Greenhouse Gas Emissions Inventory for 2017

County of Hawai‘i

Department of Research and Development

Updated March 2021

Table of Contents

Table of Contents 3

Glossary of Terms & Acronyms 4

About The Greenhouse Gas Inventory Report 5

Introduction 4

Background on Policies 6

Summary of Findings 7

Overview of Methodology 9

Sector Analyses 11

Transportation 12

Commercial Energy 13

Industrial Energy 14

Residential Energy 16

Agriculture, Forestry, and Other Land Uses (AFOLU) 18

Water and Wastewater 20

Solid Waste 21

Appendix A. Inventory Methodology & Definitions 22

Transportation 22

Commercial Energy 25

Industrial Energy 27

Residential Energy 28

Agriculture, Forestry, and Other Land Uses (AFOLU) 30

Water and Wastewater 33

Solid Waste 33

Emission Factors 35

Changes in Estimate Since the Previous Report 35

References 37

Glossary of Terms & Acronyms

AFOLU	Agriculture, Forestry, and Other Land Use
County	County of Hawaiʻi
CAP	Climate Action Plan
CO_2	Carbon Dioxide
CH_4	Methane
DBEDT	Department of Business, Economic Development, and Tourism
DFO	Distillate Fuel Oil
EIA	Energy Information Administration
eGRID	Emissions & Generation Resource Integrated Database
EPA	Environmental Protection Agency
GHG	Greenhouse Gas
GPC	Global Protocol for Community-Scale Greenhouse Gas Emission Inventories
HGL	Hydrocarbon Gas Liquids (LPG to HGL since 2015)
ICLEI	International Council for Local Environmental Initiatives
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
LPG	Liquid Propane Gas
Mcf	Thousand Cubic Feet
MSW	Municipal Solid Waste
$MTCO_2e$	Metric Tons of Carbon Dioxide Equivalent
N_2O	Nitrous Oxide
RFO	Residual Fuel Oil
SEDS	State Energy Data System

About the Greenhouse Gas Inventory

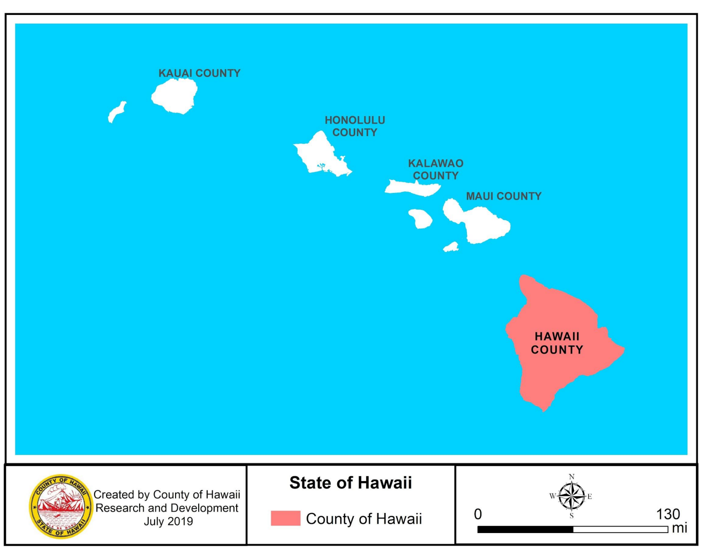
Introduction

Climate change poses a real and serious threat. The IPCC reported in 2021 that anthropogenic, human-originated, emissions are the cause of global climate change. As the effects of climate change mount, as does the urgency to understand how to reduce emissions and ensure equity while pursuing solutions. As an island community, Hawaiʻi County (Refer to Map 1) becomes increasingly vulnerable to extreme events like decreased access to potable water during droughts (Shea et al 2001); susceptible to diseases and viruses (Kolivras 2010); exposed to wildfires, cyclones, sea level rise, and other natural disasters (Trauernicht 2019); deterioration of economy such as fisheries, tourism, and food security (McclIgorm et al 2010, Rowell et al 2012, Karim et al 1999). These consequences will impact everyone and pose the greatest threat to marginalized populations.

The County is the sole local municipal government for the Island of Hawai'i, the largest of the Hawaiian Islands. It is 4,028 square miles in size and almost 200 miles by air from Honolulu, Hawai'i's State capital on the Island of Oʻahu. The island occupies 62 percent of the total land area of the Hawaiian Islands but is only home to 13 percent of the state's population. Making the Island of Hawai'i the least densely populated of the major islands. In 2005, the de facto[2] population in Hawaiʻi County was 188,612 people or 46.8 people per square mile.

In 2017 the de facto population was 227,746 people or 55.5 people per square mile. The percent ALICE (Asset Limited, Income Constrained, Employed) (2017) and poverty in Hawaiʻi County is 55% or 35,310 households. The majority of households below ALICE threshold are located in Hilo, Pāhoa, Konawaena, and Kealakehe regions (ALICE 2020). 39.9% of the workforce travel more than 50 miles one way to get to work. Hawaiʻi County saw an 8.4% increase in population from 2010 to 2020. The population grew from 185,079 people (2010) to 200,629 people (2020). The 2020 racial and ethnic demographics on Hawaiʻi Island are comprised of the following: American Indian (0.5%), Asian (22%), Black (0.6%), Hispanic and Latino (11.6%), Other (1.5%), Pacific Islander (12%), Two or More (30%), and White (34%) (Census 2020).

Map 1: Location of Hawaiʻi County in relation to other counties in the State of Hawaiʻi



The County of Hawaiʻi's Greenhouse Gas (GHG) Inventory is the first step towards understanding emissions. In addition, this inventory will help to identify and prioritize sector specific carbon mitigation and reduction strategies as well as aid as a benchmark to gauge progress. The first GHG Inventory was published in 2020 for the years 2005 and 2015. Certified emissions data lags about four to five years. Therefore, this report serves as an update to show emissions data for 2017 using 2005[1] as a baseline. The updated report also coincides with the State's 2017 GHG Inventory.

The next step toward understanding emissions in the County is to inform the Integrated Climate Action Plan (CAP). The CAP is a comprehensive roadmap that outlines specific actions to mitigate and adapt to climate change on Hawaiʻi Island. The County is currently working on updating the draft CAP to create a plan centered in equity that integrates both adaptation and mitigation. The updated CAP will include actions and implementation strategies for both reducing greenhouse gas and improving our infrastructure and communities to be resilient to climate change. The actions outlined in the CAP will enable Hawaiʻi Island to become more sustainable, self-reliant, and protect the health and safety of our community.

Background on Policies

The island comprises the County of Hawaiʻi and is governed by nine council districts. There are four total counties in the State which are the City and County of Honolulu, the County of Maui, the County of Hawaiʻi and the County of Kauaʻi (and one quasi county, Kalawao). In 2007, the State Legislature established the foundation for the Hawaiʻi GHG Program in Act 234. The program establishes a Statewide GHG emissions limit to be achieved by 2020 that is equal to or below the level of Statewide GHG emissions in 1990 (13.66 million metric tons per year). Parts of Act 234 are codified in Hawaiʻi Revised Statutes, Chapter 342B.

In 2014, Hawaiʻi Administrative Rules (HAR), Chapter 11-60.1 was amended to adopt the new Hawaiʻi GHG program. The main requirements of the program are set forth in Subchapter 11, Greenhouse Gas Emissions. The Hawaiʻi Revised Statutes section 226-109 was put into effect in 2013 and sets priority guidelines that require Counties to assess climate change vulnerability, set targets to reduce GHG emissions, and develop and implement climate mitigation and adaptation plans. Although aviation is excluded from the Act, this mode of transportation produces a substantial amount of emissions and is included in calculations.

The County of Hawaiʻi GHG Inventory is guided by the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) and estimates GHG emissions that occur in the County's jurisdiction encompassing the entire island of Hawaiʻi. The GPC is a carbon emissions accounting and reporting standard for cities and municipalities developed by the World Resources Institute, C40 Cities Climate Leadership Group, and the International Council for Local Environmental Initiatives (ICLEI) Local Governments for Sustainability.

[1] Under the Paris Agreement to the United Nations Framework Convention on Climate Change, ratified on April 22, 2016 and multiple times since the publication of this report, the United States delegation agreed to reduce GHG emissions up to 28% by 2005 levels.

[2] De facto population, or population, refers to the recorded number of people at the present time. State and County of Hawaiʻi de facto population records are obtained from the State of Hawaiʻi DBEDT Datawarehouse.

Summary of Findings

Data for this report is collected from seven greenhouse gas producing sectors made up of 42 sources for the years 2005, 2015, & 2017 (Refer to Table 1). These sectors and sources correspond with the State's GHG inventory, which were developed in accordance with the 2006 IPCC Guidelines for National GHG Inventories.

In 2017, overall emissions have decreased since 2005 by 23% (Refer to Figure 1). The Transportation & Mobile Sources has remained relatively stagnant over the years and remains the largest contributor to greenhouse gas emissions (Refer to Figure 1). Notably, Aviation remains the largest source of emissions and accounts for ~51% of the total, compared to ~32% from On-Road Motor Gasoline. The second largest contributor is Commercial Energy but between 2005 and 2017 emissions have decreased by approximately half. Comparably, the Residential Energy sector was the third largest contributor but emissions have steadily declined due to the ~28% increase in renewable energy capacity (Refer to Table 2). Solid Waste is now the third largest source (Refer to Figure 3).

Table 1: Overview of Sectors with Sources and Sinks

Sectors	Sources and Sinks
Transportation & Mobile Sources	On-Road (motor gasoline, diesel), Off-Road-Military (Distillate), Construction and Non-Construction (Diesel), Domestic and International Aviation (Jet fuel, Kerosene), and Marine (Diesel, Residual)
Commercial Energy	Non-Renewable Energy Generated by Commercial and Used by the Grid (Grid Electricity), Stationary Fuel Use (Motor Gasoline, Diesel, LPG (HGL), and Natural Gas
Industrial Energy	Electricity Generated by Industrial and Street Lights (Grid Electricity), Stationary Fuel Use (Natural Gas, Motor Gasoline, LPG), Electrical Transmission and Distribution, Cement Production, and Substitution of Ozone Depleting Substances
Residential Energy	Energy Generated by Residential and Used by the Grid (Grid Electricity), Stationary Fuel Use (Motor Gasoline, Diesel, LPG (HGL), and Natural Gas
Agriculture, Forestry, and Other Land Use (AFOLU)	Forest Carbon Sink (Sequesters), Landfilled Yard Trimmings and Food Scraps Sink (Sequesters), and Urban Tree Sink (Sequesters), Forest Fire Emissions, Agricultural Soil Carbon Emissions, Agricultural Soil Management Emissions, Enteric Fermentation Emissions, Field Burning of Agricultural Residues Emissions, Manure Management Emissions, and Urea Application Emissions
Water and Wastewater	Water and Wastewater Treatment
Solid Waste	Composting, In-Jurisdiction Landfills, and Waste Generation

Table 2: Percent of Renewable and Non-Renewable Energy Capacity

	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
% Renewable Energy	29%	31%	40%	41%	40%	35%	50%	42%	61%	61%	49%	54%	57%
% Non-Renewable Energy	71%	69%	60%	59%	61%	65%	50%	58%	39%	39%	51%	46%	43%

