Supply Chain Greenhouse Gas Inventory Meta-Analysis
April 30, 2015

Executive Summary

Project Description

For most organizations, greenhouse gas (GHG) emissions from the production of purchased goods and services (i.e. supply chain) represent the largest source of operational climate impacts. Unfortunately, many organizations do not have the resources to conduct a GHG analysis on their supply chain and thus do not know the scale of their impact. As a result, goods and services they buy are not included as part of GHG emissions reduction efforts.

This first-of-its-kind meta-analysis of publically available supply chain GHG inventories has the following objectives:

- Understand the climate impact of purchases relative to other common GHG emissions sources
- Identify "hot spots" within supply chain emissions – purchasing categories and specific goods and services
- Help target strategic procurement activities to reduce supply chain impacts

These objectives are meant to help inform other organization's supply chain GHG reduction efforts and can be used in conjunction with other resources available from the West Coast Climate and Materials Management Forum including the *Climate Friendly Purchasing Toolkit* and the *How To Conduct a Supply Chain GHG Inventory Guide*.

Method

This meta-analysis considers the results of 86 supply chain GHG inventories from 36 different public agencies, public utilities, and higher education institutions that are available publically. These supply chain GHG inventories estimate the energy use and process emissions released during the production of goods and services from extraction of raw materials to the point of retail sale of a good or service to the buying agency. The purchasing categories and associated GHG emissions from these inventories were collected, summarized, and analyzed in an Excel spreadsheet by grouping the results by like organizational attributes (e.g. organizational type, population served, and annual revenue) to reveal trends in the results. There are limitations to this methodology including a relatively small sample size and differences in accounting methodology and results summary between organizations. That said, the most significant findings of this analysis are consistent across individual institutions.

High-Level Findings

Figures ES-1 and ES-2 provide a graphic depiction of the following high-level findings of this meta-analysis.

- **Supply chain emissions are larger than other direct and indirect emissions sources typically measured for most organizations.**
- Construction and maintenance is the dominant Purchasing category regardless of the type, size, or annual budget (between 38% – 56% of total supply chain emissions). The largest sources of GHG emissions for this category include:
    - Production of materials including: concrete, asphalt and metals
    - Fuel combustion for vehicles and equipment
- Professional Services represent at least 10% of supply chain emissions for all organizational types, and when only public agencies supply chains are consider, this rises to ~27% of total emissions. The largest sources of GHG emissions for professional services include:
    - Natural gas and Electricity use by service providers
    - Business travel by service providers
- Vehicle Fleets and Equipment also represent between 7% - 19% of supply chain emissions.
- Standards and guidance are needed for a "core" group of purchasing categories so that inventory results may be compared more easily in the future. Those selected for this meta-analysis could be used for that purpose.
- Other Operating Supplies is ~15% of supply chain emissions for Utilities and Higher Education. It is difficult to identify precisely what types of materials are included in this category for individual organizations due to limitations of purchasing data for most organizations.
- Food, lodging, and transport are ~10% of purchasing GHG emissions for Higher Education.

Figure ES-1: Percentage of total emissions by organizational type and emissions category.
Note[1]: Each column color on graph sums to 100%.
Note[2]: The results presented in this analysis are based on a limited sample size. For a list of the organizations included in each organizational type, see Appendix B.

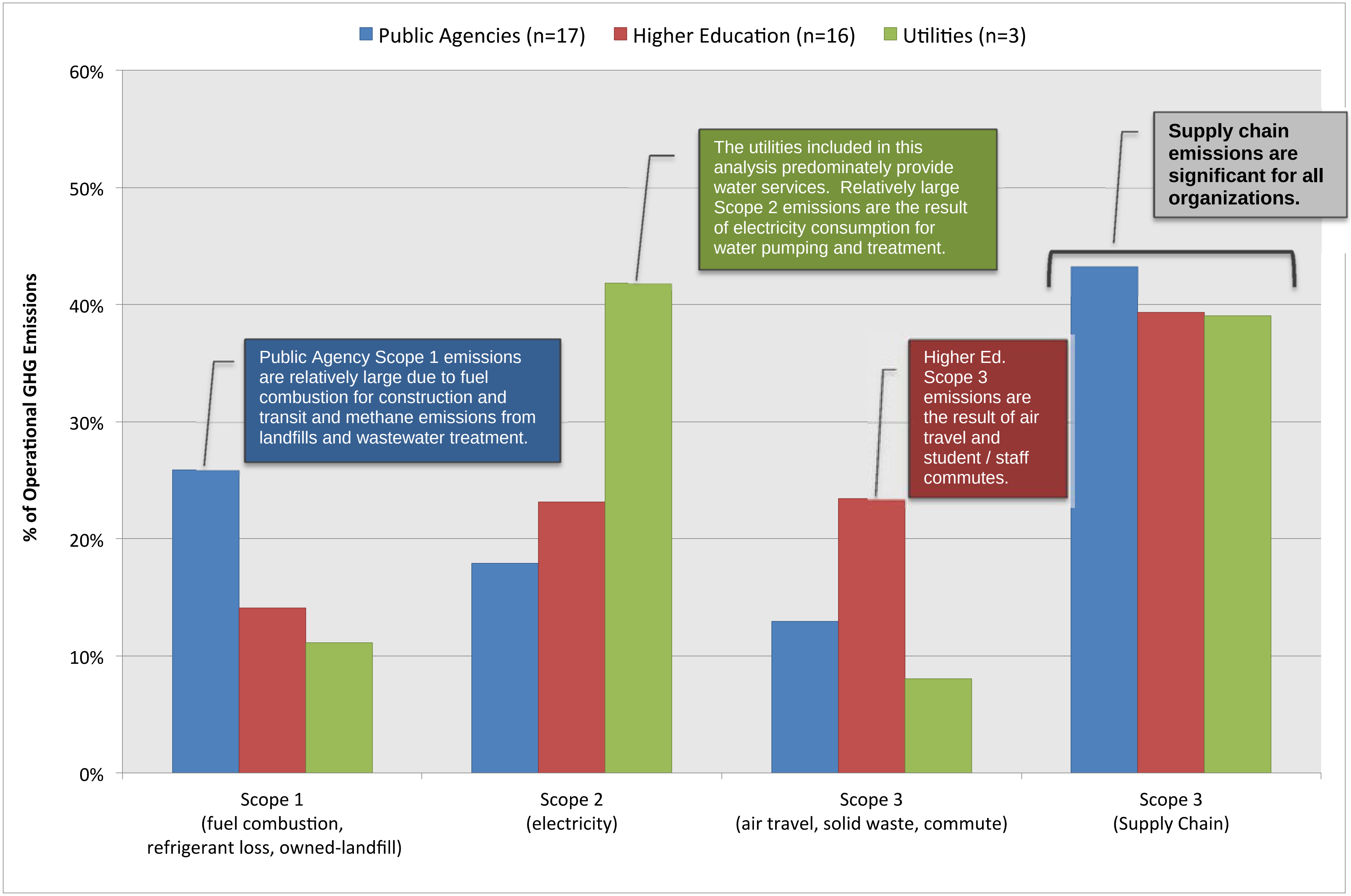
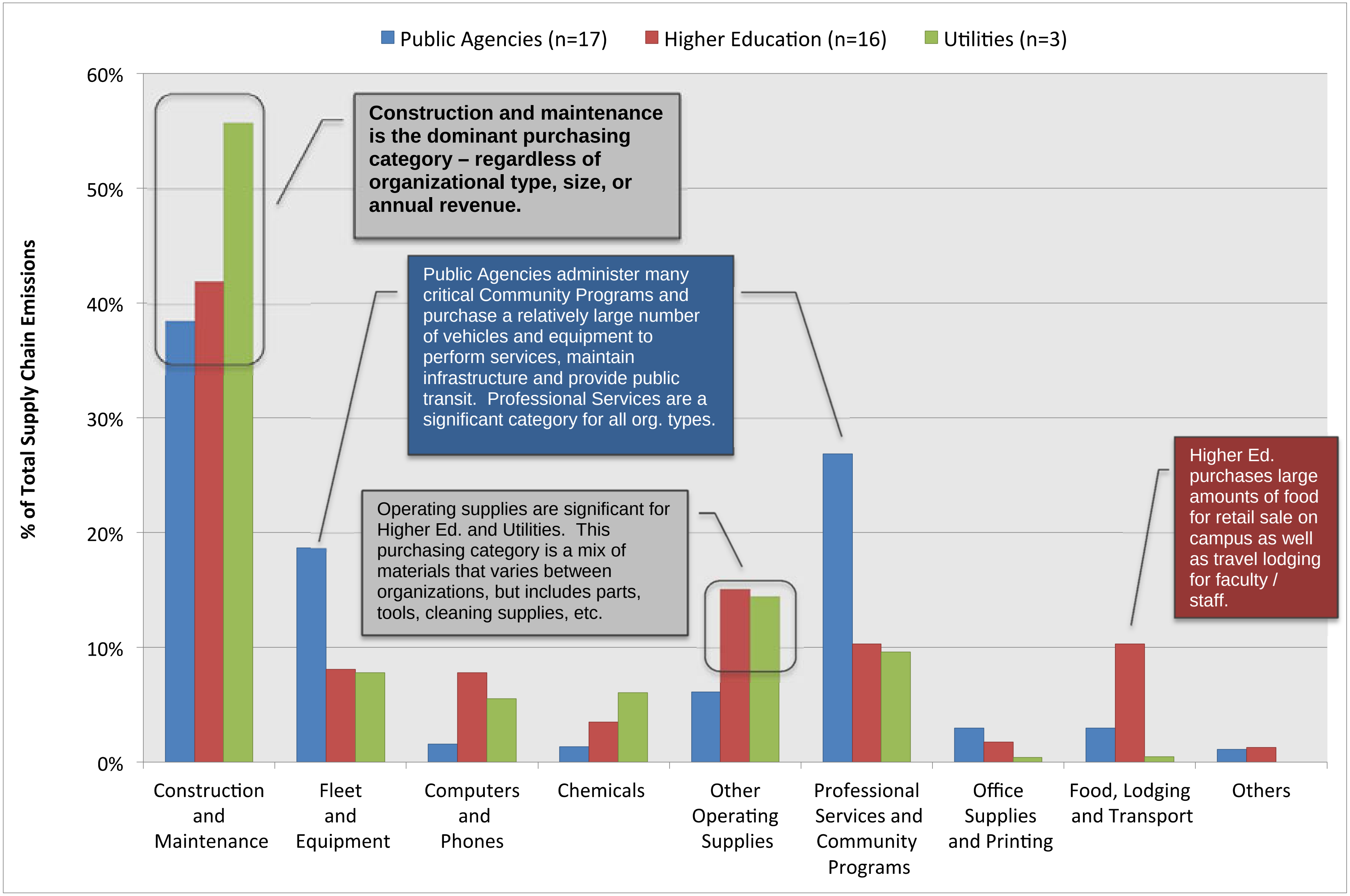


