Anthropogenic

Where did it come from?

Anthropo- *human being* from the Greek *anthropos*

Anthropogenesis – the genesis or development of the human race, especially as a subject of scientific study… **anthropogenic**, adjective (The Macquarie Dictionary, 2nd Revised Edition, 1990, The Macquarie Library Pty Ltd: Macquarie University, Australia)

What does it mean?

Anthropogenic effects are effects caused by humans; effects that relate to the influence of human beings on nature (http://www.merriam-webster.com/dictionary/anthropogenic)

Anthropogenic global warming is that which is attributable to human behaviour, through pollution and exploitation of the earth's resources and ecosystems. It is often used in connection with the increase of CO2 in the atmosphere related largely to our use of fossil fuels.

According to the Intergovernmental Panel on Climate Change[1] "Global GHG emissions due to human activities have grown since pre-industrial times, with an increase of 70% between 1970 and 2004" (Climate Change 2007: Synthesis Report, An assessment of the Intergovernmental Panel on Climate Change p.36)

"Global atmospheric concentrations of CO2, CH4 and N2O have increased markedly as a result of human activities since 1750 and now far exceed pre-industrial values determined from ice cores spanning many thousands of years. The atmospheric concentrations of CO2 and CH4 in 2005 exceed by far the natural range over the last 650,000 years. Global increases in CO2 concentrations are due primarily to fossil fuel use, with land-use change providing another significant but smaller contribution. It is very likely that the observed increase in CH4 concentration is predominantly due to agriculture and fossil fuel use. The increase in N2O concentration is primarily due to agriculture." (Climate Change 2007: Synthesis Report, An assessment of the Intergovernmental Panel on Climate Change p.37)

[1] http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf

Audit

What does it mean?

The word *audit* comes from the Latin *auditus* meaning *a hearing*. An audit is an inspection or review usually associated with an examination of financial accounts. According to Kimmel et al (2003: 25) a financial audit is an "independent examination of the accounting data presented by a company."

The term *audit* can also be applied to a review of social items such as lifestyle or workplace relations, working hours and conditions or OH&S.

More recently it has been applied to onsite environmental, social and economic accounting, often called Triple Bottom Line (TBL) accounting, which provides an examination and review (an *audit*) of an organisation's onsite environmental, social and economic effects of doing business.

What is it used for?

An audit of financial statements is an examination of an organisation's financial statements by an independent third party to provide an opinion on the accuracy and completeness of the statements

A social audit entails an examination of practices and policies conducted to address workplace inequalities or community facilities.

An environmental audit is a gathering of information to assess and monitor the effectiveness of an organisation's environmental policies and practices. It may provide an assessment of an organisation's compliance with environmental regulations or it may be used to check conformity with environmental standards.

What instruments are available?

The Global Reporting Initiative's Sustainability Reporting Guidelines take an audit approach to accounting for the Triple Bottom Line (TBL). The guidelines contain a range of specific (micro) indicators that provide good reporting scope or breadth.

In order to make the audit manageable a boundary is set. This boundary usually limits the audit to immediate on-site impacts that are deemed to be within the control of the reporting entity. Using the audit approach alone can lead to inconsistencies between assessments because boundaries can vary from year to year or project to project.

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Autopoiesis

Where did it come from?

The word was coined by Humberto Maturana and Francisco Varela to define a living system. All previous definitions had relied on a list of characteristics as definition. Maturana and Varela first introduced the term *autopoiesis* in 1973 (see reference list).

What does it mean?

The word literally means *self creation* from the Greek *auto* – self and *poiesis* – creation or production.

Autopoiesis is used to describe a system that contains all of the means to reproduce itself.

An autopoetic system is a self-producing system. A system can be a single cell, a multi-cellular organism made up of single cells or a multi-organism organization such as an eco-system. Others have applied the concept to social systems such as a community or a corporation (e.g Luhmann, 1995).

An autopoietic system is autonomous and operationally closed, that is, every process within it directly helps to maintain the whole. Autopoietic systems are structurally coupled with their medium; they are open to the flow of molecules from outside, which assist in producing the components which in turn maintain the structure that gives rise to these same components.

Maturana and Varela who coined the word describe it as "...a network of processes of production (transformation and destruction) of components that produces the components that: (i) through their interactions and transformations continuously regenerate the network of processes (relations) that produced them; and (ii) constitute it (the machine) as a concrete unity in the space in which they (the components) exist by specifying the topological domain of its realizations as such a network." Maturana and Varela, Autopoiesis and Cognition (1980), p.79

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Balancing Act

The Balancing Act report was commissioned by the Australian Government to provide a benchmark for the performance of 135 sectors of the economy against a set of ten indicators.

The work was conducted by CSIRO and the University of Sydney and the report was published in 2005[2]. *Balancing Act* uses a set of ten indicators to benchmark 135 sectors of the Australian economy providing a snapshot of the TBL performance of the Australian economy. The environmental indicators are water use, land disturbance, greenhouse emissions and energy use; the social indicators are employment, government revenue and income; and the financial indicators are operating surplus (or profits), exports and imports.

The indicators are referenced against one dollar of 'final demand', which is roughly the dollar spent on goods and services that are 'demanded' by consumers. This means that Balancing Act can tell you for example how much water is embodied in a dollar's worth of confectionery; how much energy in a dollar's worth of knitting mill products; or how much employment is created for every dollar spent in the water transport industry. It does this for every dollar spent in the Australian economy for each of the indicators. In this way the report reveals some of the social and environmental implications of financial flows in the economy.

Balancing Act facilitates informed decision making because it not only identifies direct onsite effects of doing business, within the farm or factory fence, but also the full upstream (indirect) effects throughout the whole supply chain. It provides boundary free reporting because it captures flows throughout the whole of the economy.

Balancing Act uses published, national physical, economic and social accounts from organisations such as the ABS (Australian Bureau of Statistics) and ABARE (Australian Bureau of Agricultural and Resource Economics). With these data bases at its core *Balancing Act* provides reliable, consistent and comparable results.

Balancing Act is acknowledged as a landmark study, unique in the world. It is the foundation of all subsequent TBL accounting model development carried out by the Centre for Integrated Sustainability Analysis at the University of Sydney.

[2] http://www.isa.org.usyd.edu.au/publications/index.shtml and http://www.csiro.au/resources/BalancingAct.html

Boundary

What is it?

The *boundary* within which an organisation accounts for its environmental, social and/or economic effects is usually defined as that over which the company has direct influence and can exercise control. In relation to this:

> "[I]t is critical [that] the boundaries adopted for the purposes of reporting are clearly defined and obvious to readers of reports. Careful boundary definition also ensures a report can be verified and meaningful comparisons can be made between information from different reporting periods." [3]

What's the issue?

The 'careful boundary definition' quoted above faces a number of challenges. The level of influence and control will vary from organisation to organisation and from year to year, invalidating comparisons within and between organisations. Moreover, extending the boundary beyond the immediate control of the organisation still begs the question of exactly where to draw the line. Decisions will differ between organisations and over time. Establishing a clear boundary for an analysis that is consistent across all indicators seems at first sight to be almost impossible. Notwithstanding these challenges, the boundary problem can be solved by taking a full life-cycle perspective.

A huge number of upstream suppliers feed into any organisation (see *supply chain*). Each one of them has Triple Bottom Line impacts to be accounted for. Most audit approaches, such as that taken by the Global Reporting Initiative (GRI), are not designed to extend much beyond the first level of suppliers.

The Global Reporting Initiative (GRI) is aware of the importance of the boundary problem. Its Boundaries Working Group has developed a Boundary Technical Protocol which is based on the key concepts of control and influence[4]. It provides principles and a process for setting boundaries while recognising the complex issues involved, including the problems of comparability and consistency mentioned above.

Why is boundary definition important?

Whilst important local or on-site effects are captured by the GRI audit, the considerable economy-wide effects of which the organisation is a part, are not accounted for or reported on. The same is true for downstream impacts, which are only partly accounted for in audit-type approaches (e.g. GRI Indicator EN18).

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3 Environment Australia, Triple bottom line reporting in Australia: a guide to reporting against environmental indicators, June 2003 page 8, also contains a wider discussion about the issue of boundaries

http://www.deh.gov.au/settlements/industry/finance/publications/indicators/index.html

4 GRI Boundary Technical Protocol July, 2005. For Report Guidance for Boundary Setting see

http://www.globalreporting.org/ReportingFramework/G3Online/SettingReportBoundary

Carbon Dioxide equivalent

The Intergovernmental Panel on Climate Change[5] report, *Climate Change 2007,* defines Carbon Dioxide equivalent as follows:

"GHGs [greenhouse gases] differ in their warming influence (radiative forcing) on the global climate system due to their different radiative properties and lifetimes in the atmosphere. These warming influences may be expressed through a common metric based on the radiative forcing of CO2.

"• CO2-equivalent emission is the amount of CO2 emission that would cause the same time-integrated radiative forcing, over a given time horizon, as an emitted amount of a longlived GHG or a mixture of GHGs. The equivalent CO2 emission is obtained by multiplying the emission of a GHG by its Global Warming Potential (GWP) for the given time horizon. For a mix of GHGs it is obtained by summing the equivalent CO2 emissions of each gas. Equivalent CO2 emission is a standard and useful metric for comparing emissions of different GHGs but does not imply the same climate change responses.

"• CO2-equivalent concentration is the concentration of CO_2 that would cause the same amount of radiative forcing as a given mixture of CO2 and other forcing components."

EnergyAustralia's *Carbon Emissions and You* website[6] describes CO_2-e this way:

"The long-lived greenhouse gases all have different average lifetimes and effectiveness at trapping infrared radiation (heat). To combine the different warming effects of the different gases, a unit called carbon dioxide equivalents (**CO_2-e**) is used to convert masses of each gas to a mass of CO_2 that would give the equivalent warming, generally over a 100 year timeframe.

"So for example, over 100 years, per mass, methane is 21 times stronger as a greenhouse gas, nitrous oxide is 310 times stronger, and typical halocarbons are many thousands of times stronger. This is why the comparatively small releases of non-CO_2 gases become significant in warming terms."

Reference

http://www.greenhouse.gov.au/inventory/2005/pubs/inventory2005.pdf

[5] Climate Change 2007: Synthesis Report, An assessment of the Intergovernmental Panel on Climate Change p.36 http://www.ipcc.ch/pdf/assessment-report/ar4/syr/ar4_syr.pdf)
[6] http://www.energysave.energyaustralia.com.au/carbon-emissions-and-you2

Carbon Disclosure Project[7]

CDP was launched in Millennium year, 2000 at No.10 Downing Street. The first data were collected in 2003[8]. The CDP's purpose is to provide stakeholders with climate change data from organisations. The data are obtained in response to CDP's annual request for information sent in the form of a questionnaire on behalf of institutional investors and purchasing organisations.

CDP is a not-for-profit organisations. It is funded by various organisations, governments and agencies, companies and charities, including:

AXA, Merrill Lynch, Pictet Asset Management, PricewaterhouseCoopers and Standard Chartered, DEFRA (UK), Environmental Protection Agency (US), NUTEK (Sweden) and VROM (Netherlands), DOEN Foundation (Netherlands), Esmée Fairbairn Foundation (UK), Nathan Cummings Foundation (USA), Oak Foundation (Switzerland), Renewable Energy and Energy Efficiency Partnership (REEEP) and WWF (UK, Germany and India).

In 2007 the CDP launched its Corporate Supply Chain Programme. This program extended the reporting reach of an organisation by addressing the supply chain. Twelve companies participated in the pilot program, including Cadbury, Imperial Tobacco, Nestle, Procter & Gamble and Tesco. They were asked to provide the CDP questionnaire to their suppliers. They could either forward the questionnaire to suppliers themselves of have the CDP send out the questionnaire on their behalf. The questionnaire and report of the pilot program can be found at http://www.cdproject.net/sc_documents.asp

One of the issues revealed by the pilot was the poor quality of responses. The CDP realised that it would have to develop a strategy to improve the quality of responses as well as gain the support of a larger number of companies.

In 2008 CDP extended the survey to 34 member companies who each nominated a selection of suppliers to receive questionnaires. The aim was to report on how businesses are responding to climate change and their transparency in managing carbon in the supply chain. Of 2,318 suppliers invited to participate by the 34 member companies, 634 responded. One of the conclusions of this work was the need for trust between suppliers and their customers (in this case the member companies) if there is to be collaboration on climate change issues. As one respondent said: "Suppliers are nervous about the consequences of disclosing this information, and the upfront message of why this information is requested needs to be very carefully managed."

Another conclusion was that Life Cycle Analysis is best used after having first prioritized where effort will be most rewarded. The possibility is being discussed of using input-output analysis to capture the full supply chain, especially to show

[7] http://www.cdproject.net/ (accessed 29/10/08)
[8] http://stage.cdproject.net/faqs.asp (accessed 28/10/08)

where to focus efforts for maximum effect – which suppliers it will be worthwhile working with in order to gain the biggest emissions savings.

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Carbon leakage

Carbon leakage is the increase in emissions in one place due to a reduction in emissions elsewhere.

Carbon leakage may have occurred as a side effect of the Kyoto Protocol. Placing a cost on carbon has increased the cost of energy in Annex 1 (developed) countries. It is possible that this has had the effect of shifting business to non-Annex 1 (developing) countries where energy is cheaper because there is as yet no carbon cost scheme in operation in that country. It is also likely that technologies in non-Annex 1 countries are less efficient, making energy production higher in emissions. Thus a shift of operations from developed to developing nations brought about by the placing of a cost on carbon in one country but not the other can have the unwanted effect of causing greater global pollution. In effect the Kyoto Protocol may have the undesired effect of exporting carbon-intensive industries to the developing world.

In anticipation of the 2012 Europe Union revised emissions trading scheme a number of industries, such as cement, steel and chemicals are claiming that they would be forced to move their activities outside of Europe if too stringent regulations on CO2 emissions are imposed on them. This is because they are heavily exposed to international competition. However Professor Michael Grubb, Chief Economist at The Carbon Trust (UK) suggests that the EU ETS presents little threat to overall business competitiveness[9]. However, he suggests, some free allocations could be granted to a small group of carbon-intensive facilities that may face falling competitiveness in a global market, which could lead to carbon leakage. The Carbon Trust found that total leakage by 2020 is unlikely to exceed 1% of EU emissions, but it could be much higher from some sectors[10].

In Australia the government will provide some free pollution permits to ‘emissions intensive trade exposed’ industries (EITEs) in order to prevent carbon leakage through businesses relocating elsewhere to avoid the cost of carbon permits. EITEs argue that paying for permits would reduce their global competitiveness and hence reduce their export potential.

[9] http://www.carbontrust.co.uk/News/presscentre/EU_ETS.htm (accessed 21/11/08)
[10] http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CTC728 (accessed 21/11/08)

Carbon Neutral

Carbon neutral is a term used to capture the concept of: cancelling out the harm done to the earth's atmosphere by one type of greenhouse gas[11]-generating human activity, through another human activity that: either reduces CO2 emissions by an equal amount; or prevents an equal amount being generated by an 'essential'[12] CO2 producing human activity through substituting a non- or low carbon producing alternative.

The 'other' human activity that reduces or prevents emissions can be something that:

- takes an equal amount of existing CO2 out of the atmosphere, like planting trees that, as they grow take in CO2, or like conserving trees that otherwise would have been chopped down;
- produces an essential commodity like power, in a way that does not emit new CO2 into the atmosphere as power generation usually does; or
- conducts an essential human activity like waste disposal or recycling in a way that provides an essential commodity (like power or glass or paper) and at the same time prevents greenhouse gases being emitted into the atmosphere from both usual waste disposal methods and from usual power generation or product manufacturing.

Buried in these activities are a few big questions, for example:

- how do we calculate the amount we are emitting in order to know what amount we need to 'neutralise';
- what activities do we count when we calculate the amount we are emitting;
- is creating our emissions then preventing pollution from equivalent new CO2 generating essential services or commodities, better than creating our emissions then later, once they are in the atmosphere, 'bringing them back down' over time;
- If we create emissions then prevent an equivalent amount of new emissions reaching the atmosphere that would have been produced in say, business-as-usual power generation, how can we ever reduce our overall emissions (will 'better ways of doing things' ever be able to be regarded as 'business-as-usual' while 'business-as-usual' serves such a useful purpose to would-be carbon emitters?)
- if we go in for removing emissions that we create today, by when do we need this amount to be removed from the atmosphere and for how long does it have to stay 'removed'? – trees for example grow slowly and only lock up the carbon for as long as we and/or the course of nature allow them to;
- how do we know that 'otherwise' some trees might have been chopped down (what counts and why);

[11] In this case CO2
[12] i.e. an activity that we deem to be essential to maintaining our living standards, such as power generation.

- what counts as an ‘essential’ human activity and who says how much of it is ‘essential’ – maybe that amount of power doesn’t really have to be used, or that amount of packaging used and thrown away;
- who is responsible for the CO2 emissions and therefore must redress the damage – if I as a consumer am planting trees am I accepting responsibility for say, my flight-emissions, when those emissions might have been produced in a way that included inefficient practices generating more CO2 than otherwise might have been the case;
- will my offsetting of inefficient practices discourage real change in practices; and
- does this all take our minds and efforts off the real question which is: how do we drastically reduce, not neutralise, our total emissions

Carbon Pollution Reduction Scheme, Australia (CPRS)

NOTE: Introduction of the CPRS has been shelved by the Australian Government until 2012.

The CPRS was outlined in a Government Green Paper released for discussion in July 2008[13] by the Commonwealth of Australia's Department of Climate Change. It sets a target of reducing 'Australia's carbon pollution[14] by 60 per cent below 2000 levels by 2050.' (Commonwealth of Australia, 2008, p. v).

The CPRS proposes a cap and trade system to be introduced in 2010. This means that the government will set a cap on the amount of carbon that can be emitted nationally. The cap must be consistent with achieving the targeted reduction and can be reduced year by year. It determines the number of carbon pollution permits – one for each permitted tonne of carbon – issued by the Government. Those businesses and industries that are part of the scheme will have to compete to buy the number of 'pollution permits' that they anticipate they will require. Some businesses may find it cheaper to reduce emissions than to buy permits. Other organisations with fewer or more expensive abatement opportunities will be willing to pay the price for permits. At the end of the accounting period all participating industries will be required to surrender one permit for every tonne of carbon actually emitted during that period. If the organization has emitted less than it anticipated during the accounting period it will have spare permits to sell to organizations that have exceeded their limit. If it has overshot its mark it will need to buy extra permits on the trading market. Hence the term *cap and trade*.

No caps will be placed on individual emitters but emitters must acquire enough permits to surrender for their emissions. The government will provide 'free permits to the most emissions intensive trade exposed activities'. It will also give 'some direct assistance to coal-fired electricity generators' and create 'two specific industry adjustment funds, the Climate Change Action Fund and the Electricity Sector Adjustment Scheme.' (Commonwealth of Australia, 2008, p. iv)

The CPRS will affect about 1000 Australian companies that emit more than 25,000 tonnes of carbon each year. This represents less than one per cent of Australian businesses. Initially Agriculture, which contributes 15.6% of national emissions, will be exempt from the scheme.

The government has promised to spend the money raised in selling permits to help households and businesses adjust to the system and invest in clean energy options. The government has also promised to cut fuel taxes 'on a cent for cent

[13] http://www.climatechange.gov.au/greenpaper/report/index.html
[14] CO_2-e (carbon dioxide equivalent)

basis' re-assessable after three years, to offset the impact of the scheme on the price of fuel.

Treasury modeling of the likely effects of the CPRS[15]
Modelling suggests that household incomes will continue to grow with disposable income per capita growing at around 1 per cent per year. This compares with 1.2 per cent in a do-nothing scenario. The average household can expect to pay an extra $4-5 per week for electricity and about $2 extra for gas and other fuels. Reduction in fuel taxes and the omission of Agriculture from the scheme will mean that petrol and meat are not affected initially.

Low-income households will be affected more than others because they spend a greater proportion of their income on emission-intensive goods such as electricity. The government will help low-income households to adjust through benefits and taxes[16]

Treasury modelling suggests that Australia will have to import emission permits. This is not seen as compromising the emission reduction target because emissions in Australia will be offset by emissions reductions elsewhere. However it will lower the cost of mitigation because organisations will be able to purchase their permits wherever they can buy them more cheaply.

It seems that it will be difficult for some organisations to reduce their emissions beyond a certain level. This is partly because Australian businesses already have a high standard of energy efficiency. Reducing overall emissions in Australia may also be difficult because agriculture, which has few mitigation opportunities, comprises a larger share of the economy than it does in other developed economies. In addition Australia's abundance of low cost fossil fuels makes alternative low-emission electricity generation technologies less competitive. As a result Australia will need higher emission prices to reduce emission in the electricity sector.

For these reasons a robust and efficient global emissions market is important to Australia.

Comment
Richard Dennis of The Australia Institute has identified a flaw in the whole cap and trade system. He says that "emissions trading will impose a 'floor' below which emissions cannot fall as well as a 'cap' above which emissions cannot rise. That is, once the government has decided on an acceptable level of pollution, it

[15] http://www.treasury.gov.au/lowpollutionfuture/summary/html/Australias_Low_Pollution_Future_Summary-04.asp#P426_68096 13/11/08
[16] http://www.treasury.gov.au/lowpollutionfuture/summary/html/Australias_Low_Pollution_Future_Summary-01.asp#P126_17519 (21/11/08)

will issue a corresponding number of pollution permits. If households use less energy and create less pollution, they will simply free up permits to allow other families or other industries to increase their own emissions."[17]

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[17] http://74.125.45.132/search?q=cache:sDtR3jtStzIJ:https://www.tai.org.au/file.php%3Ffile%3Dfixing_the_floor_in_the_ets.pdf+Fixing+the+Floor+in+the+ETS&hl=en&ct=clnk&cd=2

Carbon Reduction Label

"The Carbon Reduction Label shows the total greenhouse gas emissions from every stage of the product's lifecycle, including production, transportation, preparation, use and disposal" http://www.carbon-label.com/business/label.htm accessed 10/07/09

A company must commit to reducing its footprint over the following two years in order to use the Carbon Reduction Label. The label allows comparison of like products. It was originally piloted by Walkers (crisps) Boots (shampoo) and Innocent Drinks (fruit smoothies).

In June 2009 the Carbon Trust announced a memorandum of understanding with Planet Ark to establish its *Carbon Reduction Label* in Australia. The *Carbon Reduction Label* is underpinned by the PAS 2050.

The Carbon Trust is a publicly funded independent company set up by the UK Government in 2001 to help businesses transition to the low-carbon economy[18]. In 2007 The Carbon Trust set up the *Carbon Reduction Label* which is administered by the Trust's *Carbon Label Company* "to help businesses to measure, certify, reduce and communicate the lifecycle greenhouse gas (GHG) emissions of their products and services[19]". In order to display this new label on their products, manufacturers must prove that they have measured a product's carbon footprint from production to disposal, using an internationally recognised methodology.

The PAS 2050, underpinned by the Carbon Trust's 'Footprint Expert' system, is the 'recognised methodology' promoted by the *Carbon Reduction Label*. The *Carbon Label Company*'s measurement process consists of five steps[20] in accordance with BSI PAS 2050:

1. "Building a process map, including setting boundaries, understanding data available and identifying sources/contacts
2. Collecting primary data from members of the supply chain and collating secondary data
3. Assessing materiality (an iterative process)
4. Building the carbon footprint
5. Certifying the product carbon footprint model (which can require more than one iteration)."

Step five is carried out by the independent team of the *Carbon Label Company* to ensure the label has global consistency.

To ensure global consistency once the footprint has been calculated the *Carbon Label Company* applies a set of 'proprietary data and comparability rules'. This is

[18] http://www.carbontrust.co.uk/News/presscentre/carbon-label-australia.htm
[19] http://www.carbon-label.com/business/about.htm
[20] http://carbonreductionlabel.com.au/process/

because on its own the PAS 2050 cannot fully achieve consistency and comparability between products[21] (or the same product one year to the next). A Code of Good Practice[22] has been developed for the purpose of communicating product emissions and reductions consistently. For example it specifies the level of rounding for the communication of footprints and requires companies to disclose supporting information for its reduction claims including life cycle boundaries and data sources.

Because of developments in Life Cycle Analysis (LCA) techniques some of the processes necessary for PAS 2050 compliance can be addressed within ISA's input output based LCA methodology itself. This makes redundant much of the time consuming work that was previously needed for example to determine a boundary for your LCA. The ISA methodology itself takes care of the boundary (step 1 above). Whereas PAS 2050 requires that "at least 95% of the anticipated life cycle GHG emissions of the functional unit" must be captured in the assessment (BSI 2008, p. 13) the ISA methodology fully accounts for *all* inputs. There is no need to define a system boundary because every item of the economy is tracked along an infinite supply chain. This greatly simplifies the life cycle assessment process because time and energy do not have to be spent on defining system boundaries and justifying the criteria used to select them (BSI 2008: *Section 6 pp 12 – 16*[23] *)*. Without the use of input-output based life cycle analysis a tremendous amount of effort would be required to achieve a capture rate of 95% and most sectors cannot reach this capture rate even after collection of 1000 distinct data points[24] (step 2). The ISA methodology requires only the input of onsite (Scope 1 and Scope 2) emissions data and the expenditure accounts for the product in question. If your organisation produces more than one product this may require the development of a rubric for allocation of an appropriate share of non-product specific onsite data and expenditure, however once that is done it's simply a matter of entering the agreed expenditure items and amounts. All Scope 3 emissions are captured from the expenditure accounts (secondary data). Over time, as more primary information is collected from suppliers it can be substituted for the sector averages (secondary data) that are used in the ISA model.

It should be noted that the completeness that is achieved through use of input-output based LCA by far outweighs any loss of specific detail through use of sector averages. Even so, use of ISA's methodology has the added advantage of being able to substitute more and more accurate emissions data for the default averages as information becomes available. The methodology will show clearly where in the supply chain it is worthwhile spending time collecting primary (first hand/observed) data.

