College of Health and Human Development Greenhouse Gas Inventory for Fiscal Year 2021-2022 Report

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Abstract

The College of Health and Human Development (HHD) produced 8,607 metric tons of CO_2 equivalent ($MtCO_2e$) through its various operations during Fiscal Year 2021-2022 (FY2122). With respect to the United Nations Sustainable Development Goals (SDGs), most pertinent to Goal 13: Climate Action, this greenhouse gas (GHG) inventory presents a breakdown of emissions arising from utility use, air travel, fleet-leased and rented vehicles, and vended supplies (UN, 2016). This is the first emissions inventory for the College of Health and Human Development (HHD) at The Pennsylvania State University (PSU). It is recommended that HHD perform this inventory on a regular (each fiscal year) basis as a metric of success in reducing its emissions of climate-damaging greenhouse gases.

Supplemental Documentation

This document summarizes the results collated in the accompanying spreadsheet `HHD_GHG_Inventory_FY2122.xlsx`. The spreadsheet serves as an Appendix to this report.

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List of Abbreviations

Abbreviation	Definition
BBH	Biobehavioral Health
CH_4	Methane, a greenhouse gas
CO_2	Carbon Dioxide, a greenhouse gas
CO_2e	Carbon Dioxide Equivalent
ECoS	The Eberly College of Science
eGRID	Emissions & Generation Resource Integrated Database
EMS	College of Earth and Mineral Science
EPA	Environmental Protection Agency
EUI	Energy Use Intensity
FIS	Facilities Information System
FY	Fiscal Year
FY2122	Fiscal Year 2021-2022
GHG	Greenhouse Gas
GPC	General Purpose Classroom
GWP	Global Warming Potential
GWU	The George Washington University
HHD	College of Health and Human Development
HLSB	Huck Life Sciences Building
ISS	Information Systems and Services
LEED	Leadership in Energy and Environmental Design
MPH	Master of Public Health
MSC	Millennium Science Complex
$MtCO_2e$	Metric Tons of Carbon Dioxide Equivalent
N_2O	Nitrous Oxide, a greenhouse gas
OPP	Office of Physical Plant
OVPR	Office of the Vice President for Research
PSU	The Pennsylvania State University
PUE	Power Utilization Effectiveness
SDG	United Nation's Sustainable Development Goal
SI	The Sustainability Institute
UC	The University of California
UP	University Park

Introduction

Penn State University's Office of Physical Plant (OPP) produces an annual, University-wide Greenhouse Gas Inventory in order to summarize emissions related to all University operations by sector and scope for the fiscal year. Following the lead of both the College of Earth and Mineral Sciences (EMS) and Eberly College of Science (ECoS); the College of Health and Human Development (HHD) produced its first unit-level inventory to effectively analyze the emissions due to operations assigned to HHD during fiscal year 2021-2022 (FY2122).

A unit-level inventory can provide better identification and management of potentially avoidable GHG emissions, and may increase unit accountability to reduce emissions, increase sustainability, and make progress towards University climate action goals. This inventory is confined to the emissions attributed to HHD at the University Park (UP) campus. The scopes and sources of this inventory are aligned with the OPP's University-wide inventory and are being reported according to The Greenhouse Gas Protocol (Greenhouse Gas Protocol, n.d.).

- **Scope 1** emissions are direct emissions from owned or controlled sources;
- **Scope 2** are indirect emissions related to purchased utilities; and
- **Scope 3** Everything else: remaining indirect emissions that occur in the value chain. Scope 3 is considered "someone else's Scope 1."

This inventory will include all three scopes, matching what is reported in the annual Penn State University-wide inventory. Scope 1 and Scope 2 emissions include those from stationary and mobile combustion, utility services, refrigerants, fertilizers, and animal management. At University Park (UP), utilities are the main sources of Scope 1 and Scope 2 emissions. This is because a portion of electricity is produced onsite (e.g., solar) while the majority is purchased from the grid. Some utilities fall under both Scope 1 and 2. It is important to note that Scope 3 emissions are challenging to estimate as they can be difficult to accurately define, let alone measure.

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 the portion of its Scope 3 emissions that might 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 reduction 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 Colby Lyn Sinclair, a MPH candidate at the Milken Institute School of Public Health at The George Washington University and College of Health and Human Development (HHD) Staff Advisory Council (SAC) staff representative for the HHD Sustainability Council Charter, advised by JoAnn Foley-DeFiore, PhD., Associate Teaching Professor of Biobehavioral Health (BBH) and current HHD Sustainability Council Chair. This inventory was made possible by Shelley McKeague, Compliance Manager within OPP; Tara Chrzanowski, Data Analyst at OPP Energy and Sustainability; Raymond Joseph Friend Jr., Graduate Assistant in Mathematics; Sarah Sharkey, Research Assistant at

EMS; Kevin Kelliher, Facilities Manager of HHD; Jeff Kukitz, PhD., Assistant Dean for Operations in HHD; and Nicole Rigg, Financial Manager in HHD.

Methodology

0. Conventions

When preparing to perform a unit-level GHG inventory at PSU, a researcher can expect to be confronted with multiple decision points: What specific kinds of emission are most logical to compute for the specified college? What time frame should be included in the inventory: Should the inventory follow the calendar- or fiscal-year? How are the emissions quantified from shared spaces? In those shared spaces, how is it determined which unit is responsible for a particular emission? Are off-campus spaces to be included in this inventory? What level of confidence is needed in the data to publish an estimate?

It was decided to perform the HHD inventory based on the fiscal year, compared to following a calendar year, because HHD routinely observes the fiscal year. The ECoS inventory was performed following the calendar year due to its alignment with the Environmental Protection Agency (EPA) emission factors reports and the University's centralized tool for on-campus utility-use, EnergyCAP.

