GREENHOUSE GAS EMISSIONS INVENTORY
FOR
THE UNIVERSITY OF WYOMING
Fiscal Year 2018

By
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For

The Campus Sustainability Committee of the University of Wyoming

And

The American College and University Presidents Climate Commitment

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Abstract

The University of Wyoming (UW) conducts a Greenhouse Gas (GHG) Emissions Inventory as part of its commitments as a signatory to the American College and University Presidents Climate Commitment (ACUPCC). This commitment was signed in fall of 2007 by UW President Tom Buchanan. The Campus Sustainability Committee leads this annual effort. The purpose of a GHG Emissions Inventory is to better understand the University's contributions to climate change as well as track its progress towards reaching GHG reduction goals. This document is a narrative report based on UW's GHG Emissions Inventory for the Fiscal Year (FY) 2018. The inventory data is included in Appendix A and includes FY 2002 through FY 2017. SIMAP a GHG Emission calculator designed for College Campuses and developed by the Sustainability Institute at the University of New Hampshire was used to calculate emissions. Data from all division of UW's actions and activities were calculated and collected as inputs to the SIMAP calculator.

UW emitted a net total of 72,604 metric tons of eCO_2 (MTCDE) during FY 2018, a 26.6% decrease from FY 2017 (98,900 MTCDE), and a 26.8% decrease from FY 2005 (99,131 MTCDE). As a result of these reductions the University of Wyoming exceeded its 2020 reduction goal by 6,700 MTCDE. This overall reduction was a result of reduced on campus combustion of natural gas, reduced directly financed air travel, along with the implementation of a new GHG emissions calculator. Since an updated version of the calculator was used this year, the calculated emissions are slightly different from reported values in previous years. However, all data was reentered into the current calculator to ensure accurate and consistent results.

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Introduction

American College and University Presidents Climate Commitment (ACUPCC)

The ACUPCC was organized in the fall of 2006 and is supported by the Association for the Advancement of Sustainability in Higher Education (AASHE), ecoAmerica, and Second Nature. The purpose of this organization is to address global climate change by engaging institutions of higher education to commit to neutralizing their GHG emissions.

In September 2007, UW President Tom Buchanan signed onto this organization, joining 152 other presidents and chancellors representing higher education institutions across the United States. Signatories to the commitment pledge to complete a series of steps to eliminate their campuses' greenhouse gas emissions and increase sustainability over time. These steps are to:

- Complete an annual emissions inventory
- Choose from a designated list of immediate or short-term actions to reduce GHG emissions
- Complete a Climate Action Plan within two years of signing to achieve carbon neutrality
- Integrate sustainability into the curriculum
- Make the Climate Action Plan, inventory, and progress reports publicly available

UW's Climate Action Plan outlines GHG reduction goals:

"The Climate Action Plan is divided into three phases: Phase I (2010-2015), Phase II (2015-2020), and Phase III (2020-2050). The Phase I target is to reduce carbon emissions to 15 percent below 2005 levels by 2015. The Phase II target is to reduce carbon emissions to 25 percent below 2005 levels by 2020. The Phase III target is to achieve carbon neutrality by 2050."

Progress toward these goals will be discussed in the results and discussion section.

Greenhouse Gas Emissions Inventories

A GHG Emissions Inventory is an accounting of the amount of GHGs emitted to or removed from the atmosphere over a specific period of time from a spatially and conceptually defined entity—in this case the University of Wyoming. Conducting an annual GHG Emissions Inventory provides a measurement by which an institution can monitor the effects of its efforts on GHG emissions.

There are numerous emissions inventory calculators used by governments, businesses, schools, and others around the globe. However, the goal to provide a numerical value for an entity's role in contributing to global climate change is still the same. Almost all GHG emissions calculators convert emissions and energy use data into carbon dioxide equivalent units, or eCO_2. An eCO_2 is calculated based on its Global Warming Potential (GWP), which is the ratio of warming that would result from 1 kg of any GHG to x kg of CO_2 in a fixed period of time. The GWP ratio is the Radiative Forcing (RF) of a given substance being emitted in relation to the RF of CO_2, which based on wavelength and lifetime, determines the degree to which the gas traps the sun's energy. For instance, the GWP of Methane (CH_4) is 25, so 1 molecule of CH_4 warms the planet to a similar extent as 25 molecules of CO_2 meaning that emitting 1 kg of CH_4 is equivalent to emitting 25 kg of CO_2. This methodology allows for a standardized unit of comparison between various gases and facilitates meaningful comparisons both within and among measuring entities (IPCC 2007).

Second Nature is the supporting organization for the ACUPCC. Its Climate Leadership Network integrates the goals of carbon neutrality and climate resilience, and provides an opportunity for higher education institutions "to model and innovate climate solutions necessary to preserve a climate conducive to supporting human civilization" (Second Nature 2017). Second Nature's reporting platform allows colleges and universities to track and report their yearly emissions and has 597 active signatories. These inventories are also component of the Association for the Advancement of Sustainability in Higher Education (AASHE) and its Sustainability Tracking, Assessment & Rating System (STARS). STARS was created by and for higher education and designed to help partner universities gain recognition for sustainability efforts, generate ideas, engage their community, create a baseline for continuous improvement and inform strategic planning and budgeting STARS, 2019). Universities receive points for their completion of the GHG emissions inventories and the decisions they make as a result thereof.

GHG Emissions Inventory Calculator

The Campus Carbon Calculator was discontinued and replaced by SIMAP (Sustainability Indicator Management and Analysis Platform). SIMAP is still managed by the University of New Hampshire Sustainability Institute (UNHSI), but is an online platform rather than an Excel based system. SIMAP also maintains its recommendation from the Second Nature Climate Commitment for GHG emissions calculations. This most recent update includes changes in methodology and emissions factors which carries implications for the 2005 baseline and progress towards the GHG Emission Reduction Goals. The emission factor and methodology changes can be seen below in **Table 1** and **Table 2**.

Table 1. Has a summary of all changes in Methodology from CCC V.9 and SIMAP and their impacts to UW's Inventory.

Change in Emission Factors CCC V.9 to SIMAP	
Change	**Summary and Impact**
Scope 1: On-Campus Stationary ● 1990-2006 and 2012+: coal, natural gas, distillate oil, residual oil CH4. ● 1990-2006: Distillate oil, residual oil N20 ● 2012+: Coal, natural gas, distillate oil, residual oil, biomass N20 ● All years: Biomass CH4 and N20 (2012 + only)	These were updated to ensure that it was in line with 2014 IPCC Inventory standards. SIMAP claims changes will be small since CO2 factors, which make up a majority of stationary combustion emissions were not affected. However, UW's emissions were impacted by these changes.
Scope 2: Air Travel CO2	There is a 2.7 radiative forcing factor associated with high altitude emissions. SIMAP adjusted this so that it was directly correlated to passenger miles with air travel.

