Converting University Spending to Greenhouse Gas Emissions: A Supply Chain Carbon Footprint Analysis of UC Berkeley

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ABSTRACT

This study calculates a supply chain carbon footprint for UC Berkeley based on procurement expenses in fiscal year (FY) 2009. I present recommendations to reduce supply chain greenhouse gas (GHG) emissions, identify opportunities for future study, and develop a reproducible tool for UC Berkeley to facilitate annual GHG emissions reporting. I conducted a hybrid top-down life cycle assessment (LCA) to determine the total magnitude and composition of UC Berkeley's supply chain carbon footprint by reviewing over $500 million of procurement expenses. I calculated that 128,590 metric ton CO_2e of GHG emissions were released as a result of UC Berkeley's procurement in FY 2009, representing 39% of the university's total carbon footprint. The top five emitting categories of procured goods and services were construction, scientific equipment, office products, IT & telecommunications, and food; all together contributing to 80% of procurement emissions. In order to reduce these emissions, I recommend that UC Berkeley expand reuse initiatives to reduce consumption of goods, investigate food procurement and continue seeking alternatives for carbon intense food products, develop a "green" supplier score card, and survey campus buyers to understand current barriers and opportunities for reducing emissions from procurement. This analysis can be repeated in future years by the Cal Climate Action Partnership (Cal CAP) and/or student researchers.

KEYWORDS

Climate change mitigation, emission factors, hybrid methodology, life cycle assessment, procurement, scope 3 emissions

INTRODUCTION

Concern about climate change has increased significantly over the past few decades and as a result, many organizations and individuals are actively trying to quantify their impact and reduce greenhouse gas (GHG) emissions (IPCC 2007, Jones and Kammen 2011). It is essential that organizations and individuals understand how their purchasing decisions result in GHG emissions, how these emissions affect future climate change scenarios, and what can be done to proactively reduce these emissions. The quantity of GHG emissions produced over a specific time period is defined as a "carbon footprint" and is commonly used to evaluate progress towards climate mitigation goals (WRI and WBCSD 2004).

GHG emissions are produced from a variety of sources and it is useful to distinguish between three common scopes of emission sources during carbon footprint calculations. Scope 1 includes all direct GHG emissions from operations and company-owned facilities, scope 2 includes indirect GHG emissions from purchased energy, and scope 3 represents all other indirect sources including GHG emissions embedded in the supply chains of purchased goods and services (WRI and WBCSD 2004). For example, an individual who purchases a manufactured product is indirectly responsible for all of the emissions released during the product's manufacturing, assembly, transportation, usage, and disposal phases of its life cycle (Huang et al. 2009, Jones 2011). The most commonly used carbon footprint reporting standards require scope 1 and 2 emissions because there is a standardized and widely accepted approach to quantify these emissions with The Greenhouse Gas Protocol (WRI and WBCSD 2004). These standards rarely include scope 3 emissions because supply chains are complicated, unique to individual companies, and subsequently difficult to analyze with standardized approaches (Busch 2010, Matthews et al. 2008, WRI and WBCSD 2004). However, scope 3 emissions can represent 75% of an entity's total emissions and should not be overlooked (Huang et al. 2009). Although scope 3 emissions are tedious to estimate, organizations and individuals must consider supply chain emissions in order to understand their holistic carbon footprint and seek abatement options. Currently, there are a variety of methods to calculate a carbon footprint but the most thorough methods are based on life cycle assessments.

Life cycle assessments (LCA) analyze the environmental impact of a product, good, or service throughout its lifetime and provide approaches for the quantification of these impacts in terms of energy intensity, water consumption, pollutant production, and GHG emissions (Curran 2006, Haes et al. 2004, Hendrickson et al. 2006). Environmental impacts are aggregated throughout the life time of a product, good, or service, starting with raw materials extraction and ending with disposal. LCA can be performed from a "bottom-up", "top-down", or hybrid perspective (Curran 2006). A bottom-up approach attempts to quantify all impacts resulting from processes linked to the production of a single product – which is extremely tedious, time-consuming, and data intensive but is beneficial because it is product specific (Joshi 1999). Conversely, the top-down approach utilizes industry-wide environmental impact data for various economic sectors to make assumptions about the impacts of goods and services produced within those sectors (Lave et al. 1995, Hendrickson et al. 2006). The top-down approach relies upon emission factors that are in terms of environmental impact produced per dollar spent in a specific economic sector (Curran 2006). In terms of GHG emissions, Economic Input-Output Life Cycle Assessment (EIO-LCA) is an online database of nationally averaged emission factors and the Comprehensive Environmental Data Archive (CEDA) database expands upon EIO-LCA by specifying scope 1, 2 and 3 emissions within each emission factor (Carnegie Mellon University Green Design Institute 2008, Suh 2005). Although the top-down approach is less time consuming, it overlooks differences between production processes within the same economic sector (Joshi 1999). Hybrid approaches are useful because they incorporate beneficial aspects of both top-down and bottom-up approaches. Specifically, hybrid top-down approaches are relevant to carbon footprint calculations because they rely heavily upon the top-down approach to calculate a general footprint then use a bottom-up approach to better understand specific high-emitting activities (Jones 2011).

There is a demand for industry-specific supply chain carbon footprint calculation methods. Many universities, including UC Berkeley, are committed to annually report and aggressively reduce carbon emissions through the American College and University Presidents Climate Commitment (Ahmed 2007). A standard calculation approach for university supply chain carbon footprints does not currently exist. However, such a methodology would complement existing reporting standards and help campus administration identify procurement habits that result in excessive carbon emissions. A hybrid top-down LCA that differentiates between emission scopes and considers vendor location would improve overall accuracy of supply chain carbon footprint estimates.

The primary objective of my study is to calculate a supply chain carbon footprint for UC Berkeley. My study will present recommendations for procurement changes to reduce supply chain scope 3 GHG emissions and develop a reproducible tool for UC Berkeley to facilitate annual GHG emissions reporting. To accomplish these objectives, I will conduct a hybrid top-down LCA to determine the total magnitude and composition of UC Berkeley's supply chain carbon footprint by reviewing procurement and construction expenses in fiscal year 2009.