Figure 1. Total $MTCO_2e$ Emissions for 2005, 2015, and 2017

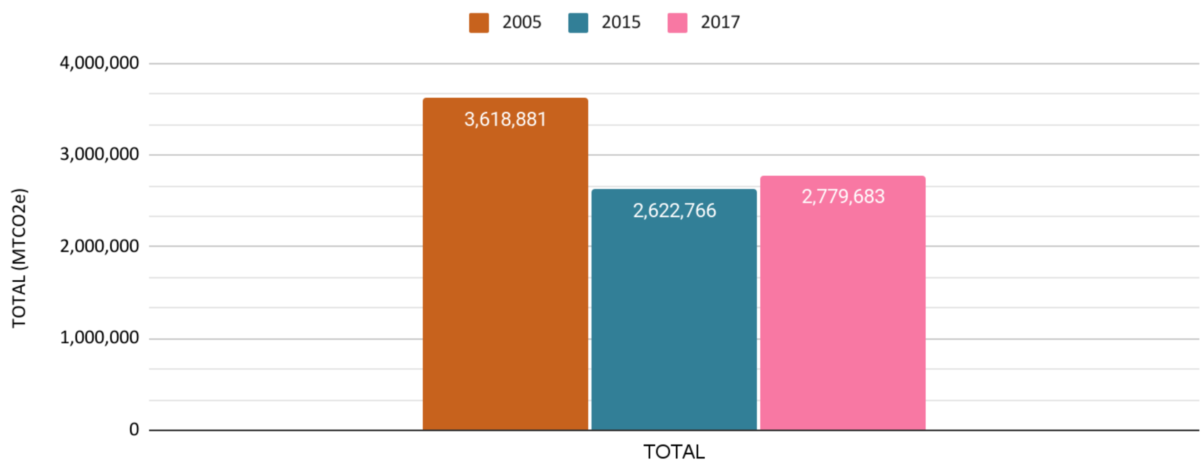


Figure 2. Percent of Emissions by Sector Contribution for 2017

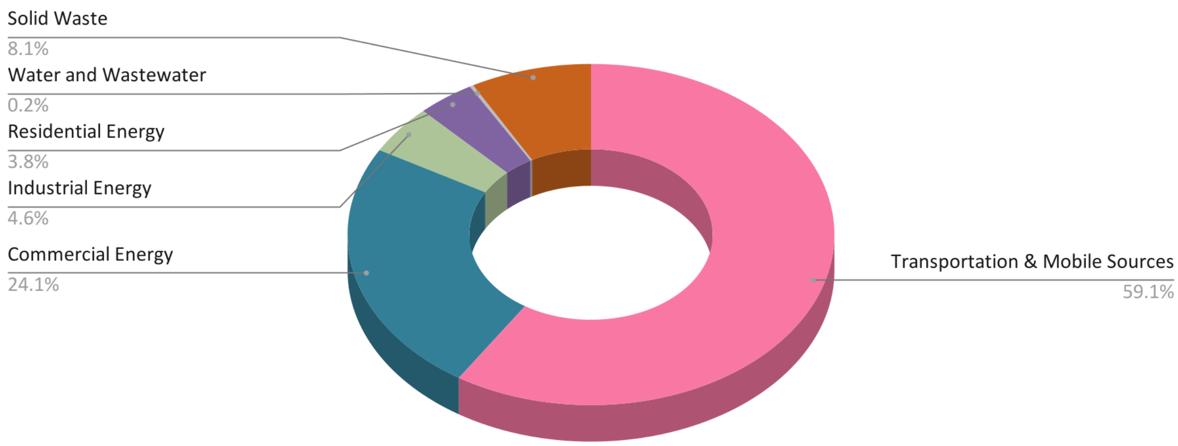
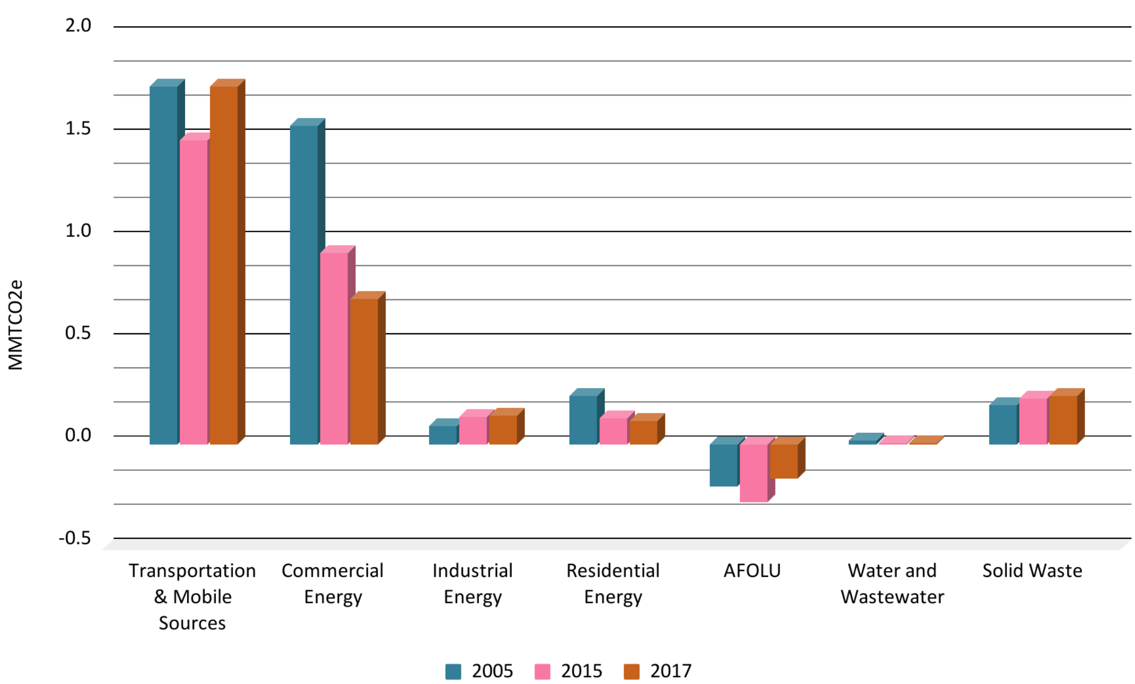


Figure 3: Sector Overview of $MTCO_2e$ Emissions for Years 2005, 2015, & 2017



Emissions increased by almost 6% from 2015 to 2017 (Refer to Table 3a). The sectors responsible for the 2017 increase in emissions are (i) AFLOU-Sources, (ii) Solid Waste, and (iii)Transportation and Mobile Sources (Refer to Table 3a & 3b). Water and Wastewater marginally contributed to the increase in emissions. For specific details about individual sector and source emissions refer to the Sector Analysis (Refer to p. 12).

AFOLU contains both sources, carbon emitters, and sinks, carbon sequesters. Specific AFOLU sources and sinks which are non-anthropogenic sources of emissions are Forest Carbon, Urban Trees, and wildfires within Forest Fires. Sources and sinks have decreased from 2005 to 2017 (Refer to Table 3b).

Table 3a: CO_2e Emission Sectors

	$MTCO_2e$					
Sectors	**2005**	**2015**	**2017**	**% Δ 2005 to '15**	**% Δ 2005 to '17**	**% Δ '15 to '17**
Transportation & Mobile Sources	1,742,228	1,485,074	1,742,191	-15%	-0.002%	17.31%
Commercial Energy	1,551,250	934,769	710,414	-40%	-54%	-24%
Industrial Energy	86,014	134,907	137,008	57%	59%	1.56%
Residential Energy	235,509	124,691	112,478	-47%	-52%	-9.79%
AFOLU				*Refer to Table 3b (below)*		
Water and Wastewater	16,024	6,992	7,158	-56%	-55%	2.38%
Solid Waste	192,248	222,950	237,234	16%	23%	6.41%
TOTAL	**3,618,881**	**2,622,766**	**2,779,683**	**-27.5%**	-23.2%	**5.98%**

Table 3b: AFOLU Sector- Emitters and Sinks (Sequesters) CO_2e Emissions

	$MTCO_2e$					
Sector	**2005**	**2015**	**2017**	**% Δ 2005 to '15**	**% Δ 2005 to '17**	**% Δ '15 to '17**
Emitters	182072	128038	148007	-42.20%	-18.71%	15.60%
Sinks (Sequesters)	-386463	-414655	-314809	6.80%	-18.54%	-24.08%
Total	**-204391**	**-286617**	**-166802**	**28.69%**	**-18.39%**	**-41.80%**

Overview of Methodology

The County of Hawai‘i applies best practices under the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)[3], identifying quality data sources, and utilizing credible estimation and scaling methods to represent an accurate depiction on what emissions look like in Hawai‘i County. A publicly available GHG inventory tool, ClearPath, is utilized to organize and segment the inventories, and to apply standard emissions factors by fuel-type, for example, $MTCO_2e$ per unit of fuel/energy type consumed. The inventory is calculated by gathering data from GHG producing sources and reported by metric tons of carbon dioxide equivalent ($MTCO_2e$). The unit “CO_2e” represents an amount of a GHG whose atmospheric impact is standardized to that of one unit mass of carbon dioxide (CO_2), based on the global warming potential (GWP) of the gas. The IPCC’s (International Panel on Climate Change) Fourth Assessment Report (IPCC 2007) is used to determine the GWP.

Scaling, modeling, or estimation methodology as opposed to direct, point-source volumetric measurements involves a level of uncertainty associated with the final output. While a precise margin of error has not been calculated, these results have uncertain elements and should be viewed accordingly. New techniques and data improve overall accuracy as they become available. Main data sources for this GHG inventory include resources from the U.S. Energy Information Agency (EIA), U.S. Environmental Protection Agency (EPA), U.S. Department of Transportation (DOT), and State of Hawaiʻi Department of Business, Economic Development, and Tourism (DBEDT).

There are six renewable energy sources in Hawaiʻi County. These renewable sources are solar, hydropower, geothermal, wind, hydrogen, and biofuel. Data is reported as "renewable" and "non-renewable". Renewable is defined as energy that can be produced without depleting natural resources long term. Non-renewable is defined as energy that cannot be produced without depleting natural resources. However, "renewable" energy is not inherently carbon free. Carbon free energy, such as solar, wind, hydropower, and hydrogen are renewable and do not produce emissions. Whereas biomass and geothermal are renewable but not carbon free. Therefore, there are limitations to the data as the energy emissions data reports lower emissions than the actual level represented. At this time, the distinction between renewable and carbon-producing is not represented in the data and products of this report.

Refer to Appendix A for a detailed description of the methodology, data sources, and calculations for this report.

[3] The Global Protocol for Community-Scale Greenhouse Gas Emission Inventories(GCP) describes their mission as “integrat[ing] knowledge of greenhouse gases for human activities and the Earth system. Our projects include global budgets for three dominant greenhouse gases — carbon dioxide, methane, and nitrous oxide — and complementary efforts in urban, regional, cumulative, and negative emissions.” https://ghgprotocol.org/greenhouse-gas-protocol-accounting-reporting-standard-cities

Sector Analyses

Transportation

The Transportation sector determines emissions from eleven sources. These sources, listed below in Figure 3, are a sum of On-Road Transportation (Motor Gasoline, Diesel), Off-Road Transportation- Military (Distillate) Construction and Non-Construction (Diesel), Domestic and International Aviation (Jet Fuel, Kerosene), and Marine Transportation (Diesel, Residual). Aviation Kerosene (JetFuel) (Domestic) is the largest source of CO_2e within the transportation sector making up ~51% compared to ~32% from On-Road Motor Gasoline. While there was some change in emissions sources from 2005 to 2017, there was essentially no overall change in emissions (-0.0021%) (Refer to Table 4).

Figure 4: 2017 Percent of CO_2e Transportation Emissions

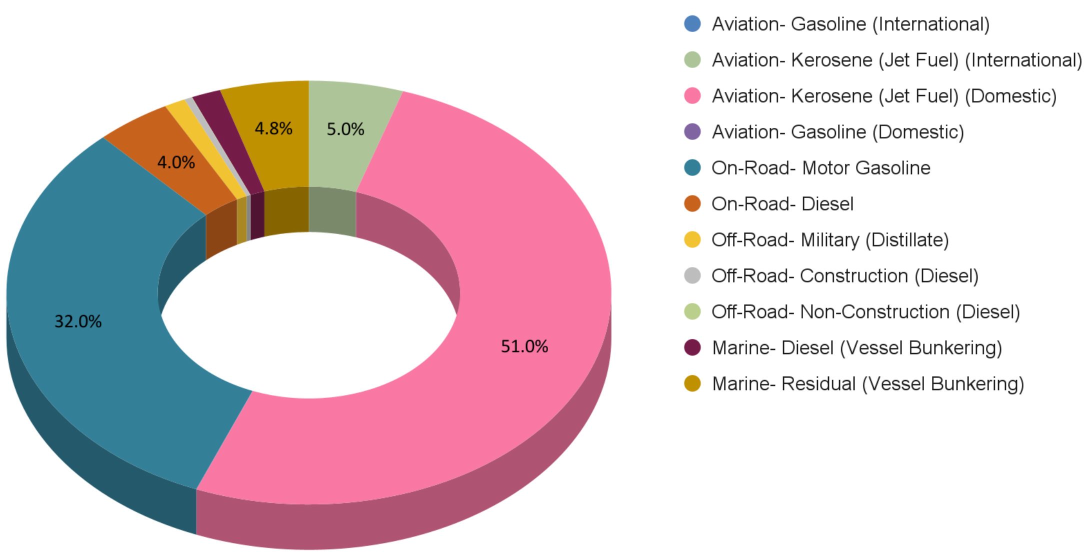
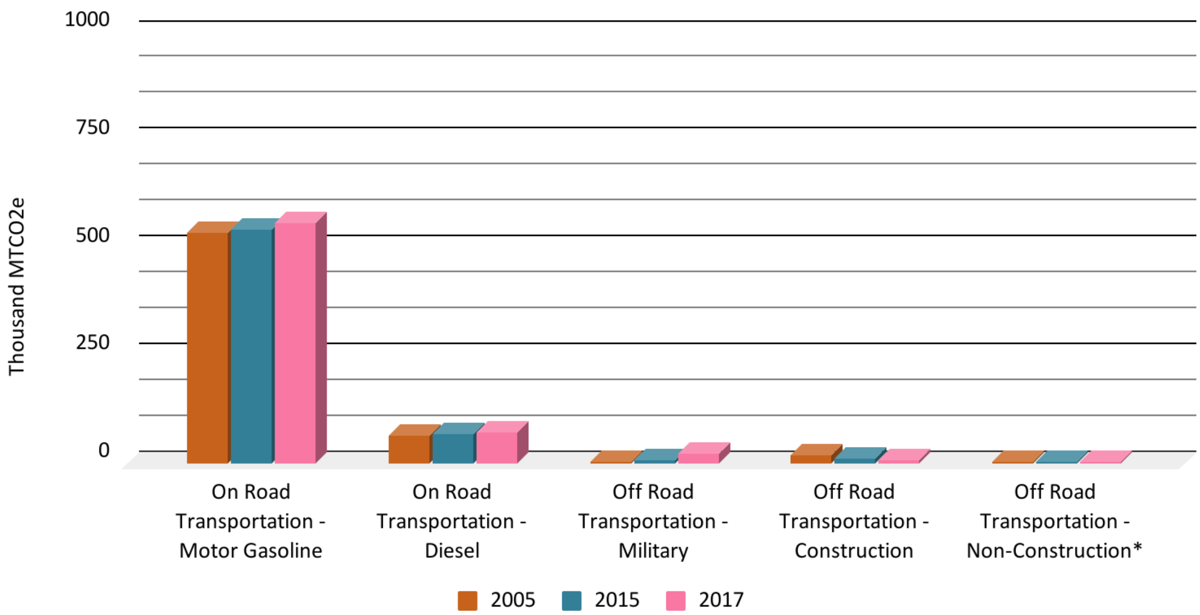


