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.

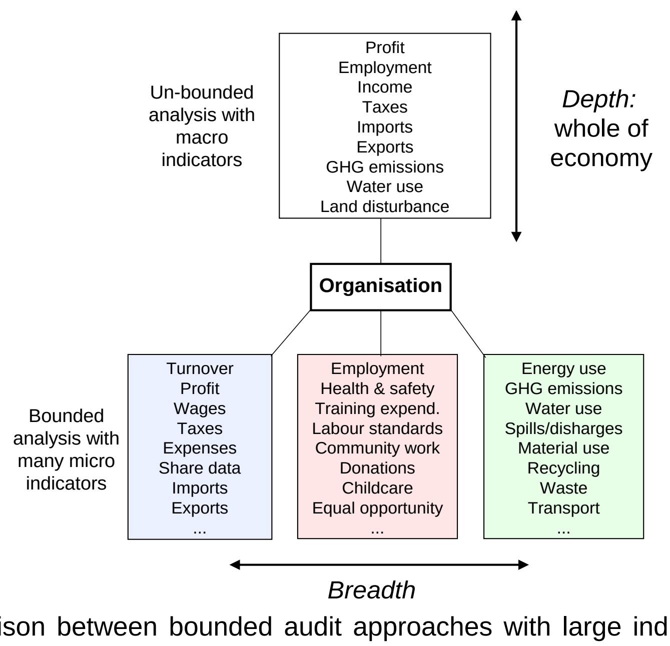

Figure: A simple comparison between bounded audit approaches with large indicator *breadth*, compared with input-output approaches with *depth* from macro indicators extending through the full supply chain (economy). Some indicators in these sets (illustrative only here) are common to both approaches.

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.

References

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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 1c paper	x 25c wood	x 10c machine	x 20c steel	x 40c iron ore	=
	$ insurance	**$ paper**	**$ wood**	**1$ machine**	**$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 0.5 pudding	x 0.5 milk	=
	person	**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

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[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,

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[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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Saunders, C., Barber, A. and Taylor, G. (2006), *Food Miles – Comparative Energy/Emissions Performance of New Zealand's Agriculture Industry*. AERU Research Report No. 285,Lincoln University, Canterbury, NZ, July 2006.

[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.

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