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Evaluation of Australian companies' scope 3 greenhouse gas emissions assessments☆

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ABSTRACT

As the dominant producers of industrial greenhouse gas (GHG) emissions, companies have a vital role to play in efforts to mitigate global warming. Focussing on scope 1 and 2 emissions alone can distort a firm's GHG estimates as scope 3 emissions often constitute a significant part of its overall GHG footprint, up to seventy-five percent in many firms. Lack of knowledge of scope 3 emissions inhibits a firm's ability to pursue the most cost-effective carbon mitigation strategies. This paper investigates the methods and data currently used by Australian organizations to assess their scope 3 emissions. The exploratory study found a wide discrepancy in the number of emission sources reported. In addition there was a general lack of rigour in determining which emission sources to include. This suggests that more comprehensive guidance on relevant emission sources by industry or sector would likely improve the completeness and relevance of inventories in accordance with The Greenhouse Gas Protocol.

1. Introduction

The build-up of greenhouse gases in the atmosphere as a result of human industrial and agricultural activity is changing the earth's climate which is projected to intensify water security problems, cause significant loss of biodiversity and cause a decline in agricultural productivity in many countries (Intergovernmental Panel on Climate Change, 2007). Large corporations have a vital role to play in efforts to mitigate global warming as the dominant producers of industrial greenhouse gas (GHG) emissions (known as 'direct' or scope 1 emissions). However, all organizations have a significant role to play in mitigating global warming from the GHG emitted throughout their value chain, or supply chain (known as 'indirect' or scope 2 and scope 3 emissions). Sanchez et al. (2010) found that focussing on scope 1 and 2 emissions alone can distort a company's GHG estimates as scope 3 emissions often constitute a significant part of a company's overall GHG footprint. Huang et al. (2009c) estimate that scope 3 emissions account for up to seventy-five percent of total direct and indirect emissions for a vast majority of businesses.

An assessment of scope 3 emissions increases understanding of a company's full GHG emissions exposure, allowing it to evaluate the financial impacts of the introduction of a carbon price (such as the European Emissions Trading Scheme and the Carbon Pollution Reduction Scheme proposed by the Australian government). Lack of knowledge of scope 3 emissions will inhibit a firm's ability to pursue the most cost-effective carbon mitigation strategies (Matthews et al., 2008). Thus including scope 3 in an emissions assessment reveals where the best opportunities lie for mitigation, regardless of whether they occur within the organization's boundary or with third party suppliers (Huang et al., 2009c; Lenzen and Murray, 2009). Nevertheless, "[a]lthough scope 3 emissions are widely known to be important, they are rarely estimated because they are not well understood, and there is little motivation or technical capacity to do so in current carbon footprint protocols" (Huang et al., 2009c: p. 8509). Some research has been undertaken to assess scope 3 emissions for specific industries and cities (Higgs et al., 2009; Hillman and Ramaswami, 2010; Huang et al., 2009b; Steuer, 2010). There are also a number of studies which use the input–output analysis methodology to measure greenhouse gas emissions (Andrew and Forgie, 2008; Gallego and Lenzen, 2005; Huang et al., 2009c; Lenzen, 2002, 2008b; Lenzen and Murray, 2009; Lenzen et al., 2007; Munksgaard and Pedersen, 2001;

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Peters, 2008). The Economic Systems Research journal devoted a special issue in 2009 to IOA and carbon footprints (Minx et al., 2009; Wiedmann, 2009).

This paper presents the results of an exploratory study of the methods and data currently used by Australian organizations to assess their scope 3 emissions. It aims to increase understanding of how organizations presently address scope 3 emissions. The paper first reviews the available academic and industry literature and then describes the methods used to collect and evaluate the data, before providing an analysis of the results. Finally, it offers some overall conclusions and theoretical implications of the research.

2. Greenhouse gas emissions assessments

Scholars reinforce the benefits of corporations understanding their greenhouse gas emissions (GHGE) (Hoffman and Woody, 2008; Lash and Wellington, 2007; Pinkse and Kolk, 2009). As such, scholars have explored: how to define 'carbon footprint' (Burtis and Watt, 2008; Hammond, 2007; Jarvis, 2007; Wiedmann and Minx, 2008); how to assign responsibility for GHGE, particularly between producers of goods and services and intermediate or final consumers (Andrew and Forgie, 2008; Bastianoni et al., 2004; Lenzen, 2008a; Lenzen, et al., 2007; Munksgaard and Pedersen, 2001; Peters, 2008); the issue of double-counting emissions (Lenzen, 2008a; Lenzen, et al., 2007; Matthews et al., 2008; Murray and Dey, 2009); and, what sources should be included in a greenhouse gas assessment (Hoffmann and Busch, 2008; Huang et al., 2009c; Lenzen and Murray, 2009; Matthews et al., 2008; Wiedmann and Minx, 2008).

