Penn State Council of Commonwealth Student Governments Greenhouse Gas Inventory Report

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Abstract

The Penn State Council of Commonwealth Student Governments (*CCSG*) produced **3104 metric tons of CO_2-equivalent** (*$MtCO_2e$*) through its various operations throughout its lifetime as an organization at Penn State (current up until the end of the 2020-2021 academic year) and continues to output roughly **87 $MtCO_2e$** 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.

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
CCSG	The Penn State Council of Commonwealth Student Governments
CH_4	Methane, a greenhouse gas
CO_2	Carbon Dioxide, a greenhouse gas
CO_2e	Carbon Dioxide Equivalent
CWC	Commonwealth Campus (non-UP)
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
$MtCO_2e$	Metric Tons of Carbon Dioxide Equivalent
N_2O	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, 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. 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*) initiated its own GHG inventory and has incluced 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 (*CWC*) 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 CWC. Councils have been occurring for essentially the entire existence of CCSG.
  - Additionally, attending Council Members and Liaisons stay overnight in a hotel.
- ***Mobile Combustion (a.k.a., Travel)***
  - Each Council draws at most 10-15 Council Members and/or Liaisons from each CWC (and UP if at a CWC), 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 the event 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 (*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). 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 space usage 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 universities' 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

0. Conventions

Throughout the process of performing a 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 or organization 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, such as 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 <u>not</u> 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.

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:

a) **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.
b) **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.

Another important note is that due to the SARS-CoV-2 pandemic and/or weather, CCSG has recently hosted six (6) of its Councils remotely, preventing all hotel, utility, and travel-related emissions from those six Councils. This includes all Councils that occurred during the 2020-2021 academic year, as well as the February Council during the 2021-2022 academic year.

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

1. 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 an equal proportion 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, and the EPA's 2019 eGRID Emissions Rates (RFCW)], and others depending on OPP estimates for onsite utilities [OPP GHG Calculator, Shelley McKeague]. Moreover, emissions factors must be normalized to Metric tons of CO_2-equivalent (*$MtCO_2e$*) because there are multiple kinds of GHGs emitted besides CO_2. Each GHG has a corresponding Global Warming Potential (*GWP*). The GWP for CO_2 is 1; the GWP for CH_4 is 25; and that for N_2O is 298. With these normalization factors, we combined the emissions factors for the three most common GHGs 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*) for the typical emissions assignable to a stay in a hotel room: we can express their estimate as 0.023 $MtCO_2e$ per room per night. Acknowledging that each CWC likely rents 2-3 rooms per Council meeting, we produced an estimate for Hotel 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.`

2. 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](), 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 CWC (indexed by i) was located by its address and global coordinates $(lat_i, long_i)$.
  - Four Councils per year occur at UP: compute the distance (via Google Maps) between each CWC i and UP, storing the result into $d_{i,UP}$.
  - One Council per year occurs at a randomly selected CC. To avoid computing distances between every possible pair of campuses via Google Maps, we estimate the average distance from each CWC to a randomly selected CWC:
    - Routes following Pennsylvania roads usually take r times as much distance to drive than the true geodesic distance between the endpoints. Estimate r by computing the average scaling on the routes from each CWC to UP, i.e., $$r \approx \frac{1}{\#CWC's} \sum_i \frac{d_{i,UP}}{dist(lat_i, long_i, lat_{UP}, long_{UP})},$$

where $dist(\cdot,\cdot,\cdot,\cdot)$ computes the geodesic distance between two points on Earth.

- The average distance $\hat{d}_{i,C,WC}$ from CWC i and a (uniformly) randomly selected other (non-UP) CWC is estimated to be the typical geodesic distance times r.