Figure ES-2: Percentage of total supply chain emissions, by organizational type, and purchasing category.
Note[1]: Each column color on graph sums to 100%.
Note[2]: The results presented in this analysis are based on a limited sample size. For a list of the organizations included in each organizational type, see Appendix B.



Project Description

Many public organizations complete annual operational greenhouse gas (GHG) inventories to identify and manage their GHG emission sources. A significant source of indirect emissions that is commonly excluded from operational GHG inventories is the "upstream" or "embodied" emissions that result from the production of goods and services consumed by an organization, otherwise known as their supply chain.

Recently, a concerted effort is being made by governments and non-profit organizations to highlight the significance of supply chain emissions and to provide guidance on how to assess and manage this large source of emissions. Two groups at the forefront of this work include the *West Coast Climate and Materials Management Forum* and the *Sustainable Purchasing Leadership Council* who are both currently developing materials and programs to assist organizations assess and lower the GHG impacts of their purchases.

Good Company, a management consulting firm focused on sustainability, has included supply chain as an emissions source in GHG inventories it completes for clients since 2007 and was selected to conduct this first-ever analysis of supply chain GHG inventories. The work presented in this report was funded by StopWaste – a public agency responsible for reducing the waste stream in Alameda County, California.

The purpose of the meta-analysis is to aggregate, summarize, analyze and share the learnings of existing supply chain GHG inventories with other organizations interested in reducing their supply chain emissions. *Specifically, this work is meant to guide the efforts of small to medium-sized governments and higher education institutions that may not have the in-house expertise or resources to conduct their own supply chain GHG inventory.*

There are two deliverables associated with this Supply Chain GHG Inventory Meta-Analysis, which include:

1. An Excel spreadsheet database of individual supply chain GHG inventory results summarized by individual purchasing categories (e.g. construction and maintenance, professional services, etc.) as well as associated sorting variables (e.g. organizational type, population served, annual revenue, etc.). A screen shot of the data base is included in Appendix C.
2. A Report describing the findings of an analysis of the supply chain GHG inventory database.

The deliverables are intended to be used for the following objectives:

- Understand the climate impact of purchases relative to other common GHG emissions sources
- Identify "hot spots" within supply chain emissions – purchasing categories and specific types of goods, materials and services
- Help target positive procurement activities to reduce supply chain impacts

This analysis is part of a larger effort by the West Coast Climate and Materials Management Forum to produce a *Climate Friendly Purchasing Toolkit*, which is scheduled for release in mid-to-late 2015. The Toolkit will provide research and guidance specific to public purchasers on best practices to reduce GHG emissions from known supply chain hot-spots (e.g. fuels, construction materials, professional services, IT equipment, etc.).

Guidance on Using this Information

Organizations interested in reducing supply chain emissions, but not able to complete their own supply chain inventory, may use this analysis in conjunction with the West Coast Forum's *Climate Friendly Purchasing Toolkit* to identify which purchasing categories likely dominate their supply chain emissions and strategies to reduce emissions from those categories. Purchasing categories in supply chain inventories and this meta-analysis represent aggregated purchases into like categories (e.g. construction, office supplies, vehicles, etc.). Figures 6 – 8 provide the percentage of emissions, by purchasing category, grouped by a variety of organizational attributes (e.g. organizational type, population served and annual revenue). The Groupings summarize the emissions by purchasing category for similar organizational characteristics across different types of organizations.

The outputs of Figures 6 – 8 summarize the relative contribution of GHGs from different purchasing categories and the variation of purchasing category emissions by organizational attribute groupings. Compare the attributes of your organization to these results to determine which purchasing categories deserve the greatest focus for your organization and use the best practices documented in the *Climate Friendly Purchasing Toolkit* to reduce the GHG emissions associated with your organization's supply chain.

Meta-Analysis Methodology

The first step in completing this meta-analysis was to identify publically available, supply chain GHG inventories. Good Company completed or provided guidance for 26 organizations that have publically available supply chain GHG inventories. In addition, Good Company identified additional published supply chain inventories. Ultimately we identified 47 individual organizations that had completed at least 1 supply chain GHG inventory and 100 total inventories (some organizations have inventories for multiple years). Unfortunately, not all of the identified inventories were usable for the meta-analysis due to inconsistencies or questions related to data, inventory boundaries, or methods. Inventory results from 36 organizations serve as the primary data for this meta-analysis.

Figure 1 shows the inventories included in this meta-analysis by organizational type and sub-type. Inventories were identified for Public Agencies, Higher Education Institutions (public and private) and public utilities (electric, water, and wastewater). A full list of the organizations as well as links to their reports is documented in Appendix B.

Figure 1: Count of organizations and inventories by type.

Org. Type	# of Organizations	# of Inventories
Public Agencies	**17**	**35**
City Government	*8*	*19*
County Government	*2*	*3*
Regional Government	*2*	*3*
City Park & Rec.	*2*	*2*
County Transit	*1*	*6*
State Environmental Agency	*2*	*2*
Higher Education	**16**	**40**
University	*14*	*31*
College	*1*	*8*
Funding Council	*1*	*1*
Utilities	**3**	**11**
Electric & Water (public)	*1*	*4*
Water (public)	*1*	*5*
Wastewater (public)	*1*	*2*
Total	**36**	**86**

After finding the inventories, our team collected and summarized the purchasing categories described in the inventory and the associated GHG emissions in metric tons of carbon dioxide equivalent (MT CO_2e). Each inventory typically included a summary table or figure of results, which summarized results for 5 to 15 individual purchasing categories. Figure 2 provides an example table of results. See Appendix C for a summary of the results used in the meta-analysis.

Figure 2: Example of publically available supply chain GHG inventory results from Hillsboro, OR.

Category	Emissions MT CO_2e				
	2010	**2011**	**2012**	**2013**	**Total**
Building Construction and Improvements	14,500	9,800	9,800	23,800	**57,900**
Office Supplies and Printing (Including IT)	2,600	2,600	2,800	2,800	**10,800**
Facilities Equipment and Maintenance	1,700	1,800	2,000	2,700	**8,200**
Chemicals & Safety Equipment	1,500	1,300	1,400	1,300	**5,500**
Fleet and Non-Roadway Vehicles	700	800	800	800	**3,100**
Library and Community Programs	700	700	700	700	**2,800**
Professional & Technical Services	700	700	400	500	**2,300**
Total	**22,400**	**17,700**	**17,900**	**32,600**	**90,600**

For the supply chain inventories completed by Good Company, full detail of the inventories was available (i.e. the spreadsheet used to conduct the supply chain inventory). This additional detail was used at times to adjust the inventory results summaries to increase the consistency and accuracy of the inventories used in the meta-analysis. These adjustments are time intensive and therefore were performed judiciously. The same level of detail is not available for many of the inventories and therefore adjustments are not possible.

The purchasing categories used in the individual supply chain inventories were compared and combined into the purchasing categories used as primary data in this meta-analysis. The intent in the selection of these categories was to maintain accounting consistency between inventories as much as possible with available information. Many of the purchasing categories are consistent between inventories. For example, a version of the Construction and Maintenance category is included in all the inventories.

That said, many organizations summarized this category using different names and at times provided further detail. For example, some inventories separated construction from maintenance, or separated infrastructure from buildings. To simplify the data, a single category name was selected, Construction and Maintenance, to capture similar types of emissions in a group that can be compared across all available inventories. While every effort was made to ensure the purchasing categories are consistent – some uncertainty still remains. For example, Computers and Phones were broken out as a specific category in some inventories, but in others, these purchases are grouped with Equipment, Operating Supplies, or Office Supplies.

Figure 3: Purchasing category descriptions used in this meta-analysis.

Purchasing Category	Category Description
Construction and Maintenance (Facilities, Grounds and Infrastructure)	All new construction, renovation and maintenance on buildings, other facilities, infrastructure and grounds.
Vehicles and Equipment	Vehicles, furniture and equipment and associated maintenance. Equipment could include items such as appliances, off-road vehicles and other medical and scientific equipment.
Computers and Phones	Hardware and software for computers and phones and related services.
Chemicals	Cleaning supplies, water treatment chemicals, lab supplies, paint, etc. Note: Use of this category was inconsistent within the inventories. In some inventories "Chemicals" are included in with the "Operating Supplies" category.
Other Operating Supplies	Consumable materials including parts, tools, and various other items. This category includes items that are varied and at times include items, which ideally would be grouped with one of the other categories used in this meta-analysis. Items included in this category vary significantly between inventories.
Professional Services and Community Programs	A variety of professions including medical, financial, law, engineering, etc. Community and support programs and grants including libraries, medical services, etc., which are exclusive to public agencies in the inventories reviewed for this analysis.
Office Supplies and Printing	Miscellaneous office supplies, printing services and paper.
Food, Lodging and Transportation	Food service, food purchased for retail sale, lodging in hotels, conferences, transit and freight.
Others	All other miscellaneous goods and services.