Two approaches to measuring GHGE widely recognized in academic literature are process analysis (PA) and input–output analysis (IOA). PA involves detailed analysis of the production process and the contribution of process inputs from the supply chain (Lenzen, 2002). IOA is a top–down macroeconomic technique using monetary transactions data to map interdependencies between industry sectors (Lenzen, 2002). A further method integrating these two approaches and overcoming some of the shortcomings of each is known as hybrid life-cycle analysis (HLCA) (e.g. Lenzen, 2002; Minx et al., 2007; Wiedmann, 2009). All three methodologies can be applied to an organizational assessment, although HLCA offers the most benefits and fewest limitations for the organizational setting if it is available (Huang et al., 2009a; Lenzen, 2002; Suh et al., 2004). HLCA uses IOA as a screening tool to determine the most significant individual scope 3 emission sources. It enables further analysis of significant sources using PA and accounts for the full upstream supply using IOA, thus avoiding boundary cut-offs (Murray et al., 2010).

Guidance is available for assessing scope 1 and 2 emissions, such as The GHG Protocol developed by the World Business Council for Sustainable Development (WBCSD) and World Resources Institute (WRI) (2004), and the International Organization for Standardization's (ISO) International Standard 14064-1 (2006). Both these are targeted at large corporations and multi-nationals. Much of their content, such as boundary setting, control and acquisitions, is less relevant to smaller organizations. Both provide examples of scope 3 emissions however little information has been published to guide practitioners on which scope 3 emissions sources are relevant to particular organizations (Hoffmann and Busch, 2008). Huang et al. (2009c) conclude that further characterization of scope 3 emissions is necessary to achieve reductions. The GHG Protocol is the most highly regarded guidance for greenhouse gas assessments (Hoffmann and Busch, 2008; Kolk et al., 2008). A supplement to The GHG Protocol for scope 3 accounting and reporting is already available in draft version, with a final version anticipated to be released in 2011 (World Business Council for Sustainable Development and World Resources Institute, 2010).

Table 1
Guidance publications on greenhouse gas reporting.

Author/Institution	Release Year	Title
Putt del Pino & Bhatia (WRI)	2002	Working 9-5 on Climate Change: An Office Guide
WBCSD & WRI	2004	The GHG Protocol – Revised Edition
Putt del Pino et al. (WRI)	2006	Hot Climate, Cool Commerce: A Service Sector Guide to Greenhouse Gas Management
Carbon Trust (UK)	2007	Carbon foot printing: An introduction for Organizations
Burtis, B & Watt, I Clean Air Cool Planet	2008	Getting to Zero: Defining Corporate Carbon Neutrality
Department of Climate Change (Australia)	2009	National Carbon Offset Standard
DEFRA & DECC (UK)	2009	Guidance on how to measure and report your GHG Emissions
DEFRA & DECC (UK)	2009	Small Business User Guide: Guidance on how to measure and report your GHG Emissions
Publications on Guidance Under Development		
WBCSD & WRI	2010	Corporate Value Chain (Scope 3) Accounting and Reporting Standard – Draft for Stakeholder Review November 2010
Emission factor Information		
WBCSD & WRI	2005	Calculating GHG Emissions from Mobile Sources v1.3
Department of Climate Change (Australia)	2010	National Greenhouse Accounts Factors: July 2010
DEFRA (UK)	2010	2010 Guidelines to DEFRA/DECC's GHG Conversion Factors for Company Reporting
Ministry for the Environment (NZ)	2009	Guidance for Voluntary, Corporate Greenhouse Gas Reporting – Data and Methods for the 2008 Calendar Year

In the Australian context, the Department of Climate Change and Energy Efficiency introduced the National Carbon Offset Standard in 2009, which primarily refers to the scope 1 and scope 2 reporting standards of the National Greenhouse and Energy Reporting (NGER) framework. Whilst scope 1 and 2 guidance of the NGER framework is highly prescriptive, the supplemental guidance on scope 3 in the National Carbon Offset Standard is extremely limited. It sets a minimum standard of including business travel, waste and paper and recommends consideration of supply chain impacts of consumed products and services as well as outsourced activities (Department of Climate Change, 2009). The National Carbon Offset Standard is not a prescriptive guidance for scope 3, nor does it set a high standard as evidenced by the substantial surpassing of this threshold by some of the participants in the research study reported on in this paper. A publication by the University of Sydney and CSIRO (Foran et al., 2005) provides comprehensive results of input output analysis on 135 sectors of the Australian economy and includes total GHGE[2] among the four environmental indicators analyzed for each sector.

