Princeton's Greenhouse Gas Inventory

Project Report

3/30/18

Prepared by Greener by Design

Introduction

This report was prepared in addition to the inventory files and data. It is meant to provide explanation about the inventory process and data. It discusses how data was collected, any issues with the data and recommendations for how to collect data in the future, as well as some of the results and analysis. There should be a folder titled "Data" and a spreadsheet titled "Princeton's GHG Inventory" to accompany this document. The folder and spreadsheet contains all the inventory data which is referenced throughout this document. It should also be used to manage and collect data moving forward as well as ClearPath™.
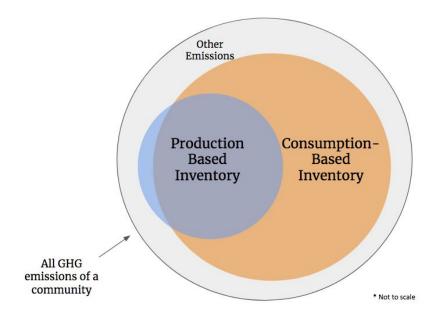
Types of Inventories

Before starting, it's important to understand emissions and the difference between the types of GHG inventories. Here are brief descriptions and a diagram to help explain the two ways of viewing emissions.

Production Based Inventory - Looks at emissions from the production of energy and decomposition of waste. Energy can mean electricity, natural gas or powering a car.

Consumption-Based Inventory - Looks at emissions from all the things consumed by humans. This can mean housing, transportation, food, goods and services.

Other Emissions - Are emissions that aren't or can't be accounted for in typical production and/or consumption based inventories such as fugitive emissions or many natural processes.

This diagram is a conceptual framework for looking at emissions and inventories. Imagine all the emissions of a community in the big circle and the two circles on top as lenses. A "Production Based

Inventory" looks at all emissions from the direct production of energy and decomposition of waste. This can be fairly easily can be tracked through energy usage, vehicle miles traveled (VMT) and waste tonnage. A "Consumption-Based Inventory" looks at emissions from all the things consumed by humans. This is harder to track, because we can't monitor everyone's consumption habits and the carbon emissions embodied in every product or services is impossible to completely accurately determine and track. Other emissions are things that aren't or can't be accounted for in a typical inventory. In this inventory, we did both a Production-Based and an estimate of a Consumption-Based inventory. Due to the accuracy and availability of data, we will primarily use the Production-Based inventory for tracking emissions.
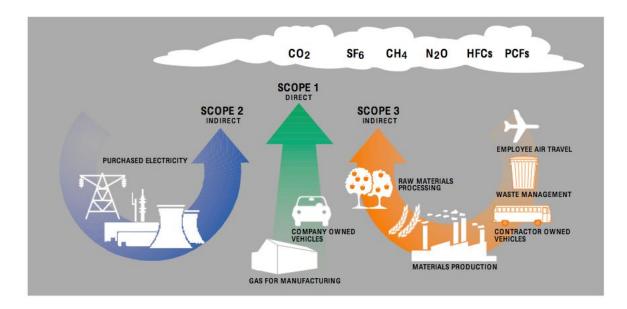
Scopes

Scopes are another way to look at carbon emissions and see where they happen and where a community has more control. Here are brief descriptions of the different types of scopes as defined by the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC)

Scope 1 - GHG emissions from sources located within the city boundary. (ie. Local combustion of natural gas or the local fleet)

Scope 2 - GHG emissions occurring as a consequence of the use of grid-supplied electricity, heat, steam and/or cooling within the city boundary.