One take-away from this analysis is the need for standards or guidance on a "core" group of purchasing categories so inventories may be compared more easily in the future. These types of comparisons are common in operational GHG inventories as emissions are grouped into Scope categories and emissions sources which are defined in GHG inventory accounting protocols, such as Greenhouse Gas Protocol's *Corporate Standard* or The Climate Registry's *General Reporting Protocol*.

In addition to the emissions data, we documented other organizational attributes including: type of organization, population served, annual revenue[1], total $ included in the supply chain inventory, owned-building / facility square footage, number of full-time employee equivalents, inventory year, inventory methodology, and geographic location. A select number of these additional attributes are used in the Results section to group, sort, and analyze the supply chain emissions data. For example, *population served* data is used to consider the supply chain emissions profile for organizations serving communities of between 1 – 50,000 people, 50,001 – 100,000, and >100,000.

Note that some organizational attributes (e.g. # of employees and building square footage) have greater uncertainty than others like *organizational type* or *population served*. The accounting methodologies for employees and square footage can vary from organization to organization. Caution should be used when analyzing emissions data with these attributes.

[1] Annual revenue represents an organization's gross receipts from taxes, fees, tuition, sale of products and services, etc.

Once data was summarized in a spreadsheet, and received a quality control review, the spreadsheet was used to sort and analyze data into the results presented in this report. If more than one year's inventory was available for a single organization, the multplie years were averaged and the averages were used in the meta-analysis. We hope that over time, this data set can be expanded for ever-greater accuracy and understanding of supply chain GHG emissions.

Specific Limitations of this Meta-Analysis Methodology

The specific uncertainties and limitations in using summarized supply chain inventory results as a primary data source include the following:

- Accounting methodologies and the categories used to summarize results are inconsistent between inventories. This meta-analysis uses the summarized results as primary data, so inconsistencies between inventories will result in uncertainty of results at the meta-analysis level.
- The meta-analysis has a relatively small sample size considering the underlying complexity of inherent to large-scale purchasing and difference between organizational types and missions (n=36 organizations and n=86 inventories). Furthermore; the groupings used to analyze the meta-analysis data set, at times, have very small sample sizes (n=3 to 17).
- The small sample sizes also results in uncertainty related to outliers. In this type of analysis, it may be prudent at times to exclude outliers to avoid skewing the data set with an extremely large or small value. The small sample size makes it impossible to identify what is truly an outlier and what is an underrepresented organization. Therefore no outliers were excluded from the presentation of results.

Scope Emissions Categories

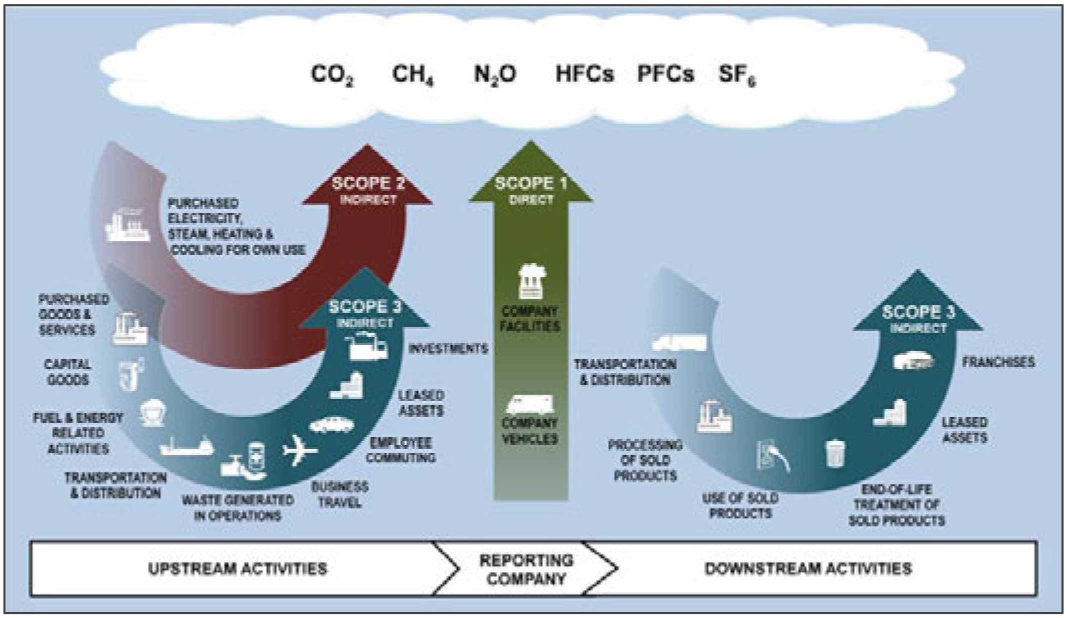
The focus on this meta-analysis is supply chain GHG emissions (purchased goods and services), which is one of a number of sources of direct and indirect emissions included in an operational GHG inventory. As part of the data collection process for the meta-analysis, our researcher team also gathered emissions data for sources other than supply chain emissions. GHG inventory protocols define emissions as either direct (owned) or indirect (shared). To distinguish direct from indirect emissions sources, three "Scopes" are defined for traditional GHG accounting and reporting.[2]

- **Scope 1:** All direct GHG emissions from equipment and facilities owned and/or operated by an organization.
- **Scope 2:** Indirect GHG emissions from purchased electricity. Indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.
- **Scope 3:** All other indirect emissions sources that result from an organizations activities but occur from sources owned or controlled by another company or entity, including: business travel, embodied emissions in supply chain goods and services, emissions from landfilled solid waste, and employee commute.

Figure 4 provides a graphic representation of the Scopes and the emissions sources included in each. As can be seen, purchased goods and supplies (the focus of this meta-analysis) is only one of many possible sources of an organizations GHG emissions. For the purpose of this meta-analysis, Scope categories are used in the Results section to compare the relative scale of Scope 3 supply chain GHG emissions to other sources of organizational emissions.

[2] Source: WRI/WBSCD Greenhouse Gas Protocol, Corporate Accounting and Reporting Standard (Revised Edition), Chapter 4.

Figure 4: Greenhouse gases and accounting and reporting Scopes[3]



Supply Chain GHG Inventory Methodology (using EIOLCA)

This meta-analysis relies on the results of 86 individual supply chain GHG inventories by 36 organizations. Most supply chain inventories are conducted as only part of an operational GHG inventory. There is more than one approach to conducting a supply chain GHG inventory, but the most common is to use a third party database or tool to estimate the upstream emissions generated during the production of the goods and services purchased by an organization. There are a number of tools and databases currently available from private software firms. Most require the user pay a one-time or annual license fee. The exception is a free, publicly available resource called the Economic Input-Output Life-Cycle Assessment (EIOLCA) model developed by Carnegie Mellon University's Green Design Institute.

For a supply chain inventory, EIOLCA is used as a database of GHG emissions factors, or carbon intensities (MT CO_2e / $1,000,000 spent) for different types of economic sectors that produce a variety of different types of goods and services. Appendix B includes a list of common sectors and compares their carbon intensities. The formula below is used to estimate total carbon dioxide emissions equivalents (CO_2e) for various types of purchasing categories. The estimate stems from multiplying the quantity of purchases, or spend, (the first term) by carbon intensity of a given economic sector per dollar spent (the second term). The product of this equation is then summed across purchasing categories to estimate total supply chain emissions of an organization.

$$\$ \bullet \frac{CO_2e}{\$} = CO_2e$$

$ = Annual expenditure, by the type of good or service provided by an organizations financial records.
CO_2e / $ = Carbon intensity (or emissions factor) for a type of good or service from EIOLCA.
CO_2e = Final estimate of total emissions for a given type of good or service.

EIOLCA, and other similar tools, are used extensively in supply chain GHG inventories, which serve as the primary data for this analysis. In addition, the EIOLCA model is used in the last section of this report to explore the emissions details for select economic sectors for purchasing categories found to have consistently large emissions.

