CITY OF ASPEN'S COMMUNITY-WIDE GREENHOUSE GAS EMISSIONS INVENTORY REPORT

For Calendar Year 2017

lotus
engineering & sustainability

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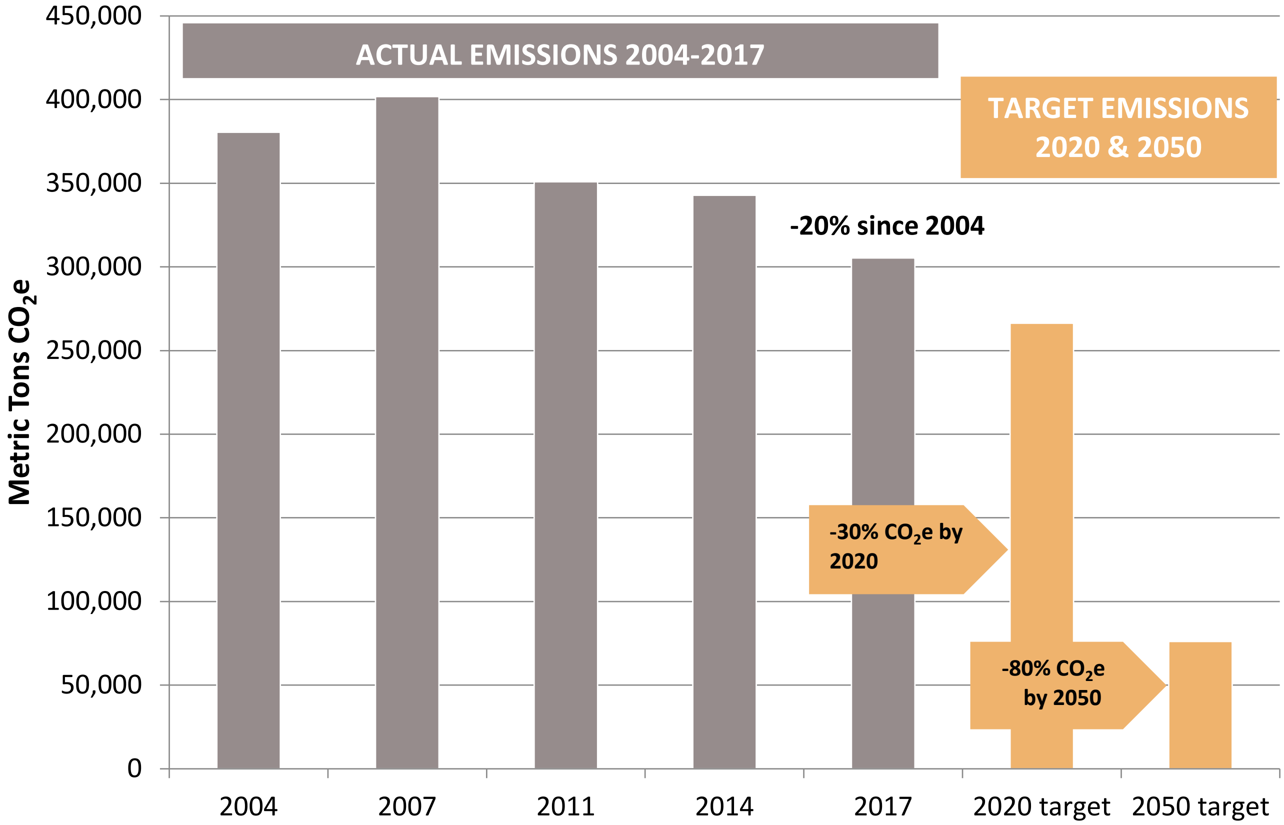
Introduction and Executive Summary

The City of Aspen (Aspen) has committed to be a leader among communities in the movement to mitigate the long-term impacts of climate change. Over the years Aspen has illustrated this leadership through innovative greenhouse gas (GHG) emissions reduction programs and policies and by sharing best practices so that other communities can learn from, and replicate, Aspen's efforts. Aspen's commitment to addressing climate change includes reducing GHG emissions and implementing climate action strategies to impact local emissions as well as global emissions. Since 2004, Aspen has tracked community-wide GHG emissions to better understand how to mitigate those emissions. A base-year GHG inventory was conducted in 2004, allowing Aspen to establish long-term emission reduction targets of a 30% reduction of GHG emissions by 2020 and an 80% reduction of GHG emissions by 2050 (below 2004 levels). Subsequent inventories for calendar years 2007, 2011, 2014, and now 2017 track progress towards the 2020 and 2050 reduction targets. These inventories provide insight as to where Aspen might focus GHG reduction efforts to have the greatest impact. This report is intended to share the results of Aspen's *2017 Community-wide Greenhouse Gas Emissions Inventory*, explain the methodology and guidelines behind the calculations, and provide insight into factors that influence changing emissions over the years.

Key Findings from the 2017 Inventory

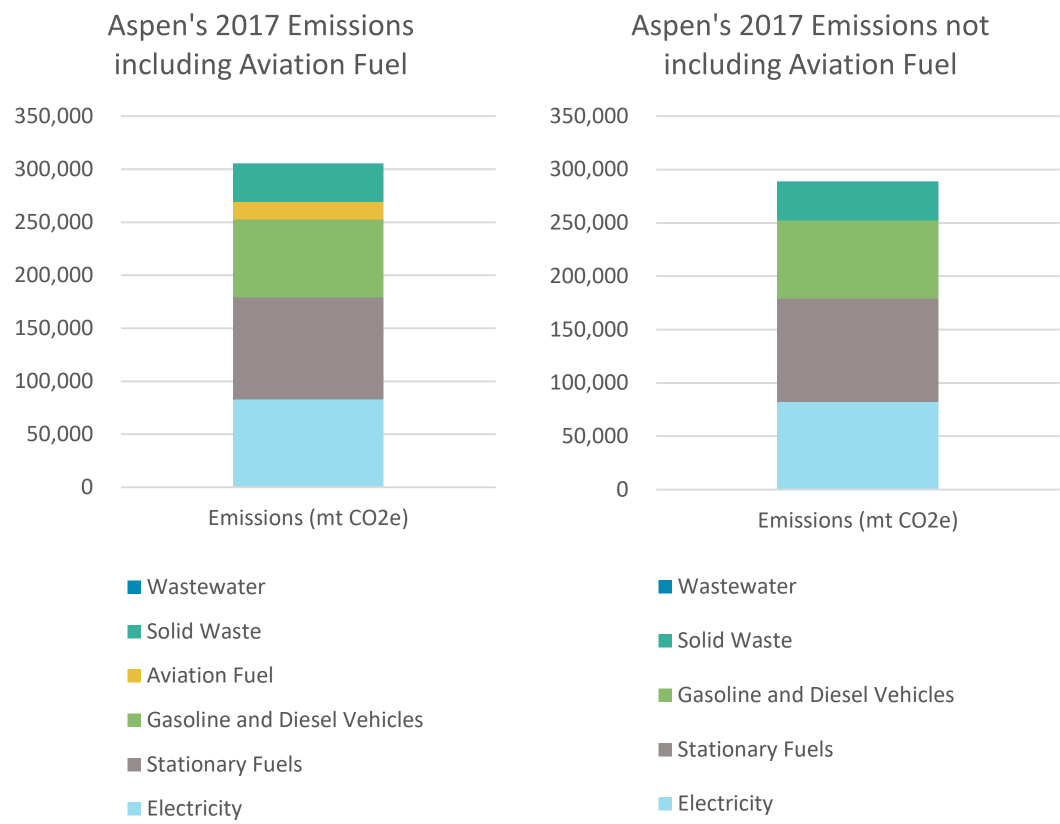
Since 2004, the Aspen community has reduced total CO_2e emissions by 20% (Figure 1); however, these emission reductions have not always been linear. After initially increasing between 2004 and 2007, total community-wide GHG emissions dropped 8% below base-year levels in 2011. From 2011 to 2014 Aspen's emissions declined by a small amount. Between 2014 to 2017, Aspen's emissions declined by 11%. This significant decrease is due in large part to the reduced carbon intensity of purchased electricity in Aspen (especially electricity purchased from the municipally-owned Aspen Electric utility, which achieved 100% renewably-sourced electricity in 2015) as well as Aspen's effective climate mitigation programs.

Figure 1: Aspen's Emissions Trends 2004-2017 and Targets

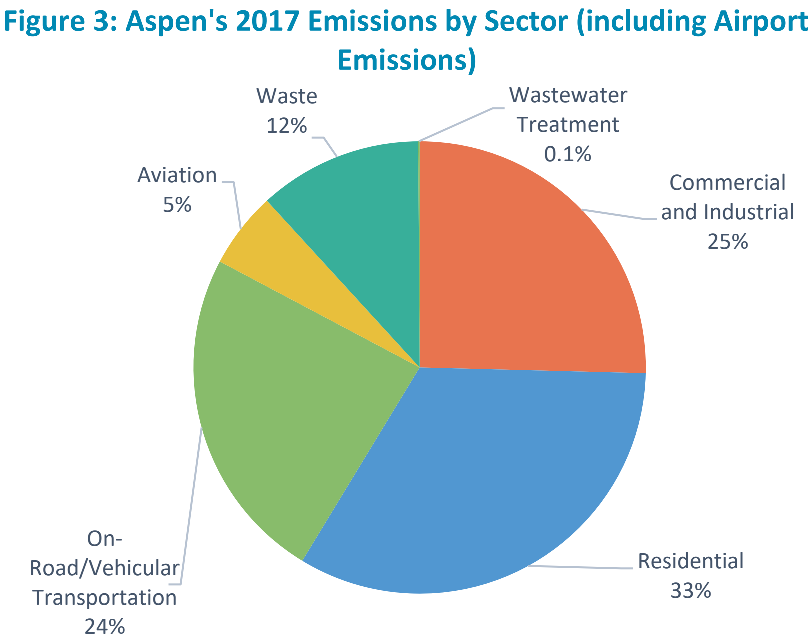


When removing the emissions attributable to Aspen from the Aspen-Pitkin County Airport (Airport), total community emissions are even lower. While emissions-generating activities at the Airport are attributable to Aspen's residents and industries, the community as a whole has little ability to influence and reduce Airport emissions, and therefore it can be helpful to consider emissions from a perspective of what Aspen or Pitkin County can control. Figure 2 illustrates Aspen's 2017 emissions profile both with and without Airport emissions included. Total emissions when including emissions from the Airport were 305,319 metric tons of carbon dioxide equivalent (mt CO_2e), while total emissions not including the Airport were 288,697 mt CO_2e. City of Aspen attributed aircraft fuel emissions represent about 5% of the total city-wide emissions when included in the total. When 'total emissions' are referenced throughout this report the value referenced includes airport emissions and is therefore 305,319 mt CO_2e.

Figure 2: Aspen's 2017 Emissions by Source with and without Airport Emissions Included



Residential energy use, including the use of electricity, natural gas, and propane in Aspen homes, accounted for 33% of Aspen's 2017 total emissions (see Figure 3), making this sector the community's largest single source of GHG emissions, followed by commercial building energy use at 25% of the community's total emissions. Between 2004 and 2017, residential energy emissions decreased by 15% and commercial energy emissions decreased by an impressive 43%—this is primarily due to the City-owned electric utility (Aspen Electric) aggressively pursuing a resource mix powered by 100% renewable energy as well as improved building efficiency in both sectors. Holy Cross Energy, which provides the remaining electricity to the community, has also increased the share of their resource mix that is powered by renewable resources.



The next largest share of emissions is from on-road transportation activity at 24% of total emissions. This demonstrates a measurable decrease since the baseline, as emissions from on-road transportation activities, including gasoline and diesel vehicles and public transit, have decreased by 14% since 2004. This reduction can be primarily attributed to increases in vehicle fuel economy over the years, as well as Aspen's effective transit, parking and walking/biking programs.

Waste emissions (from landfilling and composting waste that is created within the community, as well as wastewater generated and treated within the community) comprised 12% of the community's emissions. The proportion of overall community emissions coming from the waste sector is higher than typically seen for many communities; this is likely due to the fact that Aspen's electricity emissions are much lower than average and per capita waste generation in Aspen is higher than the national average of 4.5 pounds per person per day reported by the EPA.[1] This is largely due to three factors: 1) Aspen's tourist economy means that the waste generated by visitors is attributable to residents; 2) Aspen continues to grow, meaning that the quantity of construction and demolition (C&D) waste is higher than for most communities; and 3) Aspen has a large number of restaurants, which produce wet waste that generally weighs more than typical municipal solid waste (MSW).

Emissions from air travel that are attributable to the community comprise 5% of Aspen's total emissions. For more information on Aspen's aviation emissions see *Appendix D: Notes on Varying Inventory* Methodologies and *Appendix F: Aspen-Pitkin County Regional Airport 2017 Inventory Memo*.

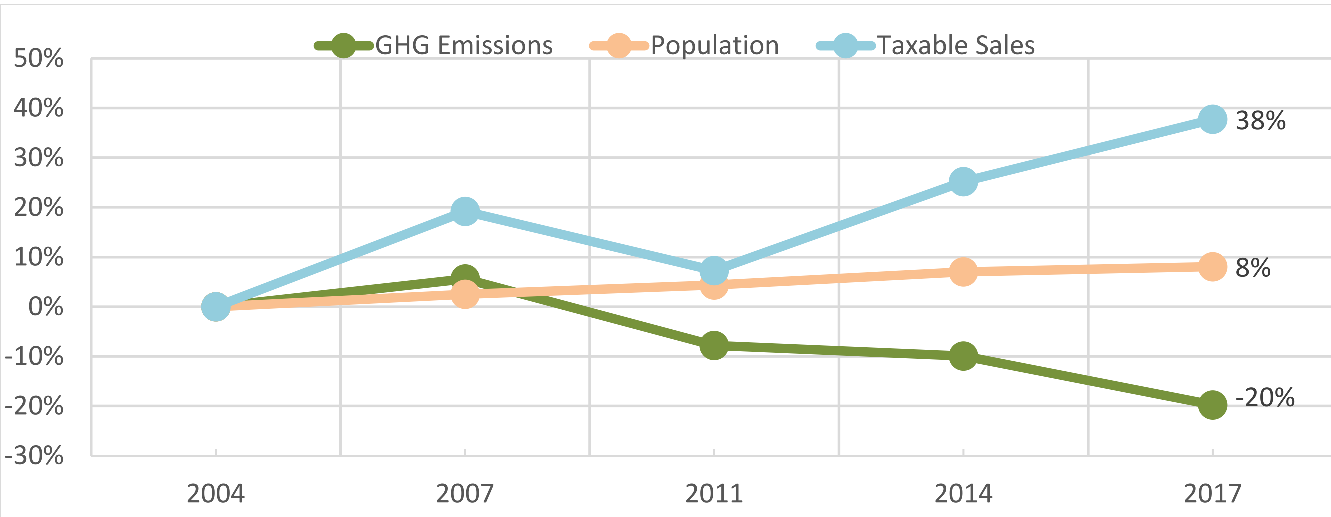
Aspen has been able to effectively reduce its GHG emissions as the community continues to experience both population and economic growth. Since 2004, the population living within Aspen has increased significantly. The Colorado Department of Local Affairs (DOLA) notes that Aspen's population within city limits increased from 6,365 in 2004 to 6,879 in 2017, an increase of 8% (DOLA, 2018). The population within the slightly larger Emissions Inventory Boundary (EIB) was 9,003 in 2017 (see Figure 6 or *Appendix C: Aspen's Emissions Inventory Boundary* for details on the boundary). Further, inflation-adjusted total

[1] See the EPA's Advancing Sustainable Materials Management Report: 2015 Facts and Figures at https://www.epa.gov/sites/production/files/2018-07/documents/2015_smm_msw_factsheet_07242018_fnl_508_002.pdf.

retail sales occurring within the City of Aspen in 2017 have grown 38% since 2004 after a decline between 2007 and 2011 during the national recession (BLS, 2017).

