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The application of a multi-faceted approach for evaluating and improving the life cycle environmental performance of service industries

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ABSTRACT

Service industries continue to be to be a driving force economically, both within the US and globally, yet their environmental impacts still tend to be overlooked. This article presents a hybrid life cycle assessment case study to assess and quantify the life cycle impacts of an engineering service firm. The data for the hybrid LCA of the firm's activities and operations was collected for one fiscal year, from January 2009 to December 2009. Data collection methods include an energy audit, personnel survey, and assessment of waste management practices. The results of the case study show that the impacts of employee travel and transportation as well as the building premises are the major contributors to the environmental impact of a service industry (40% and 24% of GWP, respectively) and should be the areas targeted for improvements to reduce life-cycle impacts of similar service firms. The study also reveals that in order to make specific targeted reductions to a firm's life-cycle impacts, more in depth evaluation of certain activities, such as workstation energy consumption, can be essential to identifying unnecessary wastes of resources.

1. Introduction

In the United States alone, service industries account for nearly 76% of the total Gross Domestic Product (BEA, 2011). Although the economic impacts of services are apparent, the environmental impacts of service industries are generally not as well known and are often overlooked (Rosenblum et al., 2000). While service industries may seem more environmentally friendly than manufacturing industries, service industries require significant flows of material and energy. These material and energy flows result in environmental impacts which are directly attributable to the upstream and downstream effects of the activities of service industries (Suh, 2006a,b). The majority of environmental regulation focuses on industries with more visible environmental impacts, such as manufacturing or mining, as their environmental effluents are generally obvious. The tendency to overlook the environmental loadings associated with service industries is likely due to their lack of point source emissions. This paper presents a framework for quantifying the life-cycle environmental impacts of an engineering consulting service firm, details improvements to reduce the largest impacts, and evaluates the implementation of the improvements.

There are a disparate number of tools and methods that could be applied to assess the environmental performance of service industries. These methods include: the Greenhouse Gas Protocol (GHG Protocol) from the World Resource Institute, Publicly Available Specification (PAS) 2050 from the British Standards Institute, ISO 14064 from the International Organization for Standardization (ISO), and the method of composed of financial statements (MC3) from Spain (World Resource Institute, 2004; ISO, 2006a,b; BSI, 2008; Carballo-Penela and Doménech, 2010). The GHG Protocol is one of the most widely recognized tools for evaluating the environmental performance of governments and businesses, but it is limited strictly to the quantification of GHGs and overlooks other environmental impacts, such as eutrophication or smog. Similarly, ISO 14064 is a specification regarding the guidance of quantifying and reporting GHG emissions only. PAS 2050 and MC3 are both life cycle assessment (LCA) based approaches for evaluating the impacts of goods or organizations.

LCA is a method used to quantify the environmental impacts of a given product, process, or service throughout its entire life cycle from raw materials extraction to end of life (ISO, 2006a,b). Multiple organizations have established guidelines for performing detailed LCAs including the US Environmental Protection Agency (USEPA), the Society for Environmental Toxicologists and Chemists (SETAC) and ISO, (Fava et al., 1991; Vigon et al., 1992; UNEP/SETAC, 2005; ISO, 2006). PAS 2050 is a process LCA based tool that, similar to the

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tools above, calculates a carbon footprint (CF) for a product or process. MC3 is described as an organization based LCA tool, also with the goal of assessing the CF of goods and businesses (Carballo-Penela and Doménech, 2010). MC3's approach calculates the CF of a corporation through assessing financial records and converting all of the products consumed by a company into mass units by using the specific product average price in the period under study (i.e. monetary unit/kg). The reliance on financial records helps to more quickly assess a business or products environmental impacts, but again focuses solely on carbon footprinting. Other LCA tools exist, such as SimaPro and GaBi; while these tools are often used for products, they can be applied to service industries (PE International, 2011; Pré Consultants, 2011).

Although historically used to assess products or processes often related to manufacturing, there are a handful of LCAs of service industries in the literature. The applicability of traditional process LCA to assessing service industries has been questioned due to data availability, difficulty in setting and determining system boundaries, and practicality associated with time constraint (Graedel, 1997). The issues of determining system boundaries make it difficult to capture the Scope 3 emissions, i.e. the indirect emissions that result from the companies' upstream and downstream supply chains (Ranganathan et al., 2004). The impacts of Scope 3 emissions have been shown to be a large contributor to service companies' environmental profiles, often accounting for more than 75% of an industry's carbon footprint (Huang et al., 2009; Downie and Stubbs, 2011). Although data availability and modeling have improved, the effectiveness of process LCA can still be limited when used to assess service industries, due to the complexity of the evaluated services and the difficulty of attributing impacts to the monetary flows that propel service industry revenue.