The scope of this inventory was chosen specifically to mimic previous inventories at PSU, e.g., EMS, to facilitate ease of comparison among the results of the University-wide inventory and across other units that utilize the fiscal year. Additionally, this methodology may be the process adopted for future unit-level inventories at PSU.

In contrast to the University-wide inventory, the HHD inventory set out to present data for non-standard emissions categories, such as Vendor Emissions, Global Program Experiences, and High-Performance Computing. Each category requires arduous research and contains data that is particularly difficult to quantify. Therefore, this inventory was only able to collate little (if any) information at the time of publishing for Vending, Global Program Experiences and High-Performance Computing. Regardless, it is important to note that the University GHG inventory does not include Vendor Emissions altogether, due to uncertainty when obtaining estimates, something that would limit the University-wide inventory's accuracy, quality, and completeness, according to OPP Compliance Manager, Shelley McKeague (Anderson & Friend, 2021). Scope 3 emissions are much greater than Scope 1 and Scope 2. For PSU to be able to precisely inventory and comprehend the climate impact of the entirety of its operations, extensive additional efforts are needed to identify and quantify all Scope 3 emissions.

Further defining the scope, specifically its point-of-view, was the next weighty decision to be made prior to performing the inventory. There are two potential approaches:

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

Each of these approaches has been performed previously at the unit-level at PSU. EMS implemented the former, treating EMS as a partner to the University that procures the University's utilities for its purposes. ECoS implemented the latter. It was determined that the best practice for completing HHD's

inventory would be to follow EMS (who also followed a fiscal year versus the calendar year) and treat HHD as a separate entity interacting with the University's provided services. This will allow for better comparison to EMS and other future inventories that follow a fiscal year approach.

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

1. Utility Emissions

Utility usage is defined as the resources consumed to operate the buildings HHD inhabits. At UP, utility usage is measured at the building level, meaning there is no more specific way to estimate the utility usage of HHD beyond estimating the College's proportional use of each building on campus. A spreadsheet, made available by OPP's Shelly McKeague and Penn State's Facilities Information System (FIS), was provided detailing how each room in every building that houses HHD is assigned. The spreadsheet also contained information regarding the floor area of each space. To accurately produce an estimate for the utility usage by HHD in each of those buildings, it was necessary to sum the floor area of each room assigned to HHD in a building and assign a proportional amount of that building's utilities to HHD. One feature of how space is assigned within buildings at UP is that general purpose rooms like closets, hallways, bathrooms, and kitchen spaces are assigned to OPP, despite these spaces primarily serving all units that inhabit the building.

The University utilizes a centralized tool for reporting summary utility usage, EnergyCap. This software reports measurements for Steam, Electric, Chilled Water, Water, Sewer, and Natural Gas. This inventory pulled measurements for each of these utilities during the 2021-2022 Academic Year, defined as July 1, 2021, through June 30, 2022. There are 13 buildings containing HHD-assigned spaces. Only 11 of these buildings are on the UP campus and were included in this inventory. Also, one building, Research Unit A, is considered fully assumed by OPP due to renovation (see Complication 1 for more information).

Emission factors for each utility were obtained via standard factors released by the EPA (US EPA, 2015a) or from OPP estimates for onsite utilities. Emission factors were normalized to Metric tons of CO_2-equivalent ($MtCO_2e$) because there are various levels of GHGs emitted, not limited to CO_2. According to the EPA, every GHG has a corresponding GWP, or Global Warming Potential (US EPA, 2016b). The GWP during FY2122 for CO_2 is 1; the GWP for CH_4 is 25; and N_2O is 298. A calculated normalized emission factor for each utility was performed based on the respective GWP.

Complication 1: Defining building space utilized by HHD was a particularly opaque process. This is because the buildings in which HHD is housed are typically shared spaces. As mentioned previously, there are 13 buildings assigned as containing HHD space. However, only 11 buildings are on the University Park campus. The other two facilities are leased spaces within the community, The Towers in downtown State College and 12 Sheraton Drive in Altoona. One HHD-assigned space was undergoing renovation during the scope of this inventory. These renovations reassigned this building, Research Unit A, as an OPP-assigned space, excluding it from the HHD inventory. It is important to include Research Unit A in future inventories when the OPP renovation has been completed.

Buildings at University Park are serviced by steam, natural gas, chilled water, electricity, water, and wastewater. Utility emissions are calculated by Penn State central plants based on the amount of fuel consumed to generate each commodity for the university-wide inventory. For this inventory, each scope is defined as the following for campus and off-campus spaces:

Campus Buildings

- **Steam**: Scope 1. Produced onsite using Natural Gas.
- **Natural Gas**: Scope 2. Purchased from the grid.
- **Electricity**: Scope 2. Purchased from the grid.
- **Water**: Scope 1 and Scope 2.
    - Gas, oil, and propane are assigned Scope 1.
    - Electricity is Scope 2.
- **Wastewater**: Scope 1. Treated onsite.
- **Chilled water**: Scope 2. Derived from electricity.

Off-Campus Buildings

- **Electricity**: Scope 2. Purchased from the grid.
- **Water**: Scope 3. Purchased from local water authority.
- **Wastewater**: Scope 1 or Scope 3.
    - Treated onsite is assigned Scope 1.
    - Treated at a local municipality is assigned Scope 3.
- **Natural gas**: Scope 1. Purchased from a company but maintains operational control.

For a college-level inventory, an emissions factor needs to be calculated for each utility used at the building per metered unit, based on emissions at each plant. Once emissions can be calculated for a building, then the portion to attribute to HHD is determined.