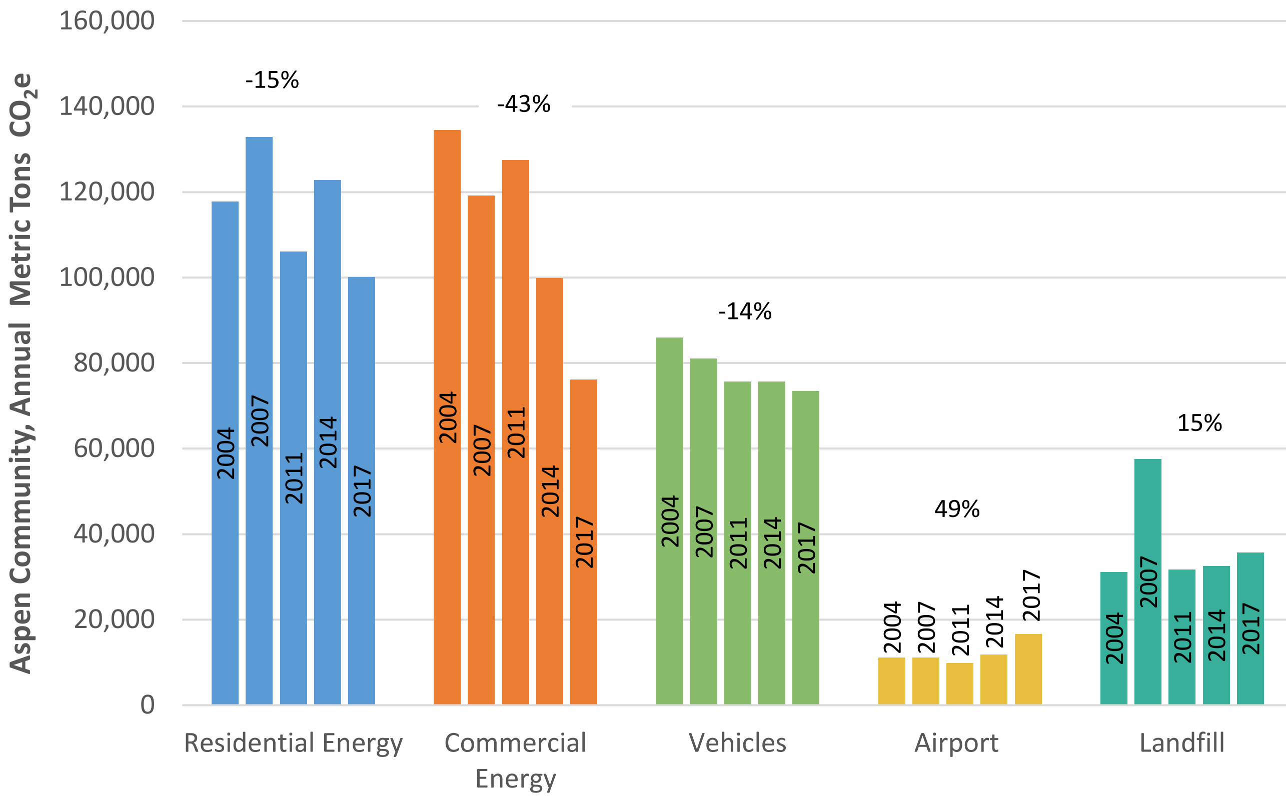
The fact that the Aspen community has reduced emissions while experiencing both population and economic growth (see Figure 4) is a testament to the success of its many GHG reduction programs, such as public transit and an increase in the amount of renewable electricity utilized by local utilities. Without these programs, community-wide emissions would have likely followed the upward trend of population and other community indicators.

Figure 4: Changes in Aspen's Population, Taxable Sales, and GHG Emissions, 2004-2017



Aspen's overall 20% drop in community-wide GHG emissions results from a combination of increases in some sectors and decreases in others (Figure 5). Not only does this decrease move Aspen closer to meeting its 2020 GHG emissions reduction goals, but it also demonstrates that it is possible to grow the economy and serve more residents while simultaneously reducing emissions.

Figure 5: Aspen's Emissions Changes by Sector, 2004-2017



Top Drivers of Aspen's GHG Emissions Reductions

The significant reduction in community-wide GHG emissions in Aspen from 2004 to 2017 brings the community closer to meeting its 2020 GHG emissions reduction goals, while making progress towards its 2050 goal of reducing emissions 80% from a 2004 baseline. The top drivers of changes in emissions (i.e. the three items that contributed most significantly to emissions reductions) from 2004 to 2017 can offer insights into the progress that has been made, as well as where there is the opportunity for further reducing emissions.[2] The top drivers that have led to the 20% reduction in community-wide emissions are:

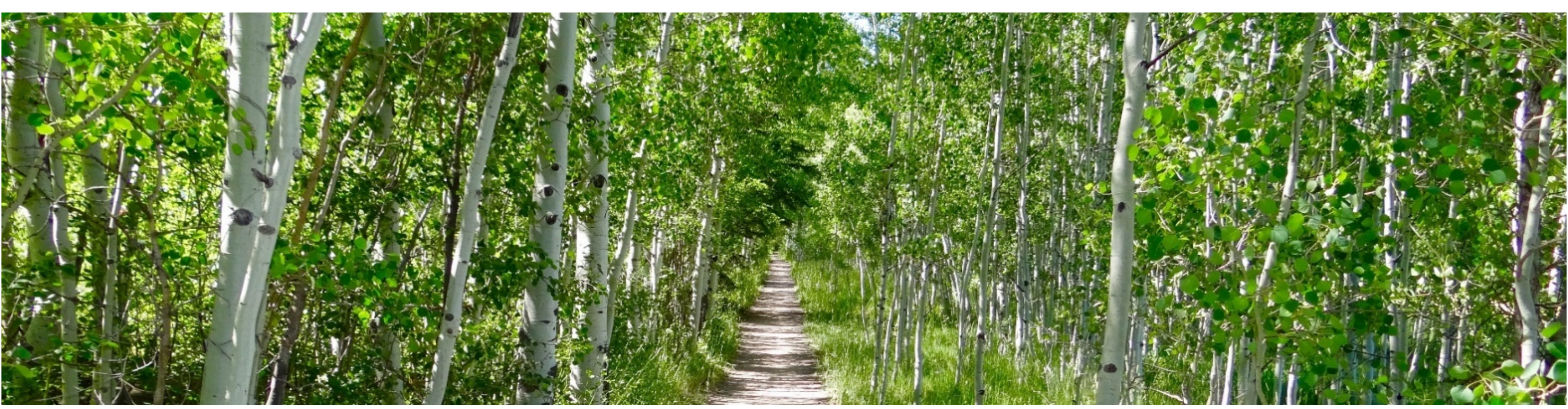
1. *Greening of the electricity fuel mix*: Aspen Electric now sources 100% of the power it provides customers from renewable resources. As the municipal utility provides approximately 19% of residential electricity and 42% of commercial electricity, this transition to renewably-sourced power has a large impact on overall community emissions. Holy Cross Energy has reported that their resource mix was 39% renewable in 2017 and has set a target of 70% of their resource mix coming from clean energy by 2030.[3]

[2] The top drivers of changes in Aspen's emissions are drawn from the ICLEI-Local Governments for Sustainability Local GHG Contribution Analysis Tool completed on behalf of Aspen by Lotus Engineering & Sustainability, LLC. Data was drawn from the 'Medium-Level Summary'.
[3] For details on Holy Cross Energy's fuel mix, see https://www.holycross.com/seventy70thirty/.

2. *Warmer winters*: Over the past several years Aspen has experienced warmer-than-average winter temperatures, which is measured by the number of heating degree days in the region. Warmer winters generally lead to less consumption of natural gas and other stationary fuels for heating.
3. *Decreased on-road emissions per mile traveled*: As the average fuel economy for vehicles has increased and Aspen has invested in programs to increase the use of transit and multi-modal options within the community, emissions from on-road transportation have decreased slightly per mile traveled.

Accelerating the Rate of Reduction

Based on Aspen's current emissions profile and the reductions in emissions that the community has achieved since 2004, it is clear that Aspen continues to follow through on its commitment to address climate change. However, additional actions will be necessary in the coming years to achieve the community's goal of reducing emissions by 30% by 2020 and 80% by 2050. Aspen's City Council adopted *Aspen's Climate Action Plan: A Roadmap to Our Sustainable Future* (CAP) in 2018; this plan describes activities and efforts towards climate action that will be implemented through 2020.[4] The City will complete its next GHG inventory in 2021 (for the 2020 calendar year), at which point further progress towards GHG reduction goals will be measured and help inform where the City should focus future efforts. The next iteration of strategies will be included in an updated CAP in 2021 based on the most recent inventory and contribution analysis.



[4] The report can be found here: https://www.cityofaspen.com/DocumentCenter/View/4506/Aspens-Climate-Action-Plan-?bidId=

GHG Inventory Purpose & Background

Climate Risk and Aspen's Role

The Intergovernmental Panel on Climate Change (IPCC) compiles international research showing that "scientific evidence for warming of the climate system is unequivocal" (IPCC, 2014) and has illustrated the already-significant impact that human activity has had on the global climate. In a recent special report, the IPCC estimates that humans have caused at least a 1 degree Celsius (C) increase in global temperatures, and this is likely to increase to 1.5 degrees C between 2030 and 2052 if GHG emissions levels are left unmitigated (IPCC, 2018). While the impacts of this change vary across the globe, humans can expect rising sea levels, more intense and frequent storms, long-range droughts, and severe impacts on human health among the consequences (IPCC, 2018). The Fourth National Climate Assessment, released by the U.S. government's Global Change Research Program in November of 2018, further expounds upon the interconnected impacts of climate change; the report notes that extreme climate impacts in one system can have far-reaching effects on other critical systems, including water resources, food access and production, energy, public health, and national security (NCA4, 2018).

Locally, Aspen's changing climate will have long-term impacts on its economy, environment, and human health, including: temperature increases of between 2.5-6.5 degrees Fahrenheit; hotter and drier summers; and greater amounts of winter precipitation falling in the form of rain rather than snow (RMCI, 2018). Observed changes in regional conditions, such as the fact that Aspen is experiencing 23 more frost-free days per year than it was in 1980, provide evidence that climate change is already manifesting itself locally (AGCI, 2014). Sophisticated climate models indicate that the degree to which Aspen will be affected by climate change over the medium and long-term is directly tied to current and future emissions trajectories (AGCI, 2014). Because Aspen's natural environment and economic model rely on stable climate conditions (AGCI, 2014), mitigating the community's contribution to climate-warming emissions has become a scientific and symbolic imperative. Accordingly, proactive planning to reduce GHG emissions is in Aspen's economic and environmental self-interest. In order to meaningfully tackle climate change, emissions must be slashed on a global scale. Therefore, Aspen aspires to lead by example, ideally affecting national and international planning efforts and inspiring visitors to do their part in supporting climate-friendly practices.

Inventory Methodology

This report and the accompanying inventory were prepared for the City of Aspen by Lotus Engineering and Sustainability, LLC (Lotus). Lotus has attempted to present this GHG study in a way that is relevant for policymakers and community members. Aspen's first GHG inventory was completed by consultants in 2004 and provides the baseline against which Aspen's reduction targets are measured. Follow-up inventories were conducted in 2007 and 2011 by consultants with assistance from the City of Aspen staff, and in 2014 internally by City staff. The 2014 inventory was calculated using methodologies outlined in the US Community Protocol for Accounting and Reporting of GHG Emissions (USCP), and as such the 2004, 2007, and 2011 inventories were recalculated in 2014 to ensure consistent comparability across years. The *2017 Community-wide GHG Emissions Inventory* is the latest quantitative analysis in assessing progress towards the 2020 and 2050 GHG targets and is compliant with guidelines laid out in the Global Protocol for Community-Scale Greenhouse Gas Emissions Inventories (GPC). [5] GPC provides a transparent GHG accounting methodology for reporting community GHG emissions and is a global standard.

Based on the available data, Aspen chose the GPC BASIC reporting level, which includes all emissions from stationary energy, in-boundary transportation, the portion of aircraft and ground support equipment at Aspen-Pitkin County Airport associated with passengers that begin or end their travel in Aspen (referred to as Airport air travel), and community-generated waste. Aspen's emissions are measured in metric tons (mt) of carbon dioxide equivalents (CO_2e). This measurement represents the combined emissions impact of carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) on the environment measured in units of CO_2. N_2O and CH_4 are converted to CO_2e using their 100-year global warming potentials (GWPs); for more information on GWPs please reference *Appendix E: Global Warming Potentials.* As was done in 2014, the 2017 inventory also used ICLEI-Local Governments for Sustainability's (ICLEI) ClearPath emissions management platform to store and input consumption data, emissions factors, and methodology notes. Further, data on community-wide emissions are reported by sector and source to provide deeper insight into specific emission factors or activities that are impacting Aspen's overall GHG emissions. Detailed emissions factor information can be found in *Appendix A: 2004-2017 Emissions Factors*.

Variations in Inventory Methodology

Ensuring consistent inter-annual comparisons is a top priority for Aspen. While the variations in methodology between a USPC and a GPC inventory are relatively minimal, allowing the 2017 inventory to be comparable to past years' inventories, there are some small variations and notes on the calculation methodology between the past inventories and GPC protocol that have impacted emissions trends. Details on variations in the inventory methodologies can be found in *Appendix D: Notes on Varying Inventory Methodologies*.

Calculating Emissions

GHG emissions are a product of emission factors and activity data. Emission factors represent the carbon intensity of the fuel or materials used in a specific activity (see *Appendix A: 2004-2017 Emissions Factors* for more information on specific emission factors used in the 2017 inventory). Activity data refers to the data measured for the community GHG emission inventory calculations, such as fuel consumed, electricity consumed, tons of waste generated, and vehicle miles traveled. Activity data is influenced by community indicators (e.g. population, economic growth, etc.), energy consumption, and other

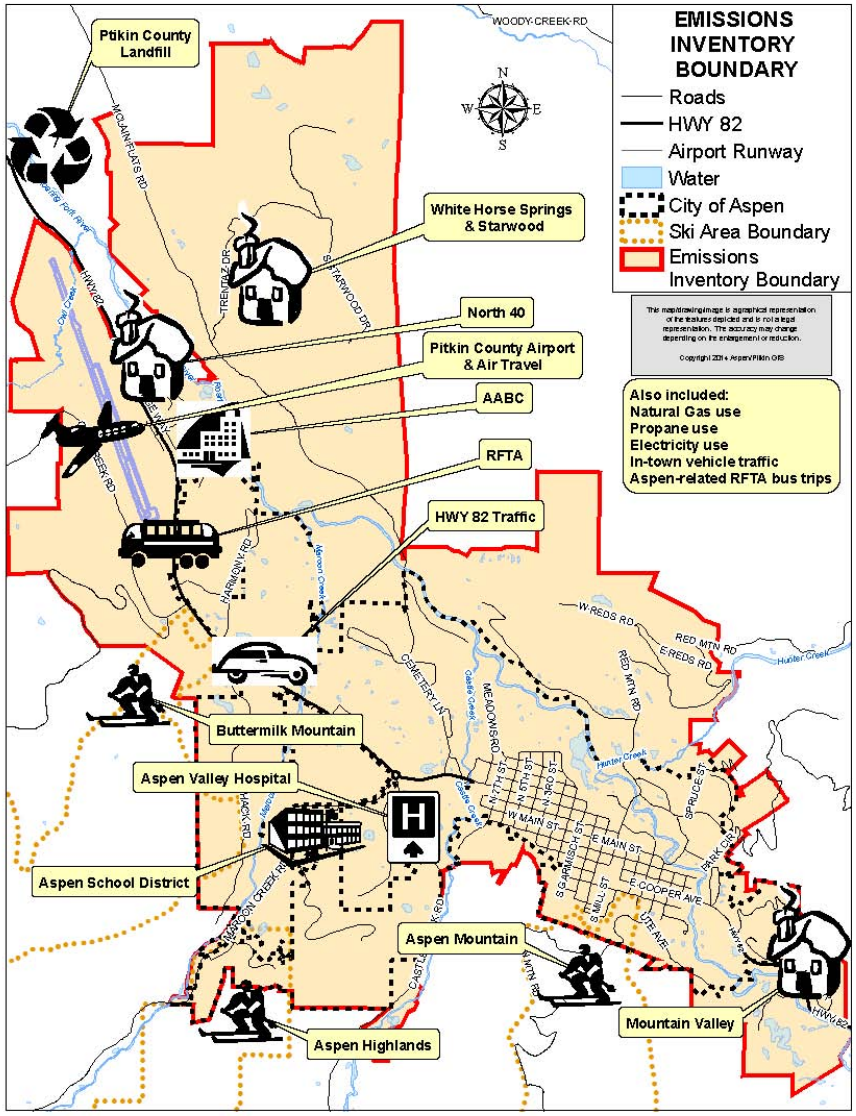
[5] For more information regarding the GPC please see https://www.globalcovenantofmayors.org/participate/tools-for-cities/.

consumption-related behaviors (e.g. mode of transportation, etc.). Changes in emissions result from the interplay of activity data and emission factors.