Table 2. Has a summary of all changes in Methodology from CCC V.9 and SIMAP and their impacts to UW's Inventory.

Change in Methodology CCC V.9 to SIMAP	
Change	**Summary and Impact**
Scope 1: On-Site Renewable	Allows tracking of on Campus Renewables, even if energy is sold as Renewable Energy Credits. This does not impact UW's Inventory
Scope 2: Utility Consumption	This changes the utility emission factors. They will be calculated based on eGrid, energy make-up. This impacts UW's inventory as a UW's inventories prior to FY 2011 were not based on this method. Impacts are discussed in the discussion section.
Scope 2: Purchased and Sold Renewable	Aligns calculator with WPA Renewable Energy Certificate Program. SIMAP states this will not change footprint as it is merely accounting methodology.
Scope 3: Student Travel to/from home data entry	In CCC V.9, users had to do this calculation whereas calculation is built into SIMAP now. This just updates fuel efficiencies.
Scope 3: Directly Financed Air Travel	Allows for the calculation of air miles from dollars spent on travel. This was derived from dollar value of air travel from international and domestic air industry averages.
Biogenic allocation for incinerated waste	Changes assumed make-up of incinerated campus waste. Not applicable to UW's Inventory.
Sinks and Offsets	Allows for better tracking of offsets whether they be purchased offsets, or compost. Not applicable to UW's Inventory
Weighted Campus User	Allows for better normalization between campuses as a campus where all students reside will be much more carbon intensive than an institution that students reside off campus. This was not done as data would not have been available for 2005.

Physical and Temporal Boundaries

The physical boundaries of this inventory extend beyond the main campus to include off-campus properties owned by UW within the state of Wyoming. This includes four research farms and Ranches, Research Outposts, and Medical Centers operated by the University. This should correlate to the boundary used for AASHE stars. The ACUPCC requires participating institutions to calculate and report emissions in periods of one year, either calendar, fiscal, or academic. This

inventory calculates and reports data according to the 2018 fiscal year (July 1, 2017 through June 30, 2018).

Methodology for Collection of Data

The FY 2018 GHG emissions inventory for UW with direction and oversight from the University's Campus Sustainability Committee and UW Operations. Data from the main campus and off-campus properties and activities were then entered into excel and uploaded to SIMAP. In addition to FY 2018 data, all previous years data was entered into this version of the CCC and recalculated to ensure a consistent historical comparison.

When collecting data, we verified with campus sources whether the data included or excluded properties outside of the main campus to avoid missing information or double counting. In the event the data provided did not include UW property outside of the main campus, we contacted satellite properties for the remaining data, which was then aggregated with the main campus data before being entered into the CCC spreadsheet for calculation. The resulting data sets include on-campus and off-campus sources. Appendix B shows each emission data category and its source.

The ACUPCC identifies three scopes of emissions that the data categories of the CCC inventory calculator fall into (Figure 1):

- Scope 1 emissions are direct GHG emissions from sources either owned or controlled by the institution.

- Scope 2 emissions are indirect emissions that are generated in the production of electricity, steam, and chilled water.
- Scope 3 refers to all other indirect emissions that occur as a consequence of activities of the university from sources not owned or controlled by the university.

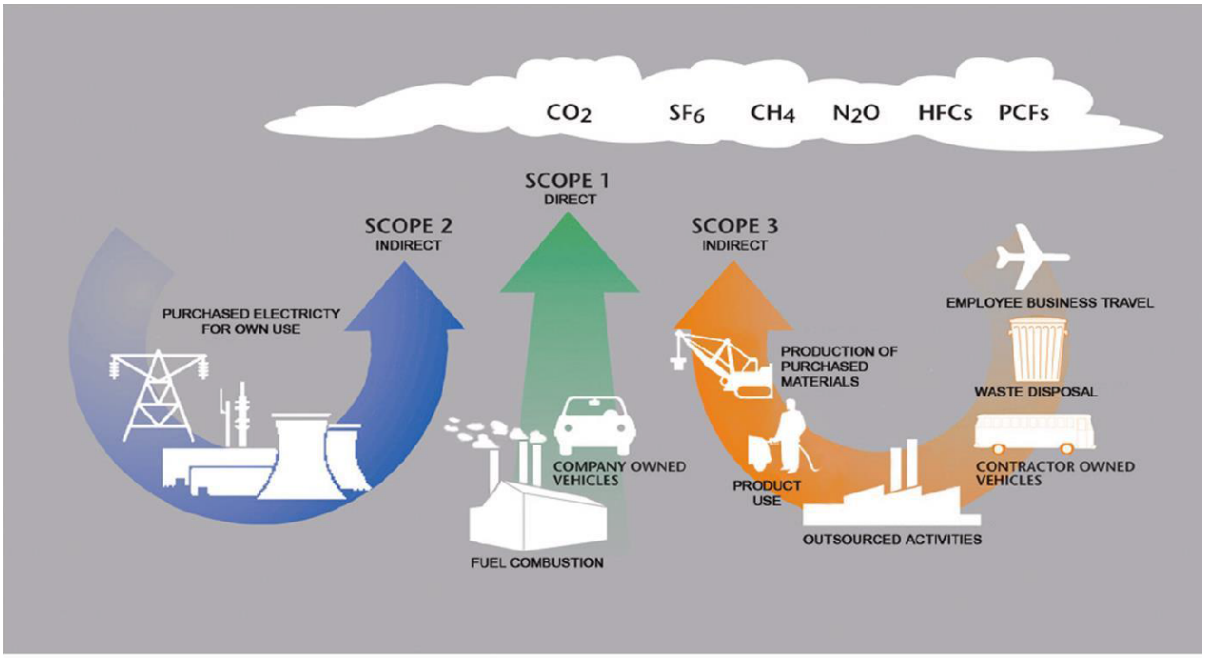

Figure 1 What sources belong to each scope.

Budget

For this inventory, data regarding the University budget is divided into three categories: operational budget, research dollars, and energy budget. This financial data allows for normalization against other institutions on a basis of size, and spending. The operational budget includes the entire energy budget as well as some of the research funds. This should be noted when interpreting data outcomes. The operational budget was sourced from the University of Wyoming Fiscal Year 2018 Operating Budget posted by the UW Budget Office.