Background

The first supply chain carbon footprint for UC Berkeley campus was calculated in 2007 as an appendix to the Cal Climate Action Partnership (CalCAP) Feasibility Study (Ahmed 2007, Jones 2007). CalCAP commits UC Berkeley to reduce its GHG emissions to 1990 levels by 2014 and requires annual emissions inventory reports to monitor progress towards this ambitious goal (Ahmed 2007). The footprint calculation in the 2007 report went beyond direct emissions from the campus vehicle fleet and steam co-generation power plant to estimate indirect emissions from procurement and construction expenses (Jones 2007). However, this pilot calculation did not distinguish between emission scopes or apply different emission factors based on the location of vendors.

A recent collaboration between UC Berkeley researchers, California utility Pacific Gas & Electric (PG&E), and carbon accounting software company Climate Earth calculated a supply chain carbon footprint for PG&E (Herrera 2010, Jones et. al 2012). This study focused on scope 3 emissions from procurement and provided specific recommendations to PG&E management to reduce supply chain emissions. CEDA emission factors from Climate Earth were applied to line item expenses after mapping each expense to a specific economic sector to identify which areas of spending produce the largest amount of GHG emissions by emission scope (Lave et al. 1995, Suh 2005, Jones et. al 2012). Based on whether or not PG&E vendors were local to California, which is known to have a less carbon-intense electricity generation energy portfolio, national emission factors were adjusted for California vendors (U.S. EPA 2007, EIA 2011). These methods are applicable to the UC Berkeley campus and are particularly of interest because they provide solutions to the aforementioned errors in the first UC Berkeley carbon footprint calculation in 2007. The methods from this PG&E study will be applied to this study to improve the accuracy of UC Berkeley's supply chain carbon footprint.

METHODS

Subject and overall study design

To calculate a supply chain carbon footprint for UC Berkeley, I conducted a top-down hybrid life cycle assessment using the Comprehensive Environmental Data Archive (CEDA) emission factor database, annual procurement reports, and vendor location data. The subject of this study is the University of California, Berkeley, which I define to include all owned property and procured goods and services for campus buildings, dining commons, athletic teams, research facilities, and residential halls (Taylor 2012). My analysis focused on campus' scope 3 emissions, since scope 1 and 2 emissions are already calculated by campus administrative staff and documented in the Cal Climate Action Partnership (CalCAP) annual emission reports.

Year selection

I considered time constraints and availability of data in order to select an appropriate time period for this analysis. I limited my study to analyze only one year of data due to time constraints and the current annual cycle of both campus procurement and emission reports. Researchers from the Renewable and Appropriate Energy Lab (RAEL) completed a similar supply chain carbon footprint analysis in 2008 and annual data prior to 2008 is inconsistent, so I could have selected 2009 or 2010 data to analyze for this project (Jones 2011). Both procurement and construction data was readily available for 2009 so I limited my study to fiscal year 2009.

Emission factor adjustments

All provided CEDA emission factors are per dollar of sector output, in which the product or service "lifecycle" ends when it leaves the manufacturer or service provider. However, there is a significant mark-up in price between producers, wholesale distributors, and retailers due to transit, distribution and retail building maintenance costs (Jones et al. 2008). This inflation in value will decrease the carbon intensity of CEDA emission factors. To adjust for this error, I calculated CEDA emission factors in terms of wholesale distributor and retailer dollars using the following equations:

$$E_{Ci,Wholesale} = \frac{PV_i}{CV_i} * E_{Pi} + \frac{PV_{Air}}{CV_i} * E_{P_{air}} + \frac{PV_{Truck}}{CV_i} * E_{P_{truck}} + \frac{PV_{Rail}}{CV_i} * E_{P_{Rail}} + \frac{PV_{Water}}{CV_i} * E_{P_{Wate}} + \frac{PV_{Wholesale}}{CV_i} * E_{P_{Wholesale}}$$

$$E_{Ci,\mathrm{Re}tail} = \frac{PV_i}{CV_i} * E_{Pi} + \frac{PV_{Air}}{CV_i} * E_{P_{air}} + \frac{PV_{Truck}}{CV_i} * E_{P_{truck}} + \frac{PV_{Rail}}{CV_i} * E_{P_{Rail}} + \frac{PV_{Water}}{CV_i} * E_{P_{Water}} + \frac{PV_{Wholesale}}{CV_i} * E_{P_{Wholesale}} + \frac{PV_{\mathrm{Re}tail}}{CV_i} * E_{P_{\mathrm{Re}tail}}$$

In the above equations, E is the CEDA emission factor in producer (p) or consumer (c) dollars for a given economic sector (i). Producer value in that sector (PV_i) is separated out for various subcategories (air, truck, rail, water, retail, wholesale) and total consumer value of expenditures in that sector is represented by CV_i (Jones et al. 2008). I obtained all producer and consumer values for economic sectors from the Bureau of Economic Analysis' Benchmark Input-Output 2002 Bridge Table for Personal Consumption Expenditure (BEA 2011). All emission factors are disclosed in Appendix E.

Preliminary economic sector mapping and emission calculations

I received campus' 2009 procurement reports from UC Berkeley's Procurement Services and applied CEDA emission factors to calculate a preliminary footprint estimate. These reports list all campus expenditures in a line item format, which includes the vendor and amount paid for the good or service. I converted all expenditures to 2002 values using the Producer Price Index (PPI) because the emission factors from the CEDA database are based on 2002 US$ (BLS 2010). See Appendix F for all PPI conversions.