Emissions Inventory Boundary

Aspen's 2017 inventory quantifies GHG emissions from sources and activities occurring within, and attributable to, the Emissions Inventory Boundary (EIB) (see Figure 6, or *Appendix C: Aspen's Emissions Inventory Boundary* for a larger version of the map). [6] In doing so, the inventory quantifies emissions that occur due to the energy consumption, activities, and people living and working within the EIB. While most communities use their geographic boundaries (i.e. city or county limits) to determine the limits of their emissions impact, the EIB has been used since 2004 under the rationale that this geographic area represents Aspen's core functionality and is a part of Aspen's foundational economy. In 2004, stakeholders determined that the Aspen community should take responsibility for emissions occurring within the EIB outside of City limits. This is a departure from best practices followed by most communities, who only measure GHG emissions within the limits under their direct jurisdictional control. The extended boundary approach ensures that Aspen measures, reports, and attempts to reduce emissions in all areas that see emission-producing activity directly due to the City's influence.

Figure 6. Aspen's Emissions Inventory Boundary



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[6] The EIB is nearly identical to the City of Aspen's Urban Growth Boundary (UGB), but also includes: 1) the Starwood and the White Horse Springs section of the McLain Flats residential areas; 2) the residential areas within and contiguous to the Aspen city limits such as Red Mountain, Mountain Valley (on the southeastern edge of town), Highlands, Buttermilk West, the Aspen-Pitkin County Airport, the Aspen Airport Business Center, and North Forty; and, 3) the electricity and natural gas used to run lifts, operations, and facilities on Aspen Mountain, Aspen Highlands, and Buttermilk ski areas (because the base facilities and many lifts are within the EIB).

Emissions Scopes, Sectors, and Sources

Aspen's 2017 inventory analyzes emissions by scope and further breaks down emissions into applicable sectors (e.g. residential building energy use, on-road transportation, etc.) and source (e.g. electricity, natural gas, mobile gasoline, etc.). The 2017 inventory quantifies emissions from six sectors, listed below in Table 1.

Table 1: Aspen's Emissions Sectors and Sources

Sector	Source
Residential	Electricity
Commercial	Natural Gas
On-Road Transportation	Natural Gas Leakage
Airport/Aviation	Propane
Solid Waste	Stationary Diesel
Wastewater	Mobile Gasoline
	Mobile Diesel
	Mobile Ethanol
	Mobile Electricity
	Mobile Biodiesel
	Mobile CNG
	Aviation gasoline
	Landfill
	Compost
	Wastewater

It should be noted that prior inventories also included emissions from landfill fuel and energy use attributable to Aspen; however, the Pitkin County Solid Waste Center (PCSWC) is not within the Aspen EIB; and therefore, the use of energy at the landfill is not included within the scope of the GPC BASIC inventory. Additionally, fugitive emissions from the use of natural gas in buildings in Aspen and stationary diesel use were absent from past inventories but were included in the 2017 inventory per the GPC protocol.

The GPC protocol does not recognize emissions avoided through local purchases of renewable energy credits (RECs), local installation of renewable energy systems (including solar and hydrogeneration), or recycling.[7] However, communities frequently want to understand the potential impact of these activities; therefore, Aspen's 2017 inventory calculates emissions avoided

GHG EMISSIONS: SCOPES 1, 2, AND 3

Per the GPC protocol, emissions sources can be organized into the following scopes:

Scope 1: GHG emissions from sources located within the boundary, including:

- energy and transportation fuel combustion;
- fugitive emissions (includes active oil wells and leakage of natural gas);
- wastewater treated within the boundary;

Scope 2: GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the boundary.

Scope 3: GHG emissions that occur outside the boundary as a result of activities taking place within the boundary, including:

- solid waste (including compost) treated outside the boundary; and
- transportation activities for which fuel combustion occurs outside the boundary.

[7] Please note, the GPC does account for renewable energy supplied or purchased as part of a utility's fuel mix.

through recycling for informational purposes only. See Table 2 for an overview of sources recorded in the 2004, 2007, 2011, 2014, and 2017 GHG inventories.

Table 2: GHG Emission Sources

Emissions Source	2004	2007	2011	2014	2017
Electricity	X	X	X	X	X
Natural Gas	X	X	X	X	X
Fugitive Emissions (Natural Gas Leakage)					X[8]
Stationary Diesel					X[9]
Propane	X	X	X	X	X
Mobile Gasoline	X	X	X	X	X
Mobile Diesel	X	X	X	X	X
Mobile Electricity				X	X
Mobile Ethanol	X	X	X	X	X
Mobile Biodiesel	X	X	X	X	X
Mobile Compressed Natural Gas				X	X
Aspen-Pitkin County Airport	X	X	X	X	X
Landfilled Waste	X	X	X	X	X
Compost					X
Landfill Energy Use	X	X	X	X	[10]
Wastewater	X	X	X	X	X[11]

The inventory considers the predominant greenhouse gases: CO_2, CH_4, and N_2O. Although less common GHGs (such as PFCs, SF_6, and NF_3) may be found in the community, their concentration (to date) is relatively small and it is assumed that their overall impact on Aspen's GHG inventory is negligible. For instance, PFCs and NF_3 are frequently released during the manufacture of electronic products, and SF_6 is used in the electric power industry as an insulator. These industries do not currently occur in large amounts in Aspen. As the ability to collect data for these gases improves over time, Aspen is encouraged to review potential sources of these gases and determine if their inclusion would significantly impact the community inventory.

[8] Fugitive emissions result from leakage in natural gas systems when the gas is transported and used in buildings. Fugitive emissions were not included in prior inventories; in 2017 these emissions accounted for just under 1% of Aspen's total emissions.

[9] Emissions from stationary diesel use in generators and ski area equipment were not accounted for in prior inventories. In 2017, emissions from this source accounted for a very small (i.e. less than one-one hundredth of one percent) of Aspen's total emissions.

[10] While past inventories attributed a portion of the energy used at the Pitkin County Solid Waste Center to Aspen, per GPC protocol these emissions should not be included in the City's inventory. Therefore, in 2017 landfill energy use was not included in the total community emissions.

[11] In 2017, emissions from septic tanks were also included which increased emissions from the wastewater sector significantly.

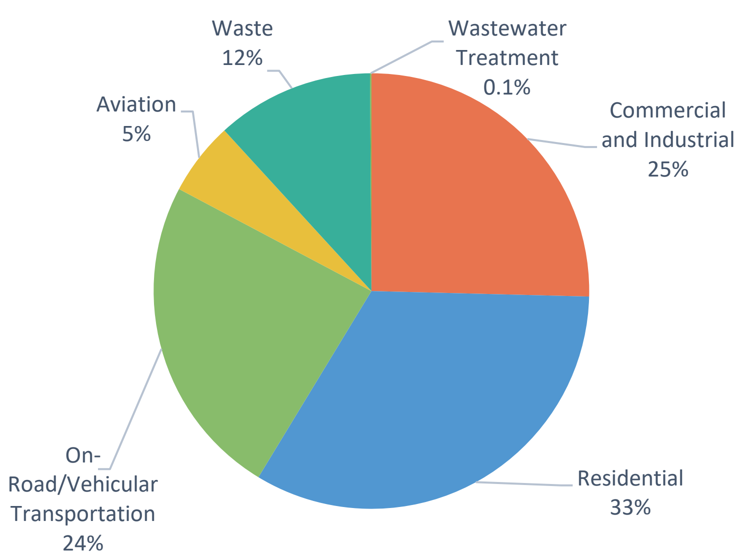
Overview of Aspen's 2017 GHG Emissions

The results of Aspen's 2017 community GHG emissions inventory show that 305,319 mt CO_2e were generated by activities within the EIB. This represents a 10% reduction in emissions since the last inventory was completed in 2014 and a 20% reduction in the community's 2004 baseline emissions. A detailed table showing changes in emissions by sector and source across all of Aspen's inventories can be found in *Appendix B: Emissions Changes over 2004 Baseline by Sector.* The following is an overview of 2017 GHG emissions and the drivers of change in Aspen's reported emissions in 2017.

2017 Emissions Summary

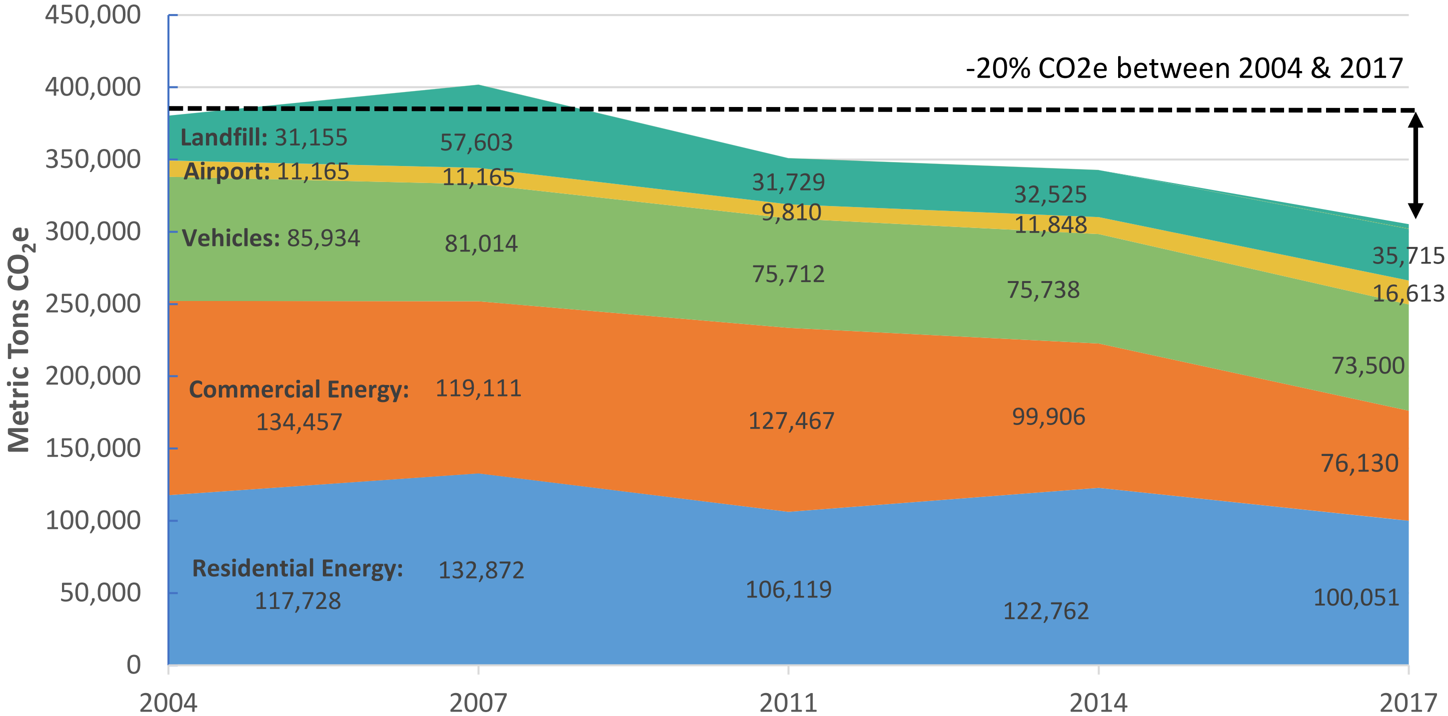
The largest share of emissions was residential electricity, natural gas, and propane use, which comprised 33% of the community's overall emissions. Energy use in commercial and industrial buildings comprised 25% of Aspen's total community emissions; this includes electricity, natural gas, and propane use in buildings as well as a small amount of stationary diesel use at ski area lift stations and supporting facilities. On- and off-road use of gasoline, diesel, and other mobile fuels (including electricity) comprised 24% of the community's total emissions in 2017. Community-generated solid waste, including waste landfilled and composted at the Pitkin County Solid Waste Center, comprised nearly 12% of the community's overall emissions, while activities at the Airport that are attributable to Aspen accounted for just over 5% of emissions. Only 37% of the total activity at the Aspen-Pitkin County Airport services the Aspen EIB (see *Appendix D: Notes on Inventory Methodologies*), therefore the amount of Airport emissions attributed to Aspen is less than the Airport's total emissions. Lastly, wastewater treatment, including activity at the Aspen Consolidated Sanitation District and septic systems throughout the community, generated a very small portion (0.1%) of Aspen's overall emissions (Figure 7).

Figure 7: City of Aspen 2017 Emissions by Sector



Overall, Aspen's emissions have been trending downwards since 2004, with the biggest reductions seen in the residential building sector and the commercial and industrial building sector, which have decreased by 15% and 43%, respectively (see Figure 8). This impressive downward trend is due in large part to the City of Aspen Electric System (i.e. Aspen Electric) pursuing and achieving an aggressive 100% renewable energy goal and Holy Cross Energy supplying more power from renewable resources.

