Life cycle analysis and assessment

The concept of conducting a detailed examination of the life cycle of a product or a process is a relatively recent one which emerged in response to increased environmental awareness on the part of the general public, industry and governments.

The immediate precursors of life cycle analysis and assessment (LCAs) were the global modeling studies and energy audits of the late 1960s and early 1970s. These attempted to assess the resource cost and environmental implications of different patterns of human behavior.

LCAs were an obvious extension, and became vital to support the development of eco-labeling schemes which are operating or planned in a number of countries around the world. In order for eco-labels to be granted to chosen products, the awarding authority needs to be able to evaluate the manufacturing processes involved, the energy consumption in manufacture and use, and the amount and type of waste generated.

To accurately assess the burdens placed on the environment by the manufacture of an item, the following of a procedure or the use of a certain process, two main stages are involved. The first stage is the collection of data, and the second is the interpretation of that data.

A number of different terms have been coined to describe the processes. One of the first terms used was Life Cycle Analysis, but more recently two terms have come to largely replace that one: Life Cycle Inventory (LCI) and Life Cycle Assessment (LCA). These better reflect the different stages of the process. Other terms such as Cradle to Grave Analysis, Eco-balancing, and Material Flow Analysis are also used.

Whichever name is used to describe it, LCA is a potentially powerful tool which can assist regulators to formulate environmental legislation, help manufacturers analyze their processes and improve their products, and perhaps enable consumers to make more informed choices. Like most tools, it must be correctly used, however. A tendency for LCAs to be used to 'prove' the superiority of one product over another has brought the concept into disrepute in some areas.

What is a Life Cycle Analysis?

Taking as an example the case of a manufactured product, an LCA involves making detailed measurements during the manufacture of the product, from the mining of the raw materials used in its production and distribution, through to its use, possible re-use or recycling, and its eventual disposal.

LCAs enable a manufacturer to quantify how much energy and raw materials are used, and how much solid, liquid and gaseous waste is generated, at each stage of the product's life.

Such a study would normally ignore second generation impacts, such as the energy required to fire the bricks used to build the kilns used to manufacture the raw material.

However, deciding which is the 'cradle' and which the 'grave' for such studies has been one of the points of contention in the relatively new science of LCAs, and in order for LCAs to have value there must be standardization of methodologies, and consensus as to where to set the limits. Much of the focus worldwide to date has been on agreeing the methods and boundaries to be used when making such analyses, and it seems that agreement may have now been reached.

While carrying out an LCA is a lengthy and very detailed exercise, the data collection stage is - in theory at least - relatively uncomplicated, provided the boundary of the study has been clearly defined, the methodology is rigorously applied, and reliable, high-quality data is available. Those of course are fairly large provisos.

Interpretation

While such a record is helpful and informative, on its own it is not sufficient. Having first compiled the detailed inventory, the next stage should be to evaluate the findings.

This second stage - life cycle assessment - is more difficult, since it requires interpretation of the data, and value judgments to be made.

A Life Cycle Inventory will reveal - for example - how many kilos of pulp, how much electricity, and how many gallons of water, are involved in producing a quantity of paper. Only by then assessing those statistics can a conclusion be reached about the product's environmental impact overall. This includes the necessity to make judgments based on the assembled figures, in order to assess the likely significance of the various impacts.

Problems

It is here that many of the problems begin. Decisions, without scientific basis, such as whether three tones of emitted sulphur is more or less harmful than the emission of just a few pounds of a more toxic pollutant, are necessarily subjective.

* How can one compare heavy energy demand with heavy water use: which imposes greater environmental burden?
* How should the use of non-renewable mineral resources like oil or gas (the ingredients of plastics) be compared with the production of softwoods for paper?
* How should the combined impacts of the land filling of wastes (air and groundwater pollution, transport impacts etc) be compared with those produced by the burning of wastes for energy production (predominantly emissions to air)?

Some studies attempt to aggregate the various impacts into clearly defined categories, for example, the possible impact on the ozone layer, or the contribution to acid rain.

Others go still further and try to add the aggregated figures to arrive at a single 'score' for the product or process being evaluated. It is doubtful whether such simplification will be of general benefit.

Reliable methods for aggregating figures generated by LCA, and using them to compare the life cycle impacts of different products, do not yet exist. However, a great deal of work is currently being conducted on this aspect of LCAs to arrive at a standardized method of interpreting the collected data.

Contradictions

Many LCAs have reached different and sometimes contradictory conclusions about similar products.

Comparisons are rarely easy because of the different assumptions that are used, for example in the case of food packaging, about the size and form of container, the production and distribution system used, and the forms and type of energy assumed.