SIMAP instructs users to include the combined costs of purchased electricity, chilled and steamed water, and any other purchases for the production of on-campus stationary sources of energy (e.g., heating, cooling, etc.). UW's energy budget includes purchased electricity, coal, propane, and natural gas. Water is not included because the water used and purchased by the university does not go towards energy production.

Research funds are separate monetary awards or grants to the University for Specific Research Projects. The research money included in the operational budget is a much lower amount that primarily covers personnel costs that are not covered by awards and grants. The dollar value used for the Research Budget was provided by the Vice President of Research for UW. Two numbers were provided, one which gave External Awards secured, and another which gave the External Award Expenditures. The External Award Expenditures was the value used for this report.

All three budget categories include data from UW's satellite locations and properties. The operational budget would include some costs that are associated with new building or facility

upgrades, including satellite buildings financed by UW. New construction costs are generally not included in the operational budget due to new buildings being financed from State grants, Alumni contributions, and Federal dollars.

Building Space
Total building space was obtained from the campus master building list maintained by UW Real Estate operations. Square footage for total building and research space excludes satellite building space with utilities not paid for by the university. UW Real Estate Operations describes building by their main use. Research space was calculated by totaling space described as "Research" or "Laboratory". It should be noted that the amount of building space recognized by UW Real Estate Operations totaled to 7,886,120 sqft vs the 7,409,262 sqft recognized by the UWYO Factbook.

The huge growth in the UW campus and demolition of old facilities each year alters the building space numbers. Research space was included in total building space. This is not considered double counting because the two numbers are graphed separately, and this inclusion follows the calculator guide.

Other On-Campus Stationary Sources
UW does not co-generate, hence this data falls under the Other On-Campus Stationary sources category. When calculating and converting total emissions in metric tons (MT) of eCO_2 from original units, the calculator automatically combines the components of on-campus stationary into one total figure of MTCDE.

Transportation
The University of Wyoming buys and provides gasoline and diesel for its own fleet, and reimburses personal vehicles for their mileage. We retrieved records of gallons of gas and diesel used in FY 2017 from UW Fleet Services, and records on reimbursed miles from Accounts Payable. This number does not reflect fuel purchased for UW fleet vehicles while they are away from Laramie.

Refrigeration
The reported refrigerants used for FY 2018 included R-407a, R409, and R-22. Data was not collected for properties not on the main campus. The weight numbers were collected from University of Wyoming Operations and are the weights of refrigerant used. This does not include new refrigeration units installed, or refrigerants used by outside contractors.

Electricity
UW purchased 98.3% of its electricity from Rocky Mountain Power and 1.68% from Black Hills Energy. Data was provided by Mr. Forrest Selmer for UWYO Main Campus and other controlled properties. UWYO Casper and the University of Wyoming Medical Building in Cheyenne Wyoming, and research farms and ranches were collected by directly contacting the facility managers. The University does not purchase any steam or chilled water.

Custom Fuel Mix
Fuel make-up of the electricity used by the campus was needed in order to determine the emissions generated by the energy production. The fuel makeup was determined using the Department of Energy's eGrid summary which gave fuel percent makeup (percent of electricity provided by Coal, Natural Gas, Oil, Nuclear, Hydro-electric, and Other Renewables) for the UW campus. All electricity was assumed to have similar fuel make-up of due to the fact that only

1.68% was from other grid regions. Due to the updates between CCC V.9 and SIMAP, it required previous years to have eGrid percent fuel makeups to be entered. Unfortunately, not all years were available. SIMAP then used set emission factors related to each energy source. 2006, 2008, and 2011 were not available. A request for data with the DOE was even submitted to secure data to no avail. In order to increase the usefulness of the inventory missing data points were calculated by interpolating the value that would be halfway between the prior and following years.

Attributable Solar- Electric

The University of Wyoming has four solar grids on campus. The Ford Array, which is by the football stadium. The Energy Innovation Center Array, located on the roof of the Energy Innovation Center. The College of Engineering and Applied Science (CEAS) Array, which is located on the roof of the College of Engineering and Applied Science. Lastly, the Haub School Array which is located on the roof of the Haub School. Output numbers are only available from the Ford Array and EIC Array. The CEAS Array is operational, but is not tracked. At the time of this report, the Haub School Array was not operational. The monitored arrays provide .165% of total campus electricity demand.

Attributable Solar- Thermal

The UW Visual Arts Facility was designed with a Solar Thermal Heat system. The Solar Thermal system was not operational during FY 2018 but will be operational during FY 2019. A tracking system should be implemented.

Commercial Air Travel

Commercial air travel was calculated based on data provided by the University of Wyoming Business Management center. This year, methodologies differed from last years in the following ways. Past years had been able to break down data using different indicators. With the implementation of WyoCloud, data could only be broken down into domestic and foreign travel for employees and non-employees. Student travel expenses could be found within both the expenses for employees and non-employees. As a result, data had to be sorted line, by line to indicate whether it was air travel or not. Since SIMAP allows for the input of dollars, the total amount spent was not converted into miles as had been the practice in previous reports. Lastly, values under $100 were not eliminated nor was a baggage fee of $12.51 and reservation fee of $10.57 subtracted as had been done in 2015, 2016, and 2017. By not making this amendment there was only a positive .68% increase in total directly financed jet travel emissions (negative values greater than -$100 were included). For 2018 values between $20.00 and -$20.00 were excluded. It should be noted that the report included negative values as it was observed that a number of negative values were present for air travel. The negative values are refunded airfare. By Using SIMAP's conversion, it will allow for greater consistency through the years. For further information on past methodologies please view the FY 2017 UW GHG Emissions Inventory.

Private Air Travel

The University of Wyoming owns two private planes—the N2UW and the N200UW (a transportation plane and a research plane). We obtained the nautical miles travelled for FY 2017 for the transport craft from the CEAS business manager. The CEAS business manager was also able to provide flight time. Private air travel by UW has negligible impacts when compared to commercial air travel and was not included due to uncertainty in values. SIMAP is using emissions

from jet travel rather than small propeller driven aircraft. Jet travel is much more emission intensive than small prop- aircrafts.

Nitrogen
Nitrogen information was gathered from the four research farms, main university campus, Glenn Jacoby Golf Course, UW Athletics, and UW Residence Life and Dining. Previous reports had not included research farms.