For more information about the EIOLCA tool and methodology visit www.eiolca.net. In addition, a detailed "How-To" manual that describes the methodology for conducting a supply chain GHG analysis using EIOLCA will be part of the West Coast Climate and Materials Management Forum's *Climate Friendly Purchasing Toolkit.*

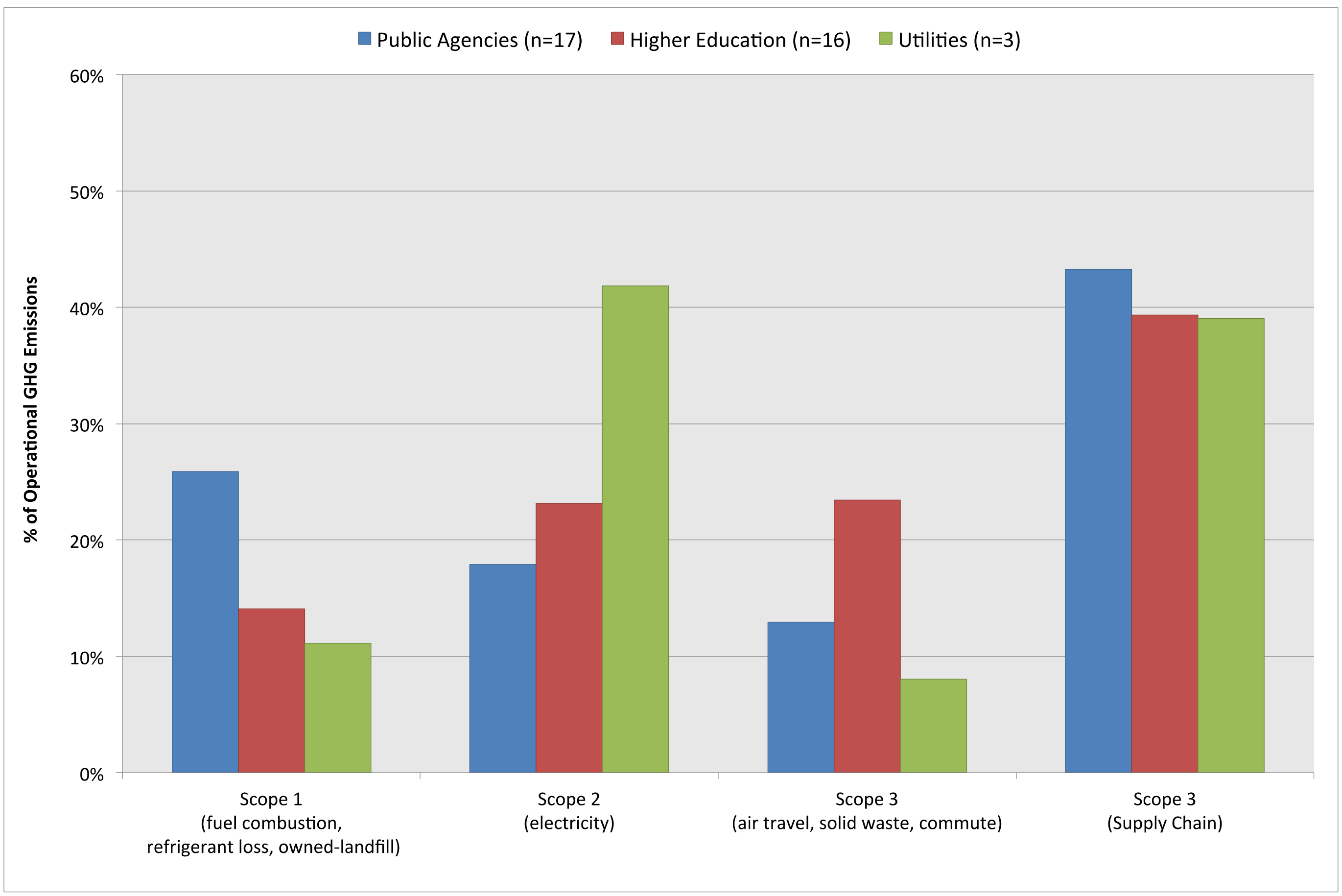
[3] Source: WRI/WBSCD Greenhouse Gas Protocol, Corporate Value Chain (Scope 3) Accounting and Reporting Standard

Results

The database of supply chain GHG inventories, created for this meta-analysis, provides a means to group and compare the results in a number of ways. Figure 5 provides the highest-level comparison of the data set – supply chain emissions versus other grouped sources of emissions (Scope categories), by organizational type. The following points summarize the major findings from Figure 5.

- **Supply chain is the largest source of GHG emissions for most organizational types.**
    - Total supply chain emissions can vary significantly year-over-year depending on the amount spent on construction and maintenance during the inventory year. See Figure 2 for an example of this variability.
- Public Organizations - Scope 1 emissions are relatively large compared to the other organizational types. This finding is driven by fuel combustion from a county-owned transit authority and methane emissions from a landfilled owned and controlled by a regional government.
- Utilities - Scope 2 emissions (electricity consumption) slightly exceeds supply chain emissions. This finding is the result of the type of utilities included in the inventory, which are predominately water utilities. Water utilities (drinking water and wastewater) consume significant quantities of electricity during pumping and treatment. A single electric utility is included in this analysis, but its important to note that their Scope 2 emissions in Figure 5 are limited to the electricity consumed at their operational facilities, but DO NOT include emissions from electricity generation owned, contracted or traded.
- Higher Education - Other Scope 3 emissions (not including supply chain) are relatively large and are driven by GHG emissions from student and employee commutes and air travel.

Figure 5: Percentage of total emissions by organizational type and emissions category.
Note: Each column color on graph sums to 100%.



Results by Groupings

Supply chain emissions were grouped and analyzed by three different groupings. Other grouping variables are included in the database, but were not used due to potential, significant discrepancies in the accounting methodologies used by individual organizations, particularly for employees and square footage. The groupings analyzed in this report were selected for data accuracy and value to the intended audience of this report. See Figure 6 – 8 for results of grouping analysis.

General Findings (for all groupings)

- Within supply chain, construction and maintenance, is the dominant purchasing category – regardless of organizational type, size, or annual revenue.
- Professional Services are significant portion of total supply chain emissions (at least 10%).
- The purchase of vehciles and equipment represent at least a 7% to total supply chain emissions.
- Office Supplies and Printing typically represent a *very small share* of supply chain emissions (<5%).

Organizational Type

- Within supply chain, Construction and Maintenance, is the dominant purchasing category – regardless of organizational type (between 38% – 56%).
- Professional Services and Community Programs represent a relatively large source of public organizations' supply chain emissions (~27%). This finding is primarily driven by Community Programs by County or regional governments related to their role providing a social-service safety-net for communities.
    - Higher Education and Utilities don't provide Community Programs at the scale or variety of public agencies, but emissions related to Professional Services remains as a relatively large purchasing category for these organizational types (~10%).
- Vehicles and Equipment also represent a relatively large emissions source for public organizations (~19%). Public agencies typically own and use vehicles and equipment to perform public services such as public transit, infrastructure construction and repair, right of way and park maintenance, etc.
- Other Operating Supplies is a relatively large category for higher education and utilities (~15%), but it is difficult to identify precisely what types of materials are included for a given organization and are significant across organizations. Other Operational Supplies typically represents a wide variety of materials. Appendix B provides examples of common EIOLCA economic sectors for operational supplies.
- Food, lodging, and transport are a relatively large category for higher education (~10%). This category is not as large for public or utilities, with the exception of a regional government that operates facilities with food operations (conference facility and entertainment venue).

Population Served (Figure 7)

- Within supply chain, Construction and Maintenance, is the dominant purchasing category – regardless of the population served. That said – the Construction category represents a greater share of supply chain emissions for organizations serving a population of less than 100,000 (~50%) compared to populations greater than 100,000 (~30%). This finding corresponds with a significant increase in Professional Services and Community Programs for Public Agencies serving larger populations.
- Professional Services and Community Programs relative emissions are larger for organizations with populations served greater than 100,000. The driver for this finding are the Community Programs provided by County and Regional governments serving large populations who tend to provide social safety-net programs.
- Note: This figure combines data from public agency and higher education organization types, but excludes utilities due to lack of data on population served.

Annual Revenue (Figure 8)

- Within supply chain, Construction and Maintenance, is the dominant purchasing category – regardless of annual revenue. That said – the construction category represents a greater share of supply chain emissions for organizations with annual revenue of less than $500,000 (~50%) compared to a budget of more than $500,000 (~35%).
- Like the previous groupings Professional Services and Community Programs (~14%) and Other Operating Supplies (~16%) represent significant purchasing categories.
- Note: This figure combines data from public agency and higher education organization types, but excludes utilities due to lack of readily available revenue data.

Results by Groupings

Figure 6: Percentage of supply chain emissions, by organizational type, and purchasing category.
Note: Each column color on Figures 6 - 8 sums to 100%

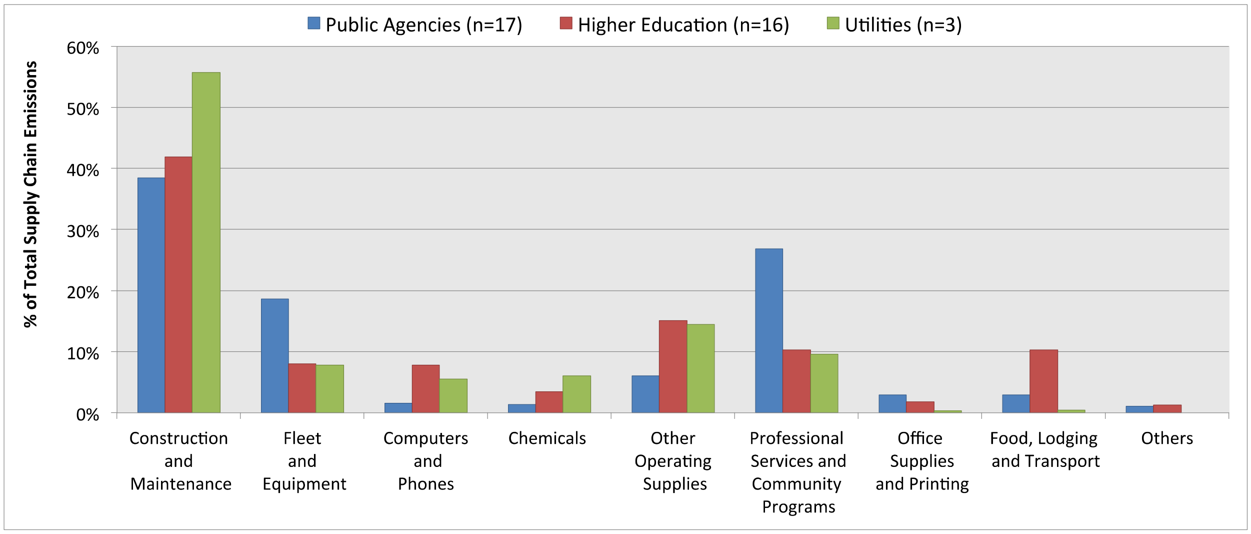


Figure 7: Percentage of supply chain emissions by population served and purchasing category.
Note[1]: Utilities are excluded as well as three organizations without population data.

