JACKSON HOLE AIRPORT

Greenhouse Gas Emissions Inventory - 2017

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April 2019

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Prepared by:

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Jackson Hole Airport

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EXECUTIVE SUMMARY

The Airport Board and staff at Jackson Hole Airport (JAC) have voluntarily commissioned the preparation of a greenhouse gas emissions inventory associated with activity at the Airport. The year 2017 was identified as the baseline year for this report to align with the Town of Jackson's emission inventory baseline. This inventory identifies emissions by the party that has ownership and control over the various sources of emissions. In the Airport case, this is based on three categories:

1) Airport Board Owned and Controlled;
2) Airlines/tenants/aircraft operators; and
3) General public.

The methodology used in this emissions inventory follows guidance from the Airport Cooperative Research Program (ACRP) as well as the Airport Carbon Accreditation (ACA) methods were also used.

This inventory reflects two themes for identifying the boundaries associated with greenhouse gas inventories: organization boundaries and operational boundaries. In the case of the Airport, the organization boundaries were limited for this review to the Airport Board's activities and associated emissions. Operational boundaries reflect the emissions associated with airport activity. Direct and indirect emissions within these boundaries reflect sources that are owned and controlled by the Airport (terminal buildings, mobile sources, and the power required to operate these resources). Other indirect emissions are a consequence of the activities of the Airport but occur by sources owned and controlled by another party. At an airport, these indirect emissions are associated with the airlines, tenants, and general public that use that airport. These indirect emissions are often referred to as optional, since they are not under the control of the entity reporting the emissions.

Based on these boundaries, approximately 56,636 metric tons of greenhouse gas emissions were emitted in 2017 as a result of air travel associated with Jackson Hole Airport. The distribution of emissions by ownership and control was:

Ownership/Control	Percent of Total	Key Sources
Airlines/Tenants	95.4%	Aircraft
Public	3.2%	Public vehicles
Airport Board	1.4%	Facility power, airport support/fleet vehicles, on-airport roadway travel

Jackson Hole Airport's owned/controlled emissions represent about 774 metric tons of CO_2 in 2017, reflecting about 1.4% of total airport-wide emissions. The largest portion of these greenhouse gas emissions was associated with airport employee work commute, reflecting 53.6% of airport owned or controlled emissions. The second largest airport owned or controlled source was associated with airport fleet vehicles/ground support equipment at 28.0% of airport owned/controlled emissions and facility energy use (electricity and propane) at 12.1%. Relative to other U.S airports, facility stationary source emissions are typically the largest source of emissions. However, Lower Valley Electric obtains its power from Bonneville Power, which has one of the lowest electricity generation emission rates of a utility in the country.

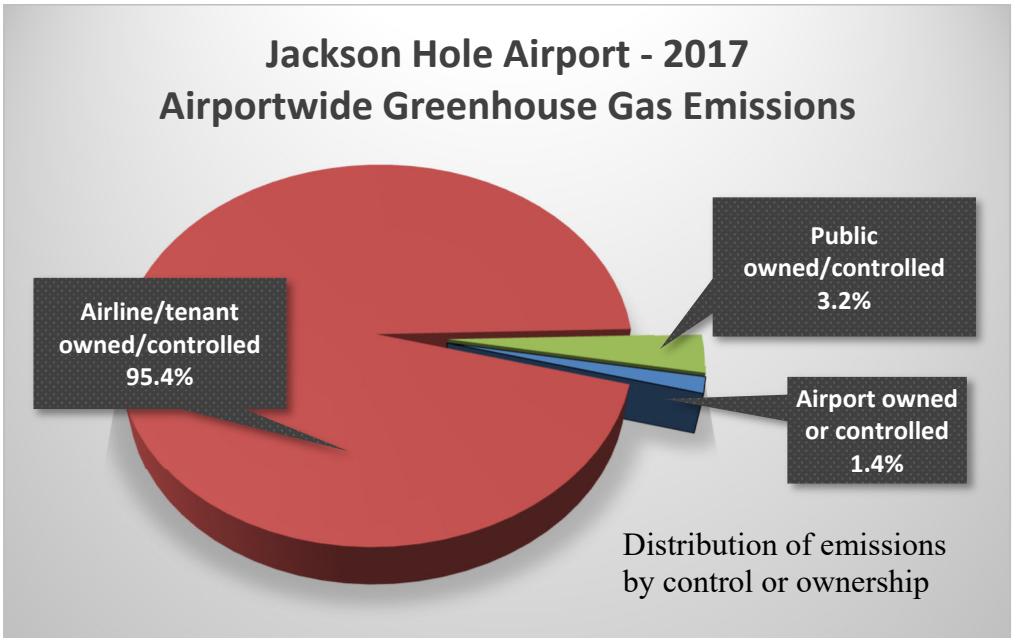
Airline/tenant/aircraft operator-owned and controlled emissions represent 54,040 metric tons of CO_2 in 2017, or 95.4% of total airport-related emissions. Of this category of ownership and control, aircraft

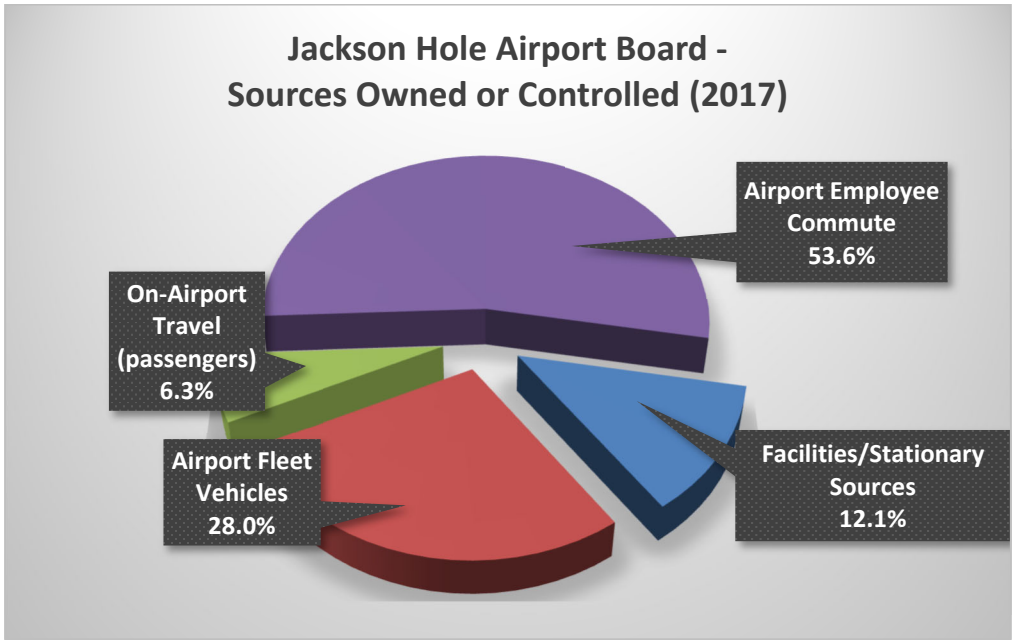
represent the single largest source of CO_2 emissions. About 99.3% of the tenant/airline/aircraft operator emissions are from aircraft, and aircraft operating above 3,000 feet (cruise) represents the primary aircraft emissions mode (80.2% of tenant emissions).

The final category of sources that were identified represents ground vehicle movements associated with air travel at Jackson Hole Airport. This category includes all ground travel on off-airport roadways and represents 1,822 metric tons of CO_2 in 2017, or 3.2% of total airport wide emissions.

Next Steps: The Airport has an ongoing sustainability initiative. The sustainability planning effort will use this information to consider strategies to reduce the carbon footprint and increase the overall sustainability of the Airport. In addition, these results are likely to be used by local communities to capture the airport-related emissions associated with visitors and residents in those communities that use the Airport.

FIGURE ES-1
SOURCES OF EMISSIONS





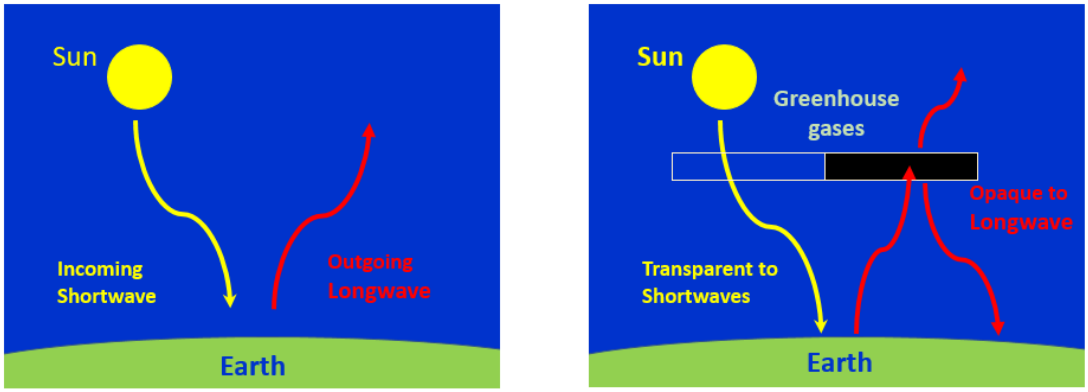
I. BACKGROUND

I.1 WHAT ARE GREENHOUSE GASES (GHG)?

Greenhouse gases are those gases that trap heat in the earth's atmosphere. Both naturally occurring and anthropogenic (man-made) greenhouse gases include water vapor (H_2O), carbon dioxide (CO_2),[1] methane (CH_4), nitrous oxide (N_2O), and ozone (O_3).[2] Because different greenhouse gases absorb and re-radiate different wavelengths of infrared light, and because they remain in the atmosphere at different levels and lengths of time, each type of greenhouse gas traps a different amount of heat. Therefore, in an inventory, emissions of greenhouse gases often focus on CO_2, because this gas constitutes most greenhouse gases. If they include other greenhouse gases, they are reported as "carbon dioxide equivalent" or $CO_{2\text{-eq}}$.

There are also gases that do not have a direct global warming effect but indirectly affect land and/or solar radiation absorption by influencing the formation or destruction of other greenhouse gases. These gases include carbon monoxide (CO), oxides of nitrogen (NOx), and non-methane volatile organic compounds (NMVOCs). Aerosols, which are extremely small particles or liquid droplets, such as those produced by sulfur dioxide (SO_2) or elemental carbon emissions, can also affect the ability of the atmosphere to absorb or shed heat.

FIGURE I-1
ATMOSPHERE WITHOUT GREENHOUSE GASES AND WITH GREENHOUSE GASES



Although the direct greenhouse gases CO_2, CH_4, and N_2O occur naturally in the atmosphere, human activities have changed their atmospheric concentrations. Since the pre-industrial era, concentrations of these greenhouse gases have increased substantially (according to IPCC (Intergovernmental Panel on Climate Change – see **Section I.2** of this report). Beginning in the

[1] All greenhouse gas inventories measure carbon dioxide emissions, but beyond carbon dioxide different inventories include different greenhouse gasses (GHGs).

[2] Several classes of halogenated substances that contain fluorine, chlorine, or bromine are also greenhouse gases, but they are, for the most part, solely a product of industrial activities. For example, chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) are halocarbons that contain chlorine, while halocarbons that contain bromine are referred to as bromofluorocarbons (i.e., halons) or sulfur (sulfur hexafluoride: SF_6).

1950s, the use of CFCs and other stratospheric ozone depleting substances (ODSs) increased by nearly 10% per year until the mid-1980s, when international concern about ozone depletion led to phased reductions in ODSs.[3] In recent years, use of ODS substitutes such as hydrofluorocarbons (HFCs)[4] and perfluorocarbons (PFCs)[5] has grown as they begin to be phased-in as replacements for CFCs and hydrochlorofluorocarbons (HCFCs).

Gases in the atmosphere can contribute to the greenhouse effect both directly and indirectly. Direct effects occur when the gas itself absorbs radiation. Indirect radiative forcing occurs: 1) when chemical transformations produce other greenhouse gases; 2) when a gas influences the atmospheric lifetimes of other gases and/or; 3) when a gas affects atmospheric processes that alter the radiative balance of the earth (e.g., affect cloud formation, etc.). The IPCC developed the Global Warming Potential (GWP) concept to compare the ability of each greenhouse gas to trap heat in the atmosphere relative to another gas. As noted in later sections of this report, the greenhouse gas inventory for Jackson Hole Airport has focused on CO_2 as 1) it is the greatest greenhouse gas emitted by airport sources; and 2) emission rates of some sources are not available for many of the other greenhouse gases.

I.2 WHO ADDRESSES GREENHOUSE GASES

The following section discusses greenhouse gases from the perspective of an airport operator, such as Jackson Hole Airport.

At this time in the US, there are no regulations specifically governing greenhouse gases. Concentrations of a few gases that also represent greenhouse gases, such as nitrogen oxides (NO_x), ozone (O_3), and carbon monoxide (CO), are regulated by the Clean Air Act for visibility and human health implications rather than for climate change effects. The primary players currently addressing greenhouse gases and climate change are:

- **The Kyoto Protocol to the United Nations Framework Convention on Climate Change** (UNFCCC) is an amendment to the international treaty on climate change, assigning mandatory targets for the reduction of greenhouse gas emissions to signatory nations. Countries that ratify the Kyoto Protocol commit to reduce their emissions of carbon dioxide and five other greenhouse gases, or engage in emissions trading if they maintain or increase emissions of these gases.

  Governments are separated into two general categories: developed countries, referred to as Annex 1 countries who have accepted greenhouse gas emission reduction obligations; and developing countries, referred to as Non-Annex 1 countries who have no greenhouse gas emission reduction obligations. A total of 192 countries had ratified the agreement. Developing countries, such as India and China, which have ratified the protocol are not

[3] The Montreal Protocol, finalized in 1987, is a global agreement to protect the stratospheric ozone layer by phasing out the production and consumption of ODSs.

[4] HFCs are used in many applications, such as solvents, domestic and commercial refrigerants, firefighting agents, propellants for pharmaceutical and industrial aerosols, foam-blowing agents, and in blends for air conditioning refrigerants

[5] PFCs are emitted as by-products of industrial processes and are also used in manufacturing.

required to reduce carbon emissions under the present agreement despite their relatively large populations.

Emissions from international aviation were specifically excluded from the targets agreed upon under the Kyoto Protocol. Instead, countries were encouraged to control international aviation-related emissions through the activities of the International Civil Aviation Organization (ICAO). ICAO's Committee on Aviation Environmental Protection continues to consider the potential for using market-based mechanisms. ICAO is currently developing guidance for states who wish to include aviation in an emissions trading scheme (ETS) to meet their Kyoto commitments, and for airlines who wish to participate voluntarily in a trading scheme. Emissions from domestic aviation are included within the Kyoto targets agreed upon by countries.