- Annual Council distance D_i by CWC i is estimated as the sum of all driving from UP and CWC Council meetings both ways by however many cars c_i are expected to travel, i.e.,
$$D_i = 2 \cdot c_i \cdot \left(4 \cdot d_{i,UP} + 1 \cdot \hat{d}_{i,CWC}\right).$$
- Therefore, Annual Council driving distance by every participating campus is the sum of every D_i. Lifetime Council driving distance equals the sum of each D_i multiplied by the number of active years in which CWC i has participated in CCSG.
- Emissions are computed by summing all the emissions factors from years in which CWC i participated in CCSG by D_i.

- *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 assumed to be 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`.

3. 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, 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 CO_2e per dollar, whereas that for office product supplies was around 0.47 kilograms of CO_2e per dollar. Most surprisingly, she found that the carbon intensity for food was around 0.83 kilograms of CO_2e 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 $MtCO_2e/\$$.

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 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

0. Main Results

First, we present the estimated lifetime emissions produced by CCSG, i.e., the emissions calculated to have been produced throughout the entire existence of CCSG throughout all its operations in the following Table 1.

CCSG Lifetime GHG Emissions by Source			
Source	**Emissions**	**Units**	**Percentage**
Steam	255.8	$MtCO_2e$	8.2%
Electric	207.2		6.7%
Chilled Water	31.6		1.0%
Water	3.1		0.1%
Sewer	3.0		0.1%
Natural Gas	10.4		0.3%
Procurement	155.6		5.0%
Hotel Accommodations	261.6		8.4%
Car Travel	2175.5		70.1%
Total	3104	$MtCO_2e$	100.0%

Table 1: Lifetime emissions for CCSG, categorized by Source.

If we categorize by Scope instead of by Source (following the Scope breakdown discussed in the section *Methodology*), we obtain the following Table 2 for CCSG's lifetime emissions.

CCSG Lifetime GHG Emissions by Scope			
Scope	**Emissions**	**Units**	**Percentage**
Scope 1	2227	$MtCO_2e$	71.7%
Scope 2	43		1.4%
Scope 3	834		26.9%
Total	3104	$MtCO_2e$	100.0%

Table 2: Lifetime emissions for CCSG, categorized by Scope.

The final way in which we might wish to present the lifetime emissions of CCSG are by a more understandable categorization of source: by *Strategic Category*. Table 3 below breaks down these lifetime emissions into these more understandable categories.

CCSG Lifetime GHG Emissions by Strategic Category			
Source	**Emissions**	**Units**	**Percentage**
Council Operations	500.0	$MtCO_2e$	16.1%
Council Travel	2173.5		70.0%
Retreats	22.6		0.7%
Banquets	24.9		0.8%
Office Space	94.4		3.0%
Office Supplies	0.7		0.0%
Merchandise & Awards	26.2		0.8%
Hotel Accommodations	261.6		8.4%
Total	3104	$MtCO_2e$	100.0%

Table 3: Lifetime emissions for CCSG, categorized by Strategic Category, a more understandable categorization.

For CCSG to understand how its emissions will progress into the future, it might be more useful to present this breakdown by Strategic Category for a modern year, rather than the lifetime of CCSG. This is because some events, emissions factors, and practices have changed throughout CCSG's existence. If we were to now quantify the annual emissions by CCSG in a year like 2021-2022, Table 4 shows the new distribution of emissions.

CCSG (Modern) Annual GHG Emissions by Strategic Category			
Source	**Emissions**	**Units**	**Percentage**
Council Operations	8.1	$MtCO_2e$ / year	9.4%
Council Travel	38.4		44.4%
Retreats	1.5		1.7%
Banquets	1.7		1.9%
Office Space	6.3		7.3%
Office Supplies	0.0		0.1%
Merchandise & Awards	26.2		30.3%
Hotel Accommodations	4.3		5.0%
Total	87	$MtCO_2e$ / year	100.0%

Table 4: Annual emissions (in a modern year) for CCSG, categorized by Strategic Category, a more understandable categorization.

Alternatively, we can present these tables as pie charts.