To compare two items which are identically sized, identically distributed, and recycled at the same rate is relatively simple, but even that requires assumptions to be made. For example, whether deliveries were made in a 9-tonne truck, or a larger one, whether it used diesel or petrol, and ran on congested city centre roads where fuel efficiencies are lower, or on country roads or motorways where fuel efficiencies might be better.

Comparisons of products which are dissimilar in most respects can only be made by making even more judgments and assumptions.

Preserving the confidentiality of commercially-sensitive raw data without reducing the credibility of LCAs is also a major problem. Another is the understandable reluctance of companies to publish information which may indicate that their own product is somehow inferior to that of a competitor. It is not surprising that many of the studies which are published, and not simply used internally, endorse the views of their sponsors.

Recycling

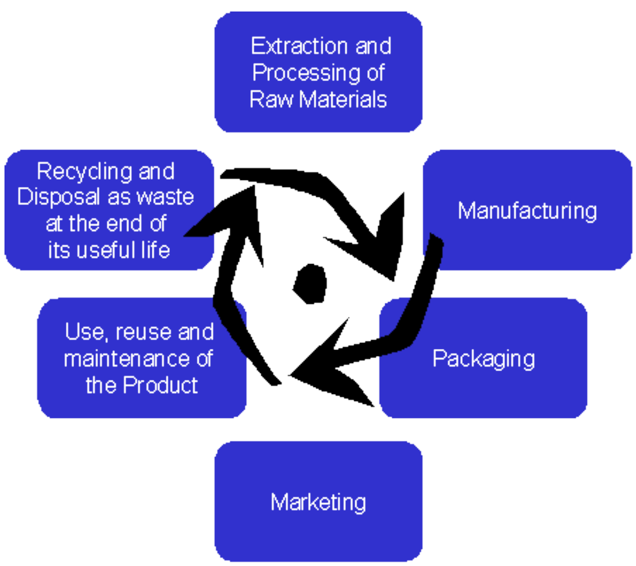
Recycling introduces a further real difficulty into the calculations. In the case of materials like steel and aluminum which can technically be recycled an indefinite number of times (with some melt losses), there is no longer a 'grave'. And in the case of paper, which can theoretically be reprocessed four or five times before fibres are too short to have viable strength, should calculations assume that it will be recycled four times, or not? What return rates, for example, should be assumed for factory-refillable containers?

For both refillable containers and materials sent for recycling, the transport distance in each specific case is a major influence in the environmental impacts associated with the process.

An LCA which concludes that recycling of low-value renewable materials in one city is environmentally preferable may not hold good for a different, more remote city where reprocessing facilities incur large transport impacts.

LCA in waste management

LCA has begun to be used to evaluate a city or region's future waste management options. The LCA, or environmental assessment, covers the environmental and resource impacts of alternative disposal processes, as well as those other processes which are affected by disposal strategies such as different types of collection schemes for recyclables, changed transport patterns and so on.



The complexity of the task, and the number of assumptions which must be made, is shown by the simplified diagram (above) showing some of the different routes which waste might take, and some of the environmental impacts incurred along the way. Those shown are far from exhaustive.

Why perform LCAs?

LCAs might be conducted by an industry sector to enable it to identify areas where improvements can be made, in environmental terms. Alternatively the LCA may be intended to provide environmental data for the public or for government. In recent years, a number of major companies have cited LCAs in their marketing and advertising, to support claims that their products are 'environmentally friendly' or even 'environmentally superior' to those of their rivals. Many of these claims have been successfully challenged by environmental groups.

All products have some impact on the environment. Since some products use more resources, cause more pollution or generate more waste than others, the aim is to identify those which are most harmful.

Even for those products whose environmental burdens are relatively low, the LCA should help to identify those stages in production processes and in use which cause or have the potential to cause pollution, and those which have a heavy material or energy demand.

Breaking down the manufacturing process into such fine detail can also be an aid to identifying the use of scarce resources, showing where a more sustainable product could be substituted.

Inconclusive

In most situations it is impossible to prove conclusively using LCAs that any one product or any one process is better in general terms than any other, since many parameters cannot be simplified to the degree necessary to reach such a conclusion.

It seems likely that, in the case of manufactured goods, the most important time for LCA information to be taken into consideration is at the design stage of new products. Where LCA is used to evaluate procedures rather than products, the information can help ensure appropriate choices are made.

Tool

Life Cycle Analysis must be used cautiously, and in the interpretation of the inventory, care must be taken with subjective judgments.

When first conceived, it was predicted that LCA would enable definitive judgments to be made. That misplaced belief has now been discredited. In combination with the trend towards more open disclosure of environmental information by companies, and the desire by consumers to be guided towards the least harmful purchases, the LCA is a vital tool.

Source: World Resource Foundation

Directions:

Using a car as your product, develop an LCA on it. Make a list of items found in a car and what these items are made up of. Include cradle to grave or cradle to cradle on the items listed.