- **Intergovernmental Panel on Climate Change (IPCC)**: While not a group that has established greenhouse gas reduction goals, the IPCC plays a major role in guiding international and national emission quantification and reduction work. Recognizing the problem of potential global climate change, the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP) established the Intergovernmental Panel on Climate Change (IPCC) in 1988. It is open to all members of the United Nations and WMO. The role of the IPCC is to understand the risk of human-induced climate change, its potential impacts, and options for adaptation and mitigation. The IPCC does not carry out research or establish regulation. It bases its assessments mainly on peer reviewed and published scientific/technical literature. The IPCC has completed five assessment reports, developed methodology guidelines for national greenhouse gas inventories, special reports, and technical papers. The IPCC has three working groups and an emissions inventory task force.

- Even though the US has not ratified the Kyoto Protocol, various regional, state, and local agencies continue to act to quantify, and control and/or reduce GHG emissions. Currently, there are 192 parties (191 states, and 1 organization) to the Kyoto Protocol.[6] Policies include carbon pricing, emission limits, energy efficiency mandates and incentives and steps to promote cleaner transportation. Examples include:

    - **Carbon Pricing**: one of the most direct policies that states use to address emissions is carbon pricing. This is currently only implemented via cap-and-trade programs, though carbon taxes are being considered in a few states as well. The nine northeastern U.S states in the Regional Greenhouse Gas Initiative (RGGI) have implemented cap and trade in the power sector. By 2020, RGGI is expected to help the states reduce annual power-sector CO2 emissions 45% below 2005 levels. The states have set a goal of reducing emissions an additional 30% by 2030. California's cap-and-trade program is not limited to the power generation sector but covers nearly its entire economy. The State of Washington has a trading program that sets individual emissions caps for large sources across the economy.
    - **Energy Efficiency Policies**: States can promote energy efficiency projects and practices through mandates or incentives. Many states take both approaches. Such mandatory policies include building codes that require low-energy features or appliance standards. At least fifteen (15) states plus the District of Columbia currently have some appliance efficiency standards that exceed federal requirements.

[6] https://unfccc.int/process/the-kyoto-protocol/status-of-ratification

- **Transportation Policies:** several techniques are used to control transportation emissions, one of the largest sources of emissions in the U.S. Rebates and incentives are used to encourage consumers to purchase electric vehicles. A low-carbon fuel standard, aimed at reducing greenhouse gas emissions by requiring a shift to lower-carbon fuel (bio fuels, etc.) are used in California and Oregon. Land use decisions and public transportation investments are also used to reduce vehicle miles travelled and associated emissions.

- In 2008, the Aviation industry developed voluntary policies designed to reduce greenhouse gas emissions and fuel use associated with commercial aviation. Several targets were established: A) a 1.5% per year reduction in fuel use through 2020; B) from 2020, aviation would cap its emissions while activity grows (referred to as carbon neutral growth post 2020); and C) the industry is committed to reducing the net carbon footprint to 50% of what it was in 2005. Companies across the sector are collaborating to reduce emissions using a four-pillar strategy of 1- new technology, 2- efficient operations, 3- improved infrastructure, and 4- market-based measures to fill the remaining emissions gap. At the same time, the airlines have been working aggressively to gain support for sustainable aviation jet fuel, fuel that can be derived from organic materials and serve as a drop-in fuel for conventional fossil fuels. The airlines estimate that sustainable aviation jet fuels could reduce greenhouse gas emissions by as much as 80% as compared with conventional fuels. [7]

I.3 SOURCES OF GREENHOUSE GASES AT AN AIRPORT

Research has shown that there is a direct link between fuel consumption and greenhouse gas emissions. Therefore, sources that require power/fuel at an airport typically are reflected in a pollutant emissions inventory and are the principal focus of a greenhouse gas inventory. Airport sources of greenhouse gas emissions would include:

1. **Aircraft including auxiliary power units** (APU): The category of aircraft includes jet and propeller driven aircraft, as well as APUs. An APU generates electricity and compressed air to operate the aircraft's instruments, lights, ventilation, and other equipment and to start the aircraft main engines. If ground-based power or air is not available, the APU may be operated for extended periods when the aircraft is on the ground with its engines shut down.

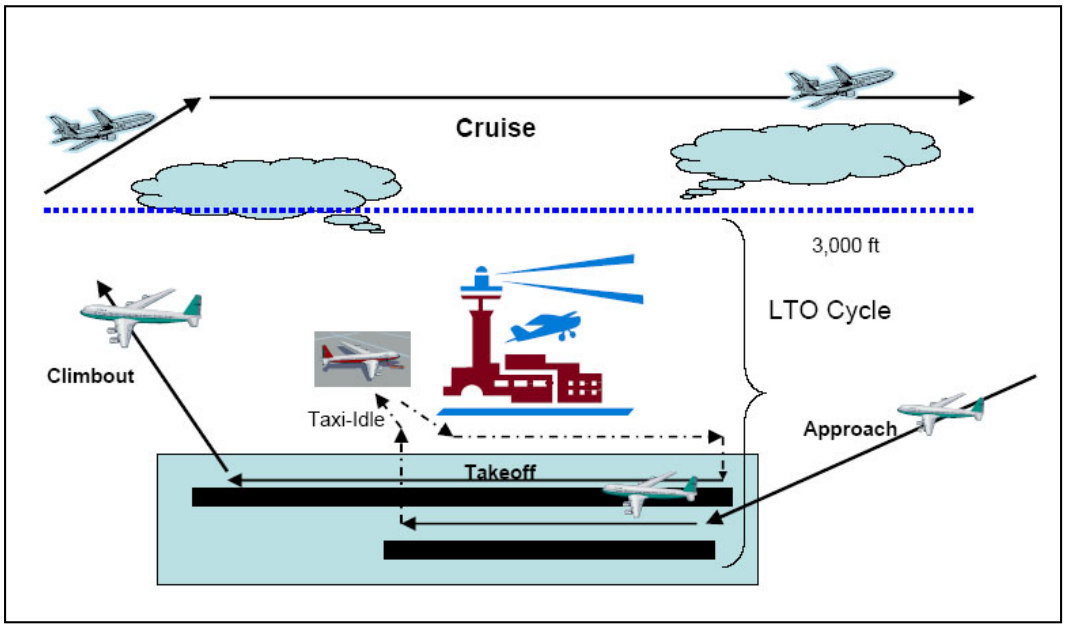
   For aircraft emissions, an inventory often presents emissions in two or three ways: Landing and takeoff-cycle (LTO), total fuel dispensed to aircraft at the airport, or a combination of these first two. The LTO cycle, shown below, only captures emissions associated with an aircraft at an individual airport up to an altitude of 3,000 feet. Fuel dispensed at an airport, reflects the fuel needed by individual aircraft leaving the airport, necessary to fly to their destination. ACRP Report 11 suggests using both in such a way to report cruise-related emissions, by subtracting LTO emissions from fuel dispensed.

2. **Ground support equipment** (GSE): A variety of ground equipment service commercial aircraft while they unload and load passengers and freight at an airport. GSE primarily consists of vehicles that do not leave the airfield, such as aircraft tugs, air start units, loaders, tractors, ground power units, cargo-moving equipment, service vehicles, etc. In

[7] Air Transport Action Group. https://www.atag.org/our-publications/latest-publications.html

general, GSE are off-road vehicles and include vehicles of the airport operator that maintain airport facilities (such as snow removal, firefighting, etc.).

FIGURE I-2
LANDING AND TAKEOFF CYCLE



Four LTO Modes: approach, taxi-in/taxi-out, takeoff, and climbout.

3. **Ground access vehicles** (GAV): Ground access vehicles (GAV) encompass all on-road or highway vehicle trips generated by the users of an airport. GAV include all vehicles traveling to and from, as well as within the airport public roadway system (excluding GSE). On-road and highway vehicles include privately-owned vehicles, government-owned vehicles, rental cars, hotel shuttles, buses, taxicabs/Uber/Lyft, private passenger vehicles, and trucks. For purposes of a greenhouse gas inventory, the on-airport roadway travel is itemized separately from the off-airport travel.
4. **Airport infrastructure and stationary sources** include sources such energy for lighting, cooling, etc. Included in airport infrastructure is purchased electricity, natural gas, propane, and stationary sources such as generators.
5. **Airport and airline maintenance industrial activities**.
6. **Airport construction activities.**

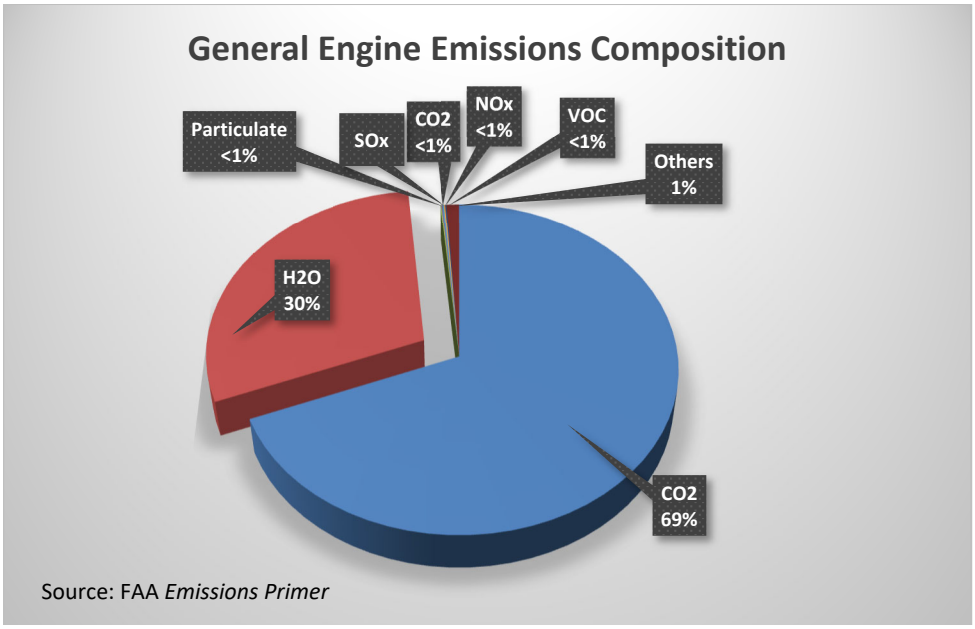
Depending on the airport, other sources of emissions may arise directly and/or indirectly. For example, some airports account for emissions produced by waste. The Jackson Hole Airport is currently going through the steps to improve its waste management and recycling programs. Perhaps future efforts could include attempting to capture emissions savings from reductions in waste.

Because the inventory documented in this report is the first in-depth greenhouse gas inventory for Jackson Hole Airport related sources, it is scoped to consider only emissions from the first four

sources (aircraft/APU, GSE, GAV, and airport infrastructure) as they are expected to be the dominant (key) sources of greenhouse gases. It is possible that in the future, construction and maintenance activities associated with Jackson Hole Airport may be itemized.

Aircraft are probably the most often cited air pollutant source, but as is noted in FAA materials, they produce the same types of emissions as cars. Aircraft jet engines, like many other vehicle engines, produce carbon dioxide (CO_2), water vapor (H_2O), nitrogen oxides (NO_x), carbon monoxide (CO), oxides of sulfur (SO_x), unburned or partially combusted hydrocarbons [also known as volatile organic compounds (VOCs)], particulates, and other trace compounds. **Figure I-3** shows the approximate composition of aircraft engine emissions.

FIGURE I-3



The *FAA's Emissions Primer* further notes that:

> About 10 percent of aircraft emissions of all types, except hydrocarbons (i.e., VOC) and CO, are produced during airport ground level operations and during landing and takeoff. The bulk of aircraft emissions (90 percent) occur at higher altitudes. For hydrocarbons and CO, the split is closer to 30 percent ground level emissions and 70 percent at higher altitudes.

The IPCC estimated that global aircraft emissions accounted for about 3.5% of the total radiative forcing by all man-made activities. However, the scientific community has identified areas that need further study to enable them to more precisely estimate aviation's effects on the global atmosphere. As for the contributions of US aviation relative to other US industrial sources, data from the USEPA show that aircraft accounted for about 3% of US greenhouse gas emissions

(nearly 3.1% of CO_2 or 3.4% of CO_{2eq}).[8] As the US General Accounting Office (GAO) noted[9] "global aviation emissions of carbon dioxide (measured in million metric tons of carbon) are a small percentage of carbon emissions worldwide; however, they are roughly equivalent to the carbon emissions of certain industrialized countries."

The GAO report noted the importance of aircraft emissions in greenhouse gases for the following reasons:

- Jet aircraft are the primary source of human emissions deposited directly into the upper atmosphere. The IPCC noted that some of these emissions have a greater warming effect than they would have if they were released in equal amounts at the surface.
- CO_2 is relatively well understood and is the main focus of international concern, as it survives in the atmosphere for about 100 years and contributes to warming the earth.
- CO_2 emissions combined with other gases and particles emitted by jet aircraft - including water vapor, nitrogen oxide and nitrogen dioxide (collectively termed NOx), and soot and sulfate — could have two to four times as great an effect on the atmosphere as carbon dioxide alone.
- The IPCC concluded that the increase in aviation emissions attributable to a growing demand for air travel would not be fully offset by reductions in emissions achieved through technological improvements alone. Experts agree that the aviation industry will continue to grow globally and contribute increasingly to human-generated emissions. The experts differ, however, in the rates of growth they project and the effects they anticipate.

8 USEPA, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2005*, USEPA #430-R-07-002, April 15, 2007 available at: http://www.epa.gov/climatechange/emissions/usinventoryreport.html

9 US General Accounting Office (GAO) *Environment: Aviation's Effects on the Global Atmosphere Are Potentially Significant and Expected to Grow*; GAO/RCED-00-57, February 2000.

II. INVENTORY PROTOCOL

This chapter documents the methodologies used to prepare the 2017 greenhouse gas emissions inventory for Jackson Hole Airport. This chapter discusses:

- Jackson Hole Airport organization and operational boundaries
- Methods to quantify airport-related sources
- Uncertainties and Data Cautions

The principles by which this inventory was prepared reflect general factors considered in most greenhouse gas inventories:

- *Relevance* means that the inventory includes the appropriate facilities and types of emissions sources to meet the entity's goals.
- *Completeness* means that an adequate percentage of the entity's (i.e., Jackson Hole Airport Board) total facilities and emissions sources have been included in the inventory.
- *Accuracy* means using accepted quantification methods and emissions factors as well as managing data quality.
- *Transparency* means that the important boundary decisions, data sources, and quantification methods are well documented.
- *Consistency* means that the same facilities, emissions sources, and emissions quantification methods are used from year to year. Therefore, this inventory was prepared in a transparent way to enable emissions presented herein to be re-tabulated as needed. As noted earlier, however, it is anticipated that the approach to considering airport-related emissions will evolve over time.