Solid Waste
Solid waste generated by UW is taken to a landfill where there is no CH_4 recovery. This number is not inclusive of annex properties. Forrest Selmer was able to provide these values.

Results

In FY 2018 the University of Wyoming emitted a gross total of 72,604 Net MTCDE (metric tons of carbon dioxide equivalent). This is a 26.6% decrease in emissions from FY 2017's gross total of 98,900 MTCDE, and a 26.8% decrease from FY 2005's gross total of 99,100 MTCDE (Figure 2).

Updating to SIMAP and newer emission factors and flobal warming potential values lead to reduced emission totals throughout inventory history. For example, the FY 2017 report found that in FY 2005 there was a gross total of 127,510 MTCDE emissions whereas the FY 2018 inventory found that in FY 2005 a total of 99,100 MTCDE was emitted by the University. It should be noted that beyond eGrid factors, no data was adjusted from previous inventories.

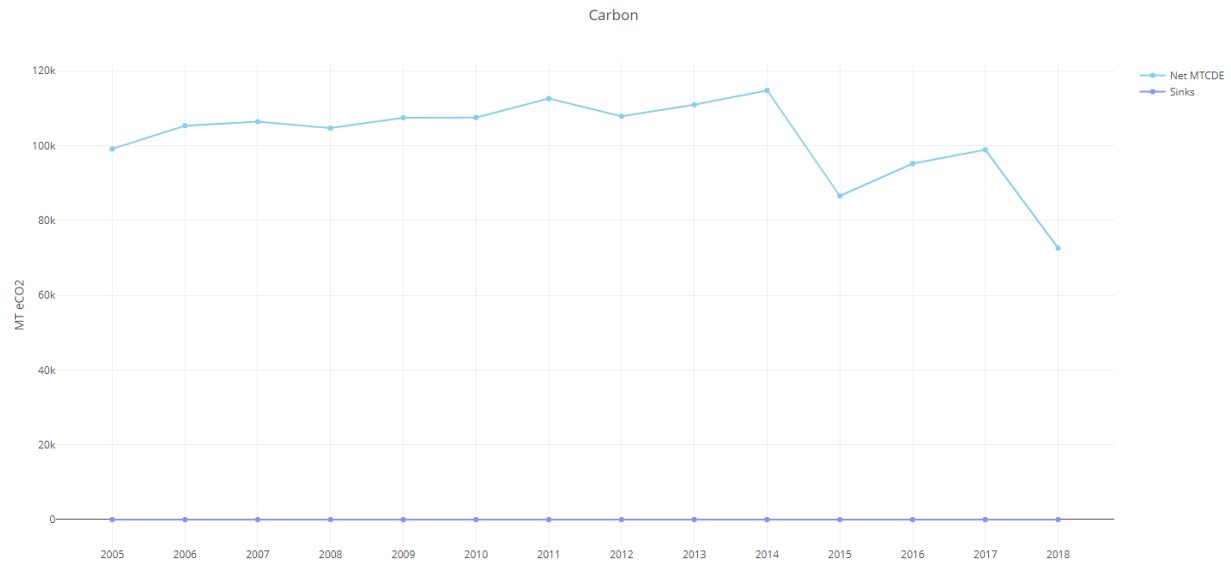

Figure 2 UWYO GHG emissions since FY 2005

The major sources of eCO_2 emission for UW are on-campus stationary sources, purchased electricity, solid waste and directly financed outsourced travel (Figure 3). The highest GHG contributor for FY 2018 was purchased electricity. Purchased electricity contributed 41.1% of overall emissions or 29,800 MTCDE. Other On-campus Stationary is the second highest source, contributing 35.9% which equaled 26,060 MTCDE. Fertilizers and animals is third, making up 7.44% of total emissions and contributing 5,400 MTCDE. Directly Financed air Travel followed closely and made up 6.58% or 4,780 MTCDE.

