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## **Pain-free scope 3**

### **Input into Greenhouse Gas Protocol Technical Working Group discussion on sectoral value chain mapping of emissions by purchased categories**

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# Pain-free scope 3

– Input into GHG Protocol Technical Working Group discussion on sectoral value chain mapping of emissions by purchased categories –

## **Summary**

The NY meeting agreed to continue the discussion on determination of significance, relevance and the idea of a 5% -20% threshold for accounting for Scope 3. It was suggested that there could well be some common significant items across all sectors and also that different sectors would have some sector specific items that were significant contributors to emissions. A screening tool would be needed in order to establish this in broad terms and allow for prioritizing at the company level.

The meeting agreed to look at the following sector groups: chemical, oil and gas, publishing and electronics industries. Following the meeting an analysis was carried out by ISA using an input-output approach. The analysis covered 12 sectors representing the nominated groups. From this analysis it is obvious that electricity is a common significant item. It is never lower than rank three in significance. However a surprising finding is that it is not always Scope 2 electricity that is high on the list. In six of the 12 examples below the electricity ranked high in significance is electricity supplied to a supplier of the sector rather than that supplied directly to the sector.

In the case of sector specific items a comparison of: recorded and media publishing; printing and stationery; books, maps, magazines; and newspapers, show that in Australia, softwoods and hardwoods are common as the most significant items. However these only account for around 60% of emissions so unless broad screening takes place to reveal the remaining 40% the many differences lower down the ranking will be missed, reducing the opportunities for abatement.

From another perspective the technical services and natural gas sectors show clearly the between-sector differences of carbon footprints. While 93% of emissions are accounted for in just two items in the natural gas footprint, the top two items of the technical services sector account for only 23% and even the top twenty items only account for 43%. This illustrates the need for a screening tool – one that as well as capturing the top one or two items is able to capture a long list of smaller items that could account for as much as 60% of total emissions. If you were to impose a significance threshold you could miss out on the majority of contributions. For example the top 20 items contributing to the footprint of the data processing services sector (see 4.2 below) make up only 44% of the total emissions. Not only that, but after the 12<sup>th</sup> item every category contributes less than 1% of the total.



## 1 Rationale

The GHG Protocol Scope 3 “What” meeting held in New York 5-6 February 2009 addressed the questions: What constitutes a ‘full list’ of Scope 3 activities and how do we determine which items from such a list are ‘significant’. To address significance ‘what I own, buy, sell, influence or don’t influence’ was suggested as a useful framework. To illustrate part of this framework the group agreed to look at sectoral value chain mapping of emissions by purchased categories for the chemical, oil and gas, publishing and electronics industries. Following the meeting, debate continued by email with a request for an example of the usefulness of input- output analysis to address the issues around screening, significance and Scope 3 completeness. This was followed by a comment that the NY meeting had outlined a general principle to include all of the upstream based on a company’s influence through its purchase spend.

## 2 Issue: Generation of ranked list for scope-3 upstream contributions to complete carbon footprint of any economic sector

Debate at the NY meeting and since then by email has centred around the upstream Scope 3 constituted by ‘what I buy’, and the downstream Scope 3 constituted by ‘what I sell’. It was considered likely that some upstream inputs would be standard across sectors (red) while some would be sector specific (yellow). It was argued that decision-makers need *complete footprints* for informed monitoring, purchasing, investing, claiming carbon credits, and policy-making. It was also recognized that *different levels of accuracy would be necessary for these different purposes*.

The first requirement is for a tool that will allow a company to gain a broad understanding of complete Scope 3 *for screening purposes*, with the ability to prioritise or rank the items that make up the complete footprint. Armed with this information, decisions can be made in a second step, about where to expend effort in gaining progressively greater accuracy *for informed purchasing, investing, claiming carbon credits, and policy-making*. This document is about the first step.

## 3 Methodology: Input-output analysis and Structural Path Analysis (SPA)

Input-output analysis has been suggested by a number of participants as a useful tool to gain understanding for purposes of screening, and with the addition of more company-specific data, for carbon footprinting at progressively greater accuracy, for example for claiming carbon neutral status. Ikea’s use of input-output analysis to provide an indication of the scale of Scope 3 emission compared with Scopes 1 & 2 offers a working example of the usefulness of this methodology.

This use of input-output analysis is based on the work of the economist Wassily Leontief, a Russian émigré to the United States who invented the technique in the 1930s. He compiled the first input-output table for the US, later receiving a Nobel Prize for his work. There are now UN Input-Output Standards adopted by more than 100 countries in their regular compilation of input-output tables, with thousands of analysts using the method. One of the best-known examples of input-output footprinting is the energy footprints that were calculated in the 1970s when oil was scarce. These energy footprints informed people about the energy implications of doing business. Today, virtually every government uses General Equilibrium Analysis to underpin its economic policy, and every General Equilibrium model has an input-output table at its core. This is why input-output-based carbon footprints align so well with other macroeconomic indicators and frameworks. For this very reason, the Australian Bureau of Statistics and the UK Department of Environment Food and Rural Affairs have for some time used the input-output method to calculate their countries’ carbon and greenhouse gas accounts.



#### **4 Sector mapping: electronics industries, publishing, chemical, and oil and gas**

A mapping of emissions by purchased categories for the chemical, oil and gas, publishing and electronics industries was suggested at the NY meeting. A number of detailed industry sectors falling under these categories will be analysed below to illustrate the screening ability of input-output analysis. The methodology provides a ‘Structural Path Analysis’ (SPA) of greenhouse gas emissions. This is a priority ranking of the most important upstream Scope-3 carbon footprint contributions from the company’s supply chain. With this output it can be seen that input-output techniques using public data can provide guidance for companies in terms of what are important scope-3 contributions and what aren’t. The company staff can then direct their detailed and specific investigations towards important scope-3 items that rank top in the SPA list, and do not need to expend staff resources on likely unimportant items.