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[21] http://www.carbon-label.com/business/thecode.htm code p.9
[22] http://www.carbon-label.com/casestudies/Opportunity.pdf
[23] http://www.bsigroup.com/en/Standards-and-Publications/Industry-Sectors/Energy/PAS-2050/
[24] For more details see: http://www.isa.org.usyd.edu.au/education/documents/20090220_ISA-USyd_Pain-Free-Scope-3v_www-version.pdf

The PAS 2050 also requires that only items with a 'material contribution' of more than 1% of the anticipated life cycle GHG emissions associated with the product be included (step 3). However except for the power generation sector, sectors in Australia generally only achieve a total capture rate of between 40% and 90% with a 1% materiality threshold; meaning that many sectors would be far below the total capture rate of 95% required by PAS 2050. With

ISA's methodology there is no need for a limit of more than 1% material contribution and a risk of not capturing 95% of anticipated emissions. Everything will be automatically included.

Of course there is also the issue of knowing what 95% looks like. Unless we know how much constitutes100% we can't know when we have reached 95%. The PAS 2050 suggests using input output analysis to 'provide an overview of the key sources of emissions' (p. 13). Use of ISA methodology means that input output analysis will provide not only an overview of key sources for follow up as time and funding permit, but also a solution to the time consuming boundary issue and materiality threshold.

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Carbon sink forest

A *carbon sink forest* refers to a forest that has been specifically grown for the purpose of sequestering carbon.

In Australia according to the Commonwealth Government's website[25] these forests are usually small and part of an integrated system of land uses in less productive regions. According to the website they provide biodiversity, manage salinity and improve 'farming productivity through land diversification'.

Growers of carbon forest sinks in Australia can claim a tax deduction for expenses incurred in establishing the sink. To qualify the trees must: occupy a continuous land area of 0.2 hectares or more; be expected to attain a 20% crown cover and reach 2m in height; and occupy land that was clear of such trees in 1989. These conditions align with those needed for inclusion towards the Kyoto Protocol target.

[25] http://www.climatechange.gov.au/land/tax-deduction.html (accessed 11/12/08)

Climate change

“Climate change in IPCC usage refers to a change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. It refers to any change in climate over time, whether due to natural variability or as a result of human activity. This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), where climate change refers to a change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods.” (From Climate Change 2007: Synthesis Report, An assessment of the Intergovernmental Panel on Climate Change p. 30).

The Climate Confidence Monitor 2008

The Climate Confidence Monitor 2008 research was conducted by HSBC[26] Climate Partnership. Researchers surveyed 12,000 people across 12 countries: Australia, Canada, France, Germany, the UK and USA, Brazil, China, the Hong Kong SAR, India, Malaysia and Mexico. The research questions were designed to measure people's concern, confidence, commitment to and optimism about climate change.

The key findings were:
48% of respondents believe that governments should play a leading role in tackling climate change, but only 25% believe that governments are doing so. Without this leadership individual commitment is stalling with people less willing to change their lifestyles further, or contribute time and money compared with 2007 results.

People want governments to focus on direct action on the 'big issues', for example, increased investment in: renewable energy, stopping deforestation, conserving water, protecting eco-systems. They viewed governments' indirect action such as carbon markets and taxation systems as less of a priority.

78% of respondents want their countries to take on at least their fair share of global emissions reductions.

26 http://www.hsbc.com/1/PA_1_1_S5/content/assets/csr/hsbc_climate_confidence_monitor_2008.pdf

Co-ontogenic structural drift

Maturana and Varela (1987) claim that we, like all living systems, are structurally determined systems. By this they mean that the way in which we respond to perturbations in our environment is determined by our structure. But the medium is also a structurally determined system. Recurrent interactions of both living system and medium will result in structural changes in both system and medium. What is true for the single cell, they say, is true for the multi-cellular unity. Who we, as living systems, are at this instant and the medium we find ourselves in mutually specify each other so that each contributes to creating the world of the next instant, and so on, creating the world by living in it. This process Maturana and Varela call *co-ontogenic structural drift*. In co-ontogenic structural drift the system does not adapt to the environment as in the classical system-environment model but both change over time; either they 'fit' or separate or disintegrate. Maturana and Varela propose that the:

> *structure of the system determines its interactions by specifying which configurations of the environment can trigger structural changes in it.*
>
> (Maturana & Varela, 1987:135)

Moreover, they argue evolution and adaptation, which Maturana and Varela (1987) say is the term used by an observer to describe co-ontogenic structural drift, are not things that happen in multi-millennium leaps, they happen to individuals nanosecond by nanosecond over lifetimes and generations.

> *The structural changes triggered in the interactions of a structure determined system arise moment after moment also as determined by its structure, but they follow a course that is generated moment after moment by the succession of encounters with the medium in which the system participates. The same applies to the medium as a structure determined system that changes following a course that arises in the interplay of its own structural dynamics and the structural changes triggered in it by the systems that interact with it.*
>
> (Maturana, 2002:16)

As Fell and Russell (1993:35) say, "[t]his means that everything we have ever done together in this world could be a part of who we are and what we do today" and:

> *We cannot know what the future holds, but we can know that everything we do (or say) contributes significantly to it . . . This awesome responsibility is what we regard as the biological basis of our human ethics.*
>
> (Fell & Russell, 1993:35; see also von Foerster, 1992 on cybernetics and ethics)

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Corporate Governance
Processes (principles, polices and procedures)

Corporate governance can be described as

> "The framework of rules, relationships, systems and processes within and by which authority is exercised and controlled in corporations."[27]

It is one aspect of what is known as *Corporate Responsibility* (Information Sheet 12) and accounts for, among other things, the management systems to support corporate social responsibility (CSR, Information Sheet 11). CSR accounts for the social, economic and environmental impacts[28] of the organisation's management systems. Environmental management systems (EMS) for example, are part of corporate governance; the practical outcomes of the organisation's EMS are accounted for as part of corporate social responsibility. Corporate governance and corporate social responsibility are both part of the wider picture of corporate responsibility.

Increasingly over the past several years environmental issues have gained prominence in corporate governance debate as board members try to balance their responsibility to shareholders with their responsibility to the environment. According to the founder of SustainAbility[29], John Elkington:

> "Corporate governance is fundamentally about such questions as what business is for - and in whose interests companies should be run, and how. Wider issues such as business ethics through entire value chains, human rights, bribery and corruption, and climate change are among the great issues of our time that increasingly cross-cut the rarefied worlds of corporate boardrooms."[30]

Globalisation has increased the need for international standards of corporate governance that ensure organisations operate ethically, that economic benefits are shared equitably and that economic growth is globally sustainable. Corporate governance is sometimes bundled together with environmental and social standards in what is referred to as corporate ESG [environmental, social and governance standards]. In 2007 the World Business Council for Sustainable Development reported that regulatory standards on corporate ESG disclosure and performance were on the rise. They point to the revised Companies Act passed in the UK in 2006 and the Accounts Modernization Directive, which mandate corporate ESG reporting. They report also that in July 2007, Indonesia adopted Article 74 requiring social and environmental responsibility programs for companies dealing in natural resources.[31]

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[27] The Failure of HIH Insurance Volume 1: *A corporate collapse and its lessons* April 2003:23.
[28] i.e. the triple bottom line
[29] http://www.sustainability.com/ (accessed 02/01/08)
[30] Elkington, John, "Governance for Sustainability". Corporate Governance: An International Review, Vol. 14, No. 6, pp. 522-529, November 2006 Available at SSRN: http://ssrn.com/abstract=939835 or DOI: 10.1111/j.1467-8683.2006.00527.x (accessed 02/01/08)
[31] http://www.wbcsd.org/plugins/DocSearch/details.asp?txtDocTitle=social%20responsibility&txtDocText=social%20responsibility&DocTypeId=1&ObjectId=Mjc1MDE&URLBack=result%2Easp%3F

The Intergovernmental Panel on Climate Change acknowledges an increasing emphasis on accountability in governance and links it to the growing use of indicators to manage and measure the sustainability of development. They site such measures as green certification, monitoring tools and emission registries as vital to this process[32].

Quality of corporate governance is increasingly becoming a criterion for investment and lending. To address the need for high standards of reporting national and international bodies are engaged in providing advice, guidelines, tools and standards. Below are some examples.

Advice and guidelines

The Global Corporate Governance Forum (GCGF)[33]

The GCGF is a multi-donor trust funded International Finance Corporation (IFC) facility. It was co-founded by the World Bank and the Organisation for Economic Co-operation and Development (OECD) to promote sustainable economic growth and poverty reduction. Its mandate is to *"*promote global, regional and local initiatives that improve corporate governance policy standards and practices in developing countries*."*[34]

The GCGF sees its primary functions as: raising awareness and building consensus; sponsoring research relevant to the issues of undertaking corporate government reform; disseminating best practice; and funding technical assistance and capacity building.

The Australian Stock Exchange (ASX) Corporate Governance Council[35]

The ASX Corporate Governance Council's guidelines[36] cover 10 principles that they believe underlie good corporate governance: the roles of management and the board; expertise of board members; integrity and responsible and ethical decision making; company reporting; timely and balanced picture of all material matters; rights of shareholders; risk management; effectiveness of board and management; rewards; serving the interests of all stakeholders.

Adherence to principles of good corporate governance is seen as essential if Australia is to retain investor confidence and compete in a global market place.

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txtDocTitle%3Dsocial+responsibility%26txtDocText%3Dsocial+responsibility%26DocTypeId%3D%2D1%26SortOrder%3D%26CurPage%3D1 (accessed 10/01/08)

[32] IPCC, 2007: Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the IntergovernmentalPanel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA., p. 693 http://www.ipcc.ch/pdf/assessment-report/ar4/wg3/ar4-wg3-chapter12.pdf (accessed 03/01/08)

[33] http://www.gcgf.org/ (accessed 02/01/08)

[34] http://www.gcgf.org/ifcext/cgf.nsf/Content/Work_Program (accessed 02/01/08)

[35] http://www.asx.com.au/supervision/governance/ (accessed 02/01/08)

[36] *Principles of Good Corporate Governance and Best Practice Recommendations* (2003)

To this end, since 2003, organisations have been required to report their corporate governance practices with reference to the guide. They must explain any failure to follow all of the recommendations contained in the guidelines.

OECD
In 2004 after extensive public consultation the OECD published its revised principles of corporate governance[37]. The principles provide guidance for "policymakers, regulators and market participants in improving the legal, institutional and regulatory framework that underpins corporate governance, with a focus on publicly traded companies."[38]

The principles cover the areas of: the basis for an effective corporate governance framework; rights of shareholders; equitable treatment of shareholders; role of stakeholders; disclosure and transparency; and responsibilities of the board. They specifically mention the provision of information related to environmental risks and to the systems for monitoring and managing risks.

The principles are non-binding. They are for use in the examination and development of regulatory frameworks for corporate governance. The report recognises that corporate governance is only one part of the context in which firms operate and that the environment and social contexts also impact on reputation and long-term success[39].

Investment and Financial Services Association (IFSA)
IFSA is an Australian not-for-profit organisation that represents funds management and life insurance industries. IFSA developed best practice guidelines for corporate governance in response to concern over high profile issues in the 1980s. Their best known publication is the Blue Book *Corporate Governance: A Guide for Fund Managers and Corporations*[40].

Institute of Chartered Secretaries and Administrators (ICSA)[41]
The ICSA is a global voice on governance and regulatory issues in the private, public and not-for-profit sectors. ICSA works with government and other statutory bodies to provide guidance on good governance. It also offers a professional qualification training for Chartered Secretaries in corporate governance, effective operations, compliance and administration.

Tools
Corporate Responsibility Exchange (CRE)
In 2006 ICSA Software acquired the Corporate Responsibility Exchange (CRE), which is an online tool developed by the London Stock Exchange for reporting on

[37] http://www.oecd.org/dataoecd/32/18/31557724.pdf (accessed 02/01/08)
[38] http://www.oecd.org/dataoecd/41/32/33647763.pdf (accessed 02/01/08)
[39] http://www.oecd.org/dataoecd/32/18/31557724.pdf (accessed 02/01/08)
[40] http://www.ifsa.com.au/documents/IFSA%20Guidance%20Note%20No%202.pdf fifth ed Oct 2004 (accessed 02/01/08)
[41] http://www.icsa.org.uk/ (accessed 02/01/08)

corporate governance and corporate social responsibility[42]. It is designed to improve reporting of Corporate and Social Responsibility and Corporate Governance information to rating agencies and institutional investors. It includes question sets from a wide range of organisations, rating agencies and codes, including the Global Reporting Initiative (GRI).

Triple Bottom Line accounting software
The software tool, developed by the University of Sydney[43] and Capiotech[44], It provides a triple bottom line management framework and monitoring tool with an extensive suite of indicators. The social, economic and environmental analysis framework provided by the software forms the foundation for an integrated suite of management systems.

Standards and ratings
New York Stock Exchange (NYSE)
The Corporate Governance Listing Standards set out in Section 303A of the NYSE Listed Company Manual were approved by the Securities and Exchange Commission on November 4, 2003 and amended 2004[45]. They were aimed at strengthening corporate governance standards for listed companies.

Australian Standards on Corporate Governance
Standards Australia has published a series of standards to help organisations develop and implement effective corporate governance practices[46]. They provide a non-prescriptive framework for small, large, public, private and not-for-profit organisations to support the development and implementation of a generic system of governance. The Corporate Governance Standards set comprises numbers AS 8000 – 8004.They have been developed around the OECD Principles of Corporate Governance, the IFSA's *Corporate Governance: A Guide for Fund Managers and Corporations* and the ASX listing rules.

GovernanceMetrics International (GMI)[47] is an independent ratings agency focused on corporate accountability. Its ratings criteria are based on the OECD code and others; In 2003 GMI rated companies on the ASX50 index; its ratings are used by pension funds, mutual funds etc

AccountAbility is an institute of social and ethical accountability in the UK. It provides assurance standards for corporate governance. Its assurance standard AA1000 was launched in 2003. AccountAbility is an International, not-for-profit, professional institute for 'promotion of social, ethical and overall organisational

[42] http://www.icsasoftware.com/unitedkingdom/index.htm (accessed 03/01/08)
[43] http://www.isa.org.usyd.edu.au/ (accessed 03/01/08)
[44] http://capiotech.com/
[45] http://www.nyse.com/Frameset.html?nyseref=http%3A//www.nyse.com/regulation/listed/1101074746736.html&displayPage=/lcm/lcm_subsection.html (accessed 03/01/08)
[46] http://www.saiglobal.com/shop/script/Details.asp?DocN=AS964071607297 (accessed 03/01/08)
[47] http://www.gmiratings.com/(kvkzkpnsl4hks4ucq1u1uhih)/Default.aspx

accountability'. AA1000 framework includes: stakeholder engagement process that generates indicators, targets, and reporting, designed to complement the GRI Reporting Guidelines. The AA1000 standard is and assurance standard for social and sustainability reporting.

The challenge

The United Nations Global Compact[48] suggests that companies "once held accountable only for the direct, contractually specified or regulated consequences of their actions now find themselves responsible for issues as disparate as environmental sustainability, the spread of HIV/AIDS, and child labor in sub-Saharan Africa"[49] (p.7).

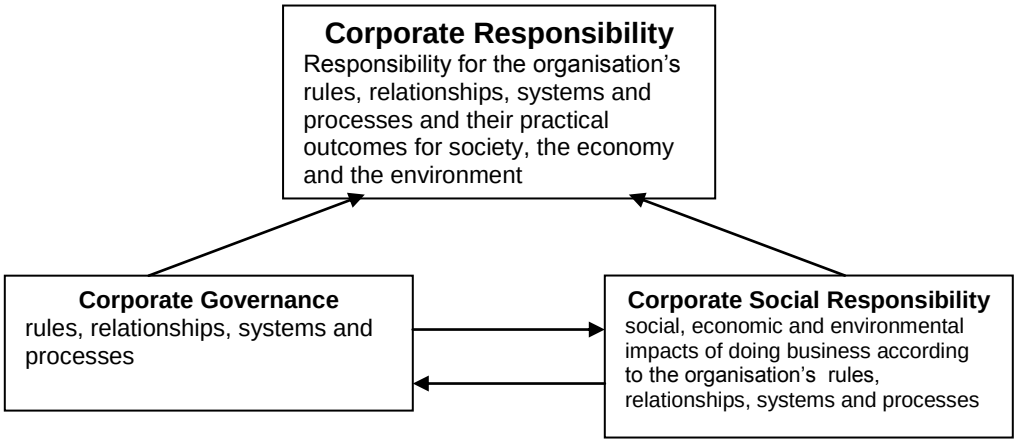
Stakeholders, including consumers and employees, taking up these issues find themselves with increasing power to threaten a company's commercial viability. Perhaps only those companies that have the tools and the will to "meet difficult environmental, social and governance (ESG) challenges will be positioned to succeed in the years ahead" p.6.

[48] an initiative established in 2000 to encourage businesses worldwide to adopt sustainable and socially responsible policies, and to report on them.

[49] http://www.unglobalcompact.org/docs/summit2007/mckinsey_embargoed_until020707.pdf (accessed 03/01/08)
Oppenheim, J., Bonini, S., Bielak, D., Kehm, T., and Lacy P. (2007) *Shaping the New Rules of Competition: UN Global Compact Participant Mirror*, McKinsey & Company.

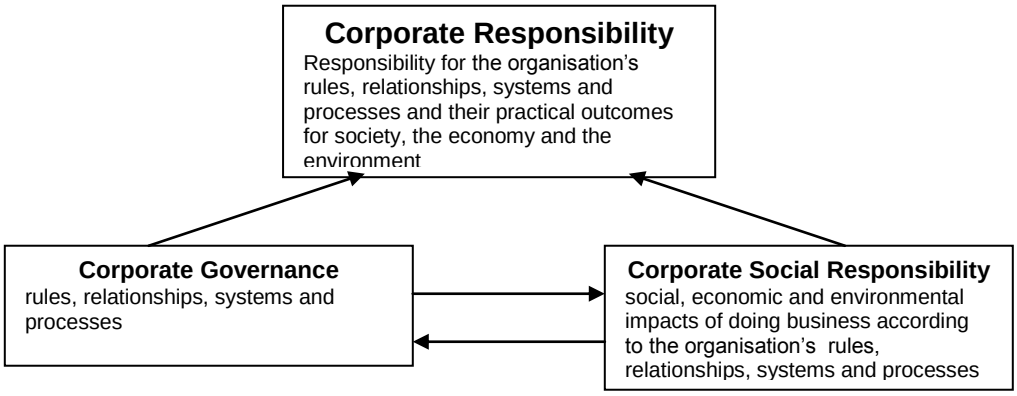
Corporate Responsibility (CR)

Corporate Responsibility is responsibility for the organisation's rules, relationships, systems and processes and their practical outcomes for society, the economy and the environment. Its relationship to Corporate governance and Corporate Social Responsibility is illustrated below.



Corporate Social Responsibility (CSR)
Practical outcomes (impacts and outcomes of corporate governance systems)

Corporate social responsibility (CSR) is one aspect of what is known generally as *corporate responsibility*. Another aspect of *corporate responsibility* is performance against standards of *corporate governance* (Information Sheet 10). While corporate governance accounts for the management systems to support corporate social responsibility CSR accounts for the social, economic and environmental impacts[50] of the application of those management systems.



A socially responsible organisation will not only have a philosophy that is fundamental to all policy documents and values statements, and a code of ethics that is applied consistently (i.e. good corporate governance practices); it will also demonstrate the application of its philosophy through, for example: social and environmental reporting; pro bono work, employee volunteering; philanthropic programs; community education and partnerships; and mentor programs. This is corporate social responsibility as an integral part of day-to-day living and doing business.

The benefits of engaging in corporate social responsibility as part of an overall strategy are thought to be many. The World Business Council for Sustainable Development suggests the following: improved financial performance; reduced risk exposure; identification of new products and markets; enhanced brand image; increased sales and customer loyalty; improved recruitment and retention performance; new business networks; increased staff motivation; enhanced skills; improved trust; enhanced reputations; improved government relations; reduced regulatory intervention; reduced costs through environmental best practice leading to more sustainable profitability.

[50]Corporate responsibility: Managing risk and creating value (21 June 2006) Department of the Treasury, *Submission 134*, p. 1. to the Parliamentary Joint Committee on Corporations and Financial Services http://www.aph.gov.au/senate/committee/corporations_ctte/corporate_responsibility/report/c02.htm#f5 (accessed 04/01/08)

Responsibility towards the environment is a key component of social responsibility, with stakeholders becoming increasingly 'greenwash' savvy. The World Business Council for Sustainable Development discusses the results of the FTSE 100 *Green Washers and Green Winners* survey[51] in which Marks and Spencer (M&S) was the top *Green Winner*, perceived to be making the most genuine effort to go green. The article quotes Mike Barry, head of corporate social responsibility at M&S who believes that the success of their comprehensive environmental program is due to the high level of communication the company has with its customers. He also cites M&S's willingness to address its weaknesses. In the Chatsworth survey[52], 75% of respondents said it was better for businesses to own up to where they were not green and show willingness to improve, rather than just shout about their good deeds.[53]

The Chatsworth survey is one of many rating surveys now available. Below is a sample of others.

Indices and Ratings

Corporate Responsibility Index (UK)[54]

The Corporate Responsibility Index was set up in 2002 by *Business in the Community* (BITC) to benchmark and monitor what they called *responsible business practice*. According to the BITC website the index is "regarded as the most comprehensive and robust measure of an organisation's positive impact on society and the environment, through its operations, products or services and through its interaction with key stakeholders such as employees, customers investors, communities and suppliers"[55]. The index, they say, is designed to help "companies to integrate and improve responsibility throughout their operations by providing a systematic approach to managing, measuring and reporting on business impacts in society and on the environment"[56]. The results of the Corporate Responsibility Index are published annually in the *Companies that Count* supplement distributed by the Sunday times.

FTSE100 and FTSE250 listed companies are invited to take part, as well as sector leaders from the Dow Jones Sustainability Index and larger Business in the Community members. The survey has continually been updated since 2002

[51] article *reproduced with permission from the November edition of the London-based global business magazine Ethical Corporation*

[52] FTSE 100 "Green Washers and Green Winners" survey, compiled 2007 by public relations consultancy Chatsworth Communications, which polled UK "opinion-formers", such as journalists and political groups

[53] http://www.wbcsd.org/plugins/DocSearch/details.asp?txtDocTitle=social%20responsibility&txtDocText=social%20responsibility&DocTypeId=1&ObjectId=MjczNjU&URLBack=result%2Easp%3FtxtDocTitle%3Dsocial+responsibility%26txtDocText%3Dsocial+responsibility%26DocTypeId%3D%2D1%26SortOrder%3D%26CurPage%3D1 (accessed 10/01/08)

[54] http://www.bitc.org.uk/ (10/01/08)

[55] http://www.bitc.org.uk/news_media/yorkshire_businesses.html (10/01/08)

[56] http://www.bitc.org.uk/what_we_do/cr_index/

based on feedback from participating organisations suggesting that the number of questions could be reduced without compromising the results. This highlights a problem for organisations having to spend time and effort on a range of different questionnaires in order to demonstrate their compliance with the requirements of various indices and ratings. *Business in the Community* for example has some overlap with the FTSE4Good index (see below) especially in the area of environmental information.

In an effort to solve the data collection issue the London Stock Exchange developed what they called the Corporate Responsibility Exchange (CRE). The Corporate Responsibility Exchange (CRE) was acquired by ICSA Software[57] in 2006. It is an online tool for the reporting of corporate governance and corporate social responsibility information. It includes comprehensive question sets from a wide range of organisations, rating agencies and codes enabling companies to input data once only to disclose against several codes and rating systems including: GRI, BITC and FTSE4 Good. Thus one data entry exercise by an organisation can satisfy the needs of many data collecting agencies and provide information for entry into the FTSE4Good rating and the BITC index.

FTSE4Good Index Series
FTSE Group is partnered with nine stock exchanges and services clients in 77 countries. The FTSE4Good Index Series, launched in 2001, was designed to measure corporate responsibility standards, and to facilitate investment in companies that meet the standard. The FTSE Group is an independent company that originated as a joint venture between the Financial Times and the London Stock Exchange. It creates and manages indices and associated data services. According to the FTSE4Good website[58] "a committee of independent practitioners in socially responsible investment, (SRI) and corporate social responsibility (CSR) review the indices to ensure that they are an accurate reflection of current CSR best practice". As a basic element of their commitment to corporate social responsibility FTSE4Good say they are committed to their own good environmental performance. To this end they say that they address a range of direct impacts (energy efficiency, waste management, recycling and use of recycled material) and indirect impacts (procurement of equipment/choice of supplier, influence on investment strategy of clients) on doing business. "All FTSE4Good fund licensing revenues go to UNICEF to help children around the world."

Corporate Responsibility Index (Australia)[59]
The Corporate Responsibility Index was initiated in Australia in 2004 by the St James Ethics Centre, *The Sydney Morning Herald* and *The Age* newspapers. It is supported in Australia by Ernst & Young who have provided a validation process on a pro-bono basis. The Index, designed by the UK not-for-profit

[57] http://www.icsasoftware.com/news/index.htm?p=10-06-cre.asp (10/01/08)
[58] http://www.ftse.com/ftse4good/index.jsp
[59] http://www.corporate-responsibility.com.au/ (10/01/08)

organisation, *Business in the Community*, has been donated under a licence agreement with the St James Ethics Society.

According to the Corporate Responsibility Index website the index is "the only voluntary non-prescriptive framework for corporate responsibility in Australia and New Zealand, enabling companies to identify their non-financial risk, as well as to develop and improve corporate responsibility in line with their business strategy". Its developers hope that it can be used as a strategic management tool to benchmark and communicate best practice in the field of corporate social responsibility. It addresses the four key impact areas of community, workplace, marketplace and environment.

Australia's top 250 companies and Business Council of Australia members are invited to participate. However only 26 companies completed the inaugural, voluntary testing process in 2004 and 27 companies took part in 2005. In 2006, to encourage greater participation, flexible engagement options were introduced allowing companies to complete single modules, or engage in private bench-marking as a first step to full participation. This helped boost participant numbers to 34 companies, 16 of which have competed each year since the Index began.