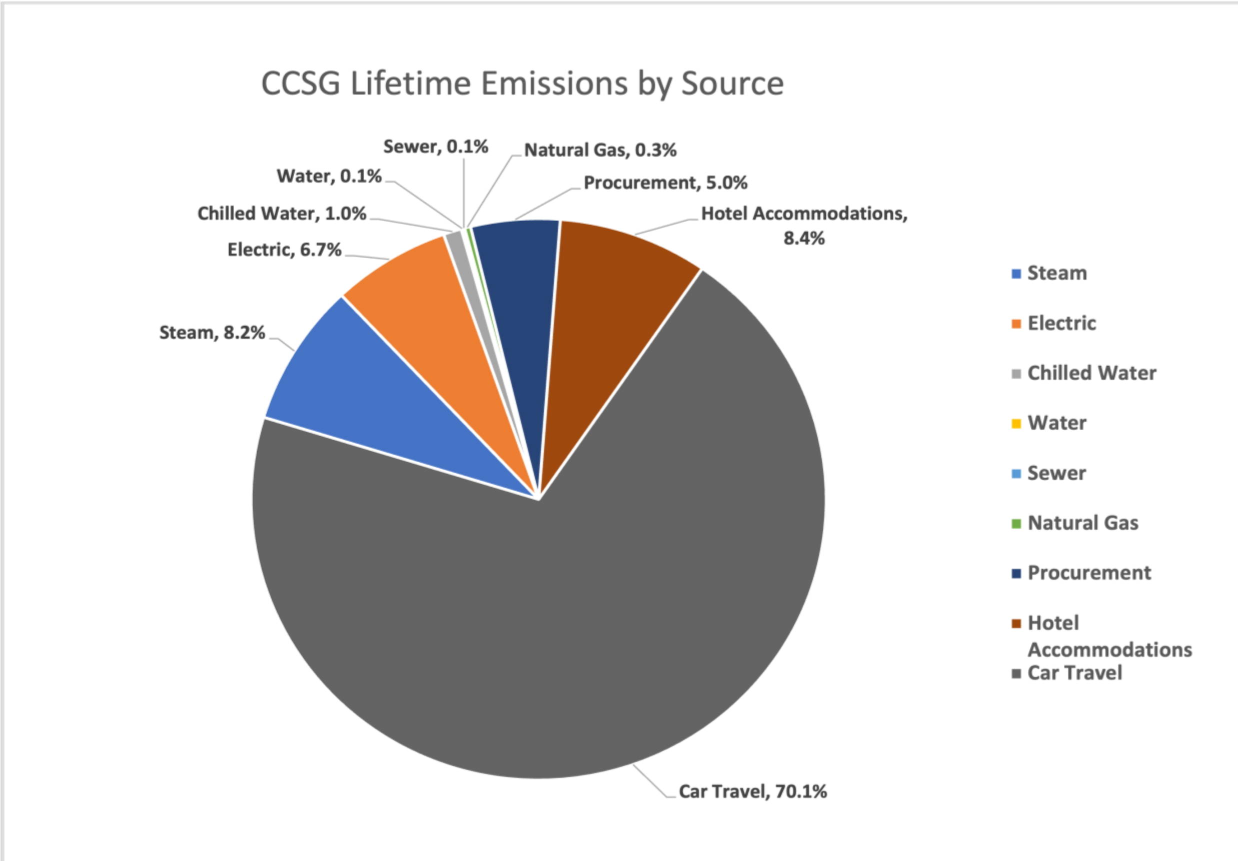

Figure 1: Lifetime emissions for CCSG, categorized by Source. Corresponds to Table 1.