Figure 8: Changes in Aspen's Emissions by Sector, 2004-2017



Community Indicator Trends

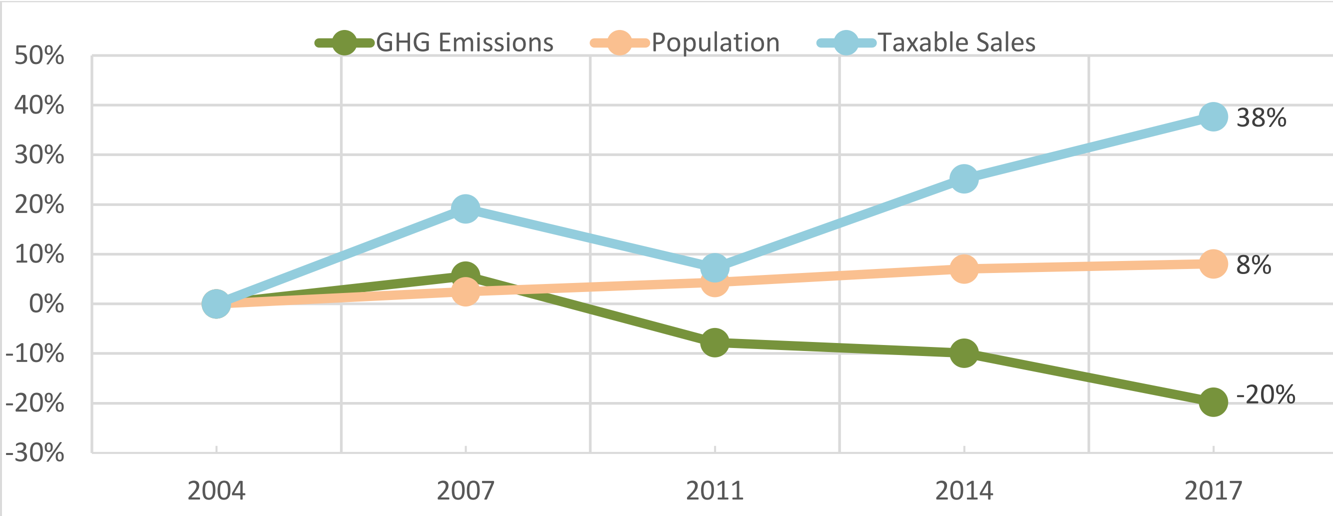
Emissions are driven by activity occurring within the community and significant changes to community size, economy, and character will impact how emissions change over time. Community indicators are used to help community members, elected officials, and City staff understand some of the drivers behind emission changes. Between 2004 and 2017, Aspen experienced an 8% increase in population inside of the EIB and a 38% increase in the total value of retail sales within the community.[12]

Aspen is reducing overall GHG emissions as it grows, thanks to innovative programs and projects that reduce emissions from energy use and transportation (see Figure 9). Recent research shows that most advanced economies do not significantly decouple emissions from economic growth, although there are indications that the relationship between emissions growth and economic growth can be mitigated through concerted policy efforts.[13]

[12] The value of historic retail sales were adjusted to account for inflation. The adjusted retail sales values were obtained from the City of Aspen Finance Department.

[13] See the International Monetary Fund working paper 'The Long-Run Decoupling of Emissions and Output: Evidence from the Largest Emitters' at https://www.imf.org/~/media/Files/Publications/WP/2018/wp1856.ashx.

Figure 9: Changes in Community Indicators, 2004-2017



Aspen's Emissions by Sector

Aspen's GHG trends and impact can be understood in greater detail by breaking emissions down into the sectors by which they are classified: stationary energy, transportation, and waste. Each of these sectors can be broken down even further and their emissions and emission-generating activity are explained in greater detail in the following sections of the report.

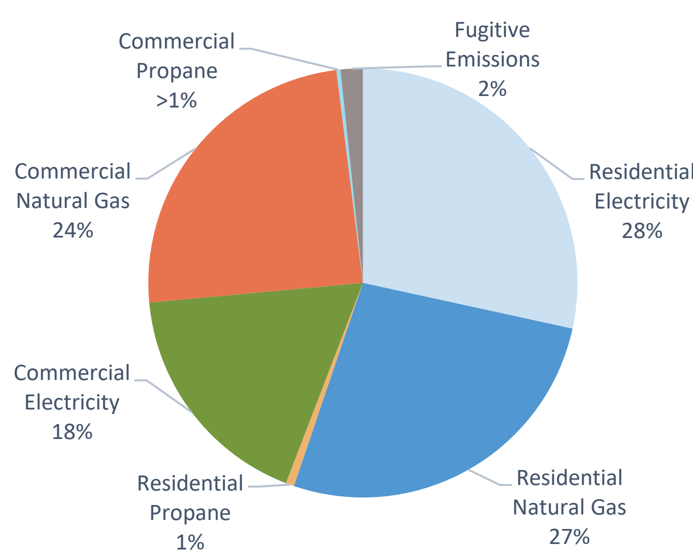
Stationary Energy Emissions

Stationary energy emissions accounted for nearly 59% of Aspen's total 2017 community emissions and include the following emission sources:

- electricity consumption;
- natural gas consumption;
- propane consumption;
- stationary diesel consumption; and
- fugitive emissions from natural gas consumption.

Both the residential and the commercial building sectors generate emissions through the use of electricity, natural gas, and propane. The use of stationary diesel is only accounted for in the commercial building sector.

Figure 10: Aspen's Stationary Emissions Detail, 2017



Active oil wells and natural gas distribution systems cause methane leakage and fugitive emissions, which must be accounted for in the GPC protocol.[14] Fugitive emissions, which were not accounted for in Aspen's past inventories, are caused by the use and distribution of natural gas in buildings and are calculated based on an assumed 3% methane leakage rate.[15]

Within the stationary energy sector, nearly 56% of emissions came from the residential building sector and just over 42% of emissions came from the commercial building sector. While Aspen has no active oil wells, fugitive emissions from the use of natural gas in both residential and commercial buildings in Aspen accounted for 2,988 mt CO_2e in 2017, or almost 2% of stationary energy emissions. See Figure 10.

Total stationary energy emissions from activity in residential and commercial buildings within Aspen's EIB have been reduced by 20% between 2014 and 2017 and have seen a 29% total reduction since the 2004 baseline inventory.

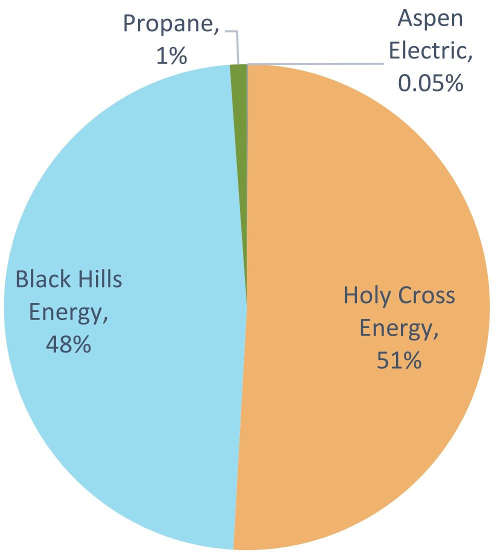
Residential Building Sector

Residential emissions from the use of electricity, natural gas, and propane within Aspen's EIB accounted for 33% of the community's overall emissions. Residential buildings can generally be categorized as single-family homes, townhomes, or duplexes where energy bills are paid by an individual homeowner, tenant, or landlord, and whereby the billing department of a given utility or fuel supplier has classified the account as 'residential'. Multifamily housing, such as apartment complexes, are usually grouped with the commercial sector.

Aspen is served by two electrical utilities: Aspen Electric, the City-owned municipal utility which provides approximately 19% of electricity for Aspen homes, and Holy Cross Energy, which provides the remainder of electricity in Aspen homes. Aspen Electric has transitioned to 100% renewable energy, and as such the emissions coming from electricity use in homes served by Aspen Electric are negligible. Holy Cross has also been actively greening their fuel mix over the past several years, and in 2017 the utility's resource mix was reported to be 39% sourced from renewable energy.[16] Natural gas is provided by Black Hills Energy and encompasses nearly 48% of emissions from the residential sector. Residents purchase propane from Ferrell Gas and AmeriGas; propane use accounts for 1% of residential emissions. See Figure 11.

[14] Fugitive emissions and natural gas leakage rates were not calculated in previous inventories; therefore, there are no comparable emissions between 2017 and past inventories.
[15] Methane leakage rate is drawn from documentation by the Environmental Defense Fund, see https://www.edf.org/sites/default/files/US-Natural-Gas-Leakage-Model-User-Guide.pdf.
[16] See https://www.holycross.com/generation-mix/ for more information.

Figure 11: Residential Energy Emissions by Source, 2017



Residential energy emissions within the Aspen EIB decreased by 15% between 2004 and 2017. This reduction is attributable to a steep reduction in emissions factors for the electrical utilities serving Aspen residences.

Total community electricity consumption has decreased only slightly since 2014 and has risen since 2004 (likely due to overall population increases), but the reduced carbon intensity related to the production of electricity (illustrated by the reduced emissions factors for electricity provided in Aspen) has resulted in a significant reduction in residential electricity emissions. See Figure 12 and Figure 13.

Figure 12: Residential Natural Gas and Electricity Consumption, 2004-2017

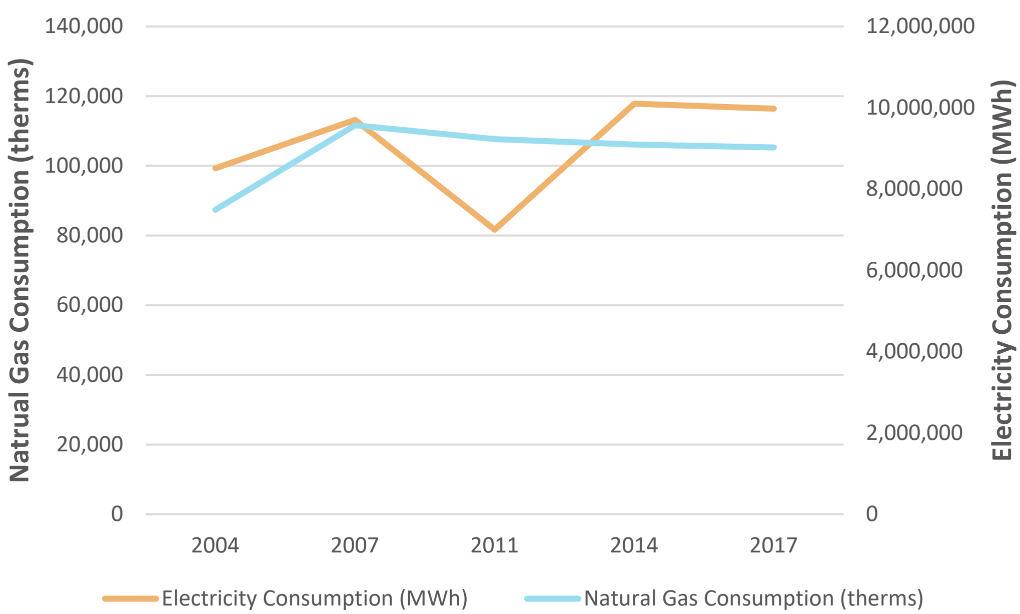
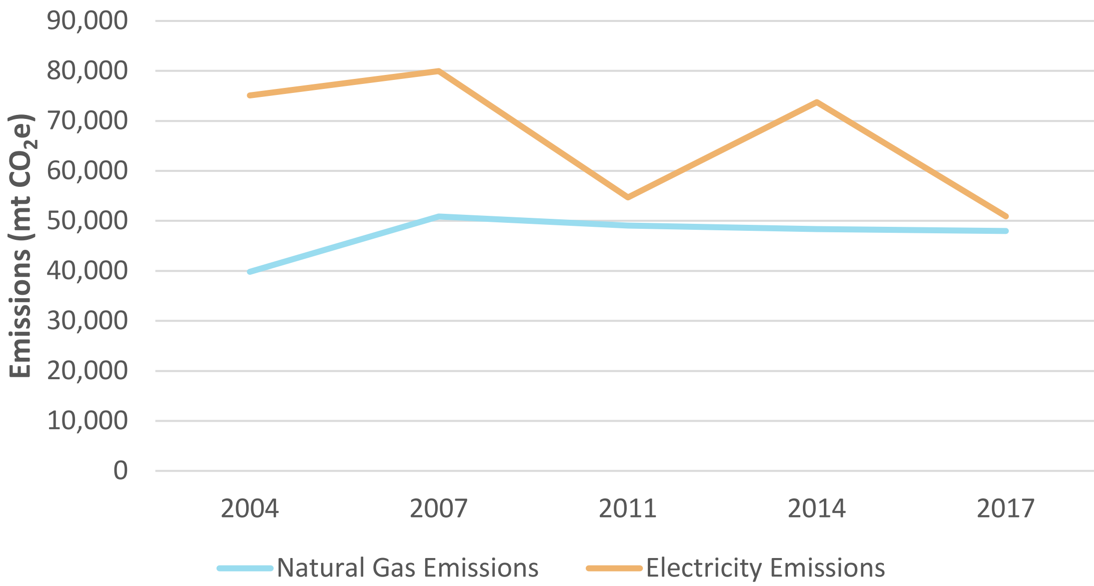


Figure 13: Residential Natural Gas and Electricity Emissions, 2004-2017

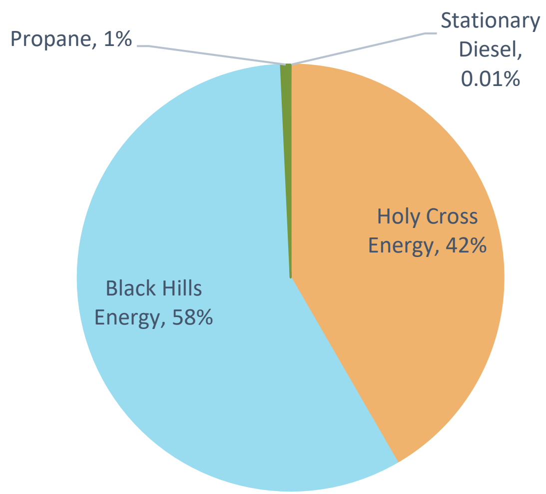


As Aspen's population continues to grow, it will remain important to implement projects and programs that will ensure emissions from residential energy use do not grow in pace with population. This can be facilitated through efforts to continue to support the reduction of Holy Cross Energy's electricity emissions factor, programs that support beneficial electrification (i.e. retrofitting buildings to replace systems traditionally powered by natural gas with those that are electrically-powered), and through programs that support improved energy efficiency in residential buildings in Aspen. The Aspen CAP includes several strategies for reducing emissions from the residential building sector in the 'Residential Energy' section of the document.

Commercial Building Sector

Emissions from energy use in commercial and industrial buildings within Aspen's EIB accounted for 25% of the community's overall 2017 emissions profile, or a total of 76,130 mt CO_2e. Emissions from commercial buildings are driven by the use of natural gas to heat commercial and industrial spaces in Aspen, as well as the use of grid-supplied electricity. A small amount of emissions comes from the use of propane to heat buildings. Stationary diesel is also used in a small number of commercial properties in Aspen, primarily driven by activity at the ski areas within the Aspen EIB.