While there are several GHGE assessment guidance documents that are publicly available (see Table 1), the most prescriptive GHGE assessment guide is the UK Department for Environment, Food and Rural Affairs (DEFRA) *Guidance on how to measure and report your GHG Emissions*. The DEFRA (2009, 2010) guidance is based on The GHG Protocol and includes emission factors for scope 1 and 2 emissions. It also covers supply chain emissions (scope 3) and provides guidance on converting financial expenditure into mass of

[2] Not broken down by scope.

CO_2 equivalence for the six greenhouse gases listed in Annex A of the Kyoto Protocol.[3] This allows organizations to calculate emissions without needing supplier cooperation or detailed analysis of units of use, both of which are frequently unavailable. Whilst DEFRA cautions against using this emission factor information for business operations or organizations outside the UK, its comprehensive set of guidelines is more accessible to business people than other guidelines. Further improvement of this could be made if these were refined to industry specific factors and guidance and if non-UK factors were added (Huang et al., 2009c).

To date, the academic and practitioner literature has not published which or how many scope 3 emission factors constitute a comprehensive assessment, either generally or within specific sectors or industries. There is little analysis of embodied emissions of goods and services and the inclusion of these in GHGE assessments. Some debate has arisen surrounding cut-off threshold levels for GHGE assessments or whether IOA should be used so that such measures are not necessary and constraints to a more comprehensive assessment are reduced (Busch, 2010, 2011; Murray et al., 2011). This paper evaluates current scope 3 emissions assessment practices of Australian companies in order to increase understanding of what methods are applied and sources are currently included in a GHGE assessment in Australia.

A more comprehensive understanding of an organization's GHGE footprint can result in a more effective corporate climate change policy but the added complexity involved can reduce the number of organizations willing or able to take part (Matthews et al., 2008). By collecting and publishing information on current practices in GHGE assessments, a secondary objective of the research study is to contribute to raising the standard and reducing the barriers to conducting quality assessments of scope 3 emissions, in order to aid overall GHG reductions (Huang et al., 2009c).

3. Methods

The research study gathered data from Australian organizations that are undertaking scope 3 emissions assessments. Potential organizations were identified by:

- Conducting internet searches to find companies who had conducted GHGE assessments;
- Contacting companies already known to the researchers that had conducted scope 3 emissions assessments;
- Using referrals from other respondents (snowballing) (Minichiello et al., 1995).

Organizations that had included some scope 3 emissions in their GHGE assessment and that had conducted a self-assessment rather than engaging external consultants were approached to participate in the research study. An assumption was made that organizations which had used external consultants would not have made their own decisions on emission source inclusion and also would not be able to nominate the emission factors used to convert their activity data to emissions. Nonetheless, during the course of the interviews it was established that while this was often the case, some organizations had received partial support from consultants but still made key decisions and performed the necessary calculations themselves. A staff member that could provide detailed information on the methodological decisions and data selection was interviewed from each organization. In some cases, participants couldn't provide full information on the history of decisions or methods as they had inherited an existing process. In the majority of cases, however, the participant was the principal architect or decision maker in both establishing and managing the assessment process.

Forty-nine organizations were approached to participate in the research study. Twenty-two agreed to participate in the study. Semi-structured interviews were held with each participant to gather data on: the motivation for the organization to conduct a scope 3 assessment; the process for selecting emissions sources; what information sources they used to guide their selection; specific emission sources included and excluded; emissions factors used; and whether the assessment was independently verified or reviewed. Nineteen face-to-face interviews and three telephone interviews were conducted in April–May 2010. Table 2 provides details of the participants. Where permission was granted, interviews were recorded in addition to the notes taken by the researchers, to ensure accuracy of data.

Data were collected on scope 3 inclusions and exclusions by asking research participants about their firm's inventory of emissions sources. The emission source data was collated into a spreadsheet to enable counts and percentages to be calculated (see Table 3). The qualitative responses were organized into themes to understand, for example, why sources were included or excluded.