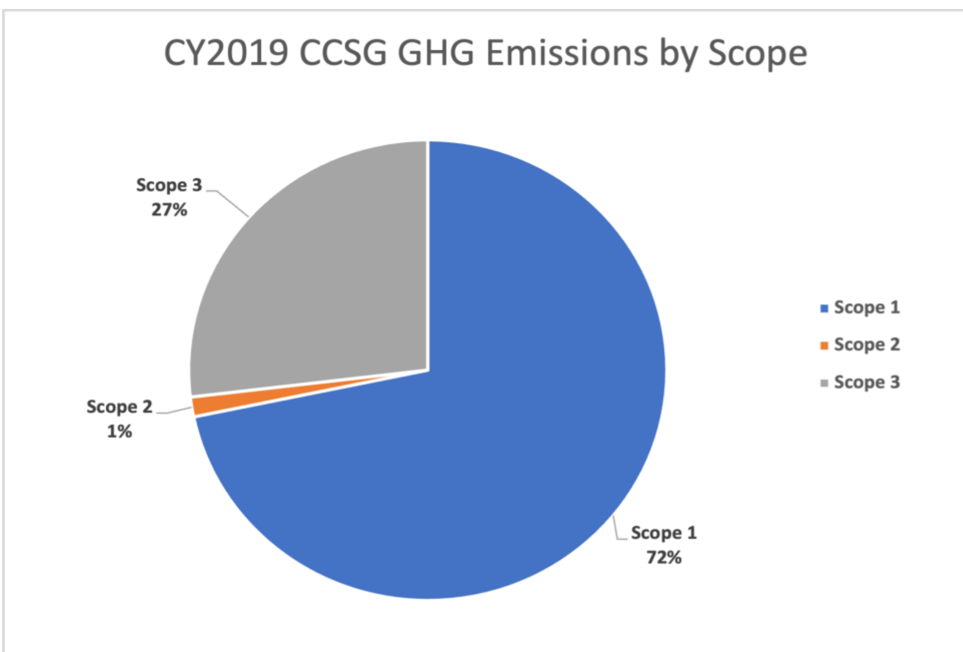

Figure 2: Lifetime emissions for CCSG, categorized by Scope. Corresponds with Table 2.

