# Penn State Council of Commonwealth Student Governments Greenhouse Gas Inventory Report

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## Abstract

The Penn State Council of Commonwealth Student Government (*CCSG*) produced \_\_\_\_ metric tons of CO2-equivalent (*MtCO2e*) through its various operations throughout its lifetime as an organization at Penn State, and continues to output roughly \_\_\_\_ MtCO2e every year. This greenhouse gas (*GHG*) inventory presents a breakdown of emissions arising from utility use, procurement, driving, and other activities. This report is the first work of its kind across student organizations within Penn State University. We recommend that CCSG commit funds to eliminating its historical footprint and produce materials to guide other student organizations to do the same. Achieving greater sustainability and resilience will require a combination of systematic and individual actions across the University.

## Supplemental Documentation

This document summarizes the results tabulated in an accompanying spreadsheet CCSG\_GHG\_Inventory.xlsx. The spreadsheet serves as an Appendix to this report.

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## List of Abbreviations

|  |  |
| --- | --- |
| **Abbreviation** | **Definition** |
| *CC* | Commonwealth Campus (non-UP) |
| *CCSG* | The Penn State Council of Commonwealth Student Governments |
| *CH4* | Methane, a greenhouse gas |
| *CO2* | Carbon Dioxide, a greenhouse gas |
| *CO2e* | Carbon Dioxide Equivalent |
| *ECoS* | The Eberly College of Science |
| *eGRID* | Emissions & Generation Resource Integrated Database |
| *EMS* | The College of Earth and Mineral Sciences |
| *EPA* | The Environmental Protection Agency |
| *EUI* | Energy Use Intensity |
| *FIS* | Facility Information System |
| *GHG* | Greenhouse Gas |
| *GWP* | Global Warming Potential |
| *HCMI* | Hotel Carbon Management Initiative |
| *MtCO2e* | Metric Tons of Carbon Dioxide Equivalent |
| *N2O* | Nitrous Oxide, a greenhouse gas |
| *OPP* | The Office of Physical Plant |
| *PSU* | The Pennsylvania State University |
| *RFCW* | ReliabilityFirst Corporation West, eGRID subregion |
| *SDG* | United Nations Sustainable Development Goal |
| *UP* | University Park |

## Introduction

Every year, Penn State’s Office of Physical Plant (*OPP*) produces a [University-wide Greenhouse Gas Inventory](https://sustainability.psu.edu/campus-efforts/climate-action/our-footprint/), summarizing the emissions related to all University operations during the (fiscal) year. For fiscal year 2018-2019, the College of Earth and Mineral Science at Penn State (*EMS*) produced the first unit-level inventory at Penn State: 2020 Drawdown Scholar Katherine Gannon analyzed the emissions due to all operations assigned to EMS during that year, including those from utilities, air travel, commuting, EMS-owned vehicles, and Fleet leased and rented vehicles. Shortly after, the Eberly College of Science (*ECoS*) performed their own [greenhouse gas inventory for Calendar Year 2019](https://pennstateoffice365.sharepoint.com/sites/PennStateEberlyCollegeofScienceSustainabilityCouncil/Shared%20Documents/Forms/AllItems.aspx?id=%2Fsites%2FPennStateEberlyCollegeofScienceSustainabilityCouncil%2FShared%20Documents%2FGeneral%2F2021%20ECoS%20GHG%20Emissions%20Inventory%2FECoS%5FGHG%5FInventory%5FCY2019%5FReport%2Epdf&parent=%2Fsites%2FPennStateEberlyCollegeofScienceSustainabilityCouncil%2FShared%20Documents%2FGeneral%2F2021%20ECoS%20GHG%20Emissions%20Inventory). These two initial inventory efforts solidified the conventions and standards for further unit-level inventories, multiple of which have been or are in the process of being performed. Nevertheless, unit-level inventories neglect the emissions from organized activities in student-led organizations and governments. Recognizing this gap and hoping to eliminate its entire historical footprint, the Penn State Council of Commonwealth Student Governments (*CCSG*) has commenced its own GHG inventory and included its results in this document.

The scope of this inventory includes emissions attributable to CCSG over the organization’s entire existence, mimicking the sources and scopes of both the University-wide and ECoS CY2019 GHG Inventories.