Scope 3 - All other GHG emissions that occur outside the city boundary as a result of activities taking place within the city boundary,

Project Scoping

Not to be confused with "Scopes", "Project Scoping" is figuring out what emissions to inventory. In order to determine what data to inventory, Greener by Design (GbD) reviewed the ICLEI Protocols and

identified what was relevant to Princeton and this project. Certain things were clearly relevant and others were not, due to the fact that the types of emission do not occur in Princeton or were too difficult/not worth measuring. We also chose categories based on access to data, replicability and sustainability of collection. Some of the general categories that were relevant included: Residential Energy, Commercial Energy (Includes the University, Municipality and actual Commercial sector), Industrial Energy, Transportation, Water, Solid Waste and Consumption. Some that were not included: Agriculture, Process & Fugitive Emissions and Upstream Impacts of Activities. More details about what data within each category can be found below.

Baseline Year

We went back forth about the baseline year as we learned more about the data since not all the data was available in the beginning. A good baseline year is the earliest year with complete data and provides the ability to track progress in future analyses. After reviewing the available data once it was collected, we determined that it would make sense to have two baseline years, one for the community inventory and another for the municipal inventory. We chose 2010 for the community inventory and 2017 for municipal inventory based on the completeness of data for each.

Factor Sets

For the factor sets, in some cases we used local (utility, county or federal) data, in others we used the default regional numbers used in the ClearPath™. For electricity emission rate (Pounds CO_2e per MWh), we used PSE&G's local data specific for Princeton -- this was lower than the ICLEI regional default, higher than the Energy Information Administration (EIA) factor for NJ and lower than the EPA eGrid multi-state regional factor. For solid waste characterization we used Mercer County Improvement Authority's (MCIA) 2013 report on Waste Characterization, rounded and reorganized the characterization percentages to match ClearPath's™. For Transportation and the average miles per gallon (MPG), we used the US Department of Transportation's Bureau of Transportation Statistics data which averages all vehicle and truck MPG every year. One critical piece for keeping track of transportation emission, which is related to the factor but differs from ICLEI's protocol, is tracking Electric Vehicles. This will be further discussed in the "Transportation and Other Mobile Emission Activities and Sources" section. In order to see the factor sets, refer to the accompanying spreadsheet.

Production Based Inventory Data Collection

Community Inventory

Community Overview

In order to fill out many of the calculators in ClearPath™, we needed to get basic information about the community such as population, number of households, workers, businesses and students. This data was taken from the US Census and Princeton University -- it can be found in the inventory spreadsheet. To give brief summary: Princeton had 28,621 residents in 2010 and 31,249 in 2016. We used the average growth rate to estimate population growth for 2017.

It should be noted that there are a number of things to kind in mind about Census data. The first and perhaps most important is that the Census is only counted every ten years. Therefore, all the years in between are just estimates from the American Community Survey (ACS) -- and sometime vary in different ways. Another issue is that before 2013, Princeton was two different municipalities, which may have made the data somewhat inconsistent due to separate record keeping. And third is that around 30% of Princeton's population is college students, which makes the total household number an imperfect measurement when it's used in a number of calculators. That being said, we used the best available data and made the best judgements to use the data for the calculators.

Built Environment Emission Activities and Sources

When we started the project, Sustainable Princeton already had Built Environment utility data starting from part of 2009 to part of 2015. The Built Environment data included electricity (kWh) and Natural Gas usage (Therms) consumed by Residential, Commercial and Industrial sectors. In order to acquire more current data, we contacted PSEG. Unfortunately, this request took several months due to a mistake on the Letter of Authorization and slowed customer service. We ultimately received data from Jill Reilly at PSEG jill.reilly@pseg.com, she should be contacted in the future for data.

Transportation and Other Mobile Emission Activities and Sources

For transportation emissions, we contacted the Metropolitan Planning Organization (MPO) for Princeton, the Delaware Valley Regional Planning Commission (DVRPC). We spoke to Transportation Analyst Matthew Gates, who sent us Princeton's Vehicle Miles Traveled (VMT) for 2010 and 2015, which were 689,000 and 787,000 miles per day respectively. These VMT numbers include all vehicles on the road including buses, motorcycles, light and heavy trucks and are based on a number of data collection tools and models to determine all VMT of a community.