Caveats:

- This procedure does not account for utility intensity. All assignable square-feet are treated as equal when that is likely a poor assumption provided the differences between general purpose classrooms (GPC) and research laboratory spaces.
- This procedure does not account for emissions located outside of the University Park campus. For a true estimate, it may be necessary to determine emissions resulting from off-campus, leased spaces.
- This procedure ignores emissions related to upkeep and maintenance of these spaces and utilities (for example, construction worksites).

Confidence: Medium to High. The absence of data (listed above) prevents true accuracy when attempting to quantify HHD's full utility usage.

See Tabs: Buildings Raw, Building vs Unit, Utility Emission Factors, and Building Utilities.

2. Mobile Combustion Emissions

The Greenhouse Gas Protocol defines mobile combustions as "combustion of fuels in transportation devices such as automobiles, trucks, buses, etc (Greenhouse Gas Protocol, n.d.)." For this inventory it was decided that emissions due to Air Travel, Global Programs, Car Travel and College-owned vehicles were all considered mobile combustion. The following assumptions were made to produce emissions totals within each category.

Air Travel: Emissions factors for air travel are dependent on a flight haul type. A short haul is defined as less than 300 miles; a medium haul is between 301-2300 miles; and a long haul is greater than 2300 miles (US EPA, 2015c). Normalized emission factors per passenger-mile using GWP were calculated for each of the three most common GHGs and their respective emission factors defined by the EPA (US EPA, 2016a). HHD air travel data was provided by the Financial Manager, Nicole Rigg. This air travel data excludes student experiences provided through Global Programs as it was not provided. This flight information includes faculty, graduate, post-doctoral and student-related business purposes for HHD.

Global Programs: The Office of Global Programs offers experiences for faculty and students of any level to travel abroad for educational and research purposes. There are many ways to participate in these experiences. Two types of faculty-led student experiences include free-standing or embedded programs. Free-standing programs are owned and provided by Global Programs whereas embedded programs are often a portion of a standing program. Information for the Global Program was unable to be obtained in time for the publication of this inventory. After further consultation with HHD leadership, it was determined that Global Programs data may be less important to inventory for the 2021-2022 Fiscal Year due to the ongoing COVID-19 Pandemic restrictions on travel. It is important to include Global Program information for HHD in future inventories as travel restrictions are discontinued.

Road Travel: Road travel in this inventory includes Car Travel and HHD-owned Vehicle calculated emissions. Each estimate is based on mileage driven and the EPA's estimations for emissions for a typical passenger vehicle. Commuting was excluded from this inventory due to the various forms of work arrangements, including typical commuting, work-from-home and hybrid schedules in practice during FY2122 due to the ongoing COVID-19 Pandemic (US EPA, 2016a).

- *Car Travel*: HHD documents all reimbursed driving trips, including personal vehicle use and University Fleet rentals. Data, provided by HHD's Nicole Rigg, included an Approved Amount for each expense, however the business distance, or length of trip in miles, was only included in some cases. For trips without business distance, average mileage was calculated based on Transaction date and Mileage Costs for other Approved Amounts with similar transaction dates. An assumed average mileage cost was estimated at $1.74 per mile.
- *HHD-Owned Vehicles*: HHD owns 2 vehicles, and both are used exclusively by Information Systems and Services (ISS) and Facilities to transport equipment between HHD buildings on campus. Both vehicles use gasoline and were driven less than 1000 miles each, specific mileage was unavailable, therefore, Estimated Mileage for FY2122 is listed at 999 miles per vehicle. Emissions were calculated from estimated mileage to $MtCO_2e$ using Formula 1:

$$\frac{\text{(Estimated Mileage / Mileage Per Gallon) *8,887 grams of } CO_2 \text{ per gallon)}}{1{,}000{,}000}$$

Formula 1: 8,887 grams of C02 per gallon is the amount burned per gallon of gasoline in a typical passenger vehicle

Vehicle No.	Description	Department	Estimated Mileage (mi) FY2122	Fuel Type	Units	Emissions	Units

0	2016 Dodge Caravan	ISS	999	Gasoline	$MtCO_2e$ /mile	0.522*	$MtCO_2e$
1	2022 Transit Connect	ISS	999	Gasoline		0.37*	
					Total	**0.892**	$MtCO_2e$

*Table 1: HHD-Owned Vehicle Summary for FY2122. *Calculated using the formula provided above. The total emissions estimate for HHD-owned vehicles for FY2122 is 0.892 $MtCO_2e$.*

Scope(s):

- **Air Travel**: Scope 3
- **Global Programs (if applicable)**: Scope 3
- **Commuting (if applicable)**: Scope 3
- **Car Travel**: Scope 1
- **HHD-Owned Vehicles**: Scope 1

Caveats:

- Categorizing Air Travel by Haul Type may be limiting considering aircraft weight, make and model.
- Without knowledge of HHD employee addresses, commuting data will remain unable to be inventoried.
- Emissions calculations for HHD-owned vehicles could be made more accurate if the exact mileage during FY2122 was provided for each vehicle.

Confidence: Medium. Air Travel was the only well-documented, trusted data information provided for mobile combustion. It remains necessary to calculate Commuter and Global Programs data to inventory mobile combustion emissions more confidently among HHD efforts.

See Tabs: Air Travel Raw, Air Travel Emissions Factors, Air Travel, Car Travel Raw, Car Travel, HHD Vehicles.