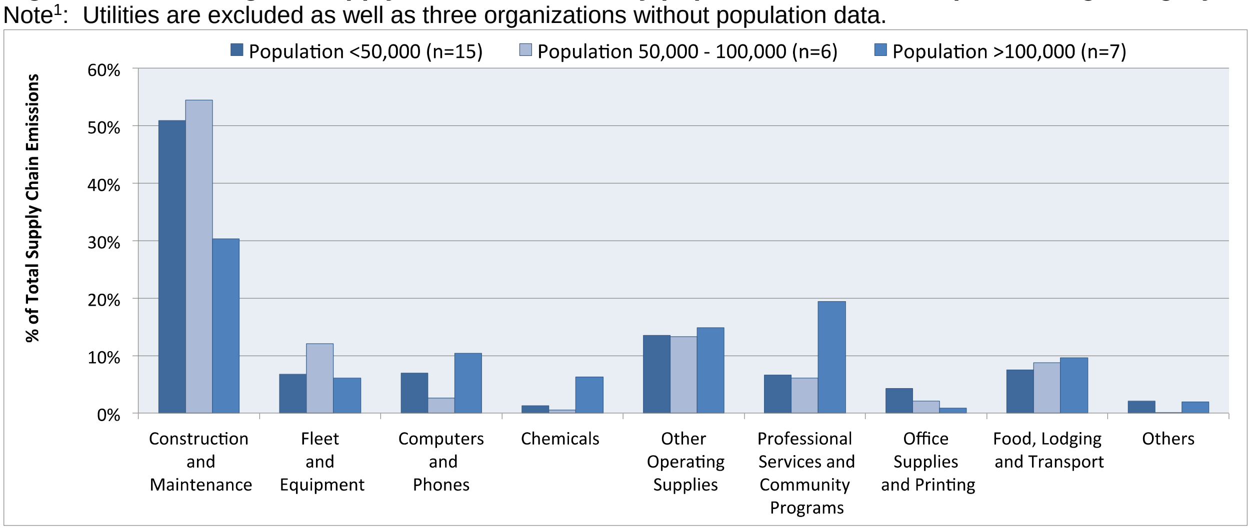
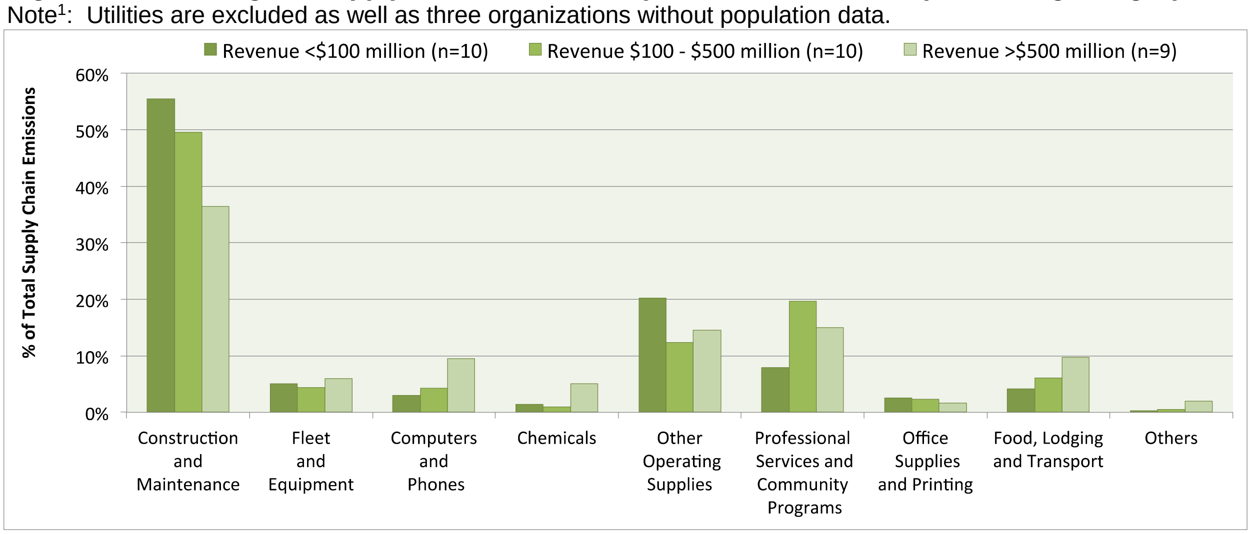


Figure 8: Percentage of supply chain emissions by annual revenue and purchasing category.
Note[1]: Utilities are excluded as well as three organizations without population data.



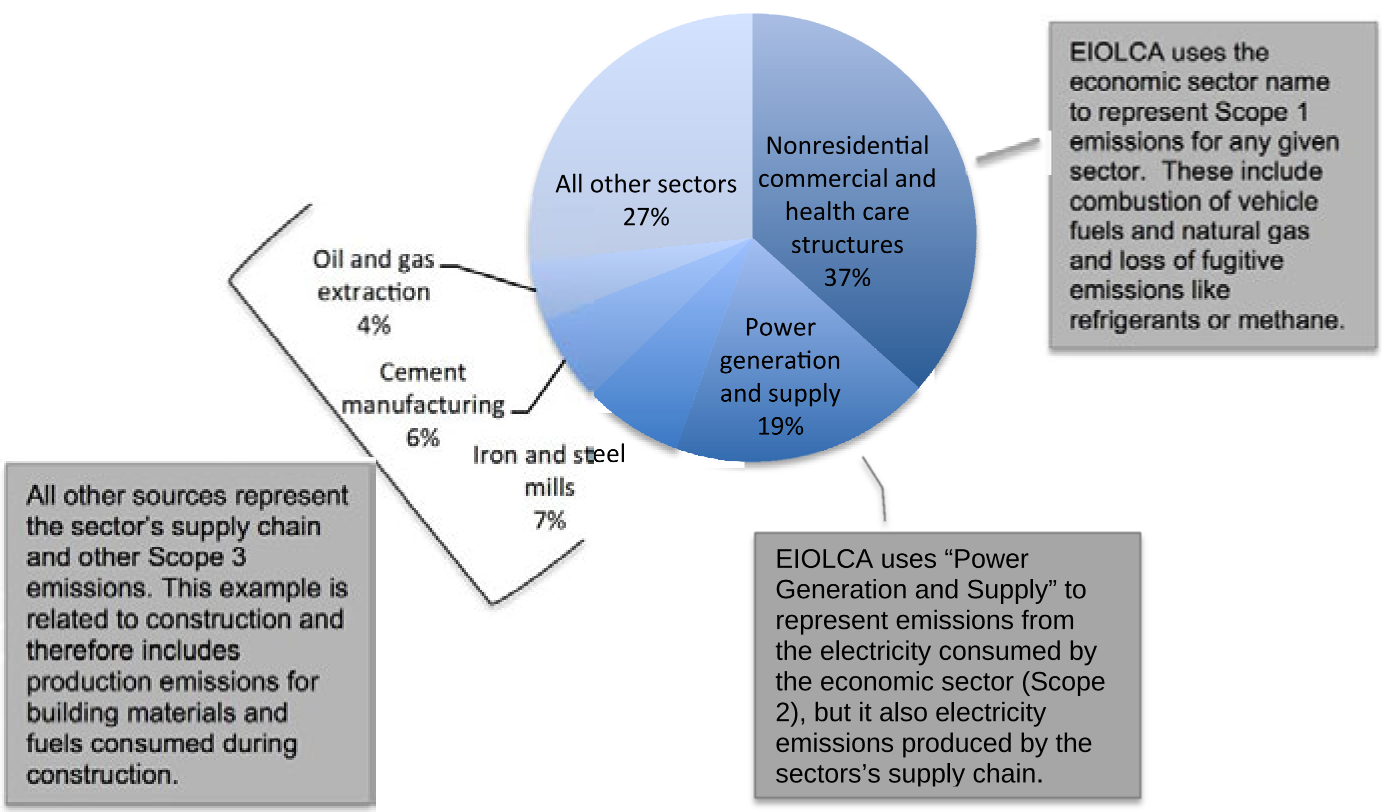
Detailed EIOLCA Results for Select Purchasing Categories

For public organizations, two purchasing categories stand out as significant in the meta-analysis – Construction and Maintenance and Professional Services and Community Programs. In this section we use the EIOLCA model to better understand what products and practices are driving the GHG emissions for these two purchasing categories. The EIOLCA model provides a summarized carbon intensity for 492 economic sectors of the U.S. economy (MT CO2e / $ spent). These summarized carbon intensities are used as emissions factors in a supply chain GHG inventory. The EIOLCA model also provides details about the sources of emissions that make up the summarized carbon intensity for any given economic sector. That additional detail is what will be considered in this section.