Table 4: 2005, 2015, & 2017 CO_2e Emissions for Transportation

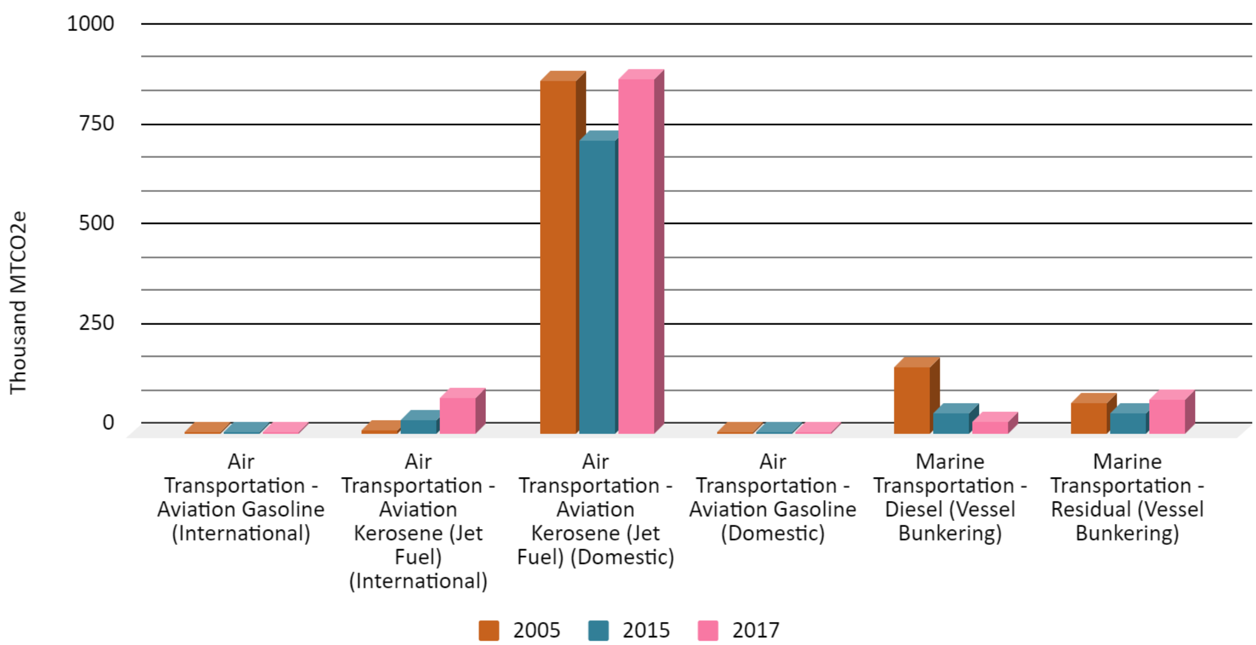
Sources	**$MTCO_2e$**			
	2005	**2015**	**2017**	**% Δ 2005 to 2017**
Air Transportation - Aviation Gasoline (International)	11	18	58	419.76%
Air Transportation - Aviation Kerosene (Jet Fuel) (International)	4,708	30,918	87,722	1763.38%
Air Transportation - Aviation Kerosene (Jet Fuel) (Domestic)	883,101	731,273	888,715	0.64%
Air Transportation - Aviation Gasoline (Domestic)	2,091	423	444	-78.79%
Marine Transportation - Diesel (Vessel Bunkering)	164,750	47,791	27,248	4.52%
Marine Transportation - Residual (Vessel Bunkering)	74,504	49,017	82,807	15.55%
On Road Transportation - Motor Gasoline	533,425	539,408	557,510	827.00%
On Road Transportation - Diesel	60,882	67,769	70,346	-56.88%
Off Road Transportation - Military (Distillate)	2,129	6,944	19,736	6285.87%
Off Road Transportation - Construction (Diesel)	16,620	11,073	7,167	-83.46%
Off Road Transportation - Non-Construction (Diesel)	7	440	440	11.14%
Total % Change of all Sources from 2005 to 2017				***-0.0021%***

Figure 5 shows emissions for On- & Off-Road Transportation for 2005, 2015, and 2017. By far, On-Road Transportation- Motor Gasoline is the largest source of CO_2e emissions from On- & Off-Road vehicles. However, Air Transportation-Aviation Kerosene (Jet Fuel) (Domestic) emitted more carbon dioxide than On-Road Transportation by 330 Thousand MTCO_2e, almost double the emissions. Off Road Transportation- Construction (Figure 4) and Marine Transportation - Diesel (Vessel Bunkering (Figure 6) show the greatest decrease in emissions, whereas On-Road Transportation- Diesel (Figure 5) and Air Transportation- Aviation Kerosene (Jet Fuel) (Domestic) (Figure 6) show the greatest increase. DBEDT State of Hawaiʻi Data Book (2021) reports, vehicle miles traveled for 2005 is 1,517 million miles which increased by ~30% to 1,967 million miles in 2017.

Figures 5: 2005, 2015, & 2017 On- & Off-Road Transportation CO_2e Emissions



Figures 6: 2005, 2015, & 2017 Air- & Water- Transportation CO_2e Emissions



Commercial Energy

The Commercial Energy sector includes emissions from five sources. These sources, listed below in Figure 7, are a sum of Non-Renewable Energy generated by Commercial and used by the Grid and Stational Fuel Use (Motor Gasoline, Diesel, LPG [HGL], and Natural Gas). Stationary Fuel Use- Diesel is the largest contributor of CO_2e within the Commercial Energy sector but has largely decreased since 2005. Non-Renewable Energy Generated by Commercial and Used by the Grid (Grid Electricity) has also experienced a decrease in emissions by ~49% (Refer to Table 5). Stationary Fuel Use- Motor Gasoline, LPG (HGL), and Natural Gas have increased over the years but represent the smallest amount of emissions. DBEDT State of Hawaiʻi Data Book (2021) reports, in 2005, the number of business establishments were 4,115 businesses. In 2017, the number of business establishments were 4,132 businesses which represents a ~0.4% increase. The number of employed civilians increased by ~16.4% from 2005 (77,850) to 2017 (90,600).

Figure 7: 2005, 2015, & 2017 Commercial Energy CO_2e Emissions

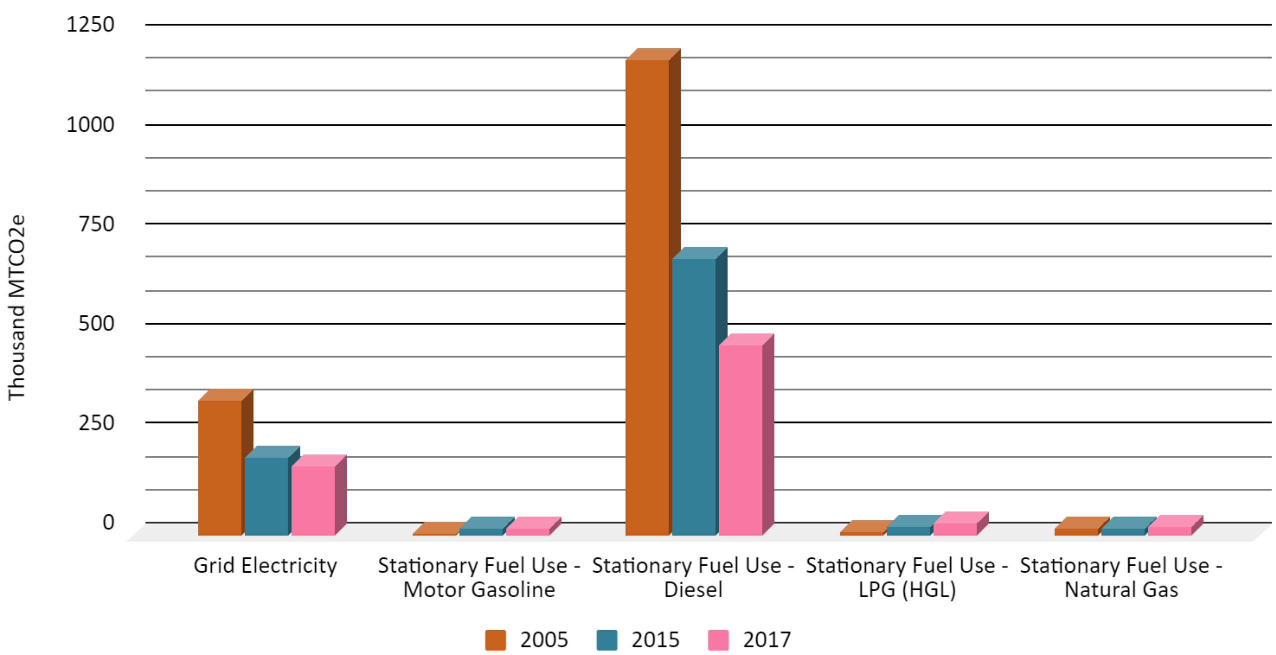
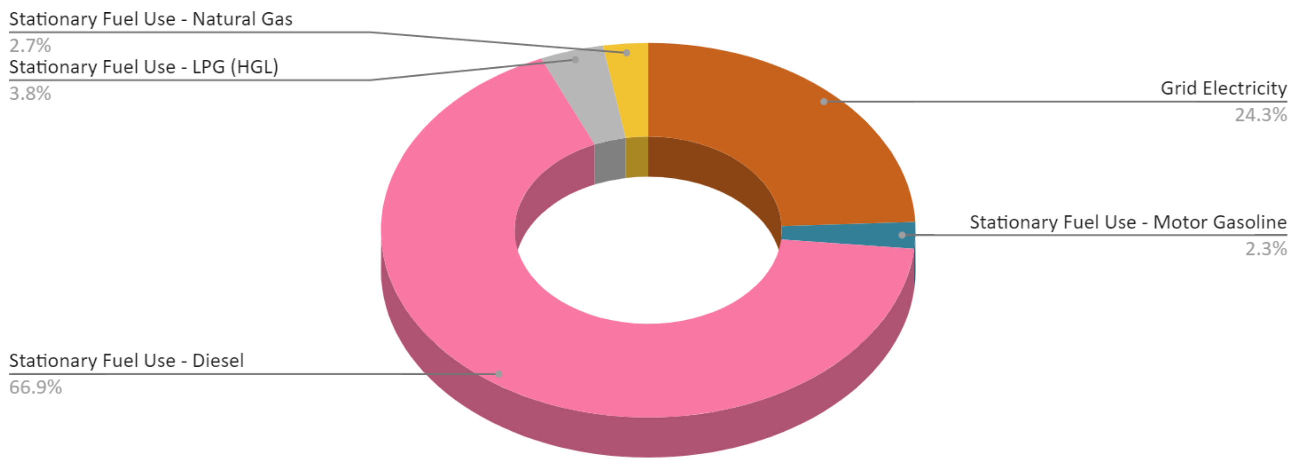


Table 5: 2005, 2015, & 2017 Commercial Energy CO_2e Emissions

	MTCO$_2$e			
Sources	**2005**	**2015**	**2017**	**Δ 2005 to '17**
Grid Electricity	368,5689	223,485	172,649	-49%
Stationary Fuel Use - Motor Gasoline	945	15,828	16,204	1615%
Stationary Fuel Use - Diesel	1,189,894	692,960	474,946	-60%
Stationary Fuel Use - LPG (HGL)	8,490	20,448	27,306	222%
Stationary Fuel Use - Natural Gas	13,530	14,715	19,309	43%
Total % Change of all Sources from 2005 to 2017				***-54***

Referring to Figure 8, Stationary Fuel Use- Diesel and Non-Renewable Energy Generated by Commercial and Used by the Grid (Grid Electricity) represent the greatest sources of emissions in the Commercial Energy sector at 91.2% combined total in 2017. Stationary Fuel Uses (LPG, Natural Gas, and Motor Gasoline) represent the smallest fraction of emissions with a total of 8.8%.

Figure 8: Percent of CO_2e Commercial Energy Emissions for 2017



Industrial Energy

The Industrial Energy sector includes emissions from eight sources. These sources, listed below in Figure 9, are Electricity Generated by Industrial and Street Lights (Grid Electricity), Stationary Fuel Use (Natural Gas, Motor Gasoline, LPG), Electrical Transmission and Distribution, Cement Production, and Substitution of Ozone Depleting Substances. Ozone Depleting Substances, like chlorofluorocarbons, is the largest emitter of CO_2e within the Industrial Energy sector. Stationary Fuel Use- Motor Gasoline is the second largest emitter but eight times less than Ozone Depleting Substances. Overall, Industrial Energy emissions have increased from 2005 to 2017 by ~59% (Refer to Table 6).