II.1 JACKSON HOLE AIRPORT ORGANIZATION AND OPERATIONAL BOUNDARIES

While a standard greenhouse gas inventory protocol has not been developed for the airport setting, protocols have evolved from a number of sources that can be used in whole or part including:

- **Intergovernmental Panel on Climate Change** (IPCC) - focused on inventories for nations, but provides guidance for other parties on various sources, including aviation;
- **US EPA** - has prepared guidance for states to prepare inventories, but has also prepared a protocol through the Climate Leaders effort to assist other entities with consistent greenhouse gas inventories;
- **World Resource Institute (WRI)** an environmental think tank, in collaboration with the World Business Council for Sustainable Development, has developed comprehensive guidance to assist corporations with preparing emission inventories, both representing the corporate entity as well as corporate projects.
- **International Council for Local Environmental Initiatives (ICLEI)** - is an international association of local governments and national and regional local government organizations that have made a commitment to sustainable development. ICLEI has implemented a program titled, the Cities for Climate Protection (CCP) to assists cities with adopting policies and programs to reduce local greenhouse gas emissions, improve air quality, and

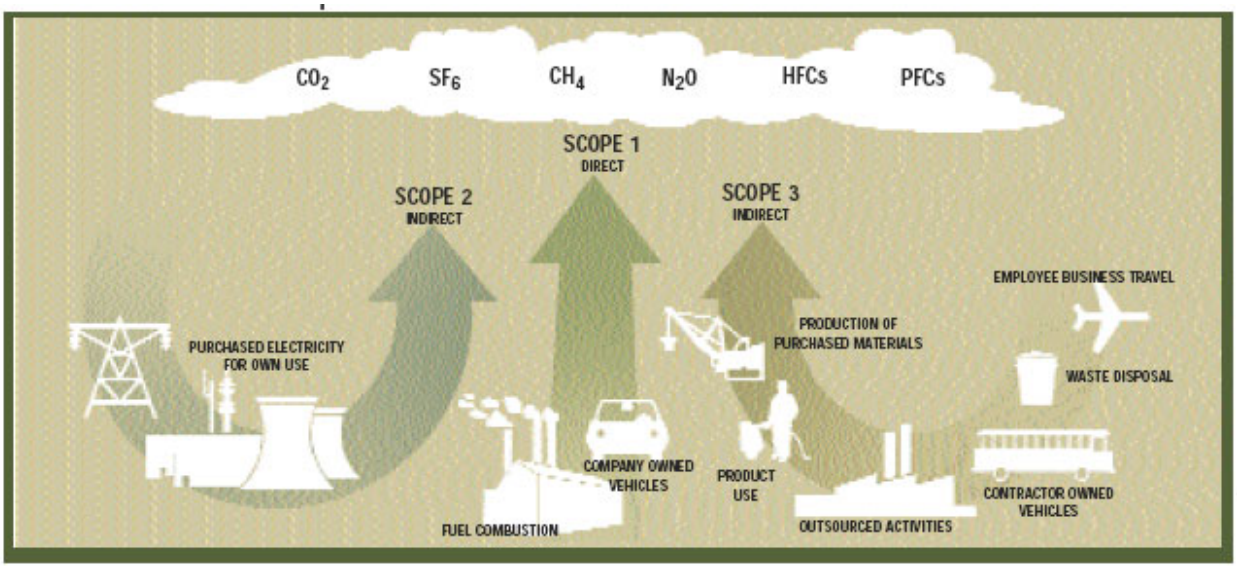
enhance urban livability and sustainability. According to their web site, more than 800 local governments participate in the CCP.

As noted by these protocols, for a greenhouse gas inventory to be of use, it must convey information in a way that allows the data to be useful and must document the conditions associated with the reporting entity. In most cases, the preparation of an inventory enables the identification of notable or key sources of greenhouse gases associated with the reporting entity and the identification of measures to reduce those emissions. To be useful, it requires the use an appropriate inventory boundary that reflects "the substance and economic reality of the entities activities" and responsibilities and presents emissions at a source level that enables the capture of changes in emissions over time and with mitigation/offset. For corporate entities, this often relates to the legal form of the business. For governmental parties, this can become less clear, but typically focuses on emissions directly from the governmental activities (sources owned by the entity), as well as those within its control. Thus, the choice of the inventory boundary is typically dependent on the characteristics of the entity, the intended purpose of the information, and the needs of the information users.

EPA and WRI guidance suggest that the following be considered when establishing the boundaries:

- **Organizational structure**: The structure, as reflected by control through ownership, legal agreements, joint ventures, etc. In the case of the Jackson Hole Airport, the organization boundaries were limited for this review to the Airport Board's activities and associated emissions.
- **Operational boundaries**: Once an entity has determined its organizational boundaries in terms of the operations that it owns or controls, it then sets its operational boundaries. This involves identifying the emissions associated with its operations and categorizing them as *direct, indirect, and optional emissions.*
    - **Direct/Scope 1** emissions are from sources that are owned or controlled by the party. For example, emissions from combustion in owned or controlled boilers, furnaces, vehicles, etc. The WRI methods refer to direct emissions as Scope 1 emissions. In the case of Jackson Hole Airport, direct emissions reflect energy consumed by Airport facilities, and fuel powering Airport owned vehicles.
    - **Scope 2** emissions are associated with the purchase of electricity necessary to power airport facilities. All electrical power billed to Jackson Hole Airport is reflected in Scope 2 emissions**.**
    - **Scope 3/ Optional** is a reporting category that allows for the identification of all other emissions that are a consequence of the activities of the entity but occur from sources not owned or controlled by the entity.

FIGURE II-1
WRI BOUNDARIES - SCOPE 1, 2, AND 3



Given the organization boundaries, the operational boundary for the Airport was defined as the Airport Board's land at Jackson Hole Airport. This land comprises the 533 acres of parkland subject to the Use Agreement with the airport. Because of the visibility of aircraft and their emissions within the physical boundaries of the Airport, as well as other activities by tenants, attempts were made to capture the emissions with those activities and note that they are owned and controlled by airlines/tenants and private parties using the Airport. In addition, because of the high amount of on-road vehicular travel associated with passengers using the Airport, emissions from these sources were also quantified based on the information available, but noted as associated with public (private) activities. The inclusion of these emissions provides further information about Airport-related activities and their associated emissions.

An important element of the inventory protocol is the use of proper boundaries that avoid the double counting of emissions. As noted in the IPCC 2017 guidance[10] "National inventories include greenhouse gas emissions and removals taking place within national territory and offshore areas over which the country has jurisdiction… For example, emissions from fuel used in road transport are included in the emissions of the country where the fuel is sold and not where the vehicle is driven, as fuel sale statistics are widely available and usually much more accurate."

In an airport setting, the issue of ownership is clear, as ownership is related to the party that has title to the asset (i.e., the aircraft is owned or leased by an airline or private entity, most buildings and facilities are owned by the Airport, but may be the subject of a long-term lease by a tenant). However, control can be more difficult to identify, as many parties contribute to the control of various sources. Therefore, the Jackson Hole Airport inventory identifies sources of emissions and attempts to focus first on ownership and then control.

[10] *2017 IPCC Guidelines for Preparing National Greenhouse Gas Inventories , Volume I - General Guidance and Reporting*, IPCC, 2017, Page 1.4

II.2 METHODS USED TO QUANTIFY GREENHOUSE GASES AT JACKSON HOLE AIRPORT

Based on the types of sources at Jackson Hole Airport, emissions from the following were quantified:

II.2.1. Aircraft Emissions (Tenant or Public Owned Sources)

Aircraft greenhouse gas emissions would be expected to be the largest sources of greenhouse gases at most commercial service airports due to the fuel requirements of air travel. To quantify aircraft-related greenhouse gases, the following steps were used:

- Information concerning the quantity of fuel dispensed at Jackson Hole Airport to aircraft (jet fuel and aviation gas) was obtained by airport staff. In 2017, a total of 5,586,409 gallons of Jet-A and 24,264 gallons of Avgas were dispensed (sometimes referred to as fuel sales). Fuel dispensed represents the amount of fuel that airlines acquired at Jackson Hole Airport for departures to reach their desired destination. It does not reflect the fuel acquired in origin cities that is necessary to enable travel to Jackson (arrival-based fuel). While the arrival-based fuel consumption is not reflected in fuel dispensed, as it would be attributed to that flight origination city, a subsequent step accounts for arrival fuel consumption in the local setting and considers fuel consumed in the LTO approach mode.

  As noted earlier, fuel sales or fuel dispensed data does not account for fuel obtained in other locations that enables the aircraft to fly to Jackson Hole and, in some cases, achieve the desired destination (travel from Jackson Hole to a destination). This is often called "tankering." With the methodology used herein, fuel dispensed at another airport would result in the emissions then being associated with that other airport.

  Fuel dispensed can be translated into CO_2 emissions based on the US Energy Information Administration's estimate that about 21.095 pounds of CO_2 is generated by burning one gallon of Jet A fuel or 18.355 pounds of CO_2 per gallon of Avgas. Thus, aircraft fuel dispensed at Jackson Hole Airport generated about 48,981 metric tons of CO_2.

- In accord with the 2017 IPCC protocol, the Tier 2 method was used to quantify aircraft greenhouse gas. In Tier 2, the second step of the evaluation process requires the calculation of fuel burn in the LTO cycle (approach, taxi-in, taxi-out, takeoff, and climbout). To quantify emissions in the LTO cycle, the FAA's Aviation Environmental Design Tool (AEDT) Version 2d was used. In the LTO cycles, aircraft at Jackson Hole Airport consumed nearly 1.1 million gallons of fuel.

- Using the IPCC Tier 2 method, LTO based CO_2 emissions was subtracted from fuel dispensed CO_2 to identify cruise/residual CO_2 emissions. As APU use is also reflected in this emission, it is titled "residual/cruise/APU use".

  Data necessary to run the AEDT Version 2d includes:

  - Types and numbers of aircraft operating: FAA ASDi data was obtained for 2017 to identify all flights at Jackson Hole Airport and the types of aircraft being operated. Based on knowledge of the airline operating each flight, the specific aircraft type and engine combinations could be identified, using industry publications, such as *Jane's Information Group* - Airline Fleet and *JP Airline Fleets International*. Information about private aircraft operating at the Airport was used to further identify the types of general aviation aircraft. The aircraft fleet used in this analysis was closely coordinated with the noise analysis prepared for Jackson Hole Airport.

- Time-in-mode: FAA's T1 data was also accessed to identify the specific time that aircraft operating at Jackson Hole Airport operate to taxi-in and taxi-out. By using actual airport data, the analysis is able to incorporate any delay and inefficiencies that aircraft actually experience at a location. Default time-in-mode data was then used for approach, takeoff, and climbout, as these times are not known to vary substantially from airport to airport.

Fuel burn was then converted to emissions for each mode using the same factor as noted above. Emissions from the AEDT were then reported according to 1) approach, 2) taxi-in/taxi-out, 3) takeoff, and 4) climbout.

As the Jackson Hole Airport does not own, control, or operate aircraft, the emissions associated with these sources are identified as Scope 3/Airline/Tenant/Aircraft Operator-owned/controlled emissions.

The FAA's AEDT was used to quantify fuel burn for aircraft and resulting CO_2, but reports no other important greenhouse gases (i.e., methane). Because CO_2 is the largest total quantity directly emitted, and because consistent factors are not available for all pollutants, a CO_2 equivalent ($CO_{2\text{-eq}}$) is not evaluated in this report at this time. Further, FAA indicates that there is little, if any, methane emitted by aircraft.

II.2.2 Airport Fleet Vehicles/Ground Support Equipment (GSE)

This category refers to all airline/tenant-owned and airport-owned vehicles that support aircraft and airport activity or vehicles used to maintain an airport. In general, these vehicles are considered off-road as they do not typically travel off of the Airport.

Separate from airline/tenant GSE, the Jackson Hole Airport operates GSE (sometimes called fleet vehicles) that include firefighting equipment, snow removal, airport administrative ground travel, and airport maintenance vehicles. In 2017, the Airport purchased nearly 1,877 gallons of gasoline, 19,667 gallons of diesel fuel, and 5,545.8 gallons-equivalent of Propane that serviced airport owned vehicles and stationary sources. CO_2 emissions associated with the consumption of these fuels were computed based on standard CO_2 factors (i.e., 19.564 lbs. of CO_2 per gallon of gasoline, 22.384 lbs. of CO_2 per gallon of diesel). While propane is consumed by fleet vehicles, is it is also used in airport stationary equipment, and is listed separately. When reviewing the liquid fuel data, it became clear that reported gas and diesel fuel was used exclusively by Jackson Hole Airport employees. However, for propane, some of the fuel is used by Airport staff but also by tenants. It was not possible to separate out the tenant information.

II.2.3 Ground Access Vehicles (GAV)

Ground access vehicles (GAV) generally are all of the street-licensed vehicles that operate to and from the Airport. GAV vehicles at Jackson Hole Airport are primarily associated with passengers, employees, and airport deliveries. Limited data exists for ground access vehicle use associated with Jackson Hole Airport. Therefore, substantial estimates were made to identify GAV travel and thus emissions.

In 2017, Jackson Hole Airport accommodated 341,192 enplaned passengers (passengers boarding aircraft, or 682,380 total enplaned and deplaned passengers).[11] A total of 29,444 annual aircraft operations occurred. [12] Based on this level of enplaned passenger travel, as well as the general aviation activity-related travel, estimates were necessary to determine the mode

[11] Source: FAA Terminal Area Forecast. 3-2019.
[12] Source: FAA Terminal Area Forecast. 3-2019.

that passengers travel to and from the Airport. The following assumptions were made to arrive at an estimate of GAV travel and the emissions from GAV sources.

- Based upon a 2016/2017 survey,[13] it was assumed that each travel party consists of 3.2 passengers. Each travel party was assumed to generate a GAV movement.
- Information was collected from a key rental car company that showed the average rental car travels 70.2 miles per day and there were about 287,925 rental car days in 2017.
- Travel distance was determined using the driving distance (or straight-line if a driving distance was not available) from web site https://www.mapdevelopers.com/distance_from_to.php
- The 2016/2017 passenger survey indicated the passenger and local part-time resident travels mode as:
    i. Rental car 43%
    ii. Van/taxi 22%
    iii. Private vehicle 17%
    iv. Lodge/Shuttle 15%
    v. Others (charter bus, limo, etc.) 3%
- For passenger distance of travel, the 2016/17 survey place of stay data was also used:
    i. Town of Jackson 45%
    ii. Teton Village 33%
    iii. Between Jackson and Teton Village 9%
    iv. Grand Targhee 5%
    v. All others 8%

  The weighted average travel distance was 16.5 miles one way.
- An average fuel economy was obtained from the US Energy Administration (26.8 MPG) and assumed for non-taxi related travel. Taxi travel was assumed to have a 22.4 MPG per vehicle for light duty vehicles.