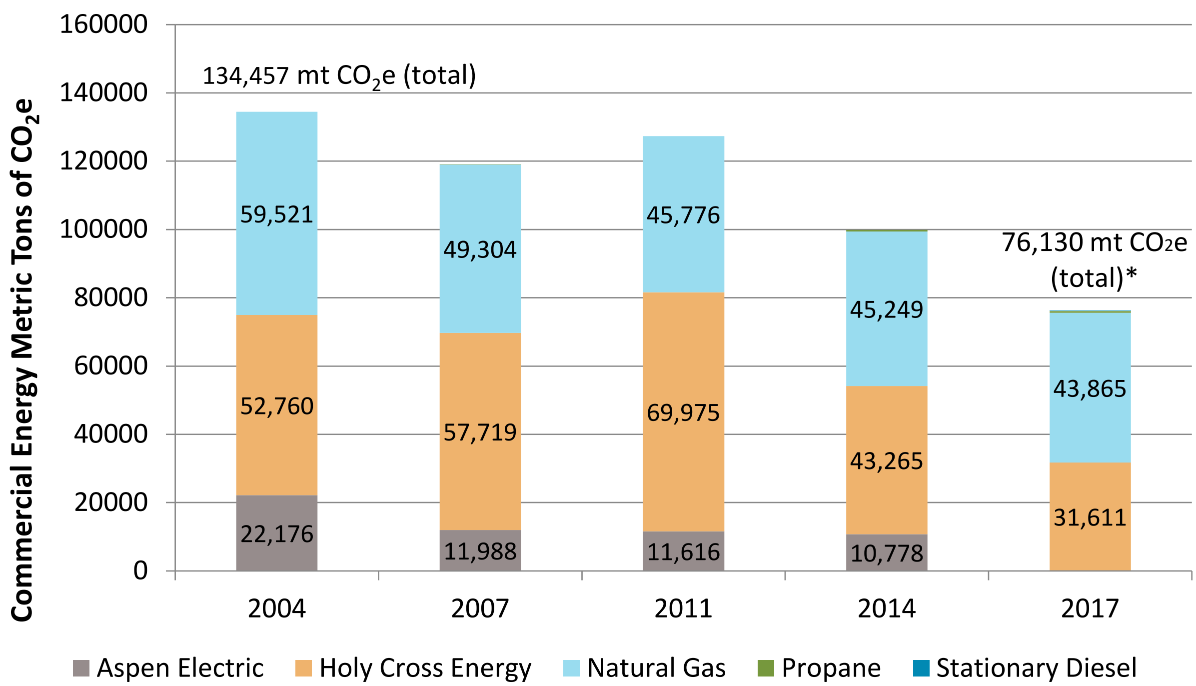
Figure 14: Commercial Emissions by Source, 2017



Natural gas use makes up the largest portion of commercial building emissions with nearly 58% of the share. Electricity use from Holy Cross Energy accounts for almost 42% of commercial building emissions, and the remaining emissions are the result of propane and stationary diesel consumption. Refer to Figure 14.

2017 emissions from commercial building energy use represent a 24% reduction in commercial building sector emissions since the 2014 inventory and a 43% reduction in commercial building sector emissions over the 2004 baseline. Refer to Figure 15.

Figure 15: Reductions in Emissions from Commercial Buildings, 2004-2017



*2017 Emissions from Aspen Electric (103 mt CO_2e), propane (546 mt CO_2e), and stationary diesel (4 mt CO_2e) are included in the total but are too small to appear visibly on the graph. Propane use was only accounted for in the 2007, 2014, and 2017 inventories, while stationary diesel use was only included in the 2017 inventory.

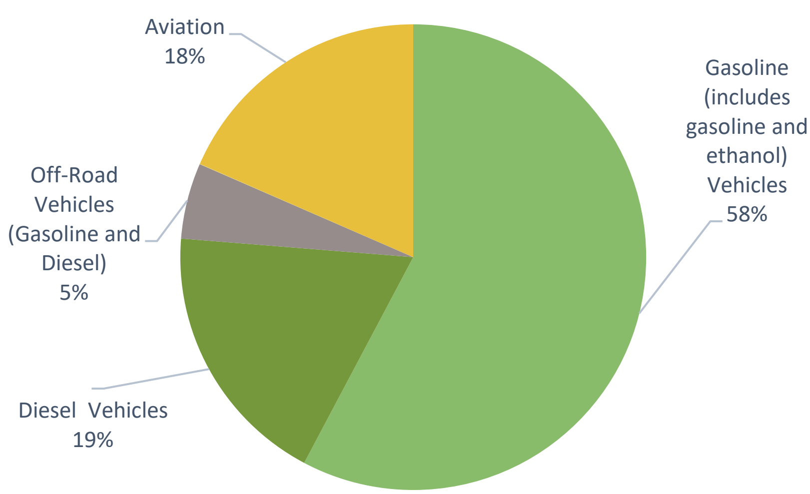
Commercial electricity use has decreased by almost 4% since 2014, while natural gas use in commercial buildings has decreased by 3%. As in the case of residential building sector emissions, the overall emissions reduction is driven primarily by the improved (i.e. reduced) carbon intensity of the electricity emissions factor for both electric utilities serving the Aspen EIB. As Aspen's population and the economy continues to grow in the coming years, it will remain important to drive towards improved building efficiency and reduced carbon intensity of the grid-supplied electricity purchased in Aspen in order to continue on this downward emissions trajectory. Aspen's CAP highlights several specific strategies that may lead to further reduced emissions in the commercial building sector, including supporting commercial energy benchmarking programs, providing incentives for building 'above code', and using green design to increase building efficiency and reduce the need for air conditioning.

Transportation Sector Emissions

The transportation sector, including both on-road vehicles and off-road vehicles and air travel, accounted for nearly 30% of Aspen's total community GHG emissions in 2017, with on- and off-road travel accounting for 24% and aviation accounting for 5% of total community emissions.

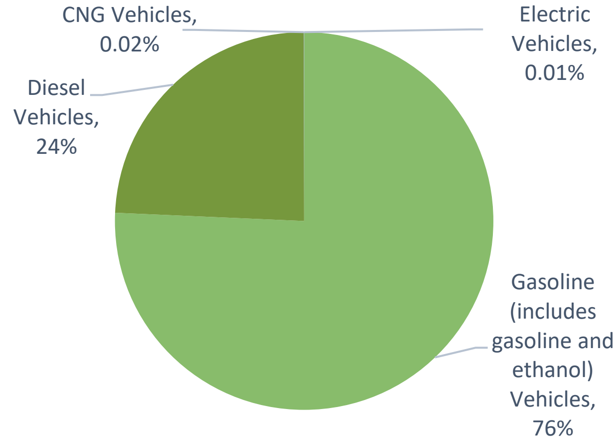
A total of 73,500 mt CO_2e (82% of transportation emissions) were generated from gasoline, diesel, compressed natural gas (CNG), biodiesel, and electrically-powered on-road and off-road vehicle activity in Aspen; this includes all uses of passenger vehicles, delivery vehicles, and public transit fleets operating in the City. The remaining transportation emissions were generated from activity at the Airport; Airport emissions in 2017 totaled 18% of transportation emissions, or 16,613 mt CO_2e. Refer to Figure 16.

Figure 16: Total Emissions from Transportation Activities, 2017



On-Road Transportation

Figure 17: Emissions from On-Road Activity, 2017



Emissions from on-road transportation activities involving gasoline, ethanol, diesel, biodiesel, and electric vehicles accounted for 23% of Aspen's total 2017 GHG emissions. On-road emissions calculations are based on several factors: emission factors, fuel efficiencies, vehicle miles traveled (VMT), and vehicle type distribution by vehicle fuel type.

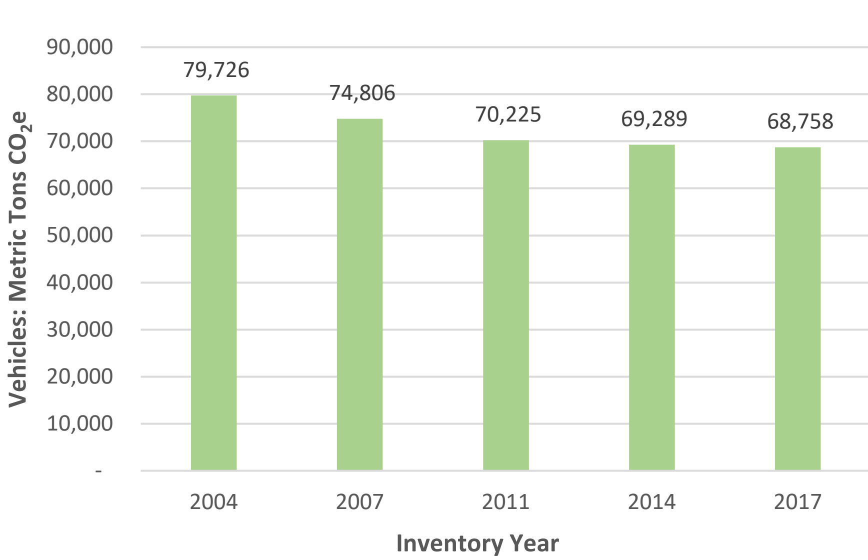
Gasoline-powered vehicles dominated the roads in Aspen in 2017, accounting for almost 90% of on-road activity. Within emissions from on-road activities, 76% was generated from vehicles using gasoline, while 24% of emissions were generated from on-road diesel activity. A very small amount of emissions were caused by the use of CNG, a relatively clean-burning fuel, in some of the Roaring Fork Transit Authority (RFTA) BRT commuter buses that operate regionally. RFTA also operates a small fleet of standard buses within Aspen that run on B5 Biodiesel, a diesel blend that includes 5% clean-burning biodiesel and 95% diesel. This also comprised a very small percentage of the inventory, and together the emissions from CNG and biodiesel comprise less than one-tenth of one percent of total community emissions. Electric vehicles also accounted for less than one-tenth of one percent of overall on-road emissions. Refer to Figure 17.

On-road activity in Aspen was calculated in the Aspen VMT Model created by a consultant team at Fehr and Peers on behalf of the City of Aspen. The model was originally developed for the 2014 inventory and was updated in early 2018 to reflect more accurate VMT counts for the 2017 inventory. The model accounts for all on-road activity occurring within Aspen and as a result of traveling to/from Aspen. Based on VMT and assumed fuel efficiencies drawn from the Environmental Protection Agency's State Inventory Tool for Mobile Combustion,[17] total community on-road fuel use and related emissions can be estimated.

Total emissions from on-road activity in Aspen have been decreasing since the baseline inventory in 2004; the 2017 inventory illustrates a reduction of 1% in on-road transportation emissions since 2014, and a reduction of 14% in on-road

[17] For more information on the EPA State Inventory Tool see https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool.

Figure 18: Emissions from On-Road Vehicles, 2004-2017



transportation emissions between 2004 to 2017. This is a result of: 1) active efforts on the part of the City of Aspen and RFTA to improve public transit access and service in the community to decrease congestion, and 2) improved vehicle fuel efficiencies over the past several years. See Figure 18.

Aspen's CAP outlines several strategies that will likely lead to further reduced emissions in the on-road transportation sector, including (but not limited to) expanding transit networks and incentives, expanding safe multi-modal (i.e. biking, walking, and transit) options in the community, and increasing the ratio of electric vehicles in fleets throughout the community.

Off-Road Transportation from Airport Activities

The 2017 inventory accounted for off-road transportation occurring in ground transportation support vehicles at the Airport. In past inventories, these emissions values were included in the total aviation emissions, but were moved to a separate 'off-road' designation in 2017 to better account for the impacts of various Airport activities on overall community emissions. As the Airport sits within the Aspen EIB while most of the service roads are privately owned and operated, it is assumed that these emissions can be appropriately attributed to Aspen and that the on-road VMT model does not account for this activity. In 2017, off-road vehicle activity at the Airport accounted for just under 2% of total community emissions, or 4,742 mt CO_2e.

Aviation Fuel Usage

Aviation fuel used at the airport that is attributable to Aspen accounts for 5% of total community emissions. In 2017, the Airport completed its own detailed emissions inventory to account for all activity occurring there; the final memo from this inventory can be found in *Appendix F: Aspen-Pitkin County Regional Airport 2017 Inventory Memo*. This memo details changes in the Airport's GHG emissions, and the drivers of those changes.

An analysis, procured by the Aspen-Pitkin County Airport, and completed by Aspen and the Community Office for Resource Efficiency determined that 37% of total Airport activity (and therefore 37% of total airport emissions) can be attributed to the Aspen EIB; the remaining emissions from the airport are attributable to unincorporated Pitkin County and the surrounding communities. This analysis was conducted using AirSage location data, which was compiled by consultants at the Parsons Transportation Group. The determination that 37% of Airport emissions are attributable to Aspen is new as of the 2017 inventory, but past inventories have been updated to reflect this change for consistency across reports (see *Appendix D: Notes on Inventory Methodologies*). The Airport inventory analyzed emissions from building energy use at the Airport (which are included in Aspen's total commercial energy emissions calculations), off-road fuel use (noted above), and the use of aviation fuel for airplanes traveling to and from the airport. Therefore, to avoid double counting emissions, the Airport emissions captured in building energy or on-road transportation are not captured in the aviation emissions. The City inventory separately itemizes aviation fuel (JetA and Avgas) and ground support equipment as aviation emissions.

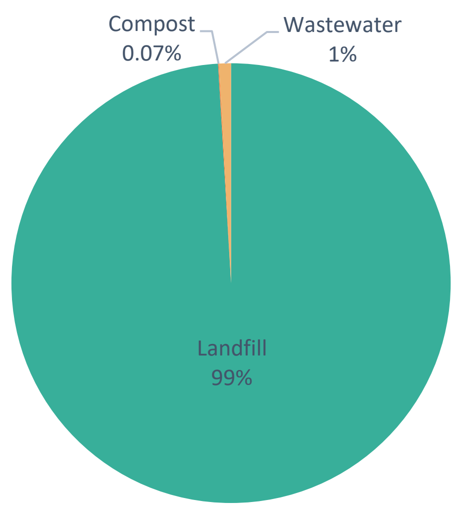
Total aviation fuel emissions attributable to Aspen have risen by 49% since the 2004 baseline and by 40% since 2014. Refer to *Appendix F: Aspen-Pitkin County Regional Airport 2017 Inventory Memo* for details.

Waste Sector Emissions

The waste sector accounted for just under 12% of Aspen's total 2017 community GHG emissions and included emissions from waste disposed of (i.e. landfilled) and composted at the PCSWC, as well as the generation and treatment of wastewater in the Aspen EIB (including through the use of septic tanks).

Ninety-nine percent of total waste sector emissions are the result of waste disposed of via the landfill, just under 1% of waste sector emissions are from the generation and treatment of wastewater, and the remaining amount (less than 0.1%) is from compost delivered to and processed at the PCSWC. Refer to Figure 19.

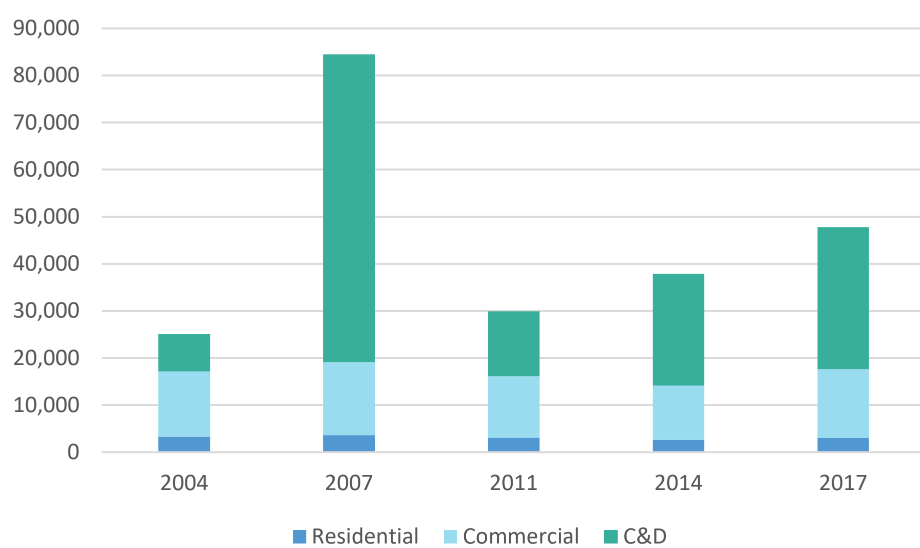
Figure 19: Emissions from Waste Sector, 2017



Community-Generated Solid Waste

Total emissions from community-generated solid waste have increased by 15% since the 2004 inventory; this is in part due to an increase in total waste tonnage. Waste emissions are historically some of the most difficult to measure for communities due to the difficulty of tracking accurate waste values from year to year. However, the staff at the City of Aspen and the PCSWC have been working to ensure accurate collection and tracking of landfill data over the past several years, which will make accurate reporting and accounting of waste emissions more straightforward in the future. While prior inventories included emissions from landfill activities (such as electricity and fuel use), the PCSWC is outside of the Aspen EIB; therefore, only emissions related to community-generated waste processed at the landfill, and not emissions related to actual landfill activities, are included in the 2017 inventory per GPC protocol. The 15% increase in landfill emissions since 2004 reflects only emissions from community-generated solid waste, not additional landfill activities. Refer to Figure 20.

