# Baseline Calculation of Goshen College's Carbon Emissions

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## Introduction

The Environmental Economics class of Goshen College was tasked with finding creative ways to move the school towards being carbon positive. Goshen College has a strong history of finding ways to decrease emissions, such as moving away from using coal and installing solar panels. Now that some of the more obvious methods have been used, however, staff and students at the college need to begin to get creative. Before it is possible to identify potential methods of decreasing Goshen College's carbon emissions, an up to date calculation of carbon emissions from Goshen College is needed. The baseline team was designated the task of looking at the methods of past calculations to determine how to calculate the amount of carbon that was emitted by Goshen College in 2017, and then come up with an official carbon emission number to guide the rest of the team.

## Objective

In the past, Goshen College has used STARS reporting, which breaks the emissions of an organization into three main scopes that combined are equal to total emissions. The first scope is made up of the combustion of natural gas, the second scope is made up of the purchased electricity, and the final scope includes sources like commuting, air travel, and waste. The last time Goshen College used this reporting to calculate a total carbon emissions number was in 2013. According to collected data, carbon emissions during 2017 totalled 6,581 metric tons (Goshen College OP-1). By using the 80/20 theory, which states that 80% of emissions are from scope one and two, and analyzing the disbursement of the remaining emissions, the team decided to focus calculations efforts on emissions from the combustion of natural gas, the purchasing of electricity, SST air travel, and daily commuting of faculty and staff (Gilbert). Remaining emissions from various sources including miscellaneous combustion, business travel, and waste were carried over from 2013.

## Methods of Calculation

To calculate the amount of carbon emissions from the combustion of natural gas and the electricity used, the team received a utilities spreadsheet from Glenn Gilbert which contained the gross therms of natural gas and KwH of electricity consumed by Goshen College. After isolating the amount used in 2017, the gross amounts were inserted into a government calculator provided by the EPA to equate the amount of natural gas burned and the amount of electricity purchased into carbon emissions on campus. The final results showed that scope two, electricity, was responsible for 3,169 metric tons of carbon emissions. Scope one, which is the combustion of natural gas, was responsible for approximately 1,386 metric tons (Greenhouse Gas Equivalencies Calculator).

Commuting mileage is one part among others that make up the third scope of emissions. Commuter mileage consists of the transit to and from school from employees and off-campus students. Often the majority of this transit is done by car, which contribute to the emissions in our atmosphere. In the past, we've guessed at this number by surveying employees and off-campus students how far they travel to Goshen College, and how frequently they use alternative (non-carbon) forms of transportation. These surveys have a very low feedback percentage and can be misleading. This year, to estimate commuter mileage we decided to base it off the actual distances people travel from their home addresses to Goshen College. With the help of Justin Heinzekehr, Director of Institutional Research at GC, we were able to gather the current living address of all employees and most off-campus students.[1] With the gracious help of another student, Spencer Aeschliman (senior Physics major) we wrote a python script to calculate the mileage between these addresses and Goshen. This program used a free package called GeoPy which taps into an open source maps to calculate the geodesic distance[2] for a matrix of addresses.

[1] There are 455 total off-campus students and we received 393 addresses from Justin Heinzekehr. There are 304 employees at Goshen, and we were able to collect addresses for all of them.

[2] This distance is "as the crow flies" so we adjusted the python distances with a coefficient. The coefficient was made by comparing a statistically representative sample of python distances to actual Google Maps distance.

Out of the total of 697 addresses, 374 were able to be calculated through this program with only a handful of errors. The remaining addresses, as well as the errors were calculated manually by plugging in addresses to Google Maps. Some distances were mildly complicated by the fact that some employees and some students are commuting to Merry Lea, for which separate calculations had to be made. We ended up with mileage for 74% of off-campus students (335 out of 455) and mileage for nearly 100% of employees (303 out of 304). The mileages calculated through python were adjusted with a coefficient (see above footnote).

With these mileages we can determine with reasonable accuracy the average distance a commuter student and employee will commute to work; 11.33 miles and 8.25 miles respectively. This average can be applied to the exact number of commuter students and employees on campus. Yet, there are a number of assumptions to make in order to come to a yearly amount of miles, let alone yearly amount of carbon dioxide equivalencies emitted. The number of days traveled by students and employees (our assumptions were 180 and 240 respectively). The number of times commuting to and from Goshen (we chose an ambitious 1 time back and forth for students and employees). The other assumption is in alternative transportation (non-carbon miles). Our estimations of the people/miles biked and walked were based completely off assumptions. These assumptions were also ambitious; 25% of students and 10% of employees that live within 2 miles biked/walked to GC all year. Despite hopeful assumptions in regard to our non-carbon miles, with the other assumptions in mind it only made up about 0.36% of our total commuting mileage. With these assumptions, we find a net (carbon transport miles - alternative transport miles) total of 2,958,814 miles commuted all year. In order to convert this mileage to metric tons of carbon dioxide equivalent, the EPA calculator requires the mileage to be in a unit like gallons of gasoline. So, by dividing the total carbon miles by the nationwide average mpg of 24.7 we get 119,790 gallons of gasoline consumed by commuting to GC. (Highlights of CO2 and Fuel Economy Trends). These gallons

converted by the EPA calculator comes to 1064 metric tons of CO2 emitted (Greenhouse Gas Equivalencies Calculator).