The analyses presented in the following 12 Sections can be undertaken at higher detail than shown, for example for particular greenhouse gases (CO<sub>2</sub>, CH<sub>4</sub>, etc), particular sources (fuel combustion, fugitive emissions, agriculture, land use change, etc), and for more than 20 paths (in fact, many hundreds if needed). These analyses can also be generated for other indicators, as in the Australian Government’s ‘Balancing Act’ Triple Bottom Line study ([www.isa.org.usyd.edu.au/publications/](http://www.isa.org.usyd.edu.au/publications/)). This way, decision trade-offs between carbon, financial and social objectives can be enumerated in a consistent and comprehensive way.

SPA lists have for some time been used by companies and government agencies. They can be created for any industry, in more than 100 countries, because the underlying input-output tables are published by national statistical agencies in a common format governed by UN standards.



#### 4.1. Electronic Equipment: Structural Path Analysis

70%	Electronic equipment	kg CO <sub>2</sub> -e/\$		% of total
1	Electricity supply > Electronic equipment	0.22	layer 2	46.6%
2	Electronic equipment	0.024	layer 1	5.1%
3	Electricity supply > Electricity supply > Electronic equipment	0.02	layer 3	4.2%
4	Iron and steel semi-manufactures > Electronic equipment	0.011	layer 2	2.3%
5	Precious metals > Electronic equipment	0.007	layer 2	1.5%
6	Natural gas > Electronic equipment	0.006	layer 2	1.3%
7	Brown coal > Electricity supply > Electronic equipment	0.005	layer 3	1.1%
8	Electricity supply > Electronic equipment > Electronic equipment	0.005	layer 3	1.1%
9	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Electronic equipment	0.003	layer 4	0.6%
10	Wholesale trade > Electronic equipment	0.003	layer 2	0.6%
11	Electricity supply > Aluminium > Electronic equipment	0.003	layer 3	0.6%
12	Sanitary and garbage disposal > Electronic equipment	0.003	layer 2	0.6%
13	Black coal > Electricity supply > Electronic equipment	0.0028	layer 3	0.6%
14	Natural gas > Electricity supply > Electronic equipment	0.0028	layer 3	0.6%
15	Road freight > Electronic equipment	0.0027	layer 2	0.6%
16	Softwoods > Pulp, paper and paperboard > Electronic equipment	0.0025	layer 3	0.5%
17	Electricity supply > Plastic products > Electronic equipment	0.0024	layer 3	0.5%
18	Iron and steel semi-manufactures > Iron and steel semi-manufactures > Electronic equipment	0.0023	layer 3	0.5%
19	Beef cattle > Fresh meat > Retail trade > Electronic equipment	0.0021	layer 4	0.4%
20	Retail trade > Electronic equipment	0.0021	layer 2	0.4%

Above is the SPA for the electronic equipment sector. Column one shows the ranked significance of items that make up the carbon footprint of the sector. The table shows ranks 1 – 20 however a longer list of many hundred items can be generated. The top 20 items cover 70% of the total emissions footprint. Column two shows the pathway of emissions through layers of the supply chain to the electronic equipment sector. For example the top-ranking item represents emissions from the supply of electricity to the electronic equipment sector (Scope 2). Item two represents the sector's Scope 1 emissions. Item four shows the emissions from making iron and steel that is used in housings for electronic equipment.

Column three shows the amount of CO<sub>2</sub>-e per dollar of expenditure. For every dollar spent on electronic equipment there is 0.22 kg of CO<sub>2</sub>-e emitted by the use of electricity by the electronic equipment sector. This represents 46.6% of the total emissions (column five). Column four shows to which layer of the supply chain this item belongs, for example layer 1 is the sector itself, layer two is the immediate suppliers of the sector, layer three is the suppliers of the suppliers etc.

The first twenty items above represent 70% of the total emissions, which means that nearly one third of emissions would not be accounted for even if the top twenty items were chosen for inclusion. If you were to include only items contributing over 5% of emissions you would capture only Scope 1 and 2 (i.e. items 1 & 2) and miss out almost half of all emissions. Note that although the top few items may be obvious to those working in the sector some items could never be anticipated. For example those in the business might anticipate the contribution from precious metals however they may be totally unaware of the contribution made by beef cattle supplied to the fresh meat industry for hotels, clubs, restaurants and cafes that are used by the electronic equipment industry for catering for meetings, conferences, industry dinners etc.



## 4.2 Data Processing Services: Structural Path Analysis

44%	Data processing services	kg CO <sub>2</sub> -e/\$		% of total
1	Electricity supply > Data processing services	0.06	layer 2	22.9%
2	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Data processing services	0.006	layer 4	2.3%
3	Electricity supply > Electricity supply > Data processing services	0.005	layer 3	1.9%
4	Softwoods > Pulp, paper and paperboard > Printing and stationery > Data processing services	0.005	layer 4	1.9%
5	Sanitary and garbage disposal > Data processing services	0.004	layer 2	1.5%
6	Beef cattle > Meat products > Data processing services	0.004	layer 3	1.5%
7	Electricity supply > Computer and technical services > Data processing services	0.0031	layer 3	1.2%
8	Softwoods > Pulp, paper and paperboard > Trade advertising > Data processing services	0.003	layer 4	1.1%
9	Electricity supply > Hotels, clubs, restaurants and cafes > Data processing services	0.003	layer 3	1.1%
10	Electricity supply > Market research and other business management services > Data processing services	0.003	layer 3	1.1%
11	Wholesale trade > Data processing services	0.0029	layer 2	1.1%
12	Natural gas > Data processing services	0.0029	layer 2	1.1%
13	Water supply; sewerage and drainage services > Data processing services	0.0024	layer 2	0.9%
14	Softwoods > Data processing services	0.0021	layer 2	0.8%
15	Electricity supply > Water supply; sewerage and drainage services > Data processing services	0.0019	layer 3	0.7%
16	Road freight > Data processing services	0.0015	layer 2	0.6%
17	Brown coal > Electricity supply > Data processing services	0.0014	layer 3	0.5%
18	Electricity supply > Electronic equipment > Data processing services	0.0014	layer 3	0.5%
19	Cement, lime > Data processing services	0.0014	layer 2	0.5%

