Jackson Hole Greenhouse Gas Emissions

Sources

14.9% natural gas & propane

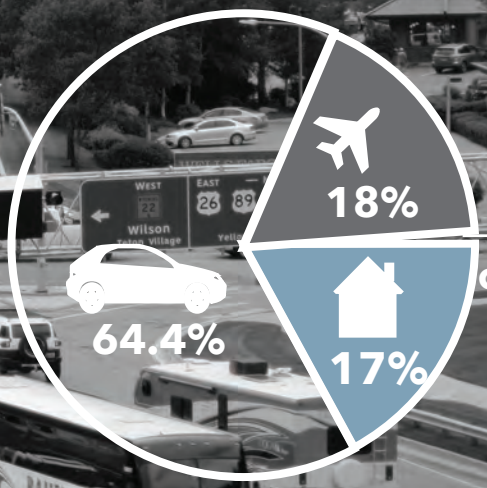
2.2% electricity

17.4% aviation

1.1% OTHER

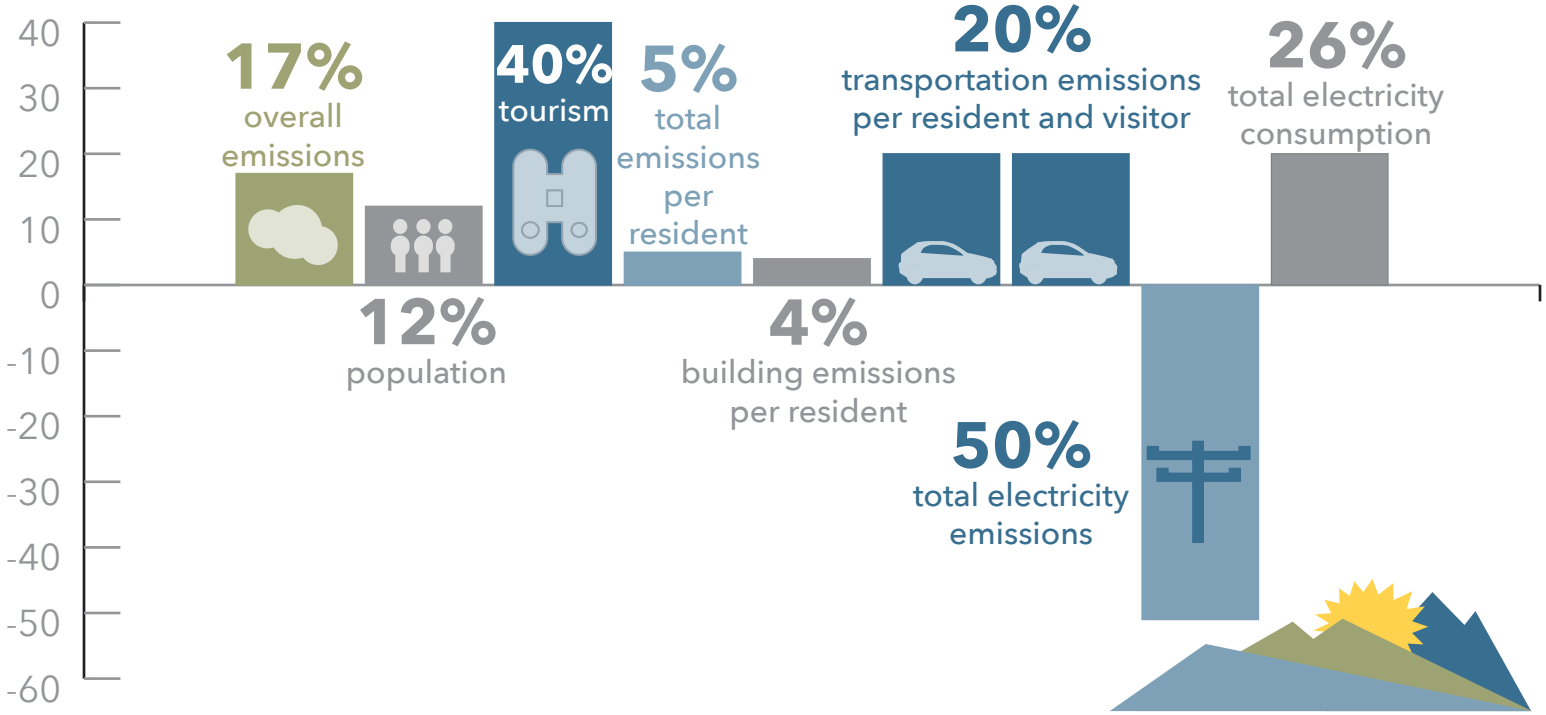
64.4% ground transportation

Sector



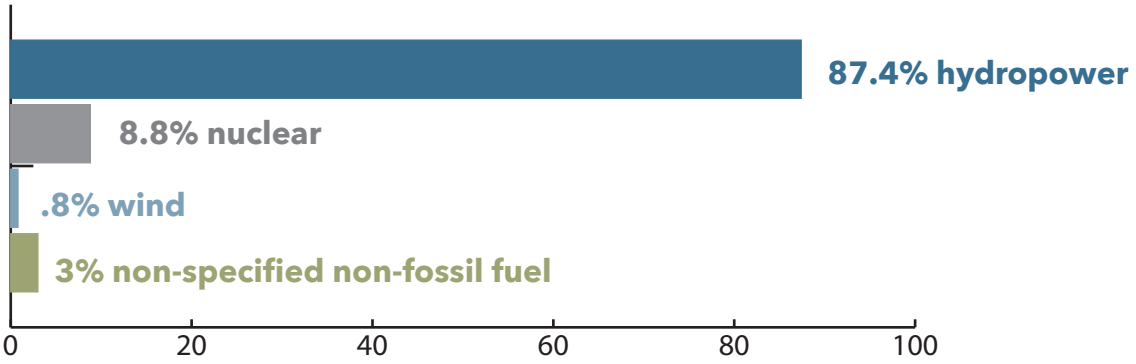
Population and Tourism growth's impact on Jackson Hole's Greenhouse Gas Emissions

Since the 2009 GHG Emissions Inventory, Teton County has seen growth in many capacities. These trends have led to an overall increase of emissions.

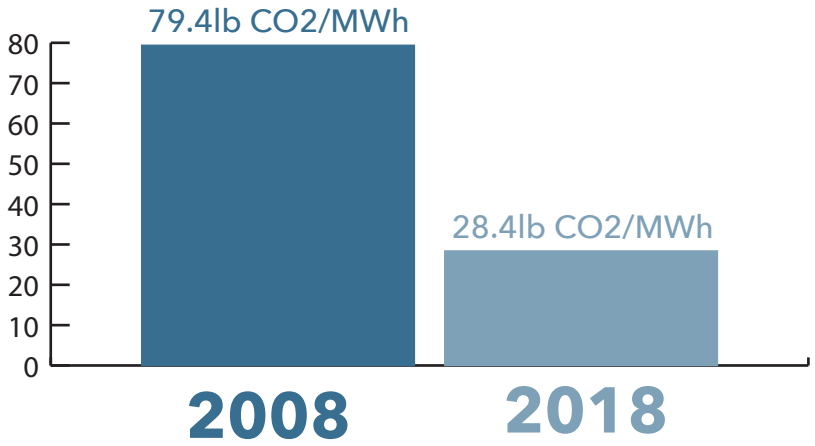


YELLOWSTONE-TETON CLEAN CITIES

Bonneville Power Administration Electricity Supply



Bonneville Power Administration Carbon Factor Comparision



Greenhouse Gas Emissions Per Person Comparison

2018 Teton County 20.75 MT CO2e

2017 Boulder 14 MT CO2e

2016 Bozeman 11.5 MT CO2e

2013 Portland 10 MT CO2e

Total Emissions and Population Data

Year	Population	Total Emissions (tons CO2e)
2008	20,686.00	409,041.00
2018	23,081.00	478,470.00

YELLOWSTONE-TETON CLEAN CITIES

YELLOWSTONE-TETON CLEAN CITIES

PO BOX 11756
JACKSON WY
83002
810.955.5811

Yellowstone-Teton Clean Cities (YTCC) in partnership with the Town of Jackson and Teton County commissioned an update to the 2009 emissions inventory. The entity that performed the original inventory, Climate Mitigation Services (CMS), was hired to update the inventory using the same methodologies and boundary as the previous report to ensure accurate comparisons over time (an apples to apples comparison).

These key takeaways are not an exhaustive explanation of everything that impacted the greenhouse gas emission findings. In addition, this is just a snapshot of projects that should be recognized, as there are many more successful programs that should be celebrated. This is a high level overview of the data as well as some suggestions as a starting point for making plans to move forward.

Based on YTCC's research into the effective coordination and reduction of greenhouse gas emissions, we have four overall key suggestions (1) develop a Climate Action Plan, while beginning easy and high impact greenhouse gas mitigation actions immediately; (2) implement the Teton County Internal Sustainability Strategy of June 2017 (2) hire a sustainability director for each the town and the county and at a minimum a joint position, to oversee the climate action plan, oversee an internal climate action committee and regularly meet with community organizations that can help carry out the climate action plan, and (3) develop one overarching ambitious goal, such as Net Zero by 2030 (suggested by the upcoming Mountain Town 2030 summit in Park City, UT). This will allow those responsible for sub goals and projects the ability to be creative and implement bold, high impact projects.

Electricity

Key Takeaways

- Total electricity consumption grew by 26%
- GHG emissions declined by 51%
- Despite an increase in electricity use, greenhouse gas emissions declined due to:
    - o Lower Valley Energy (LVE) purchases their power from Bonneville Power Administration. The carbon factor decreased 67% from an already low carbon factor. The majority of the grid mix is hydroelectric power at 87.4% and only 3% of the grid mix is fossil fuel.
- Electricity use grew in Teton County by 49% but declined in the Town of Jackson by 8%
    - o This may be due to 64 of Lower Valley Energy's 90 energy efficiency projects taking place in the Town of Jackson as well as Energy Conservation Works (ECW) many efficiency projects also taking place in the Town of Jackson

Recognition

- Lower Valley Energy and Energy Conservation Works consistently implement energy efficiency projects throughout our community. The following are just a few examples of the projects they implemented:
    - o With Specific Purpose Excise Tax Funds, Energy Conservation Works installed a 69kW photovoltaic system at the Wastewater Treatment Plant, generating over 100,000kWh annually.
    - o ECW also installed 14 energy efficient GridBee Mixers at the plan to save roughly 1.1 million kWh's annually.
    - o ECW increased the energy efficiency of the new Children's Learning Center by 47% by installing a more efficient heat pump and LED lighting.

PO BOX 11756
JACKSON WY
83002
810.955.5811

Suggestions

- Automatically sign every new Lower Valley Energy customer up for green power with the ability to opt out.
- Continue strong relationship with Energy Conservation Works to implement building energy efficiency projects and renewable energy installations.
- Set a Net Zero or Renewable Energy mandate to be implemented by 2030.
- Enforce energy efficiency mandates for new buildings.
- Continue use of Energy Mitigation Program that offsets disproportionate energy consumption of large buildings.

Natural Gas and Propane

Key Takeaways

- There is a fairly even swap of emissions coming from natural gas and propane. This is due to LVE retiring their propane services and replacing them with natural gas, particularly completing a pipeline to Teton Village.

Ground Transportation

Key Takeaways

- Ground transportation is once again the largest greenhouse gas emission source and sector for Teton County. This is not surprising considering the low carbon factor of electricity, industry is very limited and tourism is one of the largest economic engines of our community.
    - o Approximately 50% of ground transportation greenhouse gas emissions are from tourists driving to Teton County and driving in Grand Teton National Park. A little over a quarter of total ground transportation emissions do not actually take place in Teton County, this amount is a calculation derived from the average distance a “road trip” vacation travels.
    - o The high amount of emissions from transportation provides an incentive to prioritize programs and projects that reduce vehicle miles traveled and the use of gasoline and diesel.

Recognition

- START bus was awarded funding for the purchase of up to 8 all electric transit buses.
- Yellowstone-Teton Clean Cities and Energy Conservation Works has helped fund the installation of 14 stations in Teton County with 18 ports available for charging. There are now 20 electric vehicle charging stations in Teton County.
- Every year Yellowstone-Teton Clean Cities collects data on alternative fuel, alternative vehicle and petroleum reduction strategies. Last year, Teton County fleets reduced 3,231 tons of GHG emission through alternative fuel use, fuel economy improvements, vehicle miles traveled (VMTS) reductions and idle-reduction.
- Friends of Pathways has developed a robust pathway system allowing for residents and visitors to commute and travel.
- Friends of Pathways, Town of Jackson and Community Pathways’ increased daily bike counts on Snow King avenue by 15% through the Snow King Bikeway project.
- START Bus and Friends of Pathways launched START bike, providing convenient access to bikes throughout town with 55 bikes and 12 docking stations. In 2017 250 members took 4,000 rides.

PO BOX 11756
JACKSON WY
83002
810.955.5811

Suggestions

- Develop robust commuter behavior change program to decrease single occupancy vehicles com muting into Jackson
- Develop an ultra low emission zone that requires a fee for those driving older, dirty diesel and gasoline vehicles. London and other European cities have implemented this program.
- Create a Town and County Green Fleet purchasing policy in which the lowest emission vehicles must be purchased unless an alternative fuel is not available in for the specified vehicle type.
    - o Challenge the other communities in the Greater Yellowstone Ecosystem to also create and implement a Green Fleet purchasing policy.
- Install a DC Fast Charging station in the Town of Jackson using SPET and Energy Mitigation Plan funds.
- Require all new construction to offer electric vehicle charging or be "EV ready".
- Require all rental car agencies to offer plug-in hybrid vehicle options.
- Require all Town of Jackson and Teton County contracts that require driving to utilize alternative fuels.
- Research and implement multi-modal transportation options
- Designate pedestrian only street areas
- Allow remote working for a portion of the work week to reduce commuting

Aviation

Key Takeaways

- Aviation emissions had no significant change in the percent of total Teton County emissions, in 2008 aviation accounted for 17.2 percent of total GHG emission and in 2019 aviation accounted for 17.4 percent of total GHG emissions.

