



Intensities

This information sheet traces the meaning of the word *intensity* from its everyday meaning to its scientific meanings and its current use in such phrases as *carbon intensity*.

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 location¹;
- intensity of an earthquake is the strength of shaking produced at a particular location²;
- colour intensity refers to the relative purity or saturation of a colour on a scale from vivid (high intensity) to dull (low intensity)³.

Recently the term *carbon intensity* has emerged in popular usage. *Carbon intensity* commonly describes the quantity of carbon emissions⁴ 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 consumed⁵" – 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 activity⁶ – 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 CO₂-e per dollar of electricity supplied. This figure is arrived at by taking the total CO₂-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 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.

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

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

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

4 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)

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

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



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 machines⁷. 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.

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 (see Information Sheets 1-3 for details). 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) and the Commonwealth Government's online household and small business calculators (<http://cc-calc.greenhouse.gov.au/Content/Home.aspx>).

⁷ For a full explanation of how this figure is calculated see information sheet 13 *Double Counting*