I summed line item expenses based on the accounts they were paid to then I mapped each account to a specific category, subcategory, and economic sector based on the account description. I used the same category and subcategory titles from the Cal CAP Feasibility Study (Jones 2007). For example, computer equipment was mapped the "Information Technology & Telecommunications" category, "IT Distributors" subcategory, and "Electronic Computer Manufacturing" economic sector. If an economic sector name changed since 2007, I searched the online EIO-LCA database and selected the most similar up-to-date economic sector (Carnegie Mellon University Green Design Institute 2008). If an account could not be mapped to an economic sector because there was no applicable sector or because of a vague description, I highlighted the expense and discussed it with procurement staff during the review phase. Based on feedback from the reviewer, I either omitted the expense or mapped it to an appropriate economic sector (Taylor 2012). Category, subcategory, and economic sector mapping decisions for all analyzed accounts are disclosed in Appendix D. Additionally, I categorized each account as purchased from a "producer", "wholesaler", or "retailer". I made these decisions based on whether I thought the goods and services procured within that account were mostly purchased directly from manufacturers or service providers, wholesale distributors, or retailers.

Construction expenses are paid through Capital Projects, not Procurement Services, so I consulted with Capital Projects to assess their FY 2009 project budget. Capital Projects staff categorized each vendor as "General Contracting", "Construction Management", "Architecture", "Engineering", "Interior Design", "Industrial Equipment", or "Demolition" (Chess 2012). All subcategories were mapped to a specific economic sector based on the Cal CAP Feasibility Study (Jones 2007). I summed expenses within each category and applied emission factors for the mapped economic sectors.

Each economic sector has an emission factor from the CEDA database in terms of kilograms of CO_2 equivalent emitted per dollar spent in that sector. If an expense could be mapped to more than one economic sector, I used the averaged emission factor between all applicable economic sectors. I calculated indirect emissions produced per account by multiplying the money spent by the corresponding CEDA emission factor for the economic sector mapped to that account (Huang et. al 2009, Jones 2011). All line item emissions were summed to quantify emissions resulting from construction and procurement.

Review of mapping decisions

I met with representatives from Procurement Services and Capital Projects to review my preliminary data after mapping all expenditures to specific economic sectors. Some of my mapping decisions were not accurately matched because the description of the purchased goods and services in each account can be vague (Jones 2011). To account for this, I identified line items that I was unsure of during the initial mapping phase and discussed the nature of these expenses with staff in order to decide on a more appropriate economic sector designation. Following this meeting, I adjusted my initial mapping decisions to improve accuracy of my calculations.

Location adjustments

To account for the potential inflation in emissions from using nationally averaged emission factors during my calculations, I adjusted CEDA scope 2 emission factors based on the location of vendor facilities (Jones 2011). Since UC Berkeley's Capital Projects department has a separate, more detailed budget for all campus construction projects, I designated all construction vendors as "California-based" or "Not California-based" (Chess 2012). For all other procurement accounts within the Procurement Services budget, I compiled location data for vendors in top emitting procurement accounts by searching for vendor websites and designated each vendor within the top 10 emitting accounts as "California-based" or "Not California-based". Based on my findings, I assumed that 75% of vendors for services and food expenses were California based whereas 30% of vendors for manufactured goods were California based. I applied these assumptions to scope 2 emissions (S2) in all procurement accounts (except construction) using the following equations:

$$S2_{Not\ adjusted} = S2_0$$

$$S2_{Adjusted,\ Food\ and\ services} = (.75 * .527 * S2_0) + (.25 * S2_0)$$

$$S2_{Adjusted,\ Manufactured\ goods} = (.3 * .527 * S2_0) + (.7 * S2_0)$$

I reduced scope 2 CEDA emission factor by 52.7% if the vendor was located in California because California's energy portfolio is less carbon intense than the national energy portfolio (Jones 2011, EIA 2011). This adjustment is based on a comparison between California and national CO_2 emission rates per MWh (U.S. EPA 2007).

Magnitude and composition of supply chain carbon footprint, omitted accounts

To calculate the magnitude of UC Berkeley's supply chain carbon footprint, I summed all indirect emissions resulting from construction and procurement. To analyze the composition of UC Berkeley's supply chain carbon footprint, I compared both the scopes of emissions and the percentages of emissions from common categories of procured goods and services to the total sum of procurement emissions. I ranked the top 10 emitting procurement accounts and specified scope 1, 2, and 3 emissions within each account's total carbon footprint to compare vendor control of supply chain emissions between categories of goods and services. By breaking up these emissions into scope 1, 2, and 3, I was able to identify opportunities for Procurement Services and Capital Projects to reduce supply chain emissions in procurement and construction.

I did not include all procurement accounts in this analysis. I selectively omitted the following accounts: benefit and salary payments; government payments; utility services including electricity, natural gas, water and sewage, and waste management; transportation for students, staff, and faculty; depreciation and other negative sum accounts; interest, fines/penalties, and royalties; and research (Jones 2007). I explain these decisions in further detail in the Discussion section.

RESULTS

I calculated UC Berkeley's supply chain carbon footprint in fiscal year 2009 to be 128,590 metric tons CO_2e. I added this to reported emissions and calculated UC Berkeley's total carbon footprint to be 319,064 metric tons CO_2e in 2009. Indirect emissions from procurement represent 39% of UC Berkeley's total direct and indirect emissions.

Composition of carbon footprint

I analyzed 94,851 procurement transactions within 453 accounts and calculated that 80% of indirect emissions resulted from the top 5 emitting categories of goods and services. These categories include construction, scientific equipment, office products, IT & telecommunications, and food. The expenses within these 5 categories represent 67% of the procurement budget (omitting salaries, benefits, interest, donations, etc.). See Appendices B and C for detailed summaries of emissions by category and subcategory.

Construction expenses produced 30,345 metrics tons CO_2e, representing 37% of procurement expenses, 24% of campus' procurement footprint, and 9.5% of the total footprint in 2009. The average carbon intensity of construction expenses was 0.16 kg $CO_2e/\$$, which is low relative to average construction emission factors because most vendors in 2009 provided management and miscellaneous services (Chess 2012). Construction expenses can be broken down into the following subcategories: construction management (36%), mixed construction management and general contracting (31%), general contracting (20%), industrial equipment (7%), architecture (2%), electricity (2%), electrical services (1%), and HVAC/mechanical services (1%).