To address the three pillars of Corporate Social Responsibility – social, economic and environmental accountability – there is a need for a global standard, and reliable and transparent tools, that do not support 'greenwash'. Below is a description of the most advanced and comprehensive of the many TBL tools that are becoming available.

TBL accounting tools and frameworks

Triple Bottom Line Accounting

Triple Bottom Line software, developed by the University of Sydney[60] and Capiotech[61] provides a triple bottom line management framework and monitoring tool with an extensive suite of indicators. The software takes your organisation's financial accounts, together with on-site impact data, as input. Your indirect, supply chain impacts, such as emissions, are calculated by allocating your organisation's expenditure across a breakdown of sectors of the national economy. Because the total emissions for each sector of the economy are known a portion commensurate with your expenditure in each sector can be calculated. The same can be done for water use, energy, employment and hundreds more indicators. The software outputs are diagrams and tables that reveal upstream vulnerabilities, risks and opportunities. Greenwash is not possible because the entire upstream supply chain is accounted for. To date the software is available for the Australian, UK, German and Japanese economies, with USA, Ireland, Brazil, Kenya, Korea, China, India to follow. The software adds the depth of the full supply chain to the Global Reporting Initiative's breadth of onsite indicators.

[60] http://www.isa.org.usyd.edu.au/
[61] http://capiotech.com/

OECD Key Environmental Indicators[62] *(2004)*
A common approach and framework for developing, measuring and using environmental indicators: core environmental indicators (CEI); sectoral environmental indicator sets (SEI) (e.g. transport, energy); and a small set of key environmental indicators (KEI).

Ecological Footprint[63] *founded 1995*
Ecological Footprint Network: measures the land and water area that is needed by a nation, population, company, city, region or individual to produce all the resources it consumes, and absorb all the waste it generates on a continuous basis, using available technology. Calculates the Ecological Footprint using aggregate national data (compound approach). Suggests that humanity's average ecological footprint measures 2.3 hectares of ecologically productive space. In contrast only 1.7 hectares per person is available. Originally a fairly blunt measure but powerful metaphor, effective in shocking into action. Becoming a more and more sophisticated tool, as the methodology evolves.

Integrated Sustainability Analysis[64] (ISA) founded 2000, University of Sydney: macro, Input Output Analysis (IOA) approach provides depth to complement the audit (onsite) approach taken by, for example, the GRI. IOA approach includes the full upstream supply chain – provides the true bottom line by solving the boundary issue.

International Standards
International Organization for Standardization (ISO)[65]
ISO (International Organization for Standardization) is the world's largest developer and publisher of International Standards. It is a network of the national standards institutes of 157 countries, one member per country, with a Central Secretariat in Geneva, Switzerland, that coordinates the system.

ISO 14044 addresses the environmental aspects and potential impacts of a product throughout its life cycle. It covers the methodological framework for Life Cycle Analysis (LCA), reporting of your LCA and critical review of the LCA by experts or interested parties.

The University of Sydney's Integrated Sustainability Analysis (ISA) methodology that underpins its TBL software is entirely compatible with ISO 14044.

Social Accountability International[66]
Social Accountability International (SAI) is a USA based non-profit organization

[62] http://www.oecd.org/department/0,3355,en_2649_34441_1_1_1_1_1,00.html
[63] http://www.footprintnetwork.org
[64] www.isa.org.usyd.edu.au
[65] http://www.iso.org/iso/about.htm (11/01/08)
[66] http://www.sa-intl.org/index.cfm?fuseaction=Page.viewPage&pageId=472 (accessed 10/01/08)

whose role is to develop, implement and monitor social accountability standards. In 1996, SAI convened an international advisory board to develop Social Accountability 8000 (SA8000). The standard, based on ILO (International Labour Organization), the UN's Universal Declaration of Human Rights and the Convention on Rights of the Child, draws on the quality management systems of ISO programs. It promotes management systems that upgrade working conditions. The standards are developed in consultation with stakeholders and compliance is voluntary. However SAI accredits qualified organisations to verify compliance with the standards. Verified compliance is seen as a benefit to management and workers and to the whole organisation as ethical investments continue to grow and consumers make ethical purchasing decisions.

SA8000's focus is on human rights and a humane workplace. It provides support for just and decent working conditions throughout the whole supply chain. Its standard deals with: international labour rights (no child labour or forced labour); continuous improvement of factory-level management systems (in particular OH&S); freedom of association and right to collective bargaining; all forms of discrimination; disciplinary actions, punishment and abuse; working hours and wages; integration of standard into management systems. The SA8000 system became operational in 1998. There are now 1,373 certified facilities across 66 industries in 64 countries.

Corporate Social Responsibility (CSR): demonstration of an organisation's philosophy through, for example: social and environmental reporting; pro bono work, employee volunteering; philanthropic programs; community education and partnerships; and mentor programs.

Example of Online environmental calculators

Economic Input Output Life Cycle Assessment	http://www.eiolca.net/index.html Online calculator that "allows you to estimate the overall environmental impacts from producing a certain dollar amount of any of 500 commodities or services in the United States." Provides "rough guidance on the relative impacts of different types of products, materials, services, or industries with respect to resource use and emissions throughout the U.S."
The Australian Greenhouse Calculator, 2002	http://www.epa.vic.gov.au/GreenhouseCalculator/calculator/default.asp Online calculator developed by EPA Victoria to check your annual greenhouse gas emissions against a 'typical' house and a 'green' house.

ISA Greenhouse gas calculator	http://www.isa.org.usyd.edu.au/ Online calculator developed by the Centre for Integrated Sustainability Analysis (ISA) University of Sydney. Uses input/output analysis methodology. Calculates the amount of greenhouse gases emitted to support your lifestyle. Provides comparison with the average Australian and the average person in India. Calculates your "fair share" of global greenhouse gas emissions.
Eco'tude The Powerhouse Museum, Sydney	http://www.powerhousemuseum.com/ecotude/calc.asp Online footprint calculator for use in schools. The eco'tude calculator asks questions about school and uses the answers to make an estimate of the school's ecological footprint – the total amount of land disturbed by activities at the school.
Australian Conservation Foundation Consumption Atlas	http://www.acfonline.org.au/consumptionatlas/ Interactive online tool developed in partnership with the University of Sydney. Shows patterns of consumption and environmental impact across Australia. Illustrates how much water and land is needed, and how much greenhouse pollution is created, to support household consumption. Based on (1) input-output analysis of the interdependencies and material flows between Australian industries; and (2) household expenditure data collected by the Australian Bureau of Statistics. By matching the expenditure data with the results of the input-output analysis for various categories of goods and services, it is possible to assess the per capita environmental impacts of household consumption at the level of local statistical areas in Australia.
Department of the Environment and Water Resources, 2007. Household, office and hospitality greenhouse gas calculators	http://cc-calc.greenhouse.gov.au/Content/Home.aspx Part of the 2007 Federal Government's Climate Clever campaign; determines the amount of greenhouse gas emissions produced by your household or small business over the past year. Underpinned by Sydney University's Integrated Sustainability Analysis (ISA) methodology

Cybernetics

Cybernetics is one way of looking at the world.

Cybernetics comes from the Greek *kubernetes* meaning *helmsman* or *cox,* which is also where we get the word *governor*, meaning among other things, *controller* or *regulator*. You might guess therefore that *cybernetics* has something to do with steering (*helmsman*) and control (*governor*), both of which rely on communication to do a good job. In fact cybernetics originally centred around control and communication in people and machines. Cybernetic communication was unambiguous, transmitting a message such as: when the temperature reaches 22 degrees switch off the heating; when it drops to 19 degrees switch it back on. In this case feedback from temperature governed changes in the message that got sent to the switch, that changed the switching device, that changed the temperature, that changed the message and so on. This feedback-message-action-feedback made a circular feedback loop that enabled a heating system to remain at the right temperature. Thus cybernetics not only had something to do with control, communication and feedback but it also was underpinned by the idea of circularity.

However communication is not always that straight forward. When circular feedback and communication are applied to other areas of life, such as family or work, things can became complicated. Messages are often ambiguous, we can easily get the wrong end of the stick; and there is no controller sitting outside watching the dials and temperature gauge (or faces and emotions) and knowing exactly what the message said and what it meant. There is no-one who is able to simply throw a switch to fix things up if the system of social, family or work communications breaks down; no-one who can say without a doubt: this is what he said/she said, and this is what he/she meant!

We are all included in the circle and we are all part of the message. How can there be a calm, cool observer—you—outside looking in and explaining what is ‘really’ happening when you can always take a step back and bump into another observer, watching you *and* whatever it was that you were observing? Remember the Pantomime where the dame believes s/he’s in control, tippy-toeing up to the unsuspecting plotters, and all the children in the audience screaming ‘look behind you!’ and of course the baddy was always there hiding whenever the dame looked around and popping out whenever her back was turned. And then of course there are parents in the audience watching over the children, in the superior knowledge that this is all make believe; and the wider circle of family and friends watching over the parents and commenting on their parenting; districts and community watching over different social and cultural groups in their midst; local, state and federal governments; national and global organizations… and eventually The Universe. Remember when you were a kid writing your address beginning with yourself in your house, then street, then town, and ending up with The Universe. It’s the same thing. There is always a bigger system engulfing and observing us wherever we stand in the network of

interactions. Feedback is never one-way in a nice straight line, or even circular in one single line that curls back on itself. It's always much messier than that.

The observer is always part of a system that is observed by another and so on; and as part of the system the observer always, because s/he's in the system rather than outside of it, makes a difference to the system; and the system inevitably makes a difference to the would-be observer. This is cybernetics of cybernetics—a cybernetic study of cybernetics itself—called *second order cybernetics*.

If there can be no-one sitting outside the system who can explain discrepancies in the message that was sent and the messages that you received –if there is no one who knows everything and can accurately, without any doubt, explain what's going on –if there is no dame fully in control of the situation, but always someone saying 'look behind you' –then no communication is fully controlled by an outside controller. And we have no way of knowing if information is conveyed accurately. There is no-one sitting outside who can tell us this; we are all involved. Even information itself becomes a slippery customer –whose version of *information* are we talking about? The dame's or the children's or the parents' or… Nothing can be said as an unambiguous statement of fact, an absolute truth, everything is said from an individual perspective. And every individual perspective is coloured by that person's life history. We can only invite others to look in a particular way depending on our personal histories. Information, in this view of the world, does not neatly enter us from outside, but is made up by us on the inside based on who we are, our history, and whatever else we can lay hands on.

This means that by communicating with others we negotiate the meaning and we create our own meaning. It also means that by being part *of* the system we continually change it and we are changed by it. This leads us inevitably towards the idea that there is no pre-existing reality. Instead we create this world of ours by living in it as we change it and are changed by it in constant feedback/communication with the environment, each other and ourselves. This realization is one of the major implications of a cybernetic view of the world. We are all observers and as observers we describe *one* reality while being aware that there are many other views of reality. In this paradigm there is no one 'right' view of the world, no possibility of objective commentary on a fixed outside reality. We 'see' what we believe to be the 'real reality' from our own perspective and often have to agree to disagree with others who equally adamantly 'see' a different 'real reality' from a different perspective.

This does not mean that we can never ever agree on anything at all. Groups do this all the time. Experts, for example, build bodies of knowledge through discussing ideas or conducting experiments. But groups of experts can disagree with each other about how they interpret their knowledge, and bodies of knowledge, such as aspects of science and religion, can sometimes be competing. And even within groups of experts no-one can know for sure that all

hold the same view. We can never get inside someone else's head – but we can get close to believing that we understand someone else's view, through discussion over time. Even so most experts acknowledge that what they believe to be true now will inevitably change over time as we gain new knowledge through our never-ending conversations.

So circularity, feedback and communication, which are central to cybernetics of cybernetics, (which has now once more become known simply as *cybernetics*) lead inevitably to a reality that we construct in constant feedback and communication with and in an environment.

Through a cybernetic lens a particular system and a particular environment do not have an existence as system-and-environment until I, the observer, distinguish them from background noise and define them as system-and-environment. This idea of noticing a difference is, like circularity, central to cybernetics. Once we distinguish something from the background as 'different' it becomes 'information' to us. We learn something new, and in the learning we change the phenomenon as we bring it into focus, provide it with attributes and communicate our observations to others; and we are changed by it, as it becomes part of our lives.

This brings us to one of the major implications of cybernetics for learning. Circularity, feedback and communication imply change. They take place over time in a constantly changing environment. We change that environment by being part of it and are changed by the environment through feedback in communication with it. In a cybernetic view of the world we living systems do not adapt to the environment but through our history of interactions with the environment over time we, *and the environment* change. We find ways to 'fit' together. We, and our environment, have a co-history of change that happens second by second over lifetimes. This means that in the process of living our whole mind/body is changed by the people, environments and ideas with which we come into contact. At the same time we are changing that environment as we interact. According to the biologists Humberto Maturana and Francisco Varela this change is what we call *learning* and is essential to our survival. Even if the change is infinitesimal, it becomes part of who we are, and in turn who we are brings about particular changes in our environment. So you can see that everything we do and say contributes, however minutely, to evolution - the making of the future of our universe.

The fundamental principles of cybernetics can be summarised as follows.

- We are all observers
- As observers we are always embedded in a system and cannot claim an impartial outside view

- We observe through the lens of a life history and our observations cannot be other-wise because we only have this one mind/body and this one life history out of which to observe
- As observers we notice differences, pick out systems from the background environment; different observers carve out different worlds from the background 'noise'; this becomes *information* to us
- Information does not reside in observer, system or environment but arises in the process of living *between* the observer and the system/environment carved out from the background noise
- In constant communication and feedback we change our carved out world and are changed by it, with or without the intention of changing and being changed
- This change is called *learning*
- Learning arises from need for survival (in social, economic, cultural or physical terms); it enables us to go on living

Learning: is triggered by the environment; fits with life history; will be anticipated in some way; will be different for everyone

A cybernetic view of the world suggests that the only environments that exist at any moment are the inside mind/body learning environment of the living system, which has been shaped by the living system's history of interactions, and the immediate outside environment with all the opportunities that it affords. The only possible learning that can occur is learning contingent on these two environments as the living system fits with the outside world and through communication with artifacts, self and others re-organises its inside world until it feels comfortable.

From the discussion above it might be easy to conclude that since we act out of survival needs and our actions at that moment cannot be otherwise then we are not responsible for our actions and therefore should not be held accountable. But this is to distort the argument. Our society as a whole has arrived at this place and time in exactly the same way as individuals have arrived at wherever they are right now. As a society we have evolved a political system and a system of justice that sanction some actions and penalise others. This is part of the environment, part of the feedback loop, part of our relationship building. If the society that we have arrived at penalises a particular behaviour then how that behaviour arose in an individual is not relevant to the decision to penalise. The society to which we belong has long since made this decision. However how a particular behaviour arose *is* relevant to the wider discussion of what to do about it and how to prevent it happening again. A cybernetic view of the world doesn't let anyone off the hook, what it does say is that we are all in this together, we are all responsible for creating our world, we must all look out for each other.

Downstream and upstream

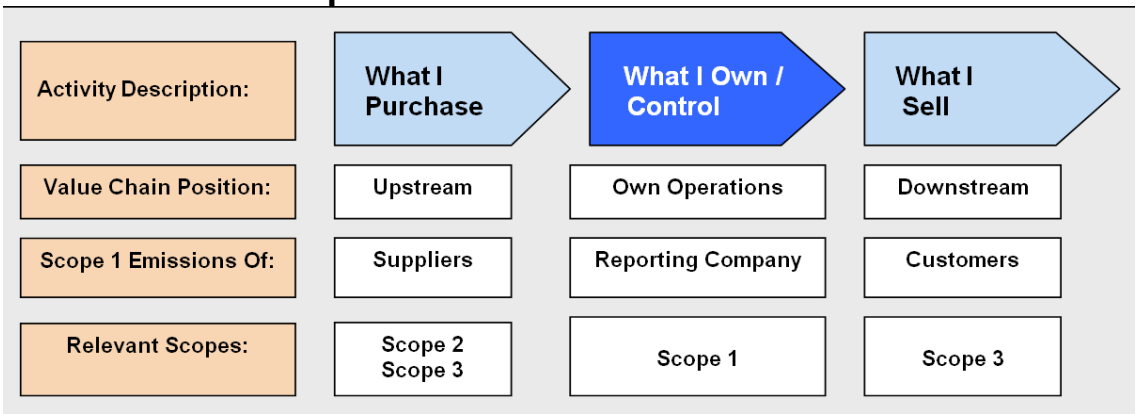


Fig. 1: Spheres of corporate responsibility; internal review draft for Greenhouse Gas Protocol Technical Working Group members, 17th June 2009.(reproduced with permission in: Lenzen M and Murray J, Conceptualising environmental responsibility, *Ecological Economics*, **70**(2), 261-270, 2010)

To be consistent, if you apply Input Output analysis to downstream you will need to conceptualise downstream in a way that is consistent with how you conceptualise upstream. If you look upstream your demand facilitates the production of your suppliers' products, and associated emissions. A part of the responsibility for these emissions is handed down to you, as *embodied* emissions. If you look downstream your supply facilitates the production of your customers' products, and associated emissions. A part of the responsibility for these emissions is handed up to you, as *enabled* emissions. From wherever you stand you play a part in the production chain and have some responsibility for what happens because *had you not* taken your position in the chain – made the purchasing, production and sales decisions that you did to put yourself in that particular chain – the outcome would have been different. Thus downstream emissions are *enabled* by your having sold goods or services – had you not made that particular sales decision, the whole downstream cascade of interactions, supported by your sale, would have occurred differently and those particular emissions, throughout the consequent downstream chain, would not have *been able* to occur.

For the downstream scope-3 case, consider the sales chain "*Technical services* provided to *Coal mining* for *Electricity generation*". The emissions associated with this sales chain are caused by *combustion in power plant boilers*, of coal that was *mined in a coal mine* that in turn was provided with *technical services*. If we look upstream we are used to saying for example that beef's emissions are *embodied* in a restaurant meal, even though there may be a considerably long supply chain between cattle station and restaurant. The logic of downstream responsibility is as follows: By choosing to sell to a coal mine that sells in turn to power plants, the technical service provider indirectly enables the power plant to buy coal, and hence to produce, and hence to emit. The more the technical service provider sells to the coal mine, the more it is responsible for the

downstream emissions liability caused by coal mining through selling to power plants.

In the literature, downstream responsibility is much less often elaborated, and hence this logic sounds less familiar. The crucial aspect here is the *choice* of selling to someone, that is to *enable someone to produce, to emit, and to sell onwards, by selling them an operating input* (compare Gallego and Lenzen 2005; Lenzen 2008). Downstream responsibility is perhaps more intuitive when considering the popular example of the responsibility of someone working (i.e. selling their labour) to a company that produces cigarettes, that in turn cause lung cancer in customers further downstream. In principle, this downstream responsibility also exists for someone working for an advertising services provider that produces ads for the cigarette company, or – to draw a long bow – for someone working for a logging company that produces timber that is made into pulp and then into paper that in turn is used by an advertising service provider that produces ads for the cigarette company. Of course, the latter sales chain is very complex and would enable the cigarette company to produce only to a very small extent. As with upstream responsibility, downstream responsibility diminishes with increasing distance of the seller from the emitter (Gallego and Lenzen 2005; Lenzen et al. 2007).

Downstream responsibility is often associated with the emissions from the use phase of a product. For example, a truck manufacturer is responsible for emissions caused by a freight company that uses their trucks. Here we argue that downstream responsibility must be seen in a wider context. Let us revert to the aspect of enabling someone to produce and emit by selling to them. The truck manufacturer alone cannot enable the freight company to emit; they have to buy petrol as well. And in a sense, the product-use emissions are even *more directly* due to the choice of the refinery to produce and sell their petrol so it can be combusted.[67] The truck – albeit necessary – is the mere device for this very combustion. In the same sense, an accounting services provider selling to our freight company enables it to emit, because our company would not be allowed to operate without proper accounts. So, downstream responsibility includes, but is not restricted to, the selling of products that directly cause emissions during their use.

Calculating downstream in IOA

Using financial revenue accounts, input-output footprint practitioners undertake the downstream calculus in just the same way as the upstream calculus, using input-output tables regularly published by statistical agencies around the world. Like the upstream footprint calculated from your company's expenditure account,

[67] In Australia, this argument has a very prominent interpretation in that some commentators assert that Australia should assume responsibility for the combustion of the coal that is exported (see for example Umwelt Environmental Consultants 2007).

44%	Electronic equipment	kg CO_2-e/$		% of total
1	Electronic equipment > Softwoods	0.04	tier 2	10.3%
2	Electronic equipment	0.03	tier 1	7.7%
3	Electronic equipment > Electricity supply	0.024	tier 2	6.2%
4	Electronic equipment > Hardwoods	0.015	tier 2	3.9%
5	Electronic equipment > Limestone	0.006	tier 2	1.5%
6	Electronic equipment > Non-residential building repair and maintenance > Beef cattle	0.006	tier 3	1.5%
7	Electronic equipment > Black coal > Electricity supply	0.006	tier 3	1.5%
8	Electronic equipment > Beef cattle	0.006	tier 2	1.5%
9	Electronic equipment > Natural gas	0.005	tier 2	1.3%
10	Electronic equipment > Forestry > Softwoods	0.005	tier 3	1.3%
11	Electronic equipment > Non-residential building construction	0.005	tier 2	1.3%
12	Electronic equipment > Black coal	0.0031	tier 2	0.8%
13	Electronic equipment > Domestic telecommunication services > Electricity supply	0.003	tier 3	0.8%
14	Electronic equipment > Brown coal	0.0028	tier 2	0.7%
15	Electronic equipment > LPG, LNG > Electricity supply	0.0023	tier 3	0.6%
16	Electronic equipment > Wholesale repair and servicing	0.0023	tier 2	0.6%
17	Electronic equipment > Electricity supply > Electricity supply	0.0021	tier 3	0.5%
18	Electronic equipment > Iron and steel semi-manufactures	0.0021	tier 2	0.5%
19	Electronic equipment > Sanitary and garbage disposal	0.002	tier 2	0.5%
20	Electronic equipment > Domestic telecommunication services > Beef cattle	0.0019	tier 3	0.5%

you can start your downstream footprint with a relatively quick and rough *input-output-only* analysis, straight from the revenue account. It will give you a first cut of your complete downstream footprint, based on economic input-output data for your company's industry sector. It will also give you the top downstream sales chains (as opposed to upstream supply chains), ranked in terms of carbon. You can use this ranked list for following up the top sales chains with your own specific in-house data. Wherever the sales of your company are substantially different from those of the sector, you replace input-output data with your in-house data, for example if your product is specifically designed for energy efficiency in the use phase and is different from the general output of your sector. This way your footprint becomes more and more accurate. The nice thing is, you can stop analysing at any stage, depending on the resources you wish to dedicate to the footprint exercise, your analysis will always be complete, because of the input-output analysis.

Electronic Equipment: Structural Path Analysis

Above is the SPA for the electronic equipment sector. Column one shows the ranked significance of items that make up the downstream carbon footprint of the sector. The table shows ranks 1 – 20 however a longer list of items can be generated. The top 20 items cover 44% of the total downstream emissions footprint. Column two shows the pathway of emissions from the electronic equipment sector through the downstream layers of the supply chain. For

example the top-ranking item says that the electronic equipment sector chooses to sell to the softwoods sector. In our example therefore electronic equipment accepts responsibility for that decision in terms of some of the emissions of softwoods. Item two represents the sector's Scope 1 emissions. Item six reads: The electronic equipment industry chooses to sell to the non-residential building and repair and maintenance sector and therefore accepts downstream responsibility for part of the non-residential building and repair and maintenance sector's onsite emissions and part of their further downstream emissions, part of which is beef. These are the greenhouse gas effects *of doing business* that are part of the web of interactions upstream and downstream, the only difference between upstream and downstream is your vantage point in the chain.

Column three shows the amount of CO_2-e per dollar of electronic equipment sold. For example, for every dollar of electronic equipment sold there is 0.006 kg of CO_2-e emitted downstream by the beef cattle sector in the course of doing business because they got an essential input from the non-residential building and repair and maintenance sector which in turn had an essential business input from the electronic equipment sector. This represents 1.5% of the electronic equipment sector's total downstream emissions (column five).

Column four shows to which tier of the downstream supply chain this item belongs, for example tier 1 is the sector itself, tier two is the immediate customers of the sector, tier three is the customers of the customers etc.

Among the top 20 contributors to the downstream footprint of electronic equipment 12 are immediate customers (Tier 2). They constitute almost 30% of the downstream footprint. This means that the electronic equipment sector has a good chance of influencing its downstream footprint through customer dialogue.

Below is an excerpt from Lenzen M and Murray J, Conceptualising environmental responsibility, *Ecological Economics*, **70**(2), 261-270, 2010

"In order to be consistent, downstream responsibility will need to be conceptualised in a way that is consistent with upstream responsibility. In the following we achieve this by first giving familiar explanations for upstream responsibility, and then we mirror the phrases by replacing as few words as possible (Tab. 1).

	Upstream	Downstream	
Emissions are caused by our	suppliers,	customers,	
because we	buy from our suppliers,	sell to our customers,	
which enables	our suppliers	our customers	to operate.
We are responsible for the emissions that we	enable by our purchases.	enable by our sales.	
We are responsible for emissions	embodied in our purchases.	enabled by our sales.	

The more we	buy from our suppliers,	sell to our customers,	the more we are responsible for their emissions.
Our responsibility is calculated from	the fraction of our purchases in the output of our suppliers, and our suppliers' emissions.	the fraction of our sales in the input of our customers, and our customers' emissions.	
Ultimate	upstream	downstream	responsibility
rests with	buyers of final outputs (eg households)	sellers of primary inputs (eg workers and investors)	

Tab. 1: Matching vocabulary for upstream and downstream responsibility. From Lenzen M and Murray J, Conceptualising environmental responsibility, *Ecological Economics*, **70**(2), 261-270, 2010"

Upstream

In the ISA model upstream refers to: suppliers, suppliers of suppliers, suppliers of suppliers of suppliers and so on to infinity.