The top 20 items from the SPA for the Data Processing Services sector make up only 44% of the total emissions. This means that over half of all emissions would not be captured even if an organization were to identify the top twenty likely categories for investigation. After the 12<sup>th</sup> item every category contributes less than 1% of the total. As for the Electronic Equipment sector the electricity supplied to the sector (Scope 2) is the highest-ranking item. However, it would probably come as a surprise that the second highest-ranking item is buried deep in the supply chain: beef cattle supplied to the fresh meat industry for hotels, clubs, restaurants and cafes that are used by the Data Processing Services sector. This is because in Australia, beef cattle grazing causes substantial emissions. Another surprise is probably that the ninth ranking item is the electricity supplied to hotels, clubs, restaurants and cafes that are used by the Data Processing Services sector.

Of the 20 most significant contributors to the total emissions, seven items, not including the sector's electricity supply (Scope 2) emissions, are from immediate suppliers (Layer 2). These constitute 6.6% of total emissions. This means that if you were able to calculate the embodied emissions passed on to you from the top seven of your immediate suppliers you would *still only be accounting for 6.6% of your total emissions*.



### 4.3 Technical Services: Structural Path Analysis

43%	Technical services	kg CO <sub>2</sub> -e/\$		% of total
1	Electricity supply > Technical services	0.06	layer 2	21.2%
2	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Technical services	0.006	layer 4	2.1%
3	Electricity supply > Electricity supply > Technical services	0.006	layer 3	2.1%
4	Softwoods > Pulp, paper and paperboard > Printing and stationery > Technical services	0.006	layer 4	2.1%
5	Sanitary and garbage disposal > Technical services	0.005	layer 2	1.8%
6	Beef cattle > Meat products > Technical services	0.004	layer 3	1.4%
7	Softwoods > Pulp, paper and paperboard > Trade advertising > Technical services	0.004	layer 4	1.4%
8	Natural gas > Technical services	0.0031	layer 2	1.1%
9	Electricity supply > Computer and technical services > Technical services	0.003	layer 3	1.1%
10	Electricity supply > Market research and other business management services > Technical services	0.003	layer 3	1.1%
11	Electricity supply > Hotels, clubs, restaurants and cafes > Technical services	0.003	layer 3	1.1%
12	Wholesale trade > Technical services	0.003	layer 2	1.1%
13	Water supply; sewerage and drainage services > Technical services	0.0026	layer 2	0.9%
14	Softwoods > Technical services	0.0023	layer 2	0.8%
15	Electricity supply > Water supply; sewerage and drainage services > Technical services	0.002	layer 3	0.7%
16	Road freight > Technical services	0.0016	layer 2	0.6%
17	Brown coal > Electricity supply > Technical services	0.0016	layer 3	0.6%
18	Electricity supply > Electronic equipment > Technical services	0.0015	layer 3	0.5%
19	Cement, lime > Technical services	0.0015	layer 2	0.5%
20	Gas oil or fuel oil > Technical services	0.0013	layer 2	0.5%

The top 20 items for the Technical Services sector represent only 43% of total emissions. Items 1-12 make up 37.4% of the total emissions. The rest of the footprint – 62.6% - is made up of contributions of less than 1%. This means that to get a complete picture of where your Scope 3 emissions are coming from *you would need to examine hundreds of supply chains* each contributing a small but collectively very significant amount. For example ranked 34 (not shown) is the Motor vehicle and lawn mower repairs sector providing services to the Technical services sector and creating 0.3% of the total emissions.

If you were to account for the top 10 contributors to your emissions, providing you got them right, because some are hidden in the supply chain, you would only be accounting for just over one third of the total. Also if you decided to address only Scope 1&2 emissions, you would only be addressing 22% of the total, missing out on more significant items with the potential to reduce emissions more quickly. *This is because Technical Services onsite emissions (Scope 1) do not appear until rank 25* (not shown above).

Like the Data Processing Services sector, the second highest-ranking item is beef cattle supplied to the fresh meat industry for hotels, clubs, restaurants and cafes that are used by the Technical Services sector. It may also surprise those in the Technical Services sector that softwoods supplied to the pulp, paper and paperboard sector for printing and stationery supplied to the Technical Services sector is the fourth highest ranking contribution to emissions. Softwoods that find their way into trade advertising for the Technical Services sector come in at seventh place.



#### 4.4 Recorded media and publishing: Structural Path Analysis

80%	Recorded media and publishing	kg CO <sub>2</sub> -e/\$		% of total
1	Softwoods > Pulp, paper and paperboard > Recorded media and publishing	0.53	layer 3	55.5%
2	Hardwoods > Pulp, paper and paperboard > Recorded media and publishing	0.08	layer 3	8.4%
3	Electricity supply > Pulp, paper and paperboard > Recorded media and publishing	0.04	layer 3	4.2%
4	Electricity supply > Recorded media and publishing	0.023	layer 2	2.4%
5	Pulp, paper and paperboard > Recorded media and publishing	0.02	layer 2	2.1%
6	Natural gas > Pulp, paper and paperboard > Recorded media and publishing	0.011	layer 3	1.2%
7	Softwoods > Pulp, paper and paperboard > Printing and stationery > Recorded media and publishing	0.01	layer 4	1.0%
8	Recorded media and publishing	0.008	layer 1	0.8%
9	Sanitary and garbage disposal > Recorded media and publishing	0.007	layer 2	0.7%
10	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Recorded media and publishing	0.005	layer 4	0.5%
11	Softwoods > Pulp, paper and paperboard > Pulp, paper and paperboard > Recorded media and publishing	0.004	layer 4	0.4%
12	Electricity supply > Electricity supply > Pulp, paper and paperboard > Recorded media and publishing	0.004	layer 4	0.4%
13	Motor vehicle and lawn mower repairs > Recorded media and publishing	0.003	layer 2	0.3%
14	Softwoods > Pulp, paper and paperboard > Trade advertising > Recorded media and publishing	0.003	layer 4	0.3%
15	Electricity supply > Hotels, clubs, restaurants and cafes > Recorded media and publishing	0.0024	layer 3	0.3%
16	Electricity supply > Motor vehicle and lawn mower repairs > Recorded media and publishing	0.0024	layer 3	0.3%
17	Electricity supply > Forwarding agencies > Recorded media and publishing	0.0022	layer 3	0.2%
18	Electricity supply > Employment placement > Recorded media and publishing	0.0021	layer 3	0.2%
19	Electricity supply > Road freight forwarding > Recorded media and publishing	0.0021	layer 3	0.2%
20	Electricity supply > Electricity supply > Recorded media and publishing	0.002	layer 3	0.2%