Scientific equipment expenses produced 25,725 metrics tons CO_2e, representing 7.7% of procurement expenses, 20% of campus' procurement footprint, and 8.1% of the total footprint in 2009. The average carbon intensity of scientific equipment expenses was 0.66 kg $CO_2e/\$$. Scientific equipment expenses can be broken down into the following subcategories: gases (52%), laboratory equipment and supplies (47%), and animal care (1%).

Office product expenses produced 16,566 metrics tons CO_2e, representing 7.0% of procurement expenses, 13% of campus' procurement footprint, and 5.2% of the total footprint in 2009. The average carbon intensity of office product expenses was 0.47 kg $CO_2e/\$$. Office product expenses can be broken down into the following subcategories: non-paper supplies (97%) and paper supplies (3%). More specific product-level data for the types of office supplies (i.e. pens, staplers, paperclips, printer ink) was not disclosed in the dataset provided by Procurement Services.

IT & telecommunications expenses produced 16,173 metrics tons CO_2e, representing 12% of procurement expenses, 13% of campus' procurement footprint, and 5.0% of the total footprint in 2009. The average carbon intensity of IT & telecommunications expenses was 0.28

kg CO_2e/$. IT & telecommunications expenses can be broken down into the following subcategories: IT goods (49%), equipment and installation (41%), and IT services (10%).

Food expenses produced 15,230 metrics tons CO_2e, representing 3.3% of procurement expenses, 12% of campus' procurement footprint, and 4.7% of the total footprint in 2009. The average carbon intensity of office product expenses was 0.83 kg CO_2e/$. It is difficult to produce an accurate estimate of emissions from food production, since different food types produce significantly different quantities of emissions (Jones et al. 2008). Additionally, more specific product-level data for food (i.e. meat, seafood, dairy, produce, baked goods) was not disclosed in the dataset provided by Procurement Services so I did not break up this category into subcategories.

Other miscellaneous expenses produced 24,549 metrics tons CO_2e, representing 33% of procurement expenses, 18% of campus' procurement footprint, and 7.7% of the total footprint in 2009. Most of these expenses were for miscellaneous services (professional, real estate, administrative, medical, facilities maintenance, mail, and insurance.) or categories of manufactured goods with small budgets (library books, materials for facility maintenance and repair, printed materials, apparel, and medical supplies).

Figure 1. UC Berkeley's 2009 Total Carbon Footprint, by Scope. Emission sources reported in UC Berkeley's 2009 emissions inventory report are shown in black and unreported sources are shown in yellow (Stoll 2012b).UC Berkeley's procurement in 2009 produced 128,590 metric tons CO_2e. UC Berkeley's total carbon footprint in 2009 was 319,064 metric tons CO_2e.

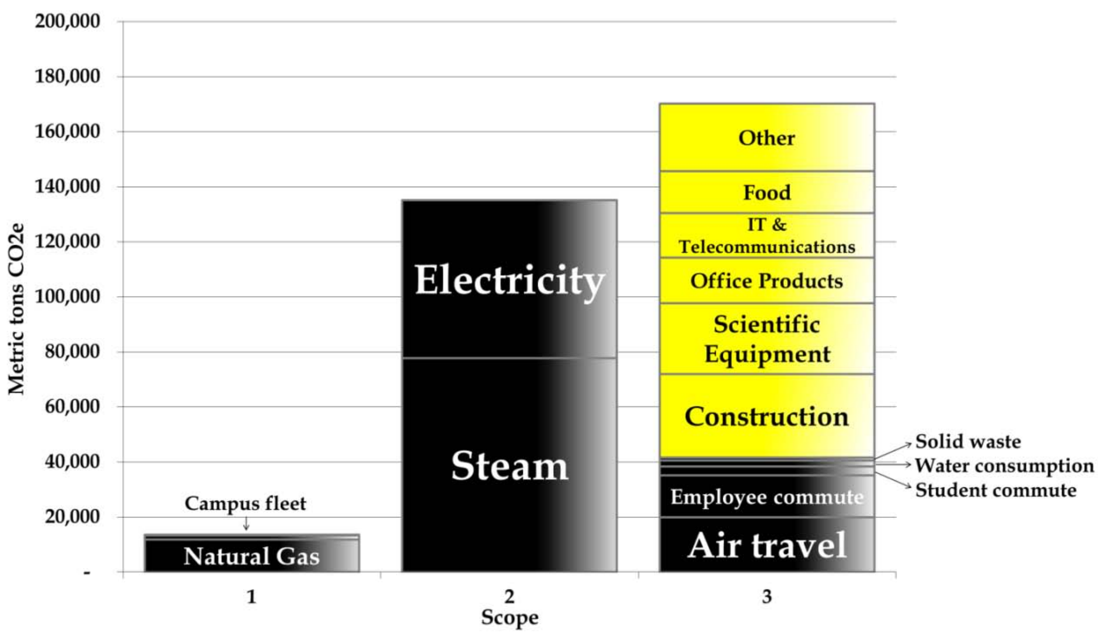


Figure 2. Comparison of category emissions and expenses relative to total procurement emissions and budget.