Below we summarize the typical operations of CCSG that were identified to contribute to the organization’s lifetime emissions:

* ***Utilities***
  + CCSG has assigned space in the HUB Robeson Center at University Park (*UP*), specifically rooms 312 and 313. It is estimated that CCSG has had this dedicated space for about 15 years.
  + CCSG organizes five Council meetings per year, hosting “Council Members” and “Liaisons” from each Commonwealth Campus (*CC*) for a weekend of meetings and food. CCSG rents space from Penn State to host its Councils. Four of these meetings occur at UP, while the remaining one Council meeting occurs at a randomly-selected Commonwealth Campus. Councils have been occurring for essentially the entire existence of CCSG. Additionally, attending Council Members and Liaisons stay overnight in a hotel.
* ***Travel***
  + Each Council draws at most 10-15 Liaisons from each CC (and UP if traveling to a CC), taking roughly 4-5 cars per campus for transportation there and back.
  + CCSG annually organizes a Retreat for its UP-based Central Staff. The Retreat is typically within a 40-minute driving radius, and it lasts an entire weekend. Retreats have only been occurring for an estimated 15 years.
* ***Procurement***
  + CCSG organizes a Banquet at the end of its fifth Council every year where food is served. This event is attended by participants in that Council. Banquets have only been occurring for an estimated 15 years.
  + Councils and Retreats each involve some level of catering.
  + CCSG invests in merchandise for its Central Staff and other Council Members each year, as well as plaques for certain graduating participants.
  + CCSG has a budget to supply its offices at UP.

A full understanding of an entity’s GHG emissions will not capture the full breadth of how “sustainable” it is, nor its environmental impact. Material waste, landscaping, human and biotic impacts, investments, and research are each important aspects of environmental impact that lie beyond the scope of this GHG inventory. Instead, this report attempts to summarize just one important dimension of how CCSG impacts the environment. With respect to the [United Nations Sustainable Development Goals](https://sdgs.un.org/goals) (*SDGs*), this inventory will provide information mostly pertaining to SDG 13: Climate Action.

It is important to distinguish between three categories of emissions, known as Scopes 1, 2, and 3.

* **Scope 1**: Direct emissions, produced onsite;
* **Scope 2**: Indirect emissions, related to purchased utilities; and
* **Scope 3**: Everything else: so the remaining indirect emissions occurring along the value chain. Scope 3 emissions are commonly called “someone else’s Scope 1.”

Penn State’s University-wide Inventory includes all Scope 1 and Scope 2 emissions (as required by the [Greenhouse Gas Protocol](https://ghgprotocol.org/corporate-standard)). Scope 1 and 2 emissions include those from stationary combustion, utility services, and mobile combustion, as well as those from smaller sources such as refrigerants, fertilizers, and animal management. At UP, utilities are our main sources of Scope 1 and Scope 2 emissions. Because a portion of Penn State’s electricity is produced onsite while the rest is purchased from the grid, some utilities fall under both Scopes 1 and 2. As a student organization that has dedicated office space, utility emissions related to CCSG’s office use will correspond to the same Scopes as those of Penn State; however, for events hosted by CCSG in spaces rented from Penn State, those utility emissions will count as Scope 3, as Penn State is the provider and CCSG is the customer. It is worth noting that Scope 3 emissions are challenging to estimate in general, as they can be nebulous and possibly involve time-intensive investigations into the life cycles of products and investments.

Penn State chooses to follow an “Operational Controlled approach,” rather than a “Financial Controlled approach,” meaning that it inventories the operations over which it has control, excluding all the operations within Penn State’s financial power yet outside of its direct control. For Penn State, all Scope 1 and Scope 2 emissions would be included in either approach. Therefore, this distinction means that Penn State misses a minor portion of its Scope 3 emissions that might reasonably be assignable to its activities and initiatives. This convention is chosen in alignment with other University GHG inventories, as well as for its ability to capture the activities where Penn State can directly control its reductions efforts. The only Scope 3 emissions inventoried by the University are Commuting, Air Travel, and Non-Fleet Car Travel, Campus Wastewater (where it counts as Scope 3 for all campuses besides University Park, Wilkes-Barre, and New Kensington), Waste in Landfills, and Electrical Transmission Loss.

This inventory was performed by Raymond Friend, a graduate assistant in Mathematics, and the author of the ECOS CY2019 GHG Inventory. This work was made possible by the superior guidance of Shelley McKeague, Compliance Manager within Penn State’s Office of Physical Plant, during previous inventory efforts, as well as the Administration and Sustainability Committee of CCSG during Academic Year 2021-2022. Thank you to Penn State alumnus and previous CCSG Sustainability Council Co-Director Matthew Long for sparking this action.

## Methodology

### Conventions

Throughout the process of performing a unit-level GHG inventory at Penn State, one will be confronted with multiple decision points: How to claim space within mixed-use buildings? What kinds of emissions are feasible to compute? What level of confidence do we need in our data to publish an estimate? Over what time frame should we perform the inventory? Which unit should be held responsible for particular emissions? In this section, we present the conventions adopted by this report.