Figure 20: Total Community-Generated Solid Waste in Tons, 2004-2017



The amount of community-generated solid waste disposed of as a result of activities within Aspen has varied significantly over the past several years and is likely closely tied to economic drivers within the community. For example, the total amount of community-generated solid waste decreased sharply between 2007 and 2011, likely as a result of reduced building activity and residents purchasing and disposing of fewer goods due to the nation-wide economic recession. As the national and local economy continued to recover in the years since the recession, the total amount of community-generated solid waste has begun to climb again. Waste generation in Aspen is higher on a per-capita basis than elsewhere in the country;[18] this is likely the result of several economic drivers: 1) Aspen is a tourist-based economy, and therefore all waste generated by out-of-town visitors is ultimately attributed to residents; 2) Aspen continues to grow, and therefore C&D waste is higher than average; and 3) Aspen has a large number of restaurants, which produce more wet waste that weighs more than typical MSW.

However, Aspen's total amount of residential and commercial waste is increasing at rates slower than the community's overall population and economic growth, which indicates that Aspen's waste diversion programs to encourage more recycling and composting have been successful over the years. While Aspen's overall population grew by 8% between 2004 to 2017, the total amount of residential solid waste tons generated within Aspen has decreased 8.5%. Likewise, as the local economy has continued to grow (reflected by a 38% increase in taxable sales between 2004 to 2017), commercial solid waste has only increased by 2.9%.

In 2017, nearly 64% of the waste attributable to Aspen was from C&D debris. The total amount of C&D waste generated by the community has increased by 27% since 2014; this likely represents increased building activity over the years as well as the improved methodology of accounting for C&D waste. Based on information in the Pitkin County Solid Waste Diversion Plan, Phases I and II, the PCSWC is actively working to more accurately track landfill data to better manage the waste stream and ensure that the landfill is operated efficiently; this includes more careful accounting of municipal solid waste versus C&D waste. Phase II recommendations from the plan include an evaluation of policies and infrastructure needed to divert greater quantities of C&D waste, programs to increase the landfill's food waste composting operations, and policies and programs to support greater waste diversion across the communities served by the landfill (Weaver Consulting Group, 2018). These recommendations are in alignment with several made in Aspen's CAP, and the implementation of these strategies is likely to lead to increased waste diversion in the community.

Wastewater Treatment

In 2017, wastewater treatment plant emissions and emissions from the use of septic systems in the community accounted for 314 mt CO_2e or 0.1% of Aspen's total community-wide 2017 GHG emissions. Wastewater in Aspen is treated within the EIB at the Aspen Consolidated Sanitation District operations

[18] Based on information in the Pitkin County Solid Waste Diversion Plan (Phase I), Aspen-Pitkin County landfill takes in approximately 11.8 pounds per capita per day of MSW. According to the *EPA's Advancing Sustainable Materials Management 2015 Facts and Figures Report*, the national average is 4.4 pounds per person per day.

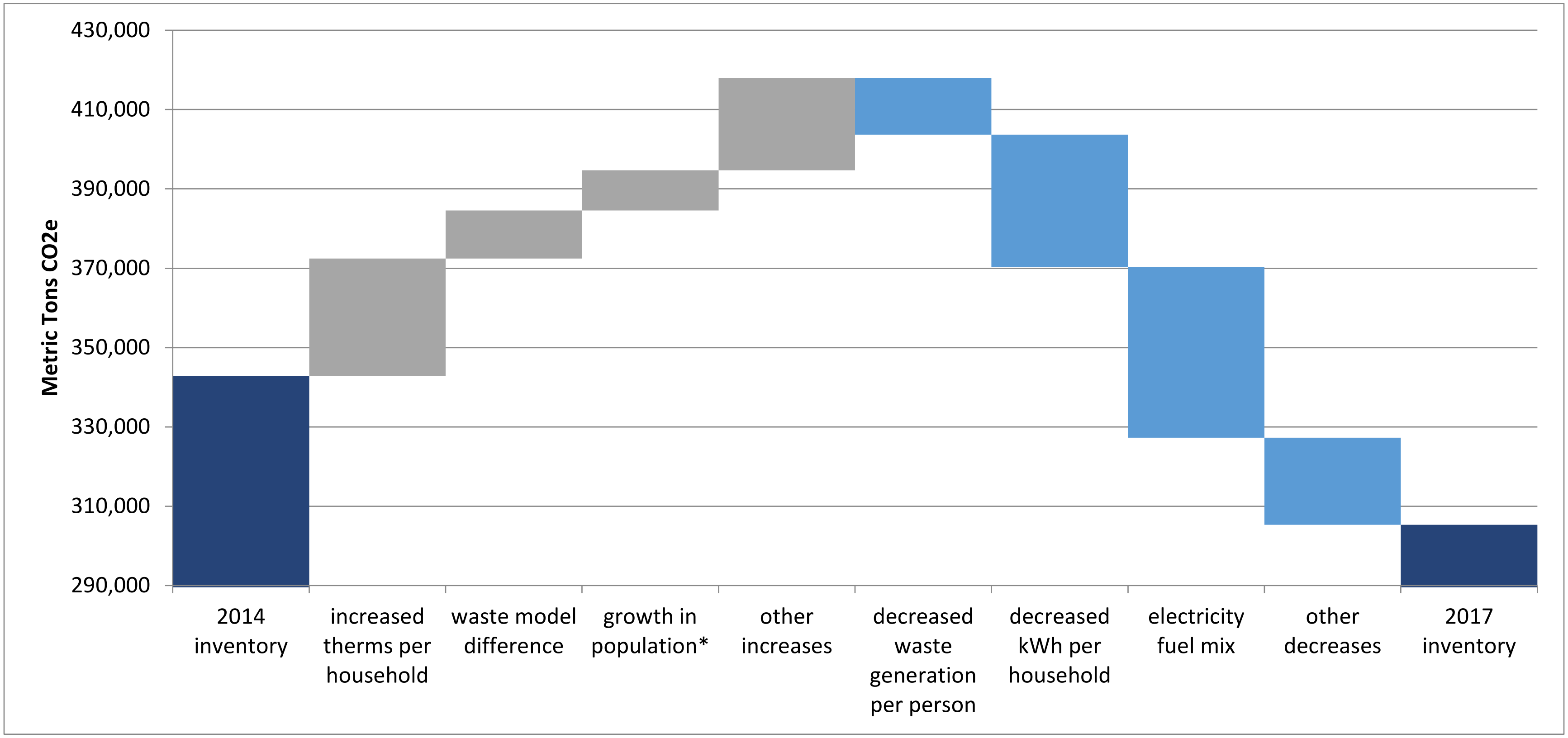
center. In addition, some residents are served by septic systems. The 2017 inventory calculated process emissions from nitrous oxide and fugitive emissions from nitrification and denitrification, as well as methane emissions from the use of septic systems. Septic systems account for 82% of total wastewater emissions in 2017, while the remainder were related to emissions from nitrification and denitrification at the wastewater treatment site.

While wastewater represents a very small portion of Aspen's overall 2017 GHG emissions inventory (0.1%), wastewater emissions have increased since the 2004 inventory; this is primarily the result of the inclusion of septic systems in the 2017 inventory, which were not accounted for in any prior inventories.

An Analysis of Primary Drivers in Emissions Changes, 2014-2017

By using an approach called a decomposition analysis, provided in a tool developed by ICLEI in partnership with Aspen and other communities, we are able to understand the major drivers of changes between inventory years. Lotus utilized the tool to better understand the changes in emissions between 2014 and 2017.[19] Through three waterfall charts, the tool highlights the reasons for increased and decreased emissions between 2014 and 2017.

Figure 21: Three Largest Increases and Decreases in Emissions (2014-2017)



[19] It should be noted that Lotus is only reporting the results from the tool. ICLEI and the partners are solely responsible for the calculations and results.

Figure 21 highlights the top reasons for an increase in emissions between 2014-2017:

- **Increased therms per household:** The model calculated an increase in therms per household.
- **Waste model differences**: The model assumes an increase in GDP leads to additional waste creation.
- **Growth in population**: The model assumes an increase in emissions due to additional waste generation, VMT, residential fuels, and residential electricity from a growth in population.
- **Other increases:** Includes all other increases to the model.

Figure 21 also highlights the top reasons for decreases in emissions between 2014-2017:

- **Decreased waste generation per person:** Highlights the decrease in per capita waste generation as Aspen's population grows at a faster rate than its total waste profile.
- **Decreased kWh per household:** Highlights the decrease in emissions due to reduced use of electricity in Aspen households.
- **Electricity Fuel Mix:** Highlights the decrease in emissions resulting from cleaner electricity.
- **Other Decreases:** Includes all other decreases to the model.

Figure 22: Medium Level Summary of Emissions Reductions and Increases (2014-2017)

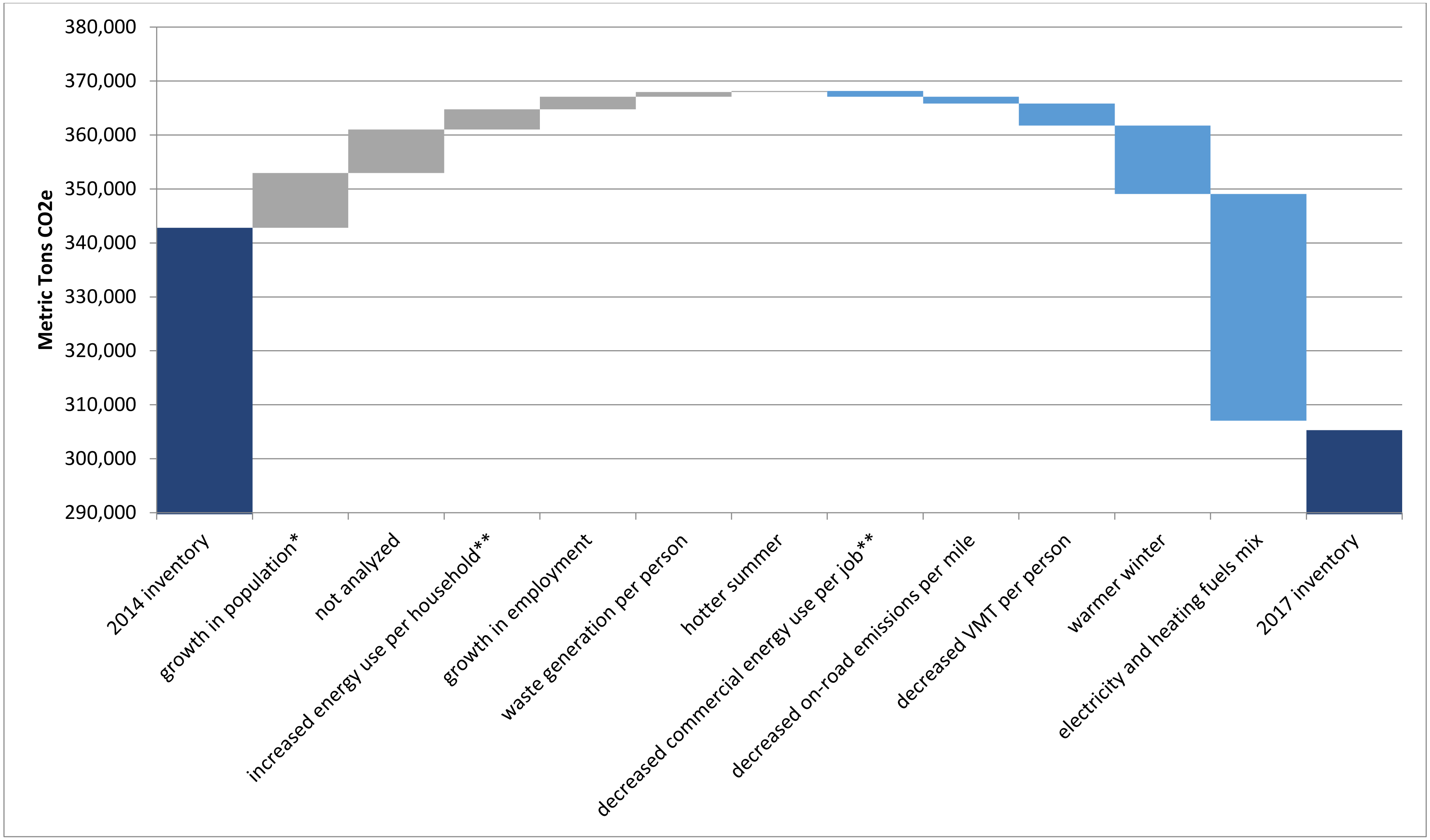


Figure 22 highlights the top reasons for an increase in addition to the items highlighted in Figure 21:

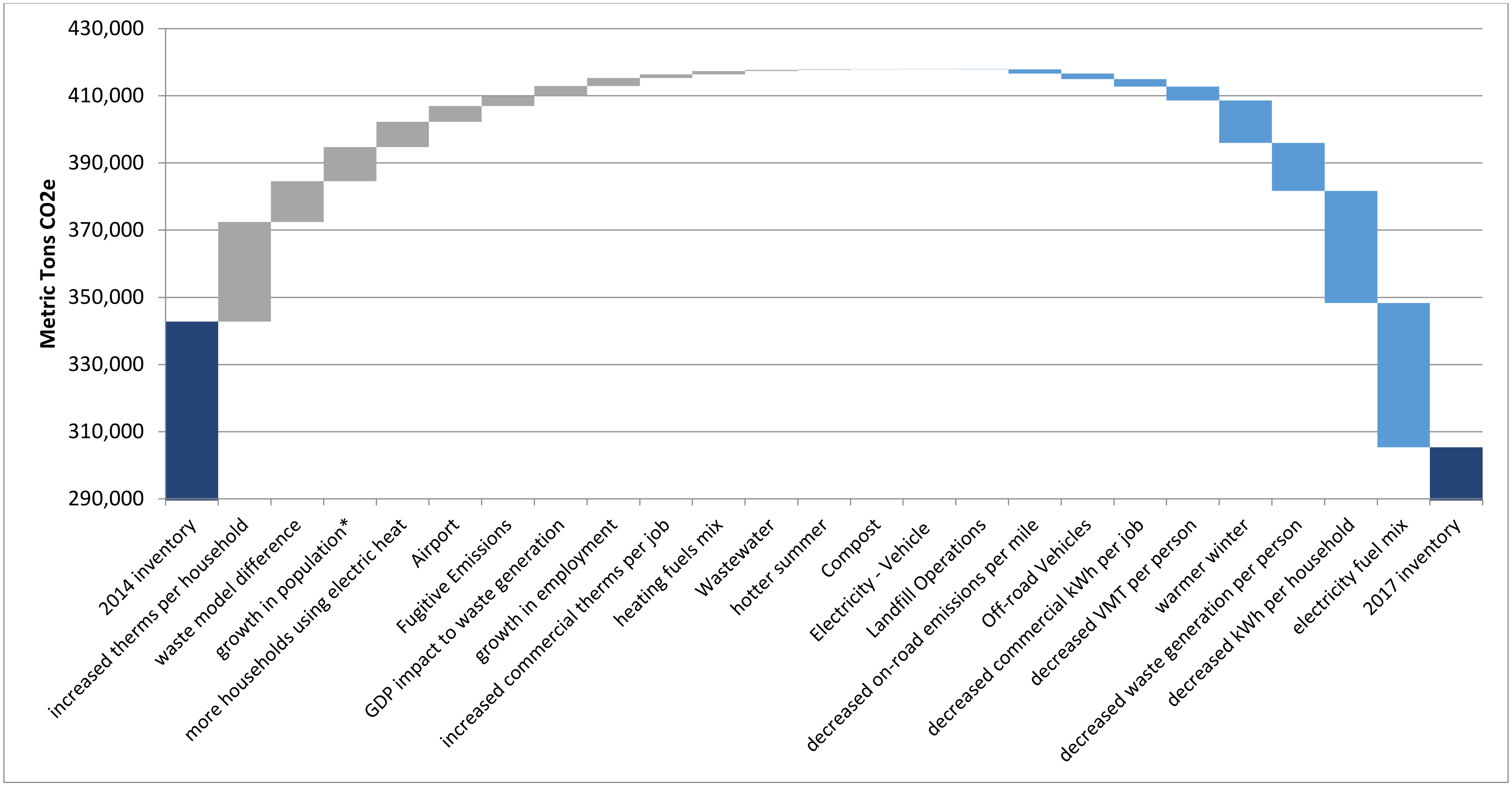
- **Growth in Employment:** The model highlighted that a bigger number of workers leads to greater consumption of resources and, therefore, higher emissions.
- **Waste generation per person:** The model calculated an increase in waste per person leading to increased waste emissions.
- **Increased energy use per household:** The model highlighted that, after accounting for weather, while electricity use per household may have decreased, total energy use per household increased, driving up emissions. This change is the net effect of factors that may include occupant behavior, changes to building types and uses, federal appliance standards, utility programs, and new electronic devices.
- **Hotter Summer**: The model highlighted that an increase in cooling degree days between 2014 and 2017 led to the need for additional electricity use for air conditioning.