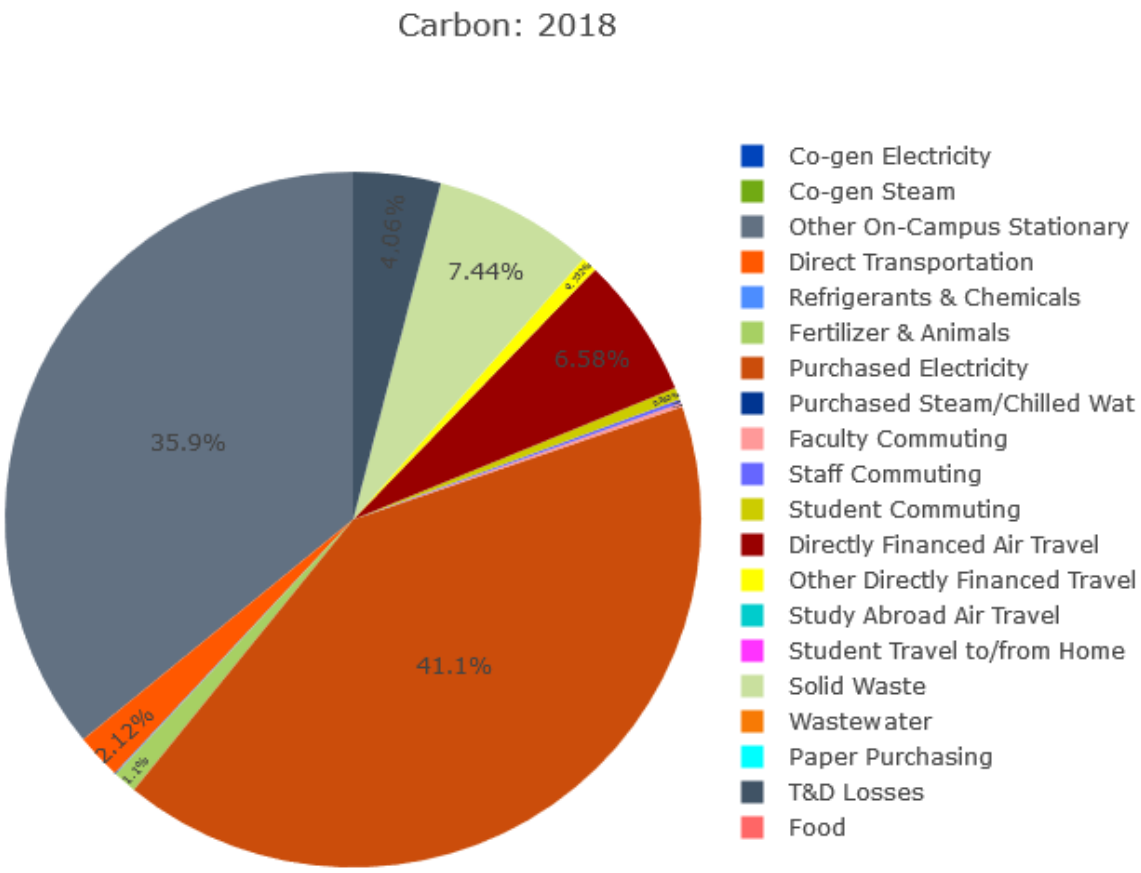

Figure 3 Shows breakdown of UWYO emissions

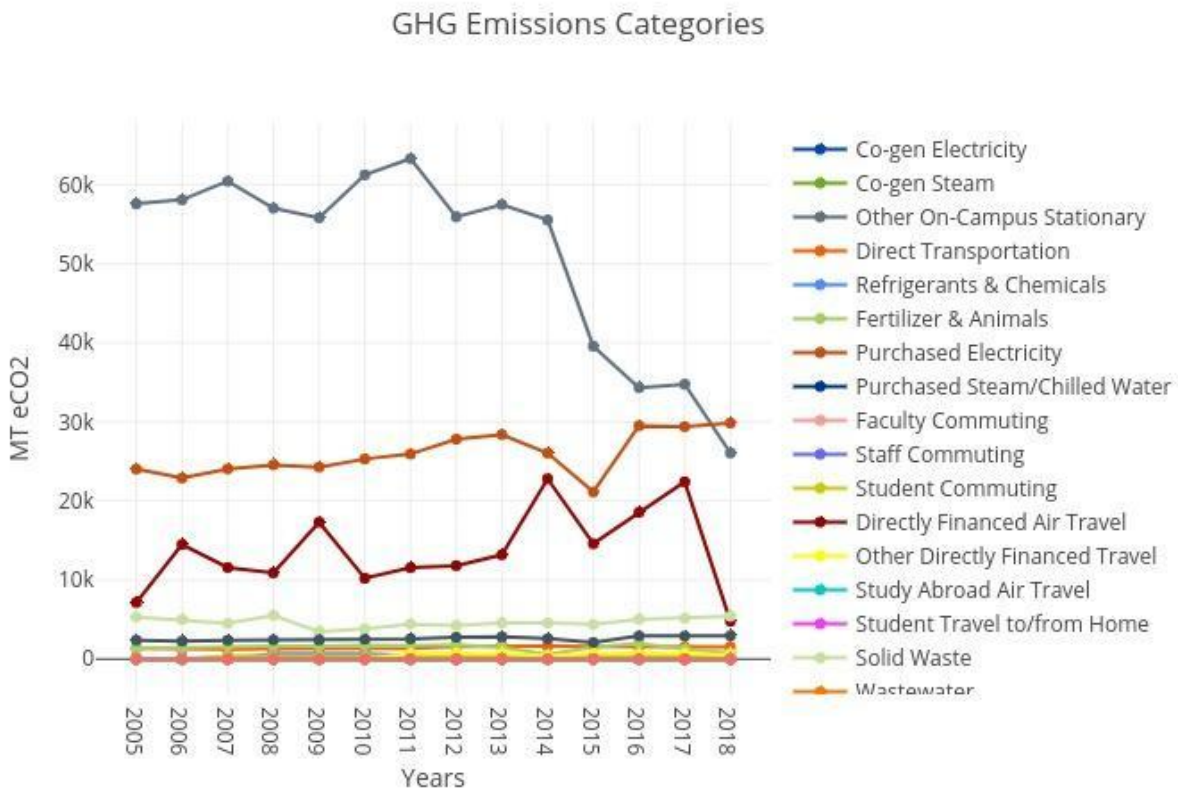

Figure 4 Shows trends in GHG sources since FY 2005.

A number of emission pattern changes lead to the over-all reduction in emissions seen in FY 2018. These trends are shown in Figure 4. This included a substantial drop in Directly Financed Air Travel which dropped from 22.4% or 22,400 MTCDE in FY 2017 to 6.58% and 4,780 MTCDE in FY 2018. Other On-campus Stationary was observed to have dropped from 34,800 MTCDE to 26,060 MTCDE. Other On-campus station may have emitted less in FY 2018 than in FY 2017, however it was still the second largest source of emissions. Agriculture and Livestock were found to have increased in total emissions and percentage of total emissions.

Scope 2 T&D losses deal with the transmission and distribution losses associated with purchased utilities such as electricity, chilled water, steam etc. Since UW only purchases electricity, the emissions from this come only from the purchased electricity. If UW does decide to purchase other utilities, then Scope 2 T&D losses would be much higher, while Scope 1 emissions would decline.