There are multiple ways to measure VMT using a regional travel model. One way is to measure all the transportation activity within a jurisdiction which is called the "In Boundary" method. Another, which is the prefered method by ICLEI and DVRPC, is an "Origin-Destination Split" method. The Origin-Destination method takes every trip and applies half distance traveled to the municipality of origin and half to the municipality of destination. This method is ideal for regional analysis because you can see where travel activity comes from and go to, but it is also good for analyzing the overall transportation activity of the town. We chose to use the Origin-Destination because it was the prefered methodology for GHG inventories and most representative of resident travel patterns. This information is further explained in a memo provided by DVRPC.

One thing to keep in mind is that DVRPC only runs the regional travel model every five years. Therefore, in order to get the VMT for the years between, we took the incremental linear estimates between the years for which we had the data. Also, for the years after 2015, we made projections using the same growth rate. Though, it is very likely that the 2020 VMT will be different. Therefore, in 2020 Sustainable Princeton should contact DVRPC for the VMT and adjust estimates accordingly. Matthew Gates's email address is mgates@dvrpc.org.

Another thing to keep in mind is that within the "On Road Transportation" subcategory, when you input your data, one has to input the percentage for vehicle types. For this, we chose to use what is recommended as the default rounded to the nearest 5%. We chose 60% passenger vehicles 35% light trucks (SUVs are considered a light truck, and 5% heavy trucks).

Additionally, we were able to obtain electric vehicle "EV" ownership data from the New Jersey Department of Environmental Protection. Based on those numbers and general car owner estimates (we used the average number of car owners in New Jersey), we were able to estimate the percentage of EV owners and subtract that from the total (petroleum) VMT. This is because EVs are included in VMT but do not produce direct carbon emissions. This approach will be critical for locally measuring reductions in transportation emissions in the future.

Solid Waste Emission Activities and Sources

We received the Solid Waste information from Phil Wagner at the Mercer County Improvement Authority (MCIA). Princeton has a contract with the MCIA to manage solid waste removal. MCIA has a contract with Central Jersey Waste/Solterra to collect waste and transport it to the GROWS landfill managed by Waste Management in Tullytown, PA . We recommend that Solid Waste data is collected every year from MCIA as waste composition can change year to year affecting emissions. It should be a simple matter of writing Phil an email requesting the data. His email address is pwagner@mercercounty.org.

One thing to keep in mind is that the GROWS landfill does have methane collection, which is asked in ClearPath™. Also, there has been discussion about closing the GROWS landfill which is important to keep in mind for future tracking.

Wastewater and Water Emission Activities and Sources

Typically, general water supply emissions are related to the extraction, treatment, transportation, and storage of water, while wastewater emissions are attributed to the energy intensive transportation and treatment of wastewater. GbD attempted to reach out to NJ American Water about water consumption and energy usage, but they were not able to provide us with that information due to security concerns. Therefore, we asked Robert Hough, PE Director of Infrastructure and Operations at the Municipality of Princeton to contact NJ American Water and he was not able to receive the data either. We did, however, receive data from the Stony Brook Regional Sewerage Authority (SBRSA) which is located within Princeton and services several neighboring municipalities as well. In order to determine the energy usage and gallons of sewage treated we took the percentage gallons of sewage pumped for Princeton (~30%) and calculate the same percentage of the energy usage.

One thing to keep in mind is that their overall energy usage is technically included within PSE&G's data for the community built environment, therefore, we noted the data as "included elsewhere" in ClearPath™.

Government-Track Inventory

Government Profile

Like the community profile, it's also important to have basic profile information about the municipal government. As shown in the spreadsheet, the municipality has 264 employees, 148 Fleet Vehicles and 1,012,384 sqft of building space. This data is used for measuring emissions per square foot for buildings, for employee commutes, and for the different fleet vehicles.