Airport employees reporting to duty at Jackson Hole Airport were also separately itemized. The Airport supplied information on the number of employees and distance travelled. The Airport Board employs about 86 individuals at JAC, with a work commute of up to 140 miles one way. The weighted average work commute, based on zip codes, was estimated as 35.5 miles. About 70% of the employees work a 4-day week, and 30% a 5-day week. Additionally, 15% of airport employees carpool to work.

Tenant employee commute information was estimated based upon airport staff estimating the number of non-Airport Board employees (about 500) and using the average travel distance of Airport Board employees (35.5 miles one way). It is estimated that 20% of the tenant employees work a 5-day week, and 80% work a 2-day week.

II.2.4. Facility/Stationary Source Emissions

Stationary fossil fuel burning equipment primarily include heating and cooling, power supplies for building (i.e., electrical consumption), and cooking activities. The following data was collected in order to quantify emissions from these sources:

[13] Jackson Hole Airport Winter 2016/2017 Passenger Survey Final Report prepared by RRC Associates.

- With limited exceptions, heating and cooling at Jackson Hole Airport is completed using purchased electricity. In addition, electricity is consumed to power lighting in the terminal, parking, support facilities, and airfield. Jackson Hole Airport records indicate that about 5,175,967 kilowatt hours (kWh) of electricity was purchased from Lower Valley Energy in 2017 by the Airport Board. Power associated with Hangars 4 and 5, which are tenant facilities, accounted for 178,840 kWh of electrical use. Rental car facility electrical use was not available at the time this report was prepared.
- The US EPA eGrid data for Wyoming was used to calculate greenhouse gas emissions from purchased electricity. eGrid data available was through 2016 which indicated 2,041 lbs of CO_2 are emitted per MWh. Information from Lower Valley Energy indicates that all power provided by the utility comes from Bonneville Power, which generates 87% of its power from hydropower, resulting in an emission factor of 27 lbs of CO2 per MWh.[14]

It is important to note that the Airport Board purchases it power from Lower Valley Energy, which is greenpower (i.e., predominantly renewable energy). At this time, the inventory does not capture the "credit" associated with greenpower, as the utility retains the energy reduction credits necessary to meet their energy portfolio goals.

[14] At 27 lbs/MWh CO_2, the Airport's purchased electricity emissions are 66 metric tons of CO_2, significantly lower than if the overall state of Wyoming eGrid factor was used, which would have produced 4,955 metric tons of CO_2.

III. EMISSIONS INVENTORY

Table III-1 provides a summary of the 2017 greenhouse gas inventory. Three colors are used to differentiate and separate the emissions by the previously discussed ownership and control, with a forth color (yellow) identifying the percent of totaling emissions by all three categories. As the table notes, 56,636 metric tons of CO_2 were emitted in 2017, not including the non-CO_2 greenhouse gases. Relative to this total, 1.37% are associated with Jackson Hole Airport owned or controlled activities, 95.42% of the emissions are associated with tenant/aircraft operator activities, and 3.22% by public access to/from the Airport and related travel.

TABLE III-1
SUMMARY OF GREENHOUSE GAS EMISSIONS ASSOCIATED WITH JACKSON HOLE AIRPORT ACTIVITY (2017)

User/Source Category	2017 CO2 (tons/year)	Percent of User	Percent of Total
Airport-owned/controlled			
Facilities/Stationary Sources	94	12.1%	0.2%
Ground Support Equipment	216	28.0%	0.4%
Ground Access Vehicles			
On-airport travel by non-employees	49	6.3%	0.1%
Airport Employee Commute (all roads)	415	53.6%	0.7%
Subtotal	**774**	**100.0%**	**1.37%**
Airlines/Tenants/Aircraft Operator-owned/controlled			
Aircraft			
Approach	2,380	4.4%	4.2%
Taxi/Idle/Delay	5,168	9.6%	9.1%
Takeoff	714	1.3%	1.3%
Climbout	2,028	3.8%	3.6%
Residual/Cruise/APU	43,366	80.2%	76.6%
Sub-total	53,656	99.3%	94.7%
Ground Support Equipment	NA	NA	NA
Ground Access Vehicles			
Tenant GAV	NA	NA	NA
Tenant Employee Commute (all roads)	382	0.7%	0.7%
Stationary Sources (purchased electricity)*	2	0.7%	0.7%
Subtotal	**54,040**	**100.0%**	**95.42%**
Public-owned/controlled			
All on-road travel	1,822	100.0%	3.2%
Subtotal	**1,822**	**100.0%**	**3.22%**
Total	**56,636**		**100%**

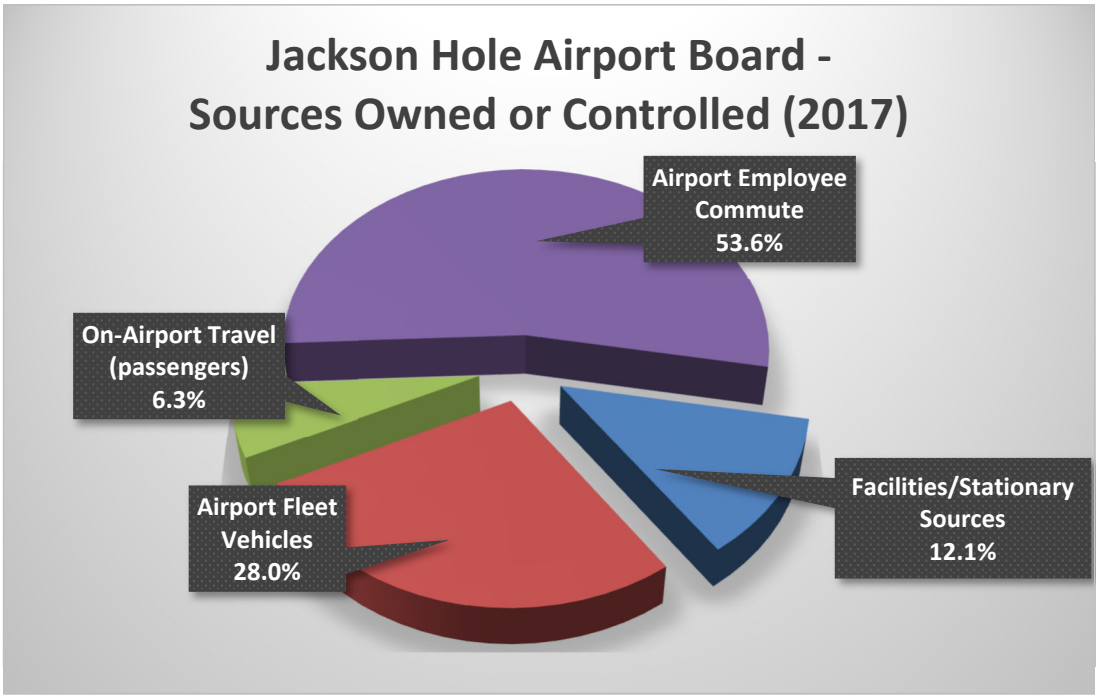
* Includes Hangars 4 and 5. Does not include rental car electrical consumption which was not available at the time the inventory was prepared.

Source: Synergy Consultants Inc and BridgeNet International 4-4-2019

III.1 JACKSON HOLE AIRPORT OWNED/CONTROLLED EMISSIONS

As noted in **Table III-1**, Jackson Hole Airport Board-related emissions represent 774 metric tons of CO_2 in 2017; these emissions reflect the greenhouse gas from sources owned or controlled by the Airport Board.

The largest portion of greenhouse gas emissions that the Airport controls is associated with airport employee work commute (53.6%) followed by airport fleet vehicles/ground support equipment (28.0%) and facility energy use (electricity and propane) (12.1%). The Airport Board purchases its power from Lower Valley Energy, which is greenpower (i.e., predominantly renewable energy). At this time, the inventory does not capture the "credit" associated with greenpower, as the utility retains the energy reduction credits necessary to meet their energy portfolio goals.



III.2 AIRLINE/TENANT/AIRCRAFT OPERATOR OWNED/CONTROLLED EMISSIONS

Airline/tenant/aircraft operator-owned and controlled emissions represent 95.4% of total airport-related emissions or 54,040 metric tons of CO_2 in 2017. As would be expected, aircraft represent the single largest source of CO_2 emissions for this category of source ownership at 99.3% (53,656 metric tons of CO_2), as shown in **Table III-1**.

III.3 PUBLIC-OWNED/CONTROLLED EMISSIONS

Within this inventory, all of the public-owned and controlled emissions reflect on-road travel associated with airport activity, either through employee and tenant work-commute travel or

vehicular access by passengers. Of airport-related emissions this user group represents 3.2% of all emissions or 1,822 metric tons of CO_2 in 2017.

Appendices

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Appendix A - Abbreviations, Glossary, and References

Abbreviations

ACRP - Airport Cooperative Research Program of the Transportation Research Board

AEDT – Aviation Environmental Design Tool

APU - Auxiliary Power Unit

CCP - Climate Protection Program of ICLEI

CO_2 - Carbon Dioxide

$CO_{2\text{-}eq}$ -Carbon Dioxide equivalent (sometimes CO_{2e})

EIA - Energy Information Administration of the Department of Energy

EPA - US Environmental Protection Agency

FAA - Federal Aviation Administration

GAV - Ground Access Vehicle

GHG - Greenhouse Gases

GSE - Ground Support Equipment

ICLEI - International Council for Local Environmental Initiatives

IPCC - Intergovernmental Panel on Climate Change

JAC - Jackson Hole Airport

kWh - Kilowatt hour

LTO - Landing and Takeoff Cycle

WRI - World Resource Institute

USEPA - US Environmental Protection Agency

Glossary

ABSORPTION OF RADIATION: The uptake of radiation by a solid body, liquid or gas. The absorbed energy may be transferred or re-emitted.

AEROSOL: Particulate matter, solid or liquid, larger than a molecule but small enough to remain suspended in the atmosphere. Natural sources include salt particles from sea spray, dust and clay particles as a result of weathering of rocks, both of which are carried upward by the wind. Aerosols can also originate as a result of human activities and are often considered pollutants. Aerosols are important in the atmosphere as nuclei for the condensation of water droplets and ice crystals, as participants in various chemical cycles, and as absorbers and scatters of solar radiation, thereby influencing the radiation budget of the Earth's climate system.

AFFORESTATION: Planting of new forests on lands that have not been recently forested.

AIR CARRIER: An operator (e.g., airline) in the commercial system of air transportation consisting of aircraft that hold certificates of Public Convenience and Necessity issued by the Department of Transportation to conduct scheduled or non-scheduled flights within the country or abroad.

AIR POLLUTION: One or more chemicals or substances in high enough concentrations in the air to harm humans, other animals, vegetation, or materials. Such chemicals or physical conditions (such as excess heat or noise) are called air pollutants.

ALTERNATIVE ENERGY: Energy derived from nontraditional sources (e.g., compressed natural gas, solar, hydroelectric, wind).

ANTHROPOGENIC: Human made. In the context of greenhouse gases, anthropogenic emissions are produced as the result of human activities.

ATMOSPHERE: The mixture of gases surrounding the Earth. The Earth's atmosphere consists of about 79.1 percent nitrogen (by volume), 20.9 percent oxygen, 0.036 percent carbon dioxide and trace amounts of other gases. The atmosphere can be divided into a number of layers according to its mixing or chemical characteristics, generally determined by its thermal properties (temperature). The layer nearest the Earth is the troposphere, which reaches up to an altitude of about 8 kilometers (about 5 miles) in the polar regions and up to 17 kilometers (nearly 11 miles) above the equator. The stratosphere, which reaches to an altitude of about 50 kilometers (31miles) lies atop the troposphere. The mesosphere, which extends from 80 to 90 kilometers atop the stratosphere, and finally, the thermosphere, or ionosphere, gradually diminishes and forms a fuzzy border with outer space. There is relatively little mixing of gases between layers.

AVIATION GASOLINE: All special grades of gasoline for use in aviation reciprocating engines, as cited in the American Society for Testing and Materials (ASTM) specification D 910. Includes all refinery products within the gasoline range that are to be marketed straight or in blends as aviation gasoline without further processing (any refinery operation except mechanical blending). Also included are finished components in the gasoline range, which will be used for blending or compounding into aviation gasoline.

BIODEGRADABLE: Material that can be broken down into simpler substances (elements and compounds) by bacteria or other decomposers. Paper and most organic wastes such as animal manure are biodegradable.

BIOFUEL: Gas or liquid fuel made from plant material (biomass). Includes wood, wood waste, wood liquors, peat, railroad ties, wood sludge, spent sulfite liquors, agricultural waste, straw, tires, fish oils, tall oil, sludge waste, waste alcohol, municipal solid waste, landfill gases, other waste, and ethanol blended into motor gasoline.

BIOMASS: Total dry weight of all living organisms that can be supported at each tropic level in a food chain. Also, materials that are biological in origin, including organic material (both living and dead) from above and below ground, for example, trees, crops, grasses, tree litter, roots, and animals and animal waste.

BIOMASS ENERGY: Energy produced by combusting biomass materials such as wood. The carbon dioxide emitted from burning biomass will not increase total atmospheric carbon dioxide if this consumption is done on a sustainable basis (i.e., if in a given period of time, re-growth of biomass takes up as much carbon dioxide as is released from biomass combustion). Biomass energy is often suggested as a replacement for fossil fuel combustion.

BRITISH THERMAL UNIT (Btu): The quantity of heat required to raise the temperature of one pound of water one degree of Fahrenheit at or near 39.2 degrees Fahrenheit.

BUNKER FUEL: Fuel supplied to ships and aircraft for international transportation, irrespective of the flag of the carrier, consisting primarily of residual and distillate fuel oil for ships and jet fuel for aircraft.

CARBON BLACK: An amorphous form of carbon, produced commercially by thermal or oxidative decomposition of hydrocarbons and used principally in rubber goods, pigments, and printer's ink.

CARBON CYCLE: All carbon reservoirs and exchanges of carbon from reservoir to reservoir by various chemical, physical, geological, and biological processes. Usually thought of as a series of the four main reservoirs of carbon interconnected by pathways of exchange. The four reservoirs, regions of the Earth in which carbon behaves in a systematic manner, are the atmosphere, terrestrial biosphere (usually includes freshwater systems), oceans, and sediments (includes fossil fuels). Each of these global reservoirs may be subdivided into smaller pools, ranging in size from individual communities or ecosystems to the total of all living organisms (biota).

CARBON DIOXIDE: A colorless, odorless, non-poisonous gas that is a normal part of the ambient air. Carbon dioxide is a product of fossil fuel combustion. Although carbon dioxide does not directly impair human health, it is a greenhouse gas that traps terrestrial (i.e., infrared) radiation and contributes to the potential for global warming.

CARBON EQUIVALENT (CE) or Carbon Dioxide Equivalent: A metric measure used to compare the emissions of the different greenhouse gases based upon their global warming potential (GWP). Greenhouse gas emissions in the United States are most commonly expressed as "million metric tons of carbon equivalents" (MMTCE). Global warming potentials are used to convert greenhouse gases to carbon dioxide equivalents ($CO_{2\text{-eq}}$).