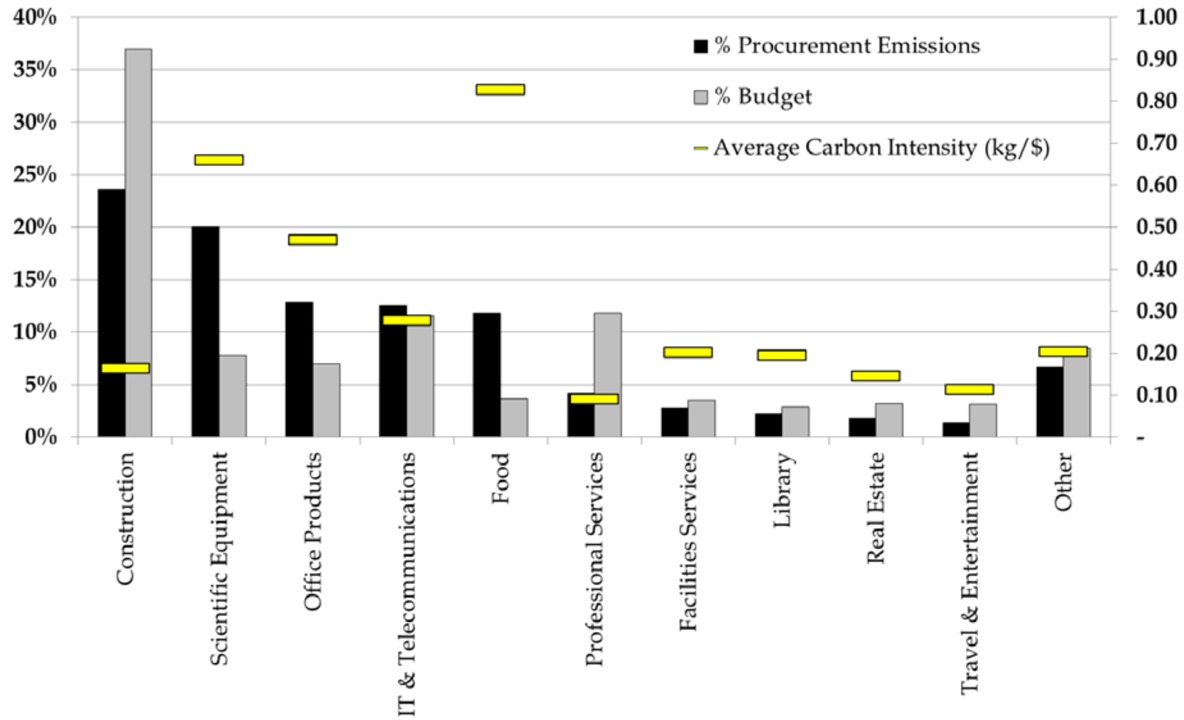


Figure 3. Composition of UC Berkeley's 2009 Procurement Carbon Footprint, by Category.

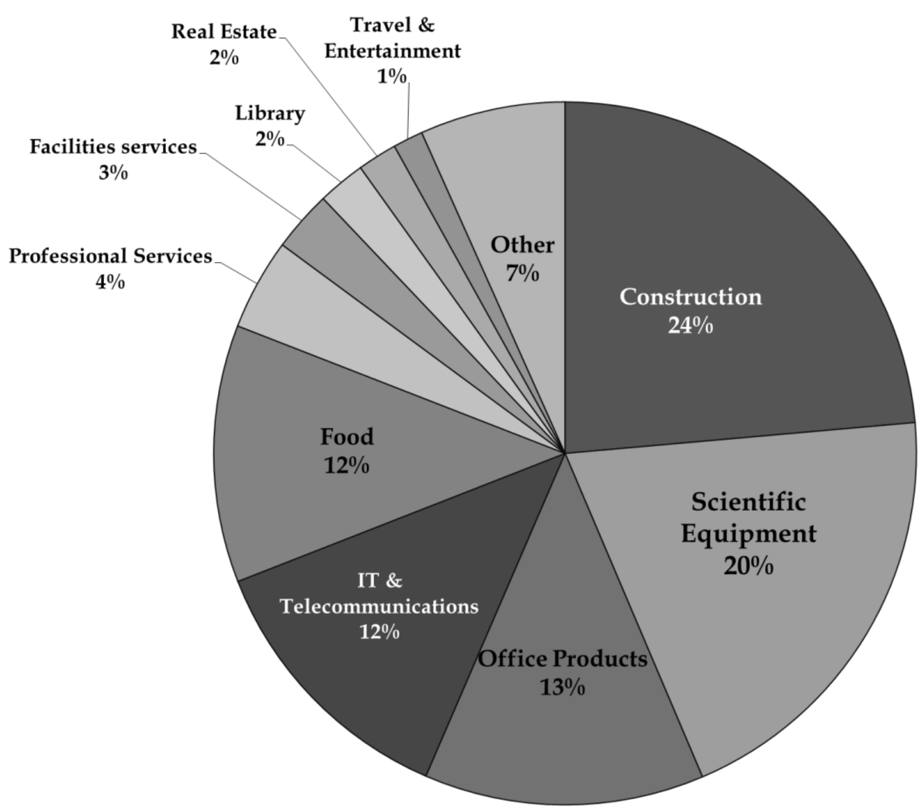
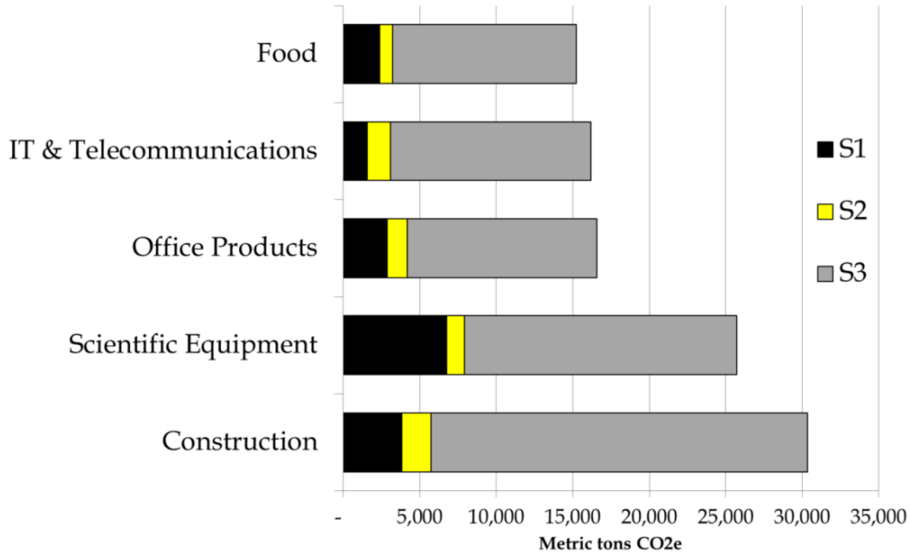


Figure 4. Compositions of Top Emitting Categories, By Subcategory.