Buildings & Facilities

The Buildings & Facilities category of the government-track inventory includes electricity usage and natural gas. In order to acquire this data, we originally downloaded the annual bills from every one of the 73 municipality's online PSEG accounts. There is an account for every facility that consumes energy. Some accounts use both electricity and natural gas and others use just electricity and other use just natural gas. There were 65 accounts that use electricity and 17 that use natural gas. Once we downloaded the data, we took the annual totals for each account and entered the data into ClearPath™. After we did this, we received the totals from PSE&G for 2016 and 2017. We recommend requesting and receiving data from PSEG moving forward.

Streetlights & Traffic Lights

The street and traffic lighting data was included in the community-wide data and municipal government energy usage data. We were unfortunately not able to identify how many streetlights there are.

Vehicle Fleet

Sustainable Princeton and the municipality keeps track of the municipal fleet using Sustainable Jersey's Fleet Template. Therefore, we received the data from the municipality. In order to input the data, we simply took the total CO_2, CH4, and N2O emissions for the municipality, which is calculated in the template and inputted it into ClearPath™. What's important to keep in mind when inputting data is that we selected direct entry, which allowed us to put in the emissions directly.

Transit Fleet

We received data about usage from the Princeton Engineering Department for the two Free-B vehicles, Marvin I and Marvin II. The VMT data was from the end of December 2016 to the end of November 2017 was 40,053 miles. This period was only for 11 months, so for the last month we took the average monthly VMT and added it, giving us 43,694 miles total. We did the same for fuel usage, and as a result we determined that the Free-b vehicles used 5,017.25 gallons of diesel fuel. Future data should be collected from January to the end of December, which should be available for future analyses.

Employee Commute

We received the employee commuter data from the municipality. This data simply consisted of a list of the places every municipal employee lives in Excel. To calculate the VMT of all the employees, we first created a pivot table in order to consolidate the same locations and then we looked up the distance of

every location to Princeton, then multiplied the number of employees for each location by the distance of their towns to Princeton, doubled that number for a round trip and multiplied it by the number of workdays in the the year (261). That gave us the total annual for VMT for every employee from each location which we then combined to create a total VMT estimate for commuting. This portion was time intensive, but provided good insight on employee commuting. In the future, one can use the existing distances which should save time in doing the processing.

Consumption-Based Inventory

For the Consumption-Based Inventory, we used and adapted the UC Berkeley's CoolClimate Carbon Footprint Calculator and data. This tool was recommended by the ICLEI protocol as the best readily available online product for measuring consumption-based emissions. While it is a good way to get a sense of consumption based emissions, the model and data used for the CoolClimate tool is from 2007 and hasn't been updated since. Therefore, it is difficult to measure the variation from year to year or know how much has changed. However, one can use the change in population and an update in the model is planned for 2018, so keep an eye for future updates. Once it's updated, it might be possible to improve the create linear estimates for the years in between.

In regard to how we used the CoolClimate data to get a community-wide assessment, we took the average carbon footprint of a household in Princeton from the CoolClimate data and multiplied it by the number of households in Princeton. We also created a profile carbon footprint of the average university student and multiplied that by the numbers of university students. We were able to get the per person number by dividing the overall footprint (households and students) by the number of total residents.

Just to clarify, this inventory is meant to provide an idea on the Consumption-Based Emissions of the community. It is not a perfect assessment, but only a general estimate. At the moment, it is semi-static because the values are based on the the 2007 model and only change based on population. We recommend that Sustainable Princeton also conduct a local consumption-base survey which could be averaged to get a more accurate representation of a Princeton household and student.

Conducting a local consumption-based emissions survey

While it was beyond the available time of this project, we recommend Sustainable Princeton conduct a local consumption-based emissions survey. We prepared a draft survey along with this inventory. This survey asks residents and students to use the CoolClimate Calculator and provide Sustainable Princeton with the results. Sustainable Princeton could then use this data to do more local analysis of consumption based emissions.