Figure 9: 2005, 2015, 2017 Industrial Energy CO_2e Emissions

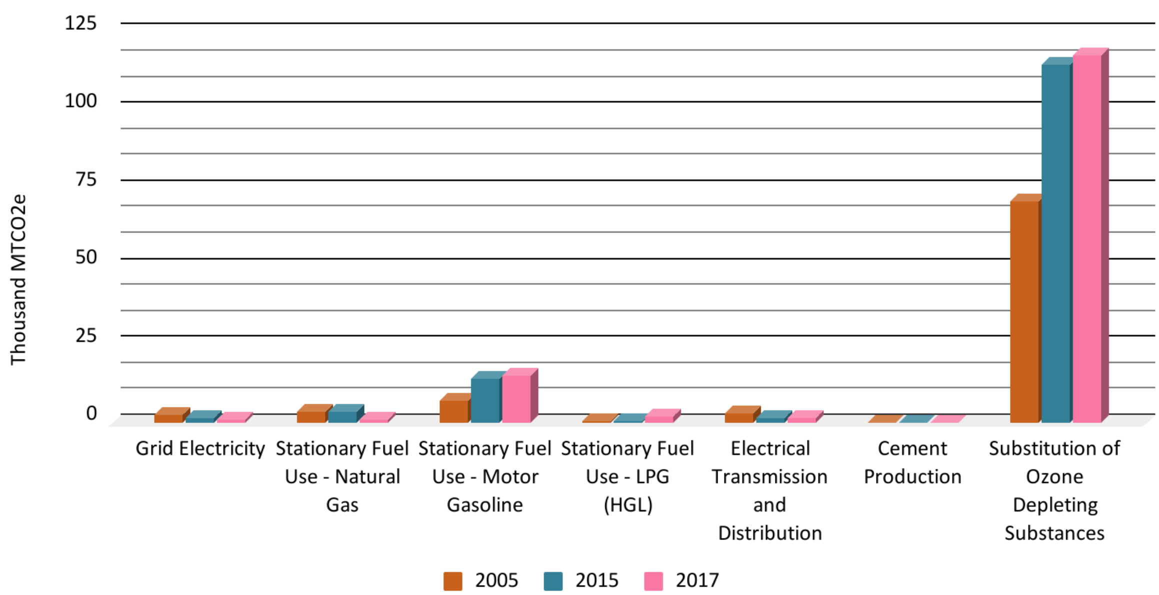
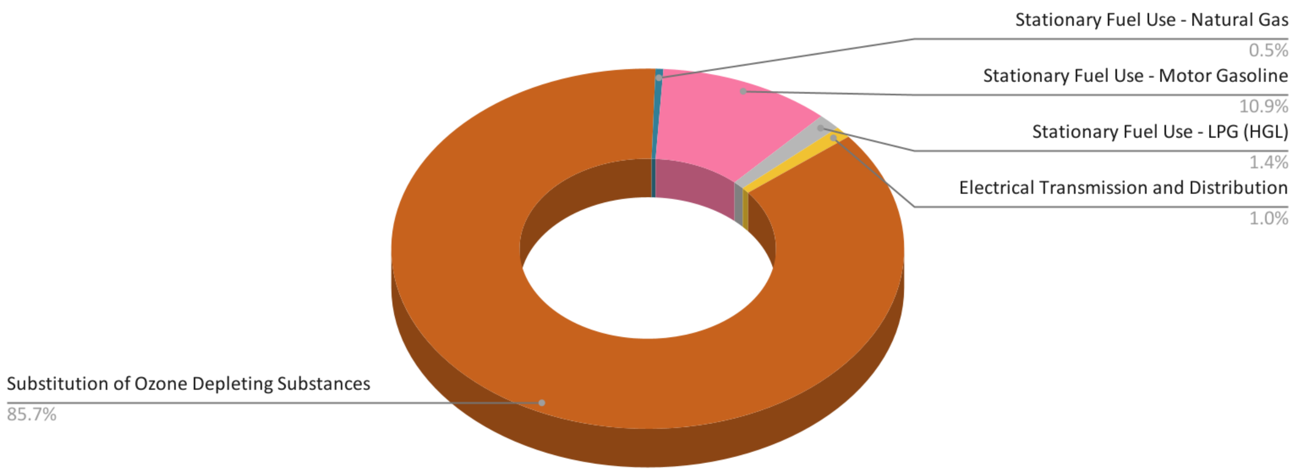


Table 6: 2005, 2015, & 2017 Emissions for Industrial Energy

	MTCO$_2$e			
Sources	**2005**	**2015**	**2017**	***%∆ 2005 to 2017***
Grid Electricity	13,861	7,844	662	*-634%*
Stationary Fuel Use - Natural Gas	3,376	3,402	672	*-80%*
Stationary Fuel Use - Motor Gasoline	6,593	13,810	14,882	*126%*
Stationary Fuel Use - LPG (HGL)	4576	308	1,964	*329%*
Electrical Transmission and Distribution	2,670	1,398	1,432	*-46%*
Cement Production	.	0	0	*0%*
Substitution of Ozone Depleting Substances	70,771	114,671	117,397	*66%*
Total % Change of all Sources from 2005 to 2017				***59%***

Referring to Figure 10, Substitution of Ozone Depleting Substances represent ~86% of sources of emissions in the Industrial Energy sector in 2017. Stationary Fuel Uses- Motor Gasoline emits 10.9% of all greenhouse gases, whereas the total combined for sectors-- Industrial Retail Sales and Street Lights (Grid Electricity), Stationary Fuel Use -LPG (HGL), and Electric Transmission and Distribution-- have the lowest emissions.

Figure 10: Percent of CO_2e Industrial Energy Emissions for 2017



Residential Energy

The Residential Energy sector includes emissions from four non-renewable energy sources. These sources, listed below in Figure 11, are a sum of Energy Generated by Residential and Used by the Grid (Grid Electricity) and Stationary Fuel Use (Diesel, LPG [HGL], and Natural Gas). Grid Electricity is the largest emitter of CO_2e within the Residential Energy Sector making up 89% of all energy sources. Grid Electricity has decreased by 55% from 2005 to 2017, and continues to see decreases (Refer to Table 7).

Figure 11: 2005, 2015, 2017 Residential Energy CO_2e Emissions

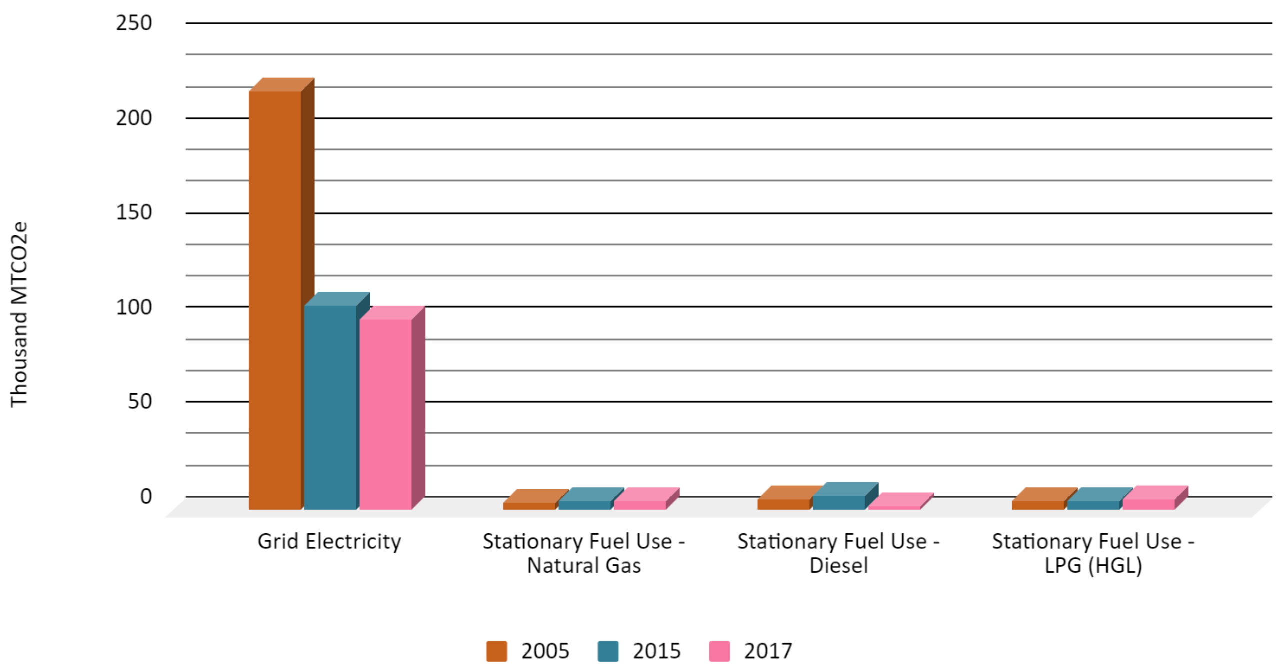
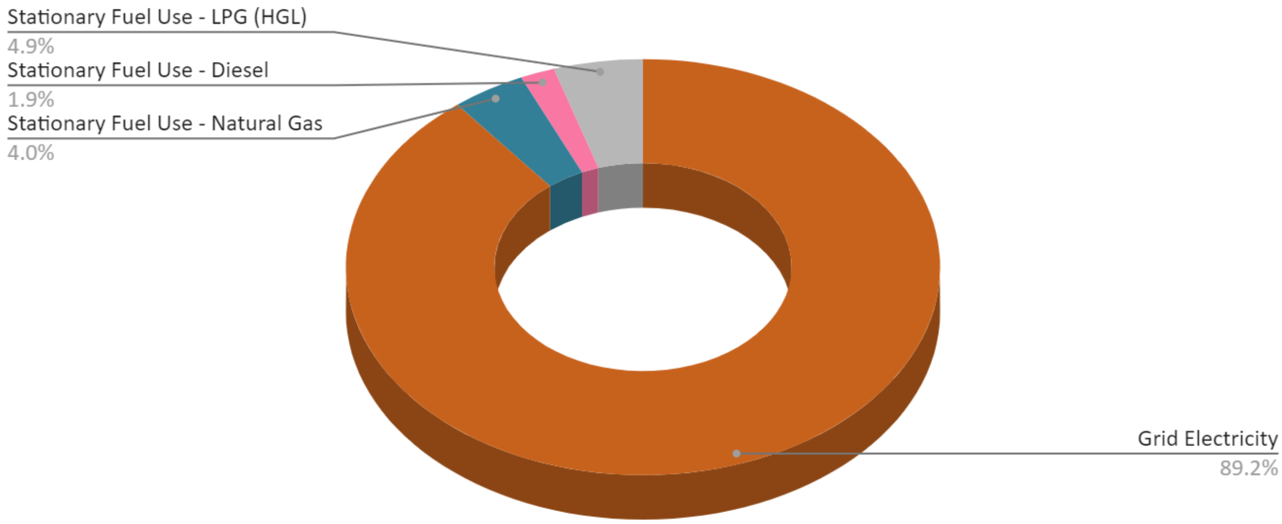


Table 7: 2005, 2015, & 2017 Residential Energy CO_2e Emissions

Sources	**$MTCO_2e$**			
	2005	**2015**	**2017**	**% Δ 2005 to 17**
Grid Electricity	235,394	129,245	100,386	-55%
Stationary Fuel Use - Natural Gas	3,798	4,411	4,518	19%
Stationary Fuel Use - Diesel	5,808	7,392	2,113	-64%
Stationary Fuel Use - LPG (HGL)	5,093	4,445	5,461	7%
Total % Change of all Sources from 2005 to 2017				-52%

Referring to Figure 12, Grid Electricity represents the greatest sources of emissions in the Residential Energy sector at 89.2% in 2017. Stationary Fuel Uses (LPG [HGL], Diesel, and Natural Gas) represent 10.8% of the sector's emissions.

Figure 12: Percent of CO_2e Residential Energy Emissions for 2017



Agriculture, Forestry, and Other Land Uses (AFOLU)

The AFOLU sector determines emissions from seven sources (emitters) and carbon sequesters (capturing atmospheric carbon) from three sinks. Referring to Figure 12, the sources emitting greenhouse gases are Forest Fires, Agricultural Soil Carbon, Agricultural Soil Management, Enteric Fermentation, Field Burning of Agricultural, Manure Management, and Urea Application. From 2005 to 2017, emitters have decreased by 19% but have increased by ~20k $MTCO_2e$ since 2015. There were also fewer forest fires in Hawai‘i County (Refer to Table Figure 13). The three carbon sequesters, known as sinks, are Forest Carbon, Landfilled Yard Trimmings and Food, and Urban Trees which sequesters two-to-three times more carbon than the seven emitters produce (Refer to Table 8). Forest Carbon captures and stores the largest amount of atmospheric carbon dioxide but has decreased 29% from 2005 to 2017. Urban Trees have increased capture and storage by 65% from 2005 to 2017, however this does not make up for the loss in capture by Forest Carbon. From 2005 to 2017, the overall loss for sinks (sequesters) in atmospheric carbon dioxide is 19%.