When deciding on a convention, we considered the following:

* **Replicability**: choose a convention that can be easily reproduced;
* **Feasibility**: choose a convention that uses the available resources without requiring an unreasonable amount of time or effort to follow;
* **Consistency**: choose a convention that, if adopted by all other units/organizations, could produce a consistent and comprehensive inventory of all University emissions at the unit level; and
* **Transparency**: choose a convention that follows a transparent procedure and accurately reflects confidence level.

Moreover, the scope of this inventory was chosen to mimic previous inventories at Penn State for the following reasons:

* Symmetry in structure with previous unit-level inventories aids in comparing results across Penn State;
* This is the most likely setup to occur in future unit-level and organization-level inventories at Penn State;
* Symmetry in structure with the University allows CCSG to assess the proportionality of its contribution to the University’s emissions footprint;
* The current structure transparently categorizes emissions by Scope and purpose; and
* The University is best equipped to answer questions matching its current procedure.

A key difference between the following CCSG GHG Inventory and the University-wide Inventory is CCSG’s inclusion of Procurement Emissions. Merchandise, food, memorabilia, and office supplies all have emissions related to their lifecycles: in their production, transportation, and disposal. According to Shelley McKeague, Compliance Manager for OPP and organizer of the annual University-wide GHG Inventory, there are a few reasons why Procurement Emissions are not considered at the University-level:

* Uncertainty when estimating Procurement Emissions would be a limiting factor to the University-wide inventory’s accuracy, quality, and completeness.
* Estimating GHG emissions from Procurement opens an arduous task of investigating the lifecycles for various products, posing a challenge for developing a reasonable estimate for all Scope 3 emissions.
* The goal of the University-wide GHG Inventory is not necessarily to numerically quantify all Scope 3 emissions; for Scope 1 and Scope 2 emissions, it is important to set a net-zero emissions goal with a near term date. As a secondary goal, we can develop policy strategies to achieve full decarbonization of value chains without performing the painstaking work of quantifying all Scope 3 emissions.

CCSG has decided to include a figure for Procurement because it wishes to make a full attempt at eliminating its historical footprint, including these tricky-to-compute emissions from procurement. Moreover, procurement represents a vital and sizeable aspect of CCSG’s annual operations, so to miss out on these emissions would likely provide a final figure far from CCSG’s real historical emissions total.

To summarize, Scope 3 emissions are all indirect emissions that occur in an entity’s value chain. For many corporations, Scope 3 emissions are much greater than Scope 1 and Scope 2. For Penn State to fully address the climate impacts of its entire operations, additional efforts are needed to identify all Scope 3 emissions and develop strategies to address them. The precise quantification of all Scope 3 emissions is not necessarily feasible or appropriate for a University-level or unit-level inventory, but potentially powerful for student organizations like CCSG.

One will note a difference between this inventory and the inventory performed by EMS in how each entity assigns its emissions to certain Scopes. There are two approaches one could take:

1. **Separate Entity**: view the entity as one interacting with the University, treating many Scope 1 emissions for the University as Scope 2 emissions for the entity.
2. **Part of the Whole**: view the entity as a subset of the University, which acts as a collective and shares emissions by Scope regardless of which entity actually directly produces the emissions.

The convention followed by EMS was the former, treating EMS as a partner to the University that procures the University’s utilities for its purposes. As the first unit-level inventory, it was not totally clear which convention to follow, but with guidance from OPP, ECOS determined that the latter approach: treating ECoS as a part of the whole University, was more appropriate. The University is purposefully organized to have OPP perform most direct fossil-fuel burning for the benefit of other units, a convenience for units and organizations like ECoS and CCSG. As such, we will always adopt the Scopes as they are defined at the University level and not treat internal demand for utilities as a separate procurement process. This will help CCSG more directly compare its inventory to those of the University and ECoS. The approach of treating CCSG as a “Separate Entity” will only be used in the situation where CCSG *pays* the University to use space for its events. In this case, it is true that CCSG plays the role of a customer to the event-space provider: Penn State.

The following subsections will highlight other specific conventions adopted for this inventory.

### Utilities

By utility usage, we refer to the resources consumed in order to operate the buildings in which CCSG resides. At University Park, utility usage is measured at the building level, meaning there is no more specific a way to estimate the utility usage of CCSG beyond estimating the organization’s proportional use of each building on campus. Thanks to the Penn State Facilities Information System (*FIS*), we were able to obtain quantities for the floor area occupied by CCSG in each of its dedicated rooms (HUB 312 and 313), as well as the same quantities for each of the rooms used for its events (in both the HUB and Osmond Laboratory). In order to produce an estimate for the utility usage by CCSG in each of those buildings, we wished to sum the floor area of each room assigned to CCSG in that building and assign a proportional amount of that building’s utilities to CCSG.