These are sometimes referred to as supply chains or value chains. In the ISA model they are defined by what an organisation spends money on – analysis of the expenditure accounts captures all upstream inputs into an organisation.

The following is taken from: Huang A, Lenzen M, Weber C, Murray J and Matthews S, The role of input-output analysis for the screening of corporate carbon footprints, *Economic Systems Research*, **21**(3), 217-242, 2009

"In an upstream scope-3 calculation, supply chains start with an emitting upstream sector, and end with the purchasing industry sector under investigation. The meaning of *upstream chain* is best explained using an example. Consider the supply chain 'Beef cattle > Meat processing > Restaurant'. The emissions associated with this supply chain are caused, for example, by land clearing or enteric fermentation in animals slaughtered for meat that is supplied to a restaurant's kitchen. Another way of expressing this is to say that emissions from beef-cattle farming become 'embodied' in the restaurant meal. The logic of upstream responsibility is that by choosing to buy from a meat processor that buys in turn from the beef cattle sector, the restaurant indirectly enables the beef cattle sector to sell beef, and hence to produce, and hence to emit. The more the restaurant buys from the meat processor, the more it is responsible for the upstream emissions liability caused by meat processing through buying beef cattle. The crucial aspect here is the *choice* of buying from someone: to *enable someone to produce, to emit, and to buy onwards, by buying from them an operating output*."

Ecological Footprint (EF)

The term *Ecological Footprint* was coined by William Rees in 1992[68]. It has proved to be a powerful metaphor, lending itself to illustration with vivid depictions of trampling on the earth and taking up more space than is available. As a result the use of *Footprint* has become wide-spread with people now talking about a *Water Footprint, Social Footprint* or *Carbon Footprint*.

The Ecological Footprint (EF) can be used alone or in *Triple Bottom Line* reports as one indicator of the sustainability of an organisation. As part of the TBL it can sit along side indicators such as employment, imports and exports, or contribution to government revenue (see Information Sheet 7 for an explanation of *Triple Bottom Line* and Information Sheet 6 for the full range of ISA indicators).

What does it measure?

The Global Footprint Network (GFN)[69] says that the Ecological Footprint is a resource management tool that "measures the extent to which humanity is using nature's resources faster than they can regenerate. It illustrates who uses how much of which ecological resources, with populations defined either geographically or socially". Also, they say, "it shows to what extent humans dominate the biosphere at the expense of wild species"[70].

The Footprint is not designed to be a complete sustainability measure. While it documents the ecological outcome – the demand on nature resulting from human activities that occurred at a given time – it does not, for example include any measure of social well-being. Neither does it evaluate the long-term viability of social and economic structures or political systems[71]. And while the EF is said to "describe how much of the *regenerative* capacity of the Earth is being used by humans, to re-generate the biosphere requires more than the regeneration of biological matter; it requires the regeneration of ecosystems, and the species relationships therein. Therefore, a more precise description [of what the EF measures] would use the term *bioproductive* capacity"[72].

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[68] Rees, W.E. (1992). Ecological footprints and appropriate carrying capacity: what urban economics leaves out. *Environment and Urbanization* **4**(2). 121-130; see also Wackernagel, M. & Rees, W. (1995). *Our Ecological Footprint: Reducing Human Impact on the Earth*. New Society Publishers Philadelphia, PA, USA.

[69] http://www.footprintnetwork.org/gfn_sub.php?content=footprint_overview (retrieved from the web 29/11/07)

[70] http://www.footprintnetwork.org/gfn_sub.php?content=footprint_overview (retrieved from the web 29/11/07)

[71] University of Sydney ISA & Global Footprint Network (2005). *The Ecological Footprint of Victoria: Assessing Victoria's demand on nature*. EPA Victoria. P. 66.
Also http://www.footprintnetwork.org/gfn_sub.php?content=standards *Ecological Footprint Standards 2006*, Global Footprint Network "Policy decisions regarding biodiversity, resource management, social well-being and other sustainability dimensions require consideration of factors beyond the Footprint. Footprint reports need to state clearly that Footprints are not complete sustainability measures." (p. 26).

[72] On the bioproductivity and land-disturbance metrics of the Ecological Footprint. ISA Research Paper 03/06, in collaboration with WWF. Manfred Lenzen, Carina Borgstrom Hansson and Stuart

What does it mean?
The WWF's *Living Planet* Report (2006, p. 16)[73] says that a "country's Ecological Footprint is determined by its population, the amount consumed by its average resident, and the resource intensity used in providing the goods and services consumed.

"It includes the area required to meet people's consumption from cropland (food, animal feed, fibre, and oil); grassland and pasture (grazing of animals for meat, hides, wool, and milk); fishing grounds (fish and seafood); and forest (wood, wood fibre, pulp, and fuelwood).

"It also estimates the area required to absorb the CO_2 released when fossil fuels are burned, less the amount taken up by the oceans."

Using the original concept and methodology this area of productive land or sea is translated into a common unit of biologically productive area called a 'global hectare' (gh). Thus a five hectare footprint would mean that five 'global hectares[74]' are in constant production to support the average individual of that country. According to calculations based on the above, in 2006 WWF reported that humanity's Footprint was 14.1 billion global hectares, which exceeded the Earth's biological capacity by about 25 percent[75] (up from 20% reported in 2004). This translates to an average of 2.2 global hectares per person[76]. However the productive area available to support the global population of 6.3 billion in 2003 was 11.2 billion global hectares, which is an average of approximately 1.8 gh each. We are considerably overshooting our planet.

The 'overshoot' is said to indicate the extent to which humanity's consumption exceeds nature's ability to regenerate (Wackernagel et al, 2002[77]). To explain this concept: in a perfectly sustainable system, human waste products would be re-used in nature at the same rate that they were produced. Waste products from human activities would not build up on land, in the sea, or in the atmosphere. Greenhouse gases, which make up about 48% of our global footprint, would be

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Bond.
http://www.isa.org.usyd.edu.au/publications/documents/ISA&WWF_Bioproductivity&LandDisturbance.pdf

[73] http://www.panda.org/news_facts/publications/living_planet_report/lp_2006/index.cfm (retrieved from the web 29/11/07)

[74] A 'global hectare' is the "average per hectare regenerative capacity of all the planet's biologically productive surfaces". According to the Global Footprint Network "the planet has approximately 11.3 billion hectares (27.9 billion acres) of biologically productive land and sea surfaces" (http://www.footprintnetwork.org/gfn_sub.php?content=national_footprints). A hectare is about the size of a football field

[75] http://assets.panda.org/downloads/living_planet_report.pdf

[76] Using 2003 data

[77] Wackernagel, M., Schulz, N.B., Deumling, D., Linares, A. C., Jenkins, M., Kapos, V., Monfreda, C., Loh, J., Myers, N., Norgaard, R. & Randers, J. (2002). *Tracking the Ecological Overshoot of the Human Economy* Proc. Natl. Acad. Sci. USA, Vol. 99, Issue 14, 9266-9271.

re-used at the same rate that they are produced. The fact that they have accumulated indicates that some 'overshoot' has occurred. One role of the Ecological Footprint (EF) is to provide a concrete method for visualising the 'overshoot', as an area of land.

Recent calculations published in the *Living Planet* Report (WWF 2006[78])

suggest that the average Australian uses 6.6 global hectares to produce the goods they consume and absorb the waste they produce. The average US resident has an Ecological Footprint of 9.4 global hectares, whereas the average Italian lives on 4.2 global hectares. The average Mexican occupies 2.6 global hectares, and the average Indian lives on about one-third of that.

Data sources and calculations issues

The Global Footprint Network has stewardship of the National Footprint and Biocapacity Accounts. These accounts provide the basis for Ecological Footprint analyses. Information that makes up the accounts is drawn largely from United Nations agencies. It documents the natural resources (e.g., cropland, pasture, forests and fisheries) available within a country as well as the country's demand on these resources. An academic license to use the accounts is available for those interested in exploring Footprint applications.

The WWF's *Living Planet* report (2006) documents national per capita footprints for all countries with populations greater than one million for which complete data are available. Each nation's footprint includes the resources embodied in the goods and services consumed (food, housing, transportation, consumer goods and services, domestically produced and imported) and the associated waste. It excludes resources embodied in exports, which are counted in the footprint of the importer. Analysis is based primarily on data published by the Food and Agriculture Organisation of the United Nations and the Intergovernmental Panel on Climate Change.

In the original ecological footprint, land categories were weighted with equivalence and local yield factors (Wackernagel *et al.* 2002) in order to express appropriated bioproductivity in world-average terms. This weighting has significant implications for ecological footprint figures: For example New Zealand and Germany run cattle. New Zealand uses far more space than Germany per unit of cattle, but when adjusted to world-average yield the differences are evened out so that a kg of meat consumed in NZ is not much different to a kg in Germany. In effect, the global-averaging of agricultural land does not reward the farmer who improves yield by using less land per kg of meat, and it does not penalise the farmer who uses more land per kg.

Both countries also produce electricity. Germany generates a lot more emissions than NZ per kWh; unlike agricultural production these don't get converted to

[78] http://assets.panda.org/downloads/living_planet_report.pdf

world-averages, so that a kWh of electricity consumed in Germany contributes considerably more to that country's EF than a kWh in NZ. Thus the EF methodology does penalise the electricity producer for high emissions, and rewards the electricity producer who reduces emissions. This anomaly - the conversion to world averages of agricultural production but not other production areas such as electricity – is still to be addressed.

Further, the intensity of human-induced changes to land is independent of productivity. Land converted to roads and buildings, used for mining or for intensive cropping – whether productive or not – is drastically altered from its natural state, whereas land used for non-intensive grazing or native forestry

may be only slightly altered. For this Lenzen and Murray (2001)[79] suggest that a better approach is to use the condition of the actual area of land used by the respective population as a basis for the EF and suggest *landcover disturbance* as a proxy for land condition. They apportion weightings for different types of land use.

Another issue inherent in using *bioproductivity* as a measure is the suggestion that changing to higher yield monocultures can improve your Footprint. Thus replacing rain forest with palm oil plantations, for example, could be seen as a positive move. To counter this notion the *Living Planet Report* includes *The Living Planet Index*, which is "a measure of the state of the world's biodiversity based on trends from 1970 to 2003 in over 3600 populations of more than 1300 vertebrate species from around the world" (WWF, 2006). Thus the *Living Planet Report* provides the two complementary indices: Ecological Footprint and Biodiversity.

Methodological developments

The methodology developed by the Global Footprint Network[80] has continued to evolve as interest has grown worldwide. Recent work in Australia, for example, has introduced into the Footprint debate some measure of biodiversity and toxicity impact[81].

Another development has been the inclusion of the full indirect upstream production chain in calculations (see Information Sheet 2 for explanation of *full production chain*) rather than using only direct inputs. In 2004 the Global Footprint Network[82] and the ISA group joined forces in an attempt to produce a hybrid Ecological Footprint methodology that included the full upstream

[79] Lenzen, M. and Murray S.A. (2001). A modified Ecological Footprint method and its application to Australia. Ecological Economics 37(2), 229-255, see also http://www.isa.org.usyd.edu.au/publications/documents/Ecological_Footprint_Issues_and_Trends.pdf

[80] http://www.footprintnetwork.org/

[81] http://www.isa.org.usyd.edu.au/research/EFARC.shtml

[82] http://www.footprintnetwork.org/newsletters/footprint_network_1-1-0.html

production chain.This improvement, while recognising the interdependence of industry sectors, makes for complex calculations. To solve this calculation problem Lenzen and Murray (2003)[83] suggest using the macroeconomic technique, *input-output analysis*. The technique was introduced by Nobel Prize laureate Wassily Leontief in1936 since when it has been applied to numerous economic, social and environmental issues. It relies on data on inter-industrial monetary transactions, as documented for example in the Australian input-output tables compiled by the Australian Bureau of Statistics. These changes form the basis of the University of Sydney ISA methodology and are an integral part of the EF standards debate[84].

ISA was represented at the EF Standards Committee meeting at the Footprint Forum in Siena, Italy in June, 2006. This meeting issued the *Ecological*

Footprint Standards 2006. These standards recognised the issue of boundary drawing when calculating the Footprint of an organisation (see ISA Information Sheet 13 for a full discussion of boundaries and double counting). For calculating the EFs of national and sub-national populations, studies usually focus on the consumption of the population as a whole. In such cases it is fairly straightforward to draw boundaries that do not overlap, so that the Footprints of all regional populations of a nation add up to the same total as the Footprint for the whole nation.

Organisations such as manufacturing companies and service providers that are in the middle of a supply chain, are more difficult to deal with. They consume goods and services in the production of other goods and services, which are either sold to a consumer, or sold to another organisation along the supply chain. These organisations are both producers and (intermediate) consumers. Defining the boundaries of such organisations so that there is no overlap is a time consuming task (see Information Sheet 8 for a discussion of boundary drawing and ISO LCA standards). Consequently the Ecological Footprint Standards Committee decided to focus on Sub-National Population studies for this first release of the Standards and take up the issue of organisations at a later date.

Meanwhile ISA has been researching the problem of system overlap and double counting when calculating the EFs of organisations. ISA's work in apportioning impacts along the supply chain has led to a consistent and quantitative framework[85] that allocates each impact – for example on a 50%-50% basis between the supplier and the recipient. This removes double-counting and solves a decades-long problem for life cycle analysis. The ISA software BL^3, which can be used to calculate your EF, systematically shares responsibility along the supply chain.

[83] Lenzen M, Murray S A, (2003). The Ecological Footprint – Issues and Trends, http://www.isa.org.usyd.edu.au/publications/reports.shtml
[84] http://www.footprintnetwork.org/gfn_sub.php?content=standards
[85] See Gallego and Lenzen 2005; Lenzen, Murray et al. 2007

In 2007 the Stockholm Environment Institute at the University of York, UK and the Centre for Integrated Sustainability Analysis at the University of Sydney, Australia, with the endorsement of the Global Footprint Network, developed a blueprint for a dynamic approach to forecasting the Ecological Footprint of Nations[86]. This work will complement the static EF accounts with "tools that can explore how past trends and human interactions with the biosphere might shape our future biocapacity and Footprints" (Mathis Wackernagel, Foreword p. 5). One of the major conclusions of this work confirms the *Living Planet Report 2006* which suggests that humankind's demands have been exceeding the world's biocapacity since 1980.

Application

The EF provides governments and organisations with a single number that can easily be communicated. The concept of Ecologic Footprint, because of its metaphorical connotations, provides a powerful tool for education. The calculation of national EFs gives a general indication of the magnitude of human impact globally. The calculation of population footprints, for example of local government areas such as Randwick City Council[87], can provide a graphic and powerful baseline and monitoring tool that can be 'operationalised' by tying the results to council policy and planning cycles. As methodologies improve and the Global Footprint Network incorporating the ISA methodology moves towards standardisation, the Ecological Footprint will allow increasingly more accurate comparisons to be made between countries and within a country's communities and organisations over time.

Online calculators

A number of footprint calculators are available on the internet. For example:

- ISA Ecological Footprint calculator[88], developed by the University of Sydney's ISA team calculates the amount of land needed to support your lifestyle, it provides comparison with the average world citizen and the average person in India;
- Eco'tude The Power House Museum[89], Sydney, provides an online calculator for use in education – it will tell you the Ecological Footprint of your school;
- WWF Ecological Footprint calculator[90] asks questions about food, home, travel and 'stuff';

[86] *Forecasting the Ecological Footprint of Nations: a blueprint for a dynamic approach*, Lenzen, Wiedmann et al (2007) http://www.isa.org.usyd.edu.au/publications/DEF.pdf

[87] Maganov, P. Lenzen, M. & Ryan, F. (2009). 'Operationalising' the ecological footprint metric within a municipal authority. Journal of Public Works and Infrastructure vol 1 No 4 pp391-406

[88] http://www.isa.org.usyd.edu.au/

[89] http://www.powerhousemuseum.com/ecotude/calc.asp

[90] http://footprint.wwf.org.uk/

Food miles

According to the BBC[91] the term food miles was coined by Dr Tim Lang, professor of food policy at the City University, London.

Its purpose was to prompt reflection on the distance travelled by food items from farm to plate and the amount of energy and greenhouse gas emissions embodied in that travel.

The term has become widely used and has apparently prompted people to think about where their food items originate. Concerned shoppers in Britain have prompted Marks and Spencer and Tesco to mark all air-freighted produce with a sticker depicting an airplane.

However there are many other factors to consider in the growing and delivery of food. Farming practices can have a much greater impact on greenhouse gas emissions than the mere act of transporting the food from farm to plate. A study by researchers at Lincoln University in New Zealand demonstrated that rearing and distributing British Lamb produced more emissions than importing New Zealand Lamb. This is because New Zealand farmers use more renewable energy and less fertilizer than British farmers[92].

Climate can also effect growing decisions. In 2005 Defra (Department of Food and Rural Affairs, UK) reported that it was more energy-efficient to grow tomatoes in Spain and transport them to the UK than it was to grow them in hot-houses in the UK.

Economies of scale can also affect embodied emissions and can in some instances make it more energy efficient to manufacture at a distance and transport food than to buy local.

[91] http://www.bbc.co.uk/food/food_matters/foodmiles.shtml accessed 28/11/08
[92] http://www.lincoln.ac.nz/story_images/2328_RR285_s13389.pdf accessed 28/11/08

Greenhouse Gas Protocol[93]

The GHG Protocol is an international accounting tool for government and business. The GHG Protocol is the result of a partnership between the World Resource Institute[94] and the World Business Council for Sustainable Development.[95]. It provides an accounting framework for the International Standards Organization's GHG standard, as well as for many other national or corporate standards.

It is currently conducting a review of the standard with the intention of including Scope 3 emissions in the framework.

[93] http://www.ghgprotocol.org/
[94] http://www.wri.org/
[95] http://www.wbcsd.org/templates/TemplateWBCSD5/layout.asp?MenuID=1

Greenwash

Where did it come from?

The origin of the term *greenwash* seems to be obscured. Alter Net says that it was coined by Greenpeace USA when it "staged a protest at the 1990 corporate Earth Tech fair, denouncing companies such as DuPont for trying to whitewash their poor environmental record with green claims". http://www.alternet.org/workplace/76793/ (accessed 17/07/08)

The organisation Business Ethics is less specific saying that it was coined by "environmental activists to describe efforts by corporations to portray themselves as environmentally responsible in order to mask environmental" http://www.businessethics.ca/greenwashing/index.html (accessed 16/07/08).

Wikipedia says the term *greenwashing* was coined by a New York environmentalist, Jay Westerveld in 1986, writing about the hotel industry's practice of placing cards in bathrooms promoting reuse of towels, ostensibly to 'save the environment'. Westerveld apparently felt that the real motive was profit increase, and labeled it *greenwashing*. http://en.wikipedia.org/wiki/Greenwash (accessed 17/07/08)

What does it mean?

According to the 10th edition of the Concise Oxford English Dictionary (1999, revised 2001) the word *greenwash* is defined as "Disinformation disseminated by an organization so as to present an environmentally responsible public image" It suggests the origin as: "from green on the pattern of whitewash".

Since this definition was proposed the term seems to have acquired a broad range of additional nuances and connotations. For example the Centre for Media and Democracy's Sourcewatch Encyclopedia defines greenwashing as "the unjustified appropriation of environmental virtue by a company, an industry, a government, a politician or even a non-government organization to create a pro-environmental image, sell a product or a policy, or to try and rehabilitate their standing with the public and decision makers after being embroiled in controversy". http://www.sourcewatch.org/index.php?title=Greenwashing (accessed 16/07/08)

The Australian consumer watchdog Choice defines *greenwash* as: "deceptive marketing designed to portray a company or product as caring for the environment"[96].

And Greenpeace says that *greenwash* is used to describe the act of "misleading consumers regarding the environmental practices of a company or the

96 http://www.choice.com.au/viewArticle.aspx?id=106166&catId=100583&tid=100008&p=1&title=Green+Watch (accessed 16/07/08)

environmental benefits of a product or service"[97].

How is it useful?

The term *greenwash*, building on the familiar concept of *whitewash*, has gained a place in sustainability discourse as a useful shorthand for anything to do with misleading the public about an organisation's green credentials. Once distinguished from the background noise of environmental issues in general *greenwash* has provided an identifying tag for capturing a specific range of environmental complaints.

When the Total Environment Centre investigated *greenwash* for its 2005 discussion paper[98]: they contacted a range of NGOs, businesses, researchers and academics. They were stunned by the scope of issues and the range of examples offered including: political greenwash; NGO involvement in greenwash; rating indices; sustainability reporting formats; voluntary codes and programs; government relations; marketing; public relations: and government policy (Mohar, T. (2005) Reputation or Reality: A discussion paper on greenwash and corporate sustainability, Total Environment Centre p.4).

Having identified the phenomenon and defined the term a space is created for addressing the issues associated with *greenwash.* A number of websites provide rules of thumb for greenwash detection. For example: follow the money trail (who does the company donate to); follow the paper trail (who do the lobby and on what issues); ask about problems such as OH&S records; test for access to information (ask to see environmental impact statements); test for international consistency (are safety records for this company the same regardless of where in the world they operate); observer how they handle critics; join a group of ethical shareholders or ask your superannuation fund about ethical investments (Bob Burton, Mining Monitor, July 2000 http://www.mpi.org.au) Mineral Policy Institute – Australian NGO

The Independent Australian Consumer watchdog, Choice, is campaigning to make sure that green claims are honest and useful. Meanwhile it has provided tips on how to avoid greenwash. It advises consumers to think about the impact of the product and not to be distracted by the fact that packaging may be recyclable. It suggests looking out for precise claims and supporting evidence; a list of all ingredients in plain English; how it handles the whole lifecycle of the product and whether or not it meets national or international standards. It also suggests that consumers should be suspicious if there is no way to find out more about the manufacturer[99].

The Total Environment Centre (TEC) in its publication *Reputation or Reality*

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97 http://www.stopgreenwash.org/ (Greenpeace, accessed 16/07/08)

98 http://www.tec.org.au/index.php?searchword=greenwash&option=com_search&Itemid= (accessed 17/07/08)

99http://www.choice.com.au/viewArticle.aspx?id=106284&catId=100285&tid=100008&p=1&title=Green+claims+on+supermarket+labels (accessed 17/07/08)

(Mohar, 2005) provides a list of certification standards as a useful guard against *greenwash*. Eco-shout[100] provides its list based on that of the TEC.

Why is it important?
Greenwashing is an ethical issue. When applied to the corporate sector it is often associated with false or misleading advertising and addressing it is an important part of Corporate Social Responsibility. Environmental claims about sustainability, energy and water efficiency or recycling can be powerful marketing tools and can be used by an organisation to differentiate itself and its products from competitors. Such claims therefore have monetary value.

The Australian Competition and Consumer Commission (ACCC), established under the 1974 Trade Practices Act[101], is responsible for ensuring compliance with the Act, Part V of which deals with Consumer Protection. Section 52 prohibits a corporation from engaging in conduct that is "misleading or deceptive or is likely to mislead or deceive". Section 53 prohibits a corporation from (amongst other things) falsely representing "that goods are of a particular standard, quality, value, grade, composition, style or model or have had a particular history or particular previous use"; and representing that "goods or services have sponsorship, approval, performance characteristics, accessories, uses or benefits they do not have".

These provisions under the law have recently found a new application in the case of *greenwashing.* For example in early 2008 the ACCC instituted legal proceedings against GM Holden Ltd, which supplies and markets Saab motor vehicles in Australia. The ACCC alleged breach of sections 52 and 53 of the Trade Practices Act concerning 'green' claims made in the advertising of Saab vehicles. http://accc.gov.au/content/index.phtml/itemId/808355/fromItemId/142 (accessed 16/07/08)

In June, 2008 the ACCC published guidelines, *Carbon claims and the Trade Practices Act*[102]*,* on the use of environmental marketing claims that employ labels such as *carbon neutral*.

Another form of redress for consumers is the *greenwash award*. CorpWatch, for example, gives out bimonthly greenwash awards to corporations that put more money, time and energy into their PR campaigns aimed at promoting their eco-friendly images, than they do into actually protecting the environment. Nominations for these awards come from visitors to the Corpwatch website. http://www.corpwatch.org/article.php?list=type&type=102 (accessed 17/07/08)

Corporate Europe Observatory, Friends of the Earth Europe, LobbyControl and

100 http://www.eco-shout.org/greenwash.php?p=codes (accessed 17/07/08)

101 http://www.austlii.edu.au/au/legis/cth/consol_act/tpa1974149/ (accessed 17/07/08)

102 http://www.accc.gov.au/content/index.phtml/itemId/833279/fromItemId/3737 (accessed 17/07/08)

Spinwatch provide an annual award known as The Worst EU Lobbying and Greenwash award http://www.worstlobby.eu/2007/gwvote_en (accessed 17/07/08) won in 2007 by the German Atomic Forum with BAE Systems as runner up. BAE Systems is a global defence and aerospace company developing weapons and technologies for military purposes.

A brief history of greenwash can be found at http://www.thegreenlifeonline.org/greenwash101.html (accessed 17/07/08)

Hybrid Analysis
A hybrid analysis is a combination of:

- a macro-economic input-output analysis (IOA) which covers the entire 'background' economy; and
- a process analysis that covers the detail of specific items usually gained through conducting an audit.

The Global Reporting Initiative's Sustainability Reporting Guidelines, for example, contain a range of specific (micro) indicators that provide good reporting scope or breadth for conducting an audit.

In order to make an audit manageable a boundary is set. This boundary usually limits the audit to immediate on-site impacts that are deemed to be within the control of the reporting entity. Using the audit approach alone can lead to inconsistencies between assessments because boundaries can vary from year to year or project to project. This issue can be addressed by using a macro-economic IOA. The IOA complements the audit approach because it includes the full upstream supply chain, thus providing reporting depth to complement the breadth of the audit, and consistency of reporting because there is no cut-off point or imposed boundary.