4. Results

All of the respondents' emission inventories used an abbreviated form of PA to compile their inventory in the three scopes format

Table 2
Research Participants.

ID	Respondent	Employees (Full Time Equivalent Count)	Use of External Consultant[a]
1	Printer	10–100	Inventory Inclusions and Emission factor Sources
2	Recruiting Consultant	<10	Inventory Inclusions and Calculations
3	Engineering and Sciences Consultant 1	1000–10,000	None
4	Regulator	100–1000	None
5	University	1000–10,000	Formal but supporting role only
6	Bank	10,000+	Informal
7	Superannuation Provider	100–1000	None
8	Environmental NGO 2	10–100	None
9	Consultant	1000–10,000	None
10	Engineering and Sciences Consultant 2	1000–10,000	None
11	Environmental NGO 1	100–1000	Inventory Inclusions and Calculations
12	NGO 1	10–100	None
13	Telecommunications Provider	10,000+	None
14	Water Utility	100–1000	None
15	Transport Infrastructure Provider	100–1000	None
16	Fast Moving Consumer Goods Producer	10,000+	None
17	Architectural Services Provider	<10	Emission factor Sources and Calculations
18	Retailer	100–1000	None
19	Municipal Government	100–1000	None
20	Statutory Resource Management Authority	10–100	None
21	NGO 2	1000–10,000	None
22	Beverage Producer	<10	Informal

[a] Does not include use of external consultants for verification of completed inventories.

[3] Carbon dioxide, methane, and nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride.

Table 3
Emission Sources Reported by Respondents.

Emission Source	Respondent ID																					Times Reported
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Flights		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●		●	●		19
Waste		●		●	●	●	●	●		●	●	●	●	●	●		●		●	●	●		16
Paper	●	●	●	●	●	●	●	●	●		●	●		●			●	●					14
Staff/Contractor Vehicles		●	●		●	●	●	●	●	●	●			●	●		●	●	●				14
Fuel, Gas & Electricity Scope 3			●	●	●	●	●	●		●		●	●	●	●								11
Taxis			●	●	●	●		●	●	●	●		●										9
Base Building Emissions	●	●	●	●			●	●												●			7
Couriers	●	●	●	●	●		●																6
Hire Cars					●	●			●	●	●							●					6
Public Transport		●		●			●		●			●											5
Water Supply & Wastewater Treatment	●		●	●	●	●																	5
Hotel Accommodation			●			●			●				●										4
Computer Equipment	●	●	●																				3
Employee Commuting				●				●											●				3
Freight	●															●						●	3
Office Furniture & Fixtures		●	●																				2
Office Stationary and Consumables	●	●																					2
Packaging	●																					●	2
Phones/Internet Usage	●	●																					2
Postage		●					●																2
Printing (if calculated differently to Paper)		●		●																			2
Catering			●																				1
Cleaning	●																						1
Electricity for POS Equipment																●							1
Equipment	●																						1
Events				●																			1
Fire Extinguishers					●																		1
Ink & Chemicals	●																						1
Planting Activities								●															1
Product Usage															●								1
Livestock					●																		1
Refrigerant Loss from POS Equipment																●							1
Repairs	●																						1
TOTAL Emission Sources	13	13	12	12	11	9	9	9	7	6	6	5	5	5	5	4	4	4	3	3	2	2	
Total scope 3 as % of Total Emissions	65	*	59	41	23	28	24	61	*	46	83	81	15	9	90	*	64	15	9	48	45	*	

*Undisclosed.

stipulated by The GHG Protocol. Whilst PA is typically applied to life-cycle analysis (LCA) of a product, firms in this research study selected and measured inputs in a twelve-month period to determine their associated emissions. In some cases this extended to measuring emissions associated with the inputs to products or services used by the firm. In all cases, emissions were calculated on the basis of quantifying particular goods or activities and applying (in one or a series of steps) emission factors to determine the contribution of each good or activity as a discrete entry in their inventory.

Only one respondent made reference to IOA in the course of their interview. This respondent had conducted a pilot program using an external consultant to conduct the IOA. The respondent reported that they returned to a simple PA method as the IOA yielded significantly lower total emissions than they had already publicly reported.