Utilities are summarized on EnergyCAP, the University’s centralized tool for reporting utility usage at the building level. EnergyCAP reports measurements for Steam, Electric, Chilled Water, Water, Sewer, and Natural Gas utilities. One limitation of data from EnergyCAP is the recency of data: we only have figures for utility usage since CY2019. We estimated annual utility use by taking the mean across the years 2019, 2020, and 2021 (excluding any anomalies), found in “Normalized Data” in EnergyCAP for each building.

The emissions factors (or numerical factors by which to multiply utility amounts to estimate emissions) for each utility were obtained from a few different sources. Each utility has a unique emissions factor, some depending on standard factors released by the EPA for, say, 2019 [see the [EPA’s Code of Federal Regulations for Greenhouse Gas Emissions](https://www.epa.gov/ghgreporting/ghg-mrr-final-rule), and the [EPA’s 2019 eGRID Emissions Rates (RFCW)](https://www.epa.gov/sites/production/files/2021-02/documents/egrid2019_summary_tables.pdf)], and others depending on OPP estimates for onsite utilities [OPP GHG Calculator, Shelley McKeague]. Moreover, emissions factors must be normalized to Metric tons of CO2-equivalent (*MtCO2e*) because there are multiple kinds of GHGs emitted besides CO2. Each GHG has a corresponding Global Warming Potential (*GWP*). The GWP for CO2 is 1; the GWP for CH4 is 25; and that for N2O is 298. With these normalization factors, we combined the emissions factors for the three most common GHG and calculated a normalized emissions factor for each utility. Using emissions factors from 2019 is a reasonable estimate for emissions factors for other recent years.

Estimating emissions from hotels while accommodating visiting Council Members and Liaisons during Council weekends is not trivial: how would we track the emissions from every hotel, or how often a certain hotel is used, or how many rooms are booked each Council? To avoid this minutia, we make use of a convenient estimate from [the Hotel Carbon Management Initiative (*HCMI*)](https://sustainablehospitalityalliance.org/resource/hotel-carbon-measurement-initiative/) for the typical emissions assignable to a stay in a hotel room: we can express their estimate as 0.023 MtCO2e per room per night. Acknowledging that each CC likely rents 2-3 rooms per Council meeting, we produced an estimate for Boarding emissions.

**Scope(s)**:

* ***Office Space***
  + *Steam*: Scope 1. Produced onsite using Natural Gas.
  + *Electricity*: Scope 2. Purchased from the grid.
  + *Chilled**Water*: Scope 2. Derived from Electricity.
  + *Water*: Both Scope 1 and Scope 2. That arising from Gas, Oil, or Propane is assigned Scope 1, while the rest is due to Electricity, so Scope 2. About 89% of energy devoted towards Water is due to Electricity.
  + *Sewer*: Scope 1.
  + *Natural Gas*: Scope 1. Used onsite.
* ***Event and Boarding Space***
  + *Steam*: Scope 3. Purchased from the University or a third party.
  + *Electricity*: Scope 3. Purchased from the University or a third party.
  + *Chilled**Water*: Scope 3. Purchased from the University or a third party.
  + *Water*: Scope 3. Purchased from the University or a third party.
  + *Sewer*: Scope 3. Purchased from the University or a third party.
  + *Natural Gas*: Scope 3. Purchased from the University or a third party.

**Caveats**:

* This procedure treats all assignable square-feet as equal in utility intensity, a poor assumption considering work performed by OPP during 2016-2017 quantifying the differences in Energy Use Intensity (*EUI*) between buildings of various functions [1617 EUI, OPP]. That report concluded that buildings coded as laboratories were between 1.62 and 1.91 times as energy intensive as buildings coded as mostly office spaces per unit area. This EUI study would not have helped us perform a more granular comparison of labs and office/classroom spaces since the EUI study was also only able to compare across buildings, not rooms.
* CY2019 emissions factors, while reasonable and most practical for use in an inventory for a Penn State organization, will invariably *underestimate* historical emissions for activities only lasting in the 2000s, because Penn State reached its peak in emissions in 2005. Data is not readily available to produce a finer analysis than what we have here.
* Data is unavailable from third parties providing housing accommodations, so we had to make an educated guess for the emissions factors for such activities with the help of HCMI’s estimate. This estimate comes with low confidence, and is roughly half of on-campus emissions.

**Confidence**: Medium. Without more granular of data, it is difficult to more accurately assess CCSG’s utility usage in full. Most of the uncertainty comes from lack of data from hotel emissions factors, as well as from differences in the utility-intensities between spaces with distinct functions.