Figure 13: Agricultural, Forestry, and Other Land Uses CO_2e Emitters and Sinks (Sequesters)

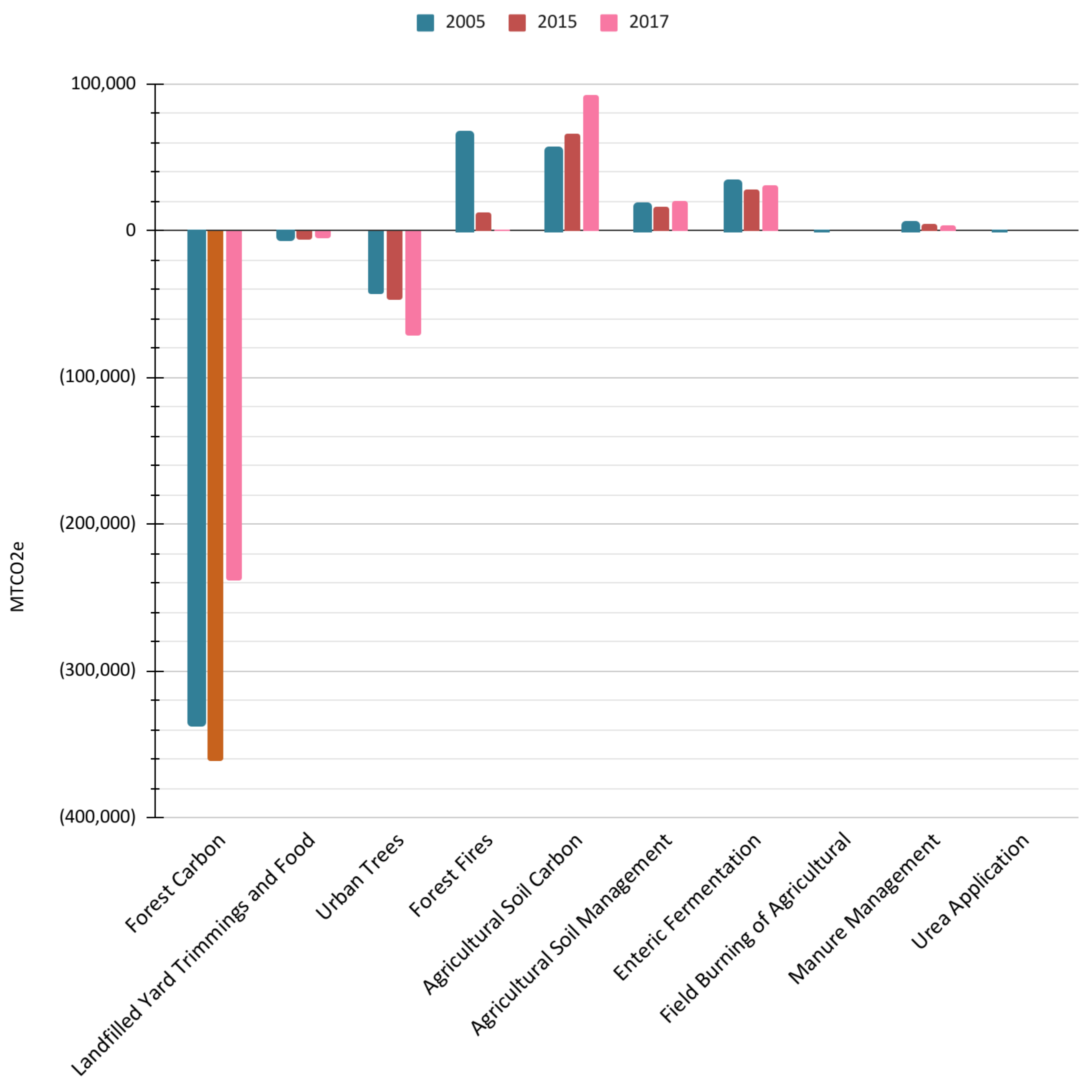


Table 8: 2005, 2015, & 2017 AFOLU Emitters and Sinks (Sequesters) CO_2e Emissions

	MTCO₂e			
Sinks (Sequesters)	**2005**	**2015**	**2017**	**% Δ 2005 to 2017**
Forest Carbon	(337,127)	(361,795)	(238,456)	-29%
Landfill Yard Trimmings and Food Scraps	(5,873)	(5,873)	(4,699)	-20%
Urban Trees	(43,462)	(46,986)	(71,654)	65%
TOTAL	**(386,463)**	**(414,655)**	**(314,809)**	**-19%**
Emitters	**2005**	**2015**	**2017**	**% Δ 2005 to 2017**
Forest Fires Emissions	66,956	12,921	1,175	-98%
Agricultural Soil Carbon	56,384	65,781	92,798	65%
Agricultural Soil Management	18,795	16,445	19,969	6%
Enteric Fermentation	34,065	28,192	30,541	-10%
Field Burning of Agricultural Residues	0	0	0	0
Manure Management	5,873	4,699	3,524	-40%
Urea Application	0	0	0	0
TOTAL	**182,072**	**128,038**	**148,007**	**-19%**

Referring to Figure 14, AFOLU Forest Carbon represents the largest amount of atmospheric carbon storage by 75.7% for 2017. The second largest atmospheric carbon storage is Urban Trees by 22.8%. Landfill Yard Trimmings and Food captures the least. Referring to Figure 15, the largest emitters of AFOLU Sources for 2017, are Agricultural Soil Carbon, Enteric Fermentation, and Agricultural Soil Management.

Figure 14: Percentages of AFOLU Sinks (Sequesters) for 2017

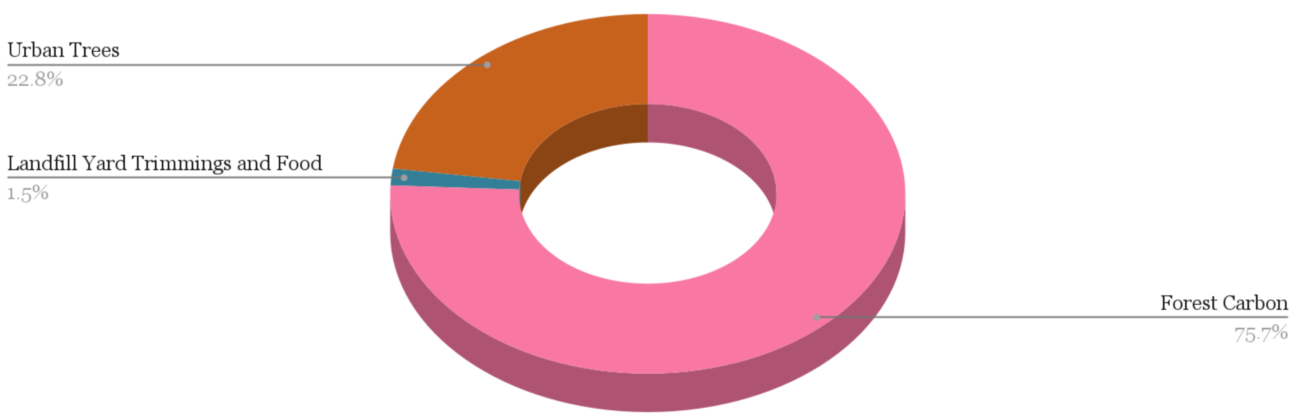
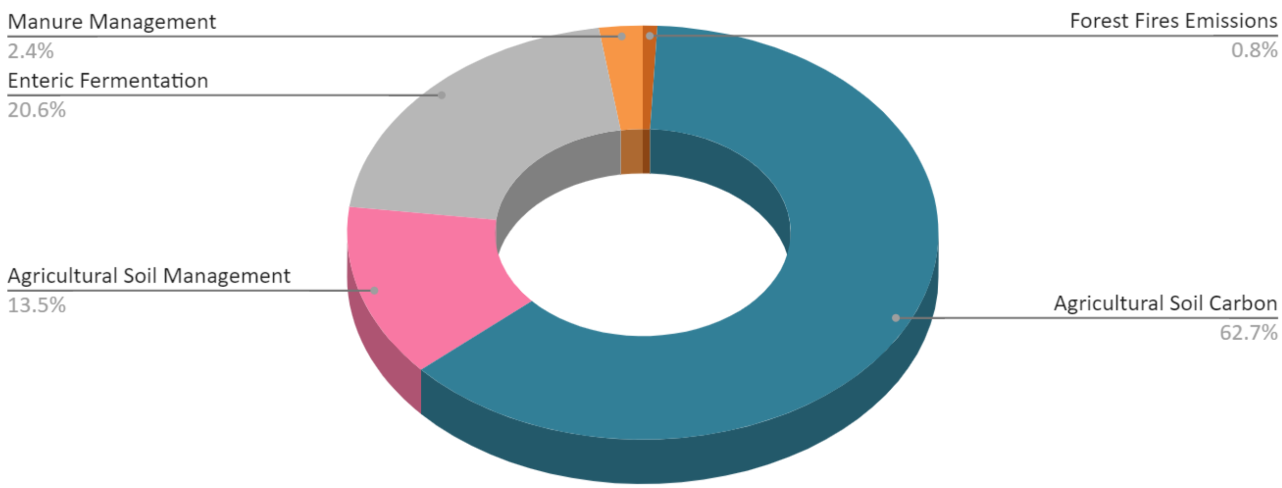


Figure 15: Percentages of AFOLU Emitters for 2017



Water and Wastewater

For 2017, Water and Wastewater GHG emissions decreased by over half of all emissions for this sector (Refer to Figure 16). This is a total reduction of 8,866 $MTCO_2e$ over a decade (2005 to 2017) (Refer to Table 9).

Figure 16: 2005, 2015, 2017 Water and Wastewater CO_2e Emissions

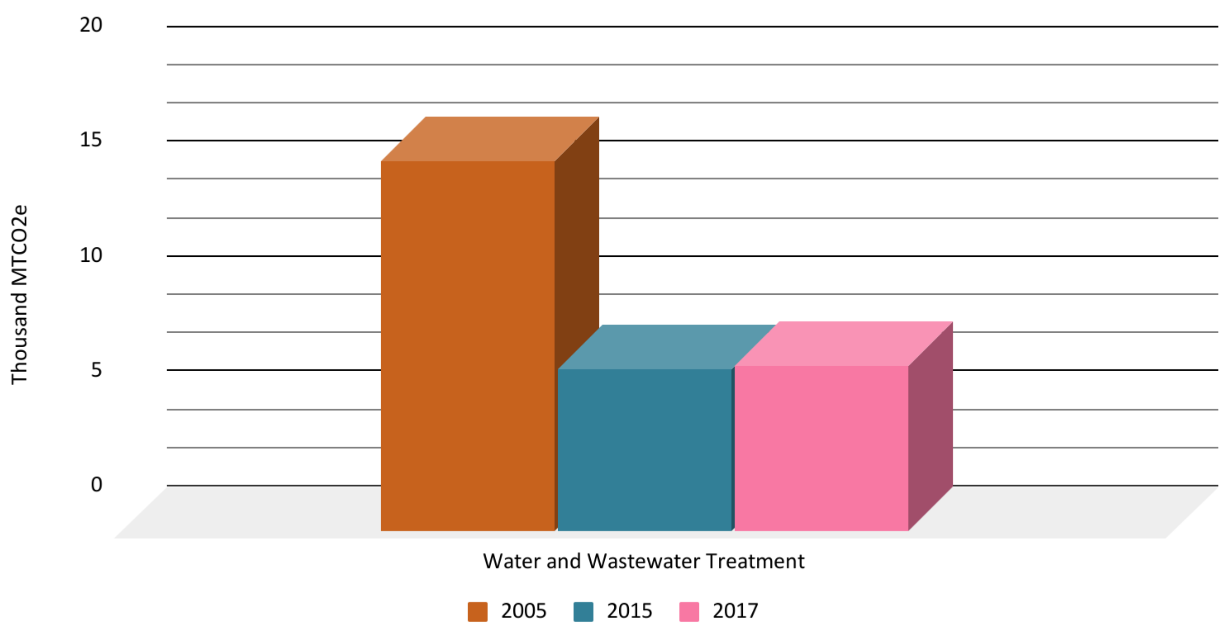


Table 9: 2005, 2015, 2017 Water and Wastewater CO_2e Emissions

	$MTCO_2e$			
Source	2005	2015	2017	**% Δ 2005 to 2017**
Water and Wastewater Treatment	16,024	6,992	7,158	-55.33%

Solid Waste

The Solid Waste Energy sector includes emissions from three sources. These sources, listed below in Figure 17, are Composting, In-Jurisdiction Landfills, and Waste Generation. The largest emitters are Waste Generation and In-Jurisdiction Landfills. In 2017, these two sources produced the majority of emissions. Between 2005 and 2017, emissions increased by 23.4% with the largest increase in Waste Generation by almost half (Refer to Table 10).

