Measuring Caltech's Carbon Footprint

S. Petkova

California Institute of Technology, Pasadena, CA, United States

Keywords:
Carbon footprint
CACP Calculator v5.0
Caltech
Greenhouse gases

ABSTRACT

The collection of data on greenhouse gas (GHG) emissions on the Caltech campus, in order to compute Caltech's carbon footprint, is crucial to making the university sustainable. The GHGs released in the atmosphere can be categorized into three scopes by source of emissions: Scope-1, direct emissions; Scope-2, indirect emissions from purchased water and electricity; and Scope-3, other indirect emissions (WRI 2001). We collected data on the university's emissions from scopes one through three and provided it as the input to a carbon footprint calculator, the Cool Air-Clean Planet (CACP) calculator v5.0 (Clean Air-Cool Planet 2006). The output generated by the calculator is the amount of GHG emissions in tons of carbon dioxide. This amount constitutes Caltech's carbon footprint, which we used as a means to estimate trends in the emissions on campus. We were able to recognize the effects of purchasing electricity with high coal content from Pasadena Water and Power (PWP). We identified the gaps in the university's current Scope-3 emissions data as well as the gaps in the records kept from previous years. Using the results of this paper, Caltech will be able to set reduction goals on its greenhouse gas emissions and become a more sustainable institution.

1. Introduction

The term footprint was first used in 1992 to describe the Earth's ecological footprint, the amount of productive land area that corresponds to every human's resource consumption (Mathis Wackernagel 1996). The carbon footprint is a subset of the ecological footprint (WRI 2001) – it converts the amount of greenhouse gases in the atmosphere to tons of carbon dioxide. Many corporations, universities and individuals are trying to reduce their greenhouse gas emissions, which have a negative impact on the environment, in an aim to be sustainable. An organization is considered sustainable if it meets its own needs without endangering the ability of future organizations to meet theirs (WRI 2001). In order to reduce greenhouse gas emissions, it is important first to classify them in terms of source and significance. Measuring the carbon footprint makes this possible.

Recently, the California Institute of Technology (Caltech) has started taking steps towards becoming more sustainable. Calculating Caltech's carbon footprint will enable us to set feasible reduction goals and keep the GHG emissions under control. This paper presents the university's first attempt to measure its carbon footprint. It includes collecting data on greenhouse gas emissions, processing the data using the CACP v5.0 calculator, comparing it to the results of another major university and suggesting possible reduction goals.

2. Materials and Methods

Throughout the project, we used the CACP v5.0 calculator, developed in EXCEL©, to record the GHG emissions data collected and compute the carbon footprint. The calculator consists of three main modules: an input, an emissions factor, and a summary module (Clean Air-Cool Planet 2006).

The user enters the collected data, which comes in a variety of metric units, in the input module. The input module can be further separated into four categories: institutional data and emissions data from scopes one through three. While literature sources differ slightly in their definitions of the scopes, the descriptions used in this paper are in accordance with the definitions provided by the calculator. Hence, Scope-1 consists of all campus stationary sources, such as the co-generation power plant, heating, cooling, cooking, laboratories, university fleet, agriculture, and animal husbandry. Scope-2 is purchased electricity, steam and chilled water. Scope-3 includes other indirect sources of GHGs such as transportation and solid waste (Clean Air-Cool Planet 2006).

Data was collected about the major carbon footprint sources. The emissions factor module of the calculator converts that data into the appropriate amount of carbon footprint. The module consists of several worksheets with coefficient tables used to perform the unit conversion from the input data to tons of carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). The result of those calculations is recorded in the summary module of the calculator. The summary module contains results regarding the emissions of each of the GHGs separately, as well as the emissions by scope and the total carbon footprint. Caltech's total carbon footprint is presented in Figure 1 (Clean Air-Cool Planet 2006).