**See Tabs:** Utility Emissions Factors **&** Building Utilities.

### Mobile Combustion

According to the Greenhouse Gas Protocol, mobile combustion includes “combustion of fuels in transportation devices such as automobiles, trucks, buses, etc.” For CCSG, this simply involves car travel for members attending Councils and Retreats. Multiple assumptions were made in order to produce corresponding emissions totals.

*Road Travel*: For all road travel, we make use of the [EPA’s estimate for the emissions due to a typical passenger vehicle](https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P1013L1O.pdf), estimating emissions due to mileage driven across the years 1975-2022. All years prior to the earliest date (1975) were assumed to have emissions factors identical to that of 1975.

* *Council Travel*: Travel to and from Council meetings was computed in a series of steps:
  + Each CC (indexed by ) was located by its address and global coordinates .
  + Four Councils per year occur at UP: compute the distance (via Google Maps) between each CC and UP, storing the result into .
  + One Council per year occurs at a randomly selected CC. To avoid computing distances between every combination of campuses via Google Maps, we estimate the average distance from each CC to a randomly selected CC:
    - Routes following Pennsylvania roads usually take times as much distance to drive than the true geodesic distance between the endpoints. Estimate by computing the average scaling on the routes from each CC to UP, i.e.,  
      where computes the geodesic distance between two points on Earth.
    - The average distance from CC and a (uniformly) randomly selected other (non-UP) CC is estimated to be the typical geodesic distance times .
  + Annual Council distance by CC is estimated as the sum of all driving from UP and CC Council meetings both ways by however many cars are expected to be traveling, i.e.,
  + Therefore, Annual Council driving distance by every participating campus is the sum of every . Lifetime Council driving distance equals the sum of each multiplied by the number of active years in which CC has participated in CCSG.
  + Emissions are computed by summing all the emissions factors from years in which CC participated in CCSG by .
* *Retreat Travel*: Annual distance for travel to and from Retreats was computed by multiplying the number of cars traveling per Retreat by 2 times the typical distance to get to the Retreat from UP. Therefore, the lifetime emissions from travel to and from Retreats is the average distance driven annually multiplied by the sum of the emissions factors from each year in which a Retreat occurred.

**Scope(s)**:

* **Car Travel**: Scope 1.

**Caveats**:

* Emissions factors for years 1960-1974 are unknown; and any emissions factors used are simply estimates for the typical passenger vehicle in that year. Council Members may have used vehicles with different emissions factors throughout the years.
* This will likely be an overestimate, because the number of cars attending a typical Council Meeting throughout the years was 4 cars per campus. While that might be true for some of the largest campuses and in recent years, there may have been a much smaller average number of cars traveling from each participating campus in the early history of CCSG.

**Confidence**: Medium High. Emissions factors for driving depend on the types of the vehicles used.

**See Tabs**: Car Travel & Raw Car Travel.

### Procurement

Procurement (or Vendor) emissions are those related to the supply chain for CCSG equipment, supplies, merchandise, and sponsored meals. Procurement emissions are purely Scope 3; including this category of emissions acknowledges that CCSG generates demand for the items that are created, distributed, and used for its work and operations. No matter how detailed the previous purchasing history of CCSG could be, unraveling the emissions associated with the products purchased by CCSG throughout its 60+ year existence would be virtually impossible. Instead, we turn to a previous initiative to establish a rough estimate of CCSG’s emissions due to procurement.

In her [UC Berkeley 2009 Procurement Carbon Footprint](http://sustainability.berkeley.edu/sites/default/files/DoyleK_Thesis_UCB2009SupplyChainCarbonFootprint.pdf), author Kelley Doyle estimated Procurement emissions for the University of California Berkeley. This analysis was one of the most thorough we could find and describes a useful process known as a hybrid top-down approach to calculate Procurement emissions. Their results are unlikely to precisely mirror the Procurement emissions at Penn State during any particular year, but they help establish an order of magnitude estimate. Doyle found that the average carbon intensity of scientific equipment was around 0.66 kilograms of CO2e per dollar, whereas that for office product supplies was around 0.47 kilograms of CO2e per dollar. Most surprisingly, she found that the carbon intensity for food was around 0.83 kilograms of CO2e per dollar, greater than all other categories. The overall intensity of UC Berkeley’s operations, including emissions related to scientific equipment, office supplies, construction, IT & telecommunication, and food equated to 0.000257 MtCO2e/$.

CCSG Central Staff were able to recover the expenditures made by CCSG in multiple fields: Office Supplies, Merchandise, Plaques, Banquet Food, Retreat Food, and Council Food.

Procurement emissions were simply estimated by multiplying each expenditure by the appropriate emissions factor from Doyle’s survey.