80% of emissions from the Recorded media and publishing sector are captured in 20 categories. The top 10 categories account for 76.8% of total emissions. The most significant category is buried at layer three of the supply chain, it is softwoods supplied to the pulp, paper and paperboard sector that supplies the recorded media and publishing sector. It accounts for 55.5% of all emissions, because in Australia, there are many more softwood plantations than hardwood plantations. The electricity supplied to the pulp, paper and paperboard sector is the third highest contributor above the sector's own electricity use.

Electricity supplied to the recorded media and publishing sector (Scope 2) ranks fourth in significance, with onsite emissions (Scope 1) ranked eighth. *If you were to account only for these (i.e. Scopes 1&2) you would be addressing only 3.2% of the total.* You would be missing out on much greater potential for emissions reductions. This is because five items out of the top twenty are hidden in layer four of the supply chain. They are suppliers of suppliers of suppliers to the recorded media and publishing industry. A further ten are in supply chain layer three meaning that they are suppliers of suppliers to the recorded media and publishing industry.



#### 4.5 Printing and Stationery: Structural Path Analysis

79%	Printing and stationery	kg CO <sub>2</sub> -e/\$		% of total
1	Softwoods > Pulp, paper and paperboard > Printing and stationery	0.55	layer 3	50.4%
2	Hardwoods > Pulp, paper and paperboard > Printing and stationery	0.09	layer 3	8.2%
3	Electricity supply > Printing and stationery	0.07	layer 2	6.4%
4	Electricity supply > Pulp, paper and paperboard > Printing and stationery	0.04	layer 3	3.7%
5	Pulp, paper and paperboard > Printing and stationery	0.02	layer 2	1.8%
6	Softwoods > Pulp, paper and paperboard > Printing and stationery > Printing and stationery	0.014	layer 4	1.3%
7	Natural gas > Pulp, paper and paperboard > Printing and stationery	0.012	layer 3	1.1%
8	Basic chemicals > Printing and stationery	0.007	layer 2	0.6%
9	Printing and stationery	0.007	layer 1	0.6%
10	Sanitary and garbage disposal > Printing and stationery	0.006	layer 2	0.5%
11	Electricity supply > Plastic products > Printing and stationery	0.006	layer 3	0.5%
12	Electricity supply > Electricity supply > Printing and stationery	0.006	layer 3	0.5%
13	Natural gas > Printing and stationery	0.005	layer 2	0.5%
14	Basic chemicals > Plastic products > Printing and stationery	0.005	layer 3	0.5%
15	Softwoods > Pulp, paper and paperboard > Pulp, paper and paperboard > Printing and stationery	0.005	layer 4	0.5%
16	Wholesale trade > Printing and stationery	0.005	layer 2	0.5%
17	Softwoods > Pulp, paper and paperboard > Paper containers > Printing and stationery	0.004	layer 4	0.4%
18	Electricity supply > Electricity supply > Pulp, paper and paperboard > Printing and stationery	0.004	layer 4	0.4%
19	Motor vehicle and lawn mower repairs > Printing and stationery	0.004	layer 2	0.4%
20	Road freight > Printing and stationery	0.003	layer 2	0.3%

Twenty categories make up 79% of emissions in the Printing and stationery sector, with the most significant category, softwoods supplied to the pulp, paper and paperboard sector that supplies the printing and stationery sector, contributing 50.4%. Onsite (Scope 1) emissions are ranked 9<sup>th</sup> in significance and Scope 2 are in third place. Together they account for only 7% of the total.



#### 4.6 Books, maps, magazines: Structural Path Analysis

80%	Books, maps, magazines	kg CO <sub>2</sub> -e/\$		% of total
1	Softwoods > Pulp, paper and paperboard > Books, maps, magazines	0.47	layer 3	54.6%
2	Hardwoods > Pulp, paper and paperboard > Books, maps, magazines	0.08	layer 3	9.3%
3	Electricity supply > Pulp, paper and paperboard > Books, maps, magazines	0.04	layer 3	4.6%
4	Electricity supply > Books, maps, magazines	0.02	layer 2	2.3%
5	Pulp, paper and paperboard > Books, maps, magazines	0.018	layer 2	2.1%
6	Natural gas > Pulp, paper and paperboard > Books, maps, magazines	0.01	layer 3	1.2%
7	Softwoods > Pulp, paper and paperboard > Printing and stationery > Books, maps, magazines	0.009	layer 4	1.0%
8	Books, maps, magazines	0.007	layer 1	0.8%
9	Sanitary and garbage disposal > Books, maps, magazines	0.006	layer 2	0.7%
10	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Books, maps, magazines	0.004	layer 4	0.5%
11	Softwoods > Pulp, paper and paperboard > Pulp, paper and paperboard > Books, maps, magazines	0.004	layer 4	0.5%
12	Electricity supply > Electricity supply > Pulp, paper and paperboard > Books, maps, magazines	0.0031	layer 4	0.4%
13	Motor vehicle and lawn mower repairs > Books, maps, magazines	0.003	layer 2	0.3%
14	Softwoods > Pulp, paper and paperboard > Trade advertising > Books, maps, magazines	0.0029	layer 4	0.3%
15	Electricity supply > Motor vehicle and lawn mower repairs > Books, maps, magazines	0.0021	layer 3	0.2%
16	Electricity supply > Hotels, clubs, restaurants and cafes > Books, maps, magazines	0.0021	layer 3	0.2%
17	Electricity supply > Forwarding agencies > Books, maps, magazines	0.0019	layer 3	0.2%
18	Electricity supply > Employment placement > Books, maps, magazines	0.0019	layer 3	0.2%
19	Electricity supply > Road freight forwarding > Books, maps, magazines	0.0019	layer 3	0.2%
20	Electricity supply > Electricity supply > Books, maps, magazines	0.0018	layer 3	0.2%