We can summarise the different approaches to TBL assessment and reporting using the notion of assessment *breadth* and *depth*. The combination of audit approach and IOA is known as hybrid analysis.

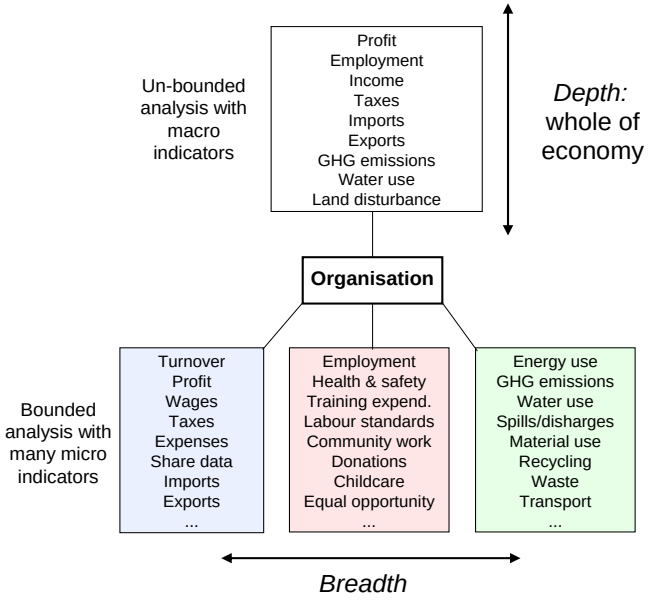

Figure: A simple comparison between bounded audit approaches with large indicator *breadth*, compared with input-output approaches with *depth* from macro indicators extending through the full supply chain (economy). Some indicators in these sets (illustrative only here) are common to both approaches.

Indicators

What are they?

Indicators are useful proxies that *indicate* the economic, environmental and social impact of doing business. They are said to be *proxies* because they can only *stand for* or *approximate* the actual impact. For example, *climate change* might be one of the environmental impacts of doing business; greenhouse gas emissions can be used as a proxy for climate change. Similarly *well-being* may be a social impact of doing business; income and employment may be proxies that indicate, or point towards, social well-being.

The indicators below are used in the 2005 CSIRO/University of Sydney publication *Balancing Act*[1] to benchmark 135 sectors of the Australian economy providing a snapshot of Australia's TBL performance.

For an indication of economic impact *Balancing Act* used:

- gross operating surplus (or profits)
- dependence on imports
- export earnings.

An indication of social impact was gained from:

- family income
- tax contributed by the organisation to the 'Commons' (government revenue)
- job/employment generation.

Environmental impact was indicated by:

- greenhouse gas emissions
- primary energy use
- managed water use
- land disturbance.

What are they used for?

Indicators are used for internal and external reporting purposes as well as for monitoring progress towards goals. For example an organisation may choose the indicator *water use* because of a vulnerability to the supply of water. They may want to calculate their water use as a benchmark and then make changes in the ways they access, transport and use water with the goal of reducing their total water use.

Organisations report on indicators that reflect their objectives and that are relevant to stakeholders. ISA provides a suite of detailed indicators. However, if you or your stakeholders do not require such detail, you can choose *aggregate* indicators. For example *water use* can either be reported on as a single (top level) indicator or it can be broken down into the categories *mains water, self-supplied water, reuse water,* and *in-stream water.*

Other indicators in the ISA suite have far more detail. For example the indicator *energy consumption* includes more than 480 separate components aggregated into 28 categories that can be accounted for either at the top level (*energy consumption*), aggregate level (e.g. *black coal*) or individual component level (e.g. *black coal, used in boilers*) if necessary. The level of detail you choose will reflect the needs and interests of your organisation and its stakeholders. The ISA reporting framework has over a thousand detailed indicators aggregated into over 180 categories which in turn are aggregated into more than 20 top-level indicators like *water use* and *energy use*. Top-level indicators

[1] http://www.isa.org.usyd.edu.au/publications/index.shtml

include such items as: imports, employment, greenhouse gas emissions, land disturbance, land use and material flow.

An ISA indicator is referred to as *positive* if more of it is generally thought to be a good thing, for example, *employment*. An ISA indicator is referred to as *negative* if more of it is generally thought to be a bad thing, for example, *greenhouse gas emissions*.

Midpoint and endpoint indicators

Led by the Global Reporting Initiative, a range of global and local organisations have developed workplace indicators that provide a method for dealing with on-site issues of sustainability in an audit framework. However if we want to reflect the notion of *sustainable system* as an integrated web of connections through time and space ultimately linking everything we do then we need to build on the on-site audit.

Starting from a concept of world society can lead us to big picture indicators such as the Ecological Footprint; delving into the complexity points to finer detail and steps along the way, both of which are important.

Taking a world view requires in the first instance big picture, or *endpoint,* indicators. For example, the ecological footprint which rolls up a great deal of complexity into a single world-view indicator, tells you how much of the planet you are taking up through your life-style. The term *endpoint* refers to aggregate measures at the end of one, or several converging impact pathways. An endpoint indicator requires painstaking data collection, and complex modeling and computation. Apart from agreeing on where the endpoint occurs it requires someone to decide what data are relevant and what events contributed to the impact (for a detailed discussion of midpoint and endpoint indicators see Lenzen, 2006).

On the other hand retaining the complexity requires a range of what are known as midpoint indicators. Midpoint indicators can be observed somewhere along the chain of impacts, for example, soil fertility reductions caused by intensive agriculture practices. Debate rages around which are more useful, endpoint or midpoint. Many think that endpoint indicators are easier for people to understand (Heijungs et al., 2003). The ecological footprint metaphor, for example, has had a powerful impact. However decision making at midpoints has advantages because it allows for more of the complexity to be examined and involves the immediate players; instead of providing a few aggregated numbers, the more multi-facetted midpoint information reveals the multi-dimensionality of the problem and can suggest a range of areas where action might be taken. Decision making based on indicators is always going to be contentious because endpoints are too uncertain to allow a decision to be made with reasonable confidence, and midpoint information is complex, revealing competing issues that need to be balanced. People will always have to make decisions and decision makers will always belong to some social and political system and make those decisions out of a particular life history. Although this may be self-evident, it is not regularly recognized.

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Heijungs, R., Goedkoop M.J., Struijs J., Effting S., Sevenster M. & Huppes G. (2003).Towards a life cycle impact assessment method which comprises category indicators at the midpoint and the endpoint level. Internet site http://www.pre.nl/download/Recipe%20phase1%20final.pdf, PRé Consultants, Amersfoort, Netherlands.

Input-Output

Where did it come from?

Wassily Leontief (1905–1999) was the founder of input-output economics, for which he received the Nobel Prize in 1973. Input-output analysis is a macro-economic method that provides a snap-shot of the economy. It shows how the output of one industry becomes the input of another, revealing supplier and demander interdependencies.

What does it mean?

Input-Output Tables

An input-output table is a matrix, which means that it has rows and columns. The row and column headers are the names of the economic sectors of an economy. All economic sectors are represented across the header row – the x axis – and the same set of economic sectors is listed down the lead column – the y axis. This means that there is an intersection between every industry sector with every other industry sector.

	black coal	**natural gas**	**iron ore**	**Etc…**	**gravel**	**clays**	**steel making**	**alumina**	**nickel**	**etc**
black coal										
natural gas										
iron ore							XXXXXXXX			
Etc…										
gravel										
clays										
steel making										
alumina										
nickel										
etc										

The number at the intersection of row **iron ore** with column **steel making** is a dollar figure (or yen, or pounds sterling etc). The dollar figure at the intersection of row **iron ore** and column **steel making** tells you the amount spent on iron ore by the steel industry that year to make steel. It is the *output* of iron ore that goes *into* steel making.

There is a dollar figure for every pair of industries. For example: the amount spent on **wool** by **knitting mills**; the amount spent on **trucks** by the **wheat industry**; the amount spent on **paper** by the **insurance industry.**

A modern economy is so complex that the input-output table is full. Looking at it you can begin to appreciate the interactions between all actors in the economy. From the input-output table you can see what everyone needs from everyone else, the whole mix of interactions is laid out in front of you. In short – you know everyone's production recipe.

The cells of each column contain the value of an industry's inputs and each row represents the value of an industry's outputs. The input-output matrix can illuminate how changes in one economic sector may have a flow-on effect in other sectors.

How is it useful?

Let's say you know from the table the cost of **paper** bought by the **insurance industry**. You work out that the insurance industry buys 1m$'s worth of paper to produce 100m$'s

worth of insurance policy[2]. That is the same as saying that they need 1 cent's worth of paper for every 1$'s worth of output.

Now you go to the paper industry. Let's say that you find that the **paper industry** needs 25c's worth of **wood** to produce 1$'s worth of paper.

Now to the **wood industry**. Let's say they need 10c's worth of **machinery** to produce 1$'s worth of timber.

Now the **machinery industry**. Say they need 20c's worth of **steel** to make 1$'s worth of forestry machines.

Next the **steel industry**. Say they need 40c's worth of **iron ore** to make 1$'s worth of steel.

Now for the million dollar question.

How much iron ore does it take to make a $2000 insurance policy[3] from this one supply chain: **iron ore** for **steel** for **machine** for **wood** for **pape**r for **insurance policy?**

And the answer is…

2000$insurance x $\frac{\text{1c paper}}{\textbf{\$ insurance}}$ x $\frac{\text{25c wood}}{\textbf{\$ paper}}$ x $\frac{\text{10c machine}}{\textbf{\$ wood}}$ x $\frac{\text{20c steel}}{\textbf{1\$ machine}}$ x $\frac{\text{40c iron ore}}{\textbf{\$1 steel}}$ =

2000 x 0.01 x 0.25 x 0.1 x 0.2 x 0.4 = 4c iron ore

But think twice before you ask your child's teacher to sneak a question onto the school's trivia night quiz list. This is just one supply chain amongst millions.

The calculation above is a **structural path**, it is one small part of a production recipe. It works in the same way as a cooking recipe. For example your recipe might require one cup of fruit per person, or one tablespoon of butter per serve[4]. In each case your reference point is a standard denominator (*per* person, *per* serve). In the case of the industrial production recipe it is cents of input *per* dollar's worth of output.

Why is it important?

You may be surprised that something material like iron is necessary to make something immaterial such as an insurance policy because you probably did not associate insurance with needing a lot of material resources.

[2] i.e. the total cost to insurance policy buyers is $100m

[3] i.e. one that costs you $2000 to buy

[4] For desert you might decide to serve sago pudding. The recipe you are following needs half a litre of milk per pudding and you calculate that you will need half a pudding per person. There are ten people for dinner…

10 guests x $\frac{\text{0.5 pudding}}{\textbf{person}}$ x $\frac{\text{0.5 milk}}{\textbf{pudding}}$ =

10 x 0.5 x 0.5 = 2.5 litres of milk

The Washington Post

Support of the Service Industry Has Large Role in U.S. Emissions

The service industry's supply chain accounts for more than one-third of U.S. commercial greenhouse gas emissions, according to a study published in the journal Environmental Science & Technology.

University of Minnesota industrial ecology professor Sangwon Suh analyzed the supply-chain network for 480 goods and services, excluding only electric utilities and transportation, and concluded that it accounts for 37.6 percent of the nation's industrial emissions.

The Environmental Protection Agency, by contrast, calculates that service industries directly account for less than 5 percent of total emissions.

A bank, for example, needs a building made of concrete and steel to operate, and producing those materials releases greenhouse gases into the atmosphere. Likewise, hospitals use surgical equipment and medical appliances to operate, and these generate carbon dioxide and other emissions as well.

"What I'm looking at is the entire supply chain that allows services to be offered," Suh said Friday. "If we take that into account, the percentage is totally different than what we have normally perceived."

People see power plants as the primary villains in the climate change story, Suh said, but other industries play a significant role in producing pollution that helps warm the earth.

— Juliet Eilperin

Monday November 6, 2006

This is not an unusual example. In 2006 the Washington Post reported the work of Sangwon Suh[1] who has shown that services are responsible for a significant percentage of US emissions just because of their supply chain network.

Hybrid input-output table

Hybrid accounts combine physical flow accounts and national, monetary accounts. In these accounts *the environment* plays an active role in providing input, such as minerals, water, or CO_2. Hybrid flow accounts record physical flows in the same way as economic transactions are presented in the National Accounts. Thus, hybrid flow accounting has the ability to connect environmental burdens to economic benefits and environmental benefits to economic costs (United Nations Statistics Division 2003). Just as monetary accounts must balance, an important feature of hybrid accounts is that inputs and outputs balance both in monetary and in physical terms.

How can this help?
If input-output analysis can tell you how many cent's worth of iron ore is needed to make the steel that made the machine that processed the wood to make the paper to get that insurance policy to you…

…then a hybrid analysis can tell your organisation, *BigInsuranceCo,* where all that CO_2-e is hidden in your supply chain…

For example:

Structural Path	Amount	Percentage
Softwoods > Pulp, paper and paperboard > Recorded media and publishing > BigInsuranceCo	489 t CO2-e	0.41 %

0.41% of *BigInsuranceCo*'s CO_2-e – that's 489tonnes – comes from softwoods used by the pulp, paper and paperboard industry to supply the recorded media and publishing industry who supply the insurance company with a publishing service.

Structural Path	Amount	Percentage
Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Market research and other business management services > Services to finance and investment > BigInsuranceCo	12.2 ha	0.61 %

…or how much land you disturb…

For example 12.2 ha of land is disturbed by beef cattle sent to the fresh meat industry to supply hotels, clubs, restaurants and cafes which are frequented by market research and other business management services which in turn are used by services to finance and investment that are used by the *BigInsuranceCo*. This constitutes 0.61% of the insurance company's total land disturbance.

Structural Path	Amount	Percentage
Grapes for wine > Wine > Hotels, clubs, restaurants and cafes > BigInsuranceCo	13.7 ML	1.54 %

…or how much water you use…

For example 13.7 ML is used in growing grapes for the wine industry to supply hotels, clubs, restaurants and cafes used by *BigInsuranceCo* to entertain its clients!

The structural paths that you can see in the example are of a finite length. The input-output insurance path has 5 nodes. In an input-output table that say, distinguishes 100 sectors there would be 100 1-node paths to the final product because the company making this product would have 100 suppliers. Each of those suppliers has 100 suppliers in turn so there would be 100x100 2-node paths (suppliers of suppliers of the product). There would be one million 3-node paths, 100 million 4-node paths, 10 billion 5-node paths and so on.

Input-output analysis covers supply chains of infinite length and it covers all of them. How can it possibly do that? The short answer is because Wassily Leontief was a genius. The longer answer is because input-output analysis uses mathematical techniques that turn and infinite series (a series is a sequence of additions) into a single matrix inverse. Since Leontief developed his input-output theory it has been used by thousands of researchers over more than five decades.

Intensities

Where did it come from?

Intensive and *intensity* come from the Latin *intensus*, meaning *stretched* or *intent*. Something that is said to be *intensive* is characterised by a high degree or *intensity*. It's commonly used in such phrases as *intensive farming*, *intensive care, intensive light* or *capital intensive.*

What's an intensity?

There are several scientific uses of the term *intensity* that have become common parlance. For example:

- sound intensity, expressed in decibels, is the amplitude of a sound wave, the usual context for its use is the measurement of sound intensity in the air at a listener's location[5];

- intensity of an earthquake is the strength of shaking produced at a particular location[6];

- colour intensity refers to the relative purity or saturation of a colour on a scale from vivid (high intensity) to dull (low intensity)[7].

Recently the term *carbon intensity* has emerged in popular usage. *Carbon intensity* commonly describes the quantity of carbon emissions[8] generated based on a relevant unit of consumption or production. The many definitions found on the web have varying degrees of accuracy, for example:

- "carbon intensity is the relative amount of carbon emitted per unit of energy or fuels consumed[9]" – although strictly speaking this is *carbon content*, not *carbon intensity* it's meaning can be captured in the explanation for example that, generating one kW of electricity using a coal-fired power station results in much more carbon being emitted than a kW of electricity from solar power; consequently electricity generated from coal is more *carbon intensive* than electricity generated using solar power;

- carbon intensity can also be expressed as the ratio of carbon emissions to economic activity[10] – the carbon emissions generated in the production of one dollar's worth of goods or services in the economy. For example the intensity of the electricity supply sector could be describes as 9,000g CO_2-e per dollar of electricity supplied. This figure is arrived at by taking the total CO_2-equivalent emissions of the electricity industry and dividing by the monetary value of the gross output of the electricity industry.

Why use intensities?

Measures of carbon intensity can provide important management and policy tools to understand and inform the reduction of greenhouse gas emissions. They are useful because they enable us to compare the effectiveness of products, companies and industries on a standardised basis irrespective of the size of an organisation or its level of

5 http://science.education.nih.gov/supplements/nih3/hearing/other/glossary.htm (accessed 21/12/07)

6 modified Mercalli Intensity Scale to depict shaking severity http://www.abag.ca.gov/bayarea/eqmaps/doc/mmi.html (accessed 21/12/07)

7 http://www.yannisstavrou.gr/art-glossary.htm (accessed 21/12/07)

8 Sometimes a carbon intensity refers specifically to a rate of carbon emitted; however sometimes this term is used as shorthand to described the combined effects of all greenhouse gas emissions, expressed in equivalent CO2 emissions (shown as CO2e)

9 http://ilrdss.sws.uiuc.edu/glossary/glossary_browseresults.asp?mc=atm&glosID=C (accessed 21/12/07)

10 http://en.wikipedia.org/wiki/Carbon_intensity (accessed 21/12/07)

output. For example, if you know the carbon intensity of particular products or industries it is possible to compare their carbon emissions efficiency relative to other products or industries.

For example: The *direct* energy use of a small machinery producer (Company A) may be 1 TJ (Terajoule) while the direct energy use of a large producer of similar machinery (Company B) may be 100 TJ. Assume the gross outputs of the two producers are half a million dollars and 100 million dollars respectively, then their energy intensities are:

- Company A = 1TJ / ½$m = 2MJ/$
- Company B = 100TJ / 100$m = 1MJ/$

So in this example, the larger producer is twice as efficient in its direct energy use.

Some examples of use
Intensities can be calculated for social, economic or environmental indicators, and for any currency, for example

- Employment generated per $
- Operating profit per £
- Carbon emissions per ¥

Consider the following example of a machinery manufacturer.

The table below shows *total* intensities for the output of machinery from this manufacturer. They are labelled *Total* because they cover all upstream supply chain impacts.

Assume the machinery workshop produces $2m worth of machinery.

The company has created employment for 15 full-time equivalent (fte) workers. Some of this employment occurs onsite at the workshop and some is created upstream through the machinery manufacturer's demand for goods and services that go into the manufacturing of their machines[11]. Now if we want to know how much employment is generated per $1m worth of output we can divide 15 (people) by $2m and find that the company's employment intensity is 7.5 fte per million dollars of gross output. The total employment intensity includes people employed onsite by the manufacturer and people employed by upstream suppliers. It's the total employment created by the demand for this product.

Indicator	**Total Intensities**
Employment	7.5 fte / $m
Operating profit	40¢ / $
Carbon emissions	200g / $

Fte = full time equivalent

The company makes a profit of $800,000 hence its profit intensity is 40¢ per $ of gross output.

The company emits 400 tonnes of carbon, hence its carbon intensity is 200g of carbon per $ of gross output.

[11] For a full explanation of how this figure is calculated see information sheet 13 *Double Counting*

How are intensities calculated?
While direct intensities can be calculated easily, for example from a company's own employment, profits, carbon emissions and gross output, its total intensities can only be calculated using information from the interdependent network of companies and industries in the entire economy. This complex calculation can be done using input-output analysis.

Input-output analysis (IOA) was conceived by Nobel Prize laureate Wassily Leontief in the 1930s and 40s. It relies only on National Accounts that are regularly published by statistical bureaux, and has therefore been described by another Nobel Prize laureate, Richard Stone, as "neutral from both an analytical and ideological point of view". As Leontief himself said, "the economic system to which [input-output analysis] is applied may be as large as a nation or even the entire world economy, or as small as the economy of a metropolitan area or even a single enterprise." *The fact that IOA is applicable across these scales, as well as being a snap-shot of the economy, means that it is an ideal approach to reporting on, and static analysis of, the complex linkages within the economy.*

The Centre for Integrated Sustainability Analysis at the University of Sydney has over ten years experience in use of input-output analysis. The Centre has provided the complex matrices that sit behind such publicly accessible tools as the Australian Conservation Foundation's Consumption Atlas (http://www.acfonline.org.au/custom_atlas/index.html); the Commonwealth Government's (2007) online household and small business calculators (http://cc-calc.greenhouse.gov.au/Content/Home.aspx; and the Commonwealth Government's (2008) Carbon Pollution Reduction Scheme Green Paper (http://www.climatechange.gov.au/emissionstrading/publications/index.html)

International Organisation for Standardisation[12] (ISO)

Where did it come from?

In 1946 delegates from 25 countries met in London to create a new international organisation. The aim was to facilitate the international coordination and unification of industrial standards. The new organisation, which became known as ISO, officially began operations on 23 February 1947[13].

ISO is from the Greek *isos*, meaning *equal*.

What is it?

ISO is the world's largest developer of technical standards. It is a non-government organisation made up of the national standards institutes of 146 countries with a Central Secretariat in Geneva. Standards are voluntary but individual nations may build them into regulatory frameworks.

Most International Organization for Standardization (ISO) standards are highly specific to a particular product or process, however the 14000 and 9000 series are known as "generic management system standards". The 14000 provides the requirements for the essential features of an environmental management system (EMS) and the 9000 a quality management system. A management system is an organisation's structure for managing the activities that transform resources into a product or service. A management system that complies with 14000 or 9000 standards means that processes and products will meet the organisation's avowed objectives and comply with regulations. According to the ISO website[14] ISO 9000 and ISO 14000 standards are implemented by approximately 610 000 organisations in 160 countries.

Every full member of ISO has the right to take part in the development of any standard which it judges to be important to its country's economy.

ISO 14000 series

The development of the ISO 14000 series followed on discussions of sustainability at the 1992 United Nations Conference on Environment and Development, in Rio de Janeiro. It is a collection of voluntary standards to assists large organisations and small and medium-sized enterprises (SMEs), to achieve environmental and financial gains through the implementation of effective environmental management; include guidelines to ensure environmental issues are considered in decision making.

ISO 14001 (1996) is the standard for Environment Management Systems (EMS)[15]. It specifies the requirements for an organisation's environmental management system that will enable it to formulate environment related policies and objectives that take into account legislative requirements and specific environmental factors. It does not provide environmental performance criteria. It relates only to environmental impacts that the organisation can control and over which it has influence. It does not account for upstream or downstream environmental impacts that the organisation deems beyond its control. However the ISO says that its standards promote EMS that "ensure a product will have the

[12] http://www.iso.org/iso/home.htm
[13] Latimer, J. (1997) *Friendship among equals* - Recollections of seven people who worked for ISO in its first fifty years
[14] http://www.iso.org/iso/en/ISOOnline.frontpage (2/09/04)
[15] http://www.standards.com.au/catalogue/script/details.asp?DocN=stds000016009 (5/08/04)

least harmful impact on the environment, at any stage in its life cycle, either by pollution, or by depleting natural resources."[16]

ISO 14044 Environmental management – Life cycle assessment – Requirements and guidelines addresses the environmental aspects and potential impacts of a product throughout its life cycle. It covers the methodological framework for LCA, reporting of the LCA and critical review of the LCA by experts or interested parties.

How is it useful?

Organisations that apply ISO 14001 generally do so in order to: introduce an EMS or improve an existing one; align policy and practice; demonstrate their conformance with this International Standard; and/or seek certification or registration of their existing EMS. The ISO says that the application of ISO 14001 will provide far more than a 'green sheen' it will make a difference to the organisation's bottom line. However research conducted by the University of Sussex, UK[17] indicates that application of the standard does not necessarily mean good environmental results for the organisation. And Suh *et al.* (2004)[18] in their discussion of the boundary problem (see *boundary* entry), point out that this issue is not dealt with in ISO Standards on Life-Cycle Assessment (LCA).

Future development

"LCA methodology is open to the inclusion of new scientific findings and improvements in the state-of-the-art of the technique". (Item 4.3e of ISO 14040)

Throughout ISO 14044 the term *allocation* occurs. In the ISO Standard *allocation* refers to the allocation of processes and resources to the production of the particular product under analysis (i.e. separating it out from other products that may share some production processes etc). It is part of boundary drawing.

The meaning of the word '*allocate'* in ISO terms is not the same as '*allocating impacts along the supply chain'* which refers to the apportioning of responsibility for impacts along a whole supply chain. Apportioning emissions, or any other impact, along the supply chain has only recently been consistently and quantitatively conceptualised[19]. Allocating each impact – for example on a 50%-50% basis between the supplier and the recipient – removes double-counting.

Some of the processes necessary for ISO compliance can now be addressed within the new LCA methodology. This makes redundant some of the time consuming work that was previously necessary for example to determine a boundary for an LCA. Input-output analysis (see entry above) takes care of the boundary, fully accounting for *all* inputs rather than only those that cumulatively contribute more than a defined amount to the total. Using input-output analysis there is no need to agree on a limit and define a system boundary because every item of the economy is tracked along an infinite supply chain. This greatly simplifies the life cycle assessment process for organisations because time and energy do not have to be spent on defining system boundaries and justifying the criteria used to

[16] http://www.iso.org/iso/en/iso9000-14000/basics/general/basics_4.html (2/09/04)
[17] http://www.environmental-performance.org/about/index.php
[18] Suh S, Lenzen M, Treloar G J, Hondo H, Horvath A, Huppes G, Jolliet O, Klann U, Krewitt W, Moriguchi Y, Munksgaard J and Norris G (2004), System boundary selection in Life-Cycle Inventories, *Environmental Science & Technology* **38** (3), 657-664.
[19] Gallego, B. and M. Lenzen (2005). "A consistent input-output formulation of shared consumer and producer responsibility." Economic Systems Research **17**(4): 365-391.
Lenzen, M., J. Murray, et al. (2007). "Shared producer and consumer responsibility - theory and practice." Ecological Economics **61**(1): 27-42.

select them (see ISO 14044: *4.2.3.3 System boundary; 4.3.3.4 Refining the system boundary; 4.4.1b; and 4.5.3.4c Consistency check)*.