Figure 17: 2005, 2015, 2017 Solid Waste CO_2e Emissions

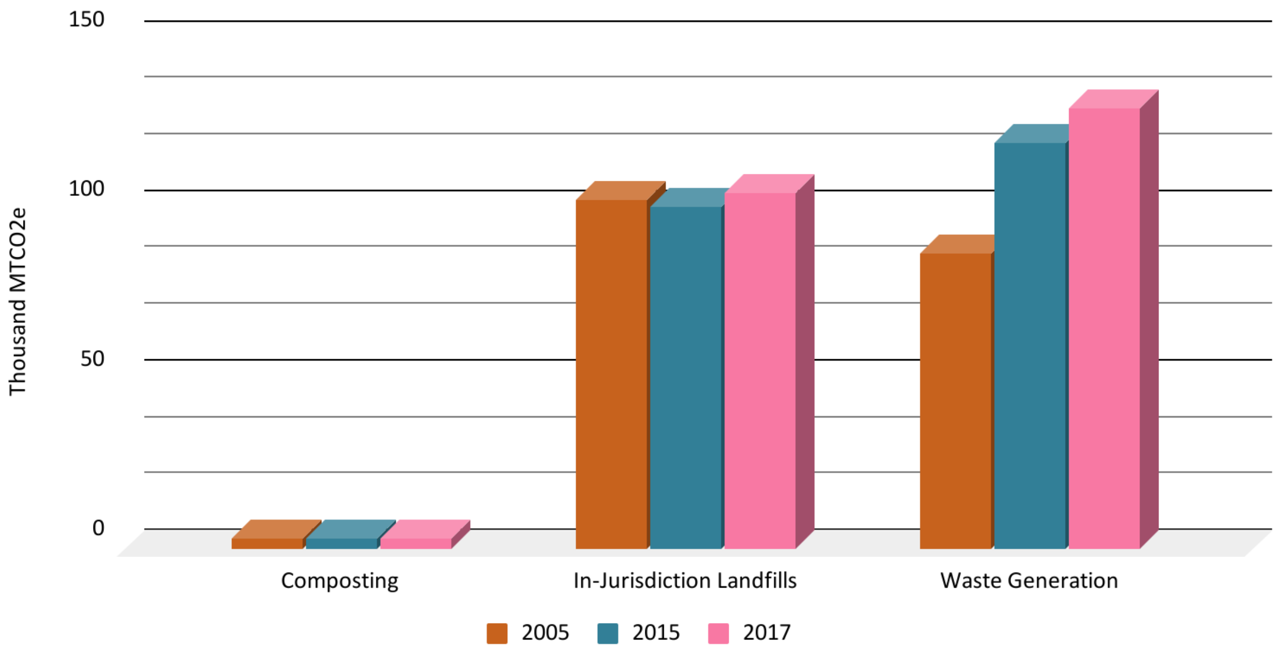


Table 10: 2005, 2015, 2017 Solid Waste $MTCO_2e$ Emissions

Sources	$MTCO_2e$ 2005	2015	2017	% Δ 2005 to 2017
Composting	2,671	2,800	2,863	7.22%
In-Jurisdiction Landfills	102,819	100,675	104,513	1.65%
Waste Generation (2019)	86,759	119,475	129,858	49.68%
Total % Change of all Sources from 2005 to 2017				23.40%

Appendix A. Inventory Methodology & Definitions

The purpose of this section is to provide clear and transparent explanations of calculations before being inputted into the ICLEI ClearPath calculator.

Transportation Sector

EIA defines the Transportation sector as "an energy-consuming sector that consists of all vehicles whose primary purpose is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles. Vehicles whose primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are classified in the sector of their primary use. In this report, natural gas used in the operation of natural gas pipelines is included in the transportation sector."

*On-Road Transportation - Motor Gasoline**

1. GHG emissions from On-Road Transportation - Motor Gasoline are calculated from EIA State Energy Data System (SEDS) Energy Estimates.
2. Since State data is used, the consumption estimates are scaled by the de facto population for the county.
3. Then the estimates are converted from thousand barrels to barrels (and multiplied by 1,000).
4. Lastly, barrels are converted to gallons (and multiplied by 42).

* Motor gasoline is defined as, "a complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D 4814 or Federal Specification VV-G-1690C, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10% recovery point to 365 to 374 degrees Fahrenheit at the 90% recovery point. Motor Gasoline includes conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline, but excludes aviation gasoline."

*On-Road Transportation - Diesel**

1. GHG emissions from On-Road Transportation - Diesel are calculated from the EIA Petroleum & Other Liquids Data: Hawai‘i No 2 Diesel Adj Sales/Deliveries to On-Highway Consumers (Thousand Gallons).
2. Since State data is used, the consumption estimates are scaled by the de facto population for the county.
3. Then the estimates are converted from thousand gallons to gallon (and multiplied by 1,000).

* Diesel fuel is defined as, "a fuel composed of distillates obtained in petroleum refining operation or blends of such distillates with residual fuel oil used in motor vehicles. The boiling point and specific gravity are higher for diesel fuels than for gasoline."

*Marine Transportation - Diesel (Vessel Bunkering)**

1. GHG emissions from Marine Transportation - Diesel (Vessel Bunkering) are calculated from the EIA Petroleum & Other Liquids Data: Hawai‘i Total Distillate Adj Sales/Deliveries to Vessel Bunker Consumers (Thousand Gallons).
2. Since State data is used, the consumption estimates are scaled by the de facto population for the county.
3. Then the estimates are converted from thousand gallons to gallon (and multiplied by 1,000).

* Residual Vessel Bunkering is defined as “including sales for the fueling of commercial or private boats, such as pleasure craft, fishing boats, tugboats, and ocean-going vessels, including vessels operated by oil companies. Excluded are volumes sold to the U.S. Armed Forces.”

*Marine Transportation - Residual (Vessel Bunkering)**

1. GHG emissions from Marine Transportation - Residual (Vessel Bunkering) are calculated from the EIA Petroleum & Other Liquids Data: Hawai‘i Total Distillate Adj Sales/Deliveries to Vessel Bunker Consumers (Thousand Gallons) .
2. Since State data is used, the consumption estimates are scaled by the de facto population for the county.
3. Then the estimates are converted from thousand gallons to gallon (and multiplied by 1,000).

* Residual Vessel Bunkering is defined as “including sales for the fueling of commercial or private boats, such as pleasure craft, fishing boats, tugboats, and ocean-going vessels, including vessels operated by oil companies. Excluded are volumes sold to the U.S. Armed Forces.”

*Air Transportation - Aviation Gasoline (Domestic)**

1. GHG emissions from Air Transportation - Aviation Gasoline (Domestic) are calculated from the Bureau of Transportation Statistics: Hilo International Airport Available Seat-miles for Hilo International and Kona International (origin only).
2. Domestic and International seat miles are reported . Record both Domestic and International seat miles for Hilo and Kona. Sum up Domestic and International seat miles for Hilo-- do the same for Kona.
3. Next calculate the Domestic Factor (to be used to scale State data to county estimates) by adding the Hilo Domestic to Kona Domestic seat miles. Then add together the Hilo International by Kona International. Divide Domestic Sum by International Sum.
4. Find the Transportation Energy Consumption Estimates at the EIA State Energy Data System (SEDS): State Energy Data 2018: Consumption, Table CT7. Transportation Sector Energy Consumption Estimates, Selected Years, 1960-2018, Hawai‘i. Since this is State Data, the Energy Consumption estimates need to be scaled by de facto population for the county.
5. Then calculate the de facto scaled estimate (from step #4) from thousand barrels to barrel (and multiplied by 1,000). Then calculate from barrels to gallon (and multiplied by 42)
6. Lastly, and multiplied the Domestic Factor (from step #3) to the scaled calculation to the gallon estimate (from step #5).

*Aviation gasoline is defined as “a complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in aviation reciprocating engines.”

Air Transportation - Aviation Gasoline (International)

1) GHG emissions from Air Transportation - Aviation Gasoline (International) are calculated from the Bureau of Transportation Statistics: Hilo International Airport Available Seat-miles for Hilo International and Kona International (origin only).
2) Domestic and International seat miles are reported. Record both Domestic and International seat miles for Hilo and Kona. Sum up Domestic and International seat miles for Hilo-- do the same for Kona.
3) Next calculate the International Factor (to be used to scale State data to county estimates) by adding the Hilo Domestic to Kona Domestic seat miles. Then add together the Hilo International by Kona International. Divide International Sum by Domestic Sum.

4) Find the Transportation Energy Consumption Estimates at the EIA State Energy Data System (SEDS): State Energy Data 2018: Consumption, Table CT7. Transportation Sector Energy Consumption Estimates, Selected Years, 1960-2018, Hawai‘i. Since this is State Data, the Energy Consumption estimates need to be scaled by de facto population for the county.
5) Then calculate the de facto scaled estimate (from step #4) from thousand barrels to barrel (and multiplied by 1,000). Then calculate from barrels to gallon (and multiplied by 42)
6) Lastly, and multiplied the International Factor (from step #3) to the scaled calculation to the gallon estimate (from step #5).

*Aviation gasoline is defined as “a complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in aviation reciprocating engines.”

Air Transportation - Aviation Kerosene (Jet Fuel) (Domestic)

1. GHG emissions from Air Transportation - Aviation Kerosene (Jet Fuel) (Domestic) are calculated from the Bureau of Transportation Statistics: Hilo International Airport Available Seat-miles for Hilo International and Kona International (origin only).
2. Domestic and International seat miles are reported. Record both Domestic and International seat miles for Hilo and Kona. Sum up Domestic and International seat miles for Hilo-- do the same for Kona.
3. Next calculate the International Factor (to be used to scale State data to county estimates) by adding the Hilo Domestic to Kona Domestic seat miles. Then add together the Hilo International by Kona International. Divide Domestic Sum by International Sum.
4. Find the Transportation Energy Consumption Estimates at the EIA State Energy Data System (SEDS): State Energy Data 2018: Consumption, Table CT7. Transportation Sector Energy Consumption Estimates, Selected Years, 1960-2018, Hawai‘i. Since this is State Data, the Energy Consumption estimates need to be scaled by de facto population for the county.
5. Then calculate the de facto scaled estimate (from step #4) from thousand barrels to barrel (and multiplied by 1,000). Then calculate from barrels to gallon (and multiplied by 42)
6. Lastly, and multiplied the International Factor (from step #3) to the scaled calculation to the gallon estimate (from step #5).

* Aviation Kerosene is defined as “a kerosene-based product having a maximum distillation temperature of 400 degrees Fahrenheit at the 10% recovery point and a final maximum boiling point of 572 degrees Fahrenheit and meeting ASTM Specification D 1655 and Military Specifications MIL-T-5624P and MIL-T-83133D (Grades JP-5 and JP-8). It is used for commercial and military turbojet and turboprop aircraft engines.”

Air Transportation - Aviation Kerosene (Jet Fuel) (International)

1. GHG emissions from Air Transportation - Aviation Kerosene (Jet Fuel) (International) are calculated from the Bureau of Transportation Statistics: Hilo International Airport Available Seat-miles for Hilo International and Kona International (origin only).
2. Domestic and International seat miles are reported. Record both Domestic and International seat miles for Hilo and Kona. Sum up Domestic and International seat miles for Hilo-- do the same for Kona.
3. Next calculate the International Factor (to be used to scale State data to county estimates) by adding the Hilo Domestic to Kona Domestic seat miles. Then add together the Hilo International by Kona International. Divide International Sum by Domestic Sum.

4. Find the Transportation Energy Consumption Estimates at the EIA State Energy Data System (SEDS): State Energy Data 2018: Consumption, Table CT7. Transportation Sector Energy Consumption Estimates, Selected Years, 1960-2018, Hawaiʻi. Since this is State Data, the Energy Consumption estimates need to be scaled by de facto population for the county.
5. Then calculate the de facto scaled estimate (from step #4) from thousand barrels to barrel (and multiplied by 1,000). Then calculate from barrels to gallons (and multiplied by 42).
6. Lastly, and multiplied the International Factor (from step #3) to the scaled calculation to the gallon estimate (from step #5).

* Aviation Kerosene is defined as "a kerosene-based product having a maximum distillation temperature of 400 degrees Fahrenheit at the 10% recovery point and a final maximum boiling point of 572 degrees Fahrenheit and meeting ASTM Specification D 1655 and Military Specifications MIL-T-5624P and MIL-T-83133D (Grades JP-5 and JP-8). It is used for commercial and military turbojet and turboprop aircraft engines."

Off-Road - Military

1. GHG emissions from Off-Road - Military are calculated from EIA Petroleum & Other Liquids Data: Hawaiʻi Total Distillate Adj Sales/Deliveries to Military Consumers (Thousand Gallons).
2. Since State data is used, the number is scaled by the de facto population for the county.
3. The data is then converted from thousand gallons to gallon conversion (and multiplied by 1,000).

* Military uses distillate fuel which is defined as "A general classification for one of the petroleum fractions produced in conventional distillation operations. It includes diesel fuels and fuel oils. Products known as No. 1, No. 2, and No. 4 diesel fuel are used in on highway diesel engines, such as those in trucks and automobiles, as well as off-highway engines, such as those in railroad locomotives and agricultural machinery. Products known as No. 1, No. 2, and No. 4 fuel oils are used primarily for space heating and electric power generation."

*Off-Road - Construction and Off-Road Non-Construction**

1. GHG emissions from Off-Road - Construction and -Non-Construction are calculated from the EIA Petroleum & Other Liquids Data: Hawaiʻi No 2 Diesel Adj Sales/Deliveries for Off-Highway Construction (Thousand Gallons).
2. Since State data is used, the number is scaled by the de facto population for the county.
3. The data is then converted from thousand gallons to gallon conversion (and multiplied by 1,000).

* Off-Road- Construction and Off-Road-Non-Construction uses diesel fuel which is defined as, "a fuel composed of distillates obtained in petroleum refining operation or blends of such distillates with residual fuel oil used in motor vehicles. The boiling point and specific gravity are higher for diesel fuels than for gasoline."

Residential Energy

Energy Generated by Residential and Used by the Grid:

1. GHG emissions from Energy Generated by Residential and Used by the Grid is calculated by first determining what percent of energy capacity is from renewable energy versus non-renewable energy. Percent generated by non-renewable energy can be found in the Renewable Portfolio Standards Reports provided by Hawaiian Electric Co. (HECO).
2. Then, the amounts of electricity sent to the system by the electric utility company for both Residential and Commercial are totaled to get the sum. This sum is used to create a percentage of how much energy is being

produced by these two sectors. The purpose of this calculation is to then identify how much of the Electricity Used by Stations (DBEDT) is used for Residential or Commercial Energy respectively. The amount of Electricity Used by Stations specifically to generate Residential Energy is added to the final sum.