Figure 22 highlights the top reasons for the decrease in addition to the items highlighted in Figure 21:

- **Decreased commercial energy use per job:** The model highlighted that commercial energy use per employee in the EIB decreased.
- **Decreased on-road emissions per mile:** Between 2014 and 2017, Aspen experienced a decrease of on-road emissions per mile. Much of this reduction can be attributed to accounting for ethanol in the 2017 inventory.
- **Decreased VMT per person:** Between 2014 and 2017, Aspen experienced a decrease in VMT per person.
- **Warmer winter:** The model highlighted that a decrease in heating degree days between 2014 and 2017 led to a reduced need in energy for heating.

Lastly, Figure 23 highlights the top reasons for decreases and increases in emissions in addition to the items highlighted in Figure 22.

Figure 23: Most Detailed Summary of Emissions Reductions and Increases (2014-2017)



Conclusion

Even in the face of significant population and economic growth, the Aspen community has successfully reduced its overall GHG emissions by 20% since 2004. This is truly an impressive feat that illustrates Aspen’s overall leadership as a sustainable community driven to address and mitigate the impacts of climate change. Aspen’s innovative approach to emissions reductions, which includes moving the municipal-owned electric utility to 100% renewable energy, investing in projects and programs to increase community-wide building energy efficiency, and decreasing emissions from the on-road transportation sector through improved public transit systems, have in large part driven these emissions reductions and have established the City as a leader in sustainability.

Aspen is on its way to meeting its goals of a 30% reduction in emissions by 2020, but much more concerted effort will be required in order to meet the community’s 2050 goal of an 80% reduction in emissions. This means that strategies, projects, programs, and policies that reduce emissions will need to continue to be developed and pursued in the coming years in order to increase the rate of emissions reductions to a rapid pace. By implementing the strategies highlighted in the Aspen CAP and reviewing and updating these strategies in 2021 and in subsequent years as needed, the community can ensure that a data-driven approach will guide even greater emissions reductions. While the current rate of emissions reductions decrease will not facilitate the successful fulfillment of Aspen’s 2050 GHG reduction goals, it does demonstrate that it is possible to grow the economy and serve more residents while simultaneously reducing emissions.

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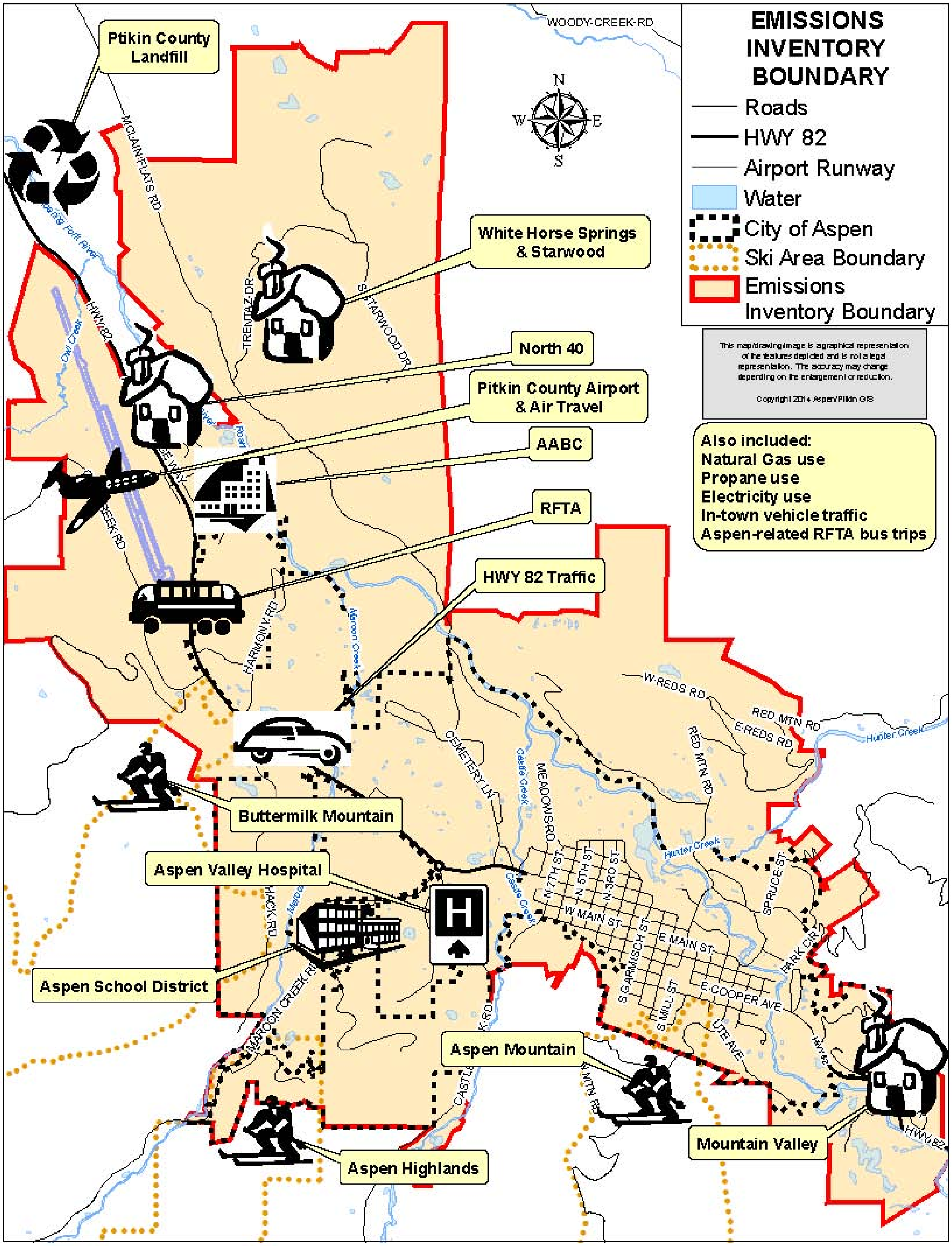
Appendix A: 2004-2017 Emissions Factors

Emissions Source	GHG	2004 Emission Factor	2007 Emission Factor	2011 Emission Factor	2014 Emission Factor	2017 Emission Factor	2017 Data Source
Aspen Electric	CO_2	1188 lbs./MWh	654 lbs./MWh	596 lbs./MWh	526 lbs./MWh	5.4 lbs./MWh	Aspen Electric
Aspen Electric	CH_4	23.63 lbs./GWh	23.63 lbs./GWh	22.66 lbs./GWh	22.66 lbs./GWh	0.00	Aspen Electric
Aspen Electric	N_2O	28.89 lbs./GWh	28.89 lbs./GWh	29.21 lbs./GWh	29.21 lbs./GWh	0.00	Aspen Electric
Holy Cross	CO_2	1795 lbs./MWh	1795 lbs./MWh	1830 lbs./MWh	1574 lbs./MWh	1180 lbs./MWh	Holy Cross Energy
Holy Cross	CH_4	23.63 lbs./GWh	23.63 lbs./GWh	22.66 lbs./GWh	22.66 lbs./GWh	0.137 lbs./MWh	eGRID 2016 (https://www.epa.gov/sites/production/files/2018-02/documents/egrid2016_summarytables.pdf)
Holy Cross	N_2O	28.89 lbs./GWh	28.89 lbs./GWh	29.21 lbs./GWh	29.21 lbs./GWh	0.020 lbs./MWh	
Natural Gas	CO_2	53.02 kg/MMBtu	53.02 kg/MMBtu	53.02 kg/MMBtu	53.02 kg/MMBtu	53.02 kg/MMBtu	ICLEI's U.S. Community Protocol for Accounting and Reporting of GHG Emissions (http://icleiusa.org/ghg-protocols/)
Natural Gas	CH_4	0.005 kg/MMBtu	0.005 kg/MMBtu	0.005 kg/MMBtu	0.005 kg/MMBtu	0.005 kg/MMBtu	
Natural Gas	N_2O	0.0001 kg/MMBtu	0.0001 kg/MMBtu	0.0001 kg/MMBtu	0.0001 kg/MMBtu	0.0001 kg/MMBtu	
Propane	CO_2	61.46 kg/MMBtu	61.46 kg/MMBtu	61.46 kg/MMBtu	61.46 kg/MMBtu	5.59 kg/gallon	ICLEI's U.S. Community Protocol for Accounting and Reporting of GHG Emissions (http://icleiusa.org/ghg-protocols/)
Propane	CH_4	0.001 kg/gallon	0.001 kg/gallon	0.001 kg/gallon	0.001 kg/gallon	0.001 kg/gallon	
Propane	N_2O	0.001 kg/gallon	0.001 kg/gallon	0.001 kg/gallon	0.001 kg/gallon	0.001 kg/gallon	
Gas Passenger Vehicle	CO_2	8.78 kg/gallon	8.78 kg/gallon	8.78 kg/gallon	8.78 kg/gallon	8.78 kg/gallon	ICLEI's U.S. Community Protocol for Accounting and Reporting of GHG Emissions (http://icleiusa.org/ghg-protocols/)
Gas Passenger Vehicle	CH_4	0.0145 g/mile	0.017 g/mile	0.0173 g/mile	0.0173 g/mile	0.020 g/mile	
Gas Passenger Vehicle	N_2O	0.0083 g/mile	0.0041 g/mile	0.0036 g/mile	0.0036 g/mile	0.017 g/mile	
Diesel Passenger Vehicle	CO_2	10.21 kg/gallon	10.21 kg/gallon	10.21 kg/gallon	10.21 kg/gallon	0.0102 mt/gallon	ICLEI's U.S. Community Protocol for Accounting and Reporting of GHG Emissions (http://icleiusa.org/ghg-protocols/)
Diesel Passenger Vehicle	CH_4	0.0005 g/mile	0.0005 g/mile	0.0005 g/mile	0.0005 g/mile	0.0005 g/mile	
Diesel Passenger Vehicle	N_2O	0.001 g/mile	0.001 g/mile	0.001 g/mile	0.001 g/mile	0.001 g/mile	

Appendix B: Emissions Changes over 2004 Baseline by Sector

	2004	2007	% Change ('04-'07)	2011	% Change ('04-'11)	2014	% Change ('04-'14)	2017	% Change ('14-'17)	% Change ('04-'17)
Residential Electricity (Aspen Electric)	12,142	7,209	-41%	6,581	-46%	5,544	-54%	54	-99%	-100%
Residential Electricity (Holy Cross)	62,933	72,760	16%	48,142	-24%	68,230	8%	50,868	-25%	-19%
Residential Propane (All Vendors)	2,830	2,018	-29%	2,342	-17%	641	-77%	1,129	76%	-60%
Residential Natural Gas (All Vendors)	39,822	50,885	28%	49,054	23%	48,347	21%	48,000	-1%	21%
Total Residential Energy Emissions	**117,727**	**132,872**	**13%**	**106,119**	**-10%**	**122,762**	**4%**	**100,051**	**-19%**	**-15%**
Commercial Electricity (Aspen Electric)	22,176	11,988	-46%	11,616	-48%	10,778	-51%	103	-99%	-100%
Commercial Electricity (Holy Cross)	52,760	57,719	9%	70,075	33%	43,389	-18%	31,611	-27%	-40%
Commercial Propane (All Vendors)	N/A	100	N/A	N/A	N/A	490	N/A	546	0	N/A
Commercial Natural Gas (All Vendors)	59,521	49,304	-17%	45,776	-23%	45,249	-24%	43,865	-3%	-26%
Stationary Diesel	N/A	N/A	N/A	N/A	N/A	N/A	N/A	4	N/A	N/A
Total Commercial Energy Emissions	**134,457**	**119,111**	**-11%**	**127,467**	**-5%**	**99,906**	**-26%**	**76,130**	**-24%**	**-43%**
Fugitive Emissions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2,997	N/A	N/A
Total Stationary Energy Emissions	**252,184**	**251,983**	**0%**	**233,586**	**-7%**	**222,668**	**-12%**	**179,177**	**-20%**	**-29%**
On-Road Transportation (gasoline)	61,878	54,206	-12%	50,006	-19%	51,573	-17%	51,791	0%	-16%
On-Road Transportation (Diesel)	14,683	18,243	24%	17,850	22%	15,417	5%	16,688	8%	14%
On-Road Transportation (Ethanol)	302	283	-6%	267	-12%	282	-7%	255	-10%	-16%
On-Road Transportation (Biodiesel)	2,863	2,074	-28%	2,102	-27%	1,997	-30%	0	-100%	-100%
On-Road Transportation (CNG)	-	-	N/A	-	N/A	20	N/A	16	-18%	N/A
On-Road Transportation (EVs)	-	-	N/A	-	N/A	-	N/A	8	N/A	N/A
Total On-Road Transportation Emissions	**79,726**	**74,806**	**-6%**	**70,225**	**-12%**	**69,289**	**-13%**	**68,758**	**-1%**	**-14%**
Off-Road Transportation (Fuel Combined)	6,208	6,208	0%	5,487	-12%	6,449	4%	4,742	-26%	-24%
Total Off-Road Transportation Emissions	**6,208**	**6,208**	**0%**	**5,487**	**-12%**	**6,449**	**4%**	**4,742**	**-26%**	**-24%**
Aviation	11,165	11,165	0%	9,810	-12%	11,848	6%	16,613	40%	49%
Total Aviation Emissions	**11,165**	**11,165**	**0%**	**9,810**	**-12%**	**11,848**	**6%**	**16,613**	**40%**	**49%**
Total Transportation Emissions	**97,099**	**92,179**	**-5%**	**85,522**	**-12%**	**87,586**	**-10%**	**90,113**	**3%**	**-7%**
Landfill and Compost, Emissions from Waste	31,116	57,451	85%	31,678	2%	32,487	4%	35,715	10%	15%
Emissions from Landfill Operations	39	152	290%	51	31%	38	-3%	N/A	N/A	N/A
Total Landfill and Compost Emissions	**31,155**	**57,603**	**85%**	**31,729**	**2%**	**32,525**	**4%**	**35,715**	**10%**	**15%**
Nitrification/Denitrification	26	24	-8%	25	-4%	23	-12%	35	54%	36%
Process N2O Emissions	7	7	0%	6	-14%	6	-14%	19	224%	178%
Septic Tanks	N/A	N/A	N/A	N/A	N/A	N/A	N/A	259	N/A	N/A
Total Wastewater Emissions	**33**	**31**	**-6%**	**31**	**-6%**	**29**	**-12%**	**314**	**982%**	**851%**
Total Waste Emissions	**31,188**	**57,634**	**85%**	**31,760**	**2%**	**32,554**	**4%**	**36,029**	**11%**	**16%**
Total Emissions for Aspen	**380,471**	**401,796**	**6%**	**350,867**	**-8%**	**342,807**	**-10%**	**305,319**	**-11%**	**-20%**

Appendix C: Aspen's Emissions Inventory Boundary



Appendix D: Notes on Varying Inventory Methodologies

The USCP and GPC require emissions to be reported and calculated differently in some situations, which results in varying methodologies between the 2017 and prior year inventories. These differences are noted here:

Fugitive Emissions

Past inventories did not account for fugitive emissions that are released from the use of natural gas systems in the community; these emissions were included in the 2017 inventory. Fugitive emissions are caused by the use and distribution of natural gas in buildings and are calculated based on an assumed 3% methane leakage rate.[20]

Stationary Diesel

Stationary diesel use was not accounted for in prior inventories but was included in the 2017 inventory analysis. It made up a very small amount (less than one-one hundredth of one percent) of total community emissions.