As stated before, this is likely an improvement to the past estimation of emissions from commuter miles. There are still assumptions that could be improved relatively easily by gathering more data. We have high non-statistical confidence in the distances between people's houses and GC, we just don't know how often they are traveling back and forth, their mpg, the number of people in their car, etc. Unfortunately, one large detriment to the distances between people's addresses and GC is that they are not easily replicable. In order to do it again with different addresses one would need knowledge in implementation or writing of python code and interpreting/troubleshooting errors in code or output. Or, they would have to manually plug hundreds of addresses into google maps. This may not be a problem for the next couple years, as the average distance might not change too much. There is an underlying philosophical question pertaining to understanding who is responsible for which emissions (what constitutes the emissions Goshen is responsible for?) Further discussion in this area is key, but that does not mean we should err on the conservative side of this discussion. Goshen has the opportunity to become a key player in sustainability initiative in the Goshen community. Goshen College has significant advantage and leverage over individuals (being an institution) and supposedly has incentive through past commitments, efforts, current values, and the imminence of climate change to which we are already feeling the effects.

The carbon footprint from flying to and from SST and off-campus May terms was also calculated. To do this, the blogs for the off-campus May Terms and SST groups for 2017 were visited, and the number of people in each group was counted. The Sustainable Travel International website was used to estimate the carbon emission from each SST and May-term group (Sustainable Travel International). The group leaders' carbon emissions from each group were also calculated. There were 3 SST units in 2017, Peru in the spring, Peru in the summer, and China in the fall. There were 16 students who went on the

spring unit (Ready to start the new year in a new country 2017), which comes to a carbon emission of 44 tons. For the summer, their were 21 students (Arrival 2017), which comes to a carbon emission of 58 tons. The SST leaders for Peru in 2017 came home, which added 3 tons of carbon emissions. The China SST unit in the fall had 15 students (Lapp 2017), which comes to a carbon emission of 86 tons or $CO_2$. The China leaders and their families also went to and from China, coming to a carbon emission of 23 tons. All of these were calculated for round trip. For May Terms, the blogs were also looked at. The first post for the 2017 blog said that there were 45 students that went on an overnight flight (Horst 2017). From O'Hare to the London Airport, the website calculated 220 tons of carbon were emitted from flying. The carbon emission from Marine Biology is a little bit harder to calculate, because some people drove, and some people flew. Other factors include the fact that some people may have flown from South Bend, and some may have flown from Chicago. Additionally, on the way back, some people may have flown home to places other than Chicago or South Bend. There were 21 people in the group (A Busy Weekend 2017). For this calculation, it was assumed that only 15 of the 21 people flew, and they had a round trip between Chicago and Miami. Using these assumptions, 14 tons of carbon were emitted from Marine Biology. Other off-campus May-Terms in this year included History of the Southwest and Boundary Waters. There was no flying involved in either of these courses.

| SST Group | Number of people in group | Tons of Carbon Emitted from Flying |
|---|---|---|
| Spring Peru 2017 | 14 | 44 |
| Summer Peru 2017 | 21 | 58 |
| Peru SST Leaders Returning | 2 | 3 |
| Fall China 2017 | 15 | 86 |

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|---|---|---|
| Fall China SST Leaders | 4 | 23 |

| May Term Group | Number of People in Group | Tons of Carbon Emitted from Flying |
|---|---|---|
| Literature in London | 45 | 220 |
| Marine Biology | 15 | 14 |

**Results**

Using these methods of calculation, Goshen College's emissions in 2017 were 6,895 before renewable energy credits were accounted for, and 3,726 after they were net against the electricity use. The overall carbon emissions did increase since 2013, but all of this increase was from commuting. As discussed before, the method to calculate emissions from commuting was changed for the 2017 calculation, so this large difference in emissions is likely due to having a more accurate way to calculate this number. The other sources, including combustion of natural gas and the purchasing of electricity, all had slight decreases. Considering that Goshen College has more students now, the decrease in emissions from electricity shows that Goshen College's efforts to lower electricity use have been paying off.

After comparing the disbursements of emissions from these sources, it was determined that the 80/20 theory is not quite applicable to Goshen College's emissions. While natural gas and electricity combined were responsible for approximately 66.1% of emissions, there were other significant sources. SST air travel and commuting combined, for example, were responsible for more carbon than the combustion of natural gas. It is essential that Goshen College continues to search for reliable and detailed calculations that are then carried over into future years. These additional sources must be considered

when searching for ways to move Goshen College towards being carbon positive, as they are responsible for nearly one third of their emissions.

In order to promote an annual calculation of carbon emissions, the team created a spreadsheet that simplifies the calculation process by putting equations in the "background". The calculators used are clearly labeled, and the main sources of Goshen College's emissions are emphasized. This spreadsheet was created in hopes that it will simplify the process of calculating emissions, making it more accessible for students to use and access. By having students included in the process of monitoring emissions, the school will better be able to view progress and identify where solutions can be found.

## Conclusion

It is essential to have an accurate and constant method of calculating emissions, otherwise weaknesses cannot be found and progress being made cannot be accounted for. According to our calculations emissions in two out of the three scopes are decreasing, but because the third scope was not being calculated effectively progress that has been made in commuting and SST air travel cannot be accounted for. Having a baseline for emissions allows us to appropriately assess our own contributions to climate change and address these emissions accordingly. By setting goals based on data collected we hold ourselves to a level of scientific accountability and are able to track our progress. Another reason for calculating our baseline emissions is so we can take credit through organizations like AASHE's Sustainability Tracking, Assessment & Rating System (AASHE STARS). Furthermore we can continue to build on the data we collect and use it to shape sustainable policy and practices. Ultimately, in order to see a significant decrease in emissions, organizations like Goshen College must find a system to account for their carbon and stick with it.

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