The Jackson Hole Airport also voluntarily commissioned a greenhouse gas emissions report to coincide with the release of this Jackson Hole emissions inventory. Since the development of the 2008 Jackson Hole Inventory of Greenhouse Gas Emissions, aviation-related carbon accounting methodologies have been updated. The JAC GHG Inventory uses industry standard methodologies from the National Academy of Sciences (Airport Cooperative Research Program, Guidebook on Preparing Airport Greenhouse Gas Inventories, 2009), as well as international standards based on Airport Carbon Accreditation of the Airports Council International (ACI) (officially adopted in 2014 by ACI-North America). The airport report is attached as Appendix 2.

The CMS report utilized the same methodologies from the 2009 Jackson Hole Greenhouse Gas Emissions Inventory, this report did not utilize the same methodologies as the airport GHG emission inventory because the intent of the 2019 emissions inventory was to provide and update to the 2009 report findings with an "apples to apples" comparison. If we used different methodology there would not be an accurate comparison over time.

For comparison's sake, placing the emissions data from the airport methodology into the 2019 report, the airport would account for 13% of total emissions, bumping ground transportation up to 68%.

YELLOWSTONE-TETON CLEAN CITIES

PO BOX 11756
JACKSON WY
83002
810.955.5811

GHG Emissions by Source	CO2e 2008	CO2e 2017	% change`	JH Air CO2e 2017
Landfill	8,119	181	-97.8%	
Nitrous Oxides	182	403	121.4%	
HFCs and Refrigerants	2,101	1,182	-43.7%	
Off-Road Transportation	3,706	3,642	-1.7%	
Aviation	*70,546**	*83,466**	*18.3%*	*56,636.00***
Buildings	70,360	81,787	16.2%	
Ground Transportation	254,638	308,207	21.0%	
Total	**409,652**	**478,868**	**16.9%**	

** 2008 & 2017 Heede report & methodology - See Appendix #1*

*** 2017 JH Airport report & different methodology - See Appendix #2*

Please note both reports use completely different methodologies to report CO2e totals for Aviation sector of our community.

Recognition-Jackson Hole Airport is a sustainable leader in the region and has implemented seveal sustainable measures in recent years, including:

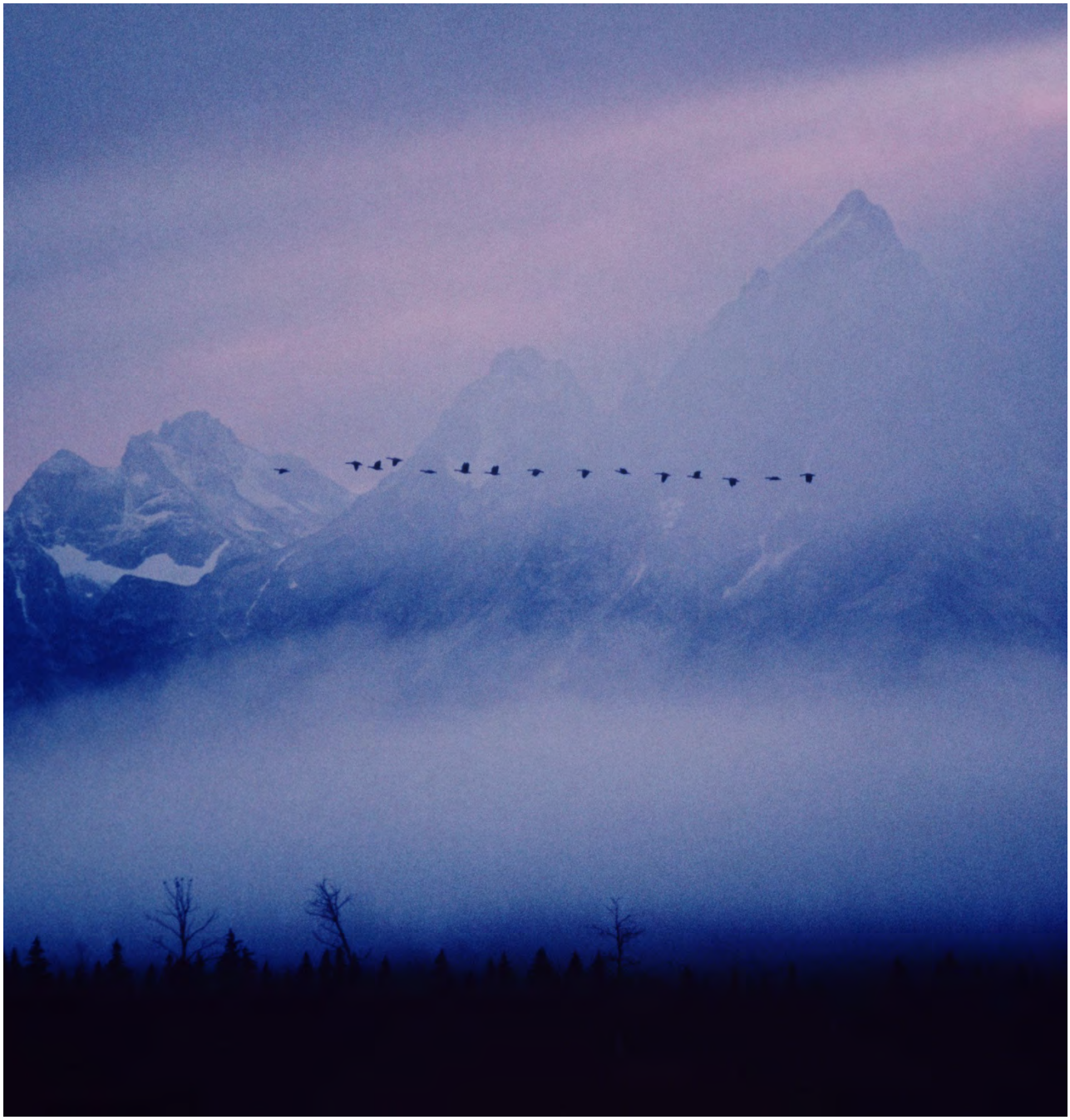
- The purchase of 2 propane trucks
- 2 all electric maintenance vehicles,
- Partnering with Yellowstone Teton Clean Cities for the installation of 6 publically available electric vehicle charging stations, they received LEED Silver Certification the Terminal Building expansion, incorporated LED lighting in the new baggage claim building, conducted an energy audit and is a two time recipient of the Green Fleet Award from Yellowstone-Teton Clean Cities.

Suggestions

- Prohibit vehicle idling by taxi vehicles and all vehicles in pickup/drop-off areas
- Require rental car companies to have plug-in hybrid vehicles options in their fleets
- Work with local partners to develop public transit to and from the Town of Jackson and Teton County.

Alicia Cox
Executive Director
Yellowstone-Teton Clean Cities
alicia@ytcleancities.org

Jackson Hole Inventory of Greenhouse Gas Emissions, 2018



By Richard Heede

Climate Mitigation Services

8 September 2019

Climate Mitigation Services

Principal Investigator: Richard Heede
heede@climatemitigation.com
1626 Gateway Road
Snowmass, CO 81654 USA
970-343-0707 mobile

Report commissioned by Yellowstone-Teton Clean Cities, Town of Jackson, and Teton County
Jackson, Wyoming; www.ytcleancities.org
810-955-5811 / info@ytcleanenergy.org

This report was additionally supported with financial contributions from the following organizations:

Special thanks to Community Foundation of Jackson Hole's competitive grant program for providing seed funding

Note on units: common US units are used throughout. The spreadsheets, however, estimate emissions in both US & metric units. Emissions of methane and nitrous oxide are also expressed in CO_2-equivalent terms (CH_4 = 28 x CO_2; N_2O = 265 x CO_2).

Cover: "Out of the Mist," Thomas D. Mangelsen, used with appreciation & thanks, www.mangelsen.com. Above: "Dawn's First Blush."

Summary

Jackson Hole Energy & Emissions Inventory 2017/2018

Richard Heede

An energy and emissions inventory was performed for the Jackson Hole / Teton County region in 2009 (with data for 2008) by Climate Mitigation Services. CMS was commissioned in 2018 to update the inventory using the same methodology and boundary definition.

This process involves gathering energy use data from electric and gas utilities and propane vendors that service Teton County. Fuel and emissions from driving and transportation is based on data on vehicle miles travelled on State, County, and local roadways (courtesy of State of Wyoming Dept of Transportation). Separate estimates were made for Town and County vehicle fleets (police and sheriff), school buses, the START fleet, and trucking waste ~100 miles from Teton County to Bonneville County Landfill. As in 2008, we estimate fuel use and emissions consumed by commercial air carriers and general aviation aircraft flying to Jackson Hole Airport in 2017/2018.

No surprise: energy use and emissions are up — by 17 percent — since 2008. Nearly everything has grown: population, traffic, tourism, electricity and gas usage, though electricity *emissions* are down.

Table 1 and Table 2 show total emissions by major category for 2018 and 2008, respectively. Additional discussion of the results and major energy and emission sources below.

Table 1. Summary of Jackson Hole greenhouse gas emissions 2018

SOURCE	TONS CO_2e	PERCENT
Electricity	**10,673**	**2.2**
Natural Gas & Propane	**71,115**	**14.9**
Ground Transportation	**308,207**	**64.4**
Air travel & aviation	**83,466**	**17.4**
Miscellaneous fuel uses	**3,642**	**0.8**
Landfill	**181**	**0.0**
Nitrous oxide	**403**	**0.1**
HFCs and refrigerants	**1,182**	**0.2**
Total	**478,868**	**100.0**

Table 2. Summary of Jackson Hole greenhouse gas emissions 2008

SOURCE	TONS CO_2e	PERCENT
Electricity	**21,896**	**5.3**
Natural Gas & Propane	**48,464**	**11.8**
Ground Transportation	**254,638**	**62.2**
Air travel & Aviation	**70,546**	**17.2**
Miscellaneous fuel uses	**3,706**	**0.9**
Landfill	**8,119**	**2.0**
Nitrous oxide	**182**	**0.0**
HFCs and refrigerants	**2,101**	**0.5**
Total	**409,652**	**100.0**

Fig. 1. Jackson & Teton County major emission sources in 2008 and 2018.

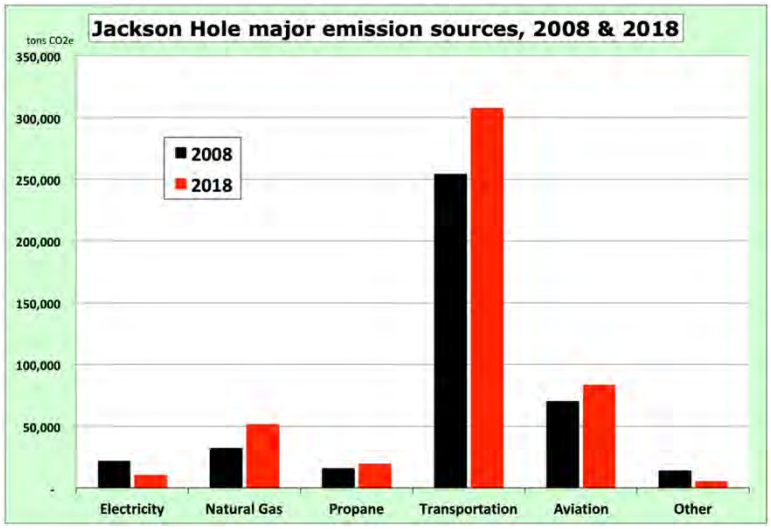


Table 3 compares 2018 to 2008, listing the same categories, and shows the percentage change for each category. Overall, emissions included in our inventory shows an increase of 16.9 percent.

Table 3. Summary of Jackson Hole greenhouse gas emissions 2008 and 2018

SOURCE	TONS CO_2e	2008	2018	% CHANGE
Electricity		**21,896**	**10,673**	**-51.3**
Natural Gas & Propane		**48,464**	**71,115**	**+46.7**
Ground Transportation		**254,638**	**308,207**	**+21.0**
Air travel & aviation		**70,546**	**83,466**	**+18.3**
Miscellaneous fuel uses		**3,706**	**3,642**	**-1.7**
Landfill		**8,119**	**181**	**-97.8**
Nitrous oxide		**182**	**403**	**+121.0**
HFCs and refrigerants		**2,101**	**1,182**	**-43.8**
Total		**409,652**	**478,868**	**+16.9**

Fig. 2. Jackson & Teton County total emissions in 2008 and 2018.

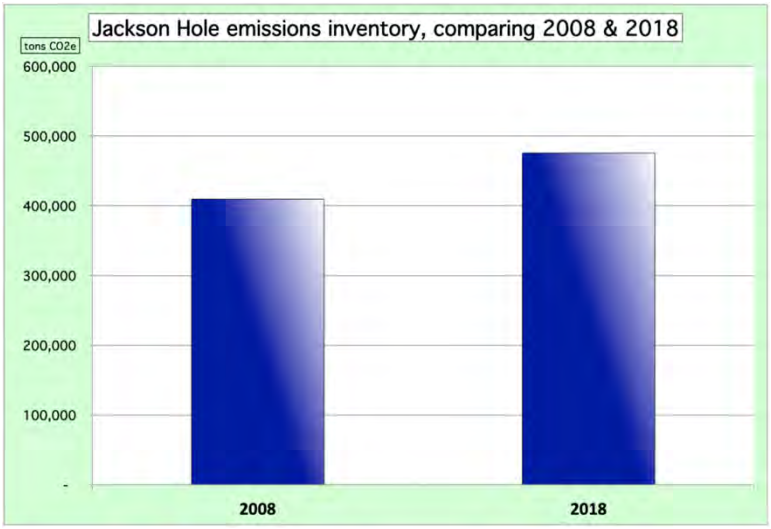


Figure 4 shows major emission sources for both 2008 and 2018, graphically showing that most sources grew by 10-20 percent, whereas electricity emissions *declined* by 51 percent — not due decreasing electricity consumption (which *increased* by 26 percent but from a lower emission factor for LVE's power purchases from Bonneville Power Administration (also shown in Fig. 3). Propane consumption has been stable (though likely under-reports total consumption due to non-reporting by a major propane company).

Fig. 3. Jackson & Teton County major emission sources in 2008 and 2018.