4.1. Analysis of emissions sources

As can be seen in Table 3, there was a wide variation in the number of activities reported under scope 3, from a low of two to a high of thirteen inclusions. Table 3 summarizes the emission sources reported by the research participants and is not an exhaustive list of all possible scope 3 emissions. The reporting of a higher number of emission sources could be a strong indicator of a more comprehensive assessment, and thus better attainment of the principle of completeness required by The GHG Protocol for a quality assessment. For this to hold true however, the sources included must be those most relevant to the organization in terms of their magnitude, and an evaluation of relevance was outside the scope of this research study.

For example, with only three sources of scope 3 emissions included, the Municipal Government could be mistakenly believed to have omitted a high number sources, making their inventory incomplete. In reality however, the high consumption of electricity for street lighting and running municipal buildings and recreational facilities makes most scope 3 sources insignificant by comparison. In reporting nine sources of emissions the Bank appears to have a more comprehensive inventory. Nonetheless omitted sources such as computer equipment purchases or postage may have been significantly larger than their included sources of hire cars or water supply, thus their higher number of reported sources may be obscuring the omission of more significant sources. The relevance of each emission source is likely to vary significantly from industry to industry.

4.2. Inclusion decisions

Some participants had accessed, either formally or informally, external consultants to help in choosing inventory inclusions (see

Table 2), four participants left the determination of inventory inclusions to a single individual within the firm, and the remainder had engaged in some internal discussions to arrive at their inventory. Half the respondents reported that their inventory inclusions were limited by the availability of activity data and an overwhelming majority of twenty participants had no formal criteria for determining which emission sources to include in their inventory. Four reported that their decisions on which sources were significant to the business were entirely subjective. These responses indicate a clear lack of methodology by the research participants for compiling their inventories.

The data in Table 3 shows which are the most popular scope 3 emission sources, namely flights, waste, paper, and staff/contractor vehicle use. Conversely, computer equipment purchases, postage and phone/internet usage appear infrequently, even though these activities could be expected to be as ubiquitous in organizations as the first group. With one exception, the frequency of inclusion of the first (popular) group relative to the second (less popular) does not appear justified by the significance of the popular emission sources in each respondent's emissions profile, as discussed below.

For eleven of the sixteen respondents reporting flight emissions, these accounted for five percent of more of total reported emissions. By contrast, waste emissions accounted for one percent or less for eight of the fourteen respondents including this source, with a further four reporting it was one to two percent of total emissions. Paper emissions were disclosed by twelve respondents, with only four reporting that this constituted over one percent of total emissions. If the printer and two other organizations producing high frequency billing/statements to large numbers of customers are excluded, there is only one respondent with more than one percent of total emissions arising from paper. Of the eight respondents disclosing their staff/contractor vehicle emissions, six reported values of less than one percent.

Whilst computer equipment, postage and phone/internet usage were not reported with enough frequency to draw any inferences regarding their general significance, on the few occasions they were reported they appeared to have at least the same level of materiality to the organizations as waste, paper, and staff/contractor vehicle use. In addition to recording the emission sources included by each respondent, information was also collected on which sources were knowingly omitted from the inventory for various reasons. Most respondents perceived a need, or had a wish, to further extend their emissions inventory, if only by a few sources. Overall however, those respondents reporting fewer emission sources did not, on average, report higher numbers of omitted sources than those already reporting a high number of sources. Participants were asked to describe impediments to including emission sources and what emission sources they excluded. Reasons given for excluding sources included:

- The limited availability of activity data within the organization for the source excluded (used as the reason for excluding nineteen emission sources across all participants);
- Inability to find emission factor information to convert the activity units to emission values (used nine times);
- Perceived or measured immateriality to the business (used five times); and,
- The emission sources were classified as a personal responsibility (used seven times, most commonly in relation to employee commuting).

The research study found that most organizations see a need, or have a wish, to further extend their emissions inventory.

4.3. Sources of information

The National Greenhouse Accounts (NGA) Factors (Department of Climate Change and Energy Efficiency, 2010) is predominantly an information source for scope 1 and 2 emission factors but it also addresses some scope 3 sources such as distribution losses in electricity transmission and waste to landfill. It is also applicable to other scope 3 sources either directly (e.g. fuel use in staff or contractor vehicles) or indirectly (e.g. as part of a sequence of conversions for using taxis or couriers where actual attributable fuel use is not known). To test whether utilization of this resource was a contributing factor to some organizations including more emission sources than others, the frequency of use of this source was analyzed.

Fifteen out of twenty-two participants used the NGA Factors, as shown by the cross-hashed portions of the columns in Fig. 1. Some of these participants made use of this source for a number of emission factors, resulting in a total of forty-nine uses of NGA Factors emission conversion factors (thirty-six percent of the total count of all emission factors used across the twenty-two participants).