Like the recorded media and publishing, and the printing and stationery sectors, the most significant contributor to emissions for the books, maps and magazines sector is softwoods supplied to the pulp, paper and paperboard sector that supplies books, maps and magazines. This constitutes 54.6% of the total. Onsite emissions are low on the significance list, at rank eight, with the sector's electricity supply (Scope 2) at rank four. *Electricity supplied to the pulp, paper and paperboard sector that supplies books, maps and magazines is of greater significance than the Scope 2 emissions.*



#### 4.7 Newspapers: Structural Path Analysis

80%	Newspapers	kg CO <sub>2</sub> -e/\$		% of total
1	Softwoods > Pulp, paper and paperboard > Newspapers	0.49	layer 3	55.6%
2	Hardwoods > Pulp, paper and paperboard > Newspapers	0.08	layer 3	9.1%
3	Electricity supply > Pulp, paper and paperboard > Newspapers	0.04	layer 3	4.5%
4	Electricity supply > Newspapers	0.021	layer 2	2.4%
5	Pulp, paper and paperboard > Newspapers	0.018	layer 2	2.0%
6	Natural gas > Pulp, paper and paperboard > Newspapers	0.01	layer 3	1.1%
7	Softwoods > Pulp, paper and paperboard > Printing and stationery > Newspapers	0.009	layer 4	1.0%
8	Newspapers	0.007	layer 1	0.8%
9	Sanitary and garbage disposal > Newspapers	0.006	layer 2	0.7%
10	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Newspapers	0.004	layer 4	0.5%
11	Softwoods > Pulp, paper and paperboard > Pulp, paper and paperboard > Newspapers	0.004	layer 4	0.5%
12	Motor vehicle and lawn mower repairs > Newspapers	0.0031	layer 2	0.4%
13	Electricity supply > Electricity supply > Pulp, paper and paperboard > Newspapers	0.003	layer 4	0.3%
14	Softwoods > Pulp, paper and paperboard > Trade advertising > Newspapers	0.0029	layer 4	0.3%
15	Electricity supply > Motor vehicle and lawn mower repairs > Newspapers	0.0022	layer 3	0.2%
16	Electricity supply > Hotels, clubs, restaurants and cafes > Newspapers	0.0022	layer 3	0.2%
17	Electricity supply > Forwarding agencies > Newspapers	0.002	layer 3	0.2%
18	Electricity supply > Employment placement > Newspapers	0.0019	layer 3	0.2%
19	Electricity supply > Road freight forwarding > Newspapers	0.0019	layer 3	0.2%
20	Electricity supply > Electricity supply > Newspapers	0.0018	layer 3	0.2%

Twenty items contribute to 80% of the emissions for the Newspaper sector. Scopes 1 & 2 (ranked 4<sup>th</sup> and 8<sup>th</sup>) together contribute only 3.2% of that total. If Scope 3 were not to be accounted for *there would be almost 97% of emissions left out of the reckoning*. As for the other sectors that make up the publishing industry, the softwoods sector is by far the largest contributor to emissions, followed by hardwoods. The electricity supplied to the pulp, paper and paperboards sector (ranked third in significance) that supplies the newspaper sector contributes more to the total emissions than the newspaper sector's Scope 1 onsite emission (ranked eighth) and more than the newspaper sector's Scope 2 emissions (ranked fourth).



#### 4.8 Natural gas: Structural Path Analysis

94%	Natural gas	kg CO <sub>2</sub> -e/\$		% of total
1	Natural gas	8.8	layer 1	91.8%
2	Electricity supply > Natural gas	0.13	layer 2	1.4%
3	Hardwoods > Natural gas	0.03	layer 2	0.3%
4	Natural gas > Natural gas	0.013	layer 2	0.1%
5	Electricity supply > Electricity supply > Natural gas	0.012	layer 3	0.1%
6	Gas oil or fuel oil > Natural gas	0.006	layer 2	0.1%
7	Sanitary and garbage disposal > Natural gas	0.005	layer 2	0.1%
8	Iron and steel semi-manufactures > Natural gas	0.005	layer 2	0.1%
9	Brown coal > Electricity supply > Natural gas	0.003	layer 3	0.0%
10	Road freight > Natural gas	0.003	layer 2	0.0%
11	Electricity supply > Coal, oil and gas extraction > Natural gas	0.0029	layer 3	0.0%
12	Softwoods > Pulp, paper and paperboard > Natural gas	0.0026	layer 3	0.0%
13	Wholesale trade > Natural gas	0.0026	layer 2	0.0%
14	Natural gas > Electricity supply > Basic chemicals	0.0019	layer 3	0.0%
15	Black coal > Electricity supply > Natural gas	0.0017	layer 3	0.0%
16	Natural gas > Electricity supply > Natural gas	0.0017	layer 3	0.0%
17	Basic chemicals > Natural gas	0.0015	layer 2	0.0%
18	Electricity supply > Storage > Natural gas	0.0013	layer 3	0.0%
19	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Natural gas	0.0012	layer 4	0.0%
20	Iron and steel semi-manufactures > Iron and steel semi-manufactures > Natural gas	0.0011	layer 3	0.0%

For every dollar spent on natural gas 8.8 kg CO<sub>2</sub>-e are emitted directly by the sector (Scope 1) through venting and flaring of gas during extraction<sup>1</sup>; this translates into 91.8% of emissions associated with the sector created onsite. The next most significant input is from Scope 2, the electricity supplied to the sector, which accounts for 1.4% of the total. The remaining 7% is made up of many small items.