3. Procurement

Vendor emissions are Scope 3 emissions related to supply chain for HHD supplies and equipment. HHD has numerous detailed accounts of each one of its thousands of purchases in 2022, however, most of this data is unidentifiable, a necessity in order to determine which types of products and their quantities were purchased. Without this data, rough estimates included in this inventory were calculated using University of California (UC) Berkeley's 2009 Procurement Carbon Footprint by author Kelley Doyle. Doyle's analysis includes a thorough, top-down approach when calculating vendor emissions. While these estimate results are unlikely to accurately represent vendor emissions of procurement at PSU during FY2122, they assist in providing an order of magnitude. Doyle lists the average carbon intensity for scientific equipment, office products or supplies, and food as 0.66, 0.47 and 0.83 kg of CO_2 per dollar,

respectively. For reference, Doyle calculated the overall intensity estimate of the entirety of UC Berkeley's operations, including construction, IT, and telecommunication, as 0.000257 $MtCO_2e$/dollar (Doyle, 2012).

HHD was able to discern the most common and largest vendors based on the data that was provided regarding procurement. However, the data provided was considered incomplete due to lack of organization and inventory management at the purchasing level for labs and offices to produce accurate estimates. It is crucial to fully comprehend HHD's emissions in procurement because these emissions are fully controllable by each department, unlike other emissions included in this inventory, such as utilities.

Scope(s): Scope 3.

Caveats:

- Many assumptions were made when estimating vendor emissions regarding procurement in HHD due to nondescriptive or lack of data. Ballpark estimates are those related to procurement at UC Berkeley in 2009.
- UC Berkeley has many differences compared to HHD, and even PSU. Differences include vendor suppliers, energy grid emissions, and procurement procedures and processes.
- Estimating emissions from dollars is a flawed and arduous task as there is no way to determine which suppliers were used and what specific products were ordered. These, along with other unknown variables, can all affect true emission totals related to each product.

Confidence: Low. See caveats above for reasonings.

See Tab: Vendor.

Results

0. Main Results

Please see below for the full FY2122 HHD GHG Emissions by Source in the following Table 2.

FY21-22 HHD GHG Emissions by Source			
Source	**Emissions**	**Units**	**Percentage**
Steam	4052	$MtCO_2e$	47.1%
Electric	3836		44.6%
Chilled Water	318		3.7%
Water	21		0.2%
Sewer	20		0.2%
Natural Gas	126		1.5%
Air Travel	156		1.8%
Global Programs	-		0.0%
Car Travel	76		0.9%
Commuting	-		0.0%
HHD Vehicles	1		0.0%

Computing	-		0.0%
Total	8607	$MtCO_2e$	100.0%

Table 2: FY2122 HHD GHG Emissions by Source. A dash (-) is listed for the entities in which data were unable.

FY21-22 HHD GHG Emissions by Scope			
Scope	**Emissions**	**Units**	**Percentage**
Scope 1	4278	$MtCO_2e$	49.7%
Scope 2	4173		48.5%
Scope 3	156		1.8%

Table 3: Emissions for HHD during FY2122, categorized by Scope.

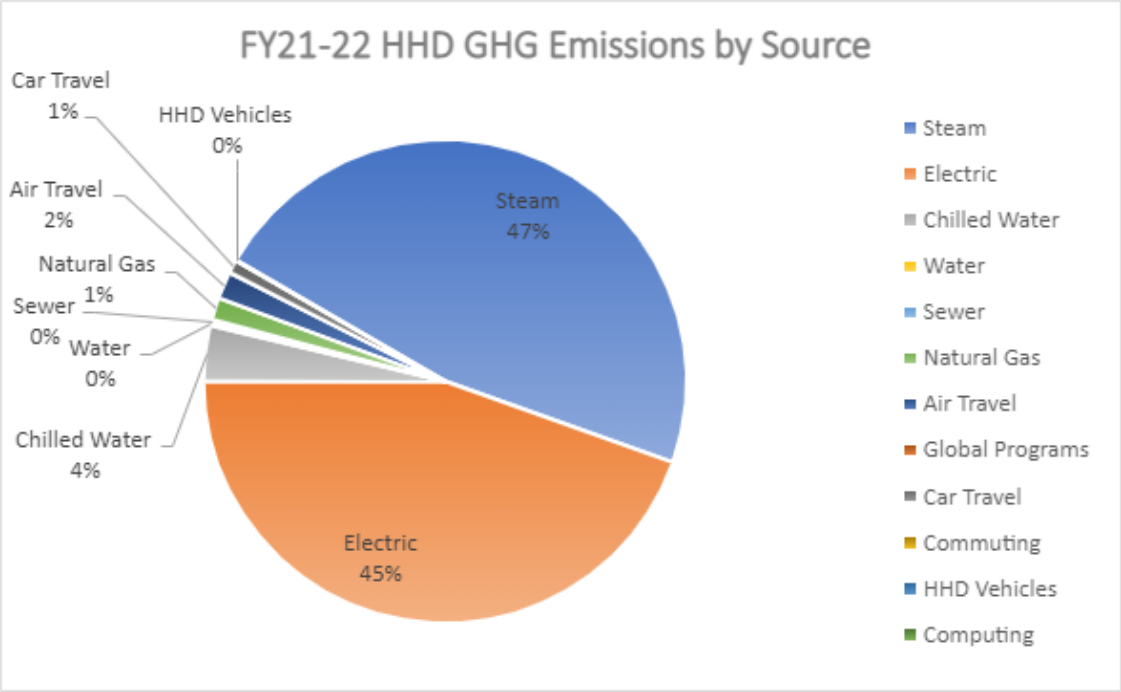

Figure 1: Emissions for HHD during FY2122, categorized by Source. (Corresponds to Table 2.)