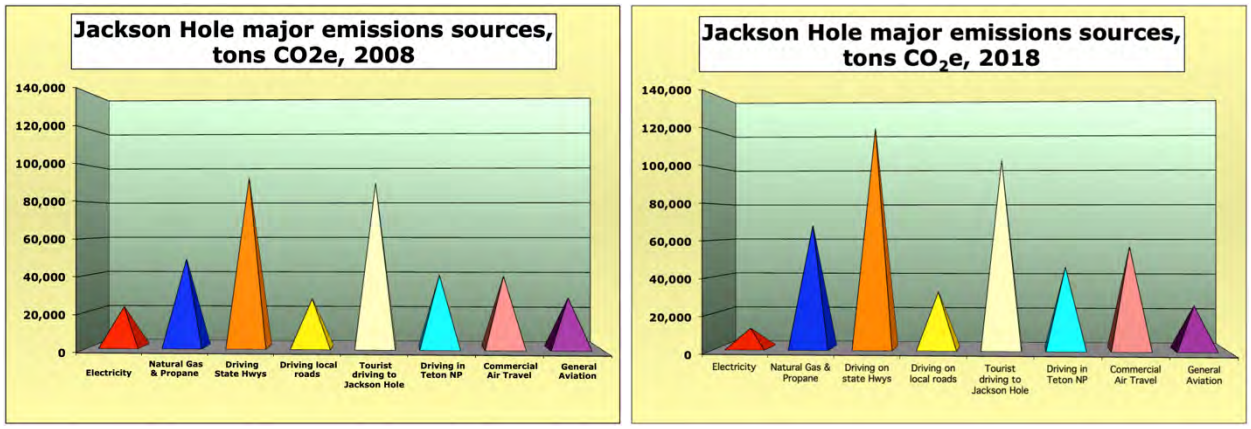
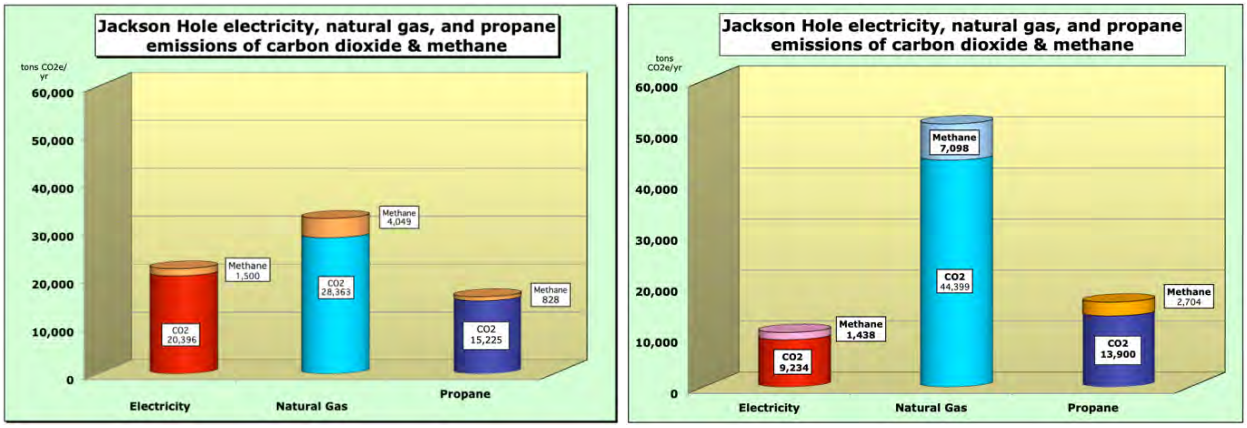
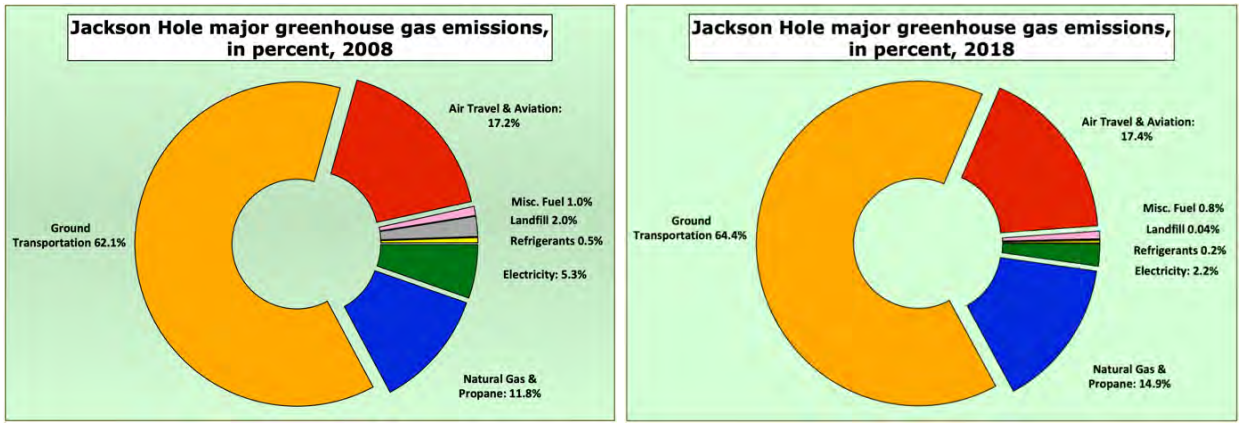
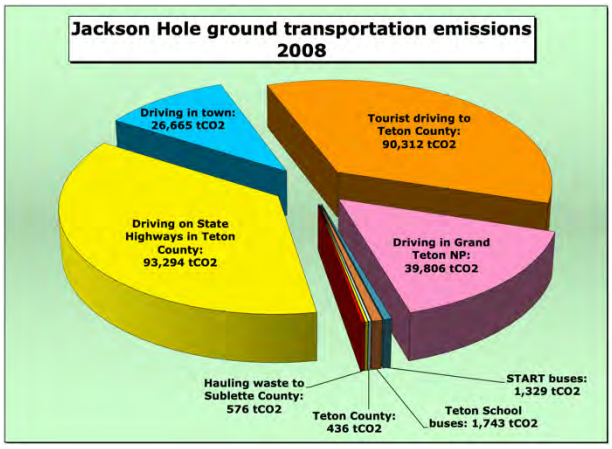


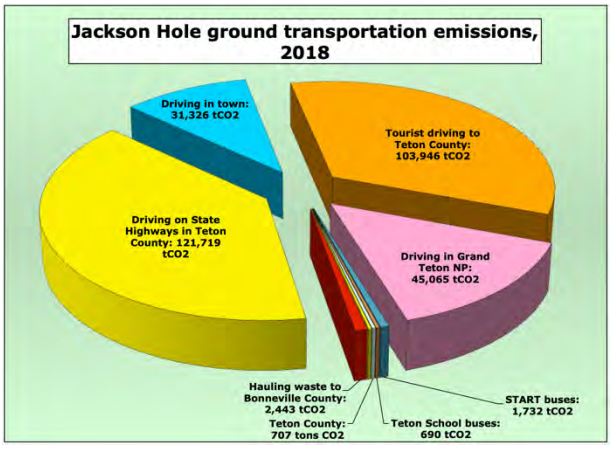
Fig. 4. Electricity, natural gas, and propane emissions in 2008 and 2018.

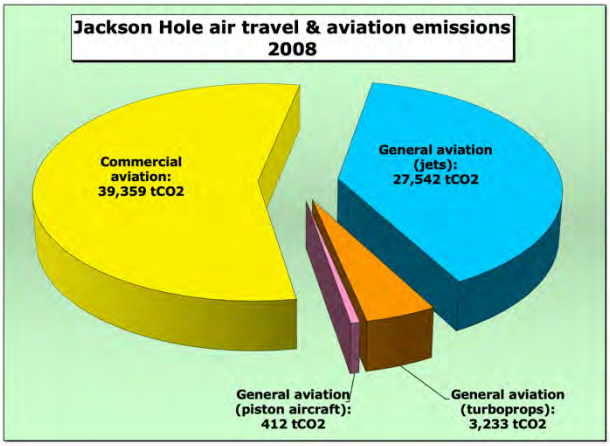


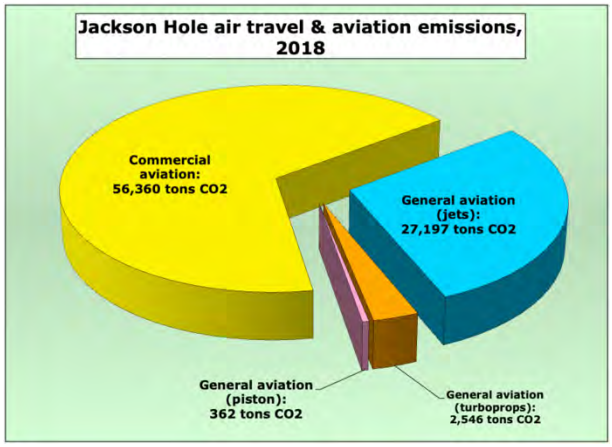
The figures below compare 2008 and 2018 from major emissions sources, ground transportation, and air travel and aviation emissions. Further discussion below.




Jackson Hole ground transportation emissions 2008
Driving in town: 26,665 tCO2
Tourist driving to Teton County: 90,312 tCO2
Driving on State Highways in Teton County: 93,294 tCO2
Driving in Grand Teton NP: 39,806 tCO2
Hauling waste to Sublette County: 576 tCO2
Teton County: 436 tCO2
Teton School buses: 1,743 tCO2
START buses: 1,329 tCO2


Jackson Hole ground transportation emissions, 2018
Driving in town: 31,326 tCO2
Tourist driving to Teton County: 103,946 tCO2
Driving on State Highways in Teton County: 121,719 tCO2
Driving in Grand Teton NP: 45,065 tCO2
Hauling waste to Bonneville County: 2,443 tCO2
Teton County: 707 tons CO2
Teton School buses: 690 tCO2
START buses: 1,732 tCO2


Jackson Hole air travel & aviation emissions 2008
Commercial aviation: 39,359 tCO2
General aviation (jets): 27,542 tCO2
General aviation (piston aircraft): 412 tCO2
General aviation (turboprops): 3,233 tCO2


Jackson Hole air travel & aviation emissions, 2018
Commercial aviation: 56,360 tons CO2
General aviation (jets): 27,197 tons CO2
General aviation (piston): 362 tons CO2
General aviation (turboprops): 2,546 tons CO2

Overview

CMS quantified greenhouse gas emissions attributable to energy use in Teton County in 2017/2018 as follow-up to the community-wide "carbon footprint" we did for energy consumption and other sources in 2008. According to our analysis, community-wide emissions increased 16.9%, from 409,652 tons carbon dioxide equivalent (tCO_2e) in 2008 to 478,868 $MtCO_2e$ in 2018. Electricity sector emissions *fell* 51.3% (even though electricity consumption rose by 26 percent), natural gas and propane emissions increased 46.7%, driving and ground transportation rose 20.1%, and air travel emissions increased 18.3%. Readers are encouraged to review the many worksheets in the attached portfolio for details.

Jackson Hole: Major sources of emissions 2017/2018

Commercial air travel: in 2017/2018 season: 3,977 commercial flights departing Atlanta, Chicago, Dallas, Denver, Houston, New York (JFK and Newark), Los Angeles, Minneapolis, Phoenix, Salt Lake City, San Francisco, and Seattle for Jackson Hole Airport ranging in distance from 205 to 1,890 miles flying a total of 2.76 million miles burning on average 1.9 gallons per mile (0.52 mpg) and emitting 56,360 tCO_2.[1]

Flight operations at JAC: Overall flight operations at Jackson Hole Airport (JAC) declined from 30,089 in 2008 to 27,189 in 2017. This is uncertain due to airport staff unable to clarify data provided in which the category "civil aviation" is listed in 2008 (at 2,714 operations, or take-offs and landings), but none listed in the 2017 data. The CMS methodology accounts for aviation and air travel emissions for all aircraft landing at JAC, since the objective is to quantify emissions for flights from the airport of origin to Jackson. In other words, we account for fuel and emissions in one direction, from all airports of origin *to* Jackson. The other half of the emissions, for each aircraft's return trip, are attributed to the communities from which they originate.

General aviation (GA): As for commercial aviation, we take *half* of the annual non-air-carrier operations (air taxi, general aviation, and military totaled 19,722 operations), or 9,861 operations in 2017, and use the same methodology as in the 2008 air travel emissions inventory. Jets comprised 63 percent of flights, flew an average distance of 613 nautical miles from various airports of origin, and consumed an average of 367 gallons of jet fuel per flight (1.9 mpg). This category of GA operations burned 2.3 million gallons of jet fuel and emitted 24,197 tCO_2 in 2018, compared to 27,542 tCO_2 in 2008. General aviation overall included 9,861 operations from airports of origin to JAC, consumed 2.6 million gallons of jet fuel and avgas, and emitted 27,105 tCO_2 (compared 31,187 tCO_2 in 2008).

[1] CMS was unable to acquire complete operational data for 2017 from airport staff, and we relied on airline operational statistics for the 2017/2018 12-month season, which differ slightly from the CY 2017 data provided by airport staff. Whereas the latter show 7,467 "air carrier" operations in CY 2017, our data for 2017/2018 show 3,977 landings (which means twice that, or 7,954, in total operations).

Electricity: Lower Valley Energy (LVE) sold 625 million kWh in Teton County in 2017 (an increase of 26 percent over 2008: 494 million kWh). However, electricity sales *decreased* 8 percent within the Town of Jackson (with a corresponding increase of 49 percent in the rest of the county).

Electricity emissions: the carbon intensity of Bonneville Power Administration (BPA), which is the wholesale supplier of electricity to LVE, decreased substantially from the already-low factor in 2008 of 79.4 lb CO_2/MWh to 28.4 lb CO_2/MWh in 2017 (MWh, megawatt-hour, or 1,000 kWh). CMS calculated emissions based on its minor fossil fuel portfolio (3% "non-specified;" non-fossil fuel: 87.4 percent hydropower, 8.8 percent nuclear, and 0.8 percent wind [without RECs]). CO_2 emissions from LVE's sales of 625 million kWh totaled 9,234 tCO_2.

BPA did not include methane emissions associated with its fossil fuel portfolio. CMS applied the US average methane emissions from fossil fuel generation: 0.00576 lb CH_4/kWh, and since the average US kWh causes the emission of 1.036 lb CO_2/kWh, this converts to 0.00556 lb CH_4/lb CO_2. Methane is 28 times as powerful a greenhouse gas per lb (per IPCC *Fifth Assessment Report*, 2013), the resulting 51 tons of methane converts to 1,438 tCO_2e, or 13.5 percent of carbon dioxide plus methane.