<sup>1</sup> Note that venting and flaring was allocated to natural gas extraction, and not to oil, even though oil and gas are sometimes extracted simultaneously.



#### 4.9 Crude Oil: Structural Path Analysis

82%	Crude oil	kg CO <sub>2</sub> -e/\$		% of total
1	Crude oil	0.39	layer 1	52.3%
2	Electricity supply > Crude oil	0.14	layer 2	18.8%
3	Hardwoods > Crude oil	0.03	layer 2	4.0%
4	Electricity supply > Electricity supply > Crude oil	0.012	layer 3	1.6%
5	Gas oil or fuel oil > Crude oil	0.006	layer 2	0.8%
6	Sanitary and garbage disposal > Crude oil	0.005	layer 2	0.7%
7	Iron and steel semi-manufactures > Crude oil	0.005	layer 2	0.7%
8	Road freight > Crude oil	0.0031	layer 2	0.4%
9	Brown coal > Electricity supply > Crude oil	0.003	layer 3	0.4%
10	Electricity supply > Coal, oil and gas extraction > Crude oil	0.003	layer 3	0.4%
11	Softwoods > Pulp, paper and paperboard > Crude oil	0.0027	layer 3	0.4%
12	Wholesale trade > Crude oil	0.0026	layer 2	0.3%
13	Black coal > Electricity supply > Crude oil	0.0017	layer 3	0.2%
14	Natural gas > Electricity supply > Crude oil	0.0017	layer 3	0.2%
15	Basic chemicals > Crude oil	0.0016	layer 2	0.2%
16	Electricity supply > Storage > Crude oil	0.0014	layer 3	0.2%
17	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Crude oil	0.0012	layer 4	0.2%
18	Iron and steel semi-manufactures > Iron and steel semi-manufactures > Crude oil	0.0011	layer 3	0.1%
19	Electricity supply > Electricity supply > Electricity supply > Crude oil	0.0011	layer 4	0.1%

Scope 1 emissions directly from the rig/drilling site account for 52.3% of the total emissions, with the electricity supplied to the crude oil sector accounting for the further 18.8%. This means that Scopes 1 & 2 together account for 71.1% of the total. However even in this industry where the source of emissions seems obvious there is still almost 30% buried in the supply chain that would not be accounted for if Scope 3 were to be omitted.

The item ranked fifth are the emissions from the refinery that produces the fuels that are used on-site. The item ranked seventh are probably iron and steel used in the construction of rigs. Items 9 and 13 comprise seam gases emanating from coal mines.



#### 4.10. Basic chemicals: Structural Path Analysis

87%	Basic chemicals	kg CO <sub>2</sub> -e/\$		% of total
1	Basic chemicals	1.2	layer 1	47.6%
2	Brown coal > Basic chemicals	0.46	layer 2	18.3%
3	Electricity supply > Basic chemicals	0.16	layer 2	6.3%
4	Basic chemicals > Basic chemicals	0.13	layer 2	5.2%
5	Brown coal > Basic chemicals > Basic chemicals	0.05	layer 3	2.0%
6	Beef cattle > Meat products > Basic chemicals	0.04	layer 3	1.6%
7	Beef cattle > Offal, hides, skins, blood meal > Basic chemicals	0.03	layer 3	1.2%
8	Electricity supply > Basic chemicals > Basic chemicals	0.018	layer 3	0.7%
9	Basic chemicals > Basic chemicals > Basic chemicals	0.015	layer 3	0.6%
10	Electricity supply > Electricity supply > Basic chemicals	0.014	layer 3	0.6%
11	Brown coal > Petroleum and coal products > Basic chemicals	0.011	layer 3	0.4%
12	Softwoods > Pulp, paper and paperboard > Basic chemicals	0.01	layer 3	0.4%
13	Beef cattle > Basic chemicals	0.007	layer 2	0.3%
14	Salt > Basic chemicals	0.006	layer 2	0.2%
15	Brown coal > Gases > Basic chemicals	0.006	layer 3	0.2%
16	Gases > Basic chemicals	0.006	layer 2	0.2%
17	Brown coal > Basic chemicals > Basic chemicals > Basic chemicals	0.006	layer 4	0.2%
18	Road freight > Basic chemicals	0.005	layer 2	0.2%
19	Wholesale trade > Basic chemicals	0.005	layer 2	0.2%
20	Hardwoods > Basic chemicals	0.004	layer 2	0.2%

It takes 20 separate supply chain items to account for 87% of the emissions from the Basic chemical sector. If all items providing over 5% of the emissions were to be counted only the top 4 items would be accounted for. If relevance were to be a criterion in deciding what to account for, at least two of the top ten items in the above list may well be overlooked – who would imagine that beef cattle for meat products and beef cattle for offal, hides, skins and blood meal would be relevant to the basic chemical industry’s emissions inventory. It is likely that these are inputs to mixed fertilisers and products like ‘meat meal’ and ‘bone meal’ that are used in organic food production as well as in gardens everywhere<sup>2</sup>.