3. The amount of Residential Energy Generated is pulled from DBEDT (Department of Business, Economic Development & Tourism), which already pre-includes the total energy generated from Independent Power Purchasers (IPP) (Refer to Figure 3 for details about Carbon Free energy).
4. The final calculation includes the sum of Electricity Used by Stations to generate Residential Energy (Refer to Step 2) is added to Residential Energy Generated (Refer to Step 3). The sum is then multiplied by percent of non-renewable energy. The purpose is to differentiate between non-renewable energy and renewable energy before inputting into ICLEI.

*Stationary Fuel Use - Natural Gas**

1. GHG emissions from Natural Gas is calculated by finding the residential volume consumed (i.e. gas used in private dwellings, including apartments, for heating, air-conditioning, cooking, water heating, and other household uses) (EIA). This data is only available at the State level.
2. Since this data is only available at the State level, the number has to be scaled by the de facto population (thousand ft3) of the County.
3. Then the scaled population for the County was converted from thousand ft3 to MMBtu multiplied by 1.037 (One thousand cubic feet (Mcf) of natural gas equals 1.037 MMBtu, or 10.37 therms).

*Natural gas is defined as "a gaseous mixture of hydrocarbon compounds, the primary one being methane."

*Stationary Fuel Use - LPG (HGL)**

1. GHG emissions from LPG are calculated by determining the residential energy consumption using EIA. This data is only available at the State level.
2. Since the data is only available at the State level, the number has to be scaled by the de facto population (trillion Btu) of the County.
3. Then the estimate is converted from trillion Btu to MMBtu and multiplied by 1,000,000 (Btu↔MMBtu 1 MMBtu = 1000000 Btu).

*Liquefied petroleum gases (LPG) is described as, "a group of hydrocarbon gases, primarily propane, normal butane, and isobutane, derived from crude oil refining or natural gas processing. These gases may be marketed individually or mixed. They can be liquefied through pressurization (without requiring cryogenic refrigeration) for convenience of transportation or storage. Excludes ethane and olefins."

*Stationary Fuel Use - Diesel**

1. GHG emissions from Diesel are calculated by determining the Adj (Adjusted) No. 2 Distillate Sales/Deliveries to Residential Consumers (thousand gallons) (EIA). This data is only available at State level.
2. Since the data is only available at the State level, the number has to be scaled by de facto population (thousand gallons).
3. Then the estimate is converted from thousand gallons to gallon conversion multiplied by 1,000.
4. Then gallons need to be converted to MMBtu and multiplied by 0.141.

* Diesel fuel is defined as, “a fuel composed of distillates obtained in petroleum refining operation or blends of such distillates with residual fuel oil used in motor vehicles. The boiling point and specific gravity are higher for diesel fuels than for gasoline.”

Commercial Energy

Non-Renewable Energy Generated by Commercial and Used by the Grid

1. GHG emissions from Non-Renewable Energy Generated by Commercial and Used by the Grid are calculated by first determining what percent of energy capacity is from renewable energy versus non-renewable energy. Percent generated by non-renewable energy can be found in the Renewable Portfolio Standards Reports provided by Hawaiian Electric Co. (HECO).
2. Then, the amounts of electricity sent to the system by the electric utility company for both Commercial and Residential are totaled to get the sum. This sum is used to create a percentage of how much energy is being produced by these two sectors. The purpose of this calculation is to then identify how much of the Electricity Used by Stations (DBEDT) is used for Commercial or Residential Energy respectively. The amount of Electricity Used by Stations specifically to generate Commercial Energy is added to the final sum.
3. The amount of Commercial Energy Generated is pulled from DBEDT (Department of Business, Economic Development & Tourism), which already pre-includes the total energy generated from Independent Power Purchasers (IPP) (Refer to Figure 3 for details about Carbon Free energy).
4. The final calculation includes the sum of Electricity Used by Stations to generate Commercial Energy (Refer to Step 2) is added to Commercial Energy Generated (Refer to Step 3). The sum is then multiplied by percent of non-renewable energy. The purpose is to differentiate between non-renewable energy and renewable energy before inputting into ICLEI.

*Stationary Fuel Use - Natural Gas**

1. GHG emissions from Natural Gas is calculated by finding commercial consumption (i.e. Gas used by non manufacturing establishments or agencies primarily engaged in the sale of goods or services. Included are such establishments as hotels, restaurants, wholesale and retail stores and other service enterprises; gas used by local, State, and Federal agencies engaged in nonmanufacturing activities) (EIA). This data is only available at the State level.
2. Since this data is only available at the State level, the number has to be scaled by the de facto population (thousand ft3) of the County.
3. Then the scaled population for the County was converted from thousand ft3 to MMBtu multiplied by 1.037 (One thousand cubic feet (Mcf) of natural gas equals 1.037 MMBtu, or 10.37 therms).

*Natural gas is defined as “a gaseous mixture of hydrocarbon compounds, the primary one being methane.”

*Stationary Fuel Use - LPG (HGL)**

1. GHG emissions from LPG are calculated by determining the commercial consumption using EIA data. This data is only available at the State level.
2. Since the data is only available at the State level, the number has to be scaled by the de facto population (trillion Btu) of the County.
3. Then the estimate is converted from trillion Btu to MMBtu and multiplied by 1,000,000 (Btu↔MMBtu 1 MMBtu = 1000000 Btu).

*Liquefied petroleum gases (LPG) is described as, "a group of hydrocarbon gases, primarily propane, normal butane, and isobutane, derived from crude oil refining or natural gas processing. These gases may be marketed individually or mixed. They can be liquefied through pressurization (without requiring cryogenic refrigeration) for convenience of transportation or storage. Excludes ethane and olefins."

*Stationary Fuel Use - Diesel**

1. GHG emissions from Diesel are calculated by determining the Adj (Adjusted) No. 2 Distillate Sales/Deliveries to Commercial Consumers (thousand gallons) (EIA). This data is only available at State level.
2. Since the data is only available at the State level, the number has to be scaled by de facto population (thousand gallons).
3. Then the estimate is converted from thousand gallons to gallon conversion multiplied by 1,000.
4. Then gallons need to be converted to MMBtu and multiplied by 0.141.

* Diesel fuel is defined as, "a fuel composed of distillates obtained in petroleum refining operation or blends of such distillates with residual fuel oil used in motor vehicles. The boiling point and specific gravity are higher for diesel fuels than for gasoline."

*Stationary Fuel Use - Motor Gasoline**

1. GHG emissions from Motor Gasoline are calculated by determining consumption estimates to Commercial Consumers (trillion Btu) (EIA). This data is only available at State level.
2. Since the data is only available at the State level, the number has to be scaled by de facto population (trillion Btu).
3. Then the estimate is converted from trillion Btu to MMBtu and multiplied by 1,000,000 (Btu↔MMBtu 1 MMBtu = 1000000 Btu).

* Motor gasoline is defined as, "a complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D 4814 or Federal Specification VV-G-1690C, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10% recovery point to 365 to 374 degrees Fahrenheit at the 90% recovery point. Motor Gasoline includes conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline, but excludes aviation gasoline."

Industrial Energy

Electricity Generated by Industrial and Street Lights

1. Electricity Generated by Industrial and Street Lights is calculated from two sources. The first source is DBEDT for Electricity Total KWH Sold for Street Lights. This number is then multiplied by the percent non-renewable energy to find the volume of how much energy is produced using non-renewable energy.
2. The second source is EIA SEDS data for Industrial Retail Sales. This data is only available at the State level, therefore the number is scaled by the de facto population (thousand ft3) of the County.
3. Then the scaled population for the County was converted from thousand ft3 to MMBtu multiplied by 1.037 (One thousand cubic feet (Mcf) of natural gas equals 1.037 MMBtu, or 10.37 therms).
4. Both the DBEDT data for Street Lights and EIA SEDS data for Industrial Retail Sales are added together to find the sum.

*Stationary Fuel Use - Natural Gas**

1. GHG emissions from Natural Gas is calculated by finding Industrial consumption (i.e. Natural gas used for heat, power, or chemical feedstock by manufacturing establishments or those engaged in mining or other mineral extractions as well as consumers in agriculture, forestry, fisheries and construction) (EIA). This data is only available at the State level.
2. Since this data is only available at the State level, the number has to be scaled by the de facto population (thousand ft_3) of the County.
3. Then the scaled population for the County was converted from thousand ft3 to MMBtu multiplied by 1.037 (One thousand cubic feet (Mcf) of natural gas equals 1.037 MMBtu, or 10.37 therms).

*Natural gas is defined as "a gaseous mixture of hydrocarbon compounds, the primary one being methane."

*Stationary Fuel Use - LPG (HGL)**

1. GHG emissions from LPG is calculated by determining the Industrial consumption using EIA data. This data is only available at the State level.
2. Since the data is only available at the State level, the number has to be scaled by the de facto population (trillion Btu) of the County.
3. Then a scaled calculation was performed at thousand barrels to gallon conversion multiplied by 42.
4. Then the estimate is converted from trillion Btu to MMBtu and multiplied by 1,000,000 (Btu↔MMBtu 1 MMBtu = 1000000 Btu).

*Liquefied petroleum gasses (LPG) is described as, "a group of hydrocarbon gases, primarily propane, normal butane, and isobutane, derived from crude oil refining or natural gas processing. These gases may be marketed individually or mixed. They can be liquefied through pressurization (without requiring cryogenic refrigeration) for convenience of transportation or storage. Excludes ethane and olefins."

*Stationary Fuel Use - Motor Gasoline**

1. GHG emissions from Motor Gasoline is calculated by determining consumption estimates (Beginning in 1993, includes fuel ethanol blended into motor gasoline. There is a discontinuity in this time series between 2014 and 2015 because of coverage) to Industrial Consumers (trillion Btu) (EIA). This data is only available at State level.
2. Since the data is only available at the State level, the number has to be scaled by de facto population (trillion Btu).
3. Then the estimate is converted from trillion Btu to MMBtu and multiplied by 1,000,000 (Btu↔MMBtu 1 MMBtu = 1000000 Btu).

* Motor gasoline is defined as, "a complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D 4814 or Federal Specification VV-G-1690C, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10% recovery point to 365 to 374 degrees Fahrenheit at the 90% recovery point. Motor Gasoline includes conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline, but excludes aviation gasoline."

*Cement Production**

1. GHG emissions from Cement Production by gas ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Cement Production by gas are then scaled by de facto population.
3. Emissions from Cement Production by gas are then converted from $MMTCO_2e$ to $MTCO_2e$ and multiplied by 1,000,000.

* According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[c]arbon dioxide emissions are released as a by-product of the clinker production process, as an intermediate product used primarily to make Portland cement. Currently, there is no cement production which requires reporting by EPA standards.”

*Electrical Transmission and Distribution**

1. GHG emissions from Electrical Transmission and Distribution by gas ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Electrical Transmission and Distribution by gas are then scaled by de facto population.
3. Emissions from Electrical Transmission and Distribution by gas are then converted from $MMTCO_2e$ to $MTCO_2e$ and multiplied by 1,000,000.

* According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[s]ulfur hexafluoride (SF6) emissions from electrical transmission and distribution systems are a result of leaks in transmission equipment. Nationally, these emissions have decreased over time due to a sharp increase in the price of SF6 during the 1990s and a growing awareness of the environmental impact of SF6 emissions (EPA 2020a).”

*Substitution of Ozone Depleting Substances (ODS)**

1. GHG emissions from Substitutes of ODS by gas ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Substitutes of ODS by gas are then scaled by de facto population.
3. Emissions from Substitutes of ODS by gas are then converted from $MMTCO_2e$ to $MTCO_2e$ multiplied by 1,000,000.

*According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[h]ydrofluorocarbons (HFCs) and perfluorocarbons (PFCs) are used as alternatives to ozone depleting substances (ODS) that are being phased out under the Montreal Protocol and the Clean Air Act Amendments of 1990. These chemicals are most commonly used in refrigeration and air conditioning equipment, solvent cleaning, foam production, fire extinguishing, and aerosols.”

AFOLU

*Enteric Fermentation Emissions - Emitter**

1. GHG emissions from Enteric Fermentation Emissions ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017 .
2. Emissions from Enteric Fermentation Emissions are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000).

* According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[m]ethane is produced as part of the digestive processes in animals, a microbial fermentation process referred to as enteric fermentation. The amount of CH_4 emitted by an animal depends upon the animal’s digestive system, and the amount and type of feed it consumes (EPA 2020a). This source includes CH_4 emissions from dairy and beef cattle, sheep, goats, swine, and horses.”

*Manure Management Emissions - Emitter**

1. GHG emissions from Manure Management Emissions ($MMTCO_2e$) is calculated from the State of Hawai'i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Manure Management Emissions are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000).

* According to the State of Hawai'i's Greenhouse Gas Emissions Report (2020), "[t]he main GHGs emitted by the treatment, storage, and transportation of livestock manure are CH_4 and N_2O. Methane is produced by the anaerobic decomposition of manure. Direct N_2O emissions are produced through the nitrification and denitrification of the organic nitrogen (N) in livestock dung and urine. Indirect N_2O emissions result from the volatilization of N in manure and the runoff and leaching of N from manure into water (EPA 2020a). This category includes CH_4 and N_2O emissions from dairy and Agriculture, Forestry and Other Land Uses (AFOLU) beef cattle, sheep, goats, swine, horses, and chickens."