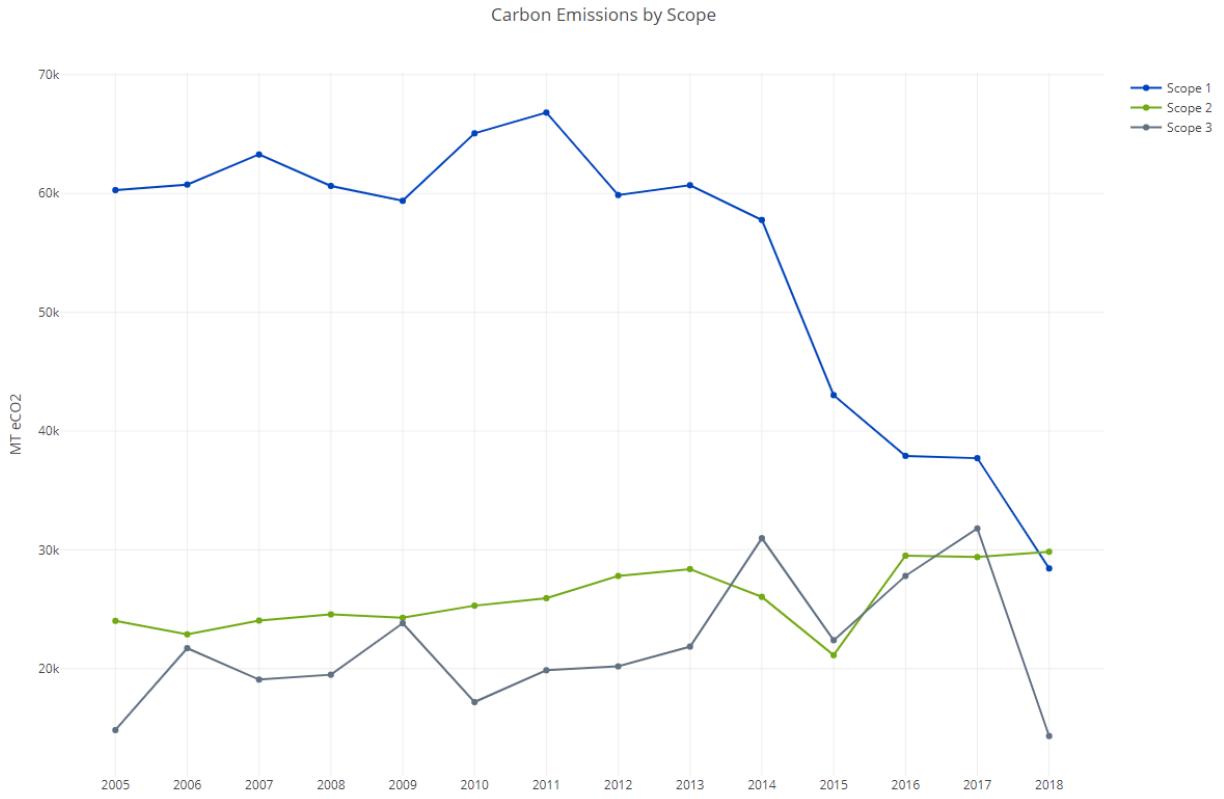

Figure 5 Shows trends in GHG sources by scope since 2005.

Scopes one and three reduced from FY 2017 to FY 2018 while scope two emissions increased. Trends in GHG emissions by scope can be seen in Figure 5. Scope one emissions decreased 25% from FY 2017 to FY 2018. Scope three emissions decreased 55% from FY 2017 to FY 2018. Scope two emissions increased 1.5% from FY 17 to FY 18.

Discussion

The FY 2018 inventory showed unprecedented reductions in GHG emissions. This was due to ever greener utility fuel sources, less coal combusted at the on-campus steam plant coupled with limited usage of Natural gas, and reduced directly financed air travel. These savings were despite the FY 2018 inventory being broader and more thorough than many recent inventories.

On campus stationary dropped 25% from FY 2017 to FY 2018. This can most easily be attributed to limited coal usage and an unprecedented drop in natural gas usage. For example, in other years with similar coal usage had nearly 2.7 times as much natural gas usage. In FY 2017 the University used 10,722 metric short tons of coal and 251,879 MMBtu of Natural Gas. In FY 2018 the University used 10,561 metric short tons of coal and only used 94,400 MMBtu of Natural Gas. After reviewing the data provided it is likely that there is a reporting error. Fuel use data can be seen in table 1.

Table 2 Fuel sources for on-campus stationary sources FY 2007 to FY 2018. All are scope one except electricity which is scope two.

Fiscal Year	Natural Gas (MMBtu)	Propane (Gallons)	Coal (Short Tons)	Electricity (kWh)
2007	107,146	6,841	25,864	63,602,733
2008	113,269	8,867	24,510	65,921,694
2009	113,076	6,416	23749	66,024,455
2010	120,815	5,418	27,137	66,990,963
2011	102,949	6,565	27,529	69,113,643
2012	89,637	6,712	25,269	68,607,169
2013	84,566	6,876	26,255	71,865,545
2014	119,494	8,117	24,282	65,875,211
2015	213,460	4,892	14,165	64,054,126
2016	451,794	4,355	5,161	66,386,071
2017	251,879	4,750	10,722	66,047,070
2018	94,400	4,178	10,561	67,066,847

Electricity usage has increased 13% since 2005, this has been associated with a 24% increase in emissions. Since 2005 coals make-up of the overall mix has dropped 11.9% and the capacity has been replaced by natural gas and wind and solar. Specific eGrid make-up year by year was not available. Again, it should be noted that eGrid data from 2006, 2008, and 2011 was not available. This information can be seen in Table 2.

Table 2 Shows changes in fuel make-up for electrical supply since 2005.

Year	Biomass %	Coal %	Distillate Oil (#1-4) %	Hydro-Electric %	Natural Gas %	Net Purchased %	Nuclear %	Renewable (wind, solar) %
2019	1.3	22.5	0	47.2	15.3	0	3.4	9.8
2018	0	36.2	0.2	39.7	11.9	0	2.8	8.9
2017	0	36.2	0.2	39.7	11.9	0	2.8	8.9
2016	0	36.2	0.2	39.7	11.9	0	2.8	8.9
2015	0	26.3	0	51.32	10.8	0	3.14	8.81
2014	0	30.43	0.3	45.8	15.32	0	2.46	5.4
2013	0	30.4	0.3	45.8	15.3	0	2.5	5.4
2012	0	30.4	0.3	45.8	15.3	0	2.5	5.4
2011	0.618	30.8	0.31395	44.677	14.819	0	2.9743	5.4672
2010	1.237	31.2	0.3279	43.551	14.338	0	3.4486	5.5344
2009	1.0927	29.834	0.3352	46.502	15.1503	0	2.4632	4.3564
2008	1.098	30.895	0.279	47.434	13.963	0	2.734	3.293
2007	1.104	31.957	0.2232	48.366	12.776	0	3.004	2.2288
2006	1.1863	33.15	0.2454	48.48	11.809	0	3.1399	1.634
2005	1.2686	34.35	0.2676	48.613	10.842	0	3.2758	1.04

FY 2018 also recorded substantial reductions in emissions from air travel. Cumulative emissions from air travel in FY 2017 totaled to 22,411 MTCDE while in FY 2018 they totaled 4,780 MTCDE. This is the result of a travel freeze and more the inclusion of negative values. During FY 2018 the University of Wyoming executed a travel freeze to limit unnecessary spending. It was further observed that past reports had excluded negative values. Negative values represent the University being refunded for canceled travel. These factors combined helped the University realize a 78.7% reduction in emissions from air travel for FY 2018.

The increase in emissions from Fertilizers and Animals can be attributed to a more accurate inventory of the University. In order to ensure consistency in reporting sustainability endeavors, the University boundary was aligned with that defined in the UWYO submissions to AASHE STARS. As a result, four research farms with large numbers of animals and land holdings that require substantial fertilizer use were added to the inventory. This number is actually small in comparison to what it might otherwise be. This is due to a significant number of animals that are

only in control of the University for a short period of time. Due to the transient nature of these animals they are not tracked by this inventory.