From the vendor perspective, 15% of all procurement emissions were scope 1, 10% were scope 2, and 75% were scope 3. This is important to consider when altering procurement practices to reduce supply chain emissions and I reflect upon this in the Discussion section.

Figure 5. UC Berkeley's 2009 Top 5 GHG Emitting Categories, by Vendor Scope. Emission scopes 1, 2, and 3 shown below are from the perspective of UC Berkeley vendors to highlight opportunities for reductions in supply chain emissions.



DISCUSSION

Overview

This study is an example for how to convert procurement data into GHG emissions. I interpreted the results of my study in terms of sources and quantities of indirect GHG emissions relative to reported UC Berkeley emissions in 2009 and similar studies. Based on my calculations and analysis, I developed recommendations for the UC Berkeley procurement strategy. I conclude by explaining the limitations of my study, opportunities for future research, and broader implications of my study beyond the UC Berkeley campus.

Magnitude of carbon footprint

When added to campus' reported direct and indirect emissions, supply chain emissions from procurement represent 39% of total emissions in FY2009. Huang et. al claimed that on average an entity's scope 3 emissions represent 75% of total emissions (2009). UC Berkeley's scope 3 emissions (including procurement, commute, water, and solid waste removal) represent about 50% of total emissions but there are other scope 3 emissions that are not accounted for in annual emissions inventories or this study including life cycle emissions of purchased electricity thus I cannot conclude that campus' scope 3 emissions are less than average. A similar study recently conducted in the United Kingdom at De Montfort University (DMU) estimated that procurement emissions represented 38% of total university emissions, which is proportionally similar to UC Berkeley's emissions even though DMU's total footprint was 6 times smaller (Ozawa-Meida et. al. 2011). These proportions could potentially be a trend within university procurement emissions, however due to a lack of additional studies I cannot conclude any significant trends.

Composition of carbon footprint

Although UC Berkeley's procurement emissions could be divided into 21 categories, the top 5 categories (construction, scientific equipment, office products, IT & telecommunications, and food) represented 80% of these emissions. Certain categories produced a large quantity of emissions because they had a large budget or they were mapped to a carbon-intense economic sector. Within the top 5 categories, construction and information technology produced emissions that were proportional to their share of the procurement budget (see Figure 3). Scientific supplies & equipment, office related products, and food related products & services categories produced emissions that were not proportional to their budgets because these goods are associated with a more carbon-intense emission factor.

UC Berkeley is a research university that has many scientific laboratories on campus which require scientific equipment, chemical supplies, and computer equipment to conduct experiments. Additionally, all libraries and offices on campus require computer and/or telecommunications equipment to be useful for students and staff. This explains why most of the top-emitting accounts are related to scientific research and technology. These goods have complicated supply chains and source carbon-intense materials such as plastics and metals.

The majority of UC Berkeley's procurement emissions were scope 3 emissions relative to its vendors, meaning that the emissions are produced further up in the supply chain and thus will be difficult for UC Berkeley to reduce. Generally, if a vendor has mostly scope 1 and 2 emissions, they can reduce emissions by improving efficiency and altering production processes. However when vendor emissions occur further up in the supply chain, it becomes more complicated because vendors have to negotiate with their vendors and so on.

The composition of UC Berkeley's supply chain emissions differed slightly from emissions at other universities. Although construction was also the largest emitting category with 56% of procurement emissions, DMU's other high emitting categories were services, manufactured products, and information and communication technologies (Ozawa-Meida et. al 2011). UC Berkeley spent 11% of its procurement budget on professional services but these emissions represent only 5% of procurement emissions because services produce fewer emissions than manufactured goods. These universities will not have identical emission sources because they have different priorities with their procurement practices; as stated before UC Berkeley is a research university and must dedicate a significant portion of its money towards supporting its research efforts across campus. However, construction represented the largest emissions and spend category for both UC Berkeley and DMU which could indicate a trend in procurement emissions at universities. More universities should conduct similar assessments to determine if these results are common or not.

Methods evaluation: Omitted expenses, hybrid approach, and location adjustments

I omitted certain categories of expenses when conducting my analysis to avoid double counting emissions that are already included in annual emission inventory reports. In particular, I omitted utility services and transportation for students, staff, and faculty because their emissions are already quantified and reported (Stoll 2012b). Some categories of expenses do not have supply chains thus they do not produce emissions that are relevant to my study. These categories include charitable donations, government payments, interest payments, and fines. I also omitted all benefit and salary payments, since their expenses represent a significant portion of UC

Berkeley's procurement. Although campus employees inevitably produce emissions or utilize goods and services that produced emissions within their supply chains, I thought it would inflate the overall supply chain carbon footprint by applying an emission factor to their benefit and salary packages.

The most important component of this hybrid LCA methodology was the review phase with campus employees; the validity and accuracy of my study would have been significantly diminished without their feedback and support. The "top-down" LCA component was not time intensive and proved to be very effective for the "hot-spot" analysis. The "bottom-up" LCA component of this methodology would be improved if more specific procurement data was available. This dataset only provided account, vendor, and total spend data, but did not explain what goods and services were being purchased from vendors. Transactions are commonly routed through accounts that don't accurately reflect what is being purchased, such as office supplies within one of the food accounts. To correct for these errors, I initially hoped to re-map individual expenses within the top emitting accounts. Unfortunately vendor names were not sufficient to complete the "bottom-up" LCA, and I did not adjust mapping decisions again after ranking top-emitting accounts.