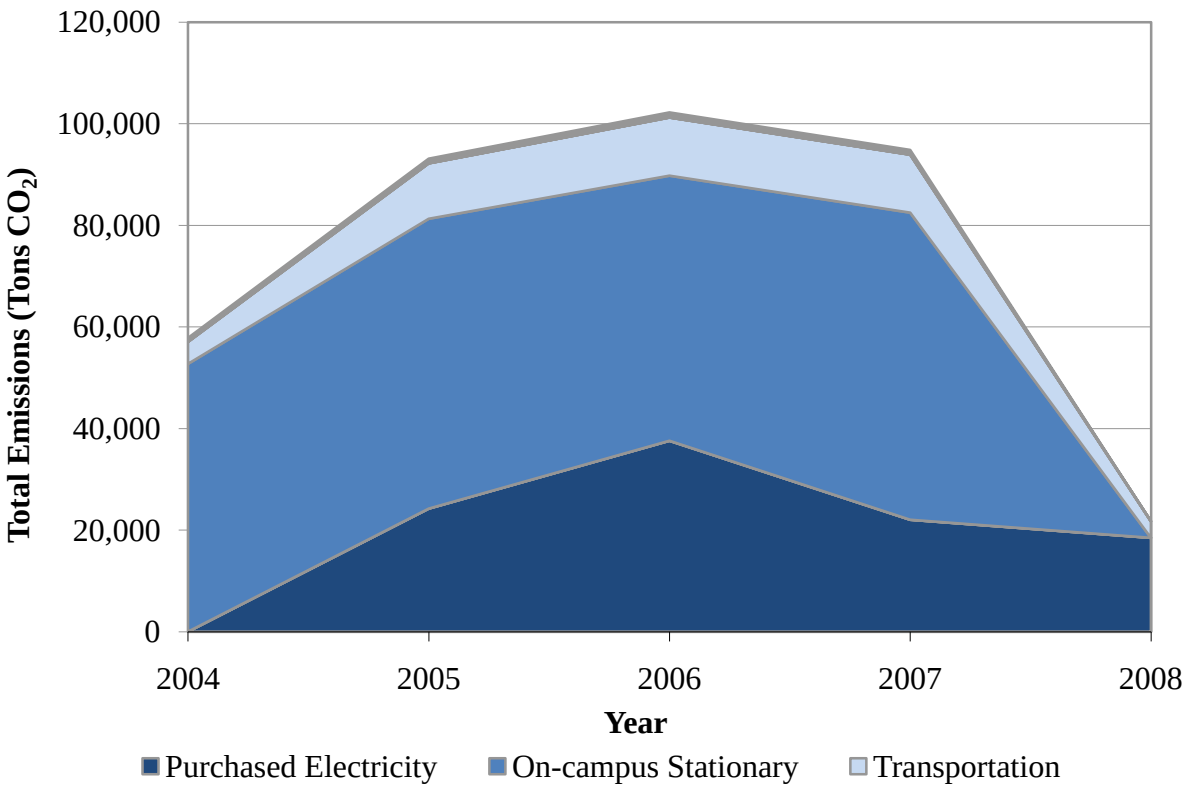

Figure 1. Total Carbon Footprint on the campus of the California Institute of Technology

To collect the greenhouse gas emissions data, we followed the protocol designed by the World Resources Institute (WRI) called *A Corporate Accounting and Reporting Standard* (WRI 2001). The first step, setting organizational and operational boundaries, involved identifying the three scopes of greenhouse gas emissions (WRI 2001). The second step of the protocol, identifying and calculating the GHG emissions, involved recognizing which of the emission factors are relevant to Caltech (WRI 2001). The last steps of the process are managing inventory quality, accounting for GHG reductions, reporting and verifying emissions (WRI 2001). Those steps involve ensuring the accuracy of the obtained data, setting reduction goals, and reporting the results online. This paper suggests possible ways of decreasing the amount of GHG emissions as guidelines for the Caltech facilities office.

3. Results and Discussion

3.1. Lack of record keeping from previous years

Although the project had aimed to gather information about Caltech's footprint since 1990, most Caltech offices keep only a few years worth of records. Consequently, only data for the years 2005 – 2007 was complete enough to be analyzed, see Table 1. Unfortunately, three years of data is not enough to identify the trends in GHG emissions in the past and predict future emissions. Since identifying these trends is a crucial step in reducing carbon footprint, this is the first area where improvements must be made at Caltech. If offices are made to keep records of their emissions for at least the past 20 years, the university will be able to reduce its carbon footprint in the long run.

3.2. Caltech carbon footprint from 2005 to 2007

Analyzing only the results in 2005 – 2007, Table 1 demonstrates a peak in the university's carbon footprint in the year 2006, accounted for by an increase of 13,358 tons in the Scope-2 emissions. In 2006 Caltech's co-generation power plant, which burns natural gas only, had to be shut down for a couple of months. As a result, it output less electricity and more had to be purchased from PWP (Table 2). The fuel, which the university buys from PWP, has very high coal content and emits significantly more carbon dioxide in the atmosphere than natural gas. In the peak year 2006, the PWP fuel was 71% coal and only 2% renewable energy.