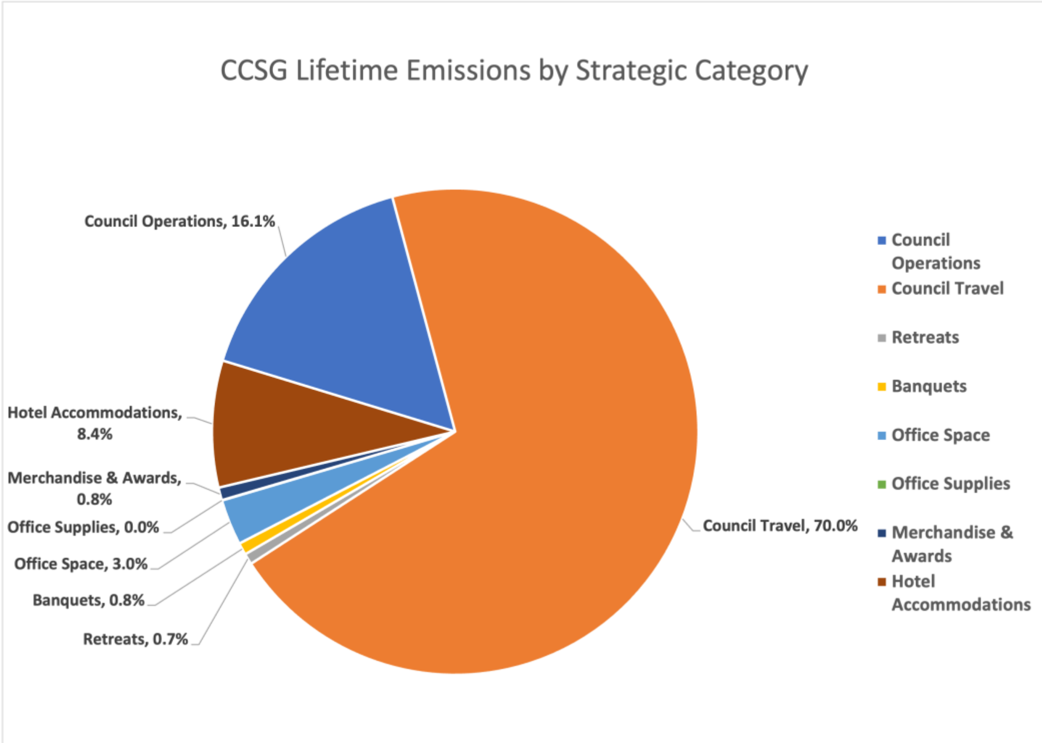

Figure 3: Lifetime emissions for CCSG, categorized by Strategic Category. Corresponds to Table 3.

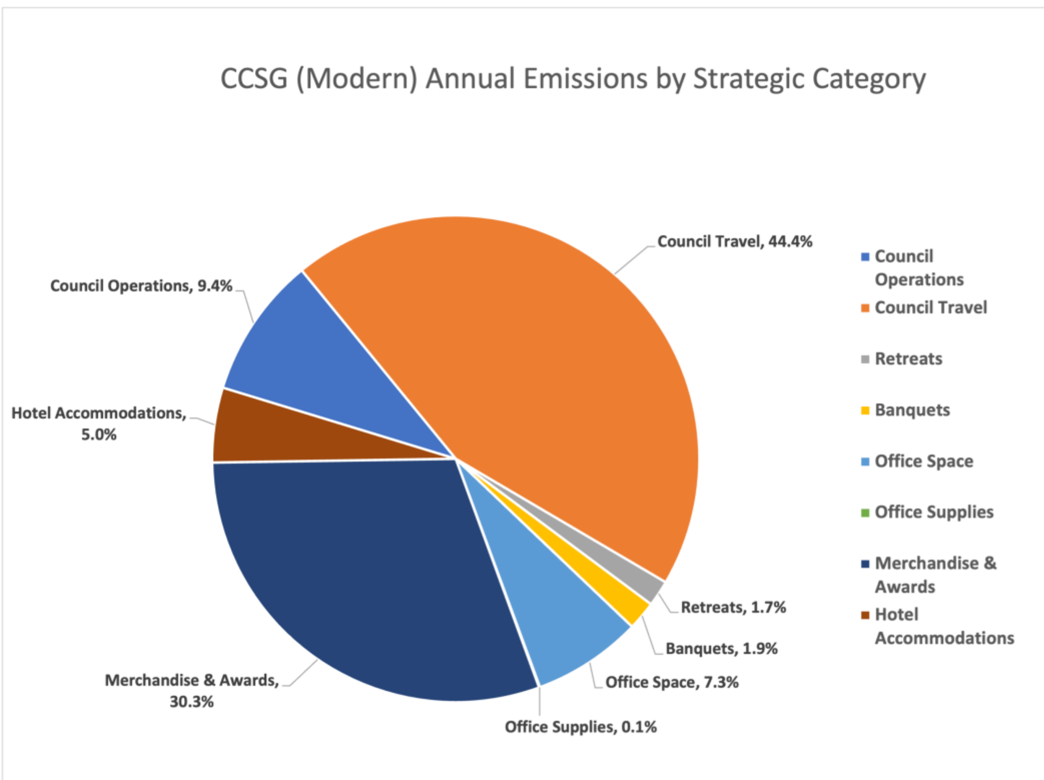

Figure 4: Annual emissions (in a modern year) for CCSG, categorized by Strategic Category. Corresponds to Table 4.

Our final remark about the general results, we found that if CCSG were to consider whether to host a Council in-person vs. remotely, CCSG should be aware that each Council typically emits about 10.2 $MtCO_2e$ in all its space, travel, and procurement needs.