Since UC Berkeley is located in California where the energy portfolio is 52.7% less carbon intense than the national energy portfolio, I adjusted scope 2 emission factors for California vendors within the top 10 emitting accounts to improve accuracy (U.S. EPA 2007). This adjustment proved to be very time intensive without significant results since scope 2 emissions represented only a small portion of total emissions for most procured categories. For example, I researched 266 vendors for construction projects and location adjustments only reduced total emissions by 5%. In principle, it is important to incorporate location adjustments in order to provide an accurate estimate. These adjustments should be considered when making claims about the quantity of emissions however they are not as important when conducting a "hot-spot" analysis because location adjustments will not change the composition of emission sources. Future studies for carbon footprint calculations should critically evaluate their objectives before incorporating location adjustments into their methodology. If time and resources are limited, future assessments could make assumptions about vendor location based on a few accounts and apply those assumptions to adjust for vendor location in all procurement accounts.

Recommendations

This assessment presents a new perspective on campus' procurement habits. Although campus should try to reduce its supply chain emissions, it still needs to purchase goods and services to ensure that all university functions are being performed. UC Berkeley cannot simply cut certain expenses because they are too carbon intensive – but we can search for less carbon intense alternatives or negotiate with vendors to reduce environmental impacts within their production processes. See Appendix A for an executive summary of recommendations to Cal CAP's Steering Committee.

1. *Expand reuse initiatives to reduce consumption & do not focus efforts on services.* In order to reduce consumption of goods, particularly office supplies, departments and research entities should expand existing reuse initiatives to allocate supplies more efficiently between campus office spaces. The ReUse campaign and the Office of Sustainability's Green Department Certification program provide strong foundations for this type of initiative (McNeilly 2012, Stoll 2012a). If successfully executed, inter-departmental sharing will result in reduced supply chain emissions and reduced costs due to decrease consumption of office products. These efforts should be focused on non-paper office supplies since they represent 97% of emissions within that category. Although professional services represent 11% of the procurement budget, they do not produce a significant amount of emissions per dollar spent. The Operational Excellence initiative should be expected to cut inefficiencies (and subsequently expenses) which also reduce emissions (McNeilly 2012, Stoll 2012a).

2. *Investigate food procurement with Cal Dining and campus departments.* My estimates for supply chain emissions of food expenses are generalized and based on average food emission factors due to a lack of product-level procurement data. Emissions throughout food production are highly dependent upon the type of food being produced and in order to improve accuracy of this estimate, future studies should conduct a more in-depth assessment of food procurement with Cal Dining and campus departments who frequently provide catered meals to students, faculty, and staff. Food procurement should be broken down into subcategories such as meat, seafood, produce, grain, dairy products, beverages,

and processed food to enable more accurate account-to-sector mapping, resulting in more accurate emission calculations. There are many potential substitutions for food products which can result in reduced supply chain emissions (Jones 2011, Rodale Institute 2011). Cal Dining oversees a student sustainability team that could conduct this type of assessment in future years (Stoll 2012a).

3. *Survey campus buyers to understand buyer behavior, particularly opportunities and barriers to including an environmental metric in campus' e-procurement system.*

   UC Berkeley is in the process of transitioning to the improved e-procurement system BearBuy through the Operational Excellence initiative. There are multiple opportunities to improve environmentally-preferable purchasing options with this new system (Stoll 2012a, McNeilly 2012, Taylor 2012). For example, BearBuy could return search queries that prioritize environmentally responsible products from environmentally preferable vendors and/or distinguish these products and vendors from other options with a unique logo. However, in order to make this system the most effective, campus should understand procurement habits from the perspective of campus buyers who initiate and oversee procurement for departments and research entities (Jones 2011). Identifying opportunities and barriers to behavior change is an essential step when developing a new program or initiating change within an existing process (McKenzie-Mohr 2011). Campus should develop and deploy a survey to campus buyers so Procurement Services, the Office of Sustainability, and the Cal CAP Steering Committee will understand opportunities and barriers to changes in procurement habits (Jones 2011). Campus is in direct contact with buyers because Operational Excellence is already training them in BearBuy procedures, implying that it is possible to deploy this survey to all buyers. Ideally, this survey should answer the following questions:

   - What factors affect a buyer's decision to purchase a good or service?
   - Do buyers care about the environmental impacts of the goods and service they purchase?
   - If so, how can BearBuy effectively distinguish environmentally responsible products from other products?

- If not, what are other feasible strategies to reduce supply chain emissions through procurement?

4. *Include GHG emissions in "green" procurement strategic sourcing plans and develop a "green" vendor scorecard to incentivize environmentally responsible suppliers.* The Office of Sustainability is currently collaborating with Procurement Services' strategic sourcing team and Operational Excellence to evaluate the environmental sustainability of various products and services available for purchase in the e-procurement system (McNeilly 2012, Stoll 2012a). The definition of "environmental sustainability" should consider the carbon-intensity of products and vendor commitment to climate mitigation. Both of these are challenging to quantify but ultimately should be considered to expand our commitment to holistic environmental sustainability. Current initiatives are focused on specific products but to continue improving UC Berkeley's supply chain sustainability, campus should consider developing and implementing a "green" vendor scorecard. Large corporations such as Walmart and Procter & Gamble use similar systems that are publicly available and thus could be used as a starting template for UC Berkeley's scorecard. These scorecards evaluate vendors in terms of various environmental metrics, including GHG emissions, efficiency in water and energy use, waste disposal and recycling rates, use of low-toxic and organic materials, and transparency in sustainability reports (Walmart 2012, P&G 2012). This system should be structured to incentivize environmentally responsible suppliers. Some possible incentives include priority in results of e-procurement search queries and/or during procurement contract bidding (Jones 2011).

5. *Standardize the process for estimating procurement emissions and include in CalCAP's annual emissions inventory.*
   This study provides a straightforward methodology that can be replicated in subsequent years. UC Berkeley already reports some scope 3 emissions so disclosing procurement emissions will improve transparency and provide a more accurate assessment of campus' indirect emissions. I have created an Excel spreadsheet tool to facilitate future calculations and have shared it with relevant Office of Sustainability staff. In future assessments, staff can input new procurement data by account but should adjust PPI for the new fiscal year and re-

evaluate my initial account-to-sector mapping decisions. If staff resources are limited, hire undergraduate students to conduct this assessment.