It should be noted that while the reductions in emissions that were observed over the course of FY 2018 were substantial, they are not unprecedented. For example, FY 2014 to FY 2015 saw similarly significant reductions in GHG emissions.

The FY 18 inventory found that the University of Wyoming met its 2020 GHG emission reduction target of 25% reductions from 2005 levels by 2020. The University was found to have reduced its emissions by 26% from the 2005 levels. The FY 2019 will likely find that the University will miss its 2020 goal despite reaching these reductions in FY 2018. At the time of this report, the University had experienced record freshman enrollment and had not experienced a travel freeze. These factors mean that the reductions recorded in this report are not permanent and more changes will need to be done to ensure future goals are met.

Recommendations & Discussions

The University of Wyoming signed the ACUPCC to demonstrate its commitment to reducing GHG emissions in a way that is compatible with the economy of the State and the University. The Campus Sustainability Committee, through the Climate Action Plan, has devised ways to achieve that goal. Additional recommendations to reduce emissions include:

- The University of Wyoming should implement a corporate travel program to save money, minimize greenhouse gas emissions, and track mileage. Corporate travel programs save money by allowing organizations to negotiate preferred partnerships with travel providers which can save money. Concur, a common corporate travel program allows users to book flights that "minimize emissions" meaning they are often direct and the shortest duration. Lastly, these programs generally allow for the tracking of flights on a mileage basis which would further increase the accuracy of the inventory.

- A notable amount of equipment still uses R-22 which is an ozone depleting hydrofluorocarbon. As a result of the Montreal protocol, all production an import of R-22 will be banned as of January 1st, 2020. All R-22 needs after that point must be satisfied from recycled and stockpiled stores. Due to phaseout, replacement costs are anticipated to increase substantially in the future for R-22 refrigerant and related equipment. Beyond this, R-22 has a huge CO2 equivalent. Refrigeration equipment that still relies on R-22 should be transitioned to R-458A. The transition can be done for approximately $175/ton.

- Continue building efficiency efforts. This includes the implementation of building automation systems and other efficiency measures such as installation of VFDs, lighting control systems, digital controls, scheduling, installation of remote boilers, temperature set points and monitoring, and HVAC retro-commissioning.

- Enhance the Universities' capital expenditure planning in order to optimize spending on maintenance vs. replacement. This will ensure that the institution isn't spending unnecessary money on maintaining equipment and systems beyond their useful lives. By having a resilient capital expenditure plan the institution can utilize its CERF funding to

its highest potential. It is recommended that the implementation of energy efficiency measures be planned to coincide with the end of the useful life of MEP equipment. This should coincide with the full roll out of a Computerized Maintenance Management System (CMMS) to ensure that all systems are accounted for. It is currently believed that not all systems have been integrated and accounted for.

- Investigate potential of energy as a service (EaaS) on campus. These schemes would allow the University to achieve energy savings at little to no upfront costs.

- The University of Wyoming should enter a Financial or Physical Power Purchase Agreement to receive renewable energy at rates that create long term savings for the purchase and use of renewable energy. A Financial Power Purchase Agreement (Financial PPA) is where an organization enters into a long-term agreement with an electricity producer or buyer for the purchase of a set amount of electricity (Financial, 2018). A Physical Power Purchase Agreement (Physical PPA) is where an organization enters an agreement with a third party who agrees to build, maintain, and operate a renewable energy system on the customer's property or offsite (Physical, 2018). Physical PPAs offer the potential for the entity to own the energy source which offers the benefit of ownership to the organization (Physical, 2018). Both of these represent attractive options to organizations that are exempt from federal tax credits that incentivize the development of renewable resources (Physical, 2018). In both of these negotiations it is important that the RECs from the energy be maintained by the organization as they can be sold independently of the electricity (Physical, 2018). Developing a Physical of Financial PPA has the potential to reduce the University's GHG emissions by up to 41.1% or 29,800 MTCDE if all energy usage were to be satisfied through these agreements. Pursuing a Physical PPA or Financial PPA would also help the University realize savings in energy spending. Changes such as these are crucial for the university to be carbon neutral by 2050.

- Transition fuel usage at the Central Energy Plant from coal to natural gas, as long as economically feasible. Natural gas emits 50 – to 60- percent less carbon dioxide when combusted with new combustion techniques when compared to a typical new coal plant. However, this neglects to consider up stream emissions. Much of the emission reduction that has been realized due to the transition of natural gas could be reduced by upstream fugitive emissions. Fugitive emissions are the emissions that escape as part of the exploration, transportation, and management of natural gas. While the University has reduced its scope one emissions, it has increased its scope two emission in a manner that is not directly tied to the University. In this case it has shifted a component of its emissions to the natural gas exploration, production, and transportation companies. At the time of this report a way to quantify how fugitive emissions impact lifecycle emissions of Natural Gas is still being developed. In a recent study, fugitive emissions from exploration and transportation were found to be 60% higher than EPA estimates (Alvarez et al. 2018). While this does not nullify the savings from transitioning from coal to natural gas, it does signify that the emissions from the University of Wyoming are likely higher than the current inventory found. This further reinforces the need to move beyond natural gas to even cleaner energy sources.

- The University of Wyoming has a unique potential to become a net-carbon sink. This could be done by pursuing regenerative agriculture. Regenerative agriculture is the practice of promoting soil carbon. It is generally noted that agricultural soils have lost 20- to 60% of the carbon that would have existed in the soil under natural circumstances (Olsson, L, et al. 2019). Strategies to rebuild soil carbon levels generally include cover crops, inter-cropping, and no-tillage to name a few (Olsson, L, et al. 2019). This offers the potential to transition from having 8.54% of GHG emissions come from solid waste and livestock and agriculture to these activities being a net carbon sink. This would also allow the University of Wyoming to leverage its Agriculture and Environment and Natural Resource leadership to become a leader in research and implementation in this field. This solution includes implementing composting.
- Much of FY 2018's reductions were due to a reduction in Natural Gas usage. As a result it is recommended that the Natural Gas usage be verified before the issuance of this report.

There continue to be financial reasons why the University of Wyoming uses fossil fuels to generate on-campus stationary energy. In such cases, there can be a balance between being environmentally friendly and financially viable. The EF_eCO2 sheet of the carbon calculator provides a summary of the emission factor for every source and is very helpful if one wants to consider replacing a particular source or to increase the use of another.