1. Utilities

Most of the data found for utilities was found on EnergyCAP, and it is summarized in the `Building Utilities` tab of the accompanying spreadsheet. Part of our calculations for utilities involved computing a CCSG Assigned Proportional Presence, i.e., the proportion of floor area assignable to CCSG within each of the buildings in which CCSG resides. Table 5 below summarizes CCSG's presence with its office space as well as its presence on campus during its Councils.

BUILDING_NAME	Assigned Proportional Area	Proportion of Year
Hetzel Union Building (Ralph Dorn), Office Space: HUB 312, 313	0.194%	100.000%
Hetzel Union Building (Ralph Dorn), Council Meeting Space e.g., 102, 107, 122, 134, 233AB	4.173%	4.110%
Osmond Laboratory: Council Meeting Space e.g., 103, 104, 105, 106, 109)	3.288%	2.740%

Table 5: Assigned Presence of CCSG within the HUB (where CCSG has its office space), according to FIS. The amount of time spent here per year also affects how much of the emissions are attributable to CCSG.

In total, on-campus utilities comprised about 16.5% of CCSG's lifetime GHG emissions, totaling about 511 $MtCO_2e$. The results are summarized in Table 6 below.

Estimated, Computed Total CCSG Utility Use and Emissions from On-Campus Spaces							
Utility	**Steam**	**Electric**	**Chilled Water**	**Water**	**Sewer**	**Natural Gas**	**TOTAL**
Annual Total	66	10656	3359	26	27	5	
Units	klb	kWh	Ton Hr	Kgal	Kgal	MMBtu	
Annual Emissions	6.6	5.2	0.8	0.1	0.1	0.3	**13.03**
Lifetime Emissions	255.8	207.2	31.6	3.1	3.0	10.4	**511.11**
Units	$MtCO_2e$						$MtCO_2e$

Table 6: Summary of on-campus utility use across all CCSG spaces (offices and Councils), both annually and lifetime.

Off-campus utilities would include the emissions related to the hotel accommodations required by Council Members and Liaisons participating in Councils from CWCs. Off-campus utility emissions totaled about half of what on-campus did historically for CCSG. However, per-year, off-campus is now about a third of the emissions as on-campus. Table 7 below summarizes the results of CCSG's off-campus utilities.

Estimated, Computed Total CCSG Emissions from Hotel Accommodations	
Description	**Value**
Number of Commonwealth Campuses (CC)	19
Number of Rooms per CC	2
Number of Nights Spent in Hotel per Council	1
Annual Hotel Accommodations Emissions	**4.30**
Emissions Savings per Remote Council	**0.86**
Lifetime Hotel Accommodations Emissions	**261.60**
Units	$MtCO_2e$

Table 7: Summary of off-campus utility use across all CCSG spaces (just hotel accommodations) both annually and lifetime.

2. Mobile Combustion

The first piece of Mobile Combustion is car travel to and from Council meetings. We were able to estimate the contribution from each CWC to CCSG's lifetime Car Travel emissions from Councils. See Table 8 below for a summary.

Estimated Car Travel for a typical Council Meeting by CWC				
Campus	**Campus' 1st Year in CCSG**	**Distance to UP**	**Annual Councils Driving Distance**	**Lifetime Councils Driving Emissions**
		miles	miles / year	$MtCO_2e$
Abington	1960	195	7817	161
Altoona	1960	44	2539	52
Beaver	1965	171	7010	121
Behrend	1960	213	8641	178
Berks	1960	143	5817	120
Brandywine	1967	178	7273	115
Dubois	1960	63	3279	68
Fayette (Eberly Campus)	1960	149	6372	131
Greater Allegheny	1960	135	5924	122
Harrisburg	1966	99	4280	71
Hazleton	1960	114	4838	100
Lehigh Valley	1960	169	6962	143
Mont Alto	1960	110	4686	97
New Kensington	1960	125	5538	114
Schuylkill	1960	122	5094	105
Scranton	1960	151	6022	124
Shenango	1965	162	7157	123
University Park	1960	0	1131	23
Wilkes-Barre	1960	122	5094	105
York	1960	117	4856	100

Table 8: Summary of car travel emissions across each CWC from Council attendance both annually and ever.