*Agricultural Soil Management Emissions - Emitter**

1. GHG emissions from Agricultural Soil Management Emissions ($MMTCO_2e$) is calculated from the State of Hawai'i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Agricultural Soil Management Emissions are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000)

* According to the State of Hawai'i's Greenhouse Gas Emissions Report (2020), "Nitrous oxide is produced naturally in soils through the nitrogen (N) cycle. Many agricultural activities, such as the application of N fertilizers, increase the availability of mineral N in soils that lead to direct N_2O emissions from nitrification and denitrification (EPA 2020a). This category includes N_2O emissions from synthetic fertilizer, organic fertilizer, manure N, as well as crop residue inputs from sugarcane, pineapples, sweet potatoes, ginger root, taro, corn for grain, and seed production."

*Field Burning of Agricultural Residues Emissions - Emitter**

1. GHG emissions from Field Burning of Agricultural Residues Emissions ($MMTCO_2e$) is calculated from the State of Hawai'i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Field Burning of Agricultural Residues Emissions are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000).

* According to the State of Hawai'i's Greenhouse Gas Emissions Report (2020), "[f]ield burning is a method that farmers use to manage the vast amounts of agricultural crop residues that can be created during crop production. Crop residue burning is a net source of CH_4 and N_2O, which are released during combustion (EPA 2020a)." However, Maui County is the only county to burn sugar cane, therefore, Hawai'i County reports as zero."

*Urea Application Emissions - Emitter**

1. GHG emissions from Urea Application Emissions ($MMTCO_2e$) is calculated from the State of Hawai'i Greenhouse Gas Emissions Report for 2017..
2. Emissions from Urea Application Emissions are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (multiplied by 1,000,000).

*According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[u]rea ($CO(NH_2)_2$) is a nitrogen fertilizer that is often applied to agricultural soils. When urea is added to soils, bicarbonate forms and evolves into CO_2 and water (IPCC 2006).”

*Agricultural Soil Carbon Emissions - Emitter**

1. GHG emissions from Agricultural Soil Carbon Emissions ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Agricultural Soil Carbon Emissions are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000)

* According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[a]gricultural soil carbon refers to the change in carbon stock in agricultural soils—either in cropland or grasslands—that have been converted from other land uses. Agricultural soils can be categorized into organic soils, which contain more than 12 to 20 percent organic carbon by weight, and mineral soils, which typically contain 1 to 6 percent organic carbon by weight (EPA 2020a). Organic soils that are actively farmed tend to be sources of carbon emissions as soil carbon is lost to the atmosphere due to drainage and management activities. Mineral soils can be sources of carbon emissions after conversion, but fertilization, flooding, and management practices can result in the soil being either a net source or net sink of carbon. Nationwide, sequestration of carbon by agricultural soils is largely due to enrollment in the Conservation Reserve Program, conservation tillage practices, increased hay production, and intensified crop production.”

*Forest Fire Emissions - Emitter**

1. GHG emissions from Forest Fire Emissions ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Forest Fire Emissions are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000).

* According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[f]orest and shrubland fires (herein referred to as forest fires) emit CO_2, CH_4, and N_2O as biomass is combusted. This source includes emissions from forest fires caused by lightning, campfire, smoking, debris burning, arson, equipment, railroads, children, and other miscellaneous activities reported by the Hawai‘i Department of Land and Natural Resources (DLNR).”

*Landfilled Yard Trimmings and Food Scraps - Sink (Sequester)**

1. GHG emissions from Landfill Yard Trimmings and Food Scraps ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Landfill Yard Trimmings and Food Scraps are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000).

* According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[y]ard trimmings (i.e., grass clippings, leaves, and branches) and food scraps continue to store carbon for long periods of time after they have been discarded in landfills.”

*Urban Trees - Sink (Sequester)**

1. GHG emissions from Urban Trees ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.

2. Emissions from Urban Trees are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (multiplied by 1,000,000).

*Trees in urban areas (i.e., urban forests) sequester carbon from the atmosphere.

*Forest Carbon - Sink (Sequester)**

1. GHG emissions from Forest Carbon ($MMTCO_2e$) is calculated from the State of Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Forest Carbon are then scaled by de facto population.
3. Then converted from $MMTCO_2$ to $MTCO_2e$ (and multiplied by 1,000,000).

* According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “Hawai‘i forests and shrubland contain carbon stored in various carbon pools, which are defined as reservoirs with the capacity to accumulate or release carbon (IPCC 2006). This category includes estimates of carbon sequestered in forests and shrubland aboveground biomass, which is defined as living vegetation above the soil, and belowground biomass, which is defined as all biomass below the roots (IPCC 2006). This analysis only considers managed forests and shrubland per IPCC (2006) guidelines because the majority of anthropogenic GHG emissions and sinks occur on managed land.”

Water and Wastewater*

1. GHG emissions are calculated from the sum of (1) EPA GHG Data: West Hawai‘i Landfill/Puu Anahulu 2010 & 2019 Waste Disposal Quantity Estimation Details-Prior Year Annual Waste Quantity Method and (2) from EPA GHG Data: South Hilo Sanitary Landfill 2012 & 2019 Waste Disposal Quantity Determination Details-First Year to Current Year Annual Waste Quantity Method.
2. Totals are then converted from metric tons to tons (and multiplied by 1.10231).

*According to the State of Hawai‘i’s Greenhouse Gas Emissions Report (2020), “[w]astewater produced from domestic, commercial, and industrial sources is treated either on-site (e.g., in septic systems) or in central treatment systems to remove solids, pathogenic organisms, and chemical contaminants (EPA 2020a). During the wastewater treatment process, CH_4 is generated when microorganisms biodegrade soluble organic material in wastewater under anaerobic conditions. The generation of N2O occurs during both the nitrification and denitrification of the nitrogen present in wastewater. Over 20 centralized wastewater treatment plants operate in Hawai‘i, serving most of the State’s population. The remaining wastewater is treated at on-site wastewater systems.”

Solid Waste

*In-Jurisdiction Landfills**

1. GHG emissions from In-Jurisdiction Landfills are calculated from Hawai‘i Greenhouse Gas Emissions Report for 2017.
2. Emissions are then scaled by the de facto population for the county.
3. Emissions from In-Jurisdiction Landfills are then converted from $MMTCO_2e$ (million metric tons of carbon dioxide) to $MTCO_2e$ (metric tons of carbon dioxide) multiplied by 1,000,000.
4. Then emissions are converted from $MTCO_2e$ (metric ton of carbon dioxide) to $MTCH_4$ (metric tons methane) (division by 25).

According to the Intergovernmental Panel on Climate Panel on Climate Change (IPCC), Fourth Assessment Report, "typically, greenhouse gas emissions are reported in units of carbon dioxide equivalent (CO_2e). Gases are converted to CO_2e by and multiplying by their global warming potential (GWP) (Refer to Table 11 below)."

Table 11: 100-Year GWP by Gas Type

Gas	100-Year GWP
CH_4	25
N_20	298

* According to the State of Hawai'i's Greenhouse Gas Emissions Report (2020), "[w]hen placed in landfills, organic material in municipal solid waste (MSW) (e.g., paper, food scraps, and wood products) is decomposed by both aerobic and anaerobic bacteria. As a result of these processes, landfills generate biogas consisting of approximately 50 percent biogenic CO_2 and 50 percent CH_4, by volume (EPA 2020a). Consistent with IPCC (2006), biogenic CO_2 from landfills is not reported under the Waste sector."

Waste Generation

1. GHG emissions are calculated from the sum of (1) Waste Generation of the West Hawai'i Landfill/Puu Anahulu Waste Quantity (MT) + (2) South Hilo Sanitary Landfill Waste Quantity are calculated and summed up from the EPA GHG Data: West Hawai'i Landfill/Puu Anahulu 2010 & 2019 Waste Disposal Quantity Estimation Details-Prior Year Annual Waste Quantity Method.
2. The sum of all landfill waste generation is then converted from metric tons to tons (and multiplied by 1.10231).

*Composting**

1. GHG emissions from Composting (CH_4 + N_2O) ($MMTCO_2e$) is calculated from the State of Hawai'i Greenhouse Gas Emissions Report for 2017.
2. Emissions from Composting are then scaled by de facto population.
3. Emissions from Composting are then converted from $MMTCO_2e$ to $MTCO_2e$ multiplied by 1,000,000.
4. Then emissions are then converted from $MTCO_2e$ to $MTCH_4$ (division by 25).

* According to the State of Hawai'i's Greenhouse Gas Emissions Report (2020), "[c]omposting involves the aerobic decomposition of organic waste materials, wherein large portions of the degradable organic carbon in the waste materials is converted into CO_2. The remaining solid portion is often recycled as a fertilizer and soil amendment or disposed [of] in a landfill. During the composting process, trace amounts of CH_4 and N_2O can form, depending on how the compost pile is managed."

Emissions Factors

Emissions factors (i.e., $MTCO_2e$ per unit of consumption) are used to determine sector-specific emissions by fuel type and category. For grid electricity, system-level carbon emissions intensity factors reported by eGRID are used for this inventory (Refer to Table 12).

Table 12: eGrid Emissions Factors for 2005, 2015, & 2017

eGrid Emission Factors	CO_2 (lbs/MWh)	CH_4 (lbs/GWh)	N_2O (GWh)
2005	1,467	60	12
2015	1,170	47	9
2017	1,263	51	10

Transportation emissions factors are based on the IPCC 4 standard using national average data and input into the ClearPath inventory tools. Local waste data did not coincide with available factor set fields, therefore, the assumption of 100% mixed solid waste is used. To retrieve eGrid Emission Factors for 2015, the years for 2014 and 2016 were averaged due to 2015 being unavailable. Similarly, for 2017, the years 2016 and 2018 were averaged because of the unavailable data for the year reported

Changes in Estimate Since the Previous Report

In the 2015 inventory report, Flaring of Landfill Gas was assumed to be seperate from Waste Generation calculation under Solid Waste. However, based on further review of the EPA data, the total of Waste Generation includes the Flaring of Landfill Gas. Therefore, emission from Flaring of Landfill Gas is excluded from this report until additional data can be obtained to make correct assumptions on how gas is flared at the landfill. Additionally, the ClearPath Calculator underestimated emissions for Waste Generation by 100% due to calculator settings. Therefore, settings for the calculator were improved to estimate more accurate emissions.

Additional changes in estimates are made to all the Energy sectors. Industrial energy used a similar equation which was double- or triple counting- energy generated. Due to limited data, the new calculation used EIA SEDS data from the State report and scaled by de facto population and incorporated the amount of energy used by Street Lights. In addition, using the ICLEI ClearPath calculator, it was assumed the total percent of renewable and nonrenewable energy was factored into the equation. However, based on further review of the calculator, the percent on renewable energy needed to be excluded from the totals for Residential, Commercial, and Industrial Sectors. Therefore, emissions of non-renewable energy are included in the change. However, there is a limitation in using renewable energy. The capacity of renewable energy is used rather than renewable energy generated. This is due to data limitations and therefore it is recommended to amend this in future reports.

Additional changes in estimates are made to the Residential, Commercial, and Industrial Energy sectors. In the 2015 inventory report, it was assumed that all energy produced for "Energy Generated by Residential and Used by the Grid" was generated from the residential energy sector. However, further review of DBEDT data revealed that the total amount of energy generated by the grid was for both the Residential and Commercial energy sectors. Therefore, energy used by the grid was double-counted. For this report, Energy Used by the Grid was separated into Commercial and Residential based on the percentage of overall energy emissions from Commercial and Residential energy. Industrial energy used a similar equation which was double- or triple- counting energy generated. Due to limited data, the new calculations used EIA SEDS data from the State report and scaled by de facto population and incorporated the amount of energy used by Street Lights.

In the ICLEI ClearPath calculator it was assumed that the total percentages of renewable and nonrenewable energy were factored into the equation. However, based on further review of the calculator, the percent of renewable energy needed to be excluded from the totals for Residential, Commercial, and Industrial Sectors. Therefore, emissions of non-renewable energy are included in the change. Table 13 represents emission estimate changes from the 2015 report and 2017 report.

Table 13: Emission Estimate Changes from 2015 Report and 2017 Report

Emission Estimates	**2005**	**2015**	**2017**
Solid Waste			
2015 Inventory Report (MMT CO2 Eq.)	105,489	103,475	-
2017 Inventory Report (MMT CO2 Eq.)	192,248	222,950	237,234
Percent Change	+ ~82%	+ ~115%	-
Residential			
2015 Inventory Report (MMT CO2 Eq.)	250,094	145,492	-
2017 Inventory Report (MMT CO2 Eq.)	235,509	124,691	112,478
Percent Change	+ ~6%	- ~14%	-
Commercial			
2015 Inventory Report (MMT CO2 Eq.)	1,581,426	967,436	-
2017 Inventory Report (MMT CO2 Eq.)	1,551,250	934,769	710,414
Percent Change	- ~2%	- ~3%	-
Industrial			
2015 Inventory Report (MMT CO2 Eq.)	97,731	141,432	-
2017 Inventory Report (MMT CO2 Eq.)	86,014	134,907	137,008
Percent Change	- ~12%	- ~5%	-
Total			
2015 Inventory Report (MMT CO2 Eq.)	3,588,582	2,563,228	
2017 Inventory Report (MMT CO2 Eq.)	3,618,881	2,622,766	2,779,683
Percent Change	+ ~0.84%	+ ~2.32%	

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