Input-output analysis require two sets of information: an organisation's financial accounts and the direct onsite impacts such as water use, land use, emissions and employment. Each is a discrete and distinct data set and once entered will not be requested (and therefore entered) a second time so is not likely to be counted twice (see ISO 14044 *4.3.2.1:"To decrease the risk of misunderstandings (e.g. resulting in double counting when validating or reusing the data collected), a description of each unit process shall be recorded").*

Leakage, carbon leakage

Carbon leakage occurs when EITES [emission-intensive trade-exposed sectors] move to other locations that are more emission intensive than Australia, but do not yet price emissions.
http://www.treasury.gov.au/lowpollutionfuture/summary/html/Australias_Low_Pollution_Future_Summary-01.asp#P126_17519 (accessed 13/11/08)

Competitiveness distortions may arise where Australia prices emissions before other economies do: emission-intensive trade-exposed sectors (EITES) could move to other locations that are more emission intensive than Australia, but not yet pricing emissions. As a result, global emissions could rise, a process called 'carbon leakage'.
http://www.treasury.gov.au/lowpollutionfuture/summary/html/Australias_Low_Pollution_Future_Summary-04.asp#P426_68096 (accessed 13/11/08)

Leontief, Wassily (1905–1999)

Early life

It seems to be agreed that Wassily Leontief was born in Munich in 1905, although in his autobiographical contribution to the Nobel Prize website[20] Leontief says that he was born August 5, 1906. He spent his early years in St Petersburg (now Leningrad) where his father was a professor of economics. He counts among his earliest memories:

> "the country plunged into deep mourning the day of Leo Tolstoy's death; stray bullets whistling by during the first days of the February Revolution; Lenin addressing a mass meeting from a high tribune in front of the Winter Palace" (http://nobelprize.org/nobel_prizes/economics/laureates/1973/leontief-autobio.html#not)

In 1921 at the age of 16 he entered the University of Leningrad (which according to Wikipedia was at that time called Petrograd State University[21] renamed Leningrad State University in 1924), one of the oldest and most prestigious universities in the country. Apparently he expressed his opposition to the lack of freedom under Communism and was arrested several times[22]. In 1925 he earned the degree of Learned Economist and was allowed to leave the country.

His studies continued in Berlin where Leontief gained his PhD degree. In 1927 he joined the staff of the Institute for World Economics at the University of Kiel where he researched 'derivation of statistical demand on supply curves'.

In 1929 Leontief moved to China for twelve months where he was advisor to the Ministry of Railroads. In 1931 he moved to New York to work with the National Bureau of Economic Research and in 1932 he moved to the Department of Economics at Harvard University. He became Professor of Economics in 1946.

In 1932 Leontief received a research grant for the 'compilation of the first input-output tables of the American economy (for the years 1919 and 1929)'[23]. Three years later he was able to make use of a mechanical computing machine and another eight years after that, in 1935, he was able to use the Mark I – the first large-scale electronic computer.

In 1941 he published *Structure of the American Economy, 1919-1929*.

In 1973 Leontief was awarded the Nobel Prize in Economic Sciences. By that time he was concentrating his energy on 'analysis of environmental disruption and economic growth'. His Nobel Memorial lecture, *Structure of the World Economy: Outline of a Simple Input-Output Formulation,* can be found at http://nobelprize.org/nobel_prizes/economics/laureates/1973/leontief-lecture.pdf

Leontief's finding, that U.S. exports were relatively more labour-intensive and imports more capital intensive, became known as the Leontief Paradox[24]. From 1975 until 1991 he was Director of the Institute for Economic Analysis of New York University. He died in 1999, aged 93 years.

Leontief was married to poet, Estelle Marks, in 1932 and in 1936 had a daughter Svetlana Alpers who became Professor of the History of Arts at the University of California,

[20] http://nobelprize.org/nobel_prizes/economics/laureates/1973/leontief-autobio.html (accessed 3/06/09)
[21] http://en.wikipedia.org/wiki/Saint_Petersburg_State_University (accessed 3/06/09)
[22] http://www.iioa.org/leontief/index.html (accessed 03/07/09)
[23] http://nobelprize.org/nobel_prizes/economics/laureates/1973/leontief-autobio.html
[24] http://www.britannica.com/EBchecked/topic/336547/Leontief-Paradox (accessed 02/07/09)

Berkeley and later Professor Emerita.

The Leontief memorial site can be found at http://www.iioa.org/leontief/index.html (02/07/09)

For more information http://homepage.newschool.edu/het//profiles/leontief.htm
http://nobelprize.org/index.html

Locavore

Where did it come from?

According to the Oxford University Press blog[25] the word Locavore was coined in 2005 by a group of women – Jen Maiser, Jessica Prentice, Sage Van Wing, and DeDe Sampson – in San Francisco, who proposed that local residents should try to eat only food grown or produced within a 100-mile radius. In 2007 the word was a runner up word of the year in the Oxford American Dictionary (whatever that means).

What does it mean?

The locavore movement[26] encourages consumers to buy from farmers' markets or produce their own food. They argue that local products are more nutritious and taste better. They also claim that locally grown food is more environmentally friendly because it does not use fossil fuels in transporting the food from grower to plate.

The New York Times recently[27] reported on the 'lazy locavores' phenomenon. These are city dwellers who employ a gardener in order to grow their own fruit and vegetables. Some also buy shares in live-stock raised locally (known as 'cow pooling' and 'pork pooling').

How is it useful?

The movement has helped raise awareness about 'food miles' however greenhouse gas emissions from transporting food can be a very small percentage of the total. A 2007 report by Saunders and Barber found that 'the UK had 34 per cent more emissions per kilogram of milk solids and 30 per cent more per hectare than NZ for dairy production even including the shipping to the UK' (p. vii).

Corey Watts, sustainable rural landscapes co-ordinator, Australian Conservation Foundation, advises: "Eat a plant-based diet, eat seasonally, eat locally as much as you can, don't waste food, choose organic and grow some of your own."[28]

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[25] http://blog.oup.com/category/economics/business/
[26] http://en.wikipedia.org/wiki/
[27] http://www.nytimes.com/2008/07/22/dining/22local.html?_r=1&ref=us&oref=slogin
[28] http://www.smh.com.au/news/environment/still-a-long-way-to-go-in-travel-debate/2008/11/11/1226318651883.html?page=2

Model

A concept from which to deduce effects in comparison to observations. The 'model' may be conceptual, physical or mathematical. Models are essential in any interpretation or inversion. http://www.nrm.gov.au/publications/books/salinity-mapping.html

Inversion
Deriving from field data a geologically plausible model of the subsurface that is consistent with observed data (also known as inverse modelling).

Interpretation
The process of converting data to useable information. In a geoscientific context, interpretation is the derivation of a simple, plausible geological or other model that is compatible with all observed data. The model is never unique or complete and should be refined as more data comes to hand. Everything about an area should be considered when formulating an interpretation

Modelling
The process of developing a better understanding of observations.
1. The use of interpolating techniques to produce a contiguous picture of the Earth expressed in two and three dimensions from point based data (put simply, the joining of the dots).
2. Forecasting into the future the likely extent, location and amount of a feature. In this book, modelling is often used in this context; as a forecasting technique for the likely location and concentration of salinity in the future. Therefore modelling introduces the fourth dimension, time.
3. The computer simulation of a mapping method over a particular scenario in order to determine whether that mapping method is suitable for the particular mapping task. Modelling in this sense is often used as a survey planning tool.

From Salinity mapping methods in the Australian context
Prepared for the Natural Resource Management Ministerial Council
Department of the Environment and Heritage and
Department of Agriculture, Fisheries and Forestry, January 2005
ISBN: 0 642 55128 6

http://www.nrm.gov.au/publications/books/salinity-mapping.html
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National Greenhouse and Energy Reporting[1] (NGER) Australia

The NGER Act, 2007, established the legislative framework for a National Greenhouse and Energy Reporting System. An electronic version of the Act is available at www.comlaw.gov.au

The reporting system established under the Act will underpin the Carbon Pollution Reduction (emissions trading) Scheme as well as meeting Australia's international reporting obligations.

Reporting is mandatory if a controlling corporation's[2] corporate group – i.e. the controlling corporation, subsidiary, joint venture or partnership – emits greenhouse gases or produces or consumes energy at or above the specified thresholds for a financial (reporting) year[3].

Corporations are required to report at two threshold levels: facility and corporate. That is, when a controlling corporation's group hits a facility or corporate threshold the controlling corporation must register and report to the Greenhouse and Energy Data Officer its ghg emissions and energy data.

The facility reporting threshold is 25kt or 100TJ of energy consumed or produced.

The corporate group thresholds are 125kt or 500TJ in the first reporting year (2008-9); 87.5kt or 350TJ in the second reporting year (2009-10); and 50kt or 200TJ in the third reporting year.

Registration and activity data are entered into the Online System for Comprehensive Activity Reporting (OSCAR) to create an organisation's Greenhouse Gas Report.

Reporting applies to Scope 1 and Scope 2 emissions only. Reporting of Scope 3 emissions is not mandatory.

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[1] http://www.climatechange.gov.au/reporting/register/index.html (accessed 28/11/08)

[2] "A controlling corporation is a constitutional corporation that does not have a holding company in Australia; it is generally the corporation at the top of the corporate hierarchy in Australia. Foreign corporations may also be controlling corporations." http://www.climatechange.gov.au/reporting/guidelines/pubs/nger-reporting-guidelines-aug08.pdf (accessed 28/11/08) page 7

[3] http://www.climatechange.gov.au/reporting/guidelines/pubs/nger-reporting-guidelines-aug08.pdf (accessed 28/11/08) page 5

Online System for Comprehensive Activity Reporting (OSCAR)

The Online System for Comprehensive Activity Reporting (OSCAR) creates an organisation's Greenhouse Gas Report from data entered by an organisation.

"OSCAR is a tool used for reporting greenhouse gas emissions and energy data under the [National Greenhouse and Energy Reporting] Act; it has the ability to calculate greenhouse gas emissions from activity data submitted in reports.

"OSCAR uses default emissions factors. Alternatively, reporters can elect to provide their own emissions factors or emissions estimates, although only the methods for calculating emissions and energy prescribed in the National Greenhouse Energy Reporting (Measurement) Determination 2008 can be used. …

"Reporters are given access to OSCAR, including logon and password details, once they are registered by the Greenhouse and Energy Data Officer. OSCAR is currently being reconfigured to meet the reporting requirements of the National Greenhouse and Energy Reporting System."[4]

[4] http://www.climatechange.gov.au/reporting/guidelines/pubs/nger-reporting-guidelines-aug08.pdf (accessed 28/11/08)

Primary data, secondary data

In life cycle analysis primary data refers to all observable data that can be accounted for first hand from on-the-ground analysis of the actual processes and products involved.

Secondary data refers to data from compiled data bases or sector averages used in input output tables. …

Profit and Loss (P&L)

The profit and loss (P&L) statement is usually an internal report of revenue and expenses for use by managers. P&Ls are often prepared monthly or however frequently managers need them. They are a decision making tool and not intended to be used for reporting to stakeholders. The bottom line of the report (figuratively and literally) is the net profit or net loss.

When a P&L statement is prepared in accordance with financial standards for external reporting it is called a *statement of financial performance*. The P&L and the *statement of financial performance* are not identical. The P&L statement usually shows more detail than that for an external audience.

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Publically available specification (PAS) 2050

The PAS 2050 is a UK specification released October 2008 to assist firms to measure the carbon footprint of goods and services. It is designed to help customers to know how much CO_2 has been emitted during production, use and disposal of a range of products.

The specification was developed by the British Standards Institute (BSI)[5] at the request of the Department of Environment, Food and Rural Affairs (Defra) and The Carbon Trust. Its aim is to address the need for a consistent and reliable tool to assess greenhouse gas emissions associated with goods and services. The PAS is not a British Standard, European Standard or International Standard, but could become the basis of such a standard. In that event the PAS would be withdrawn.

Development of the PAS 2050 began in June 2007 when The Carbon Trust and Defra approached BSI Standards Solutions to oversee the development of the standard. Research to support this process was commissioned from The Stockholm Environment Institute.

According to the Carbon Trust website[6] the new standard is expected to help businesses 'move beyond managing the emissions their own processes create and to look at the opportunities for reducing emissions in the design, making and supplying of products.' The PAS 2050 was piloted with 75 product ranges from a number of companies including Coca Cola and Cadbury.

Defra also carried out its own testing of the PAS on about 100 food products examining the production, manufacture and distribution.

According to The Carbon Trust website development of the PAS 2050 involved almost a 1000 industry experts. They say that the resulting framework is 'robust' and will provide businesses and the public sector with a tool for consistent assessment of embodied GHG emissions and the ability to compare products and services. It is also intended to give the consumer a better understanding of life cycle ghg emissions and an ability to compare products and services.

[5] http://www.bsi-global.com/en/Standards-and-Publications/How-we-can-help-you/Professional-Standards-Service/PAS-2050/ accessed 31/10/08
[6] http://www.carbontrust.co.uk/News/presscentre/PAS-2050.htm accessed 31/10/08

The PAS 2050 builds on existing LCA methods supported by BS[7] EN ISO 14040 and 14044. The BS EN ISO 14044 (2006) and the Intergovernmental Panel on Climate Change IPCC (2006) *Guidelines for National Greenhouse Gas Inventories*[8] are considered to be indispensible support documents for the application of the PAS.

Scope of the PAS 2050[9]

The PAS 2050 addresses:

- Requirements for specifying a system boundary
- Sources of ghg emissions within the boundary
- Data requirements
- Calculation of results

One of the intentions of the PAS 2050 is to facilitate comparisons of ghg emissions between products and assist in communicating this information. However it is not intended that it specify any requirements for communication.

Principles of the PAS 2050 (adapted from BS ISO 14064: 2006, Clause 3)

- Relevance: appropriate ghg sources, carbon storage, data and methods have been selected
- Completeness: all ghg emissions and storage that provide a material contribution to the assessment have been included
- Consistency: meaningful comparisons can be made
- Accuracy: biases and uncertainties are minimised
- Transparency: all ghg emissions related information is provided to enable decisions based on the results of the LCA to be made with confidence.

System boundary

Where a Product Category Rule (PCR) developed in accordance with BS ISO 14025 exists and where it does not conflict with the PAS 2050 system boundary rules then it should be used. Where a PCR does not exist the system boundary must be defined.

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[7] BSI implementation of international standard

[8] National Greenhouse Gas Inventories Programme, Intergovernmental Panel on Climate

[9] The following sections are adapted from: British Standards Institute (BSI) (2008). PAS 2050:2008 Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. BSI: UK

Emissions arising from the following products are counted as within the system boundary.

- Raw materials
- Energy
- Manufacturing and service provision
- Operation of premises (inc lighting, heating ventilation)
- Transport
- Storage
- Use phase (for business to business, cradle-to-gate, assessment downstream emissions are excluded)
- Final disposal (for business to business, cradle-to-gate, assessment final disposal emissions are not relevant)

Greenhouse gas emissions resulting from production of capital goods used in the life cycle of the product are excluded from the calculations.

Comment

It is difficult to see how this PAS provides any greater certainty around emissions calculations or how it enhances the ability to make comparisons. The principle of *Relevance* demands that all appropriate ghg sources have been selected however it would seem impossible to know this unless the whole of the supply chain has been examined. The principle of *Completeness* demands inclusion of all ghg emissions and storage that provide a material contribution to the assessment. Again this will be difficult to know unless a full upstream examination has taken place.

The principle of *Consistency* requires that meaningful comparisons can be made, however if boundaries have to be drawn by each reporting organisation then comparisons will continue to be difficult to make because boundaries may be drawn in different ways by different organisations. The principles of *Accuracy* and *Transparency* are compromised by the fact that Scope 3 emissions cannot be accurately accounted for using the PAS 2050.

Renewable Energy Target[10] (Australia)

The Government's Mandatory Renewable Energy Target was instigated in April, 2001 and was reconfirmed in 2004. It aims to increase the uptake of renewable energy.

The Renewable Energy (Electricity) Act 2000 required the generation of 9,500 gigawatt-hours of extra renewable electricity per year by 2010, enough power to meet the residential need of 4m people. This resolution was strengthened in 2007 when the incoming Labor Government committed to ensuring that 20% of Australia's electricity supply (or 45,000 gigawatt-hours) would come from renewable energy sources by 2020. The government also committed to bringing existing state-based targets into one single, national scheme.

The Act requires that electricity retailers and wholesale buyers on grids exceeding 100MW in all states and territories contribute proportionately to increase renewable energy sources

Renewable Energy Certificates (RECs) are an electronic form of currency initiated by the *Renewable Energy (Electricity) Act 2000.* RECs are created by registered persons, validated by the Office of the Renewable Energy Regulator, traded between registered persons, and eventually surrendered to demonstrate liability compliance against the requirements of the Australian Government's mandatory renewable energy target. Owners or operators of eligible renewable power stations are eligible for RECs provided the Renewable Energy Regulator accredits the renewable energy power station. Owners of eligible small generation unit installations are eligible for RECs. Small generation unit installations include: photovoltaic systems; wind systems; small hydro electric systems.

On 14 February each year, liable parties are required to surrender a number of registered RECs equal to their liability for the previous calendar year. Liable parties surrender RECs in the REC registry between 1 January and 14 February each year.

Each REC represents one megawatt hour of renewable energy form an eligible renewable energy source.

The new Renewable Energy Target (RET) scheme is being designed in cooperation with the Council of Australian Government (COAG) Working Group on Climate Change and Water.

The RET is seen as a transitional measure to assist in moving to a low emissions economy. It will be phased out between 2020 and 2030 as the emissions trading scheme matures.

[10] http://www.climatechange.gov.au/renewabletarget/index.html

Responsibility

The issue of who should take responsibility, for example for damaging environmental impacts, or for laudable job creation, is a vexed one. Organisations often would like to claim the latter but shy away from the former. Not only that but how far up the supply chain should you go? In their sustainability report a multi-national organisation based in France claimed responsibility for job creation in the local area through their buy-local policy but failed to mention any responsibility they may have had for land disturbance or emissions caused by their increased use of primary resources as their business expanded.

They may argue that since the consumer demands the goods that the company manufactures then the consumer should be held responsible for the emissions and the land disturbance (they may not suggest this about job creation however). So who should be held responsible?

> *"While responsibility for the environmental impacts of production has been commonly assigned to producers, production is driven by consumer demand, and it is valid to question whether impacts should instead be assigned to consumers. However, in each of these approaches producers and consumers either bear the full burden of responsibility or none at all. An example of this is the Kyoto Protocol, where all greenhouse gas emissions are assigned to the producer and no consideration is given to where goods are finally consumed… A shared responsibility approach appears to distribute the burden of responsibility and associated liability between parties more fairly, and is likely to be more widely acceptable than pure producer or consumer perspectives." (Andrew, R. & Forgie, V. 2008).*

Allocating responsibility

The question is: who *should* count, and therefore take responsibility for, the inputs and therefore the effects of doing business.

Is it the producer?

If a gadget is made in China by an American company and exported and used by consumers from Stockholm to Sao Paulo, Brazil, should the Chinese government be held responsible for the carbon released in manufacturing it? (Wall Street Journal. N.Y. Nov 12, 2007. pg. A.2)

If the Chinese government were to take *full responsibility* (the blame-the-producer approach) this would mean that the *producer* takes responsibility for all the effects of its production.

Is it the consumer?

As China's emissions rise, everyone is pointing the finger of blame at China … The real responsibility for rising emissions should lie with the final consumers in Europe, North America and the rest of the world. (Wall Street Journal. N.Y. Nov 12, 2007. pg. A.2)

Full consumer responsibility (the blame-the-buyer approach) means that the final consumer calculates her or his full upstream footprint, accounting for all

emissions, land use etc embodied in the goods and services purchased and takes full responsibility for it.

Is it everyone's responsibility?

… emissions are embedded in goods that move around the world through trade -- so if the U.S. imports iPods from China, Americans should share some responsibility for the pollution produced in making them (Wall Street Journal. N.Y. Nov 12, 2007. pg. A.2)

Shared responsibility means that we acknowledge that we're all in this together, we're an integrated system, and we must all take our share of the good and the bad effects of doing business. We're all responsible for creating employment along the supply chain just as we're all responsible for creating greenhouse gas emissions along the supply chain. If we are all responsible then the question now is: how can the responsibility of an individual or an organisation be calculated consistently and fairly.

Apportioning the effects of doing business along the supply chain – sharing responsibility

Apportioning emissions, or any other impact, along the supply chain has only recently been consistently and quantitatively conceptualised by ISA researchers. Allocating each impact – for example on a 50%-50% basis between the supplier and the recipient – removes double-counting and solves a decades-long problem in Life Cycle Analysis.

ISA's framework allocates a 50:50 split of all impacts, so that they cascade along the supply chain. This means that, for example, the portion of jobs (which could just as easily be greenhouse gas emissions) retained/accepted by your organisation is 50% of the on-site total[11] plus 50% of your allocation of the upstream impacts embodied in the goods and services that you purchase[12]. The other 50% gets passed on to your customers, pro-rata-ed according to the amount of goods that each customer purchases. This could just as easily be a negotiated split or responsibility could be allocated according to the amount of value added to the goods or services by an organisation.

The above methodology was used in 2009 by the Economic Analysis Team, Institute for Global Environmental Strategies, Japan, to account for embodied emissions in trade between developed and developing nations.

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[11] In the case of emissions this is the equivalent to the Scope 1 emissions category of the Factors and Methods Workbook (Australian Bureau of Statistics (2006). 2003-04 Household Expenditure Survey - Detailed Expenditure Items. Canberra, Australia, Australian Bureau of Statistics.)

[12] In the case of embodied emissions these are proportionally allocated to producer and consumer at every intersection so that when the good or service is purchased by an entity it arrives with its own allocation of the emissions generated by every stage of its production and delivery. In the ISA framework *indirect emissions* covers the Scope 3 category of emissions identified in the Factors and Methods Workbook as well as the Scope 2 emissions caused by the consumption of purchased electricity, steam or heat produced elsewhere (Australian Greenhouse Office 2006). Furthermore, emissions occurring further upstream from Scope 3 are also accounted for.

Table 1 is an example from the NZ economy. In column two it shows, under a full producer responsibility model, the percentage of responsibility assigned to *producers*, aggregated into major groups of industries (Primary, Manufacturing and Services).

Table 1: Summaries of responsibilities for New Zealand's domestic greenhouse gas emissions using three perspectives: Producer responsibility, Consumer responsibility, and Shared responsibility. (Andrew, R. & Forgie, V. 2008).

Sector	**Producer (%)**	**Consumer**	**Shared**
Primary	37	–	14
Manufacturing	18	–	12
Services	30	–	17
NZ households	15	43	29
RoW	–	52	26
Other FD	–	5	2
Total	100	100	100

Note that NZ households must accept some producer responsibility. This is for their direct emissions, mainly from energy consumption. The third column illustrates the amount of responsibility allocated to *consumers*, split into NZ households, the Rest of the World (RoW) and 'other' final demand (FD) categories in a consumer responsibility model. The final column shows what the split would look like if consumers and producers were to share responsibility. This shared responsibility model shows percentages of responsibility assigned according to value added along the supply chain with the remaining responsibility being 'passed on' to downstream industries or final demand.

In the case of NZ most of the output from Agriculture is consumed overseas, however the emissions from the sector are assigned to the *producer* under the Kyoto Protocol accounting regime. This means that to reduce emissions NZ would need to reduce its exports and therefore its export earnings which is not something that it is prepared to do. You may think that the answer is to move to a consumer responsibility model, either NZ residents or consumers overseas. However if this were to result in higher prices for NZ goods overseas once again this may impact on the economy. Another disadvantage is that if goods are exported to countries not bound to reduce their ghg emissions then responsibility for the emissions is not taken by anyone thus losing an opportunity for motivation to reduce emissions. Sharing responsibility has the potential to be more politically acceptable all round. In addition it solves the issue of double counting.

Further reading

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Scopes 1, 2 and 3

Organisations may cause the emission of greenhouse gases either directly - for example, by on-site fossil fuel combustion - or indirectly through their consumption of electricity or other products which resulted in GHG emissions during their production. The accurate accounting and reporting of organisational *carbon footprints* is an increasingly important requirement to guide effective climate change policy, organisational management and investment. For greenhouse gas accounting and reporting purposes three 'scopes' were defined by the World Resources Institute (WRI) in their 2004 Greenhouse Gas Protocol.

Scope 1 accounts for direct GHG emissions from sources owned or controlled by the company. This does not include direct emissions from the combustion of biomass, neither does it cover those not covered by the Kyoto Protocol.

Scope 2 accounts for GHG emissions associated with the generation of electricity, heating/ cooling, or steam purchased for the reporting entity's own consumption.
Scope 2 emissions occur at the facility where the generation of electricity, heating/ cooling, or steam takes place.

Scope 3 accounts for all other indirect GHG emissions. These are emissions that occur as a result of the activities of the company – the company's demand for goods and services – but are from sources not owned or controlled by the company.

Issues

Whilst the boundaries of scope 1 and 2 emissions are quite clearly defined, scope 3 accounting is more problematic – it requires an analysis that extends back through many stages of the upstream supply chain. Consequently, methodological and practical difficulties have inhibited consistent reporting of scope 3 emissions and raised concerns over double counting; examples are given below.

Inter-company comparisons: the GHG Protocol states that "[S]ince companies have discretion over which categories they choose to report, scope 3 may not lend itself well to comparisons across companies." (p.29). Companies must determine which scope 3 emissions to include and how many levels up the supply chain they want to investigate. Whatever the decision it is likely that other companies will have made different decisions.