Table 9 concludes that driving to and from Councils has contributed over 2,170 $MtCO_2e$ to CCSG's lifetime emissions and continues to contribute over 38 $MtCO_2e$ each year when Councils run as normal.

Car Travel and Emissions due to Councils	
Description	**Value**
Annual Council Distance	1.10E+05
Lifetime Council Distance	6.69E+06
Units	miles
Annual Council Driving Emissions	38.40
Lifetime Council Driving Emissions	**2173.46**
Units	$MtCO_2e$

Table 9: Summary of car travel emissions from Councils for CCSG both annually and over its lifetime.

As postulated in the *Methodology*, routes following Pennsylvania roads usually take r times as much distance to drive than the true geodesic distance between the endpoints; this value was estimated to be $r \approx 1.311$ during our analysis of car travel for Councils.

The other component behind CCSG's Mobile Combustion emissions is the car travel related to Retreat attendance. Table 10 summarizes the results of this investigation.

Car Travel and Emissions due to Retreats	
Description	**Value**
Annual Retreat Distance	360
Lifetime Retreat Distance	5.40E+03
Units	miles
Annual Retreat Driving Emissions	0.13
Lifetime Retreat Driving Emissions	**2.03**
Units	$MtCO_2e$

Table 10: Summary of car travel emissions from Retreats for CCSG both annually and ever.

3. Procurement

Working with CCSG's Treasurer, we were able to make our best estimates of the typical expenditures by CCSG in multiple procurement fields: office supplies, merchandise, awards, and food for each of the usual events: Banquets, Retreats, and Councils. The results and corresponding emissions calculations are summarized in Table 11 below.

Typical CCSG Procurement Practices and Calculated Emissions			
Expenditure Type	**Annual Expenditures**	**Annual Estimated Emissions**	**Lifetime Estimated Emissions**
Office Supplies	$ 100.00	4.70E-02	7.05E-01
Merchandise	$ 400.00	1.88E-01	1.17E+01
Awards	$ 500.00	2.35E-01	1.46E+01
Banquet Food	$ 2,000.00	1.66E+00	2.49E+01
Retreat Food	$ 1,650.00	1.37E+00	2.05E+01
Council Food	$ 1,650.00	1.37E+00	8.33E+01

Table 11: Summary of typical annual expenditures by CCSG in multiple expenditure categories and their associated emissions.

Using these figures as our baseline for typical CCSG activity, as well as Doyle's factors, we estimate the lifetime and annual emissions from all CCSG's Procurement practices in Table 12 below.

CCSG Procurement Expenditures and Emissions	
Annual Total	$ 6,300.00
Estimated Annual Emissions	**4.87**
Units	$MtCO_2e$ / year
Estimated Lifetime Emissions	**155.64**
Units	$MtCO_2e$

Table 12: Summary of typical aggregated annual expenditures by CCSG and their associated emissions.

Conclusion

Throughout its existence and through its various strategic operations, CCSG has emitted approximately **3104 metric tons of CO_2-equivalent** and continues to output about **87 $MtCO_2e$** annually. In this report, we have developed a reasonable methodology for performing a lifetime GHG inventory on a student organization, the first action of this kind across the entirety of the Pennsylvania State University. Emissions sources considered in this inventory include those from utility use, procurement practices, car travel, hosted events, accommodations, and more. We recommend that CCSG commit funds to eliminate its historical footprint and produce materials to guide other student organizations to do the same. We hope this effort serves as a call to action for other student governments, student organizations, and units within the University to perform their own GHG inventories and commit to acting upon the results of such investigations. Achieving greater sustainability and resilience will require a combination of systemic and individual actions across the University.