Appendix A: Major Sources of Emission in Metric Tons eCO2 before SIMAP Update

Fiscal Year (MTeCO2)	Agriculture (MTeCO2)	On-Campus Stationary (MTeCO2)	Purchased Electricity (MTeCO2)	Solid Waste (MTeCO2)	Directly Financed Airfare (MTeCO2)	Direct Transportation (MTeCO2)
2002	1,653.00	53,626.00	47,166.00	6,543.00	5,306.00	1,100.00
2003	1,268.00	56,832.00	50,402.00	5,473.00	5,939.00	1,190.00
2004	1,089.00	57,635.00	50,392.00	5,258.00	3,113.00	1,309.00
2005	1,216.00	57,584.00	50,469.00	4,737.00	7,149.00	1,371.00
2006	1,312.00	58,089.00	49,251.00	4,443.00	14,490.00	1,228.00
2007	1,489.00	60,445.00	55,111.00	4,014.00	11,577.00	1,218.00
2008	1,515.00	57,037.00	57,120.00	4,938.00	10,902.00	1,273.00
2009	1,469.00	55,819.00	54,767.00	3,095.00	17,323.00	1,290.00
2010	1,597.00	61,250.00	57,763.00	3,406.00	10,217.00	1,400.00
2011	1,553.00	63,308.00	59,594.00	3,944.00	11,563.00	1,346.00
2012	1,672.00	55,896.00	56,851.00	3,779.00	11,815.00	1,610.00
2013	1,350.00	57,453.00	59,551.00	4,064.00	13,199.00	1,690.00
2014	511.00	55,510.00	54,588.00	4,064.00	22,806.00	1,632.00
2015	1,404.00	39,535.00	53,078.00	3,913.00	14,586.00	1,564.00
2016	1,794.00	34,304.00	55,011.00	4,480.00	18,562.00	1,600.00
2017	766.00	61,754.00	60,222.00	2,432.00	18,131.00	1,781.00

Appendix B: Major Sources of Emission in Metric Tons eCO2 After SIMAP Update

Fiscal Year	Fertilizer & Animals (MTeCO2)	On Campus Stationary (MTeCO2)	Purchased Electricity (MTeCO2)	Solid Waste (MTeCO2)	Directly Financed Air Travel (MTeCO2)	Directly Financed Transportation (MTeCO2)
2005	1,339.62	57,574.70	24,021.28	5,305.35	7,146.45	1,368.85
2006	1,442.07	58,079.60	22,888.20	4,976.35	14,485.04	1,226.75
2007	1,630.72	60,434.11	24,048.21	4,495.37	11,573.52	1,216.32
2008	1,658.28	57,027.35	24,565.89	5,530.90	10,898.28	1,271.37
2009	1,607.86	55,809.55	24,280.82	3,466.79	17,317.30	1,288.54
2010	1,748.78	61,239.17	25,302.08	3,815.03	10,213.37	1,397.66
2011	1,701.56	63,296.70	25,931.10	4,417.81	11,559.22	1,343.78
2012	1,832.05	55,927.72	27,802.56	4,233.03	11,811.10	1,607.71
2013	1,480.45	57,487.45	28,381.75	4,551.79	13,194.89	1,687.65
2014	555.44	55,541.86	26,042.76	4,551.79	22,797.88	1,629.94
2015	1,544.07	39,561.35	21,132.11	4,382.29	14,580.70	1,562.20
2016	1,964.82	34,324.70	29,508.81	5,017.11	18,555.81	1,597.43
2017	1,260.53	34,756.18	29,391.46	5,155.92	22,411.43	1,524.28
2018	795.38	26,055.54	29,841.29	5,401.36	4,780.41	1,541.64

Appendix C: Emissions Data and University Metrics Providers

Contact	Email	Data Requested	Campus
Amanda Larson	Shauna@uwyo.edu	Research Budget	UWYO ALL
Suzanne Koller	ssavor@uwyo.edu	Student population/Faculty and Staff	UWYO ALL
Christina Maki	cmaki1@uwyo.edu	Building Size and Research Space	UWYO ALL
Forest Selmer	fselemer@uwyo.edu	Energy Budget and Energy Usage	UWYO Main
Dr. Carrick Eggleston	carrick@uwyo.edu	Solar	EIC
Vic Bershinsky	vbershin@uwyo.edu	Solar	CEAS
Jerry Hamann	hamann@uwyo.edu	Solar	CEAS
N/A		Solar	UWYO Main (Haub)
N/A		Solar	UWYO Main (Ford Array)
Forest Selmer	fselmer@uwyo.edu	Natural Gas	UWYO Main
Forest Selmer	fselemer@uwyo.edu	Propane	UWYO Main
Shawn Fletcher	sfletche@uwyo.edu	Fleet Transportation info	UWYO ALL
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Andy Smith	flowers@uwyo.edu	Fertilizers	UW
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Doug Zalesky	dzalesky@uwyo	Fertilizers	ASF
Shelby Gaddis	shgaddis@uwyo.edue	Animal Husbandry	ASF
Forest Selmer	fselemer@uwyo.edu	Purchased Electricity	UWYO Main
Paul Kunkel	paul.kunkel@uwyo.edu	Commuting	UWYO Main
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John D. Kelly	jon.kelly@uwyo.edu	Personal Mileage Reimbursement	UWYO ALL
Forest Selmer	fselemer@uwyo.edu	Solid Waste	UWYO Main
Aaron Sullivent	asullive@uwyo.edu	Institutional Footprint	UWYO ALL
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Powell R&E Center	uwprec@uwyo.edu	Animal Husbandry/Fertilizer	R&E Center Powell

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Sheridan R&E Center	shrec@uwyo.edu	Animal Husbandry/Fertilizer	R&E Center Sheridan
Pat Allen		Electrical/Fertilizer/Refrigerants	UWYO Casper
Scott L Lake	scott.lake@uwyo.edu	Animal Husbandry/Fertilizer	Laramie R&E
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Steven Paisley	spaisley@uwyo.edu	Animal Husbandry/Fertilizer	R&E Center SAREC
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Kelly T. Greenwald	kgreenwa@uwyo.edu	Animal Husbandry/Fertilizer	R&E Center SAREC
Samantha Fulton	sfulton3@uwyo.edu	Fertilizer	R&E Center Powell
John P Ritten		Animal Husbandry/Fertilizer	R&E Center SAREC
Kathi Lou Zubrod	klzubrod@uwyo.edu	Electrical/Fertilizer/Refrigerants/Gas	UWYO Residency Program
Lyn Cook	lcook@caspercollege.edu	Electrical	UW Casper College
Dan McCoy	dan.McCoy@uwyo.edu	Carbon free modes of transport	UWYO Main

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