Emissions from Teton County's consumption of 625 million kWh totals 10,673 tCO_2e. Due to the lower carbon factor for BPA's power sales in 2018, electricity-related emissions *declined* by 51 percent from 2008 (21,896 tCO_2e).

Natural Gas: LVE sold 7.6 million therms (one therm is 100,000 Btu, or ~100 cubic feet of gas) in Teton County in 2017, compared to 4.9 million therms in 2008. Sales in Town increased modestly (from 3.9 to 4.2 million therms, but increased sharply in the rest of the County, presumably from infra-structure extension to residential areas outside of town). The emission factor from combustion of natural gas is 11.7 lb CO_2 per therm, and a factor for fugitive and leaked methane from the production and processing of natural gas (0.0057 tCH_4/tCO_2), adding 13.8 percent to gas-related emissions. CO_2 and methane emissions in Teton County totaled 51,497 tCO_2e in 2018, an *increase* of 59 percent over 2008 (32,411 tCO_2e).

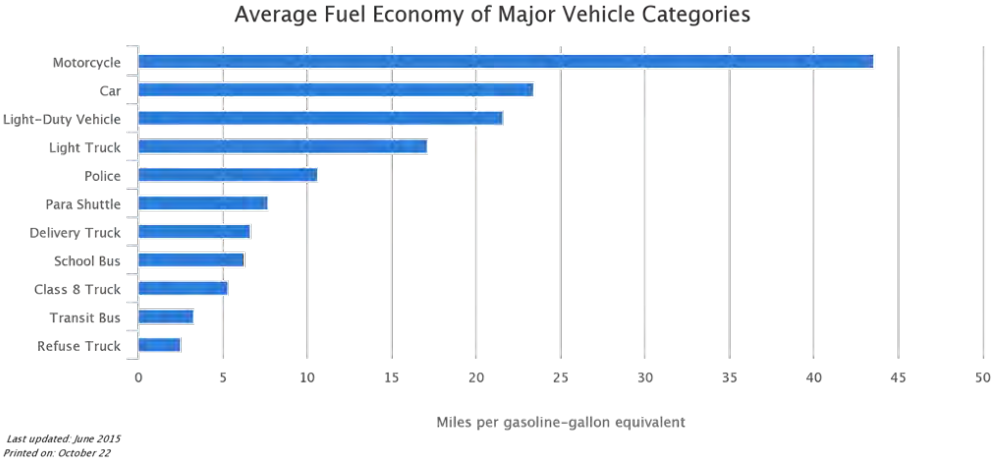
Propane: Propane serves several residential areas in Teton County, particularly beyond the natural gas grid. Sales totaled 2.7 million gallons in 2017 (though AmeriGas declined to provide sales data, and LVE stopped selling propane). We added Valley Wide Cooperative, so total sales in 2008 are not strictly comparable to 2018 sales. The emission factor for propane is 12.7 $lbCO_2$/gallon, plus a fugitive methane factor for the natural gas liquids derived from natural gas production of 0.0057 tCH_4/tCO_2. Based on the sales data available, emissions from propane sales are 16,914 tCO_2, plus 2,704 tCO_2 from associated methane, totaling 19,618 tCO_2e, an increase of 22 percent. (In lieu of AmeriGas sales data we averaged sales by the three vendors that did provide data, on the theory that an imperfect number is better than a certain wrong (zero) number.)

Ground transportation: Based on data supplied by Wyoming Dept of Transportation (WYDOT), 317 million miles were driven on 184 miles of State highways in Teton County in 2017 (26 million miles were by large trucks). Alicia Cox and Richard Heede completed a vehicle-type survey in Jackson and other locations in the County in order to establish the kinds of vehicles commonly driven in or through Teton County; this informs the model used to estimate fuel consumption and emissions. Passenger cars comprised 18.8 percent of all vehicles, light SUVs and pick-up trucks 29.4 percent, medium & large SUVs and pick-up trucks 40.4 percent, large two-axle trucks 3.9 percent, three-axle trucks 1.0 percent, semis 0.2 percent, RVs 4.5 percent, buses 1.0 percent, and motorcycles 0.9 percent. Each of these vehicle types have differing fuel consumption rates per mile.

CMS has separate estimates for driving within Grand Teton National Park, which totals 94 million miles, 4.5 million gallons of gasoline and diesel consumed, and emissions of 45,065 tCO_2.

Driving on other State highways total 235 million miles, 12 million gallons fuel, and 121,719 tCO_2.

Additional driving on local roads (non-State highways) results in 62 million miles driven, 3.2 million gallons of fuel, and 31,326 tCO_2.



Tourist driving: CMS attributes *one-quarter* of the average distance driven by tourists (which is in turn based on a fraction of 3.32 million visitors to Grand Teton National Park) of 637 miles from point of origin (based on a survey of license plates) and the fuel used to Teton County. The 1.43 million tourist vehicles visiting Teton County from points beyond in 2017 drove an average 159 miles (228 million miles in total), consumed 10 million gallons, and emitted 103,946 tCO_2.

CMS includes fuel and emissions attributable other transportation such as the Teton School District's school buses (62,724 gallons and 690 tCO_2), County vehicles such as Sheriff's vehicles (309 of County total of 707 tCO_2), Town of Jackson (such as Police cruisers: 239 of town's 579 tCO_2). Jackson & Teton's fuel use totals 126,251 gallons and 1,286 tCO_2.

Hauling 31,400 tons of waste from the Waste Transfer Station to the Bonneville County Landfill in Great Falls (a roundtrip of 204 miles, 117,013 gallons of diesel, and 1,363 tCO_2).

Miscellaneous fuel includes Jackson Hole Mountain Resort use of gasoline and diesel for groomers and snowmobiles (181,991 gallons, 864 tCO_2), snowmobiling at Grand Teton NP and Snow King Hill Climb, boat fuel, and construction equipment (combined 174,492 gallons, 1,778 tCO_2).

Yellowstone-Teton Clean Cities estimates that through alternative fuel use programs, fuel economy improvements, reduced vehicle miles traveled, electric vehicle charging stations, and idle-reduction strategies Teton County governments and fleets reduced emissions by 3,248 tons CO_2e in 2018.

Other sources include nitrous oxide, a strong greenhouse gas emitted by fertilizers applied to parks, golf courses, and back yards, totaling 402 tCO_2e, and loss of refrigerants from household refrigerators and freezers and automobile air conditioning units. Even slow leakage of refrigerants from the County's 13,852 households and nearly 30,000 vehicles, given that refrigerants are 1,300 times to 10,900 more powerful than carbon dioxide per pound; all told we estimate annual emissions of 1,182 tCO_2e. Compared to 2008, annual emissions of fertilizer emissions rose 121 percent (chiefly from additional golf course), and refrigerant losses declined by 44 percent (chiefly from a lower loss rate at refrigerator recycling and recovery sites).

Methane: Fugitive methane comes from a number of sources, nearly all occurring in the fuel supply chain, such as coal mining for BPA's small fossil fuel portfolio, landfill emissions, and natural gas supply. Estimated methane emissions declined by 23 percent, from 14,638 tCO_2e in 2008 to 11,309 tCO_2e in 2017 — chiefly due to a much lower methane leakage rate at Bonneville versus the 2008 disposal site at Sublette County. Note: Sublette Landfill had a fugitive methane rate nearly three times higher (34.2 vs 12.6 grams CH_4 per yard of waste-in-place).

~~~
~~~

Annex A:

Boundary definition

Jackson Hole Energy & Emissions Inventory

Boundary definition (Town of Jackson, Jackson Hole, and Teton County except for areas west of Teton Pass and Yellowstone National Park).

Buildings sector

- Electricity
- Natural Gas
- Propane
- Fuel oil (if material)
- City buildings and facilities
- Special District buildings and facilities (e.g., Wastewater Treatment Facility, JH's share of County Landfill)
- School district buildings and facilities.
- Residential, commercial, government, institutional, and other building energy uses.
- Jackson Hole Mountain Resort: electricity for lifts, gondolas, tram, and snowmaking (195 acres)

Transportation

- About town (gasoline and diesel)
- Commuting and local driving (gasoline and diesel)
- Tourist travel (e.g., to Jackson Hole and/or Teton NP)
- Commercial vehicles: freight, delivery, trucking, trash collection, etc.
- City, County, State, and Federal vehicles (e.g., police cruisers, sheriff, snowplows, GTNP)
- Waste hauling from Waste Transfer Station to Bonneville County Landfill
- Local bus system (START)
- School buses
- Jackson Hole Mountain Resort: on-mountain diesel and gasoline for groomers and snowmobiles

Air travel and aviation

- Commercial air travel to Jackson Hole Airport (United, American, Delta, Frontier: all flights arriving Jackson from Atlanta, Chicago, Dallas, Denver, Houston, New York (JFK & Newark), Los Angeles, Minneapolis, Phoenix, Salt Lake City, San Francisco, and Seattle)
- Business and personal jets and turboprops flying to Jackson Hole Airport
- Locally based personal and commercial aircraft, sightseeing operators, etc.

Other "transportation"

- Fuel purchased at Jackson Lake marinas.
- Other (if material: snowmobiles, mowers, graders, construction equipment)

Methane and nitrous oxide emissions

- Wastewater Treatment Facility (deemed not material)
- Jackson Hole's share of Bonneville County Landfill (methane: if material)
- Methane emissions BPA's fossil-fired electricity for Lower Valley Energy's purchased electricity
- N_2O from fertilizer application (chiefly for Town Parks and golf courses)

References & List of Worksheets

Annex B:

References

Note: numerous additional references are listed in individual worksheets

Airport Cooperative Research Program (2008) *Guidebook on Preparing Airport Greenhouse Gas Emission Inventories, Appendix A-F*, ACRP Transportation Research Board; National, Academies of Sciences, Engineering, and Medicine, September, 91 pp. http://www.trb.org/Publications/Blurbs/160829.aspx

Alvarez, Ramón A., et al. (2018) Assessment of methane emissions from the U.S. oil and gas supply chain, *Science*, vol. 361:186-188.

BPA (2013) *Measuring the carbon content of BPA's power supply: Fact Sheet*, March, 4 pp. BPA 2011 resource mix emission factor as 48.37 lb $CO2_e$/MWh. Updated with Kristina Rohe: 34.17 lb $CO2_e$/MWh.

Darby, Marta, Richard Heede, & Kim Peterson (2009) *Aspen Greenhouse Gas Emissions Inventory, 2007: An update to the 2004 baseline*, for the City of Aspen's Canary Initiative, commissioned by the City of Aspen, Climate Mitigation Services, 64 pp, 14 worksheets, www.climatemitigation.com

Davis, Stacy, Susan Diegel, & Robert Boundy (2018) *Transportation Energy Data Book*, edition 36, Oak Ridge National Laboratory, USDOE, www-cta.ornl.gov/rpts.

Grand Teton National Park (2019) *GHG emissions FY 2014*, courtesy Margaret Wilson

Grand Teton National Park visitors 2008: 2.486 M; 2017: 3.317 M. https://irma.nps.gov/Stats/SSRSReports/Park Specific Reports/Annual Park Recreation Visitation (1904 - Last Calendar Year)?Park=GRTE

Heede, Richard (2008a) *Carbon In Our Daily Lives: an exploration of everyday climate impacts*, commissioned by Sopris Foundation, Aspen, Colorado, 8 pp (fully footnoted), and 2 pp (brochure only).

Heede, Richard (2007) *Anybody Home? Energy Consumption and Carbon Emissions from Second Homes in Aspen*, Aspen Second Homes Energy Study, commissioned by Sopris Foundation, Aspen, 21 pp.

Heede, Richard (2006) *Aspen Greenhouse Gas Emissions 2004: For City of Aspen's Canary Initiative*, Climate Mitigation Services, Snowmass, Colorado, 50 pp, plus 42 pp of worksheets and notes.

Intergovernmental Panel on Climate Change (2007) *Climate Change 2007, Fourth Assessment Report, The Physical Science Basis*, IPCC Working Group 1, Cambridge University Press, 996 pp.

Intergovernmental Panel on Climate Change (in preparation) *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*, https://www.ipcc.ch/report/2019-refinement-to-the-2006-ipcc-guidelines-for-national-greenhouse-gas-inventories/

Intergovernmental Panel on Climate Change (2013) *Climate Change 2013: The Physical Science Basis, Summary for Policy Makers*. WG1 Contribution to IPCC AR5, 27 September 2013, 36 pp.

Jackson Hole Mountain Resort (2015) *JHMR Achieves Benchmark Environmental Goal with 10% Reduction in Greenhouse Gas Emissions*, 20 April. (no news postings since 2015)

Kirchgessner, David A., Robert A. Lott, R. Michael Cowgill, Matthew R. Harrison, & Theresa M. Shires (~2000) *Estimate of Methane Emissions from the U.S. Natural Gas Industry*, US EPA: AP 42, Fifth Edition, vol. 1 chapter 14: Greenhouse Gas Biogenic Sources; www.epa.gov/ttn/chief/ap42/ch14/

National Park Service (2019) various statistical reports for GRTE: visitors by year, traffic counts by location; https://irma.nps.gov/Stats/Reports/Park/GRTE

U.S. Environmental Protection Agency (2019) *Inventory of U.S. Greenhouse Gas Emissions and Sinks, 1990-2017*, 675 pp. https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2017

Vincent, Richard C., Kevin William Cleary, Alberto Ayala, & Richard Corey (2004) "Emissions of HFC-134a from Light-Duty Vehicles in California," California Air Resources Board, *Society of Automotive Engineers*, May04, SAE # 2004-01-2256.

World Resources Institute & World Business Council for Sustainable Development (2004) *The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard*, Revised Edition, 112 pp., www.ghgprotocol.org

World Resources Institute (2005) *GHG Protocol HFC Tool* (Version 1.0) Calculating HFC and PFC Emissions from the Manufacturing, Installation, Operation and Disposal of Refrigeration & Air-conditioning Equipment (Version 1.0) Guide to calculation worksheets (January 2005)

Wuebbles, Donald (editor) (2006) *Workshop on the Impacts of Aviation on Climate Change: A Report of Findings and Recommendations*, Jun06, Cambridge, MA, 64 pp.