<sup>2</sup> Thanks to Barney Foran for this additional information



#### 4.11 Chemical products: Structural Path Analysis

56%	Chemical products	kg CO <sub>2</sub> -e/\$		% of total
1	Electricity supply > Chemical products	0.09	layer 2	16.8%
2	Basic chemicals > Chemical products	0.06	layer 2	11.2%
3	Brown coal > Basic chemicals > Chemical products	0.025	layer 3	4.7%
4	Natural gas > Chemical products	0.018	layer 2	3.4%
5	Brown coal > Chemical fertilisers > Chemical products	0.012	layer 3	2.2%
6	Softwoods > Pulp, paper and paperboard > Chemical products	0.01	layer 3	1.9%
7	Electricity supply > Basic chemicals > Chemical products	0.008	layer 3	1.5%
8	Electricity supply > Electricity supply > Chemical products	0.008	layer 3	1.5%
9	Wholesale trade > Chemical products	0.007	layer 2	1.3%
10	Basic chemicals > Basic chemicals > Chemical products	0.007	layer 3	1.3%
11	Beef cattle > Meat products > Chemical products	0.007	layer 3	1.3%
12	Electricity supply > Forwarding agencies > Chemical products	0.007	layer 3	1.3%
13	Road freight > Chemical products	0.007	layer 2	1.3%
14	Beef cattle > Offal, hides, skins, blood meal > Chemical products	0.006	layer 3	1.1%
15	Hardwoods > Chemical products	0.005	layer 2	0.9%
16	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Chemical products	0.005	layer 4	0.9%
17	Natural gas > Chemical fertilisers > Chemical products	0.004	layer 3	0.7%
18	Cement, lime > Chemical products	0.004	layer 2	0.7%
19	Electricity supply > Chemical fertilisers > Chemical products	0.004	layer 3	0.7%
20	Chemical products	0.004	layer 1	0.7%

Twenty items make up 56% of emissions in the chemical products sector. Of those, eleven are in the third layer which means they are suppliers of the sector's suppliers; one is in layer 4 – a supplier of supplier of supplier to the chemical products industry. Scope 2, electricity supplied to the sector is 16.8% of the total with onsite emissions ranking 20th in significance at 0.7% of the total. This highlights the point that the obvious places to look (i.e. onsite emissions) are not always the most important. There are several items, such as basic chemicals and electricity that you might consider obvious for such an industry however several that appear in the top twenty may not immediately come to mind. The use of brown coal for basic chemicals used by the chemical products sector is prominent ranked at three and five. This has two possibilities. It could be for the process of reacting coal with calcium carbonate to give calcium carbide to give acetylene (classified under basic chemicals); or it could be brown coal for gasifying to give synthesis gas from which any number of basic chemicals can be made using different catalysts<sup>3</sup>.

Beef by-products feature in the supply chain at ranks eleven and fourteen. These are likely to be for gelatine which is classified under the “other chemical products” category. Item sixteen is beef for the table that finds its way into meal for the Chemical products industry. Cement and lime supplied to the chemical products sector is significant at rank eighteen.

<sup>3</sup> Thanks to Barney Foran for this additional information



## 4.12 Pharmaceutical goods for human use: Structural Path Analysis

53%	Pharmaceutical goods for human use	kg CO <sub>2</sub> -e/\$		% of total
1	Electricity supply > Pharmaceutical goods for human use	0.04	layer 2	14.7%
2	Hardwoods > Pharmaceutical goods for human use	0.022	layer 2	8.1%
3	Oats, sorghum and other cereal grains > Pharmaceutical goods for human use	0.016	layer 2	5.9%
4	Sanitary and garbage disposal > Pharmaceutical goods for human use	0.012	layer 2	4.4%
5	Softwoods > Pulp, paper and paperboard > Paper containers > Pharmaceutical goods for human use	0.006	layer 4	2.2%
6	Natural gas > Pharmaceutical goods for human use	0.006	layer 2	2.2%
7	Electricity supply > Employment placement > Pharmaceutical goods for human use	0.005	layer 3	1.8%
8	Oats, sorghum and other cereal grains > Oats, sorghum and other cereal grains > Pharmaceutical goods for human use	0.005	layer 3	1.8%
9	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Pharmaceutical goods for human use	0.004	layer 4	1.5%
10	Basic chemicals > Pharmaceutical goods for human use	0.004	layer 2	1.5%
11	Electricity supply > Forwarding agencies > Pharmaceutical goods for human use	0.003	layer 3	1.1%
12	Electricity supply > Electricity supply > Pharmaceutical goods for human use	0.003	layer 3	1.1%
13	Electricity supply > Market research and other business management services > Pharmaceutical goods for human use	0.003	layer 3	1.1%
14	Pharmaceutical goods for human use	0.0029	layer 1	1.1%
15	Paper containers > Pharmaceutical goods for human use	0.0028	layer 2	1.0%
16	Road freight > Pharmaceutical goods for human use	0.0025	layer 2	0.9%
17	Hardwoods > Paper containers > Pharmaceutical goods for human use	0.0025	layer 3	0.9%
18	Electricity supply > Hotels, clubs, restaurants and cafes > Pharmaceutical goods for human use	0.0023	layer 3	0.8%
19	Electricity supply > Plastic products > Pharmaceutical goods for human use	0.002	layer 3	0.7%
20	Basic chemicals > Plastic products > Pharmaceutical goods for human use	0.0016	layer 3	0.6%

It takes 20 items to make up 53% of the pharmaceutical goods for human use sector's carbon footprint. This means that many small items contribute to the total.

The sector's use of electricity (Scope 2) is 14.7% of the total with onsite emissions (Scope 1) making up 1.1%. Hardwoods, softwoods and oats, sorghum and other cereal grains feature prominently in the supply chain. Some of this is wood used for packaging (item 5). Purified wood cellulose is used as a binder/filler in the manufacture of tablets. The gluten in grains is also used as a filler in the manufacture of tablets. Also grains contain certain proportions of vitamins that are extracted as residuals when grain is converted to flour and some oil grains have high contents of essential amino acids<sup>4</sup>.

Prominent at ninth place is beef cattle for fresh meat supplied to hotels, clubs, restaurants and cafes used by the pharmaceutical goods for human use sector.

Eleven of the top twenty items are in layer 3 of the supply chain or beyond.

<sup>4</sup> Thanks to Barney Foran for this additional information



## 5 Conclusion

Having looked at the 12 sectors above individually, in the following figure the sectors have been combined<sup>5</sup> to show an overall picture.