CARBON SEQUESTRATION: The uptake and storage of carbon. Trees and plants, for example, absorb carbon dioxide, release the oxygen and store the carbon. Fossil fuels were at one time biomass and continue to store the carbon until burned.

CARBON SINKS: Carbon reservoirs and conditions that take-in and store more carbon (i.e., carbon sequestration) than they release. Carbon sinks can serve to partially offset greenhouse gas emissions. Forests and oceans are large carbon sinks.

CARBON TETRACHLORIDE (CCl_4): A compound consisting of one carbon atom and four chlorine atoms. It is an ozone depleting substance. Carbon tetrachloride was widely used as a raw material in many industrial applications, including the production of chlorofluorocarbons, and as a solvent. Solvent use was ended in the United States when it was discovered to be carcinogenic.

CHLOROFLUOROCARBONS (CFCs): Organic compounds made up of atoms of carbon, chlorine, and fluorine. An example is CFC-12 (CCl_2F_2), used as a refrigerant in refrigerators and air conditioners and as

a foam blowing agent. Gaseous CFCs can deplete the ozone layer when they slowly rise into the stratosphere, are broken down by strong ultraviolet radiation, release chlorine atoms, and then react with ozone molecules.

CLIMATE: The average weather, usually taken over a 30 year time period, for a particular region and time period. Climate is not the same as weather, but rather, it is the average pattern of weather for a particular region. Weather describes the short-term state of the atmosphere. Climatic elements include precipitation, temperature, humidity, sunshine, wind velocity, phenomena such as fog, frost, and hailstorms, and other measures of the weather.

CLIMATE CHANGE: The term "climate change" is sometimes used to refer to all forms of climatic inconsistency, but because the Earth's climate is never static, the term is more properly used to imply a significant change from one climatic condition to another. In some cases, "climate change" has been used synonymously with the term, "global warming"; scientists however, tend to use the term in the wider sense to also include natural changes in climate.

CLIMATE FEEDBACK: An atmospheric, oceanic, terrestrial, or other process that is activated by direct climate change induced by changes in radiative forcing. Climate feedbacks may increase (positive feedback) or diminish (negative feedback) the magnitude of the direct climate change.

CLIMATE SYSTEM (OR EARTH SYSTEM): The atmosphere, the oceans, the biosphere, the cryosphere, and the geosphere, together make up the climate system.

COMBUSTION: Chemical oxidation accompanied by the generation of light and heat.

CONCENTRATION: Amount of a chemical in a particular volume or weight of air, water, soil, or other medium.

CONIFEROUS TREES: Cone-bearing trees, mostly evergreens that have needle-shaped or scale-like leaves. They produce wood known commercially as softwood.

CONTRAIL: Contrails are line-shaped clouds or "condensation trails," composed of ice particles that are visible behind jet aircraft engines, typically at cruise altitudes in the upper atmosphere. Aircraft engines emit water vapor, carbon dioxide (CO_2), small amounts of nitrogen oxides (NOx), hydrocarbons, carbon monoxide, sulfur gases, and soot and metal particles formed by the high-temperature combustion of jet fuel during flight.

CRITERIA POLLUTANT: A pollutant determined to be hazardous to human health and regulated under EPA's National Ambient Air Quality Standards. The 1970 amendments to the Clean Air Act require EPA to describe the health and welfare impacts of a pollutant as the "criteria" for inclusion in the regulatory regime. In this report, emissions of the criteria pollutants are carbon monoxide (CO), nitrogen oxides (NOx), volatile organic compounds (VOCs), and sulfur oxides (SOx).

DECIDUOUS TREES: Trees such as oaks and maples that lose their leaves during part of the year.

DEFORESTATION: Those practices or processes that result in the conversion of forested lands for non-forest uses. This is often cited as one of the major causes of the enhanced greenhouse effect for two reasons: 1) the burning or decomposition of the wood releases carbon dioxide; and 2) trees that once removed carbon dioxide from the atmosphere in the process of photosynthesis are no longer present.

DISTILLATE FUEL OIL: A general classification for the petroleum fractions produced in conventional distillation operations. Included are products known as No. 1, No. 2, and No. 4 fuel oils and No. 1, No. 2,

and No. 4 diesel fuels. Used primarily for space heating, on and off-highway diesel engine fuel (including railroad engine fuel and fuel for agricultural machinery), and electric power generation.

EMISSION FACTOR: The rate at which pollutants are emitted into the atmosphere by one source or a combination of sources.

EMISSION INVENTORY: A list of air pollutants emitted into a community's, state's, nation's, or the Earth's atmosphere in amounts per some unit time (e.g. day or year) by type of source. An emission inventory has both political and scientific applications.

EMISSIONS COEFFICIENT/FACTOR: A unique value for scaling emissions to activity data in terms of a standard rate of emissions per unit of activity (e.g., grams of carbon dioxide emitted per barrel of fossil fuel consumed).

EMISSIONS: Releases of gases to the atmosphere (e.g., the release of carbon dioxide during fuel combustion). Emissions can be either intended or unintended releases.

ENERGY CONSERVATION: Reduction or elimination of unnecessary energy use and waste.

ENERGY INTENSITY: Ratio between the consumption of energy to a given quantity of output; usually refers to the amount of primary or final energy consumed per unit of gross domestic product.

ENERGY QUALITY: Ability of a form of energy to do useful work. High-temperature heat and the chemical energy in fossil fuels and nuclear fuels are concentrated high quality energy. Low quality energy such as low-temperature heat is dispersed or diluted and cannot do much useful work.\

ENERGY: The capacity for doing work as measured by the capability of doing work (potential energy) or the conversion of this capability to motion (kinetic energy). Energy has several forms, some of which are easily convertible and can be changed to another form useful for work. Most of the world's convertible energy comes from fossil fuels that are burned to produce heat that is then used as a transfer medium to mechanical or other means in order to accomplish tasks. In the United States, electrical energy is often measured in kilowatt-hours (kWh),while heat energy is often measured in British thermal units (Btu).

ENERGY-EFFICIENCY: The ratio of the useful output of services from an article of industrial equipment to the energy use by such an article; for example, vehicle miles traveled per gallon of fuel (mpg).

ENHANCED GREENHOUSE EFFECT: The concept that the natural greenhouse effect has been enhanced by anthropogenic emissions of greenhouse gases. Increased concentrations of carbon dioxide, methane, and nitrous oxide, CFCs, HFCs, PFCs, SF6, NF3, and other photochemically important gases caused by human activities such as fossil fuel consumption, trap more infra-red radiation, thereby exerting a warming influence on the climate.

ENPLANEMENTS: The number of passengers on departing aircraft.

ETHANOL (C_2H_5OH): Otherwise known as ethyl alcohol, alcohol, or grain spirit. A clear, colorless, flammable oxygenated hydrocarbon with a boiling point of 78.5 degrees Celsius in the anhydrous state. In transportation, ethanol is used as a vehicle fuel by itself (E100), blended with gasoline (E85), or as a gasoline octane enhancer and oxygenate (10 percent concentration).

FAA ASDi (Aircraft Situation Display to Industry): This represents data collected by the FAA that tracks the minute-by-minute progress of their aircraft in real-time. The ASDI information includes the location, altitude, airspeed, destination, estimated time of arrival and tail number or designated identifier of air carrier and general aviation aircraft operating on IFR flight plans within U.S. airspace.

FAA T-1 DATA: This data base refers to information collected by the FAA and reported by the Bureau of Transportation Statistics concerning on-time arrival data for non-stop domestic flights by major air carriers, and provides such additional items as departure and arrival delays, origin and destination airports, flight numbers, scheduled and actual departure and arrival times, cancelled or diverted flights, taxi-out and taxi-in times, air time, and non-stop distance.

FIXED BASED OPERATOR (FBO): A private operator that may conduct refueling, aircraft or ground support equipment services for others at the airport.

FLUOROCARBONS: Carbon-fluorine compounds that often contain other elements such as hydrogen, chlorine, or bromine. Common fluorocarbons include chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), hydrofluorocarbons (HFCs), and perfluorocarbons (PFCs).

FORCING MECHANISM: A process that alters the energy balance of the climate system (i.e., changes the relative balance between incoming solar radiation and outgoing infrared radiation from Earth). Such mechanisms include changes in solar irradiance, volcanic eruptions, and enhancement of the natural greenhouse effect by emission of carbon dioxide.

FOREST: Terrestrial ecosystem (biome) with enough average annual precipitation (at least 76 centimeters or 30 inches) to support growth of various species of trees and smaller forms of vegetation.

FOSSIL FUEL: A general term for buried combustible geologic deposits of organic materials, formed from decayed plants and animals that have been converted to crude oil, coal, natural gas, or heavy oils by exposure to heat and pressure in the Earth's crust over hundreds of millions of years.

FOSSIL FUEL COMBUSTION: Burning of coal, oil (including gasoline), or natural gas. The burning needed to generate energy release carbon dioxide by-products that can include unburned hydrocarbons, methane, and carbon monoxide. Carbon monoxide, methane, and many of the unburned hydrocarbons slowly oxidize into carbon dioxide in the atmosphere. Common sources of fossil fuel combustion include cars and electric utilities.

FUGITIVE EMISSIONS: Unintended gas leaks from the processing, transmission, and/or transportation of fossil fuels, CFCs from refrigeration leaks, SF6 from electrical power distributor, etc.

GENERAL AVIATION: That portion of civil aviation, which encompasses all facets of aviation except air carriers. It includes any air taxis, commuter air carriers, and air travel clubs, which do not hold Certificates of Public Convenience and Necessity.

GEOTHERMAL ENERGY: Heat transferred from the Earth's molten core to underground deposits of dry steam (steam with no water droplets), wet steam (a mixture of steam and water droplets), hot water, or rocks lying fairly close to the Earth's surface.

GLOBAL WARMING POTENTIAL (GWP): The index used to translate the level of emissions of various gases into a common measure in order to compare the relative radiative forcing of different gases without directly calculating the changes in atmospheric concentrations. GWPs are calculated as the ratio of the radiative forcing that would result from the emissions of one kilogram of a greenhouse gas to that from the emission of one kilogram of carbon dioxide over a period of time (usually 100 years). Gases involved in complex atmospheric chemical processes have not been assigned GWPs.

GLOBAL WARMING: The progressive gradual rise of the Earth's surface temperature thought to be caused by the greenhouse effect and responsible for changes in global climate patterns.

GREENHOUSE EFFECT: Trapping and build-up of heat in the atmosphere (troposphere) near the Earth's surface. Some of the heat flowing back toward space from the Earth's surface is absorbed by water vapor, carbon dioxide, ozone, and several other gases in the atmosphere and then reradiated back toward the Earth's surface. If the atmospheric concentrations of these greenhouse gases rise, the average temperature of the lower atmosphere will gradually increase.

GREENHOUSE GAS (GHG): Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include, but are not limited to, water vapor, carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), hydrochlorofluorocarbons (HCFCs), ozone (O3), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF6).

HEAT CONTENT: The amount of heat per unit mass released upon complete combustion.

HEAT: Form of kinetic energy that flows from one body to another when there is a temperature difference between the two bodies. Heat always flows spontaneously from a hot sample of matter to a colder sample of matter. This is one way to state the second law of thermodynamics.

HYDROCARBONS: Substances containing only hydrogen and carbon. Fossil fuels are made up of hydrocarbons.

HYDROCHLOROFLUOROCARBONS (HCFCS): Compounds containing hydrogen, fluorine, chlorine, and carbon atoms. Although ozone depleting substances, they are less potent at destroying stratospheric ozone than chlorofluorocarbons (CFCs). They have been introduced as temporary replacements for CFCs and are also greenhouse gases.

HYDROELECTRIC POWER PLANT: Structure in which the energy of fading or flowing water spins a turbine generator to produce electricity.

HYDROFLUOROCARBONS (HFCS): Compounds containing only hydrogen, fluorine, and carbon atoms. They were introduced as alternatives to ozone depleting substances in serving many industrial, commercial, and personal needs. HFCs are emitted as by-products of industrial processes and are also used in manufacturing. They do not significantly deplete the stratospheric ozone layer, but they are powerful greenhouse gases with global warming potentials ranging from 140 (HFC-152a) to 11,700 (HFC-23).

HYDROPOWER: Electrical energy produced by falling or flowing water.

HYDROSPHERE: All the Earth's liquid water (oceans, smaller bodies of fresh water, and underground aquifers), frozen water (polar ice caps, floating ice, and frozen upper layer of soil known as permafrost), and small amounts of water vapor in the atmosphere.

INDUSTRIAL SECTOR: Construction, manufacturing, agricultural and mining establishments.

INFRARED RADIATION: The heat energy that is emitted from all solids, liquids, and gases. In the context of the greenhouse issue, the term refers to the heat energy emitted by the Earth's surface and its atmosphere. Greenhouse gases strongly absorb this radiation in the Earth's atmosphere, and re-radiate some of it back towards the surface, creating the greenhouse effect.

INORGANIC COMPOUND: Combination of two or more elements other than those used to form organic compounds.

INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC): The IPCC was established jointly by the United Nations Environment Programme and the World Meteorological Organization in 1988. The purpose of the IPCC is to assess information in the scientific and technical literature related to all significant components of the issue of climate change. The IPCC draws upon hundreds of the world's

expert scientists as authors and thousands as expert reviewers. Leading experts on climate change and environmental, social, and economic sciences from some 60 nations have helped the IPCC to prepare periodic assessments of the scientific underpinnings for understanding global climate change and its consequences. With its capacity for reporting on climate change, its consequences, and the viability of adaptation and mitigation measures, the IPCC is also looked to as the official advisory body to the world's governments on the state of the science of the climate change issue. For example, the IPCC organized the development of internationally accepted methods for conducting national greenhouse gas emission inventories.

INTERNATIONAL COUNCIL FOR LOCAL ENVIRONMENTAL INITIATIVES (ICLEI):http:/www.iclei.org/ is an international association of local governments and national and regional local government organizations that have made a commitment to sustainable development. More than 630 cities, towns, counties, and their associations worldwide comprise ICLEI's growing membership. ICLEI works with these and hundreds of other local governments through international performance-based, results-oriented campaigns and programs. The ICLEI Cities for Climate Protection (CCP) Campaign assists cities to adopt policies and implement quantifiable measures to reduce local greenhouse gas emissions, improve air quality, and enhance urban livability and sustainability. More than 800 local governments participate in the CCP, integrating climate change mitigation into their decision-making processes. http://www.iclei.org/index.php?id=800

JET FUEL: Includes both naphtha-type and kerosene-type fuels meeting standards for use in aircraft turbine engines. Although most jet fuel is used in aircraft, some is used for other purposes such as generating electricity.

JOULE: The energy required to push with a force of one Newton for one meter.