Data availability and accuracy: the GHG Protocol says that "[W]hile data availability and reliability may influence which scope 3 activities are included in the inventory, it is accepted that data accuracy may be lower. (p. 31). The Protocol says that verification will often be difficult, something that is confirmed

by the Carbon Disclosure Project's 2007 report on the results of their FT500 questionnaire (p. 18)[13].

Double counting: the GHG Protocol states that "[S]copes 1 and 2 are carefully defined in this standard to ensure that two or more companies will not account for emissions in the same scope. This makes the scopes amenable for use in GHG programs where double counting matters." (p.25). However if scope 3 is to be reported on it is likely that at least some of the emissions have already been captured in someone else's reporting as scope 1 or 2 emissions. The Protocol points out that for participation in GHG trading two organisations cannot claim ownership of the same emissions and that it is necessary therefore to be able to differentiate ownership.

Current Position

Although scope 3 is an optional reporting category its importance is rapidly increasing with the need to close loopholes for purposes of carbon trading; to manage the financial impacts of carbon pricing in the supply chain; and the need to maintain consumer confidence and avoid accusations of 'greenwash'.

The Global Reporting Initiative's advice is that a sustainability report should include "entities over which the reporting organization exercises control or significant influence both in and through its relationships with various entities upstream (e.g., supply chain) and downstream (e.g., distribution and customers)." (Sustainability Reporting Guidelines, GRI 2000-2006, p. 17). Further it states that an organisation "should include in its boundary all entities that generate significant sustainability impacts (actual and potential)" (p. 18).

The Carbon Disclosure Program's questionnaire asks respondents to provide, where feasible, estimates of their supply chain emissions as well as estimates of external distribution/logistics and employee business travel.

Stress free Scope 3

Reporting scope 3 emissions would normally require organisations to survey their entire supply chains – and the supply chains of their suppliers; an administratively complex, expensive and methodologically problematic approach for most organisations. The Centre for Integrated Sustainability Analysis at the University of Sydney has developed a solution to this problem by modeling supply chain emissions throughout the economy. The ISA methodology based on Input-Output Analysis automatically carries out a complete upstream life-cycle assessment of your organisation's impacts.

In order to do this it requires **only one** set of information – your organisation's financial accounts.

[13] http://www.cdproject.net/cdp5reports.asp

Of course the more detailed your financial accounts are the more accurate the assessment of your scope 3 greenhouse gas emissions will be. If you, for example, sort *packaging* expenditure into *paper* expenditure and *plastics* expenditure, which will have different GHG implications, then you will get more accurate results than if you lumped them together. However you can get useful and meaningful results with as few as 20 expenditure items.

What's the big deal about scope 3? Who cares?
The big deal is that unless you examine your supply chain you won't know what's hidden there. And unless you examine it using Input/Output analysis you will never be able to uncover more than an arbitrary scattering of potential risks.

Who cares? Well you might if you've made an important strategic decision – based on the wrong information.

How does the ISA methodology evaluate scope 3 emissions?
Your indirect (supply chain) emissions, such as emissions from air travel, are calculated by allocating your organisation's expenditure across a breakdown of 344 sectors of the national economy, based on Australian Bureau of Statistics data. The total emissions for each sector of the economy are known and a portion commensurate with your expenditure in each sector is calculated. So, for example, you provide your expenditure on airline tickets and the software calculates your share of the average emissions of an airline.

The ISA methodology takes all your expenditure data and converts it into your chosen indicators. For example, say you chose *CO_2 emissions* as an indicator, and you provided a value of, say, *100$* for paper purchased. Then the ISA methodology calculates how many kilograms of CO_2 are 'embodied' in this 100$ worth of paper. This will be added to the *CO_2 emissions* embodied in all of your other expenditure items.

The methodology traces every one of your purchases through your supplier, the supplier of your supplier, the supplier of your supplier's supplier and so on in an infinite chain of interactions. The thoroughness of the ISA analysis can be appreciated when you consider that in the ISA model of the Australian economy

- supply chain layer above you – your suppliers – has 344 members, who each have 344 suppliers, so that
- the next supply chain layer has 118,336 "suppliers of suppliers",
- the one above that has over 4 million "suppliers of suppliers of suppliers",

and so on throughout the whole of the economy. To assess all these suppliers' impacts manually is impossible. The ISA methodology and software account for the impacts of *all* suppliers.

The ISA model provides consistency of reporting because there is no cut-off point or imposed boundary. **Thus results between organisations are more comparable**.

Shadow price of carbon (SPC)

In 2008 the UK Department for Environment, Food and Rural Affairs (Defra) published guidelines on how to value greenhouse gas emissions in policy and project appraisals. The Shadow Price of Carbon (SPC)[14] was adopted in the guidelines as the basis for incorporating ghg emissions in cost-benefit analyses and impact assessments across government.

The SPC is used to value the increase or decrease in emissions that will result from a proposed policy. According to an article in the Guardian (Sat. Dec. 22, 2007) Ministers must factor a carbon cost into their policy decisions covering transport, construction, housing, planning and energy. The shadow price for carbon, representing the cost of environmental damage, has been set by the UK government for each year up to 2050. This cost must be factored into, for example, the building of a new power station. This will show up the relative real costs (i.e. including emissions costs) of building a nuclear power plant and a coal fired power plant. It will show up the real cost of building a new road. It will make 'zero-carbon' building regulations appear more economic.

[14] http://www.defra.gov.uk/Environment/climatechange/research/carboncost/index.htm (accessed 20/11/08)

Social sustainability

From: Murray J, Dey C, and Lenzen M, Systems for Social Sustainability: Global Connectedness and the Tuvalu Test, *Journal of Sociocybernetics*, 5(1-2), 34-56, 2007

Alan Black (2004) in his address to the Effective Sustainability Education Conference in Sydney, Australia, defined social sustainability as the extent to which social values, social identities, social relationships and social institutions can continue into the future. This raises the question of time scales: how long do social systems need to continue into the future to be called sustained? Or are they always sustained for x number of years (in which case who's counting?). There are social organisations that last a lifetime and those that are sustained over the rise and fall of many lifetimes; rituals, arts and stories that carry a culture and bind a social group can continue over generations. Membership may change, wax and wane, but, like my old broom that's had four new handles and six new heads, the social system goes on. (This would bear out Luhmann's argument that the social system cannot be the actors, they come and go, they are part of the environment, it is communication that is sustained, that goes on manufacturing and transforming itself, and is therefore the social system.) But how can we call any social system a sustainable system when it is disappearing into an unknown future (and how do we know the future will want a system that seems like a good idea now?).

Furthermore, although in some respects Black's definition echoes the oft-quoted sustainability definition of "development that meets the needs of the present world without compromising the ability of future generations to meet their own needs" (UNWCED, 1987) it makes no judgments about the type of social system that is sustained or its impact on future generations. It leaves room for social upheaval: if current social norms are not sustainable over the long term, because say, they are unjust, they will be overturned (e.g. if social relationships are based on a class system and at some time it is overthrown then it wasn't socially sustainable in the long term). This implies a striving for social balance, a kind of social equilibrium maybe, and the notion of equity where no one group is living at the expense of another (the lifestyle of that particular group wouldn't be socially sustainable, because at some time there would be a reshuffle of power, bloody or otherwise, and a realignment of resources). Someone would have overstepped the mark living at the expense of others. As a recent UK government report points out, "A world disfigured by poverty and inequality is unsustainable"[15] (HM Government, 2005:13), implying that 'someone' should do something about it. However, in practice, Córdoba and Midgley (2003) suggest that there are always implicit or explicit boundaries to the extension of human concern for others. Also we cannot escape our history and what one group may see as overstepping the mark another may see as their inalienable right. One group can, and history has shown that they will, cause the complete annihilation of another if they do not find

[15] "over a billion people live on less than a dollar a day, more than 800 million are malnourished, and over two and a half billion lack access to adequate sanitation." (HM Government, 2005:13)

ways to 'fit' (Wright, 2005). As Maturana and Varela (1987) suggest, if they cannot find ways to fit they will 'separate' or 'disintegrate'. But bringing about the 'disintegration' of one group, as Wright (2005) points out, can be about the survival of another. Social sustainability is not an innocent concept. Gray and Milne (2004:77) discuss the political minefield of social sustainability, suggesting that it "rests on nothing less than interpretations and explanations of the relationships between modern capitalist activity and social justice – the probability of a consensus on this area" they say, "seems slim, indeed". Others who may or may not operate in a modern capitalist society may say that social sustainability rests on ethics, human relationships and survival of kin, local, and ultimately global community. Which looks as though we, who are lucky enough to have communication systems that allow us to live to some extent in a global community, cannot escape an obligation to act to find ways for social systems to fit together. However, as in many other political dilemmas throughout history the danger lies in creating insiders and outsiders (Córdoba & Midgley, 2003; Ulrich, 1983; Midgley, 2000).

Thus social sustainability is a restless concept, it cannot escape the messiness of human life on earth. It implies interrelationships and interdependencies built on communication over time; local or global communities in constant struggle towards living together without exploitation in an ever-changing world. On a small scale this could be about sharing services and paying for those services (where those more able may pay for services enjoyed equally by those less able to pay, such as through taxes to pay for social infrastructure) or in providing different but essential services according to our abilities, to maintain the functioning of, say, a sport or social club. On a larger scale however since all communities are interdependent and ultimately form one global social system the sustainability of one community (of geography or interest) ultimately affects and is affected by that of others. To achieve social sustainability, it seems, would be to achieve lasting global harmony, and not just between social systems but also between social systems and their environments. Striving for a new utopia! Something that Luhmann (1997) cautions us about looking for because, he says, it can only lead to new disappointments.

Perhaps then, rather than a meaningless quest for a utopian social sustainability grounded in say, well-being, it is better to settle for the struggle itself and the constant learning that this implies. Perhaps our focus should be on the "sustainable quest for systems of inquiry" (Bawden, 1997:3); sustainability-as-process, learning to manage in a shifting world (Cox, MacLeod & Shulman, 1997) as we living systems in communication with ourselves in reflection (Schön, 1979, 1983) and others in discussion find novel ways to deal with the tensions created by ethical dilemmas and competing demands. Perhaps it is sufficient to strive towards social sustainability which implies a framework in which to consider the likely issues embedded in our actions.

Summary
This section of the discussion has suggested some problems inherent in the definition of social sustainability. A god's eye view is implied in the idea that someone is counting and judging, we cannot know for example:

- *how long something must persist for it to be called 'sustainable';*
- *if social sustainability connotes an ethical position based on principles of equity, whose notion of 'equity' should prevail and be sustained; or*
- *whether an identified social system, pronounced 'sustainable' today will 'fit' in a future world.*

We are of the system and cannot take an outside point of view. Instead we can ask from the messiness of our relationships:

- *if social sustainability is something utopian and unattainable like lasting global harmony should we shift the focus of our debate to something attainable like a sustainable process of learning as we communicate as living systems in our environment over time[16]; and*
- *how long can this (process, activity etc) be sustained; what are the likely issues to arise from this activity/behaviour – locally, globally, now, and in the future?*

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[16] This may, of course, be more akin to the Little Prince commanding the sun to rise in the morning since living systems have always learned –that's how they/we go on living (Maturana et al, 1987).

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Social system

Excerpt from: Murray J, Dey C, and Lenzen M, (2007). Systems for Social Sustainability: Global Connectedness and the Tuvalu Test, *Cybernetics and Human Knowing*, volume 14, no. 1, pp. 87-105.

Biologists Maturana and Varela (1987) claim that we, like all living systems, are structurally determined systems. By this they mean that the way in which we respond to perturbations (or irritations) in our environment is determined by our structure. But the environment is also a structurally determined system. Recurrent interactions of both living system and environment will result in structural changes in both system and environment. Who we, as living systems, are at this instant and the environment we find ourselves in mutually specify each other so that each contributes to creating the world of the next instant, and so on, creating the world by living in it. This process Maturana and Varela call co-ontogenic structural drift. In co-ontogenic structural drift, they say, the system does not adapt to the environment as in the classical system-environment model (Krohn, Kuppers, Novotny, 1990) but both change over time as they become structurally coupled (Maturana, 2002); either they 'fit' together or separate or disintegrate (Maturana et al, 1987; Maturana, 2002). Luhmann (1995, 1997) uses this concept in his work on human social systems. In a social context, he says, communication is the social system and everything else including living systems, is the environment in which communication operates (i.e. living systems – in this case human actors - are part of the environment of social systems rather than composing them). However, he says, "[T]he concept of the environment should not be misunderstood as a kind of residual category. Instead, relationship to the environment is constitutive in system formation" (Luhmann, 1995:176, italics in the original). Communication, he says, becomes structurally coupled with the consciousness of individuals (1997) and, "[O]nly consciousness can produce the noise necessary for the emergence and evolution of social order" (1997:4). A particular social system arises out of the difference between system (communication) and environment as they bump up against each other and (because of their differences) change over time as they find ways to 'fit'.

Viewed through Luhmann's social frame communication and its environment, which is the consciousness of individuals, change over time as they become coupled in a never-ending reciprocal relationship. Viewed through Maturana and Varela's biological frame all living systems and their environments (which include other living systems as well as all communication) become coupled so that they grow and change together, each influencing the possibilities of the other. In both cases we are structurally changed in the process of living and communicating over time. This means, as Fell and Russell (1993:35) say, "that everything we have ever done together in this world could be a part of who we are and what we do today" and "[w]e cannot know what the future holds, but we can know that everything we do (or say) contributes significantly to it . . . This awesome responsibility is what we regard as the biological basis of our human ethics." (Fell & Russell, 1993:35; see also von Foerster, 1992 on cybernetics and ethics).

Thus the social impact of doing business is part of the web of interactions that are life on this planet. Socially sustainable activities, like all of our activities, become part of who we are and what we do. They are activities that, because they become part of who we are and what we do (and the 'we' referred to includes all of humanity including ourselves, carrying with us our histories, and future generations) must, for us if we accept this position, be bound by human ethics. Moreover if human ethics have a biological basis, as suggested by Fell and Russell above, it is probably reasonable to suggest, as Maturana (1988) argues, that they play a role in human survival.

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Structural coupling

Maturana and Varela (1987:75) describe structural coupling as a process of engagement – a “history of recurrent interactions leading to the structural congruence between two (or more) systems”. This means that systems reciprocally change and are changed by their interactions. They have a co-history of structural transformation, mutually specifying their trajectories.

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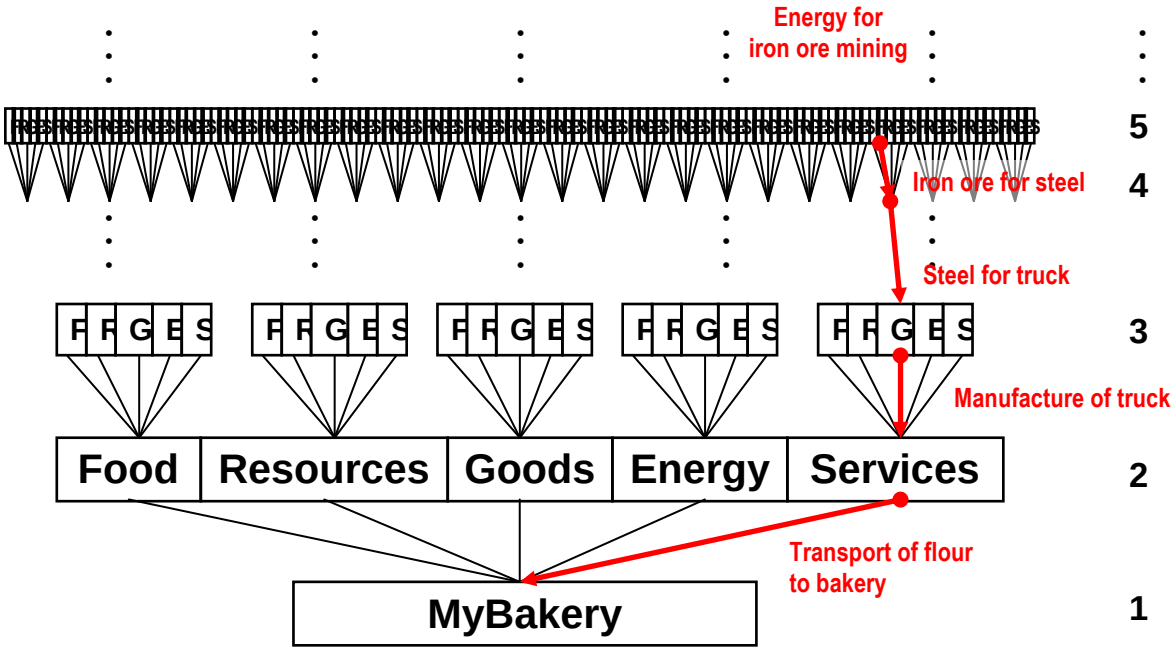
Supply Chain

What does it mean?

A supply chain is a network of suppliers, transporters, manufacturers, storage facilities, distributors, and any other process or entity that participates in the production, delivery and sale of goods and services.

Imagine MyBakery at the foot of a tree that represents MyBakery's supply chain. The first "canopy" up from the foot is MyBakery's suppliers. The next canopy up is the suppliers of MyBakery's suppliers, and so on. This tree is an infinite tree of suppliers. The foot is called *production layer 1*, the first canopy is labelled '2', the second '3', and so on.

Figure 1: Example of a MyBakery supply chain



Accounting for supply chain impacts

Impacts occur in every production layer. Take the indicator 'energy' for example. MyBakery is connected to town gas to fire its ovens. The gas used on-site belongs into production layer 1. My Bakery buys flour. This flour needs to be produced by a flour mill. The energy used in the flour mill belongs into production layer 2, since the flour mill is a direct supplier of MyBakery. The flour also needs to be delivered to MyBakery by a transport firm. The diesel used by the truck also belongs into production layer 2, since the truck company supplies the transport service to MyBakery. The truck that the transport firm uses needs to be assembled by a vehicle manufacturer. The energy used during this assembly process belongs into production layer 3, since the vehicle manufacturer is a supplier of the transport firm which in turn supplies MyBakery. And so on.

The chain of red arrows in the supply chain tree is called a *structural path*. There are millions and millions of structural paths in a typical supply chain tree. This is because the economy is so complex. The complexity of the calculations can be appreciated when you consider that in the ISA model of the Australian economy

- production layer number 2 has 344 members, who each have 344 suppliers, so that
- production layer number 3 has 118,336 "suppliers of suppliers",
- production layer number 4 has over 4 million "suppliers of suppliers of suppliers",

and so on. ISA methodology accounts for the effects of *all* suppliers.

Greening the supply chain

Greening the supply chain refers to an organisation working with (or putting pressure on) parts of its supply chain in order to improve environmental or social outcomes. For example in October, 2008 Wal-Mart[17] announced that it wanted its suppliers to meet tighter environmental and social standards. It said that it wanted to work closely with a smaller group of suppliers so that it could monitor their practices and at the same time keep prices low. This included a large number of suppliers based in China where Wal-Mart was demanding environmentally friendly manufacturing practices and product-safety guidelines. Wal-Mart not only made demands on its direct suppliers but it also demanded that they in turn put pressure on their own suppliers. The avowed aim was to 'build a more environmentally and socially responsible global supply chain'.

One of the issues identified in this plan[18] was the vast network of suppliers of suppliers, and suppliers of suppliers of suppliers, and so on along the chain. Apparently Wal-Mart's suppliers in China are fed by a network of smaller and smaller organisations spread out across China, Vietnam and Thailand.

Carbon Disclosure Program Corporate Supply Chain Programme[19]

According to their website the CDP Corporate Supply Chain Programme is designed to assist companies in identifying risks and opportunities in the supply chain. It will, they say, help to 'anticipate and manage new pressures from climate change which are not directly within their organisational control.' To this end the CDP has produced a questionnaire for member organisations to distribute to their immediate suppliers. The questionnaire, they hope, will assist in calculating the upstream supply chain emissions, using GHG emissions data obtained directly from the suppliers. In turn this will help member organizations to extend their carbon disclosure to include 'related activities', reported under

[17] http://www.environmentalmanagementnews.net/StoryView.asp?StoryID=447523 & http://www.itworld.com/green-it/56771/wal-mart-aims-go-green-global-supply-chain-makeover (accessed 28/10/08)
[18] http://www.itworld.com/green-it/56771/wal-mart-aims-go-green-global-supply-chain-makeover (accessed 28/10/08)
[19] http://www.cdproject.net/corporate-supply-chain.asp (accessed 28/10/08)

Scope 3 of the GHG Protocol, and to take 'the first step towards calculating their carbon footprint'[20]

In September 2007 Wal-Mart provided the CDP with a case study piloting use of its supply chain questionnaire[21] with seven of its major suppliers. The seven suppliers were encouraged to fill in the questionnaire and provide information on greenhouse gas emissions. This provided Wal-Mart with insights into emissions embodied in their products. The questionnaire revealed the major source of emissions to be refrigerants used in grocery stores rather than the expected fuel used in its truck fleet.

In October 2007 the CDP created the Supply Chain Leadership Collaboration (SCLC) with 12 participating companies undertaking the pilot collaboration. The SCLC's aim was to standardise a process for supply chain reporting of carbon emissions, risks, opportunities and strategies. These 12 companies distributed the CDP questionnaire, including additional supply chain-related questions, to 328 suppliers asking for information on climate change initiatives. One hundred and forty-four suppliers responded. The challenges for CDP are now to improve the quality of responses and to include more organisations in the project.

Many of the suppliers of participating companies are new to GHG reporting. The CDP has therefore suggested that these suppliers should first become familiar with understanding their Scope 1 (direct or onsite) and Scope 2 (indirect from electricity, heat and steam purchases) emissions before moving to Scope 3 (other indirect or supply chain) emissions.

References

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[21] http://www.cdproject.net/wal-mart-case-study.asp (accessed 28/10/08)

Supply Chain Thinking

Supply Chain Thinking refers to the embedding of supply chain considerations in 'the way we do business'. This requires tools and frameworks to ensure that everyone in the organisation is aware of 'the supply chain' – what it means and what benefits an examination of the full supply chain can provide.

Examination of the full supply chain can reveal hidden costs and vulnerabilities but it can also reveal hidden opportunities for change.

For example in the case of land disturbance analysis of the supply chain for a fictitious Bank shows that the greatest effect on the Bank's land disturbance is from beef cattle supplied to the fresh meat industry supplied to hotels, clubs, restaurants and cafes that are used by the Bank (21.6%). Being able to identify this supply chain input would enable the bank to change its catering strategy to include less meat and more vegetarian options in all of the organisation's catering.

Rank	Path Description	Path Value	Path Order	Percentage in total impact
1	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > BigBank	434 ha	4	21.6 %
2	Beef cattle > Meat products > Hotels, clubs, restaurants and cafes > BigBank	92.7 ha	4	4.60 %
3	Shorn wool > Computer and technical services > BigBank	64.4 ha	3	3.19 %
4	Computer and technical services > BigBank	57.7 ha	2	2.87 %
5	Services to finance and investment > BigBank	51.9 ha	2	2.58 %
6	Sheep and lambs > Fresh meat > Hotels, clubs, restaurants and cafes > BigBank	51.1 ha	4	2.54 %
7	Business services > BigBank	44.4 ha	2	2.20 %
8	Beef cattle > Meat products > Computer and technical services > BigBank	39.0 ha	4	1.94 %
9	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Services to finance and investment > BigBank	35.0 ha	5	1.74 %
10	Electronic equipment > BigBank	32.4 ha	2	1.61 %
11	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Computer and technical services > BigBank	31.1 ha	5	1.54 %
12	BigBank	26.5 ha	1	1.32 %
13	Wholesale trade > BigBank	18.9 ha	2	0.94 %
14	Market research and other business management services > BigBank	17.4 ha	2	0.86 %
15	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Market research and other business management services > BigBank	16.9 ha	5	0.84 %
16	Horses > Property operator and developer services > BigBank	13.9 ha	3	0.69 %
17	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Legal services > BigBank	13.0 ha	5	0.65 %
18	Market research and other business management services > Services to finance and investment > BigBank	12.5 ha	3	0.62 %
19	Beef cattle > Fresh meat > Hotels, clubs, restaurants and cafes > Market research and other business management services > Services to finance and investment > BigBank	12.2 ha	6	0.61 %
20	Beef cattle > Meat products > Property operator and developer services > BigBank	11.8 ha	4	0.59 %

Sustainability

"development that meets the needs of the present world without compromising the ability of future generations to meet their own needs" (UNWCED, 1987)

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sustainable development

"Sustainable development or sustainability means finding a way to improve quality of life for people today and in the future by breaking the link between economic growth and environmental damage and social exclusion. It means developing our economy in ways that minimise pollution, protect natural habitats, use resources efficiently and tackle social inequalities to ensure that people, in this region and elsewhere, do not suffer as a consequence of our economic growth and are able to enjoy the benefits of it.

"In a sustainable region we would have thriving cities, towns and villages with strong economies, good access to services, attractive and safe surroundings and a healthy community. Resources would be used more productively with much less waste. To make sustainable development happen needs integrated economic, social and environmental objectives and consideration of the longer term impacts of decisions." (Yorkshire and Humber Assembly, 2003:4)

Weak and strong sustainability

"Weak and strong sustainability are two concurrent concepts that are very frequently used to classify empirical approaches to durable development (e.g. Dietz and Neumayer, 2004).

The term of *weak sustainability* has been coined to characterize economic approaches to sustainability that emerged during the 1970s. These approaches were extensions of standard neo-classical growth theories. Standard growth models generally consider that output is only determined by technology and the available quantities of two production factors, labor and capital. The main innovation of this literature has been to introduce natural resources as an additional production factor in these models, and to specify the laws for the evolution of this natural factor, for instance a modeling of extraction behavior in the case of an exhaustible mineral resource - this literature developed after the first oil shock.

These models generally assumed large substitution possibilities between natural resources, capital and labor. Combined with exogenous technical progress, this offered one solution to the finiteness of resources, at least from a theoretical point of view: as oil resources decline, production is expected to use less and less of them but without any decline in standard of living, either thanks to pure technological progress, or by replacing oil by some alternative fossil energy or any other man-made production factor.