As can be seen in Fig. 1, not all participants using this publication as a source included high numbers of emissions in their assessment, so its use alone does not appear to contribute to reporting a higher quantity of emission sources. Fig. 1 also indicates that there is no apparent over-representation of use of the NGA Factors by those companies with high counts of emission sources.

The Victorian Environment Protection Authority's (EPA) (2009) work on measuring emissions was listed as the source of eleven inclusions (eight percent) by seven participants (as indicated by the solid grey portions of the columns in Fig. 1). Once again there was no apparent over-representation of this source by those organizations with high counts of emission sources.

A third item identified as a possible contributor towards a high number of inclusions was the use of expenditure in dollars as a unit of measure of an activity. Some participants stated that they could not obtain useful activity data for emission sources such as taxi travel, couriers or telecommunications. Others calculated a mass of CO_2-e per dollar spent for these same sources, seemingly overcoming the challenges in gathering activity data. Participants either found suitable single step conversion values for mass of CO_2-e per dollar spent,[4] or used a conversion from dollars to some other unit of measurement which could then be converted to CO_2-e. To examine whether these alternative approaches contributed to some participants reporting more emissions sources than others, the number of source inclusions based on expenditure were counted for each respondent. Nine of the twenty-two participants used at least one expenditure based activity measure, as denoted by the solid black portions of the columns in Fig. 1. Even discounting the one participant who placed very high reliance on expenditure as a measure of activity data, there is a clear bias in the use of this method by organizations reporting higher number of emission sources.

Eighteen of the twenty-two participants used other information sources to calculate emissions, as shown by the white column portions in Fig. 1, accounting for fifty-three emissions sources in total (thirty-eight percent). These results indicate that there is not a clear standard or guideline being utilized by the participants for

[4] Popular sources included Foran, Lenzen, DeyForan, B., Lenzen, M. and Dey, C., 2005. Balancing Act: A triple bottom line analysis of the Australian Economy. University of Sydney and CSIRO, Canberra, Australia; and values derived from emissions and financial disclosures of either governing bodies or dominant industry suppliers.