KEROSENE: A petroleum distillate that has a maximum distillation temperature of 401 degrees Fahrenheit at the 10 percent recovery point, a final boiling point of 572 degrees Fahrenheit, and a minimum flash point of 100 degrees Fahrenheit. Used in space heaters, cookstoves, and water heaters, and suitable for use as an illuminant when burned in wick lamps.

KYOTO PROTOCOL: An international agreement struck by nations attending the Third Conference of Parties (COP) to the United Nations Framework Convention on Climate Change (held in December of 1997 in Kyoto, Japan) to reduce worldwide emissions of greenhouse gases. If ratified and put into force, individual countries have committed to reduce their greenhouse gas emissions by a specified amount.

LANDING AND TAKEOFF CYCLE (LTO): LTO refers to an aircraft's landing and takeoff (LTO) cycle. One aircraft LTO is equivalent to two aircraft operations (one landing and one takeoff). The standard LTO cycle begins when the aircraft crosses into the mixing zone as it approaches the airport on its descent from cruising altitude, lands and taxis to the gate. The cycle continues as the aircraft taxis back out to the runway for takeoff and climbout as its heads out of the mixing zone and back up to cruising altitude. The five specific operating modes in a standard LTO are: approach, taxi/idle-in, taxi/idle-out, takeoff, and climbout. Most aircraft go through this sequence during a complete standard operating cycle.

LIFETIME (ATMOSPHERIC): The lifetime of a greenhouse gas refers to the approximate amount of time it would take for the anthropogenic increment to an atmospheric pollutant concentration to return to its natural level (assuming emissions cease) as a result of either being converted to another chemical compound or being taken out of the atmosphere via a sink. This time depends on the pollutant's sources and sinks as well as its reactivity. The lifetime of a pollutant is often considered in conjunction with the mixing of pollutants in the atmosphere; a long lifetime will allow the pollutant to mix throughout the atmosphere. Average lifetimes can vary from about a week (e.g., sulfate aerosols) to more than a century (e.g., CFCs, carbon dioxide).

LIGHT-DUTY VEHICLES: Automobiles and light trucks combined.

LIQUEFIED NATURAL GAS (LNG): Natural gas converted to liquid form by cooling to a very low temperature.

LIQUEFIED PETROLEUM GAS (LPG): Ethane, ethylene, propane, propylene, normal butane, butylene, and isobutane produced at refineries or natural gas processing plants, including plants that fractionate new natural gas plant liquids.

LONGWAVE RADIATION: The radiation emitted in the spectral wavelength greater than 4 micrometers corresponding to the radiation emitted from the Earth and atmosphere. It is sometimes referred to as terrestrial radiation or infrared radiation, although somewhat imprecisely.

LOW EMISSION VEHICLE (LEV): A vehicle meeting the low-emission vehicle standards.

METHANE (CH_4): A hydrocarbon that is a greenhouse gas with a global warming potential most recently estimated at 21. Methane is produced through anaerobic (without oxygen) decomposition of waste in landfills, animal digestion, decomposition of animal wastes, production and distribution of natural gas and petroleum, coal production, and incomplete fossil fuel combustion. The atmospheric concentration of methane has been shown to be increasing at a rate of about 0.6 percent per year and the concentration of about 1.7 per million by volume (ppmv) is more than twice its pre-industrial value. However, the rate of increase of methane in the atmosphere may be stabilizing.

METHANOL (CH_3OH): A colorless, poisonous liquid with essentially no odor and little taste. It is the simplest alcohol with a boiling point of 64.7 degrees Celsius. In transportation, methanol is used as a vehicle fuel by itself (M100), or blended with gasoline (M85).

METRIC TON: Common international measurement for the quantity of greenhouse gas emissions. A metric ton is equal to 1,000 kilograms, 2,204.6 pounds, or 1.1023 short tons.

MIXING HEIGHT: The height of the completely mixed portion of atmosphere that begins at the earth's surface and extends to a few thousand feet overhead where the atmosphere becomes fairly stable. See also "inversion".

MOBILE SOURCE: A moving vehicle that emits pollutants. Such sources include airplanes, cars, trucks and ground support equipment.

MONTREAL PROTOCOL ON SUBSTANCES THAT DEPLETE THE OZONE LAYER: The Montreal Protocol and its amendments control the phase-out of ozone depleting substances production and use. Under the Protocol, several international organizations report on the science of ozone depletion, implement projects to help move away from ozone depleting substances, and provide a forum for policy discussions. In the United States, the Protocol is implemented under the rubric of the Clean Air Act Amendments of 1990.

MOTOR GASOLINE: A complex mixture of relatively volatile hydrocarbons, with or without small quantities of additives, obtained by blending appropriate refinery streams to form a fuel suitable for use in spark-ignition engines. Motor gasoline includes both leaded and unleaded grades of finished gasoline, blending components, and gasohol.

NATURAL GAS: Underground deposits of gases consisting of 50 to 90 percent methane (CH_4) and small amounts of heavier gaseous hydrocarbon compounds such as propane (C_3H_4) and butane (C_4H_{10}).

NITROGEN CYCLE: Cyclic movement of nitrogen in different chemical forms from the environment, to organisms, and then back to the environment.

NITROGEN OXIDES (NO_X): Gases consisting of one molecule of nitrogen and varying numbers of oxygen molecules. Nitrogen oxides are produced, for example, by the combustion of fossil fuels in vehicles and electric power plants. In the atmosphere, nitrogen oxides can contribute to formation of photochemical ozone (smog), impair visibility, and have health consequences; they are considered pollutants.

NITROUS OXIDE (N_2O): A powerful greenhouse gas with a global warming potential most recently evaluated at 310. Major sources of nitrous oxide include soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, and biomass burning.

NONBIODEGRADABLE: Substance that cannot be broken down in the environment by natural processes.

NON-METHANE VOLATILE ORGANIC COMPOUNDS (NMVOCS): Organic compounds, other than methane, that participate in atmospheric photochemical reactions.

NON-POINT SOURCE: Large land area such as crop fields and urban areas that discharge pollutant into surface and underground water over a large area.

NUCLEAR ELECTRIC POWER: Electricity generated by an electric power plant whose turbines are driven by steam generated in a reactor by heat from the fissioning of nuclear fuel.

NUCLEAR ENERGY: Energy released when atomic nuclei undergo a nuclear reaction such as the spontaneous emission of radioactivity, nuclear fission, or nuclear fusion.

ORGANIC COMPOUND: Molecule that contains atoms of the element carbon, usually combined with itself and with atoms of one or more other element such as hydrogen, oxygen, nitrogen, sulfur, phosphorus, chlorine, or fluorine.

OXIDIZE: To chemically transform a substance by combining it with oxygen.

OZONE: A colorless gas with a pungent odor, having the molecular form of O3, found in two layers of the atmosphere, the stratosphere and the troposphere. Ozone is a form of oxygen found naturally in the stratosphere that provides a protective layer shielding the Earth from ultraviolet radiation's harmful health effects on humans and the environment. In the troposphere, ozone is a chemical oxidant and major component of photochemical smog. Ozone can seriously affect the human respiratory system.

OZONE DEPLETING SUBSTANCE (ODS): A family of man-made compounds that includes, but is not limited to, chlorofluorocarbons (CFCs), bromofluorocarbons (halons), methyl chloroform, carbon tetrachloride, methyl bromide, and hydrochlorofluorocarbons (HCFCs). These compounds have been shown to deplete stratospheric ozone, and therefore are typically referred to as ODSs.

OZONE LAYER: Layer of gaseous ozone (O_3) in the stratosphere that protects life on Earth by filtering out harmful ultraviolet radiation from the sun.

OZONE PRECURSORS: Chemical compounds, such as carbon monoxide, methane, non-methane hydrocarbons, and nitrogen oxides, which in the presence of solar radiation react with other chemical compounds to form ozone, mainly in the troposphere.

PARTICULATE MATTER (PM): Solid particles or liquid droplets suspended or carried in the air.

PARTS PER BILLION (ppb): Number of parts of a chemical found in one billion parts of a particular gas, liquid, or solid mixture.

PARTS PER MILLION (ppm): Number of parts of a chemical found in one million parts of a particular gas, liquid, or solid.

PERFLUOROCARBONS (PFCs): A group of human-made chemicals composed of carbon and fluorine only. These chemicals (predominantly CF_4 and C_2F_6) were introduced as alternatives, along with hydrofluorocarbons, to the ozone-depleting substances. In addition, PFCs are emitted as by-products of industrial processes and are also used in manufacturing. PFCs do not harm the stratospheric ozone layer, but they are powerful greenhouse gases: CF_4 has a global warming potential (GWP) of 6,500 and C_2F_6 has a GWP of 9,200.

POINT SOURCE: A single identifiable source that discharges pollutants into the environment. Examples are smokestack, sewer, ditch, or pipe.

POLLUTION: A change in the physical, chemical, or biological characteristics of the air, water, or soil that can affect the health, survival, or activities of humans in an unwanted way. Some expand the term to include harmful effects on all forms of life.

POLYVINYL CHLORIDE (PVC): A polymer of vinyl chloride. It is tasteless, odorless and insoluble in most organic solvents. A member of the family vinyl resin, used in soft flexible films for food packaging and in molded rigid products, such as pipes, fibers, upholstery, and bristles.

RADIATION: Energy emitted in the form of electromagnetic waves. Radiation has differing characteristics depending upon the wavelength. Because the radiation from the Sun is relatively energetic, it has a short wavelength (e.g., ultraviolet, visible, and near infrared) while energy re-radiated from the Earth's surface and the atmosphere has a longer wavelength (e.g., infrared radiation) because the Earth is cooler than the Sun.

RADIATIVE FORCING: A change in the balance between incoming solar radiation and outgoing infrared (i.e., thermal) radiation. Without any radiative forcing, solar radiation coming to the Earth would continue to be approximately equal to the infrared radiation emitted from the Earth. The addition of greenhouse gases to the atmosphere traps an increased fraction of the infrared radiation, reradiating it back toward the surface of the Earth and thereby creates a warming influence.

RECYCLING: Collecting and reprocessing a resource so it can be used again. An example is collecting aluminum cans, melting them down, and using the aluminum to make new cans or other aluminum products.

REFORESTATION: Replanting of forests on lands that have recently been harvested.

RENEWABLE ENERGY: Energy obtained from sources that are essentially inexhaustible, unlike, for example, fossil fuels, of which there is a finite supply. Renewable sources of energy include wood, waste, geothermal, wind, photovoltaic, and solar thermal energy.

RESIDENCE TIME: Average time spent in a reservoir by an individual atom or molecule. Also, this term is used to define the age of a molecule when it leaves the reservoir. With respect to greenhouse gases, residence time usually refers to how long a particular molecule remains in the atmosphere.

RESIDUAL FUEL OIL: The heavier oils that remain after the distillate fuel oils and lighter hydrocarbons are distilled away in refinery operations and that conform to ASTM Specifications D396 and D975. Included are No. 5, a residual fuel oil of medium viscosity; Navy Special, for use in steam-powered vessels in government service and in shore power plants; and No. 6, which includes Bunker C fuel oil and is used for commercial and industrial heating, electricity generation, and to power ships. Imports of residual fuel oil include imported crude oil burned as fuel.

SECTOR: Division, most commonly used to denote type of energy consumer (e.g., residential) or according to the Intergovernmental Panel on Climate Change, the type of greenhouse gas emitter (e.g., industrial process).

SHORT TON: Common measurement for a ton in the United States. A short ton is equal to 2,000 lbs. or 0.907 metric tons.

SINK: A reservoir that uptakes a pollutant from another part of its cycle. Soil and trees tend to act as natural sinks for carbon.

SOLAR ENERGY: Direct radiant energy from the sun. It also includes indirect forms of energy such as wind, falling or flowing water (hydropower), ocean thermal gradients, and biomass, which are produced when direct solar energy interact with the Earth.

SOLAR RADIATION: Energy from the Sun. Also referred to as short-wave radiation. Of importance to the climate system, solar radiation includes ultra-violet radiation, visible radiation, and infrared radiation.

SOURCE: Any process or activity that releases a greenhouse gas, an aerosol, or a precursor of a greenhouse gas into the atmosphere.

STRATOSPHERE: Second layer of the atmosphere, extending from about 19 to 48 kilometers (12 to 30 miles) above the Earth's surface. It contains small amounts of gaseous ozone (O3), which filters out about 99 percent of the incoming harmful ultraviolet (UV) radiation. Most commercial airline flights operate at a cruising altitude in the lower stratosphere.

STRATOSPHERIC OZONE: See ozone layer.

SULFUR CYCLE: Cyclic movement of sulfur in different chemical forms from the environment, to organisms, and then back to the environment.

SULFUR DIOXIDE (SO_2): A compound composed of one sulfur and two oxygen molecules. Sulfur dioxide emitted into the atmosphere through natural and anthropogenic processes is changed in a complex series of chemical reactions in the atmosphere to sulfate aerosols. These aerosols are believed to result in negative radiative forcing (i.e., tending to cool the Earth's surface) and do result in acid deposition (e.g., acid rain).

SULFUR HEXAFLUORIDE (SF_6): A colorless gas soluble in alcohol and ether, slightly soluble in water. A very powerful greenhouse gas used primarily in electrical transmission and distribution systems and as a dielectric in electronics. The global warming potential of SF_6 is 23,900.

TEMPERATURE: Measure of the average speed of motion of the atoms or molecules in a substance or combination of substances at a given moment.

TERRESTRIAL: Pertaining to land.

TERRESTRIAL RADIATION: The total infrared radiation emitted by the Earth and its atmosphere in the temperature range of approximately 200 to 300 Kelvin. Terrestrial radiation provides a major part of the potential energy changes necessary to drive the atmospheric wind system and is responsible for maintaining the surface air temperature within limits of livability.

TRANSPORTATION SECTOR: Consists of private and public passenger and freight transportation, as well as government transportation, including military operations.

TROPOSPHERE: The lowest layer of the atmosphere and contains about 95 percent of the mass of air in the Earth's atmosphere. The troposphere extends from the Earth's surface up to about 10 to 15 kilometers. All weather processes take place in the troposphere. Ozone that is formed in the troposphere plays a significant role in both the greenhouse gas effect and urban smog.

ULTRAVIOLET RADIATION (UV): A portion of the electromagnetic spectrum with wavelengths shorter than visible light. The sun produces UV, which is commonly split into three bands of decreasing wavelength. Shorter wavelength radiation has a greater potential to cause biological damage on living organisms. The longer wavelength ultraviolet band, UVA, is not absorbed by ozone in the atmosphere. UVB is mostly absorbed by ozone, although some reaches the Earth. The shortest wavelength band, UVC, is completely absorbed by ozone and normal oxygen in the atmosphere.

UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC): The international treaty unveiled at the United Nations Conference on Environment and Development (UNCED) in June, 1992. The UNFCCC commits signatory countries to stabilize anthropogenic (i.e., human-induced) greenhouse gas emissions to "levels that would prevent dangerous anthropogenic interference with the climate system". The UNFCCC also requires that all signatory parties develop and update national inventories of anthropogenic emissions of all greenhouse gases not otherwise controlled by the Montreal Protocol. http://www.ipcc.ch/

VEHICLE MILES TRAVELED (VMT): One vehicle traveling the distance of one mile. Thus, total vehicle miles is the total mileage traveled by all vehicles.

VOLATILE ORGANIC COMPOUNDS (VOCs): Organic compounds that evaporate readily into the atmosphere at normal temperatures. VOCs contribute significantly to photochemical smog production and certain health problems.

WATER VAPOR: The most abundant greenhouse gas; it is the water present in the atmosphere in gaseous form. Water vapor is an important part of the natural greenhouse effect. While humans are not significantly increasing its concentration, it contributes to the enhanced greenhouse effect because the warming influence of greenhouse gases leads to a positive water vapor feedback. In addition to its role as a natural greenhouse gas, water vapor plays an important role in regulating the temperature of the planet because clouds form when excess water vapor in the atmosphere condenses to form ice and water droplets and precipitation.

WEATHER: Weather is the specific condition of the atmosphere at a particular place and time. It is measured in terms of such things as wind, temperature, humidity, atmospheric pressure, cloudiness, and precipitation. In most places, weather can change from hour-to-hour, day-to-day, and season-to-season. Climate is the average of weather over time and space. A simple way of remembering the difference is that climate is what you expect (e.g. cold winters) and 'weather' is what you get (e.g. a blizzard).

WORLD RESOURCE INSTITUTE (WRI): The World Resources Institute (WRI) is an environmental think tank. WRI, in combination with the World Business Council for Sustainable Development published guidance in 2005 concerning the development of greenhouse gas inventories. www.wri.org

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APPENDIX B

Jackson Hole Airport Greenhouse Gas Calculations

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Jackson Hole Airport CO2 Emissions

User/Source Category	2017 CO2 (tons/year)	Percent of User	Percent of Total
Airport-owned/controlled			
Facilities/Stationary Sources	94	12.1%	0.2%
Ground Support Equipment	216	28.0%	0.4%
Ground Access Vehicles			
On-airport travel by non-employees	49	6.3%	0.1%
Airport Employee Commute (all roads)	415	53.6%	0.7%
Subtotal	**774**	**100.0%**	**1.37%**
Airlines/Tenants/Aircraft Operator-owned/controlled			
Aircraft			
Approach	2,380	4.4%	4.2%
Taxi/Idle/Delay	5,168	9.6%	9.1%
Takeoff	714	1.3%	1.3%
Climbout	2,028	3.8%	3.6%
Residual/Cruise/APU	43,366	80.2%	76.6%
Sub-total	53,656	99.3%	94.7%
Ground Support Equipment	NA	NA	NA
Ground Access Vehicles			
Tenant GAV	NA	NA	NA
Tenant Employee Commute (all roads)	382	0.7%	0.7%
Stationary Sources (purchased electricity)*	2	0.7%	0.7%
Subtotal	**54,040**	**100.0%**	**95.42%**
Public-owned/controlled			
All on-road travel	1,822	100.0%	3.2%
Subtotal	**1,822**	**100.0%**	**3.22%**
Total	**56,636**		**100%**

* Includes Hangars 4 and 5. Does not include rental car electrical consumption which was not available at the time the inventory was prepared.

Jackson Hole Airport CO2 Emissions

Units of Energy

User/Source Category	2017	
Airport-owned/controlled		
Facilities/Stationary Sources		
- Electricity	5,175,967	Kwhr
Airport Fleet Vehicles		
- Fleet Vehicles Gas	1,876.70	Gallons
- Fleet Vehicles Diesel	19,666.70	Gallons
- Fleet Vehicles/stationary sources Propane	5,545.80	Gallon-eq
Airlines/Tenants/Aircraft Operator-owned/controlled		
Aircraft	29,444	Operations
- Jet A	5,586,409	Gallons
- AvGas	24,264	Gallons
Electrical Consumption*	178,840	kWh
Public-owned/controlled		
Passenger	682,384	Tot Pax

Passengers	682,384	TAF x 2
Enplanements	341,192	FAA TAF
Operations	29,444	FAA TAF

* Includes Hangars 4 and 5. Does not include rental car electrical consumption which was not available at the time the inventory was prepared.

Jackson Hole Airport

Greenhouse Gas Inventory - Facilities

Jackson Hole Airport -2017

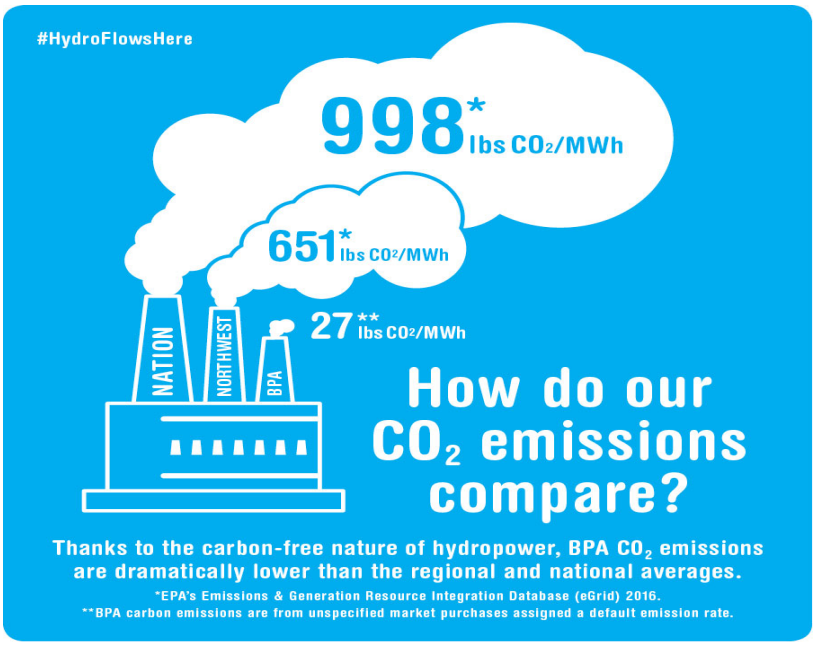
Airport Board owned/controlled

Power Type	Use	Units	Use	Source	CO2 Emission Rate (lb/unit)	Conver	Unit Conv	CO2 (tons)
Electrical	5,175,967	Kwh	See below	Airport staff	0.03	0.000453592	lbs to ton	63.4
Natural Gas	Not Applicable	Therms		NG (kg/therm)	-	0.001	kg to ton	0
Propane	5,545.8	Gal	See below	NG (lb/1000 ft3)	120.593	0.000453592	kg to ton	30.3
Fuel Oil/Diesel	NA	Gal		Diesel (lb/gal)		0.000453592	lbs to ton	0
					Total			93.7

Tenant Facilities

Power Type	Use	Units	Use	Source	CO2 Emission Rate (lb/unit)	Conver	Unit Conv	CO2 (tons)
Electrical	178,840	Kwh	See below	Airport staff	0.03	0.000453592	lbs to ton	2.2
Natural Gas	Not Applicable	Therms		NG (kg/therm)	-	0.001	kg to ton	0
Propane	Not available	Gal		NG (lb/1000 ft3)	120.593	0.000453592	kg to ton	NA
Fuel Oil/Diesel	Not Applicable	Gal		Diesel (lb/gal)		0.000453592	lbs to ton	0
					Total			2.2

eGrid output for 2016 (the most recent year) - State of Wyoming CO2e lb./MWh		2041.0 lb/MWh
	convert lb/MWh to lb/KWh	2.041
Lower Valley Energy data see graphic below		27.0 lb/MWh
		0.027



Jackson Hole Airport

Greenhouse Gas Inventory - Facilities

Airport Board Electrical use - below 5,175,967 kWh

Lower Valley Energy

Details of Electric Consumption

Energy Used / Amount Paid

Sub#	Service Code	Service Address	Meter#	Total 12/23/16-12/26/17	
001	Elec-S61	Airport GPS Building	14027055	-	$ 190.09
003	Elec-S61	Control Tower	14791419	83,320	$ 4,939.71
007	Elec-S61	Parking Lot Lights	14025796	64,869	$ 3,880.71
008	Elec-S61	Rescue & Firefighting	14792106	102,520	$ 6,047.50
009	Elec-S61	Runway 18-Mals	14620854	36,708	$ 2,287.60
010	Elec-S61	Runway 36-Mals	14025794	29,946	$ 1,899.87
011	Elec-S61	North Fuel Farm	14995980	9,233	$ 717.86
012	Elec-S61	Runway Snow Melt South	14791387	120	$ 198.87
013	Elec-S61	Runway Snow Melt North	14792091	1,920	$ 301.31
014	Elec-S61	JHG&T Noise Abatement	16414051	927	$ 244.86
015	Elec-S61	7750 SpringGulch Noise Abatement	14026470	187	$ 202.64
016	Elec-S61	4LazyF Noise Abatement	14619080	-	$ 192.00
018	Elec-S61	Moose Wilson Rd Noise Abatement	14622204	-	$ 192.00
019	Elec-L74	Hangar 1	14792070	221,800	$ 13,170.01
020	Elec-S61	Hangar 1 Office Space	14025795	4,137	$ 428.42
021	Elec-S61	Hangar 2	14792102	127,640	$ 7,495.37
022	Elec-L74	JH Airport North Wing	16932743	2,776,800	$ 150,809.88
023	Elec-L74	Airfield Lighting Vault	82287636	113,520	$ 8,986.43
024	Elec-L74	New South Service	84469738	1,577,200	$ 83,486.48
025	N/A	New Waste Water Plant	82287592	12,800	$ 776.11
026	Elec-S61	New Lift Station 2016	84469744	12,320	$ 895.57
				5,175,967	$ 287,343.29

Tenant Electrical	Hangar 4	62,600	kWh
	Hangar 5	116,240	kWh
	Total	178,840	kWh

Jackson Hole Airport

Greenhouse Gas Inventory - Facilities

Details of Propane Consumption			
Date	**Number**	**Use**	**Gallons**
01/25/17	1545-70180	Ops1 Propane22.9gal@2.4613	22.9
01/25/17	1438-036038	AirportFireplace/Heater 237.1g	237.1
01/25/17	1438-036037	MotorVehicleDispenser @112.3g	112.3
01/27/17	1438-010245	PropaneSteamerFireDept11.0gl	11
01/27/17	1438-010246	PropaneWWTP 598.6g	598.6
02/13/17	1438-010406	Fireplace/Heater@136.4g	136.4
02/13/17	1438-010407	MotorVehicleDispenser @155.7g	155.7
02/13/17	70473	PropaneDock 34gal@2.6313	34
02/23/17	5948	PropaneTankNozzleReplacement	
03/06/17	1438-029410	AirportFireplace/Heater@184.8g	184.8
03/14/17	63603	Bulk TankRental 1yr@14Mar17	
03/14/17	1438-010522	PropaneWWTP 515.0gal@2.8813	515
03/20/17	1438-029554	MotorVehicleDispenser @116.7g	116.7
03/27/17	71179	DockSale Vehicle42.2gl@2.4609	42.2
04/18/17	1438-010736	AirportFireplace/Heater@309.9g	309.9
04/24/17	1438-010787	MotorVehicleDispenser 137.3gal	137.3
05/18/17	1438-010989	Steamer-FireDept 32.9gal	32.9
05/18/17	1438-010988	Fireplace/Heater 230.6gal	230.6
06/05/17	1438-029790	MotorVehicleDispenser 138.6gal	138.6
06/28/17	1438-011470	MVDispenser 190.2gal	190.2
07/06/17	73490	DispenserParts	
07/14/17	146564	Heater PropTank 14Jul17@1yr	
07/15/17	1438-011533	Steamer-FireDept 13.0gal	13
07/15/17	1438-011532	Fireplace/Heater 349.7gal	349.7
07/28/17	1438-029901	MVDispenser 127.50gal	127.5
08/07/17	1438-70473CR	CQ#33494 CR 1438-70473	
08/14/17	167460	MVDispenseTank Rent 14Aug17@1y	
08/28/17	1438-020325	MVDispenser 151.0gal	151
09/08/17	75316	DockSale Vehicle12.60gl@2.8401	12.6
10/02/17	1438-020871	MVDispenser 106.0gal	106
10/09/17	1438-021002	Fireplace/Heater 47.4gal	47.4
10/09/17	1438-021003	Steamer-FireDept 41.60gal	41.6
10/20/17	1438-21243	MVDispenser 392.50gal	392.5
10/20/17	1438-21243	MVDispenser 392.5g@2.8950	
10/24/17	6301	Tank Regulator/Hose Install	
11/06/17	1438-021496	MVDispenser 218.0gal	218
11/24/17	1438-6372	Hook-up Hose to Heater	
11/26/17	1438-021774	MVDispenser 137.6gal	137.6
12/09/17	1438-022077	Fireplace/Heater 208.2g@2.950	208.2
12/09/17	1438-022078	MVDispenser 106.0g@2.950	106
12/15/17	251656	Bulk Tank Rental 1yr@15Dec17	
12/23/17	1438-022371	Fireplace/Heater 285.2g@2.950	285.2
12/23/17	1438-022372	MVDispenser 117.8g@2.950	117.8
12/23/17	1438-022373	Steamer-FireDept 25.5g@2.950	25.5
		Gallon equivalents	5545.8

JACKSON HOLE AIRPORT

Greenhouse Gas Inventory - GSE/Fleet Vehicles

Ground Support Equipment - GSE 2017

Off-Road GSE - Airport Fleet Vehicles

Power Type	Use	Units	Conversion Factors	Converted	CO2 factor	Units CO2	CO2 (tons)
Gasoline	1,876.70	gal	none	None	19.564	Lbs/gal	16.7
Diesel	19,666.70	Gal	none	None	22.384	lbs/gal	199.7
Propane	See facilities	GalEquiv			12.669	lbs/gal	NA
					Total		216.3

Source: Airport fuel records see below

No Tenant GSE Data Available

0.00045359237 Lbs/ton

Airport fuel records

JACKSON HOLE AIRPORT BOARD
Vehicle Fuel Log (in gallons)
YTD - QTR Summary FY 2017