**Scope(s)**: Scope 3.

**Caveats**:

* We assume that the Procurement emissions at UC Berkeley in 2009 provide a ballpark estimate of those related to procurement within CCSG during CCSG’s lifetime.
* The composition of activities and equipment required at UC Berkeley as a whole may differ greatly from that of CCSG.
* UC Berkeley may have a very different set of suppliers, energy grid emissions, and procurement practices than CCSG.
* Estimating emissions from dollars is inherently flawed. The supplier, specific product, and more variables can all affect the true emissions related to that product.

**Confidence**: Low. The numbers used by Doyle are from a power grid on the West Coast in 2009, and the composition of supplies, construction, and equipment for the entirety of UC Berkeley may be very different from that of CCSG. Most likely, our Procurement emissions will be larger, especially as we learn more about the emissions that go into gathering raw materials, manufacturing, and shipping supplies to Penn State.

**See Tab**: Procurement.

## Results

### Main Results

First, we present the full CY2019 ECoS GHG Emissions by Source in the following Table 2.

|  |  |  |  |
| --- | --- | --- | --- |
| **CY2019 ECoS GHG Emissions by Source** | | | |
| **Source** | **Emissions** | **Units** | **Percentage** |
| **Steam** | 12257 | MtCO2e | 43.5% |
| **Electric** | 11652 | 41.4% |
| **Chilled Water** | 1637 | 5.8% |
| **Water** | 134 | 0.5% |
| **Sewer** | 129 | 0.5% |
| **Natural Gas** | 38 | 0.1% |
| **Air Travel** | 748 | 2.7% |
| **Global Programs** | 33 | 0.1% |
| **Car Travel** | 197 | 0.7% |
| **Commuting** | 853 | 3.0% |
| **ECoS Vehicles** | 1 | 0.0% |
| **Computing** | 474 | 1.7% |
|  |  |  |  |
| **Total** | 28152 | MtCO2e | 100.0% |

Table 2: Emissions for ECoS during CY2019, categorized by Source.

If we categorize by Scope instead of Source (following the Scope breakdown discussed in the section *Methodology*), we obtain the following Table 3.

|  |  |  |  |
| --- | --- | --- | --- |
| **CY2019 ECoS GHG Emissions by Scope** | | | |
| **Scope** | **Emissions** | **Units** | **Percentage** |
| **Scope 1** | 12636 | MtCO2e | 44.9% |
| **Scope 2** | 13882 | 49.3% |
| **Scope 3** | 1601 | 5.7% |

Table 3: Emissions for ECoS during CY2019, categorized by Scope.

Alternatively, we can present these tables as pie charts.

Figure 1: Emissions for ECoS during CY2019, categorized by Source. Corresponds to Table 2.

Figure 2: Emissions for ECoS during CY2019, categorized by Scope. Corresponds with Table 3.

We may compare our results to those of both the University’s and EMS’s FY18-19 inventories, as seen in Table 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Comparison of ECoS to University Emissions** | | | | |
| **Source** | **University Emissions** | **ECoS Emissions** | **Units** | **ECoS Percentage** |
| **Steam Plant** | 107143 | 12257 | MtCO2e | 11.4% |
| **Purchased Electricity** | 184199 | 13882 | 7.5% |
| **Stationary Sources** | 28797 | 379 | 1.3% |
| **Campus Vehicles** | 7220 | 1 | 0.0% |
| **Commuting** | 70716 | 853 | 1.2% |
| **Air Travel** | 19220 | 781 | 4.1% |
| **Waste** | 2558 | N/A | N/A |
| **Synthetic Chemicals** | 7640 | N/A | N/A |
| **Animal Management** | 2467 | N/A | N/A |
| **Other** | 12665 | N/A | N/A |
|  |  |  |  |  |
| **Total** | 442625 | 28152 |  | 6.36% |

Table 4: A comparison of ECoS’s CY2019 emissions to those of the University (FY18-19; chosen because FY19-20 was significantly impacted by the SARS-CoV-2 pandemic). The right column shows how much of each source category ECoS composes of the entire University’s emissions (including all Commonwealth campuses besides Hershey Medical).

From Table 4, we see that ECoS comprised roughly 11.4% of all Steam use across the University, 7.5% of all Purchased Electricity, and 4.1% of all Air Travel. In total, ECoS made up about 6.36% of the University’s total emissions [caveat: we currently have no way of quantifying ECoS’s Synthetic Chemicals, Animal Management, Waste, or Other categories yet, and we certainly contribute to those source categories]. To clarify the table: 6.36% is equal to ECoS’s 28,152 MtCO2e out of the University’s 442,625 MtCO2e throughout the year. If we were to eliminate the rows corresponding to sources for which we are missing data for ECoS, then we would estimate that ECoS more likely makes up 28,152 MtCO2e out of the University’s 417,295 MtCO2e, or about **6.74%**.