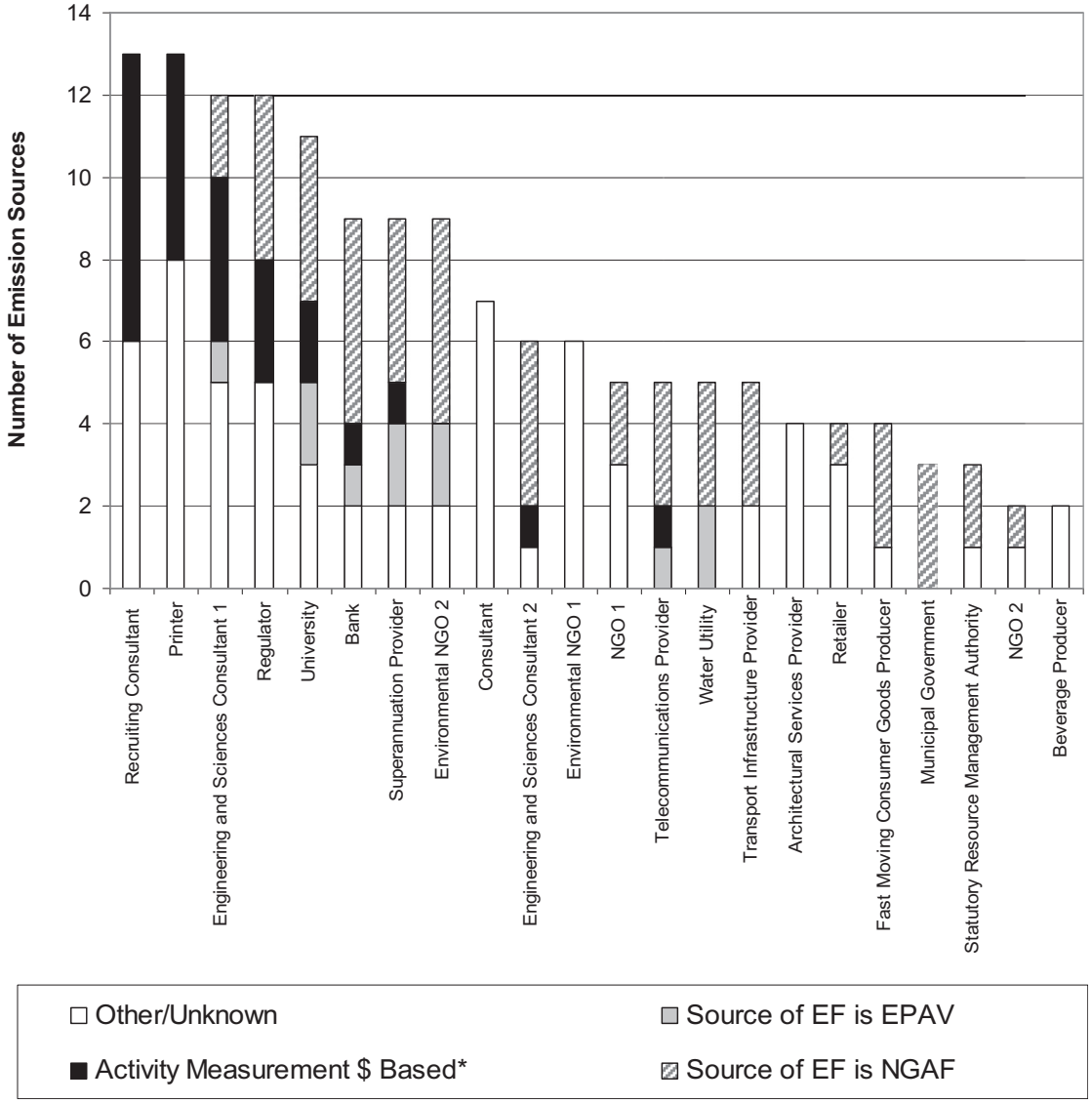

Fig. 1. Summary of emission factor sources by respondent. *Use of dollar based activity units overlaps on three occasions with the use of the NGA Factors (NGAF) or EPA Victoria (EPAV) as source of the Emission Factor (EF) but they are shown here as a mutually exclusive for the sake of simplicity.

what emission sources to include, or conversion factors to use, in a scope 3 assessment. Furthermore, there is no single information source which provides a complete, nor comprehensive, set of emission factors. Nonetheless, the use of dollars of expenditure as a measure of activity for several sources does differentiate organizations reporting higher numbers of emission sources from those reporting lower numbers sources.

5. Discussion

Analysis of the count of inclusions and exclusions of the scope 3 assessments of the research participants shows a wide disparity in the number of included emission sources. Between two and thirteen scope 3 sources were reported. The group of participants reporting higher numbers of sources did not generally rely on a particular sourcebook to achieve these results, although they did all rely on utilizing expenditure as a form of activity measurement for several sources.

Further analysis of the availability of emission factor information showed that the accessibility of both an emission factor and reliable activity data did not necessarily result in that source being included. Equally, participants who included fewer emission sources showed no greater ambition to add emission sources to their inventory than those who were already reporting a much larger number of emission sources – the number of desired additions to respondents' inventories were the same for both groups.

Lastly, sixteen emission sources that one or more participants desired to include, but had been unable to for various reasons, were already being reported by other participants. This indicated that these information barriers were not universal to all participants.

Minx et al. (2009: p. 201) observed that for many organizations "establishment of a comprehensive carbon footprint account, including all scope 3 emissions, can be an administratively complex, expensive and methodologically challenging task" and that would certainly appear to be the case here. With the exception of flight emissions, the scope 3 emission sources most frequently reported by participants typically represented very small percentages of total GHGE. There was generally a lack of methodology to objectively determine which sources were most relevant to include in an inventory or how many might be required to form

a comprehensive assessment of each organization. Accordingly the presence of errors due to truncation of the inventory, as is often highlighted as a shortcoming of PA (e.g. Lenzen, 2002; Minx et al., 2007), would be expected to be present in the inventories in this research study.

The lack of mention of IOA among the participants suggests that the lack of acceptance of IOA noted by Wiedmann (2009) may be due as much to lack of awareness as to perceived shortcomings. It is possible that the PA method was dominant amongst the respondents because the sample was restricted to participants that had not used external consultants.