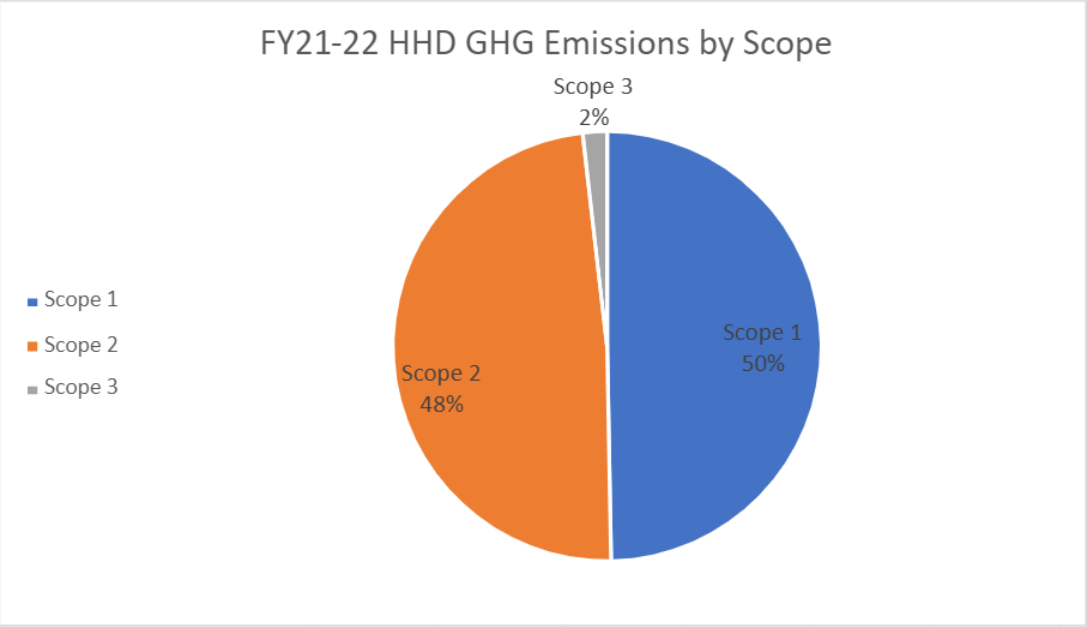

Figure 2: Emissions for HHD during FY2122, categorized by Scope. (Corresponds to Table 3.)

HHD GHG results compared to the University's, ECoS's CY2019 and EMS's FY1819 inventories, as seen below in Table 4.

Comparison of HHD to University Emissions				
Source	**University Emissions**	**HHD Emissions**	**Units**	**HHD Percentage**
Steam Plant	97734	4052	$MtCO_2e$	4.15%
Purchased Electricity	153787	4.17E+03		2.71%
Stationary Sources	25626	2.25E+02		0.88%
Campus Vehicles	5987	1		0.01%
Commuting	59841	-		0.00%
Air Travel	14097	156		1.11%
Other (includes waste, land management, synthetic chemicals, animal management)	12220	N/A		N/a
Total	369292	8607	$MtCO_2e$	2.33%

Table 4: A comparison of HHD's FY2122 emissions to those of the University and other units (EMS, ECoS) that have completed unit specific GHG inventories.

Source	**HHD Percentage of University (FY2122)**	**ECoS Percentage of University (CY2019)**	**UNITS**	**EMS Percentage of University (FY18-19)**

Stationary Sources/Purchased Electricity/Steam Plant	**3.05%**	8.28%	$MtCO_2e$	4.40%
Campus Vehicles	**0.01%**	0.01%		1.10%
Commuters	**0.00%**	1.21%		1.70%
Air Travel	**1.11%**	4.06%		5.10%
Total	**2.33%**	6.36%		4.10%

Table 5: HHD FY2122 compared to Penn State's ECoS CY2019 and EMS FY1819 GHG emissions.

Caveats: Based on Table 5 results, HHD appears to have a smaller GHG footprint than both ECoS and EMS. Again, due to the missing data for HHD included in the other inventories (e.g., commuting, high-performance computing, and global programs), this is not a complete estimate. Additionally, caution is necessary when comparing each unit to another due to the varying sizes among HHD, ECoS and EMS.

1. Utilities

As previously mentioned, much of the data for utilities was pulled from EnergyCap, a utility assistance program utilized by PSU's OPP. A summary of this data can be found in the **Building vs Unit** tab of the accompanying spreadsheet. The main calculation when quantifying utilities was determining the HHD Assigned Proportional Presence, i.e., the proportion of floor area assigned to HHD within each building that HHD resides in. This is critical to calculate because more than one unit may reside within each building, for example OPP or ISS. Table 6 outlines the HHD Assigned Proportional Presence on UP campus.

BUILDING_NAME	HHD's Assigned Presence (sq. ft)	HHD Assigned Proportion
Biobehavioral Health Bldg.	81961.63	1.00
Chandlee Lab	58478.25	1.00
Ford Bldg.	57186.64	1.00
Health and Hum Dev.	106187.64	1.00
Henderson Bldg.	45945.88	1.00
Keller Bldg.	43103.40	1.00
Marriott Foundation Bldg.	11401.57	1.00
Mateer Bldg.	39365.53	1.00
Noll Lab	43495.92	1.00
Rec Hall	117014.72	1.00
Research Unit A	12081.40	1.00

Table 6: Assigned Presence of HHD within each of the 11 buildings in which HHD has any assigned space according to FIS. For this inventory, Assigned Presence depends on not only HHD spaces but other present units as well.

Estimates of emissions related to the operations of HHD within each of the buildings where HHD resides. See results in Figure 3.