Vehicle Name /	Fuel Used	2017 Jan-Mar	2017 Apr-Jun	2017 Jul-Sep	2017 Oct-Dec	Total 2017 YTD
PROPANE*						
2015 Ford F250 (Op#1)	Propane	230.80	207.30	159.10	309.60	906.80
2015 Ford F250 (Op#2)	Propane	196.20	177.50	205.40	286.40	865.50
	Total	427.00	384.80	364.50	596.00	1,772.30
	SUBPOP	639.50	466.10	291.10	1,077.90	2,474.60
	MTD Var	212.50	81.30	(73.40)	481.90	702.30
GASOLINE						
1996 Ford F350 PU (Op#4)	Gasoline	111.10	89.70	119.60	201.80	522.20
2002 Chev Silverado (Op#5)	Gasoline	170.30	72.30	24.60	120.90	388.10
1999 Chev Tahoe (Op#6)	Gasoline	242.80	69.00	98.60	109.60	520.00
Generator	Gasoline	12.80	18.20	23.70	12.00	66.70
1995 Chevrolet C3500 Spec (Crash#4-Medic Car)	Gasoline	20.00	15.50	14.50	20.90	70.90
1995 Ford Bus (Crash#5-Command Post)	Gasoline	18.00	58.50	24.30	34.40	135.20
	Total	575.00	323.20	305.30	499.60	1,703.10
	JHA LLC	708.40	356.40	275.50	536.40	1,876.70
	MTD Var	133.40	33.20	(29.80)	36.80	173.60
DIESEL						
1989 OSH Kosh Firetruck (DA 1500) (Crash#1)	Diesel	39.50	80.50	27.30	25.40	172.70
2008 OSH Kosh Striker Firetruck (Crash#2)	Diesel	139.70	64.80	94.50	14.10	313.10
1995 Peterbilt Firetruck (Crash#3)	Diesel	47.00	-	38.80	18.50	104.30
2006 CAT 824-H Plow # 1 (Dozer 1)	Diesel	712.50	48.00	-	488.30	1,248.80
1997 CAT 824-G Plow # 2 (Dozer 2)	Diesel	1,620.80	131.25	-	142.00	1,894.05
1998 CAT IT62 Plow # 3	Diesel	820.40	101.10	350.50	426.10	1,698.10
2004 Sterling FB Truck Plow # 4	Diesel	98.00	-	-	71.00	169.00
2014 CAT Skid 259-D	Diesel	325.70	-	-	84.60	410.30
1996 Plow Truck # 15	Diesel	-	-	-	121.70	121.70
1996 Truck # 16 (now Plow 7)	Diesel	339.40	-	-	276.10	615.50
Broom 7	Diesel	579.00	-	-	510.90	1,089.90
2006 Kubota	Diesel	39.80	-	-	-	39.80
John Deere 5510	Diesel	-	-	-	-	-
Gehl Skid Steer	Diesel	30.90	-	-	-	30.90
2006 Snow Blower # 1 (Rotary 1)	Diesel	1,628.40	170.00	-	135.00	1,933.40
1994 Snow Blower # 2 (Rotary 2)	Diesel	1,378.10	-	-	164.00	1,542.10
Truck 5	Diesel	824.00	78.00	-	40.00	942.00
Broom 5	Diesel	927.90	110.00	-	373.10	1,411.00
Truck 6	Diesel	915.00	95.00	-	798.60	1,808.60
Broom 6	Diesel	980.50	175.90	-	469.60	1,626.00
Loader 972 (new) + rented + old loader	Diesel	-	-	-	177.00	177.00
Gas Can / Mower / Generator	Diesel	-	-	38.10	51.50	89.60
	Total	11,446.60	1,054.55	549.20	4,387.50	17,437.85
	JHA LLC	14,127.80	1,119.70	759.30	3,659.90	19,666.70
	MTD Var	2,681.20	65.15	210.10	(727.60)	2,228.85

*While propane is consumed by fleet vehicles, is it is also used in airport stationary equipment, and is included under facilities.

JACKSON HOLE AIRPORT

Greenhouse Gas Inventory - Ground Access Vehicles

Distance from Web site https://www.mapdevelopers.com/distance_from_to.php
37th edition of the Energy Data Book, Jan 2019 https://cta.ornl.gov/data/tedbfiles/Edition37_Full_Doc.pdf
Table 4.1 &4.2 Average Fuel economy 2016 26.8 MPG car, 19.1 truck
Table 4.3 - Light vehicles 2016: 22.4 MPG

Airport Employees Commute Travel

Employee On Road Travel	Employees	MPG	1-way trip Dist (mi)	Fuel (Gallons)	CO2 lbs/gal	CO2 (lbs)
Employee 1 - 82513 (1)	1	22.4	86.81	1,666.4	19.5640	32,602
Employee 2 - 82922 (2)	2	22.4	51.5	1,977.2	19.5640	38,683
Employee 3- 83001 (20)	20	26.8	13.3	4,267.9	19.5640	83,497
Employee 4 - 83002 (20)	20	26.8	10.7	3,433.6	19.5640	67,175
Employee 5 - 83011 (2)	2	26.8	14.7	471.7	19.5640	9,229
Employee 6 - 83013 (3)	3	26.8	30.7	1,477.7	19.5640	28,910
Employee 7 - 83114 (2)	2	22.4	136	5,221.4	19.5640	102,152
Employee 9 - 83110 (1)	1	22.4	87.1	1,672.0	19.5640	32,711
Employee 10 - 83118 (1)	1	22.4	52.9	1,015.5	19.5640	19,867
Employee 11 - 83120 (2)	2	22.4	53.5	2,054.0	19.5640	40,185
Employee 12- 83127 (6)	6	22.4	63.4	7,302.3	19.5640	142,863
Employee 13 - 83128 (5)	5	22.4	62.11	5,961.5	19.5640	116,630
Employee 14 - 83221 (1)	1	22.4	143.2	2,748.9	19.5640	53,780
Employee 15 - 83422 (1)	5	22.4	56.97	5,468.1	19.5640	106,978
Employee 16 - 83428 (1)	1	26.8	23.73	380.7	19.5640	7,449
Employee 17 - 83442 (1)	1	22.4	89.09	1,710.2	19.5640	33,459
Employee 18 - 83452 (3)	3	26.8	48.34	2,326.8	19.5640	45,522
Employee 19 - 83455 (10)	10	26.8	36.43	5,845.1	19.5640	114,354
Source: Aiport email 2-18-2019 Zip codes						
4.3 days average FTE						
15% reduction for car pooling	86			**Total Pounds**		914,638
			Total	55,001	**Tons**	414.9

Distances over 50 miles assume LDT (22.4 mpg)

Tenant Employees Commute Travel

Employee On Road Travel	Employees	MPG	Rnd trip Dist (mi)	Fuel (Gallons)	CO2 lbs/gal	CO2 (lbs)
Estimates of FTEs	250	26.8	35.5	43,050	19.5640	842,238
	250	26.8	35.5	43,050	19.5640	842,238
Tenant Employees - 20% work 5 days	-					
80% work 2 days - blended avg 2.6 days			**Total**	86,101	**Tons**	382.0

JACKSON HOLE AIRPORT

Greenhouse Gas Inventory - Ground Access Vehicles

Jackson Hole Airport Passenger Travel 2017

Passenger On Road Travel	**%**	**Vehicles**	**MPG**	**Dist** (mi)	**Fuel** (Gallons)	**CO2 lbs/gal**	**CO2** (lbs)
Annual Passengers							
Total Passengers		682,384					
Passenger parties (3.2 pax per party)		213,245.0					
Rental Cars (rental days	43.0%	287,925		70.2			
Van/Taxi	22.0%	46,914					
Private Vehicle	17.0%	36,252					
Lodge Shuttle	15.0%	31,987					
Other	1.5%	3,199					
Charter bus	1.0%	2,132					
Limo	0.5%	1,066					
On-Airport Roads (2,400 ft) measured google maps							
Rental Car days x 1 mile			26.8	37,531.12	1,400	19.5640	27,397.7
Van/Taxi			22.4	0.8	1,675	19.5640	32,779.4
Private Vehicle			26.8	0.8	1,082	19.5640	21,171.0
Lodge Shuttle			22.4	0.8	1,142	19.5640	22,349.6
Other			22.4	0.8	114	19.5640	2,235.0
Charter bus			22.4	0.8	76	19.5640	1,490.0
Limo			22.4	0.8	38	19.5640	745.0
				Total Gallons	3,076	Total Lbs	108,167.6
						Tons	49.1
Off-Airport (avg distance to rdtrp)							
Rental Cars (at 69.2 miles per day)			26.8	3,246,441.88	121,136	19.5640	2,369,902.6
Van/Taxi			22.4	16.46	34,473	19.5640	674,436.4
Private Vehicle			26.8	16.46	22,265	19.5640	435,592.6
Lodge Shuttle			22.4	16.46	23,505	19.5640	459,843.0
Other			22.4	16.46	2,350	19.5640	45,984.3
Charter bus			22.4	16.46	1,567	19.5640	30,656.2
Limo			22.4	16.46	783	19.5640	
				Total Gallons	206,080	Total Lbs	4,016,415.1
						Tons	1,821.8
MPG - Transp Data Energy Book #37				**Total**	209,156	Total Tons	1,870.9

4/4/2019

Passenger characteristics

			Source
Average length of stay	5.8	nights	Jackson Hole Airport Survey Winter 2016/17, page 6

Place they stayed			
Town of Jackson	45	%	Jackson Hole Airport Survey Winter 2016/17, page 7
Teton Village	33	%	Jackson Hole Airport Survey Winter 2016/17, page 7
Between Jackson and TetonVillage	9	%	Jackson Hole Airport Survey Winter 2016/17, page 7
Grand Targhee	5	%	Jackson Hole Airport Survey Winter 2016/17, page 7
Not defined	8	%	Jackson Hole Airport Survey Winter 2016/17, page 7
	100		

Visitor Type			
Full time local resident	4	%	Jackson Hole Airport Survey Winter 2016/17, page 16
Part time local resident	3	%	Jackson Hole Airport Survey Winter 2016/17, page 16
Visitor	93	%	Jackson Hole Airport Survey Winter 2016/17, page 16

	Party Size			
1	Alone	16	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
2	Two (spouse)	36	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
3	Three	14	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
4	Four	16	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
5	Five	7	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
6	Six	4	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
8	7-9	4	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
11	10+	3	%	Jackson Hole Airport Survey Winter 2016/17, page 30 Figure 34
3.18	Weighted Average	100		

Mode of Transport to/from airport visitors/part time locals (96% of travelers)			
Rental car	43	%	Jackson Hole Airport Survey Winter 2016/17, page 72 Figure 79
Van/Taxi	22		Jackson Hole Airport Survey Winter 2016/17, page 72 Figure 79
Private Vehicle	17		Jackson Hole Airport Survey Winter 2016/17, page 72 Figure 79
Lodge Shuttle	15		Jackson Hole Airport Survey Winter 2016/17, page 72 Figure 79
Other	1.5		Jackson Hole Airport Survey Winter 2016/17, page 72 Figure 79
Charter bus	1		Jackson Hole Airport Survey Winter 2016/17, page 72 Figure 79
Limo	0.5		Jackson Hole Airport Survey Winter 2016/17, page 72 Figure 79
	100		

JACKSON HOLE AIRPORT

Greenhouse Gas Inventory - Aircraft

Aircraft CO2 Emissions - 2017

Aircraft	Convert Factor kg to Lbs Fuel	Lbs Fuel	Convert Factor Lbs to Gal	Gallons	Convert gal to CO2 (lbs/gal)	CO2 (lbs)	CO2 Tons
JET A							
Approach	2.2046	1,674,943	6.8200	245,593	21.095	5,180,780	2,350.0
Taxi-Idle-Delay	2.2046	3,664,246	6.8200	537,279	21.095	11,333,910	5,141.0
Takeoff	2.2046	504,334	6.8200	73,949	21.095	1,559,960	707.6
Climbout	2.2046	1,433,371	6.8200	210,172	21.095	4,433,572	2,011.0
Subtotal		7,276,894		1,066,993.3		22,508,223	10,209.6
AvGas							
Approach	2.2046	21,770	6.0000	3,628	18.355	66,598	30.2
Taxi-Idle-Delay	2.2046	19,321	6.0000	3,220	18.355	59,106	26.8
Takeoff	2.2046	4,473	6.0000	746	18.355	13,684	6.2
Climbout	2.2046	12,013	6.0000	2,002	18.355	36,750	16.7
Subtotal		57,577		9,596.2		176,138	79.9
Total LTO		7,334,471		1,076,589			10,289.5

Fuel Dispensed	**Jet A**	5,586,409	21.095	117,845,298	53,453.7
	Av Gas	24,264	18.355	445,366	202.0
	Total	5,610,673		118,290,664	53,655.7
Cruise (Fuel dispensed - LTO)	**Jet A**	4,519,416	21.095	95,337,075	43,244.2
	Av Gas	14,668	18.355	269,228	122.1
	Total	4,534,084		95,606,303	43,366.3

0.00045359237 Lbs/ton

1 gallon =	6.84 lbs Jet A	lbs Jet A
	6.0 lbs Av-Gas (100LL)	lbs Av-Gas (100LL)

Jackson Hole Aviation LLC data for January 2017 through December 2917 (see email 2017 Fuel Pumped Summary.pdf)

AEDT Runs Version 2d See file AEDT Aircraft Fuel Consumption 3-14-2019 from BridgeNet

JACKSON HOLE AIRPORT

Greenhouse Gas Inventory - Aircraft

		JETS	PROPS TURBO	PROPS PISTON
Operation Group	Mode	Fuel (lb)	Fuel (lb)	Fuel (lb)
CASE_1.0	Climb Taxi	2,633,001	99,419	14,487
CASE_1.0	Climb Ground	3,429,139	110,862	16,389
CASE_1.0	Climb Below 1000	3,914,578	129,757	20,862
CASE_1.0	Climb Below Mixing Height	5,294,526	185,180	32,875
CASE_1.0	Climb Below 10000	8,640,222	370,063	79,569
CASE_1.0	Above 10000	23,663	-	-
CASE_1.0	Descend Below 10000	2,972,867	304,779	42,864
CASE_1.0	Descend Below Mixing Height	2,516,270	199,963	27,286
CASE_1.0	Descend Below 1000	1,370,221	113,287	13,812
CASE_1.0	Descend Ground	982,478	58,812	5,516
CASE_1.0	Descend Taxi	877,668	54,259	4,834
CASE_1.0	Full Flight	11,636,748	674,841	122,434

		JETS	JETA	AvGas
		Fuel (lb)	Fuel (lb)	Fuel (lb)
	Approach	1,533,792	141,151	21,770
	Taxi-in	877,668	54,259	4,834
	Gate	Not applicable	Not applicable	Not applicable
	Taxi-out	2,633,001	99,419	14,487
	Takeoff	485,439	18,895	4,473
	Climbout	1,379,948	55,423	12,013
		6,909,848	369,147	57,577
	Approach	1,674,943		21,770
	Taxi-in	931,927		4,834
	Gate	Not applicable		Not applicable
	Taxi-out	2,732,420		14,487
	Takeoff	504,334		4,473
	Climbout	1,435,371		12,013

The Landing and Takeoff Cycle (LTO cycle) comprises those phases of the flight trajectory which are below 3000 feet Above Ground Level (AGL). These include the takeoff roll, the climbout to 3000 feet AGL, the approach from 3000 feet AGL, and the ground taxi/idle phase. The ground taxi/idle phase includes both the departure and the arrival taxi phases.

Mead
&Hunt