Application of HLCA methods has the potential to improve the validity of the respondents' GHGE assessments by ensuring they are comprehensive in capturing all relevant and material sources of emissions to the organization and removing the current subjectivity in emission source selection. An accounting standard which "defines in detail which upstream Scope 3 emissions shall be included… in industry specific terms" (Busch, 2010, p. 375), would also clearly be of benefit to the respondents through the provision of unambiguous guidelines for their inventory inclusions. Nonetheless as each company has a unique scope 3 profile there will still be some relevant emissions sources which are not mentioned even in an industry specific guideline (Huang et al., 2009a). All of which further supports the use of HLCA methodology to avoid the need for thresholds or creation of truncation errors in emissions accounting (Murray et al., 2011).

The lack of uptake of IOA, or of the HLCA, by the respondents to this study, supports the lack of acceptance of this methodology among practitioners noted by Wiedmann (2009). The research study shows that there is little awareness of IOA, but it is acknowledged that the participant selection criteria could have removed those firms using external consultants who employ IOA or HLCA methods. Tools such as Simapro and Bottomline3 might save the user from the need to understand the complexities of HLCA calculation (Minx et al., 2007), but the research participants preferred the simplicity of a spreadsheet tool and using internet searches to find emission factors information. To achieve widespread acceptance of HLCA, it is important that the relevant tools and information to support this methodology are more widely available to practitioners and their advantages more widely promoted.

Whilst the majority of respondents did not achieve scope 3 ratios near the seventy five percent of total GHGE suggested by Huang et al. (2009c), they nonetheless represented a significant portion of total GHGE for most respondents (see Table 3). Methodological improvements by the respondents would be expected to result in more comprehensive assessments and thus increase the ratios of scope 3 to total GHGE over those reported at the time of this study. An area of potentially significant future research would be to compare the inventory results achieved by the abbreviated PA methodology employed by the respondents in this research study with a formal HLCA methodology.

6. Conclusion

The aim of this paper was to report the results of a research study that investigated the methods and data currently used by Australian organizations to assess their scope 3 GHGE. Shedding light on current practice provides further guidance to organizations conducting scope 3 assessments in the future and thereby facilitates more targeted and effective emission reduction efforts.

There was wide variation in the number of scope 3 emissions reported by the respondents and there was a clear lack of methodology to define which sources to include in each organization's GHGE assessment. The reported information barriers for some respondents could possibly have been overcome if they had clearer and more comprehensive guidance, supporting the observations of Busch (2010, p. 375) that "there is a clear need for accounting standards that define in detail which upstream Scope 3 emission shall be included".

The research indicates that the two key areas in which guidance is required are: what sources are material and relevant to their industry to include in a GHGE assessment; and emission factors to convert each activity into expenditure. The new Scope 3 standard from the GHG Protocol should provide more general guidance to alleviate the first of these barriers. An Australian equivalent of the *2010 Guidelines to DEFRA/DECC's GHG Conversion Factors for Company Reporting* (2010) would also help overcome both these barriers by Australian organizations. This would allow organizations to translate their expenditure into emissions across a wide number of categories and thus enable organizations to do their own screening to determine the most material and relevant emission sources. Additional guidelines on likely relevant emission sources for industries and individual sectors would further assist firms to understand their emissions and pursue more cost effective mitigation strategies (Matthews et al., 2008). To assist in the dissemination of the more robust methods advocated by the academic literature and encapsulated by Wiedmann (2009), further research could explore the barriers to higher adoption of these methods.

There a number of limitations of this research study. The small sample size, due to the difficulty in finding organizations that report scope 3 emissions and self-assess, provides only a snapshot of how organizations are identifying scope 3 emissions and conducting assessments. Therefore, definitive conclusions cannot be drawn until further research is done to verify and extend these findings, using larger sample sizes and including consultants. In addition, the snowballing method of participant recruitment may have resulted in bias within the sample, through the recruitment of a particular subset of the population of organizations that have conducted a greenhouse gas assessment. Efforts to collect a broad sample and limited filtering of eligible participants mitigated this to some degree. Additionally, a selection bias could be present if organizations agreeing to participate in the study are not representative of the broader population of organizations that have conducted a greenhouse gas assessment. For example, organizations may have been more inclined to participate if they believed their process and data were robust – firms that were not confident in their assessment processes may have been discouraged from participating.

Without an indication of the total population of companies that have conducted greenhouse gas assessments it is difficult to understand the implications of these limitations. The data and analysis presented here must then be regarded as exploratory, and a first step, which can be built upon with further qualitative and quantitative research studies. Nevertheless, this paper contributes to understanding how firms are currently estimating their scope 3 emissions and the associated challenges. It provides guidance to organizations wishing to understand their GHGE exposure, and to understand more fully the contribution of their business operations to global warming.

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