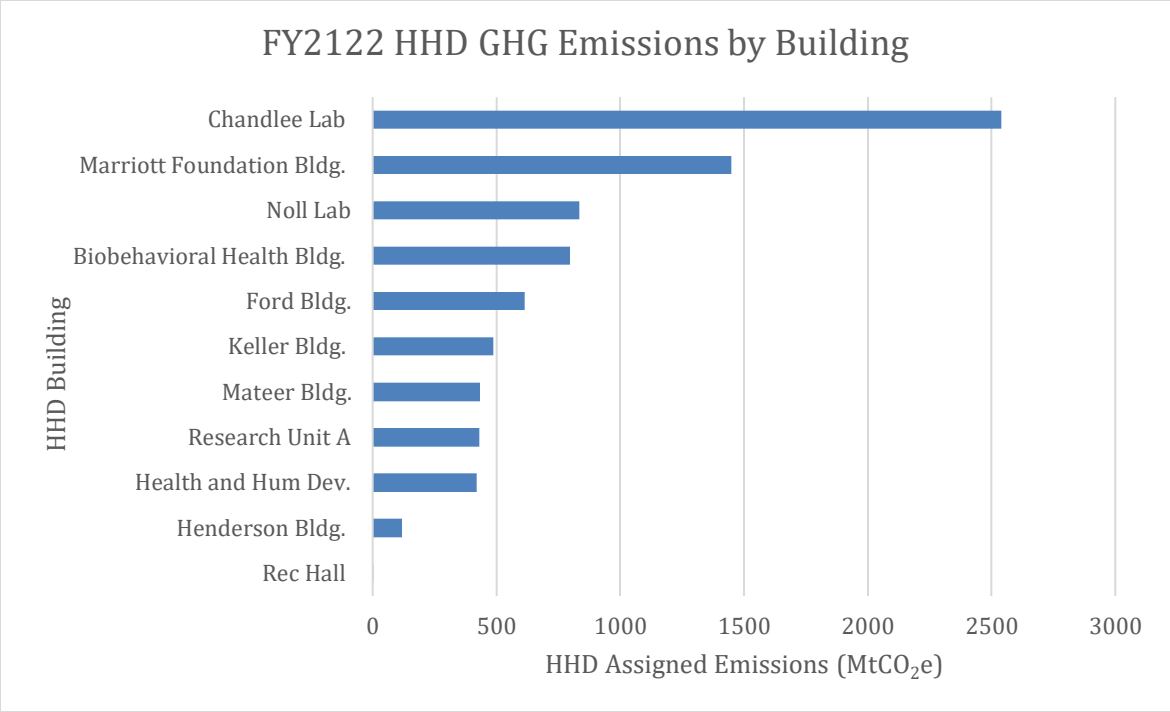

Figure 3: Assigned HHD Emissions categorized by building. This graph reflects that HHD produces over 2,500 MtCO2e through its utility-usage within Chandlee Lab over FY2122.

The following plot shows emissions by building after being normalized by floor area. This quantifies the utility-intensity for each unit of space in each HHD building (considering the portion of utilities and space assigned to HHD). Compare Figure 3 above to Figure 4 below.

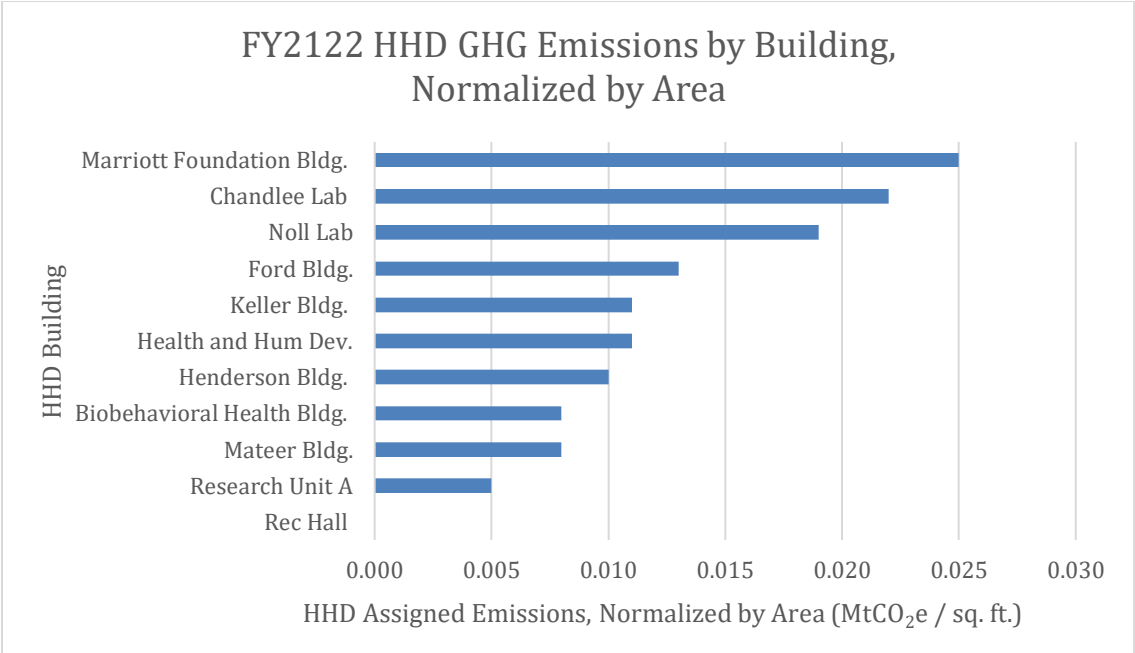

Figure 4: Assigned HHD Emissions categorized by building and normalized by floor area. For example, HHD produces over 0.020 $MtCO_2e$ per square foot through its utility-usage in Chandlee Lab.

In total, Utilities comprised most of HHD's FY2121 GHG emissions, totaling 8,131 MtCO2e. The results are summarized in Table 7 below.