The following ideas and recommendations are intended to reduce emissions or further investigate categories that were identified as high-emitting in this assessment:

<u>Construction</u>

1. *Understand what types of services are provided by contracted vendors and be able to distinguish between carbon-intensive practices (i.e. use of industrial equipment) vs. less carbon-intensive practices (i.e. management or architectural services). This will inform future calculations for supply chain emissions resulting from construction expenses.*
2. *Estimate on-site emissions from construction equipment by requiring contracted vendors to disclose fuel consumption (Jones 2011).*
3. *Conduct pilot life cycle assessment of a specific construction project on campus with student researchers (Chess 2012, Jones 2011).*

<u>Scientific Equipment</u>

1. *Collaborate with Berkeley Center for Green Chemistry to evaluate less carbon intense alternatives for chemical reagents and other laboratory supplies.*
2. *If possible, prioritize buying equipment and supplies from California vendors to reduce supply chain emissions.*
3. *Ensure that used chemicals and supplies are disposed of properly with EH&S to avoid release of climate forcing gases and mitigate risk of pollution (Stoll 2012a).*

<u>Office Products</u>

1. *Reduce consumption by encouraging reuse and exchange of office supplies between departments.*
2. *Evaluate carbon intensity of office supply products when assessing "environmentally-preferable" office supplies in Office Max strategic sourcing contract (Stoll 2012a, McNeilly 2012).*

<u>Food</u>

1. *Work with Cal Dining and department event planning employees to conduct more detailed assessment of food purchasing habits with product-level data (Stoll 2012a).*
2. *Buy less meat and dairy products and replace with less carbon intensive alternative such as organic produce (Jones 2011, Rodale Institute 2011).*
3. *Prioritize organic (no pesticide or fertilizer inputs) food options (Rodale Institute 2011).*

Limitations

Potential sources of error in my study are subjective bias during the mapping phase and uncertainty in location adjustments. I linked each category to an economic sector based on my interpretation of the expense description, leading to an inevitable subjective bias imbedded in my methods. However, I tried to overcome this by bias maintaining a systematic approach through the EIO-LCA online database and by reviewing my decisions with my research mentor and employees in Procurement Services and Capital Projects. My mentor is very familiar with the methodology of this study and the campus employees supervised the budgets that I was analyzing so they all were extremely qualified to answer my questions and critically review my mapping decisions. Location adjustments were based on the address displayed on the vendor's website, which could have been a headquarters, office space, distribution center, or manufacturing facility. While this is not the most accurate assessment of a vendor's location, it was the most time-efficient method. If locations listed on the website were not consistent with locations where good/services procured by UC Berkeley were produced, then emission estimates could be inflated or deflated depending on the true location and what was adjusted for. For example, if a company's corporate headquarters are located in California but their manufacturing facilities are located out of state, then my decision to reduce the scope 2 emission factor by 52.7% would unnecessarily deflate the emissions produced by that vendor throughout its supply chain because their out-of-state manufacturing facilities are more carbon intensive than their headquarter offices.

My study was also limited by the accuracy of emission factors and linked expenses to accounts. The CEDA emission factors that I used throughout my study were calculated by an external third party to my research so I did not have control over their methods (Carnegie Mellon

University Green Design Institute 2008). I assume that all emission factors are accurate in magnitude and scope 1, 2, and 3 contributions. Professors, graduate students, and staff all self-report individual expenses less than $5,000 through the e-procurement system, Berkeley Financial System (BFS) (Stoll 2012a, Taylor 2012). I assume that all of these expenses were routed correctly to the appropriate account such that all office supply expenses are represented in the "Office Supply" account, all athletic equipment expenses are represented in the "Sporting Goods/Equipment" account, etc.

As with most life cycle assessments, my study was constrained by time, availability of data, and external validation. I could not assess every single line item expense within the time frame of my study but this would have been the most thorough approach. The procurement reports I analyzed did not describe the good or service procured but instead only listed the account description and vendor. Ideally, these reports would have more detail to better inform my mapping decisions. Due to scheduling conflicts, it was difficult to have multiple campus employees review my data set. I was able to meet with Judy Chess (Assistant Director of Green Buildings Program in Capital Projects) and Rich Taylor (Director of Procurement Services) to answer questions and review my dataset, however I would have preferred to have more employees review my decisions to improve accuracy.

Future study

Due to time limitations, I did not complete all of the planned components of my thesis project so these parts are opportunities for further study. In particular, future studies could sort procurement data by vendors and vendor-categories, conduct in depth case studies with large contract vendors, apply methods to Operational Excellence's new e-procurement system Bear Buy, assess construction emissions more thoroughly, and ultimately develop a more fool-proof method for incorporating supply chain emissions into the annual emissions inventory. These opportunities would identify new recommendations for campus procurement, improve the accuracy of estimated emissions, and facilitate future supply chain emissions reporting at universities.

Broader implications

My recommendations are unique to Berkeley's campus but the underlying concepts behind my approach are applicable to other campuses with similar electronic decentralized procurement systems. Hopefully other campuses will utilize this methodology to carry out pilot supply chain carbon footprint assessments. As reporting standards become more rigorous and transparent, supply chain emissions will need to be addressed. Thus, if campuses start piloting these studies now, they will be better prepared when new requirements are established.

Additionally, this research could be applied to corporations with large procurement budgets and existing emissions reporting processes. If corporations are serious about holistically reducing their emissions and working with vendors within the supply chain, they should calculate supply chain carbon footprints and make strategic changes to their spending habits.

The results of a supply chain carbon footprint are meant to inform responsible entities about the carbon implications of their spending decisions. It is unrealistic to believe that entities can reduce emissions drastically across their entire supply chain; however, it is possible to identify emission "hot spots" that can be prioritized. Climate change is the largest environmental problem of our generation thus we must consider all contributions if we plan to slow future climatic effects. Both direct and indirect emissions should be considered when aggregating environmental impacts and this methodology enables us to assess a variety of emission sources without spending valuable time or financial resources.

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