We can also compare our results to those of EMS: see Table 5.

|  |  |  |
| --- | --- | --- |
| **Simplified Comparison of ECoS & EMS to University** | | |
| **Source** | **ECoS Percentage of University (CY2019)** | **EMS Percentage of University (FY18-19)** |
| **Stationary Sources/Purchased Electricity/Steam Plant** | 8.28% | 4.40% |
| **Campus Vehicles** | 0.01% | 1.10% |
| **Commuters** | 1.21% | 1.70% |
| **Air Travel** | 4.06% | 5.10% |
|  |  |  |
| **Total** | 6.36% | 4.10% |

Table 5: The first unit-level comparison at Penn State: ECoS CY2019 vs. EMS FY18-19 GHG emissions. We were unable to make a more specific comparison due to differences in data details between this and EMS’s report.

We notice that ECoS, as a larger college, makes up more of the University’s total GHG footprint than EMS, but the two units differ substantially in their activities. ECoS seems to require significantly more utilities for its activities on campus, but much less for any College-owned Vehicles or Air Travel.

Does ECoS’s footprint “make sense?” That is, how far is ECoS from the “average” unit? Using some rough numbers: Penn State employs roughly 17,000 full time faculty and staff at University Park, and welcomes about 14,000 graduate students at UP. Considering only faculty, staff, and graduate students as comprising ECoS, we estimate that ECoS houses about 1,600 people. If everyone at UP contributed equally to the University’s emissions, we would expect ECoS to compose roughly 1,600 / 31,000, or about 5.16% of Penn State’s emissions. This is below our actual footprint (both the 6.36% and the adjusted 6.74% figure), meaning we contribute more than average to the University’s GHG emissions.

### Utilities

Most of the data found for utilities was found on EnergyCAP, and it is summarized in the Building vs Unit tab of the accompanying spreadsheet. Part of our calculations for utilities involved computing an ECoS Assigned Proportional Presence, i.e., the proportion of floor area assignable to ECoS within each of the buildings in which ECoS resides. As described in the *Methodology* section, a portion of OPP space was also assigned to the ECoS space, producing the following Table 6 of ECoS Assigned Proportional Presences within the 21 buildings identified to contain ECoS-assigned space:

|  |  |  |
| --- | --- | --- |
| **BUILDING\_NAME** | **ECoS's Assigned Presence (sq. ft)** | **ECoS Assigned Proportion** |
| **McAllister (Hugh N)** | 59582 | 1.00 |
| **Spruce Cottage** | 4997 | 1.00 |
| **Joab L Thomas Building** | 86568 | 0.80 |
| **Chemistry Building** | 169046 | 1.00 |
| **Ritenour Building** | 22720 | 0.56 |
| **Botany Greenhouse** | 6664 | 1.00 |
| **Frear North Building** | 61010 | 1.00 |
| **Osmond Laboratory** | 120023 | 1.00 |
| **Pond Laboratories** | 7501 | 0.20 |
| **Whitmore Laboratory** | 82364 | 1.00 |
| **Mueller Laboratory** | 70981 | 0.95 |
| **South Frear Building (Life Science II)** | 71990 | 0.89 |
| **Althouse Laboratory** | 43539 | 0.92 |
| **Davey Laboratory** | 105281 | 0.79 |
| **Chemical Storage I (Farm No 13)** | 1848 | 0.24 |
| **Pine Cottage** | 4510 | 1.00 |
| **Forum Building** | 4214 | 0.16 |
| **Guion S. Bluford Building (230 Building)** | 3358 | 0.06 |
| **Huck Life Sciences Building** | 54792 | 0.39 |
| **Millennium Science Complex** | 32138 | 0.12 |
| **Wartik Laboratory** | 34133 | 0.53 |

Table 6: Assigned Presence of ECoS within each of the 19 buildings in which ECoS has any assigned space according to FIS. Assigned Presence, according to this inventory, depends not only the space assigned to ECoS by FIS, but other present units.

We were also able to estimate the emissions related to the operations of ECoS within each of the buildings in which is resides. See results in Figure 3.

Figure 3: Assigned ECoS Emissions categorized by building. For instance, ECoS produces over 6,000 MtCO2e through its utility-usage in the Chemistry Building over the course of a year.

A more useful plot might be that showing emissions by building but further normalized by floor area, quantifying the utility-intensity for each unit of space in each ECoS building (considering only the portion of utilities and space assigned to ECoS). Compare Figure 3 above to Figure 4 below.

Figure 4: Assigned ECoS Emissions categorized by building and normalized by floor area. For instance, ECoS produces over 0.035 MtCO2e per square foot through its utility-usage in the Chemistry Building over the course of a year. That is equivalent to 77.2 lbs. of CO2-equivalent emissions per square foot per year.