Computed Total HHD Utility Use and Emissions FY2122							
Utility	**Steam**	**Electric**	**Chilled Water**	**Water**	**Sewer**	**Natural Gas**	**TOTAL**
Total	40454	8042564	1334703	6704	6656	2382	
Units	klb	kWh	Ton Hr	Kgal	Kgal	MMBtu	
Emissions	4052	3614	300	20	18	126	**8131**
Units	$MtCO_2e$						$MtCO_2e$

Table 7: Summary of utility use across all HHD spaces, FY2122 and related emissions.

2. Air Travel

Due to flight data provided by HHD excluding department-identifying data, less information was determined regarding department behaviors for air travel. Haul type (short haul < 300 miles; medium haul >= 300, < 2300 miles; long haul >= 2300 miles) is the categorization used by the EPA when computing air travel emissions (US EPA, 2015c). As mentioned, Global Programs data would be included in this section if it were received by the time of publication. This inventory was able to summarize the air travel emissions and haul type breakdowns for HHD during FY2122 (Table 8).

Computed Total HHD Air Travel Use and Emissions FY2122				
Haul	**Short Haul**	**Medium Haul**	**Long Haul**	**Total**
Count	285	657	116	1058
Total Mileage	5.11E+04	6.12E+05	3.79E+05	1.04E+06
Units	miles			
Average Mileage	179	931	3271	985
Units	miles / trip			
Emissions	11.11	82.16	63.20	**156.47**
Units	$MtCO_2e$			
Emissions per Trip	0.04	0.13	0.54	0.15
Units	$MtCO_2e$ / trip			

Table 8: Air Travel emissions and mileage by Haul Type for HHD during FY2122.

3. Car Travel

Car Travel data, specifically rental or fleet services and HHD owned vehicles, was analyzed to produce summary statistics for HHD during FY2122. Commuter data was not made available to be included in this inventory. The average distance of a trip taken by an individual from HHD renting a vehicle or using a personal vehicle and receiving mileage reimbursement during FY2122 was 414 miles. HHD employees took 457 trips, costing an average of $237.68 per trip. The emissions due to an average trip was 0.17 $MtCO_2e$. Table 9 summarizes these results.

Computed Total HHD Car (Non-Commuting) Travel Use and Emissions FY21-22	
	Total
Trips	457

Average Cost per Trip	$237.68
Cost	$108,620.43
Total Distance	189206
Units	miles
Average Distance	414
Units	miles / trip
Total Emissions	**76.44**
Units	$MtCO_2e$
Emissions per Trip	0.17
Units	$MtCO_2e$ / trip

Table 9: Computed Car Travel for HHD FY2122, and related summary statistics. This includes all reimbursed/rental trips by University Fleet or personal vehicles.

4. Vender Emissions

HHD spent $933,671.23 on supplies and equipment during FY2122 based on the procurement data provided. Using Dolye's factor of 0.000257 $MtCO_2e/\$$, an estimate for HHD's Vender Emissions for FY2122 is 240.16 $MtCO_2e/\$$. Vender Emissions are not included in the final summary for the HHD GHG FY2122 inventory due to our low confidence in the ability to estimate procurement accurately. HHD was able to produce totals for various budget numbers and top vendors. See Table 10.

Top HHD Vendors FY2122	
Vendor	**Subtotal**
MESO SCALE DIAGNOSTICS LLC	$84,626.55
PHILIPS HEALTHCARE	$63,000.00
Amazon	$49,939.04
RESPIRONICS INC	$44,994.80
DOBIL LABORATORIES INC	$40,820.14
(blank)	$35,831.49
QIAGEN LLC	$29,603.21
B&H FOTO & ELECTRONICS GROUP	$17,747.06
LETSFIT/LLC	$17,600.00
ACTIGRAPH LLC	$17,502.62

Table 10: Top venders for HHD FY2122. HHD Spent nearly one million dollars on supplies and equipment in FY2122. This number may significantly differ from other fiscal years due to the ongoing COVID-19 Pandemic.

Future Work

Future inventories should strive to improve the procedure for collecting precise data regarding Commuting, High Performance Computing and Procurement. Additionally, future inventories should also

consider the several types of Scope 3 emissions, such as construction (for example, Research Unit A), telecommunication, IT, and computing services.

For future inventories it may be pertinent to consider fostering new or existing carbon offset programs. Additionally, it would be comprehensive to include emissions due to Penn State's 2020 Power Purchase Agreement with Lightsource BP, or solar power operations and maintenance (Lightsource BP, 2022). Carbon offset programs, or activities that refer to a reduction in GHG emissions, can include increases in carbon storage, e.g., planting trees or My Green Lab, that is then used to recoup emissions occurring elsewhere (GHG Management Institute, n.d.). These programs/initiatives must be separated from traditional emissions to transparently compute a net carbon footprint. Applying this structure would allow HHD to determine how implemented carbon offset efforts are influencing the overall GHG output. The effects of the Power Purchase Agreement need to be investigated further as PSU leans increasingly on solar power for operations. For example, solar emissions factors and scope of electricity may be different than what is reflected within this inventory for HHD. It is important to note that PSU still purchases a significant amount of electricity from the power grid, despite these active programs.

Transmission loss is an additional factor to consider in future inventories within HHD. The U.S. Energy Information Administration (EIA) estimates that an average of five to six percent of the energy in electricity is lost during transmission and distribution for the entire U.S., although the average widely varies from state to state and year to year (Wirfs-Brock, 2015). The 2021 eGRID factor for transmission loss in our region, RFCW, is 4.5% Grid Gross Loss (US EPA, 2020). That means that PSU's metered data in electricity is approximately 4.5% lower than the amount generated at the electricity plant, causing emissions to be higher than what has been calculated. It is important to determine how to best account for transmission loss in future inventories, be that through working with OPP or other PSU units.