Annex C:

List of worksheets

1. Summary 2017/2018
2. Electricity
3. Electricity – carbon and methane factors
4. Natural Gas
5. Propane
6. Transportation - StateHighways
7. Transportation - Local Roads
8. Transportation - Grand Teton NP
9. Transportation - Tourists
10. Transportation - Misc TownSchoolCountyJHMR
11. Transportation - START
12. Transportation - TrafficData
13. Transportation – TrafficSurvey
14. Transportation – WYDOT data
15. Aviation & Air travel - Commercial
16. Aviation & Air travel - General Aviation
17. Aviation & Air travel - Landings Jan19
18. Aviation & Air travel - OpsData
19. Miscellaneous - Fertilizers
20. Miscellaneous - Landfill
21. Miscellaneous – Refrigerants

Courtesy of Thomas D. Mangelsen, and used with gratitude, www.mangelsen.com.

Appendix 1

Jackson Hole

Rick Heede Climate Mitigation Services, 970-343-0707

Summary

Community Greenhouse Gas Emissions Inventory, 2018

Last Modified: 17 August 2019

data not complete	Physical Units		Energy Units		GHG Emissions		CO2e Equivalent		Percent of Total	2018 tons CO2e	% change
Buildings: electricity											
Electricity, Jackson (Lower Valley Energy)	180,954,031	kWh	1,845,731	10^6 Btu	2,675	tons CO2	2,675	tons CO2	0.6%	8,119	-67%
Electricity, Teton County (Lower Valley Energy)	443,767,058	kWh	4,526,424	10^6 Btu	6,560	tons CO2	6,560	tons CO2	1.4%	12,278	-47%
Electricity (fugitive methane)	51	tons CH4	2,455	10^6 Btu	51	tons CH4	1,438	tons CO2e	0.3%	1,500	-4%
Total electricity	**624,721,089**	**kWh**	**6,374,610**	**10^6 Btu**	**na**	**tons CO2e**	**10,673**	**tons CO2e**	**2.2%**	**21,896**	-51.3%
Buildings: natural gas and propane											
Natural Gas, Jackson (Lower Valley Energy)	4,227,202	therms	422,720	10^6 Btu	24,706	tons CO2	24,706	tons CO2	5.2%	22,735	9%
Natural Gas, Teton County (Lower Valley Energy)	3,369,466	therms	336,947	10^6 Btu	19,693	tons CO2	19,693	tons CO2	4.1%	5,628	250%
Natural Gas (fugitive methane)	254	tons CH4	12,115	10^6 Btu	254	tons CH4	7,098	tons CO2e	1.5%	4,049	75%
Propane / AmeriGas	667,553	gallons	60,970	10^6 Btu	4,229	tons CO2	4,229	tons CO2	0.9%	6,025	-30%
Propane / Ferrellgas	346,622	gallons	31,658	10^6 Btu	2,196	tons CO2	2,196	tons CO2	0.5%		na
Propane / Suburban Propane	919,631	gallons	83,993	10^6 Btu	5,825	tons CO2	5,825	tons CO2	1.2%		na
Valley Wide Cooperative	736,406	gallons	67,258	10^6 Btu	4,665	tons CO2	4,665	tons CO2	1.0%		
Propane / Lower Valley Energy (no longer sells propane)		gallons		10^6 Btu		tons CO2		tons CO2	0.0%	9,200	-100%
Propane (fugitive methane)	97	tons CH4		10^6 Btu	97	tons CH4	2,704	tons CO2e	0.6%	828	227%
Heating oil		gallons		10^6 Btu		tons CO2		tons CO2e	0.0%	-	na
Total natural gas & propane	**2,670,212**	**gallons**	**1,015,661**	**10^6 Btu**	**na**	**tons CO2e**	**71,115**	**tons CO2e**	**14.9%**	**48,464**	46.7%
Total buildings	**na**	**gallons**	**7,390,271**	**10^6 Btu**	**na**	**tons CO2**	**81,787**	**tons CO2e**	**17.1%**	**70,360**	16.24%
Transportation: highway, around town, buses, and waste hauling											
Driving on State Highways in Teton County	12,096,714	gallons	1,512,948	10^6 Btu	121,719	tons CO2	121,719	tons CO2	25.4%	93,294	30%
Highway vehicles on local roads	3,211,941	gallons	401,721	10^6 Btu	31,326	tons CO2	31,326	tons CO2	6.5%	26,665	17%
Tourist driving to Teton County (one-quarter of one-way)	10,415,449	gallons	1,302,671	10^6 Btu	103,946	tons CO2	103,946	tons CO2	21.7%	90,312	15%
Driving in Grand Teton National Park	4,544,238	gallons	568,352	10^6 Btu	45,065	tons CO2	45,065	tons CO2	9.4%	39,806	13%
Transit Buses (START)	155,332	gallons	21,544	10^6 Btu	1,732	tons CO2	1,732	tons CO2	0.4%	1,329	30%
School Buses & other fuel use (Teton School District)	62,724	gallons	8,700	10^6 Btu	690	tons CO2	690	tons CO2	0.1%	1,743	-60%
Teton County fuel use (Sheriff)	31,508	gallons	4,370	10^6 Btu	309	tons CO2	309	tons CO2	0.1%	22	1333%
Teton County fuel use (Other fuel)	39,011	gallons	4,879	10^6 Btu	398	tons CO2	398	tons CO2	0.1%	414	-4%
Town of Jackson fuel use (Police Dept.)	24,408	gallons	3,053	10^6 Btu	239	tons CO2	239	tons CO2	0.0%	217	10%
Town of Jackson fuel use (Other fuel)	31,325	gallons	3,918	10^6 Btu	340	tons CO2	340	tons CO2	0.1%	258	32%
Waste hauling (Transfer Station to Idaho Falls; off-road diesel, trash)	207,507	gallons	28,013	10^6 Btu	2,443	tons CO2	2,443	tons CO2	0.5%	576	324%
Total highway vehicles, around town, buses, & waste hauling	**30,820,157**	**gallons**	**3,860,169**	**10^6 Btu**	**308,207**	**tons CO2**	**308,207**	**tons CO2**	**64.4%**	**254,638**	21.0%
Transportation: commercial and private aviation, one-way											
Air Travel - Commercial inbound to Jackson Hole Airport (2018)	5,345,277	gallons	721,612	10^6 Btu	56,360	tons CO2	56,360	tons CO2	11.8%	39,359	43%
Air Travel - General Aviation (jets) (2017)	2,294,917	gallons	309,814	10^6 Btu	24,197	tons CO2	24,197	tons CO2	5.1%	27,542	-12%
Air Travel - General Aviation (turboprops)	241,478	gallons	32,600	10^6 Btu	2,546	tons CO2	2,546	tons CO2	0.5%	3,233	-21%
Air Travel - General Aviation (piston aircraft)	39,423	gallons	4,738	10^6 Btu	362	tons CO2	362	tons CO2	0.1%	412	-12%
Total commercial and private aviation	**7,921,096**	**gallons**	**1,068,764**	**10^6 Btu**	**83,466**	**tons CO2**	**83,466**	**tons CO2**	**17.4%**	**70,546**	18.3%
Off-road transportation: boating, ski area, snowmobiles, & misc.											
Grand Teton Lodge Company (boat fuel)	18,052	gallons	2,258	10^6 Btu	183	tons CO2	183	tons CO2	0.04%	156	17%
Signal Mountain Lodge & Leeks' Marina (boat fuel)	16,213	gallons	2,028	10^6 Btu	159	tons CO2	159	tons CO2	0.03%	136	17%
Grand Teton National Park: NPS vehicles & off-road equipment	80,873	gallons	10,918	10^6 Btu	855	tons CO2	855	tons CO2	0.18%	1,071	-20%
Snowmobiles (Grand Teton National Park)	7,072	gallons	884	10^6 Btu	69	tons CO2	69	tons CO2	0.01%	137	-49%
Snow King Hill Climb World Championships	2,486	gallons	311	10^6 Btu	24	tons CO2	24	tons CO2	0.01%	19	25%
Jackson Hole Mountain Resort (diesel & biodiesel)	156,774	gallons	21,164	10^6 Btu	1,617	tons CO2	1,617	tons CO2	0.34%	1,356	19%
Jackson Hole Mountain Resort (gasoline)	25,217	gallons	3,154	10^6 Btu	247	tons CO2	247	tons CO2	0.05%	452	-45%
Off-road (lawn care, gas widgets)	49,796	gallons	6,228	10^6 Btu	488	tons CO2	488	tons CO2	0.10%	377	29%
Total off-road fuel and emissions	**356,483**	**gallons**	**46,945**	**10^6 Btu**	**3,642**	**tons CO2**	**3,642**	**tons CO2**	**0.8%**	**3,706**	-1.7%
Total transportation	**39,097,736**	**gallons**	**4,975,879**	**10^6 Btu**	**308,464**	**tons CO2e**	**395,572**	**tons CO2**	**82.6%**	**329,112**	20%
Landfill (Jackson Hole's share of Teton County Landfill)											
Electricity	minimal	kWh		10^6 Btu	-	tons CO2	-	tons CO2	0.00%	7	-100%
Propane	minimal	gallons		10^6 Btu	-	tons CO2	-	tons CO2	0.00%	16	-100%
Fuel consumption (diesel & gasoline: onsite)	37,500	gallons	4,688	10^6 Btu	92	tons CO2	92	tons CO2	0.02%	145	-36%
Landfill: fugitive methane	3	tons CH4	146	10^6 Btu	3	tons CH4	88	tons CO2e	0.02%	7,950	-99%
Total landfill	**various**		**4,834**	**10^6 Btu**	**95**	**na**	**181**	**tons CO2e**	**0.04%**	**8,119**	-97.8%
Nitrous Oxide sources											
Teton School District athletic fields	1,021	kg N	na		32	kg N2O	9	tons CO2e	0.0%	10	-10%
Town of Jackson & Teton County athletic fields and parks	2,371	kg N	na		74	kg N2O	22	tons CO2e	0.0%	24	-10%
Jackson Hole Golf & Tennis Club	6,516	kg N	na		203	kg N2O	59	tons CO2e	0.0%	-	
Teton Pines Country Club & Resort	6,308	kg N	na		197	kg N2O	57	tons CO2e	0.0%	64	-10%
3 Creek Ranch Private Golf Club	6,516	kg N	na		203	kg N2O	59	tons CO2e	0.0%	-	
Shooting Star Golf, Teton Village (estimated)	6,725	kg N	na		210	kg N2O	61	tons CO2e	0.0%	68	-10%
Snake River Sporting Club, Jackson, Wyoming	6,516	kg N	na		203	kg N2O	59	tons CO2e	0.0%	-	
Private greenspace in Teton County & Town of Jackson	1,629	kg N	na		51	kg N2O	15	tons CO2e	0.0%	15	2%
Targhee Village Golf Course	6,516	kg N	na		203	kg N2O	59	tons CO2e	0.0%		
Snow King Hill Climb World Championships: nitrous fuel additive	4	kg N	na		1	kg N2O	1	tons CO2e	0.0%	0.54	79%
Total nitrous oxide sources	**37,603**	**kg N**			**1,377**	**kg N2O**	**403**	**tons CO2e**	**0.08%**	**182**	121.0%
HFCs and refrigerants											
Refrigerant leakage from refrigerators, freezers, and AC units	47	kg HFC-134a	na	10^6 Btu	75	tons CO2e	75	tons CO2e	0.0%	66	14%
Improper venting of refrigerant at appliance disposal	11	kg R-12	na	10^6 Btu	91	tons CO2e	91	tons CO2e	0.0%	1,144	-92%
Refrigerant leakage from vehicle air conditioners	709	kg HFC-134a	na	10^6 Btu	1,016	tons CO2e	1,016	tons CO2e	0.2%	892	14%
Total HFCs	**767**	**kg refrigerants**			**1,182**	**tons CO2e**	**1,182**	**tons CO2e**	**0.2%**	**2,101**	-43.8%
Total	**various**	**units**	**12,370,983**	**10^6 Btu**	**various**	**units**	**478,868**	**tons CO2e**	**100.0%**	**409,652**	16.9%
Credit for LVE greenpower (Town plus County)	**23,286,893**	**kWh**	**237,526**	**10^6 Btu**	**0.034**	**lb CO2e/kW**	**398**	**tons CO2e**	**0.1%**	**611**	-34.9%
Total net emissions after renewable energy credits	**various**	**units**	**12,133,457**	**10^6 Btu**	**various**	**units**	**478,470**	**tons CO2e**	**99.9%**	**409,041**	17.0%
Methane emissions					308	tons CH4	11,329	tons CO2e	2.4%	14,638	-23%
Nitrous oxide emissions					1,377	kg N2O	403	tons CO2e	0.1%	182	121%
Refrigerant leakage					767	kg HFC-134	1,182	tons CO2e	0.2%	2,101	-44%
Carbon dioxide emissions							465,954	tons CO2	97.3%	394,832	18%

1 ton CH4 = 47.792 million Btu (EPA "Natural Gas Methane Units Converter")

Cell: K2
Comment: Rick Heede:
This worksheet summarizes all sources of greenhouse gas emissions attributable to the community of Jackson Hole for 2018 (note: a few calculations are for 2017). See the boundary definition in the Summary Report and the set of worksheets for details. All relevant sums -- physical units, energy units, GHG emissions, and CO2e equivalent -- are linked to their respective worksheets and thus automatically updated whenever any changes are made.

Cell: F5
Comment: Rick Heede:
EPA (undated) "Natural Gas Methane Units Converter," 2 pp., www.epa.gov/gasstar; PDF in Climate / Emissions / Emissions Factors. 1 ton CH4 = 47.792 million Btu

Cell: B16
Comment: Rick Heede:
CMS estimates fugitive methane from the production, processing, pipelining, and distribution of natural gas. It is an estimate of system losses, and is not attributed to Lower Valley Energy. CMS assumes the U.S. average heating valeu of 1,027 Btu per cubic foot in converting tons of fugitive methane into cubic feet.

Cell: P35
Comment: Rick Heede:
In 2008 CMS reported Town and County fuel and emissions by gasoline and diesel. In 2017 CMS reports Teton Sheriff and Other and Jackson Police and Other. Hence totals are comparable but line items are not.

Cell: J66
Comment: Richard Heede:
Includes a small amount of fugitive carbon dioxide. See Landfill worksheet.

Cell: B90
Comment: Rick Heede:
LVE provided 2017 data on "green power" purchases in Jackson and the rest of Teton County within this inventory's emission boundary. This sum (23.3 million kWh, up from 13.8 million kWh in 2008) is multplied by LVE's delivered electricity emission factor.

Cell: I90
Comment: Rick Heede:
LVE's emission factor per delivered kWh. See "Electricity" worksheet for details.

