land	*(3.0)*	*(3.0)*	*(3.0)*	*(3.0)*	*(3.0)*	*(3.0)*	*(3.0)*	*(3.0)*
Forest land converted to other land	*3.5*	*3.5*	*3.6*	*3.7*	*3.8*	*3.9*	*3.9*	*3.9*
Urban trees	(1.1)	(1.3)	(1.4)	(1.5)	(1.6)	(1.6)	(1.5)	(1.6)
Landfilled yard trimmings and food scraps	(0.5)	(0.3)	(0.2)	(0.3)	(0.2)	(0.3)	(0.3)	(0.3)
Forest fires (CH_4 and N_2O)	1.2	0.3	2.5	2.6	31.4	4.5	27.8	18.9
N_2O from settlement soils	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Agricultural soil carbon flux	0.2	0.1	0.4	1.4	0.9	0.4	0.2	0.3



Data Inputs

- **LANDFIRE fuelbed data**: Fuel Characteristics Classification System (FCCS)
- **Forest biomass data**: TreeMap 2016
- **Fuel moisture data**: Fire Environment Mapping System (FEMS)
- **Wildfire perimeter and attribute data**: Washington DNR and the National Interagency Fire Center
- **Burn severity data**: Monitoring Trends in Burn Severity (MTBS)
- **First Order Fire Effects Model default fuelbed input values**: from FOFEM

Wildfire Emissions Modeling: Methodology and Workflow

STEP 1 Collect and Prepare Input Data

Collect wildfire perimeters (limited to fires >1,000 acres), vegetation classifications, and fuel condition data. Align all datasets spatially and clip to the Chelan County boundary. For each fire, determine ignition and burn dates using wildfire perimeter metadata, then extract corresponding fuel moisture conditions from FEMS for nearby weather stations on those dates.

STEP 2 Estimate Biomass by Fuel Size Class

Calculate spatially explicit biomass loads for 100-hour and 1,000-hour fuels using TreeMap forest inventory data. TreeMap provides 30x30 meter resolution raster layers derived from imputed U.S. Forest Service Forest Inventory and Analysis (FIA) plot data. These layers include modeled tree lists for each pixel, from which species, diameter, and biomass are used to estimate fuel loads by size class. The resulting biomass estimates reflect the quantity of coarse woody fuels available for combustion within each burned area.

STEP 3 Integrate Fuelbed Characteristics from FCCS

Merge TreeMap-derived biomass layers with fuelbed characteristics from the FCCS. This step fills in additional surface and ground fuel attributes not captured by TreeMap—such as duff depth, litter, 1-hour and 10-hour fuels, herbaceous material, and cover type. To ensure consistency across datasets, the FCCS raster is spatially aligned with the TreeMap biomass raster. Where TreeMap lacks data (e.g., non-forested areas), FCCS provides default fuel loading values by vegetation type, enabling full fuelbed representation for every 30x30 meter pixel within the fire perimeter.

STEP 4 Define Modeling Plots by Fuel and Fire Conditions

Fuel moisture values from FEMS were matched to each wildfire based on ignition and containment dates, and seasonal attributes were assigned accordingly. Burn severity was converted to crown fire ratio inputs using MTBS classifications. Using these variables—vegetation type, fuel load, fuel moisture, season, and burn severity—we generated a set of 12,730 unique “plot types”. Each plot represents a distinct combination of fire-relevant conditions and serves as a modeling unit for batch processing in FOFEM.

STEP 5 Format Plots for FOFEM and Run Batch Processing

Each unique plot—defined by its vegetation, fuel load, moisture, season, and burn severity—is assigned a count of matching pixels (acres) across the wildfire footprint. These plots are then formatted into a FOFEM-compatible batch input file, with each row representing a distinct set of fire behavior conditions. The batch file is processed through FOFEM 6.8+, which simulates combustion and calculates emissions per acre for each plot. Output values include CO_2, CH_4, and N_2O, as well as combustion-phase-specific breakdowns (e.g., flaming vs. smoldering). The result is a library of plot-level emission factors, which can be scaled to the full fire area based on the number of acres represented by each plot type.

STEP 6 Calculate Total Emissions and Summarize by Fire and Year

FOFEM outputs—containing per-acre emissions estimates for each unique plot—are merged back with the plot area summaries generated earlier. For each wildfire, total greenhouse gas emissions (CO_2, CH_4, and N_2O) are calculated by multiplying the emissions per acre by the number of acres represented by each plot. The results are then aggregated by individual fire and calendar year, enabling year-over-year tracking and comparison across fire events. Final outputs include both total emissions (in metric tons) and emissions intensities (e.g., MT CO_2e per acre burned), supporting integration into county- or state-level inventories.

Limitations

Data coverage was incomplete for the study area for fuel beds and burn intensities, so proxy values were inserted to avoid undercounting emissions. For fuel bed characteristics, missing data was filled with averages from the set of fuelbeds covering the study area, and for burn intensity, missing values were replaced with a 'low' burn intensity, corresponding to 25% crown scorch. Of these two sets of proxies, filling fuelbed data is more likely to materially impact the result. Additionally, though FOFEM is an authoritative and widely used model for wildfire impact estimation, results are sensitive to a range of inputs, which all have inherent uncertainty. Results are expected to be generally representative, not precise.