Since 2006, PWP has been improving the quality of the fuel they sell to Caltech. In 2008, the coal content was down to only 62% and the percentage of renewable energy went up to 8%. If this trend persists, it will automatically lead to a reduction in the carbon footprint. However, if the drop in coal content does not carry on, PWP does offer more sustainable, but also more expensive energy contracts. If Caltech wants to reduce the Scope-2 emissions, it will have to either increase the capacity of the co-generation power plant or buy cleaner but more costly electricity from PWP. However, we are unsure how feasible those two options may be.

Table 1. Carbon footprint during the years 2005 – 2007 on the Caltech campus (Clean Air-Cool Planet 2006)

Year	Carbon Footprint						
	Scope-1		Scope-2		Scope-3		Total
	tons	%	tons	%	tons	%	tons
2005	57,041	61.6	24,220	26.1	11,370	12.3	92,632
2006	52,168	51.3	37,578	37.0	11,951	11.7	101,696
2007	60,437	64.0	22,033	23.4	11,878	12.6	94,348

Table 2. Electric output during the years 2005 – 2007 on the Caltech campus (Clean Air-Cool Planet 2006)

Year	Electric Output			
	On-Campus Power Plant	Purchased Electricity		
	MWh	MWh	% Coal	% Renewable
2005	72,093	26,136	71	1
2006	67,863	40,800	71	2
2007	83,611	25,757	65	8

3.3. Comparison between UC Berkeley and Caltech

To understand better the significance of the size of Caltech's footprint, it is important to compare it to the footprint of another university. We considered universities that officially report their carbon footprint data such as Princeton, Harvard, the University of California, Berkeley and Harvey Mudd College. Harvard and Princeton are located on the east coast and have a different energy profile than California schools. Harvey Mudd, though comparable in size, has far fewer research facilities. Hence, we determined UC Berkeley is best suited for our comparison, even though it is a significantly larger institution than Caltech with a student body of about 36,000 students compared to Caltech's 2000 students.

In 2006, UC Berkeley has reported that its carbon footprint for that year was 209,000 tons (University of California 2006). Out of those 209,000 tons, 46.2% came from Scope-1, 30.6% came from Scope-2, and 22.9% came from Scope-3 (University of California 2006). In 2006, Caltech's Scope-3 emissions were only 11.7% (table 1). Hence, there is a noticeable difference in Caltech's and UC Berkley's footprint coming from Scope-3. It could be partially explained by Berkeley's bigger campus and larger population. The university has far more people commuting and faculty traveling by air. Another reason is that many departments at Caltech are not reporting the information needed to accurately compute the Scope-3 footprint. Commuters and air travel are the major sources of Scope-3 emissions. However, only a small percent of the faculty uses the centralized university system for reserving flights and thus air travel data is incomplete. Moreover, the commuter survey performed every year by the transportation office obtains incomplete results. In comparison, knowing that UC Berkley has already officially published its carbon footprint, we believe that their data is significantly more complete.

This outcome demonstrates that there are large gaps in our data. Currently, a considerable part of the Scope-3 emissions are not being accounted for. All departments and offices in the university that contribute to the campus's GHG emissions need to keep track of their activities and report them. A unified system should be developed for recording and reporting the data. A greater incentive should be given to faculty and students to report their travel miles. Information on heating, cooling, cooking and laboratory use was not entered in the calculator since each lab had to be contacted individually. Thus, individuals in each lab should be assigned to collect and organize that data. At this point of the project, Caltech's best attempt at reducing its carbon footprint is to obtain more accurate data of its GHG emissions.

4. Conclusion and Future Directions

The present paper demonstrates how we measured Caltech's carbon footprint using the Cool Air-Clean Planet calculator v5.0. It represents only the beginning of one of the university's current sustainability projects, attempting to make the campus more environmentally friendly. In order to achieve that goal, Caltech has to continue recording its GHG emissions, keeping record of at least the past 20 years. The university needs to make improvements in the process of collecting data, paying special attention to the use of transportation. Lastly, Caltech should attempt to purchase cleaner electricity than the one it is currently buying from Pasadena Water and Power.

5. References

Clean Air-Cool Planet, I. (2006). Clean Air-Cool Planet, Campus Carbon Calculator.

Mathis Wackernagel, W. E. R. (1996). Our Ecological Footprint: Reducing Human Inpact on the Earth, New Society Publishers.

University of California, B. (2006). "2006 Emissions Inventory." from http://sustainability.berkeley.edu/calcap/inventory-2006data.html.

WRI (2001). The Greenhouse Gas Protocol. A Corporate Accounting and Reporting Standard**:** 116.