Jackson Hole Energy & Emissions Inventory: Electricity, 2017

Future inventorists need to update electricity sales by Lower Valley Energy and to check the carbon dioxide and methane emission factors with LVE's power provider (Bonneville Power Administration). All calculations are linked and automatically updated all the way to the Sum2017.xlsx worksheet and its derived charts.
Note: Carbon offsets from LVE customer' green power purchases are credited in the Sum2017.xlsx summary and calculated below.

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 8 August 2018
Last Modified: 17 February 2019

1 metric tonne: 2,204.62 lb

Data provided by:
Tammy Spraklen &
Jim Webb (Pres / CEO)
Lower Valley Energy
307-885-6125
tammys@lvenergy.com

Data provided by:
Kristina Rohe
Bonneville Power Adm
BPA Bulk Marketing
503-230-7528
kerohe@bpa.gov

Table 1		Carbon factor for BPA power delivered to LVE		
Kristina Rohe, BPA (generation)	28.44	lb CO2/MWh	0.0284	lb CO2/kWh (gen)
CMS calculation of T&D losses	3.8%	T&D loss percentage		
LVE emission factor per unit of delivered electricity	29.56	LVE EF/MWh (delivered)	0.0296	lb CO2/kWh (del)

2008 BPA emission factor 79.40 lb CO2/MWh

Methane attributed to fossil gen

Table 2	lb CH4/MWh gen	g CH4/kWh gen
Coal mining	3.82	1.73
Natural Gas systems	1.83	0.83
Petroleum	3.59	1.63
Total	2.24	1.02
all US electric gen:	-	-

see worksheet on "Electricity methane factor"

2017	Electricity		Carbon dioxide	Emissions				
Town of Jackson	Consumption kWh	Consumption MWh	Emission factor CO2e/kWh	Carbon Dioxide tons CO2	Methane tons CH4	Methane tons CO2e	Total tons CO2+CH4	Total tonnes C-eq
	Update this column		lb CO2/kWh (delivered) 0.0296		lb CH4/lb CO2 0.0056	28xCO2 28	lb CO2e/kWh 0.03417	kg C-eq/kWh 0.004
Residential	70,135,156	70,135		1,037	5.8	161	1,198	297
Small Commercial	42,809,264	42,809		633	3.5	99	731	181
Large Commercial	61,361,296	61,361		907	5.0	141	1,048	260
Large Commercial over 1000 KVA	6,362,280	6,362		94	0.5	15	109	27
LVE Electric (own use)	108,135	108		2	0.0	0	2	0
Street & other contract lighting	177,900	178		3	0.0	0	3	1
Total, Town of Jackson	180,954,031	180,954		2,675	15	417	3,091	765

Jackson + Teton County								
	Residential usage	346,754,224	kWh	Small Com'l usage	91,257,501	kWh	Irrigation, lighting, LVE	2,086,246
	Municipal usage		kWh	Large Com'l usage	184,623,118	kWh	Total	624,721,089

Teton County (excluding ToJ)	Consumption kWh	Consumption MWh	Emission factor CO2e/kWh	Carbon Dioxide tons CO2e	Methane tons CH4	Methane tons CO2e	Total tons CO2+CH4	Total tonnes C-eq
	Update this column		lb CO2/kWh (delivered) 0.0296		lb CH4/lb CO2 0.0056	28xCO2 28	lb CO2e/kWh 0.0342	kg C-eq/kWh 0.004
Residential	276,619,068	276,619		4,089	22.7	637	4,726	1,170
Small Commercial	48,448,237	48,448		716	4.0	112	828	205
Large Commercial	86,736,622	86,737		1,282	7.1	200	1,482	367
Large Commercial over 1000 KVA	30,162,920	30,163		446	2.5	69	515	128
Irrigation	1,138,014	1,138		17	0.1	3	19	5
LVE-Electric	600,005	600		9	0.0	1	10	3
Street & other contract lighting	62,192	62		1	0.0	0	1	0
Total, Teton County (excluding Jackson)	443,767,058	443,767	-	6,560	36	1,022	7,581	1,877

Jackson + Teton County								
	Residential emissions	5,924	tons CO2e	Small Com'l emissions	1,559	tons CO2e	Irrigation, lighting, LVE	640
				Large Com'l emissions	2,530	tons CO2e	Total	10,653

Teton County & Town of Jackson	Consumption kWh	Weighted factor CO2e/kWh	Weighted factor CO2e/kWh	Carbon Dioxide tons CO2	Methane tons CH4	Methane tons CO2e	Total tons CO2+CH4	Total tonnes C-eq
Total, Teton County + Town of Jackson	624,721,089	0.030	0.034	9,234	51	1,438	10,673	2,643
						13.48%	CH4 (CO2e) of total	

	kWh green power		emission factor		CO2 offset		% elec emissions
Credit for LVE greenpower (Town plus County)	23,286,893		0.0342	lb CO2e/kWh	398	tons CO2e	3.7%

Cell: H11
Comment: Rick Heede:
This table summarizes (and is linked to) the "Electricity methane factor" worksheet, which calculates the methane emission rate of coal mining, natural gas systems, and petroleum sources.
Methane emissions from EPA (2018) US Greenhouse Gas Emissions 1990-2016. Electricity generation by fossil source from EIA (2019) Monthly Energy review.
See "ElectricityCarbon2017.xlsx" worksheeet for details.
The calculation shows US average methane rate as 2.34 lb CH4 per MWh of generation, which we dilute below for BPA's resource mix.

Cell: D13
Comment: Rick Heede:
BPA emission factor for 2017: 0.0129 tonne CO2e per MWh.
CY 2017 data from Kristina Rohe, Bulk Marketing Contract Support, 503-230-7528. CMS confirmed that the datum applies to all BPA bulk sales, that LVE is a customer, and that the emision factor includes carbon dioxide as well as unknown (but apparently small) percentages of methane and nitrous oxide. CMS calculates methane emissions in the tables below, but excludes nitrous oxide emissions.

Cell: D14
Comment: Rick Heede (Jul09):
BPA's Janelle Schmidt provided BPA's low transmission loss factor of 1.9 percent (BPA uses high voltage AC transmission lines and DC distribution, which reduce line losses). This 1.9 percent T&D loss factor is lower than the U.S. average of approximately 6.5 percent. CMS assumes that local distribution and transformer losses are equivalent to BPA's factor, which doubles the overall T&D loss rate to 3.8 percent

Cell: B21
Comment: Rick Heede:
Lower Valley Energy provided electricity sales data for 2008 (by month) by rate class for Town of Jackson. Data from Tammy Spraklen, LVE, 30Jun09. CMS adds "Lighting" to Town of Jackson.

Cell: G21
Comment: Rick Heede (Jan19):
CMS estimated the additional emissions of methane in 2008, since BPA only supplied a carbon factor for CO2 emissions in that year, excluding methane associated with coal mining, natural gas, and petroleum. In 2017, however, BPA calculations include methane and nitrous oxide emissions, though the precentage of total is unknown (Kristina Rohe, BPA).

Cell: H21
Comment: Rick Heede:
Fugitive methane emissions of coals mined for each utility's coal-fired power plants diluted by coal-fired percentage of total generation and specific to each utility's coal-mining regions. This column converts tons of methane into tons of CO2-equivalent by multiplying by methane's conversion factor of 28xCO2 (100 hundred year horizon, mole basis), per IPCC Fifth Assessment Report.

Cell: E23
Comment: Rick Heede:
Calculated in Table 1.

Cell: B37
Comment: Rick Heede:
Lower Valley Energy provided electricity sales data for 2008 (by month) by rate class for Town of Jackson. Data from Tammy Spraklen, LVE, 30Jun09. CMS adds "Lighting" to Town of Jackson.

Cell: B62
Comment: Rick Heede:
LVE provided 2017 data on "green power" purchases in Jackson and the rest of Teton County within this inventory's emission boundary. This sum is multiplied by LVE's delivered electricity emission factor.

Jackson Hole Energy & Emissions Inventory: electric power CO2 and methane factors

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 24 June 2009
Last Modified: 17 February 2019

Table 1 — US CO2 emissions by generating source 2016-2017 (*Monthly Energy Review*)

2016 & 2017

		Emissions	Emissions	Generation	Elec emissions rate
		million tonnes CO2	million tons CO2	billion kWh	lb CO2/kWh gen
Electric Power Sector	**2016**	Table 12.6		Table 7.2b	
Coal		1,241.41	1,368.4	1,229.7	**2.285**
Gas		546.55	602.5	1,279.4	**1.007**
Petroleum		21.67	23.9	20.0	**2.384**
Other gases				3.9	
Total fossil		1,809.6	1,994.8	2,533.0	**1.649**
Other (MSW, Geo, Hydro, Nuclear)		1,149.02	1,266.6	1,385.1	**1.737**
Total Generation		1,821.28	2,007.6	3,918.1	**1.036**
Electric Power Sector	**2017**	Table 12.6		Table 7.2b	
Coal		1,205.67	1,329.0	1,197.8	**2.219**
Gas		506.97	558.8	1,196.8	**0.934**
Petroleum		19.11	21.1	20.0	**2.103**
Other gases				4.1	**-**
Total fossil		1,731.8	1,908.9	2,418.8	**1.578**
Other (MSW, Geo, Hydro, Nuclear)		11.65	12.8	1,458.7	**0.018**
Total Generation		1,743.40	1,921.7	3,877.5	**0.991**

2016

Table 2	LVE-specific methane factor	
Elec emissions rate		
lb CH4/kWh	lb CO2/kWh	lb CH4/lb CO2
0.0058	1.036	0.005563044

linked to Electricity2017 worksheet

2017 0.1613

Table 2 — US methane emissions by generating source 2016

2016

28-Jan-19

	Emissions	Emissions	Generation	Elec emissions rate	Elec emissions rate	Source to energy	Elec emissions rate	Elec emissions rate		MER
	million tonnes CH4	million tons CH4	billion kWh	lb CH4/kWh gen	g CH4/kWh gen	percent	g CH4/kWh gen	lb CH4/MWh gen		MtCO2
Table 12.5 Methane emissions	Table 3.2		Table 8.2a		If all source to gen		harmonized	0.00220462	lb per gram	Table 12.6 MER
Coal mining	2.15	2.37	1,198	0.004	1.80	85.8%	1.54	3.40		1,206
Natural Gas systems	6.54	7.21	1,197	0.012	5.47	31.7%	1.73	3.82		507
Petroleum	1.54	1.70	20	0.170	77.05	1.1%	0.83	1.83		19
Total fossil generation	10.24	11.29	3,918	0.00576	2.61					
	updated to 2016 data		updated to 2016 data	linked to Table 2						1,732

Methane emissions attributed to fossil generation	million tonnes CH4	percent	million tonnes CH4	million tons CH4	billion kWh	lb CH4/MWh gen	g CH4/kWh gen
Coal mining	2.15	85.8%	1.8	2.04	1,198	3.40	1.54
Natural Gas systems	6.54	31.7%	2.1	2.28	1,197	3.82	1.73
Petroleum	1.54	1.1%	0.0	0.02	20	1.83	0.83
Total	10.24		3.9	4.34	2,415	3.59	1.63
If spread across all US electric generation:			3.9	4.34	3,877	2.24	1.02

Table 3 — Calculation of methane emissions rate for the natural gas industry

Methane from natural gas industry:	**7.06**	million tonnes CH4
CO2 from natural gas consumption:	**1,237**	million tonnes CO2
Methane emissions rate as CH4	**0.00571**	kg CH4/kg CO2
Methane emissions rate as CO2e	**0.15987**	kg CO2e/kg CO2
CO2 plus methane emissions rate (short tons)	**66.787**	tons CO2e/billlion Btu
Carbon plus methane emissions rate (metric)	**16.535**	tonnes C-e/billlion Btu

AR5 methane GWP
28xCO2

Table 4 — Carbon factors (Jackson Hole)

		Standard conversion
116.89	lb CO2/million Btu	tonne = 1.1023 to
133.57	lb CO2e/million Btu	1 tonne = 1,000 kg
0.0117	lb CO2/cf	1 kg = 2.2046 lb
0.0134	lb CO2e/cf	
1.169	lb CO2/ccf	
1.336	lb CO2e/ccf	
11.69	lb CO2/Mcf	
13.36	lb CO2e/Mcf	
1,017	cubic feet/million Btu	
983.3	Btu/cubic foot	
58.44	tons CO2/billion Btu	

Table 5 — Carbon factors (Standard sea level)

117.08	lb CO2/million Btu (sea level)
0.121	lb CO2/cf (sea level)
120.59	lb CO2/Mcf (sea level)
973.7	cubic feet/million Btu (sea level)
1,027.0	Btu/cubic foot
58.44	tons CO2/billion Btu

Table 6

tonnes CH4 from gas system, 2007	7,063,000	tonnes
Bcf produced, 2007	19,089	Bcf
g CH4 per cf of gas produced, 2007	0.370	g CH4/cf

Cell: D12
Comment: Rick Heede:
Energy information Administration (2019) Monthly Energy Review 2019, data on emissions by source, 1973-2017. Table 12.6 Carbon Dioxide Emissions From Energy Consumption: Electric Power Sector.
https://www.eia.gov/totalenergy/data/monthly/

Cell: B19
Comment: Rick Heede:
Blast furnace gas, propane gas, and other manufactured and waste gases derived from fossil fuels.

Cell: F34
Comment: Rick Heede:
Environmental Protection Agency (2018) US Greenhouse Gas Emissions 1990-2016. Chapter 3.

Cell: C35
Comment: Rick Heede:
EPA (2018) US Greenhouse Gas Emissions 1990-2016, Table 3-2 (p. 3.3, pdf page 120), in kt of gas, recorded as MtCH4. Excludes abandoned oil and gas wells 0.284 MtCH4) or abandoned coal mines 0.268 MtCH4.

Cell: H36
Comment: Rick Heede:
EIA data for 2017: coal, natural gas, and petroleum consumption for power generation:
Coal production 774.5 Mt, of which 665.0 Mt for power (85.8%);
Gas: 29.2 Tcf, of which 9.3 Tcf for power (31.7%);
Petroleum: 3,413 Mb, of which 37 Mb for power (1.08%).