Promoters of *strong sustainability* rather consider that substitution possibilities necessarily face physical limits. Critical levels must be maintained for most of natural resources. These critical levels must be at least equal to those necessary for basic-life support functions, and more probably higher if we want to keep reasonable levels of environmental *resilience*, i.e. the capacity of eco-systems to regenerate and return to equilibrium after shocks. The concept of strong sustainability is often considered as irreducible to monetary approaches. All environmental variables of interest have to be followed in physical terms."

p. 236. Report by the Commission on the Measurement of Economic Performance and Social Progress. J. Stiglitz, A. Sen, & J-P Fitoussi *September, 14, 2009* http://www.stiglitz-sen-fitoussi.fr/en/index.htm

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System

Gianfranco Minati and Arne Collen provide the following definition of system.

> *"At a specific level of description adopted by the observer, a system is an entity, established by interacting components, assuming properties different from those of its components. The transition from a set of components to a system of interdependent components takes place during and not as a result of interaction. In the process of interacting, new properties are established, as detected by the observer, thanks to the continuous process of interacting. Congruent with the above distinctions, two principal categories of examples are 1) human made devices assuming properties, that is those becoming systems, such as electronic and mechanical devices (specifically TVs, radios, telephones and engines) when power is supplied to enable their components to interact; and 2) natural, living systems comprised of human beings interacting in social contexts (specifically, transportation, markets, businesses, governments, festivals, sports events, ceremonies, private celebrations, and community affairs). While elements are considered to possess non-systemic properties like age, quantity, location, speed and weight; in contrast, systems acquire new properties when interactions among components occur."*
> Gianfranco Minati & Arne Collen, 2009. Architecture as Self-Design in Human Social Systems. Cybernetics and Human Knowing, v 16 n 1-2 p103.

Systems can be non-living like a bicycle or a house; living like a single cell, or a person or frog or plant made up of many cells; or they can be social systems like a club or an organization. There seems to be two major ways of visualizing these systems. The first is to consider a system in terms of a whole and its parts, for example a bicycle made up of seat, wheels, cross bar, breaks etc; or a frog made up of heart, liver, lungs etc. A parts/whole perspective can be useful for examining non-living systems however it can be difficult to examine living systems in this way because you might have to kill the whole to examine the parts.

The second way to visualize a system is as an integral part of an environment, for example a plant growing in a particular ecosystem or a child in a family. A system/environment perspective is more like a network of relationships in which parts of a system only make sense in the context of the whole. For example take the child out of the family and everything about the family changes; an ecosystem minus one of the plants that makes it this particular interdependent ecosystem becomes something entirely different. When you look at them this way systems, far from being understood if you take them apart, will cease to exist if you take them apart. In this interdependent world there is no linear hierarchy of parts stacking up step by step to make a whole. Instead there is a network of relationships in an interacting whole where every bit is just as important as every other. With its central idea of circularity it is easy to see why cybernetics embraces a system and environment way of carving up the world rather than the hierarchical system of parts building up into wholes.

Now comes the tricky bit. If I create the world by living in it, which is a conclusion I reached above when I examined the implications of a cybernetic view of the world, and if I see the world in terms of system and environment, then I must also create the system and environment. Again the implications of this idea are far

reaching. I can draw boundaries for systems and environments wherever I like. I may see myself as a system in the environment of my family or my work or my local ecosystem. Another member of my family, my work or my ecosystem will not be able to draw the same boundary as I do, the boundary that separates my system from its environment. They will make their own distinction between system and environment and will therefore be in a different environment. For a start their environment will include me – this leads to the idea, used in some branches of family therapy, that every family member is in a different family. I may also distinguish my family as a system in the environment of my community, or my ecosystem in the environment of the country's ecology.

The universe is an environment out of which I can carve many systems. A system jumps out from the background environment when I notice it as a coherent whole against the background noise. For example, I may notice that car drivers are becoming more aggressive, this is a difference in the normal pattern of events. It jumps out from the background of car driving. I give it a label, road rage. I identify conditions in which I think it occurs and talk about it. Road rage becomes a phenomenon, soon it is noticed by others. The distinction I made between road rage and other driving arose from my interest in pondering over this phenomenon and in extracting this particular meaning from it. Once I have made this distinction the system I have distinguished from other driving (i.e. Road Rage) becomes information to me. The information did not belong to me independent of the phenomenon, I had to notice something, a difference, for there to be any information to know. Nor did the information belong to the phenomenon, which did not 'exist' until I distinguished it from the background environment of everyday driving and gave it a name. The information, and associated learning, arose in interaction between living system (in this case me) and environment, it belongs to us both, created somewhere in the space between us.

Through a cybernetic lens a particular system and a particular environment do not have an existence as system-and-environment until I, the observer, distinguish them from background noise and define them as system-and-environment. This idea of noticing a difference is, like circularity, central to cybernetics. Once we distinguish something from the background as 'different' it becomes 'information' to us. We learn something new, and in the learning we change the phenomenon as we bring it into focus, provide it with attributes and communicate our observations to others; and we are changed by it, as it becomes part of our lives.

Systems thinking

According to Asayesh (1993) 'Systems thinking' emerged from the Massachusetts Institute of Technology in the late forties and early fifties where scientists began applying software developed for mapping electronic systems to other kinds of systems (Asayesh, 1993). This field of study, Asayesh says, used single and double loop learning as metaphors to explore change in organisations, which those working in the field of oganisational change viewed in terms of the relationship of the parts to the whole and the interactions between the two. It assumed that the system could be objectively observed.

In the 1980s systems thinking began to be applied to schools as organisations. It employed such tools as 'organisational storytelling' to generate a feeling of shared knowledge and values and 'feedback loop diagramming' to help people map out long and short term consequences of their actions (Asayesh, 1993). Organisational story telling was critiqued by Hargreaves and Fullan (1992:13) as possibly "self indulgent navel gazing" and "top down control" disguised as therapy.

The whole area of applying systems thinking to organisations was further advanced by Senge, in his book *The Fifth Discipline: The Art and Practice of the Learning Organization* (1990) where 'systems thinking' was in fact Senge's 'fifth discipline'.

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The Carbon Trust[22]

The Carbon Trust is an independent, UK government funded organisation set up to assist business and industry and the public sector measure, account for and reduce their carbon emissions. The Carbon Trust has developed a Carbon Reduction Label to provide the public with an indication of the carbon footprint of products and services. The Carbon Trust also has developed a standard that certifies that an organisation has reduced its carbon footprint.

The Carbon Trust and the Department of Environment, Food and Rural Affairs (Defra) requested the British Standards Institute to develop a Publically Available Specification (PAS) to standardise the measurement of embodied GHG emissions. PAS 2050 was launched October 2008.

[22] http://www.carbontrust.co.uk/default.ct

The Club of Rome[23]

The Club of Rome was founded in 1968 following a meeting of members of the diplomatic, industrial, academic and civil society. They were called together by an Italian industrialist, Aurelio Peccei, and a Scottish scientist, Alexander King, who were concerned about resource consumption and short term thinking in an increasingly interdependent and globalised world. Each participant agreed to spend the following year raising awareness of the issues with world leaders and decision makers. Their focus was to apply systems thinking to understanding of the long-term consequences of the growing globalization.

A group of systems scientists at the Massachusett's Institute of Technology was commissioned in 1972 by the Club of Rome to report on the results of its modeling of the interaction of five global economic subsystems: population, food production, industrial production, pollution and consumption. The report, *The Limits to Growth* (Meadows et al, 1972) caused a stir at the time and has been misquoted ever since. The report presented a number of scenarios and the choices open to society for 'sustainable progress' within 'environmental constraints'. The establishment of Ministries of the Environment in many countries is attributed to the report and its influential ambassadors.

In 2008 CSIRO produced a report[24] comparing historical data 1970 – 2000 with the scenarios presented in *The Limits to Growth.* The report found that key-features of the 'business as usual' scenario compared favourably with the 30 years of historical data. This study validates the report's conclusion that "Unless the LtG [Limits to Growth] is invalidated by other scientific research, the data comparison presented here lends support to the conclusion from the LtG that the global system is on an unsustainable trajectory unless there is substantial and rapid reduction in consumptive behaviour, in combination with technological progress." (Turner, 2008).

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[23] http://www.clubofrome.org/eng/home/
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Trial Balance

"A trial balance is a list of accounts and their balances at a given time. Customarily, a trial balance is prepared at the end of an accounting period. The accounts are listed in the order in which they appear in the ledger. Debit balances are listed in the left column and credit balances in the right column. The totals of the two columns must be equal." (Kimmel, P.D., Carlon, S., Loftus, J., Mladenovic, R., Kieso, D. E. & Weygandt, J.J. (2003). *Accounting; Building business skills*. John Wiley & Sons Australia, Ltd: Queensland p. 95).

A trial balance does not guarantee that there are no errors, transactions may have been missed or items may have been entered in the wrong columns. Items may have been entered twice.

A trial balance is prepared to check the accuracy of accounting – to check the mathematical equality of debits and credits.

Triple Bottom Line (TBL)

Where did it come from?

John Elkington[25] coined the term *triple bottom line*[26] in 1997. Elkington used the term to mean an expanded baseline for measuring performance. Instead of the usual financial bottom line he talked of the social, environmental and economic *bottom lines*.

The difference between *economic* bottom line and *financial* bottom line is blurred. Some say there is no difference and others draw a distinction between the traditional financial reporting and what they see as reporting on the economic impact of the organisation's activities on the life of a community. The Australian *Group of 100*[27] sees economic and financial as different but intimately connected, with TBL reporting identifying risks that can affect financial performance[28]. In the Group of 100's view, the business case for reporting on TBL centres on improved relationships with key stakeholders as well as specific commercial advantages, the enhancement of reputation and brand being top of their list.

There is also a move to add *governance* to the bottom line, making Quadruple Bottom Line reporting. Other commentators see good governance as a consequence of TBL reporting. Both discussions are ongoing.

What is it used for?

Triple Bottom Line can be viewed as a reporting device (e.g. information presented in annual reports) and/or an approach to improving decision-making and the fundamental functions of organisations (e.g. the provision of tools and frameworks for considering the economic, environmental and social implications of decisions, products, operations, future plans).

TBL provides a framework for measuring and reporting corporate performance against economic, social and environmental benchmarks. Reporting on TBL makes transparent the organisation's decisions that explicitly take into consideration impacts on the environment and people, as well as on financial capital. [29]

Useful proxies to indicate the economic, environmental and social impact of doing business

An indication of economic impact can be gained from such items as:

- gross operating surplus
- dependence on imports

[25] UK based: consultant to companies like BP, DuPont and the World Bank; member of the European Forum on the Environment & Sustainable Development; co-founder of SustainAbility in 1987; elected in 1989 to the UN Global 500 Roll of Honour for his 'outstanding environmental achievements'.
[26] In his book *Cannibals With Forks: The Triple Bottom Line of 21st Century Business* (Capstone, 1997).
[27] The Group of 100 is an association of senior accounting and finance executives representing the major companies and government-owned enterprises in Australia (http://www.group100.com.au/home.htm).
[28] Group of 100 (2003) *Sustainability: A guide to triple bottom line reporting*. Group of 100 Inc.
[29] http://www.cpaaustralia.com.au

- stimulus to the domestic economy by purchasing of locally produced goods and services.

An indication of social impact can be gained from, for example:

- OH&S records
- the organisation's tax contribution
- employment.

An indication of environmental impact can be gained from measures like:

- the ecological or carbon footprint
- emissions to soil, water and air
- water and energy use.

Such *indicators* can distil complex information into a form that is accessible to stakeholders. Organisations report on indicators that reflect their objectives and are relevant to stakeholders. One difficulty in identifying and using indicators is to ensure consistency within an organisation, over time, and between organisations. This is important for benchmarking and comparisons.

A 2005 CSIRO/University of Sydney publication[30] *Balancing Act* uses a set of ten indicators to benchmark 135 sectors of the Australian economy providing a snapshot of the TBL performance of the Australian economy.

[30] http://www.isa.org.usyd.edu.au/publications/index.shtml

Upstream and downstream

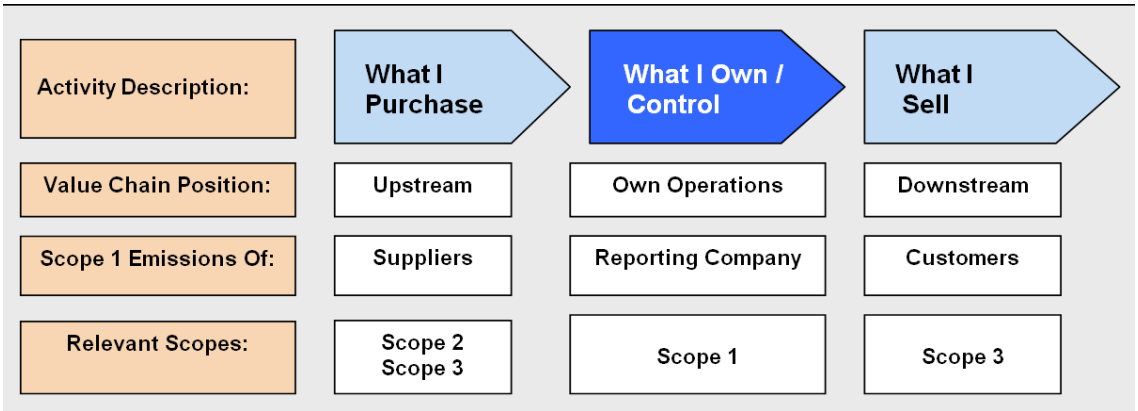

Fig. 1: Spheres of corporate responsibility; internal review draft for Greenhouse Gas Protocol Technical Working Group members, 17th June 2009.(reproduced with permission in: Lenzen M and Murray J, Conceptualising environmental responsibility, *Ecological Economics*, **70**(2), 261-270, 2010)

Upstream

In the ISA model upstream refers to: suppliers, suppliers of suppliers, suppliers of suppliers of suppliers and so on to infinity.

These are sometimes referred to as supply chains or value chains. In the ISA model they are defined by what an organisation spends money on – analysis of the expenditure accounts captures all upstream inputs into an organisation.

The following is taken from: Huang A, Lenzen M, Weber C, Murray J and Matthews S, The role of input-output analysis for the screening of corporate carbon footprints, *Economic Systems Research*, **21**(3), 217-242, 2009

"In an upstream scope-3 calculation, supply chains start with an emitting upstream sector, and end with the purchasing industry sector under investigation. The meaning of *upstream chain* is best explained using an example. Consider the supply chain 'Beef cattle > Meat processing > Restaurant'. The emissions associated with this supply chain are caused, for example, by land clearing or enteric fermentation in animals slaughtered for meat that is supplied to a restaurant's kitchen. Another way of expressing this is to say that emissions from beef-cattle farming become 'embodied' in the restaurant meal. The logic of upstream responsibility is that by choosing to buy from a meat processor that buys in turn from the beef cattle sector, the restaurant indirectly enables the beef cattle sector to sell beef, and hence to produce, and hence to emit. The more the restaurant buys from the meat processor, the more it is responsible for the upstream emissions liability caused by meat processing through buying beef cattle. The crucial aspect here is the *choice* of buying from someone: to *enable someone to produce, to emit, and to buy onwards, by buying from them an operating output*."

Downstream

In the ISA model downstream refers to: customers, customers of customers, customers of customers of customers and so on.

In the ISA model this is defined by where an organisation gets its income from – analysis of the revenue accounts captures all downstream outputs from an organisation.

The following is an excerpt from Lenzen M and Murray J, Conceptualising environmental responsibility, *Ecological Economics*, **70**(2), 261-270, 2010

"Downstream emissions responsibility has been defined quantitatively in an input-output context (Gallego and Lenzen 2005; Rodrigues *et al.* 2006; Rodrigues and Domingos 2007; Lenzen 2008). The contribution of this article is to add understanding and intuitive terminology, so that downstream responsibility can be used amongst non-experts, in the same way as upstream responsibility is commonly articulated through terms such as "footprints", "life-cycle", and "embodied". In the following Section we mirror the input-output terminology for upstream effects in order to create an equivalent downstream vocabulary. Talking about upstream and downstream emissions invariably means talking about suppliers, customers, supply and sales chains and transactions. The definitions below are all plain-English interpretations of input-output parlance; they provide a quick-reference glossary for what follows:

- A *commodity* is a good or a service.
- A *primary* input is a commodity that is not produced using something else (for example labour, or capital such as land and resources).
- *Intermediate* inputs and outputs are commodities (for example coal) that are traded between companies in order to produce something else (for example electricity).
- A *final* output is a commodity (for example household electricity) that is not used to produce something else.
- *Suppliers* can be sellers of primary inputs into production (labour), such as households (as workers), or they can be sellers of intermediate inputs (coal), such as companies (coal mines).
- *Customers* can be buyers of final outputs of production (household electricity), such as households (as consumers), or they can be buyers of intermediate outputs (coal), such as companies (power plants).
- A *supply chain* is a succession of buyers and sellers, starting with an emitting intermediate seller (for example coal mines), and ending in a final output (household electricity).
- A *sales chain* is a succession of buyers and sellers, starting with a primary input (labour for a coal mine), and ending in an emitting intermediate buyer (power plant).
- A *transaction* is the exchange of a commodity between a primary or intermediate seller, and an intermediate or final buyer.

...

1.1. Responsibility

In the complex interconnected web of supply and sales chains, everyone is supplier and customer at the same time. This is true from the perspective of a corporation (buying primary and intermediate inputs, and selling intermediate and final outputs), as well as from the perspective of a household (buying final outputs and selling primary inputs).

Any effort to reduce emissions implies allocating responsibility to actors involved in causing these emissions. We accept some responsibility for emissions of those that we buy from (upstream) because we choose to buy their product or service. We have responsibility for what we emit (on-site) because we have control over our actions. We take some responsibility for the emissions of those that we sell to (downstream) because we choose to sell to them.

There is, in the above, an implied balance in the power relationship between supplier and customer: the supplier has the power to make decisions about to whom it sells (downstream); the customer has the power to decide from whom it buys (upstream). Every organisation is both supplier and purchaser and will therefore have both sets of responsibilities, and both sets of expectations of others.

In reality the power relationship is not always balanced. Sometimes in order to make a living it may be extremely difficult to choose a supplier or to choose to whom one sells. Monopolies can manipulate the market in their favour and to survive small companies may have to 'take it or leave it'. Likewise households may sometimes have little choice in where they sell their labour or from whom they purchase particular goods. However the actual responsibility remains despite all extenuating circumstances. The consequences of our decisions, no matter how compromised the ‘freedom’ to choose, remain the same: the emissions exist; the water has been used; the waste created. And in theory there is always choice, however difficult it is to make the decision. The arguments about power relationships are ultimately a societal issue, to be tackled through socio-political processes.

1.2. Downstream vs upstream

In order to be consistent, downstream responsibility will need to be conceptualised in a way that is consistent with upstream responsibility. In the following we achieve this by first giving familiar explanations for upstream responsibility, and then we mirror the phrases by replacing as few words as possible (Tab. 1).

Looking upstream, our demand enables the production of our suppliers' products, which in turn causes emissions. A part of the responsibility for these emissions is handed down to us, as embodied emissions. Looking downstream, our supply

enables the production of our customers' products, which in turn causes emissions. A part of the responsibility for these emissions is handed up to us, as enabled emissions.

Whichever direction we look, we play a part in the production chain and have some responsibility for what occurs, because had we not taken our position in the chain – made our purchasing, production and sales decisions – emissions would have been different. Thus, upstream emissions are enabled by us having purchased goods or services. Had we not made that particular purchasing decision, the whole upstream cascade of interactions, initiated by our purchase order, including associated emissions, would have occurred differently. Downstream emissions are enabled by us having sold goods or services. Had we not made that particular sales decision, the whole downstream cascade of interactions, initiated and supported by our sale, including associated emissions, would have occurred differently.

There is always the 'road not taken' as Robert Frost reminded us in his 1915 poem[31]. Does this mean that we're only responsible for the difference between the two hypothetical scenarios in which we either act or we don't act? Such a point of view is taken for example in the additionality clause of the Clean Development Mechanism (Shrestha and Timilsina 2002), and in Consequential Life-Cycle Assessment (Sandén and Karlström 2007; Finnveden *et al.* 2009), whilst in everyday life this is exemplified by statements such as "the plane would have flown anyway, even if I had not bought my ticket". Additionality and future consequences of actions are difficult to assess, partly because the reality in which these actions take place is overwhelmingly complex, and partly because statements about hypothetical future events are fraught with uncertainty in any case. For the purpose of this article, we take an *ex-post* perspective, in which actions have occurred, so that the problem of evaluating alternative scenarios does not come up.

A practical example for the downstream scope-3 case is the sales chain 'Technical services > Coal mining > Electricity generation'. The emissions associated with this sales chain are caused by combustion in power plant boilers, of coal that was mined in a coal mine, which in turn was provided with technical services. If we look upstream we are used to saying for example that emissions from the coal seams of the mine are embodied in the electricity we use, even though there may be a considerably long supply chain between the coal seam and our power point. The logic of downstream responsibility is as follows: By choosing to sell to a coal mine that sells in turn to power plants, the technical service provider directly enables the mine to produce coal, and hence indirectly enables the power plant to buy coal, and hence to produce, and hence to emit. The more the technical service provider sells to the coal mine, the more it is responsible for the downstream emissions liability caused by coal mining through selling to power plants.

[31] http://www.poets.org/viewmedia.php/prmMID/15717.

In the literature, downstream responsibility is much less often elaborated, and hence this logic sounds less familiar. The crucial aspect here is the choice of selling to someone, that is, to enable someone to produce, to emit, and to sell onwards, by selling them an operating input. Downstream responsibility is perhaps more intuitive when considering the popular example of the responsibility of someone working (i.e. selling their labour) to a company that produces cigarettes, that in turn cause lung cancer in customers further downstream. In principle, this downstream responsibility also exists for someone working for an advertising services provider that produces ads for the cigarette company, or – to draw a long bow – for someone working for a logging company that produces timber that is made into pulp and then into paper that in turn is used by an advertising service provider that produces ads for the cigarette company. Of course, the latter sales chain is very complex and would enable the cigarette company to produce only to a very small extent.[32]

Downstream responsibility is often associated with the emissions from the use phase of a product. For example, a truck manufacturer is responsible for emissions caused by a freight company that uses their trucks presumably because the truck manufacturer controls to a certain degree how fuel-efficient their trucks are. Here we argue that downstream responsibility must be seen in a wider context. Let us revert to the aspect of enabling someone to produce and emit by selling to them. The truck manufacturer alone cannot enable the freight company to emit; they have to buy petrol as well. And in a sense, the product-use emissions are even more directly due to the choice of the refinery to produce and sell their petrol so it can be combusted. The truck – albeit necessary – is the mere device for this very combustion. In the same sense, an accounting services provider selling to our freight company enables it to emit, because our company would not be allowed to operate without proper accounts. So, downstream responsibility includes, but is not restricted to, the selling of products that directly cause emissions during their use.

	Upstream	Downstream	
Emissions are caused by our	suppliers,	customers,	
because we	buy from our suppliers,	sell to our customers,	
which enables	our suppliers	our customers	to operate.
We are responsible for the emissions that we	enable by our purchases.	enable by our sales.	
We are responsible for emissions	embodied in our purchases.	enabled by our sales.	
The more we	buy from our suppliers,	sell to our customers,	the more we are responsible for their emissions.
Our responsibility is calculated from	the fraction of our purchases in the output of our suppliers, and our suppliers' emissions.	the fraction of our sales in the input of our customers, and our customers' emissions.	
Ultimate	upstream	downstream	responsibility
rests with	buyers of final outputs (eg households)	sellers of primary inputs (eg workers and investors)	

Tab. 1: Matching vocabulary for upstream and downstream responsibility. From Lenzen M and Murray J, Conceptualising environmental responsibility, *Ecological Economics*, **70**(2), 261-270, 2010

[32] Diminishing responsibility with increasing distance of buyers and sellers from emitters is an inherent feature in input-output theory of environmental responsibility (Gallego and Lenzen 2005).

Weak and strong sustainability

"Weak and strong sustainability are two concurrent concepts that are very frequently used to classify empirical approaches to durable development (e.g. Dietz and Neumayer, 2004).

The term of *weak sustainability* has been coined to characterize economic approaches to sustainability that emerged during the 1970s. These approaches were extensions of standard neo-classical growth theories. Standard growth models generally consider that output is only determined by technology and the available quantities of two production factors, labor and capital. The main innovation of this literature has been to introduce natural resources as an additional production factor in these models, and to specify the laws for the evolution of this natural factor, for instance a modeling of extraction behavior in the case of an exhaustible mineral resource - this literature developed after the first oil shock.

These models generally assumed large substitution possibilities between natural resources, capital and labor. Combined with exogenous technical progress, this offered one solution to the finiteness of resources, at least from a theoretical point of view: as oil resources decline, production is expected to use less and less of them but without any decline in standard of living, either thanks to pure technological progress, or by replacing oil by some alternative fossil energy or any other man-made production factor.

Promoters of *strong sustainability* rather consider that substitution possibilities necessarily face physical limits. Critical levels must be maintained for most of natural resources. These critical levels must be at least equal to those necessary for basic-life support functions, and more probably higher if we want to keep reasonable levels of environmental *resilience*, i.e. the capacity of eco-systems to regenerate and return to equilibrium after shocks. The concept of strong sustainability is often considered as irreducible to monetary approaches. All environmental variables of interest have to be followed in physical terms."

p. 236. Report by the Commission on the Measurement of Economic Performance and Social Progress. J. Stiglitz, A. Sen, & J-P Fitoussi *September, 14, 2009* http://www.stiglitz-sen-fitoussi.fr/en/index.htm

See also: Ayres, R.U., van den Bergh, J.C.J.M., & Gowdy, J.M. (1998). Viewpoint: Weak versus Strong Sustainability. Tinbergen Institute in its series Tinbergen Institute Discussion Papers with number 98 103/3 http://ideas.repec.org/p/dgr/uvatin/19980103.html