The emissions details in EIOLCA are similar and presented in a form that can be compared to the Scope emissions categories previously explained in the Methodology section. Figure 9 shows the top 6 emissions catagories for one economic sector in EIOLCA, "Nonresidential Commercial and Health Care Structures". In EIOLCA, Scope 1 emissions are called by the sector name, which are the direct emissions from the sector itself. The example sector used in Figure 9, which is engaged in construction of commercial buildings, has significant direct GHG emissions (37%) from the combustion of fuel by trucks and equipment. Scope 2 emissions, in the EIOLCA model, are represented by the "Power Generation and Supply" sector (19% of emissions). This sector represents emissions from the electricity being consumed by the sector (e.g. Nonresidential Commercial and Health Care Structures) *as well as* the electricity being consumed by the sector's supply chain. The remaining emissions details in the EIOLCA results may be thought of as Scope 3, which will include the goods and services purchased for the sector's supply chain; landfill emissions from the sector's waste disposal; business travel; etc.

By looking at this level of detail, we are able to identify GHG emissions reduction opportunities. For example, direct emissions from construction activities represent ~30% of the total GHGs for the construction-related economic sectors in EIOLCA (Figures 9-11), so policies and incentives to promote use of low-carbon fuels, or more efficient equipment by contractors represent potential opportunities to lower the carbon intensityof construction related services. The following sections of this report use figures similar to Figure 9 to examine the emissions details for EIOLCA economic sectors commonly used in supply chain GHG inventories for Construction and Maintenance and Professional Services and Community Program purchasing categories..

Figure 9: Example of emissions details for one economic sector in EIOLCA.



Construction and Maintenance – Category Details

The Construction and Maintenance purchasing category in the meta-analysis consistently represented the largest source of supply chain emissions. The details of the three most prevalent EIOLCA economic sectors used in supply chain GHG inventories are compared in Figures 10 – 12. These pie graphs represent the 6 largest sources of emissions for each sector. Figure 10 is specific to nonresidential commercial construction; Figure 12 considers nonresidential maintenance and repair; and Figure 12 considers other nonresidential structures (e.g. roads, water infrastructure, electricity infrastructure, bridges, etc.). A variety of economic sectors, including those related to Construction and Maintenance, are compared in Appendix B.

The largest source of emissions for each of the figures is the sector name, which may be thought of as Scope 1 emissions for the sector. These emissions represent the direct emissions from that sector – for construction and maintenance these emissions will be dominated by fuel combustion. The second largest named sector is Power Generation and Supply, which are the emissions from electricity generation that serves the sector as well as the electricity that is used throughout that named sectors supply chain.

After those sources of emissions – a few items of notes are consistent for the EIOLCA economic sectors related to Construction and Maintenance.

- Cement manufacturing
- Oil and gas extraction
- Iron and steel mills

These graphics provide high-level insight for how to approach emissions reductions associated with the Construction and Maintenance purchasing category.

- Specify the use of recycled content products. Concrete and asphalt are common, GHG intensive construction materials that have market-ready, low-GHG substitute materials such as blast-furnace slag or fly ash, which also provide performance improvements and may reduce material costs.
- Specify energy efficiency and lower-GHG processes for material production. For example, warm-mix asphalt processing provides a 7% reduction in GHG emissions per short ton compared to hot mix asphalt.
- Purchase low-GHG fuels (e.g. waste grease biodiesel) and electricity (e.g. PV solar or wind generation).
- Purchase and specify that contractors utilize energy-efficient and low-emissions vehicles and equipment

These and other emissions reduction opportunities will be addressed in the *Climate Friendly Purchasing Toolkit,* which is currently in development and will be released in mid-to-late 2015.

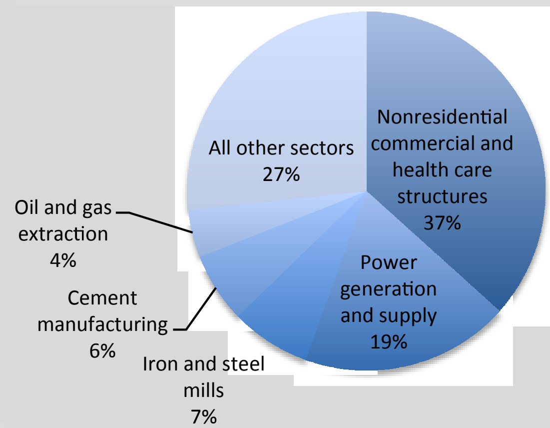


Figure 10: Nonresidential Commercial Construction – breakdown of sector emissions.

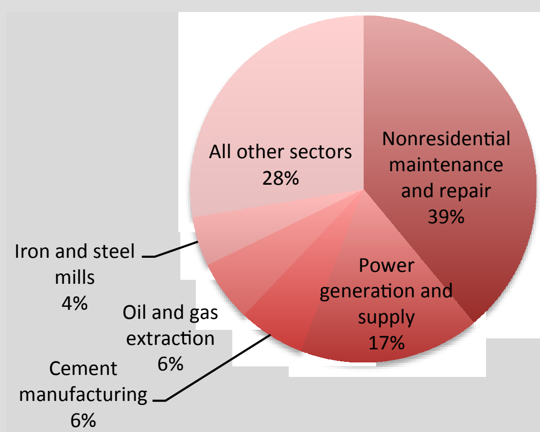


Figure 11: Nonresidential maintenance and repair.

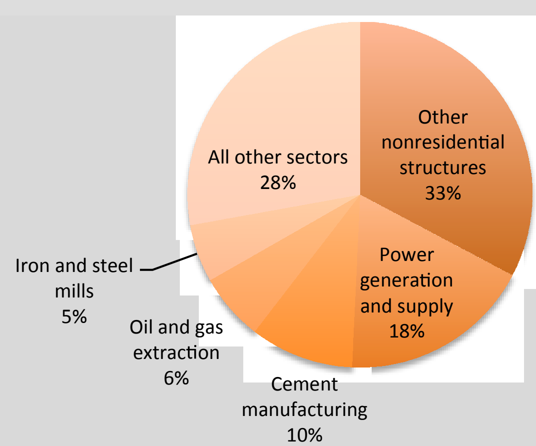


Figure 12: Other nonresidential structure construction (includes infrastructure construction).

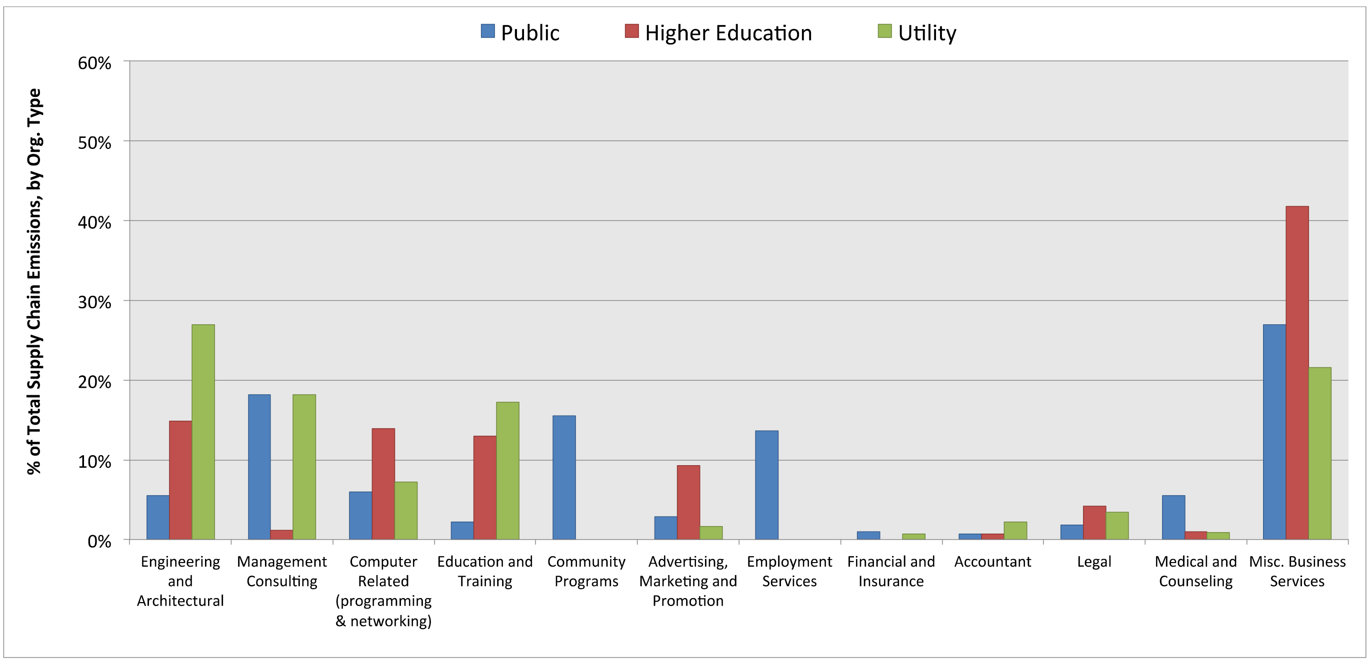
Professional Services – Category Details

Professional services and Community Programs make up a relatively large percentage of many organizations' annual budgets. While the carbon intensity of these services is lower than construction – the amount of dollars spent on this category, particularly by public organizations, make it a significant purchasing category. A variety of economic sectors, including those related to Professional Services, are compared in Appendix B.

A breakdown of professional service types is not available for all the inventories included in the meta-analysis. Specifics on Professional Services is available for 22 of the 36 total inventories used in this analysis. Figure 12 shows a breakdown of service types for all 22 inventories. As can be seen, Engineering and Architecture, Employment Services and Management Consulting represent the top 3 service sectors in the supply chain inventories.

Figure 13 shows the percentage of emissions for various service sectors by organizational type. For public organizations services are dominated by Management Consulting, Community Programs, and Employment Services. For higher education institutions, services are dominated by Engineering, Computer-Related, and Education and Training. Finally for utilities, services are dominated by Engineering, Management Consulting, and Education and Training. All organizational types had a significant portion of their service budget that was not classified in their accounting systems (~20% - 42%).