Economic Input–Output Life Cycle Assessment (EIO–LCA), an alternative or supplement to process LCA, was developed in part to address some of the issues of process LCA (Hendrickson et al., 1998). EIO–LCA combines environmental data with an economic input–output (I–O) model to determine primary energy, economic, and environmental releases associated with producing a product. EIO–LCA has also been used to assess the impacts of services, as it is better suited to deal with the impacts of financial flows to capture the Scope 3 emissions (Rosenblum et al., 2000; Suh et al., 2003). However, it too, has limitations associated with high levels of aggregation, as well as potential uncertainty and thus, is often used as an effective high level screening tool (Lenzen, 2000; Bilec, 2007).

Hybrid LCA offers the ability to combine the strengths of both process and I–O based LCA approaches in order to avoid some of the issues associated with both methods (Bilec et al., 2006; Horvath, 2006; Suh, 2006). Hybrid LCA allows for flexibility within the inventory of the assessment, which aids in setting appropriate boundaries and data collection. Hybrid LCA is often used to assess production of products such as laptops, incorporating economic data where process manufacturing or material data is unavailable or proprietary (Deng et al., 2011). The flexibility of hybrid LCA has proven to be valuable when working with assessing impacts of companies, since not all of the inputs have directly accountable mass and energy values. Hybrid LCA has been used to assess marine shipping services companies and found that the majority of impacts result from direct operations, but that the supply chain has significant impacts (Ewing et al., 2011). Hybrid LCA has also been utilized to evaluate the impacts of ambulance services in Australia, again finding that direct impacts from fuel use and manufacturing were major components of the life cycle impact, but indirect impacts also contributed significantly (Brown et al., 2012). Most similar to this study, Junnila used hybrid LCA to assess the impacts of select service sector based companies (e.g. banking and consulting) within Europe and the US (Junnila, 2006, 2007). The method presented and utilized in this research takes a similar approach to that used by Junnila in evaluating and reducing the environmental impacts of service industries, and the findings of this study are compared to Junnila's findings.

2. Approach and data collection

The goal of this paper is to develop a framework to assess the environmental impacts of service sectors. A hybrid LCA of an engineering consulting firm was conducted to establish the framework and identify major environmental impacts of a service industry. The hybrid LCA approach was selected for its ability to attribute life cycle impacts to monetary flows, which a major portion of the life cycle inventory inputs consisted of. The economic data collected from financial records complimented the process data, and provided a more refined picture than would be possible with process or EIO–LCA alone. Using the results from the LCA, improvements were identified and implemented.

The case study evaluated Gewalt Hamilton Associates Incorporated (GHA), a civil and environmental engineering and consulting firm. GHA is headquartered in the suburbs of Chicago and supports a full time staff of 75 employees as well as 10–20 seasonal interns. GHA had no specific existing environmental sustainability programs, however it had expressed a desire to improve the sustainable performance of their operations. Data for the hybrid LCA of GHA's activities and operations was collected for one fiscal year, from January 2009 to December 2009. Additionally, follow up data to monitor the effectiveness of the facility and program improvements was collected as the changes were implemented, and again one month after implementation to assess the impact of the improvements.

2.1. Data collection and hybrid LCA framework

For organizational purposes, five categories of the engineering company's activities were defined: *purchased services*, *building premises*, *travel and transportation*, *office and field equipment*, and *office supplies* as illustrated in Fig. 1. The scope of the hybrid LCA included all of the material, waste, and energy flows as well as monetary flows for fiscal year 2009. Salary was excluded as it was as it was determined to be outside the scope of the study, and GHA had little control over how employee salary was spent. Different data collection approaches for each category were employed to obtain the necessary LCI data to construct a hybrid LCA. Table 1 summarizes the process data sources and assumptions. Where process data or inventory were unavailable, EIO–LCA was used. All of the data assessed using EIO–LCA was collected from financial records and general ledger data, and was then matched to the corresponding sectors designated by the North American Industry Classification System (NAICS), summarized in Table A.1 in Appendix A. The NAICS classification system is the method for classifying businesses in order to collect and assess data related to the US economy and its performance.

The data collected for the hybrid LCA is discussed in more detail in subsequent sections. Primarily, data was obtained from financial records, utility bills, billable miles and related services, solid waste, personnel survey, and an energy audit. The personnel survey obtained information on employee commuting habits and workspace energy use habits. The energy audit collected plug load data for office equipment, quantified employee electricity use, and modeled the building premises and its components to generate the energy profile and consumption of the building facilities. The model was validated by comparing the model results to the actual energy consumption acquired from the utility bills for the office during the corresponding time period.