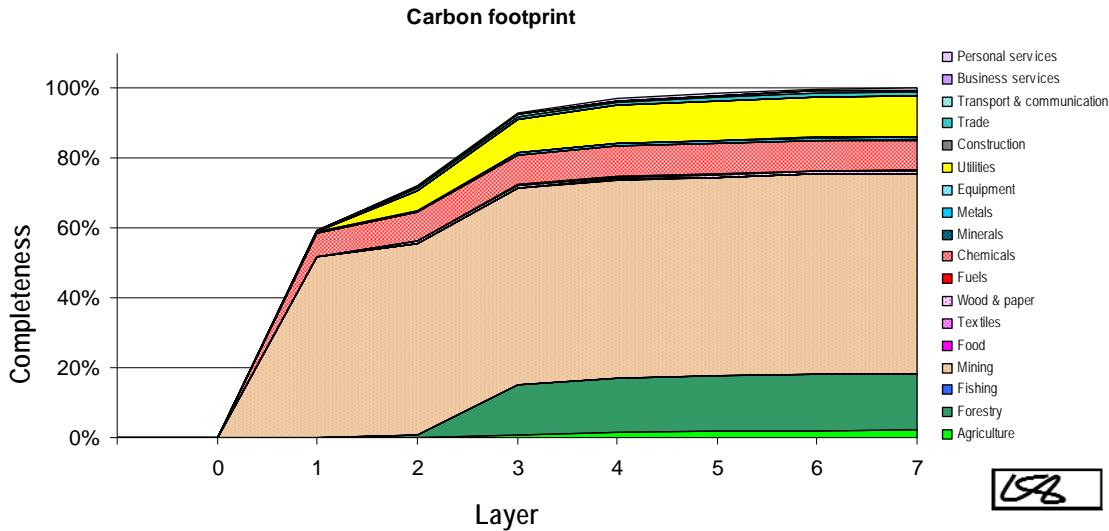


Figure 1: Carbon footprint for the 12 sectors combined

Figure 1 shows that the emissions from our 12 items are concentrated in five broad areas of the economy: the light green represents agriculture, dark green is forestry, light brown is predominantly venting and flaring during natural gas extraction (part of 'Mining'), pink represents chemicals and yellow is electricity (main contributor to 'Utilities').

The one path representing venting and flaring from gas sites (top path in Section 4.8) dominates by far the mix of our 12 sectors, so we will take this one component out, and look at the remainder (Figure 2), which will give a clearer picture of the structure of supply chains.

<sup>5</sup> Basically we have analysed an expenditure of \$12, that is \$1 on each item.

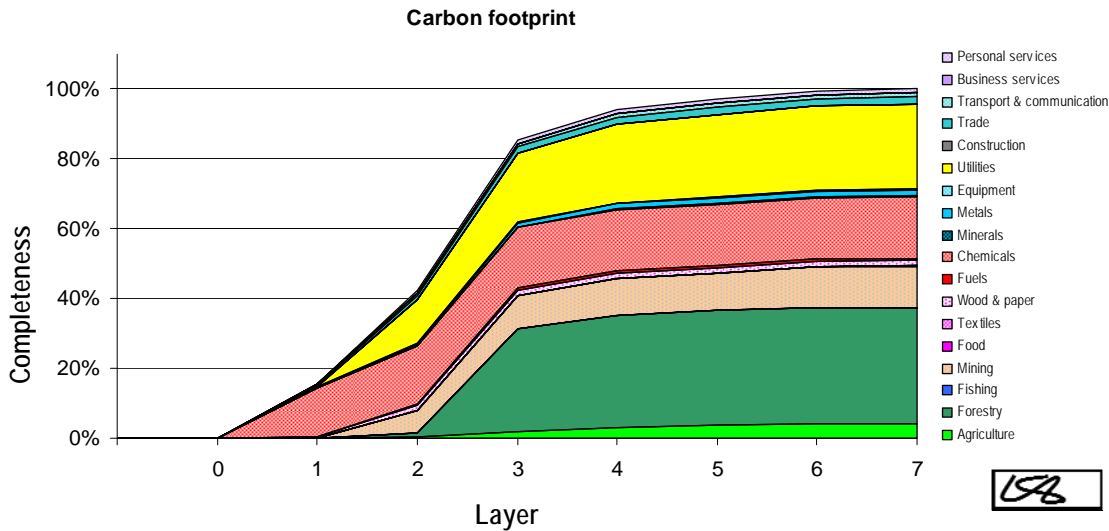


Figure 2: Carbon footprint for the 12 sectors combined minus venting and flaring

In Figure 2 layer 0 represents the customer who buys from the 12 sectors; we only deal with scope 3 so we haven't attributed any emissions here. Layer 1 represents the 12 sectors from which we buy \$1 worth of output. The emissions in this layer are the scope 1 emissions of these sectors. Layer 2 contributions are the sectors' immediate suppliers. Layer 3 represents suppliers of suppliers and so on.

Amongst our 12 sectors, having removed venting and flaring, we find only fuel use in the chemicals sectors to contribute significantly to scope 1 emissions, represented by the pink wedge that opens up at layer 1. Electricity use (scope 2) is not accounted in layer 1 but is in layer 2 because the emissions occur in the power plant, therefore the yellow wedge opens up in layer 2. Further upstream we find agriculture and forestry which are only significant at layer 3 and above because they are the emissions of associated with the production of primary commodities, sitting far back in the supply chain, such as timber and livestock.

Including only scope 1 emissions across all 12 case studies will yield less than 20% completeness. Including layer 2 (includes full scope 2) will give us up to 40% completeness, and the addition of layer 3 will give us just above 80% completeness. If we want 95% completeness we would have to go to layer 4. To give an impression of what this means for someone wanting to do this manually, assume that each of our 12 sectors has 100 suppliers, so in layer 2 you would have 1200 contributions to check. In layer 3 you would have 120,000 to check. To achieve 95% completeness you would have to follow up on 12 million individual contributions.

Because of the work of the Nobel-Prize winning economist Wassily Leontief these scope 3 calculations are made simple using input-output analysis.