Figure 13: Percentage of supply chain emissions by organizational type and service category.



To further explore the Professional Services and Community Programs purchasing category, the details of the three most prevalent EIOLCA economic sectors related to this category are compared in Figures 14 – 16. These pie graphs represent the 6 largest sources of emissions for each sector. Figure 14 is specific to community programs; Figure 15 considers architecture and engineering services; and Figure 16 considers management consulting services.

The largest source of emissions (excluding "All Others") for each of the figures is Power Generation and Supply. All of these services are supported by buildings and other facilities and equipment that consume electricity in order to bring these services to the marketplace. The 2nd largest source of emissions for Community Services and A&E services is the sector name, which is primarily emissions from fuels combusted in owned vehicles, buildings, and equipment.

After those sources of emissions – a few items of note are specific to the different services.

- Community services: Cattle ranching and farming ranks as a relatively large source of emissions in this sector, presumably related to food service.
- A&E and Management Consulting: Air travel for business ranks as a relatively large sector for these sectors.
- All sectors: The combustion of oil and gas products is a significant source of GHG emissions, but the extraction of these products also releases significant "upstream" emissions.

These graphics provide high-level guidance of how to approach emissions reductions associated with the Professional Services and Community Programs purchasing category.

- Specify that contractors or inquire about their use of energy efficient vehicles and equipment
- Specify or inquire about their use of low-GHG fuels and renewable sources of electricity.
- Specify that when possible meetings are conducted via phone or video conference instead of in-person when it involves air travel.

These and other emissions reduction opportunities will be addressed in the *Climate Friendly Purchasing Toolkit,* which is currently in development and will be released in mid-to-late 2015.

Figure 14: Community food, housing and relief services – breakdown of sector emissions.

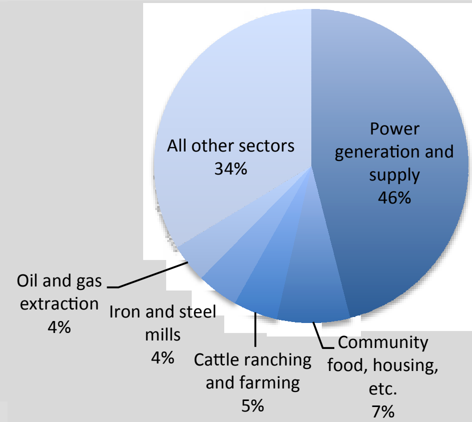


Figure 15: Architecture and engineering services

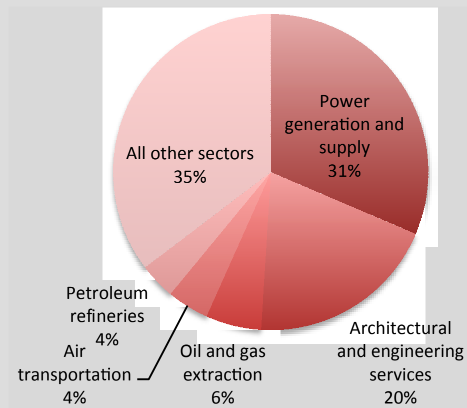
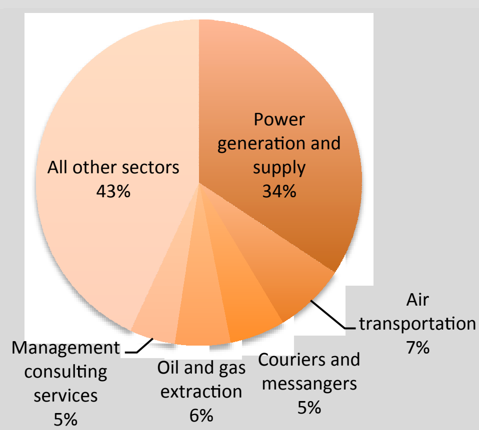


Figure 16: Management consulting services.



Appendix A: Comparing the Carbon Intensity of EIOLCA Economic Sectors

Figure 17 provides economic sectors commonly selected in a supply chain GHG analysis for the purchasing categories used in this meta-analysis. This table may be used by interested parties to compare the GHG-intensity (MT CO_2e / $1 million spent) of specific items within a single purchasing category. This comparison could be used to inform and guide supply chain GHG reduction initiatives.

Figure 17: List of Greenhouse Gas Inventories included in the meta-analysis.

Purchasing Category / EIOLCA Sector	Total GHG Emissions MT CO_2e / $1 million	Carbon Dioxide (CO_2) MT CO_2e / $1 million	Methane (CH_4) MT CO_2e / $1 million	Nitrous Oxide (N_2O) MT CO_2e / $1 million	HFC / PFC MT CO_2e / $1 million
Construction & Maintenance					
230101: Nonresidential commercial and health care structures	589	545	29	10	4
230103: Other nonresidential structures	612	559	38	10	5
230301: Nonresidential maintenance and repair	624	572	36	10	6
561700: Services to buildings and dwellings	491	389	91	7	3
Vehicles and Equipment					
336111: Automobile Manufacturing	563	493	42	13	15
336112: Light Truck and Utility Vehicle Manufacturing	603	532	42	12	17
336120: Heavy duty truck manufacturing	682	613	46	9	15
333120: Construction machinery manufacturing	651	588	45	6	12
333112: Lawn and garden equipment manufacturing	611	552	38	7	13
337127: Institutional furniture manufacturing	647	579	41	12	14
33721A: Office furniture manufacturing	464	410	31	18	4
337215: Showcases, partitions, shelving, and lockers	892	808	55	15	14
333414: Heating equipment (except warm air furnaces) manufacturing	660	601	41	6	12
333415: Air conditioning, refrigeration, and warm air heating equipment	581	527	34	5	14
333911: Pump and pumping equipment manufacturing	563	510	33	5	15
Computers and Phones					
334111: Electronic computer manufacturing	284	244	18	3	18
334210: Telephone apparatus manufacturing	316	272	21	4	19
334220: Broadcast and wireless communications equipment	322	277	21	4	21
Chemicals and Operating Supplies					
325510: Paint and coating manufacturing	1,070	910	100	38	26
325190: Other basic organic chemical manufacturing	2,720	2,238	216	203	66
325610: Soap and cleaning compound manufacturing	812	677	81	34	20
313310: Textile and fabric finishing mills	1,130	960	83	79	10
33221B: Handtool manufacturing	782	715	44	6	18
336300: Motor vehicle parts manufacturing	757	671	51	13	21
811300: Commercial machinery repair and maintenance	263	230	23	4	6
811200: Electronic equipment repair and maintenance	190	166	14	2	8
8111A0: Automotive repair and maintenance, except car washes	328	292	26	4	5
339111: Laboratory apparatus and furniture manufacturing	414	368	30	8	8
339112: Surgical and medical instrument manufacturing	314	280	23	6	5
Professional and Community Services					
541300: Architectural and engineering services	186	166	15	3	2
541610: Management consulting services	129	113	13	2	1
541511: Custom computer programming services	183	168	12	2	2
561300: Employment services	88	79	7	1	1
541100: Legal services	99	88	9	2	1
611B00: Other educational services	194	171	20	2	2
562000: Waste management and remediation services	2,570	327	2,210	30	5
541800: Advertising and related services	239	214	19	4	2
624200: Community food, housing, rehabilitation services, and other relief services	325	271	38	14	2
Office Supplies, Printing and Paper					
339940: Office supplies (except paper) manufacturing	535	472	38	15	11
33331A: Vending, commerical, industrial, and office machinery manufacturing	567	505	44	7	11
325910: Printing ink manufacturing	1,200	1,014	147	19	20
322120: Paper mills	1,520	1,394	85	32	12
323110: Printing	546	489	39	11	6
Food, Lodging and Transport					
722000: Food services and drinking places	580	442	82	52	4
7211A0: Hotels and motels, including casino hotels	559	492	53	10	3
484000: Truck transportation	1,400	1,326	67	3	3
481000: Air transportation	1,980	1,881	98	4	3
485000: Transit and ground passenger transportation	1,870	1,720	136	7	7

Appendix B: List of Supply Chain GHG Inventories used in this Analysis

Figure 18 provides a summary of the organizations and the source of the information related to their supply chain GHG inventories. This list may be useful parties interested in exploring a single GHG inventory in greater detail.

Figure 18: List of Greenhouse Gas Inventories included in the meta-analysis.