Cell: B43
Comment: Rick Heede:
This table calculates the methane emission rate of coal mining, natural gas systems, and petroleum sources. CMS attributes CH4 emissions on the basis of each energy source generation or electricity. For example, methane emissions from natural gas production in the United States (7.06 million tonnes of methane) in 2007 is diluted by the proportion of natural gas used in the generation of electricity (35.8 percent); the 2.5 million tonnes CH4 attributed to natural gas generation is divided by gas-fired generation of 815 billion kWh: thus 6.85 ob CH4 per MWH, or 3.11 g CH4/kWh. If all energy-related methane emissions (totaling 5.2 million tonnes CH4) is divided by total US generation of electricity (4,157 billion kWh), the the "average" methane emission rate is 2.76 lb CH4 per MWh generated. Which is the figure applied to BPA's market power: 8.8 percent of 2.76 lb CH4/MWh, or 0.2427 lb CH4 per MWh delivered to LVE's customers. This calculation is deemed conservative (the factor would be 2.48 times higher if we apply the natural gas-fired emission rate of 6.85 lb CH4 per MWh.

Cell: D52
Comment: Rick Heede (Jan19):
CMS calculates a methane emission rate associated with the production, processing, and delivery of natural gas (excluding CO2 from end-use combustion, which is estimated in column "F") from EPA's (2018) US Greenhouse Gas Emissions 1990-2016.
The calculated unit is kg CH4 per kg CO2
EPA 2018, table 3-3 shows methane emissions from natural gas systems (6.54 MtCH4) and table 3-5 shows CO2 emissions from Fossil Fuel Compbustion, of which natural gas = 1,476 MtCO2. Note: several sources shows that US methane emissions are significantly lower than EPA estimates, eg “13 ± 2 teragrams per year, equivalent to 2.3% of gross U.S. gas production, 60% higher than EPA.
See also Kirchgessner, David A., Robert A. Lott, R. Michael Cowgill, Matthew R. Harrison, & Theresa M. Shires (~2000) Estimate Of Methane Emissions From The U.S. Natural Gas Industry, US EPA: AP 42, Fifth Edition, vol. 1 chapter 14, www.epa.gov/ttn/chief/ap42/index.h

Cell: H52
Comment: Rick Heede:
These factors are for easy visibility and are derived from the factors calculated in the main worksheet.
The main factors are 19.7 percent lower than at sea level, eg, 96.22 lb CO2/Mcf vs 120.593 lb CO2/Mcf at sea level.

Cell: C53
Comment: Rick Heede:
Environmental Protection Agency (2018) US Greenhouse Gas Emissions 1990-2016. Chapter 3.

Cell: J53
Comment: Rick Heede:
lb CO2 per million Btu should be the same in Aspen as at sea level at STP. The minor difference derives from the factors supplied by SourceGas. This factor is from the DOE.

Cell: E54
Comment: Rick Heede:
IPCC (2013) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. AR5 uses a methane GWP factor of 28 x CO2, 100-year time horizon.

Jackson Hole Energy & Emissions Inventory: Natural Gas, 2017

Future inventorists must update annual sales from Lower Valley Energy to Town of Jackson and the rest of Teton County. Enter updated data in column C (divide LVE data in therms by 10^4 to get sales in billion Btu).

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started 1 June 2009
Last Modified: 31 January 2019

Data provided by:
Tammy Spraklen &
Jim Webb (Pres. & CEO)
Lower Valley Energy
307-885-6125
tammys@lvenergy.com

Table 1	Natural Gas		Emissions	Emissions				
2017	Consumption	Consumption	factor	Carbon Dioxide	Methane	Methane	Total	Total
	Therms (10^5 Btu)	Billion Btu (10^9)	carbon per btu	short tons CO2	short tons CH4	tons CO2e	tons CO2e	tonnes C-eq
	cubic feet/million btu	Btu per cubic foot (adj)	tonnes C/billion Btu	tons CO2/billion Btu	tons CH4/ton CO2	tons CO2e/ton CO2	tons CO2e/billlion Btu	tonnes C-e/billlion Btu
Town of Jackson	1,017	983.30	14.47	58.44	0.00571	0.15987	67.79	16.78
	Update this column							
Natural Gas sales (coml & resl)	4,226,888	422.7		24,704	141.1	3,949	28,653	7,094
LVE natural gas use	314	0.0		2	0.0	0	2	1
Total, Town of Jackson	**4,227,202**	**423**	**-**	**24,706**	**141**	**3,950**	**28,656**	**7,095**

Table 2	Consumption	Consumption	Emissions factor	Carbon Dioxide	Methane	Methane	Total	Total
	Therms (10^5 Btu)		carbon per btu	short tons CO2	short tons CH4	tons CO2e	tons CO2e	tonnes C-eq
Teton County (excluding Jackson)	1,017							
	Update this column							
Natural Gas sales (coml & resl)	3,356,750	335.7		19,618	112.0	3,136	22,755	5,634
LVE Gas (own use)	12,716	1.3		74	0.4	12	86	21
Total, Teton County (excluding Jackson)	**3,369,466**	**337**	**-**	**19,693**	**112**	**3,148**	**22,841**	**5,655**

Table 3								
2017	Consumption	Consumption	Emissions factor	Carbon Dioxide	Methane	Methane	Total	Total
	Therms (10^5 Btu)	Billion Btu (10^9)	carbon per btu	short tons CO2	short tons CH4	tons CO2e	tons CO2e	tonnes C-eq
Total, Teton County + Town of Jackson	**7,596,668**	**760**		**44,399**	**254**	**7,098**	**51,497**	**12,750**
		773 million cubic feet				13.78% CH4 (CO2e) of total		
		Natural Gas sales (coml	51,408 tons CO2e			LVE natural gas use	88 tons CO2e	
			99.83%				0.17%	

Table 4			
Calculation of methane emissions rate for the natural gas industry			
Methane from natural gas industry:	**7.06**	million tonnes CH4	
CO2 from natural gas consumption:	**1,237**	million tonnes CO2	AR5 methane GWP
Methane emissions rate as CH4	**0.00571**	kg CH4/kg CO2	28xCO2
Methane emissions rate as CO2e	**0.15987**	kg CO2e/kg CO2	
CO2 plus methane emissions rate (short tons)	**67.788**	tons CO2e/billlion Btu	
Carbon plus methane emissions rate (metric)	**16.783**	tonnes C-e/billlion Btu	

Table 5		Standard conversions
Carbon factors (Jackson Hole)		
116.89	lb CO2/million Btu	1 tonne = 1.1023 tons
135.58	lb CO2e/million Btu	1 tonne = 1,000 kg
0.0117	lb CO2/cf	1 kg = 2.2046 lb
0.0136	lb CO2e/cf	
1.169	lb CO2/ccf	
1.356	lb CO2e/ccf	
11.69	lb CO2/Mcf	
13.56	lb CO2e/Mcf	
1,017	cubic feet/million Btu	
983.3	Btu/cubic foot	
58.44	tons CO2/billion Btu	

Table 6	
Carbon factors (Standard sea level)	
117.08	lb CO2/million Btu (sea level)
0.121	lb CO2/cf (sea level)
120.59	lb CO2/Mcf (sea level)
973.7	cubic feet/million Btu (sea level)
1,027.0	Btu/cubic foot
58.44	tons CO2/billion Btu

EIA revised the density of methane from 42.28 to 42.37 pounds per thousand cubic feet

Cell: E12
Comment: Rick Heede:
Lower Valley Energy supplied natural gas sales data in therms (10^5 Btu). Emissions from the combustion of natural gas varies slightly (+/- 3 percent) by its heating value. CMS uses the national average heating value of 14.47 milligrams/Btu or, as it is usually reported, Tg/QBtu (teragrams/quadrillion Btu); in normal parlance this factor equals 14.47 kg of carbon per million Btu, which, at average heating value, equals ~974 cubic feet of gas.
Factors reported in this column include: 14.47 kg C per million Btu. Source: U.S. Environmental Protection Agency (2005) Inventory of U.S. Emissions and Sinks: 1990-2003, Annex B: Methodology for Estimating the Carbon Content of Fossil Fuels, http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html
Tonnes CO2 per billion Btu simply multiplies C by 3.664191 -- the isotopically accurate conversion factor -- to convert carbon to CO2, assuming full combustion of the natural gas.
* While the energy content of a cubic foot of natural gas is highly dependent on the pressure altitude at which it is delivered, the carbon content per million Btu, which is the method we employ here, only varies slightly, as mentioned above. At normal sea level pressure and energy value, one cubic foot of natural gas has a heating value of 1,027 Btu (but can vary from 950 - 1,100 Btu/cf). At sea level, one hundred cubic feet (ccf) emits 12.0953 lb CO2 upon combustion. At altitude, both the energy content and the carbon emissions will be less per ccf.

Cell: F13
Comment: Rick Heede:
Carbon dioxide emissions are a product of natural gas sales in billion Btu times the carbon emissions factor in column "E" (in tonnes) and converted to tons in column "F".

Cell: G13
Comment: Rick Heede:
See notes in Tables 3-5 below for methodology used to estimate fugitive methane emissions rate applied to the consumption of natural gas.

Cell: C15
Comment: Heede (Jul09)
CMS does not have a Btu value per cubic foot of delivered natural gas for LVE's system. At sea level 1 cubic foot (cf) of natural gas contains, on average, 1,027 Btu.
SourceGas (serving Aspen and Roaring Fork Valley) calculated a thermal conversion factor in its 2008 Rate Case of 823.2 Btu per cf, or 1,215 cf per million Btu, in Aspen. Woody Creek: 1,198 cf/million Btu, and Snowmass Village: 1,232 cf/million Btu. Since billing pressure adjustment is altitude dependent (and on the caloric value of the gas pipelined), CMS estimates Jackson Hole's (elevation 6,237 feet) pressure adjustment is proportional to that in Woody Creek, Colorado (elevation 7,347 ft): 1,198 cf/10^6 Btu * (6,237/7,347) = 1,198 * 0.8489 = 1,017 cf per million Btu, or, conversely, 983.3 Btu per cf.

Cell: B16
Comment: Rick Heede:
Lower Valley Energy provided electricity sales data for 2008 (by month) by rate class for Town of Jackson. Data from Tammy Spraklen, LVE, Jul09. CMS adds "Lighting" to Town of Jackson.

Cell: B25
Comment: Rick Heede:
Lower Valley Energy provided electricity sales data for 2008 (by month) by rate class for Town of Jackson. Data from Tammy Spraklen, LVE, 30Jun09. CMS adds "Lighting" to Town of Jackson.

Cell: D46
Comment: Rick Heede (Jan19):
CMS calculates a methane emission rate associated with the production, processing, and delivery of natural gas (excluding CO2 from end-use combustion, which is estimated in column "F") from EPA's (2018) US Greenhouse Gas Emissions 1990-2016. The calculated unit is kg CH4 per kg CO2.
EPA 2018, table 3-3 shows methane emissions from natural gas systems (6.54 MtCH4) and table 3-5 shows CO2 emissions from Fossil Fuel Compbustion, of which natural gas = 1,476 MtCO2. Note: several sources shows that US methane emissions are significantly lower than EPA estimates, eg "13 ± 2 teragrams per year, equivalent to 2.3% of gross U.S. gas production, 60% higher than EPA.
See also Kirchgessner, David A., Robert A. Lott, R. Michael Cowgill, Matthew R. Harrison, & Theresa M. Shires (~2000) Estimate Of Methane Emissions From The U.S. Natural Gas Industry, US EPA: AP 42, Fifth Edition, vol. 1 chapter 14, www.epa.gov/ttn/chief/ap42/index.h

Cell: G46
Comment: Rick Heede:
These factors are for easy visibility and are derived from the factors calculated in the main worksheet.
The main factors are 19.7 percent lower than at sea level, eg, 96.22 lb CO2/Mcf vs 120.593 lb CO2/Mcf at sea level.

Cell: C47
Comment: Rick Heede:
Environmental Protection Agency (2018) US Greenhouse Gas Emissions 1990-2016. Chapter 3.

Cell: I47
Comment: Rick Heede:
lb CO2 per million Btu should be the same in Aspen as at sea level at STP. The minor difference derives from the factors supplied by SourceGas. This factor is from the DOE.

Cell: E48
Comment: Rick Heede:
IPCC (2013) Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. AR5 uses a methane GWP factor of 28 x CO2, 100-year time horizon.

Jackson Energy & Emissions Inventory: Propane, 2017

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 1 June 2009
File last modified: 1 August 2019

Future inventorists must request updated propane sales figures from AmeriGas, Ferrellgas, Suburban Propane, and Valley Wide Cooperartive. Enter data in column "C". The calculations are automatic and are linked to the summary worksheet.

2019	2019	2019	2019	2019
Data provided by:	**Data provided by:**	**Data NOT provided by:**	**Data provided by:**	**Data provided by:**
Earle Lindell	Scott Brockelmeyer	Richard Woodard	Anthony Owens	Shannon Carter
Ferrellgas	Ferrellgas	AmeriGas	Valley Wide Cooperative	Suburban Propane
307-734-3939		307-733-3769	307-733-4328	307-733-3628
earlelindell@ferrellgas.com	scottbrockelmeyer@Ferrellgas.com	richard.woodard@amerigas.com	aowens@valleywidecoop.com	scarter@suburbanpropane.com

2019
LVE no longer sells propane
Tammy Spraklen &
Jim Webb (Pres. & CEO)
Lower Valley Energy
307-885-6125
tammys@lvenergy.com

Note: JHMR consumed 2.81 million gallons in 2008 2,813,726 gallons

2017	Propane Sales	Consumption	Carbon Factor	Carbon Dioxide	Methane	Methane	Total Emissions	Total Emissions
	gallons	Million Btu	lb CO2/gallon	tons CO2	tons CH4	**tons CO2e**	tons CO2e	tonnes C-e
Propane vendor			12.669		tons CO2e/ton CO2	tons CO2e/ton CO2		
	Update this column				0.00571	0.15987		
					linked to NaturalGas2017 Table 4: GWP 28xCO2			
AmeriGas (average of three vendors below)	**667,553**	**60,970**		**4,229**	**24**	**676**	**4,905**	**1,214**
Valley Wide Cooperative	**736,406**	**67,258**		**4,665**	**27**	**746**	**5,410**	**1,340**
Ferrellgas	**346,622**	**31,658**		**2,196**	**13**	**351**	**2,547**	**631**
Suburban Propane	**919,631**	**83,993**		**5,825**	**33**	**931**	**6,757**	**1,673**
Lower Valley Energy (Town of Jackson)		-		-	-	-	-	-
Lower Valley Energy (Teton County)		-		-	-	-	-	-
Lower Valley Energy (LVE own use)		-		-	-	-	-	-
Total propane sold in Jackson & Teton	**2,670,212**	**243,878**		**16,914**	**97**	**2,704**	**19,618**	**4,857**

Ferrellgas provided data by delivery zipcode

Methane, tons, @28xCO2	96.57	tons CH4
Methane, percent of total	13.78%	

Conversions		
1 gallon propane	91,333	Btu
1 bbl of propane	3.84	million Btu
1 million Btu	10.95	gallons
1 million Btu	138.71	lb CO2
1 million Btu	158.51	lb CO2e
1 gallon propane	12.669	lb CO2
1 gallon propane	0.072	lb CH4
1 gallon propane	14.477	lb CO2e

Cell: C19
Comment: Rick Heede:
CMS note: Make sure total propane includes all JHMR consumption.