Princeton's GHG Inventory Results Summary

This is brief summary and overview of Princeton's production based GHG inventory from 2010 to 2017, with more detail about 2017, as well as an explanation of the consumption based emissions. It's meant to give a general understanding of emissions groups in comparison to one another.
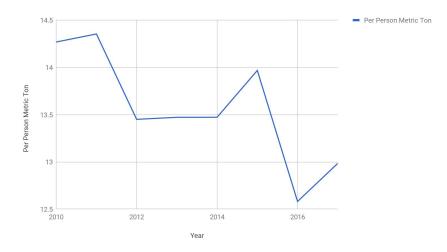
Community

The following charts show all of Princeton's emission from 2010 to 2017

Year	Transportation & Mobile Sources	Solid Waste	Water & Wastewater	Commercial Energy	Industrial Energy	Residential Energy
2010	117,152	9,618	2,749	212,739	821	89,484
2011	120,797	9,057	2,753	211,945	809	89,565
2012	123,289	8,602	2,864	192,670	339	79,154
2013	125,483	8,874	3,111	187,121	838	81,538
2014	128,904	9,296	3,307	181,403	1,359	81,966
2015	128,589	9,623	2,995	191,309	1,255	86,579
2016	131,233	8,880	3,348	161,713	968	75,491
2017	127,111	8,216	3,152	176,641	968	77,782

As seen above, the community emissions have decreased slightly over the past seven years, but not that much has changed. While we don't know all the exact causes, it's promising to see to overall reductions over time. Certainty spikes, for example 2015, may be attributed to weather and other special events. Additionally, the installation of the University's solar array in 2012, the opening of Merwick Stanworth in 2015 as well as the demolition of the hospital in 2016 may contribute to these changes year to year.
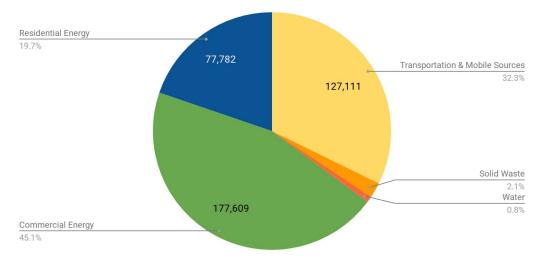
Per Person

An important thing to keep in mind is that overall emissions may remain constant while the per person emissions may decrease and vice versa. This is due to changes in population. Princeton has seen a steady increase in population since 2010, but as seen below, the per person emission has decreased over time. The only exception is 2015, which also saw a spike on the residential and commercial energy usage and may be weather related such as an extraordinary cold winter and/or hot summer. For example, February 2015 was one of the coldest months on record in New Jersey and yearly average temperature for 2015 ranking as one of the warmest overall in New Jersey.
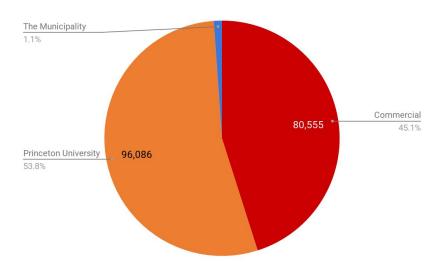

Community by Sector

At first glance, the Commercial sector makes up the majority of the emissions, which is nearly half, but this also includes the university and the municipality along with the other commercial entities. Taking those two majors entities aside, Transportation makes up the actual majority of the emissions, which is typical for most carbon inventories, while Solid Waste and Water make up less than 3% of emissions.