Off-Road Vehicles

The 2017 inventory accounted for off-road transportation occurring in ground transportation support vehicles at the Aspen-Pitkin County Airport. In past inventories, these emissions values were included in the total aviation emissions, but were moved to a separate 'off-road' designation in 2017 to better account for the impacts of various airport activities on overall community emissions.

Airport Emissions

Past inventories included airport building energy use, ground transportation fuel use, and aviation fuel use in the total airport emissions attributed to Aspen. Further, past inventories attributed a larger share of airport emissions to Aspen than the 2017 inventory does. Per GPC protocol, the 2017 inventory only includes aviation fuel emissions in the aviation emissions sector; airport building energy use is included in total commercial building energy consumption for Aspen, while fuel use in ground transportation at the airport is included in the off-road vehicles sector, noted above. Airport emissions from the past inventories were updated to reflect the removal of non-aviation fuel use emissions and to account for only the 37% of aviation emissions that are attributable to Aspen. Comparative numbers in the aviation section of this document reflect the updated airport emissions for 2004-2014.

Waste

In both 2014 and 2017, tons of C&D waste attributable to Aspen were calculated by determining the share of total permitted new building and renovations in Pitkin County that

[20] Methane leakage rate is drawn from documentation by the Environmental Defense Fund, see https://www.edf.org/sites/default/files/US-Natural-Gas-Leakage-Model-User-Guide.pdf.

occurred within Aspen (determined to be 79%) and applying this factor to the total amount of C&D waste disposed of at the PCSWC.

Septic Tanks

Prior inventories did not include emissions from septic tanks in Aspen. These were included in the 2017 inventory per GPC protocol. Septic systems account for 82% of total wastewater emissions in 2017.

Contribution Analysis

In 2017, Aspen partnered with ICLEI and several other organizations to create a Contribution Analysis toolkit that any government could use to help tell a more nuanced and accurate story about how and why emissions are changing in their community. The toolkit not only provides a detailed analysis of the underlying trends in energy use per household and per commercial square foot but also helps Aspen understand how vulnerable their energy use is to changes in the weather. Lotus utilized the tool to better understand the changes in emissions between 2014 and 2017.[21]

[21] It should be noted that Lotus is only reporting the results from the tool. ICLEI and the partners are solely responsible for the calculations and results.

Appendix E: Global Warming Potentials

For ease of reporting and comparing the absolute effects of different gases, all GHGs have different, defined global warming potentials (GWP). The GWP of a GHG defines its contribution to global warming (i.e. the ability of each gas to trap heat in the atmosphere), whereas a GWP of one is equal to the impacts of one unit of CO_2. The effect of a non-CO_2 GHG or the combination of different GHGs is expressed as carbon dioxide equivalents or CO_2e.

In 2017, GWPs have been sourced from the IPCC Fifth Assessment Report. Methane and nitrous oxide are converted to CO_2e by multiplying their value by the 100-year GWP coefficient.

Global Warming Potentials, 2017

Common Name	Formula	GWP
Carbon Dioxide	CO_2	1
Methane	CH_4	28
Nitrous Oxide	N_2O	265

Appendix F: Aspen-Pitkin County Regional Airport 2017 Inventory Memo

Aspen-Pitkin County Airport

2017 Greenhouse Gas Inventory

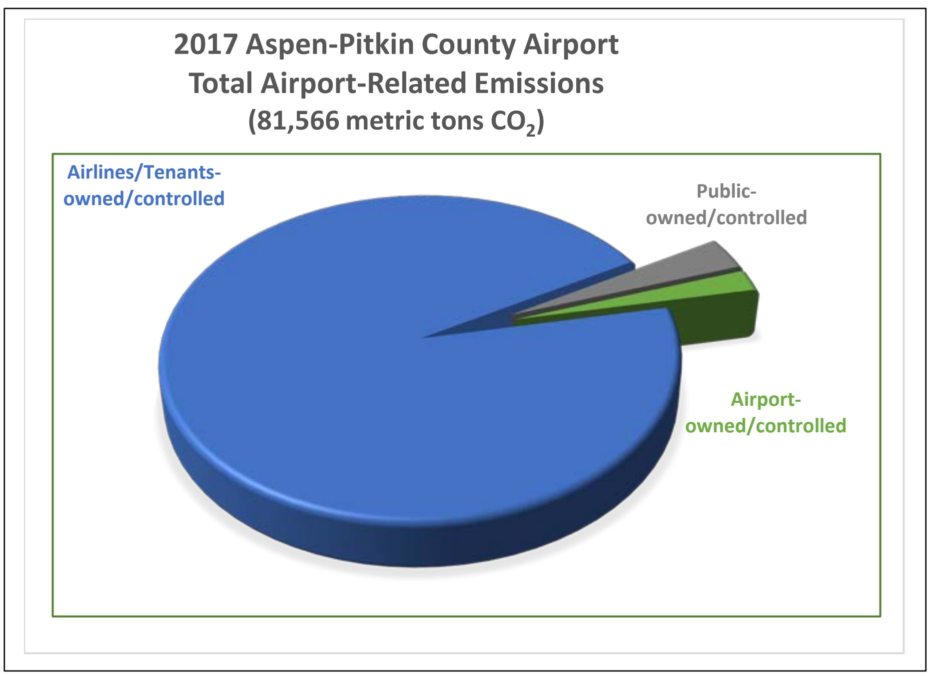
Pitkin County was one of the first airports in the US to prepare a total airport-related emissions inventory that captured the emissions of sources by ownership and/or control. The County has performed its updated emissions inventory for year 2017. Pitkin County has voluntarily prepared a greenhouse gas emissions inventory associated with its Airport Section, which operates Aspen-Pitkin County Airport. The approach used by the Airport reflects the Airport Cooperative Research Program (ACRP) Report 11 *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*. The approach used by Pitkin County is intended to dovetail with the City of Aspen's Climate Action Office which relies on the guidance of the International Council for Local Environmental Initiatives (ICLEI) for community-based emissions inventories.[22]

Most notable in the approach, is that the emissions are separated by those sources that the Airport has ownership or control, versus emissions owned and controlled by tenants/users or the general public that uses the Airport.

Results

Table 1 shows the results of the 2017 inventory in comparison to the 2014, 2011, and 2006 inventories.[23] In 2017, total airport-related emissions were 81,566 metric tons of carbon dioxide (CO_2). Key findings:

- Pitkin County owns and/or controls sources at the Airport that represent 2.1% of total emissions
  - Pitkin County-owned or controlled emissions **decreased** 0.5% in 2017 over 2014 levels;
  - While emissions are greater than 2006, Airport-owned and controlled emissions have **decreased** from 2011 to 2014 and **decreased** again from 2014 to 2017.



[22] The ICLEI guidance suggests the use of ACRP Report 11 for the airport portion of the community inventories.

[23] The GHG inventory for Aspen-Pitkin County Airport is updated every three years.

- Aircraft operator/tenant emissions reflect 94.7% of total airport-related emissions.
  - Aircraft emissions reflect 89.3% of total airport-related emissions.
  - Total tenant-owned and controlled emissions **increased** 32.5% between 2014 and 2017.
  - Tenant ground support equipment emissions **decreased** 31% between 2014 and 2017.
- Public owned and controlled emissions, from travel to and from the Airport, increased 13.7% over 2014, but represents only 3.2% of total airport-related emissions

The inventory prepared by Pitkin County for the Airport, is used by the City of Aspen Climate Action Office to identify airport emissions so the methodology remains consistent. For the City of Aspen Climate Action Office inventory, specific lines in the information in **Table 1** are used:

- Airport owned or controlled ground support equipment (fleet vehicles) – 256 metric tons (**decreased**)
- Aircraft emissions – 72,879 metric tons in 2017 (**increased**)
- Airline/tenants ground support equipment – 4,319 metric tons (**decreased**)
- Subtotal – 77,454 metric tons in 2017, an **increase** of 32 percent over 2014 (58,525 metric tons)

This increase is due to the increase in the quantity of Jet A fuel dispensed, which increased by 40% between 2014 and 2017.

The City of Aspen Climate Action Office does not use the Airport's building/facility emissions or ground travel emissions, as those emissions are rolled up into the overall city building/facility and ground travel emissions.

Tracking Key Metrics

Table 2 lists many of the key metrics that are used in the underlying greenhouse gas inventory. This is the same methodology that has been used in the previous four reports. Most notable in the changes between 2014 and 2017 are:

- Total operations increased by 19.8% whereas the number of passengers increased by 11.1%
- A 5% increase in the use of electricity by airport facilities
- A 10% reduction in airport facility use of natural gas
- A 64% increase in airport fleet vehicle unleaded gas use with a reduction of 15% in the use of diesel gas in the airport fleet vehicles
- A 40% increase in the quantity of Jet A fuel dispensed (sold) to aircraft: at the Airport
  - Commercial Jet fuel sales represented 40.6% of total fuel sold in 2017
  - General Aviation Jet fuel sales represented 59.4% of fuel sold in 2017
  - Increase in overall fuel dispensed/sold at the Airport is tied to a 19.8% increase in operations paired with an over 20% increase in the overall stage length (i.e. the distance an aircraft flies).
- Avgas sold to general aviation aircraft increased 3.8%
- Rental car activity increased by 16.8%

- Use of the Airport's parking lot decreased. This decrease was likely due to a change in the reporting process during 2017 that will show a notable increase in 2018.

Mitigation Measures

The following mitigation measures have been identified in the Pitkin County Climate Action Plan by the Airport for implementation as funds become available.

- Replace the old terminal with more energy efficient terminal
- Consider geo thermal or other renewables as part of the terminal complex
- Identify high emission vehicles that are in line for replacement and replace earlier
- Consider replacing airfield lighting with LED lighting
- Aircraft: Encourage reliance on alternative fuels
- AUP use of apron parking—installation of preconditioned air and electric GPUs
- Rental Cars: with the new facility, include energy efficiency and water conservation in the QTA
- Investigate rewards for increase vehicle occupancy/ride share
- Increase ridership of public transportation
- Require taxi and airport shuttles to meet an MPG standard
- Rental Cars: require rental car operators to meet an MPG standard for on-site rental agreements

TABLE 1 – Aspen-Pitkin County Airport CO2 Emissions (metric tons)

User/Source Category	2017 CO2 (tons/year)	Percent of User	Percent of Total	2014 CO2 (tons/year)	2011 CO2 (tons/year)	2006 CO2 (tons/year)	% change 2014-2017
Airport-owned/controlled							
Facilities/Stationary Sources	1,334	77.2%	1.6%	1,350	1,529	1,326	-1.2%
Ground Support Equipment	256	14.8%	0.3%	256	147	155	0.1%
Ground Access Vehicles							
Passenger vehicles (on-airport roads)	15	0.9%	0.0%	15	16	15	3.5%
Hotel shuttles (on-airport roads)	6	0.3%	0.0%	6	6	7	0.0%
Rental Cars (on-airport roads)	6	0.4%	0.0%	5	3	1	16.8%
Airport Employee Commute (all roads)	111	6.4%	0.1%	105	80	81	6.3%
Subtotal	**1,728**	**100.0%**	**2.1%**	**1,736**	**1,781**	**1,584**	-0.5%
Airlines/Tenants/Aircraft Operator-owned/controlled							
Aircraft							
Approach	3,357	4.3%	4.1%	2,236	1,852	2,110	50.1%
Taxi/Idle/Delay	2,503	3.2%	3.1%	3,644	3,017	3,433	-31.3%
Takeoff	10,183	13.2%	12.5%	4,110	3,402	3,869	147.8%
Climb out	2,556	3.3%	3.1%	1,069	886	1,009	139.0%
Residual/Cruise/APU	54,281	70.3%	66.5%	40,915	33,877	38,560	32.7%
Sub-total	72,879	94.4%	89.3%	51,974	43,034	48,982	40.2%
Ground Support Equipment	4,319	5.6%	5.3%	6,295	5,210	5,924	-31.4%
Ground Access Vehicles							
Tenant GAV	0	0.0%	0.0%	0	0	0	0.0%
Tenant Employee Commute (all roads)	29	0.0%	0.0%	23	25	25	25.0%
Stationary Sources	0	0.0%	0.0%	0	0	0	0.0%
Subtotal	**77,227**	**100.0%**	**94.7%**	**58,292**	**48,270**	**54,931**	32.5%
Public-owned/controlled							
Passenger Vehicles (off-airport roads)	584	22.4%	0.7%	561	603	557	4.1%
Rental Car Travel (on-airport roads)	2,022	77.4%	2.5%	1,731	1,929	589	16.8%
Hotel Shuttles (off airport roads)	6	0.2%	0.0%	6	6	6	0.0%
Subtotal	**2,612**	**100.0%**	**3.2%**	**2,298**	**2,537**	**1,152**	13.7%
Total	**81,566**		**100%**	**62,326**	**52,588**	**57,667**	30.9%

Note: In 2017, the Airport's aircraft emissions in the LTO were calculated using AEDT, the FAA's new emissions model.

TABLE 2 TRACKING METRICS

User/Source Category	2017	2014	2011
Airport-owned/controlled			
Facilities/Stationary Sources			
- Electricity (kWh)	1,652,578	1,551,872	1,491,019
- Natural Gas (ccf)	42,675	47,688	49,636
Terminal	28,786.0	30,435.0	33,613.0
Airport Main Term-TSA	661.0	305.0	824.0
AOC	13,228.0	16,948.0	15,199.0
Airport Fleet Vehicles (gallons)			
- Fleet Vehicles Gas	8,789.40	5,371.20	4,820.60
- Fleet Vehicles Diesel	17,499.50	20,471.30	10,242.50
Subtotal			
Airlines/Tenants/Aircraft Operator-owned/controlled			
Aircraft (annual Operations)	42,426	35,395	37,671
- Jet A (gallons)	7,587,108	5,403,433	4,472,392
- Avgas (gallons)	33,804	32,559	28,797.00
Subtotal			
Public-owned/controlled			
Passengers (total passengers)	487,287	438,258	432,586
Rental Car Travel (assuming 6- day rental)	21,488	18,398	18,527
Parking Lot (parking exits x 2)	63,072	64,776	69,390

Note: Rental cars - reflect 128,931 rental days in 2017 @ 6 days rental