Cell: E22
Comment: Rick Heede:
CMS uses standard EF of 12.669 lb CO2 per gallon from DOE, EPA, etc.
Carbon factor from Environmental Protection Agency (2005) Inventory of U.S. Emissions and Sinks: 1990-2001 Annex B: Methodology for Estimating the Carbon Content of Fossil Fuels,
http://yosemite.epa.gov/oar/globalwarming.nsf/content/ResourceCenterPublicationsGHGEmissionsUSEmissionsInventory2003.html

Cell: F22
Comment: Rick Heede:
Propane sales times carbon factor of 12.669 lb CO2 per gallon at full combustion / 2000 lb per ton.

Cell: G22
Comment: Rick Heede:
A fugitive methane rate is applied to the propane production and processing infrastructure. See "methane" comments on the "Natural Gas" worksheet, Table 4.
For 2017, CMS calculates methane from natural gas industry (6.54 MtCH4) divided by CO2 from Natural Gas consumption (1,476 MtCO2), yields 0.00443 kg CH4 per kg of CO2 emissions. We apply this factor to estimate methane emissions from the propane fuel cycle.

Cell: B28
Comment: Rick Heede (Feb19):
I contacted Richard Woodard by email and phone in January, requesting propane sales data for 2017. No response. Alicia Cox will follow up.
Johnny Ziem (Interim Public Wroks Director) offered in June 2019 to contact Woodard at AmeriGas, to no avail. AmeriGas has apparently refused to provide data.
CMS has therefore averaged the propane sales data for the three companies that did provide data in order to have an estimate for AmeriGas substantial sales in Teton County.

Cell: B30
Comment: Rick Heede:
Antony Owens indicated he would provide sales data for Teton County, 29 January 2019. Alicia Cox will follow up.
Owens: "We have delivered 736,406 gallons of clean burning propane in Teton County form 2017 to 2018." unclear if this is for two years or one. Alicia will follow up. CMS assumes a 12-month perriod.

Cell: B32
Comment: Rick Heede:
Scott Brockelmeyer & Earle Lindell provided propane sales for each of Teton County's six zipcodes -- 83001, 83002, 83011, 83013, 83014, and 83025 (see Excel worksheet for 2017 [not printed on the PDF] for details. 2017 totaled 346,622 gallons; 2018 totaled 388,854 gallons.

Cell: B34
Comment: Rick Heede
Shannon Carter, 22Jan19: 2018 sales:
Jackson Proper – 367,852 gallons
Teton County – 551,779 gallons
Total Gallons – 919,631 gallons

Cell: B36
Comment: Rick Heede:
Lower Valley Energy provided propane sales data for 2008 (by month) by rate class for Town of Jackson and the rest of Teton County. Data from Tammy Spraklen, LVE, Jul09.
2017 update: LVE no longer sells propane. Source: Tammy Spracklen.

Cell: E49
Comment: Rick Heede:
Basic data from EIA Emission Coefficients (1605b Program), e.g., 532.085 lb CO2 per bbl, 139.178 lb CO2 per million Btu, and 3.836 million Btu per bbl (AER 1995).

Jackson Hole Energy & Emissions Inventory: Driving on State Highways in Teton County

The principal variables that need to be updated in future fuel and emissions inventories is the traffic and VMT data from the Wyoming Dept of Transportation summarized in Table 2 below.
Inventorists may elect to update fuel consumption for each vehicle type (if needed).

Richard Heede
Climate Mitigation Services
Snowmass, Colorado
File Started: 1 June 2009
File last modified: 22 October 2018

Data from:
Darin Kaufman
District 3 Traffic Engineer
Rock Springs
307-352-3034
darin.kaufman@wyo.gov

Data from:
Chad Mathews
District 3 Traffic Engineer
Rock Springs
307-777-4190
chad.mathews@wyo.gov

WyDOT
Transportation Surveys
http://www.dot.state.wy.us/home/planning_projects/Traffic_Data.default.html

Table 1	Update this column		Update this column				
Driving on State Highways	**Vehicle by type**	**Miles driven (VMT)**	**Fuel economy**	**Fuel consumed**	**Carbon factor**	**Carbon dioxide**	**Carbon**
	10-Sep-18	miles	mpg	gallons/yr	CO2/gallon	tons CO2/yr	tonnes carbon
Passenger cars (sedans, stationwagons, etc)	**18.8%**	44,175,620	26.8	1,648,344	19.59	**16,149**	**3,998**
Small SUVs and small pick-up trucks	**29.4%**	69,011,682	22.4	3,080,879	19.59	**30,183**	**7,473**
Medium/Large SUVs and large "light" trucks	**40.4%**	94,865,616	19.1	4,966,786	19.59	**48,660**	**12,047**
2-axle medium-duty trucks (Class 3)	**3.9%**	9,160,843	10.4	880,850	20.99	**9,244**	**2,289**
3-axle trucks, dump trucks, etc (Class 4-7)	**1.0%**	2,442,891	7.5	327,905	22.38	**3,670**	**909**
Semis, combination trucks (Class 8)	**0.2%**	407,149	5.9	69,008	22.38	**772**	**191**
RVs and camper trailers	**4.5%**	10,585,863	14.0	756,133	23.38	**8,841**	**2,189**
Buses (tour buses, not transit)	**1.0%**	2,239,317	7.0	319,902	23.38	**3,740**	**926**
Motorcycles	**0.9%**	2,035,743	43.4	46,907	19.59	**460**	**114**
Total	**100%**	**234,924,724**	**19.4**	**12,096,714**	**20.12**	**121,719**	**30,136**
Compare Total in 2008 Inventory		**171,157,513**	**18.2**	**9,400,790**	**19.8**	**93,294**	**23,098**
Percent change		**37.3%**	**6.7%**	**28.7%**	**1.4%**	**30.5%**	**30.5%**

	Update this column	Update this column			Subtract	
Table 2	**2017 Vehicle Miles on State Highways by County: Teton County**				**Grand Teton NP**	**Net Non-GTNP**
Vehicle travel data for Teton County	**Roadway length**	**Vehicle Miles/day**	**Vehicle Miles/day**	**Vehicle Miles/year**	**Vehicle Miles/year**	**Vehicle Miles/year**
	Mileage	DVMT*	DVMTT**	Annual DVMT*	Annual DVMTT**	"GTNP driving"	
Interstate	-	-	(Class 4 and above)	-			
Other Principal Arterial	155.1	558,614		203,893,983			
Minor Arterial	17.6	170,898		62,377,635			
Major Collector	6.6	64,394		23,503,763			
Minor Collector	-	-		-			
Local	5.0	3,155		1,151,698			
Total	**184.2**	**797,060**	**71,771**	**290,927,079**	**26,196,396**	**56,002,355**	**234,924,724**

* Daily Vehicle Miles Traveled **Daily Vehicle Miles Traveled by Trucks

CMS deducts GTNP's VMT on state highways within the park
The 50 million VMT in the park is thus subtracted from the WY DOT's estimate of VMT on State Highways so as to avoid double counting.

	Annual Veh & Trucks	Annual in 2008	Percent change
Annual VMT total	**317,123,475**	238,333,747	33.1%

WYDOT VMTbyCounty (Teton)	367,693,090
WYDOT VMTbyCounty (Teton) excl. local roads / s	337,043,310

Vehicle Class	**Truck classifications**
Class 1 Light duty	The Class 1 truck GVWR ranges from 0-6000 lbs.[1] Examples of trucks in this class include the Toyota Tacoma and GMC Sonoma.
Class 2	The Class 2 truck GVWR ranges from 6,001-10,000 lbs.[1] Examples of vehicles in this class include the Nissan Titan and the Ford E-250.
Class 3, Medium duty	The Class 3 truck GVWR ranges from 10,001-14,000 lbs. Examples of vehicles in this class include the Ford F-350 and the GMC Sierra 3500.
Class 4	The Class 4 truck GVWR ranges from 14,001-16,000 lbs. Examples of vehicles in this class include the Ford F-450 and the GMC W4500.
Class 5	The Class 5 truck GVWR ranges from 16,001-19,500 lbs. Examples of trucks in this class include the International MXT and GMC Topkick.
Class 6	The Class 6 truck GVWR ranges from 19,501-26,000 lbs. Examples of trucks in this class include the International Durastar and GMC Topkick C5500.
Class 7, Heavy duty Kenworth dump truck	The Class 7 GVWR ranges from 26,001-33,000 lbs. Examples of trucks in this class include the International TranStar 8500.
Class 8	The Class 8 truck GVWR is anything above 33,000 lbs.

Cell: C14
Comment: Rick Heede:
Vehicle classification was determined by traffic surveys in Jackson (and other sites in Teton County) on 10 and 11 September 2018. See worksheet "Traffic Survey 2018" for survey results.

Cell: E14
Comment: Rick Heede:
CMS uses fuel economy data from Davis et al Transportation Energy Data Book, ed. 36, 2018.
For passenger cars we use TEDB Table 4.1 Summary Statistics for Cars, 1970–2016 shows fleet fuel economy of 26.8 mpg in 2016 (latest year available), vs 22.5 mpg in 2007.
For Small SUVs amd small pick-up trucks we use Table 4.3 Summary Statistics for Light Vehicles, 1970–2016 and 2016 fuel economy of 22.4 mgp (vs 20.4 mpg in 2007).
For Medium/Large SUVs and large "light trucks" we use TEDB table 4.2 Summary Statistics for Two-Axle, Four-Tire Trucks, 1970–2016 and 2016 fuel economy of 19.1 mpg (vs 18.0 mpg in 2007).
For 2-axle medium-duty trucks (Class 3) there is no updated fuel economy data. CMS uses Table 5.4 Truck Statistics by Gross Vehicle Weight Class, 2002, shows Class 3 (10,001 – 14,000 lb) at 10.5 mpg,
For 3-axle trucks, dump trucks, etc CMS uses average of Class 4 through 7: Class 4 (14,001 – 16,000 lb) at 8.5 mpg, Class 5 (16,001 – 19,500 lb) at 7.9 mpg, Class 6 (19,501 – 26,000 lb) at 7.0 mpg,, and Class 7 (26,001 – 33,000 lb) at 6.4 mpg. The average is 7.45 mpg. (Most such trucks are Class 6.)
For Semis, combination trucks we use Table 5.2 Summary Statistics for Class 7-8 Combination Trucks, 1970–2016, average fuel economy of 5.9 mpg (vs 6.0 mpg in 2007, though Federal Highway Administration changed mpg methodology ie 2006: 5.1 mpg).
New cars and trucks get better fuel economy. Table 4.8 Production, Production Shares, and Production-Weighted Fuel Economies of New Domestic and Import Cars, Model Years 1975-2017 shows new cars (81%) at 30.0 mpg and new car SUV (19%) at 26.0 mpg.
Table 4.10 Production, Production Shares, and Production-Weighted Fuel Economies of New Domestic and Import Light Trucks, Model Years 1975-2017 shows 2017 fuel economies of 18.9 mpg for Pick-ups (28.4%), 22.8 mpg for Vans (7.6%), and 22.2 mpg for Truck SUVs (64%).
Davis, Stacy C., Susan E. Williams, & Robert G. Boundy (2018) Transportation Energy Data Book, edition 36, Oak Ridge National Laboratory, US DOE, 400 pp. cta.ornl.gov/data/

Cell: F14
Comment: Rick Heede:
Miles driven / fuel economy. Conservative estimates.

Cell: E23
Comment: Rick Heede:
A big 40-foot bus style (class A) consumes 18- 29 litres/100km (8-13 mpg). A smaller class C can expect to get 16-23 litres/100km (10-15 mpg); a van style class B gets a thrifty 11-13 litres/100km (18-20 mpg) or better.
CMS averages Class A, B, and C to 14.0 mpg.

Cell: E26
Comment: Rick Heede:
Average of all vehicle types: VMT / estimated fuel consumption.

Cell: H32
Comment: Rick Heede:
CMS subtracts estimated VMT within Grand teton National Park made on designated State Highways (which CMS estimates on the "GTNP driving" worksheet as 56.0 of 70.4 million vehicle miles driven with GTNP. The 50 million VMT in the park is thus subtracted from teh WY DOT's estimate of VMT on State Highways so as to avoid double counting.

Cell: G33
Comment: Rick Heede:
Traffic counts and VMT data for Teton County are available at: http://www.dot.state.wy.us/home/planning_projects/Traffic_Data.default.html

Cell: D34
Comment: Rick Heede:
Wy DOT's worksheet "County Sum 2" details mileage and VMT for Teton County (and other WY counties) by roadway type in "Daily Vehicle Miles Traveled." CMS multiplies this column by 365 days per year to get annual VMT.

Cell: C42
Comment: Rick Heede:
Total roadway length of state highways in the Wyoming DOT dataset for Teton County. CMS estimated roadway length by measuring distance on the map used to designate the inventory boundary, counting only roadways marked with Route Numbers: 112 miles.

Cell: D48
Comment: Rick Heede:
Chad Mathews, District 3 Engineer, chad.mathews@wyo.gov sent a file of annual transportation statistics with data by county for years 2003 to 2017. This data includes statistics on VMT on all roadway types, including local roads and streets (83,972 Daily VMT in 2017, or 30.6 million annual VMT). It is unclear why this WYDOT dataset does not agree with VMT data for the same year in the publicly accessible data on "Vehicle Miles on State Highways by County." (http://www.dot.state.wy.us/home/planning_projects/Traffic_Data.default.html)
CMS uses the latter dataset for consistent update of 2007 CMT data.