Breakdown of emissions by sector (values are metric ton CO_2e)

Commercial Sub Category

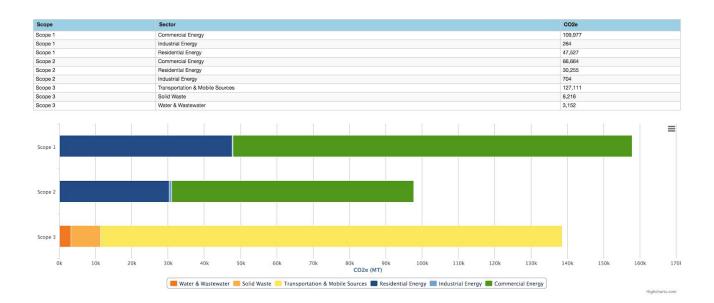*Breakdown of the Commercial Category (values are metric ton CO$_2$e)*

Perhaps the most noticeable thing about Princeton's GHG is that the majority of carbon emission come from the commercial category. However, a deeper analysis within the commercial sector shows that over half of the commercial emissions are from the university. As is with any carbon footprint, any industrial or commercial activity, which may help the local economy also contributes a great amount of emissions to a local footprint.
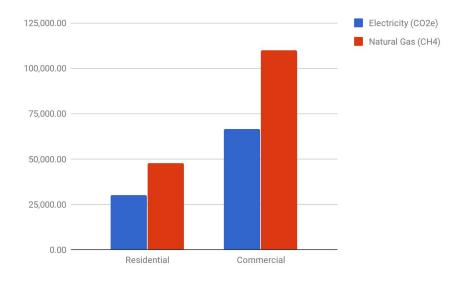
Scope and Sector Breakdown

Scope 1 incorporates all emissions that happen within the boundary of the municipality, which means all energy consumed is consumed on site and their resulting emissions occur within the boundaries of Princeton. In this case, natural gas is depicted on the following page and is the largest emitter of the different scopes. Other fuel sources such as oil and wood are harder to track on a community level and therefore were omitted.

Scope 2 measures electricity usage which is produced outside the boundaries of the municipal, but is still critical to highlight in carbon inventory. As stated above, these emissions are based off the PSE&G factor set, which is lower than the national values due to the utilization of nuclear power. While the municipality has little control on this scope, changes in the utility's power production mix may change the factor set. Additionally, installation of local solar systems would drop the need for outside power and lower the emissions from this particular scope.

Scope 3 mostly occurs outside the boundaries of a municipality such as transportation, water and wastewater emissions, and solid waste emission. While water and solid waste related activities make up a small portion of this scope, transportation is the greatest contributor to footprint, making Scope 3 second largest scope.
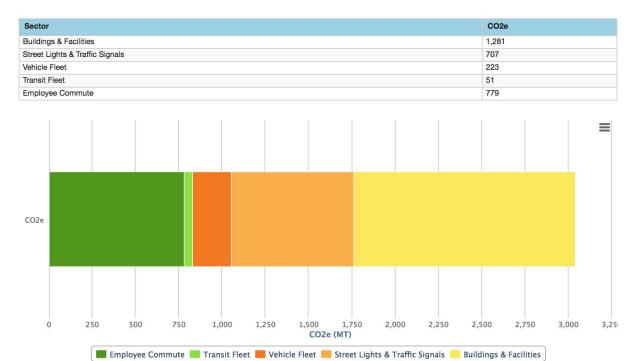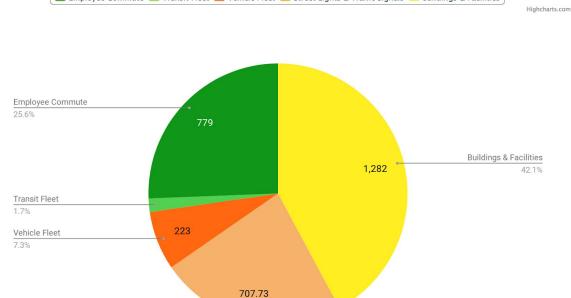
Scope	Sector	CO2e
Scope 1	Commercial Energy	109,977
Scope 1	Industrial Energy	264
Scope 1	Residential Energy	47,527
Scope 2	Commercial Energy	66,664
Scope 2	Residential Energy	30,255
Scope 2	Industrial Energy	704
Scope 3	Transportation & Mobile Sources	127,111
Scope 3	Solid Waste	8,216
Scope 3	Water & Wastewater	3,152

Princeton's natural gas usage emits more carbon than electricity.