This inventory was more difficult to collate than other unit-level inventories at PSU due to the ongoing COVID-19 pandemic. Procedure differences when performing the next inventory, FY2223, will need to better account for the changes that occurred within each unit pertaining to emissions because of the pandemic. As mentioned previously, collection of commuting, high-performance computing and procurement data were each hindered uniquely by the ongoing pandemic. It has been hypothesized that commuting and procurement emissions data may be significantly less than in previous fiscal years due to remote work options and active quarantines that were in place. Considering that this is the first and only GHG inventory for HHD, exact comparisons to previous yearly emissions data were unavailable. Accounting for remote/hybrid work schedules would be a necessity when collating the next GHG inventory for HHD. In doing so, it will be important to determine how each non-office workday would contribute to the overall emissions totals for HHD. The University-wide inventory may already be implementing procedural differences regarding the pandemic. Therefore, it would be beneficial for the next GHG author to consult the University-wide inventory for its perspectives on emissions across PSU, post-pandemic.

Another potential collaboration that HHD could foster would be with the Sustainability Operations Council through the Sustainability Institute. This partnership would result in HHD staying up to date on the most recent and effective GHG inventorying practices.

HHD is also encouraged to further collaborate with other relevant units, in addition to EMS and ECoS, to ensure the effectiveness of each of the various data collection measures when performing future inventories. It would be particularly useful to investigate how other units have collected data on

procurement expenses, commuting and high-performance computing, so that such data may be included in future HHD GHG inventories. Preforming a GHG inventory should be made a regular occurrence in HHD, as it is a good example that HHD is committed to sustainability and will provide outcome data on the current and future emission-lowering efforts adopted by HHD.

Opportunities for Action

Previously performed unit-level inventories within PSU have taken their inventory estimate totals and intended to invest in carbon offsets in an attempt to counterbalance a significant portion of their carbon footprint (both EMS and ECoS). EMS initiated this counterbalance by producing a thorough Action Plan with specific objectives and key performance indicators on how the college can collectively reduce its carbon footprint (EMS Sustainability, 2021). ECoS has focused on the generation of more carbon offsets through the application of Gold Standard-certified programs, each containing strict criteria, with corresponding SDGs, when evaluating carbons offset projects (Gold Standard, 2023). Additionally, both ECoS and EMS have started actively working together as well as with SI to ensure that intended offset purchases align with standing University Strategic Plans and the SDGs. Based on the results with this inventory, HHD should consider the following calls to action:

- HHD should produce its own Sustainability Action Plan that thoroughly outlines specific goals, objectives and key performance indicators on all aspects of operations within HHD that produce a carbon footprint. For example, EMS lists objectives such as: to reduce the CO_2 impact due to all activities of EMS faculty, staff, and students; to maximize energy and resource-use efficiencies through design specifications to achieve high-performance buildings; and by providing students agency in HHD Sustainability efforts, through the creation of paid part-time internships that enable student efforts and other educational opportunities.
- HHD should continue to develop and adopt official, Gold Standard-certified, carbon offset programs. Currently, HHD has piloted the My Green Lab initiative, as suggested by SI. Currently only two of twenty-five research labs in HHD have adopted this initiative. This initiative seeks to introduce sustainability into the research laboratory via ways of reducing unnecessary waste, whether it be in the form of energy, water, or plastics (*My Green Lab*, 2022). All labs in HHD must join the My Green Lab initiative for HHD to produce additional carbon offset through this program. Other Sustainability Institute-sponsored initiatives should also be considered with determining criteria for additional initiatives.
- HHD should continue seeking financial support from the University and external grants and funds to afford carbon offsets.
- Utilities (Scope 1 and 2) comprised the majority of HHD's emissions (98.2%), meaning that the most signification reduction in GHG emissions would result from HHD aggressively reducing its energy consumption via utilities. It was assumed that HHD has experienced a reduction in emissions due to the COVID-19 Pandemic. It is imperative for HHD to not return to the emission levels it produced prior to the pandemic. However, directly reducing utility consumption is not within HHD's control, therefore HHD is left to address Scope 3 emissions or procurement, data that was mostly unattainable by the time of publication, thus producing the minimal figures reported in this inventory among Scope 3 emissions.
- If HHD assumes the likely possibility that its Scope 3 emissions are much larger than estimated, it would be necessary for HHD to begin to gauging its current procurement practices by 1)

precisely quantifying ALL HHD procurement data and then 2) developing an exhaustive understanding of all HHD procurement practices, particularly when pursuing meaningful corporate partnerships that prioritize and met sustainability requirements. When taking on this initiative, HHD should consult the EPA's recently updated Supply Chain Guidance document to determine emerging trends in supply chain emissions engagement (US EPA, 2015b).

HHD cannot control its entire footprint. Due to this lack of control, HHD requires many resources from the University-level. HHD must establish the sources of emissions that are out of the College's control and subsequently request formal University intervention. Advocacy for, and education of appropriate actions to be taken need to be brought to the attention of University and Community leadership roles for substantial changes to occur among sustainability efforts among PSU. It is critical for all HHD faculty, staff, and students to actively support and contribute to all HHD Sustainability Charter efforts to reduce GHG emissions within the College. HHD's emissions do not just affect HHD or the University Park campus, they also propose a threat to the entire surrounding community.

Conclusion

HHD can advance its current and future sustainability efforts through various initiatives. That said, it is important to note that not all emissions assigned to HHD within this inventory are controllable by HHD to eliminate. It is with hope that this GHG emissions inventory will serve as a guiding platform for all HHD operational efforts regarding sustainability and reducing GHG emissions. It is HHD's charge to cultivate a sustainability action plan (in accordance with SI), to strive towards the adoption and development of carbon offset initiatives, to precisely quantify and restructure procurement practices, and to continue to champion for more sustainable and renewable resources among all aspects of HHD operations.

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