In total, Utilities comprised the lion’s share of ECoS’s 2019 GHG emissions, totaling about 25,800 MtCO2e. The results are summarized in Table 7 below.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Computed Total ECoS Utility Use and Emissions CY2019** | | | | | | | |
| **Utility** | **Steam** | **Electric** | **Chilled Water** | **Water** | **Sewer** | **Natural Gas** | **TOTAL** |
| **Total** | 122370 | 23910890 | 6719785 | 42642 | 42696 | 710 |
| **Units** | klb | kWh | Ton Hr | Kgal | Kgal | MMBtu |
| **Emissions** | 12257 | 11652 | 1637 | 134 | 129 | 38 | **25846** |
| **Units** | MtCO2e | | | | | | MtCO2e |

Table 7: Summary of utility use across all ECoS spaces, CY2019, and related emissions.

### Mobile Combustion

We analyzed data received about Commuting and Car Travel to produce a few summary statistics for ECoS during 2019. The median one-way commute was only 2.50 miles for any commuter at ECoS. But the average distance was greater: 9.14 miles. This may seem short (to a driver), but 9.14 miles is a long distance over which to expect an employee to consider alternate means of commuting such as bicycling or public transit, especially given the lack of infrastructure for these types of transit in areas outside State College. The reality for ECoS is that we mostly rely on personal vehicles to get to work. Commuters outside a 15-mile radius of campus produce half of the commuting emissions, whereas the commuters living within 15 miles make up the other half. Table 12 below summarizes these statistics:

|  |  |  |
| --- | --- | --- |
| **STATISTICS** | | |
| **PARAMETERS** | **VALUES** | **Units** |
| **Median 1-way Commute** | 2.50 | miles |
| **Mean 1-way Commute** | 9.14 |
| **OPP FY16-17 Median 1-way** | 8 |
| **OPP FY16-17 Mean 1-way** | 13 |
| **50-th Percentile for Emissions** | 15 |

Table 12: Summary statistics of ECoS commuters. OPP performed a study in 2016-2017 to analyze commuters at UP, so we compare ECoS to the sampled UP commuters.

The average distance of a trip taken by an individual from ECoS renting a vehicle (or using a personal vehicle and receiving a reimbursement) during 2019 was 276 miles total. ECoS employees took a total of 1768 ECoS-related trips, or just over one trip per person in the College on average. The emissions due to a typical trip was 0.11 MtCO2e. Table 13 below summarizes these results.

|  |  |
| --- | --- |
| **ECoS Car Travel (Non-Commuting) Use and Emissions CY2019** | |
|  | **Total** |
| **Trips** | 1768 |
| **Average Cost per Trip** | $160.25 |
| **Cost** | $283,321.87 |
| **Total Distance** | 488535 |
| **Units** | miles |
| **Average Distance** | 276 |
| **Units** | miles / trip |
| **Total Emissions** | **197.37** |
| **Units** | MtCO2e |
| **Emissions per Trip** | 0.11 |
| **Units** | MtCO2e / trip |

Table 13: Computed Car Travel for ECoS during CY2019, and related summary statistics. This includes all reimbursed/rental trips by car, either University Fleet or personal.

### Procurement

ECoS spent $11,381,758.42 on supplies and equipment during CY2019. Using Doyle’s factor of 0.000257 MtCO2e/$, we produced an estimate for ECoS’s Vendor Emissions at 2900 MtCO2e. We do not include Vendor Emissions in our inventory for 2019 because of the low confidence in this figure, as discussed in the *Methodology* section. We were able to produce Table 15 detailing ECoS’s top vendors during CY2019.

|  |  |
| --- | --- |
| **Top ECoS Vendors CY2019** | |
| **Vendor** | **Subtotal** |
| **FISHER** | $ 1,835,195.51 |
| **VWR** | $ 1,503,160.20 |
| **AGILENT TECHNOLOGIES** | $ 404,755.56 |
| **SIGMA** | $ 343,305.88 |
| **ILLUMINA INC** | $ 302,067.10 |
| **GE HEALTHCARE BIO SC** | $ 272,835.12 |
| **PRAXAIR DISTRIBUTION** | $ 265,480.79 |
| **BRUKER BIOSPIN CORP** | $ 207,996.00 |
| **JANIS RESEARCH COM** | $ 203,985.92 |
| **General Stores (OPP)** | $ 158,687.44 |
| **SHIMADZU S** | $ 151,062.35 |

Table 15: Top vendors for ECoS during CY2019. For instance, ECoS spent a collective $1,835,000 on supplies and equipment from Fisher Technology.