Public	Link to Document
Portland, OR - Parks and Recreation Average	Not publically available.
Tualatin Hills, OR - Parks & Recreation District Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Eugene, OR Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Vancouver, WA Average	Not publically available.
Gresham, OR Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Hillsboro, OR Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Beaverton, OR Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Corvallis, OR Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Lake Oswego, OR Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Springfield, OR Average	https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/4185/greenhse_gas_inven.pdf
Orange County, CA - Transportation Authority Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Washington County, OR Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Alameda County, CA Operational Average	DRAFT data as of this writing provided by Alameda County staff.
Portland Metro Regional Government	http://www.goodcompany.com/services/implementation/baseline/past-participants/
East of England Local Authorities Average	http://www.sustainabilityeast.org.uk/wp-content/uploads/2014/07/sustainability-east-trucost-report-5.pdf
Minnesota Pollution Control Agency Average	http://www.pca.state.mn.us/index.php/view-document.html?gid=20329
Oregon DEQ Operational Average	DRAFT data as of this writing provided by ODEQ staff.
Higher Education	**Link to Document**
Higher Education Funding Council for England (HEFCE) Average	NEED LINK.
Portland Community College	http://www.goodcompany.com/services/implementation/baseline/past-participants/
University of California - Berkeley Average	http://www.aashe.org/files/resources/student-research/2009/doylek_thesis_ucb_2009_supply_chain_carbon_footprint_no_appendix_oct_2012.pdf
University of Cambridge Average	http://www.environment.admin.cam.ac.uk/files/university_of_cambridge_scope_3_element_1_final.pdf
De Montfort University Average	http://www.dmu.ac.uk/documents/about-dmu-documents/dmu-estate/environmental/dmu-carbon-management-plan.pdf
Nottingham Trent University Average	http://www.ntu.ac.uk/ecoweb/document_uploads/165140.pdf
Yale University Average	www.emeraldinsight.com/1467-6370.htm
University of Oregon Average	http://www.ous.edu/sites/default/files/dept/capcon/files/ous_fy2012_ghg_inventory_reportfinal061013.pdf
Southern Oregon University Average	http://www.ous.edu/sites/default/files/dept/capcon/files/ous_fy2012_ghg_inventory_reportfinal061013.pdf
Eastern Oregon Univeristy Average	http://www.ous.edu/sites/default/files/dept/capcon/files/ous_fy2012_ghg_inventory_reportfinal061013.pdf
Western Oregon University Average	http://www.ous.edu/sites/default/files/dept/capcon/files/ous_fy2012_ghg_inventory_reportfinal061013.pdf
Oregon State University Average	http://www.ous.edu/sites/default/files/dept/capcon/files/ous_fy2012_ghg_inventory_reportfinal061013.pdf
Portland State University Average	http://www.ous.edu/sites/default/files/dept/capcon/files/ous_fy2012_ghg_inventory_reportfinal061013.pdf
Oregon Institute of Technology Average	http://www.ous.edu/sites/default/files/dept/capcon/files/ous_fy2012_ghg_inventory_reportfinal061013.pdf
University of Texas - Austin Average	Not publically avaialbe.
University of North Carolina - Willmington Average	Not publically available.
Oregon Health and Science University	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Utilities	**Link to Document**
Joint Water Commission Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/
Eugene Metropolitan Wastewater Management Commission Average	http://www.mwmcpartners.org/Meetings/Agendas/2013-Agendas/6-14-13-Agenda/Item8-GHG.pdf
Eugene Water and Electric Board Average	http://www.goodcompany.com/services/implementation/baseline/past-participants/

Appendix C: Summary of Meta-Analysis Spreadsheet

Figure 19 provides the details of the meta-analysis spreadsheet including: organization, type of organization, population served, annual revenue, GHG inventory emissions data, and supply chain emissions data. This list may be useful parties interested in exploring a single GHG inventory in greater detail.

Figure 19: Summary organizational attributes and emissions data for supply chain GHG inventories included in the meta-analysis.

Organizational Information					Operatonal GHG Emissions Summary				Supply Chain GHG Emissions Summary									
Name of Organization	Type of Organization	Population Served	Annual Revenue (millions of $)	Total Spend (millions of $)	Scope 1 Emissions	Scope 2 Emissions	Scope 3 (minus Supply Chain)	Scope 3 (Supply Chain)	Construction and Maintenance	Fleet and Equipment	Computers and Phones	Chemicals and Safety Equipment	Other Operating Supplies	Professional Services	Office Supplies and Printing	Food, Lodging and Transport	Community Programs	Others
Joint Water Commission Average	Utility	250,000	na	na	11	15,908	843	4,294	717	0	0	1,722	1,727	102	25	0	0	0
Eugene Metropolitan Wastewater Management Commission Average	Utility	218,190	na	na	6,179	6,585	1,482	4,735	3,047	500	0	0	940	248	0	0	0	0
Eugene Water and Electric Board Average	Utility	218,190	na	na	1,936	8,114	3,566	19,539	12,155	1,732	1,574	0	1,456	2,396	85	142	0	0
Higher Education Funding Council for England (HEFCE) Average	Higher Education	na	$707	na	590,000	1,330,000	1,470,000	2,129,836	649,271	96,196	256,368	157,018	359,199	338,900	0	230,770	0	42,114
Portland Community College Average	Higher Education	28,631	$89	$60.93	9,851	10,986	21,350	26,302	11,236	2,554	502	215	2,658	2,449	1,689	5,000	0	0
University of California - Berkeley Average	Higher Education	36,204	$2,160	$500.00	na	na	na	127,186	34,203	25,725	18,745	0	0	6,430	16,566	16,516	0	9,001
University of Cambridge Average	Higher Education	5,576	$1,825	na	19,467	53,533	46,283	133,603	35,918	14,269	12,272	10,190	26,304	11,271	4,900	9,962	0	8,517
De Montfort University Average	Higher Education	27,000	$138	na	3,131	8,164	20,229	16,235	7,226	0	1,650	275	2,285	3,677	296	277	0	549
Nottingham Trent University Average	Higher Education	43,765	$520	na	na	na	11,696	29,480	6,141	619	4,375	795	3,850	8,033	1,686	2,647	0	1,334
Yale University Average	Higher Education	11,443	$2,848	$1,500.00	na	na	na	315,400	253,300	8,800	7,800	0	0	11,000	0	34,500	0	0
University of Oregon Average	Higher Education	24,181	$595	$188.35	26,724	27,656	22,858	70,273	28,038	1,596	4,505	0	23,820	6,402	5,912	0	0	0
Southern Oregon University Average	Higher Education	4,800	$50	$31.09	4,491	4,576	6,292	13,080	4,985	193	868	0	5,985	582	467	0	0	0
Eastern Oregon University Average	Higher Education	2,785	$24	$7.60	3,655	3,672	2,823	3,527	867	85	310	0	1,920	186	159	0	0	0
Western Oregon University Average	Higher Education	4,996	$61	$29.19	4,045	3,774	5,239	12,629	4,651	465	1,027	0	5,642	482	362	0	0	0
Oregon State University Average	Higher Education	19,753	$587	$212.95	35,989	39,861	27,836	89,648	33,766	4,911	6,722	0	36,171	3,742	4,336	0	0	0
Portland State University Average	Higher Education	21,453	$324	$123.94	7,777	21,421	20,992	43,564	25,009	1,655	2,774	0	9,800	2,907	1,419	0	0	0
Oregon Institute of Technology Average	Higher Education	2,350	$29	$19.44	323	3,375	2,923	8,148	3,193	940	354	0	3,127	202	332	0	0	0
University of Texas - Austin Average	Higher Education	51,325	$1,237	$2,017.31	241,655	37,982	38,602	258,828	132,425	34,532	7,944	0	36,443	13,631	6,043	27,811	0	0
University of North Carolina - Wilmington Average	Higher Education	16,891	$149	$33.46	10,471	30,430	21,087	15,011	10,540	0	1,822	0	822	744	1,006	77	0	0
Portland, OR - Parks and Recreation Average	Public	538,091	$100	$24.58	5,023	8,292	7,247	8,773	4,443	711	81	0	1,907	862	246	61	462	0
Tualatin Hills, OR - Parks & Recreation District Average	Public	na	$41	$11.16	3,758	3,019	1,713	5,839	4,258	472	210	0	264	344	0	193	0	98
Eugene, OR Average	Public	155,088	$335	$40.36	3,033	5,566	1,109	29,596	18,725	273	1,022	1,201	3,512	3,298	162	1,221	157	24
Vancouver, WA Average	Public	159,111	$130	$69.38	5,934	7,671	4,952	22,317	16,317	1,810	430	245	1,682	1,622	112	100	0	0
Gresham, OR Average	Public	96,996	$286	$55.01	1,659	12,125	2,642	11,422	7,545	1,504	72	0	826	1,288	174	14	0	0
Hillsboro, OR Average	Public	94,807	$91	$49.57	na	na	na	24,025	16,525	775	0	1,375	4,075	575	0	0	700	0
Beaverton, OR Average	Public	95,538	$87	$29.36	1,568	4,287	2,295	14,613	12,563	592	357	199	240	226	176	83	179	0
Corvallis, OR Average	Public	55,298	$121	$31.01	3,598	11,803	na	4,220	0	946	48	92	1,321	1,430	0	166	217	0
Lake Oswego, OR Average	Public	37,610	$54	$26.20	1,449	9,414	12,015	10,983	6,480	0	0	0	1,757	2,746	0	0	0	0
Springfield, OR Average	Public	60,177	$62	$27.08	1,485	1,701	1,928	7,914	5,723	331	130	0	0	1,336	123	14	0	258
Orange County, CA - Transportation Authority Average	Public	3,114,000	$1	na	88,172	4,361	27,824	69,760	24,556	31,137	0	0	2,604	11,035	0	0	85	342
Washington County, OR Average	Public	538,394	$355	$66.03	6,878	11,535	4,452	25,882	3,253	874	520	0	664	119	386	20	20,049	0
Alameda County, CA Operational Average	Public	1,510,271	$2,594	$736.19	na	na	na	178,063	42,134	13,007	0	0	0	12,682	14,564	4,032	87,400	4,244
Portland Metro Average	Public	2,314,554	$206	$70.77	19,500	14,849	5,183	21,721	5,362	954	0	0	1,775	2,097	865	10,057	145	468
East of England Local Authorities Average	Public	na	na	$0.00	na	na	na	16,200	8,675	0	350	0	0	2,375	0	1,550	3,250	0
Minnesota Pollution Control Agency Average	Public	na	na	$96.00	na	na	na	48,709	363	11,110	7,428	4,693	10,976	6,662	5,568	0	0	1,909
Oregon DEQ Operational Average	Public	na	na	$0.00	1,548	4,582	551	6,866	24	452	308	0	0	2,248	85	202	3,472	75