Government Track

Based on our preliminary analysis, the Buildings & Facilities make up the majority of municipal government emissions, followed by Employee Commuting and then Street Lights & Traffic Signals. This breakdown is important because a municipality has direct control in reducing its own emissions.

Sector	CO2e
Buildings & Facilities	1,281
Street Lights & Traffic Signals	707
Vehicle Fleet	223
Transit Fleet	51
Employee Commute	779

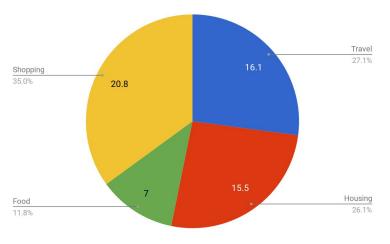*Breakdown of emissions by category (values are metric ton CO$_2$e)*

These portions are where energy conservation measures and alternative fuels can be implemented on the municipal level and directly tracked. If Princeton has not done so already, it should conduct Local Government Energy Audits on all their facilities to find any deficiencies and discover any potential energy conservation measures "ECMs" to implement. Some simple examples of these measures include replacing lighting, installing motion detectors, and setting timers for electrical equipment. Other recommendations include promoting employee carpools and encouraging electric vehicles "EVs", while also incorporating alternative fuel vehicles (AFV)s within the Transit and Municipal fleets. Lastly, to tackle street and traffic lights, implementing LEDs is a large up-front investment, but can reduce energy usage by as much as 80%.

Consumption Inventory

In order to look at Princeton's consumption-based emissions we used UC Berkley's CoolClimate tool. While the tool is based on a 2007 model and data, it is still relevant and useful. However, one thing we know has changed is the average household income has substantially increased, which would increase the average household footprint. New data will likely be available in 2018.
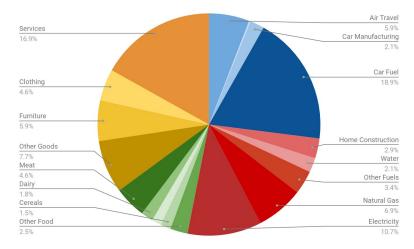

The average Princeton household carbon footprint according the CoolClimate tool is 59.4 tones of CO_2e per year. According to the CoolClimate team, if you select one person household and income under $10,000, then that is reflective of an average student.

Breakdown of emissions by category (values are metric ton CO$_2$e)

As seen above, the "Shopping" in a Consumption Inventory makes up the majority of emissions, followed by Travel and Housing. Shopping and food are not fully accounted for in a production based inventory.

Breakdown of emissions by subcategory

If we break it down further, gasoline is the largest sub category of consumption based emissions, followed by services and electricity. Meat consumption is the largest source of food based emissions. Healthcare makes up the majority of emissions in the "Service" category.

Final Thoughts

As noted earlier in this document, there are different ways to look at, inventory and calculate carbon emissions -- and data collection can also be easy or challenging. What we hope to have explained in this report is the two major types of inventories (production and consumption), the methodologies used for Princeton, and some of the results. We recommend that Sustainable Princeton continue to use the methodology used for the production inventory, with special attention to the transportation category.

We suggest that Sustainable Princeton collect all data again in 2020 and get the updated VMT and the number of EVs in Princeton in particular to update the transportation data accordingly. This should be done every subsequent five years. We also highly recommend conducting a consumption-based survey to better understand the consumption carbon footprint of Princeton residents, because while a production inventory is a good way to get a sense of certain emissions and tracking progress, our footprint is likely substantially larger, and we need to get a broader sense of what residents footprints are and how they can be reduced.