Life Cycle Analysis & Assessment

Information Sheet

The technique known as life cycle assessment grew from the work of practitioners in the US. The precursors were the global modelling studies and energy audits of the late 1960s. These sought to assess resource costs and environmental implications of different human behaviour patterns. By the mid-1990s, the discipline had become widespread, especially in the fields of plastics, detergents, personal products and automobiles.

What is Life Cycle Analysis?

An LCA requires detailed measurements relating to product manufacture, from the mining of raw materials used in production and distribution, through use, possible re-use or recycling and eventual disposal. To assess the environmental burdens, two stages are involved. The first is the collection of data, and the second is the interpretation of those data.

A number of different terms have been coined to describe the process. One of the first used was life cycle analysis, but more recently life cycle inventory (LCI) and life cycle assessment (LCA) have gained a wider use - these better reflect the different stages of the process.

LCAs show how much energy and raw materials are used, and how much waste is generated, during each stage of a product's life. These studies would normally ignore second generation impacts, such as the energy required to fire the bricks used to build the kilns which produce the raw material. Although an LCA is a lengthy, detailed exercise, the data collection is (in theory at least) relatively uncomplicated, provided boundaries are clearly defined, the methodology rigorously applied, and reliable data is used. These are, of course, fairly large provisos.

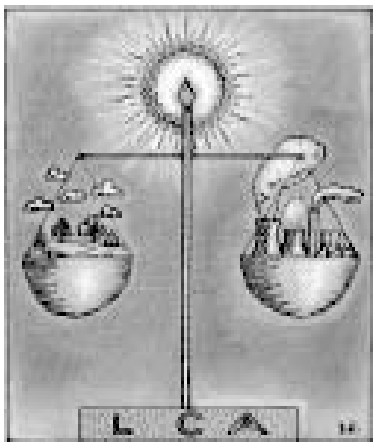
Deciding which is the cradle and which the grave for such studies is difficult. If LCAs are to be useful, there must be standardisation of methodologies.

Much effort has been spent on agreeing methods and boundaries, and it seems that agreements may have now been reached. LCA methodologies have largely been standardised. The agreed form has been set out by the International Standards Organisation (ISO) as a series of four documents (see Box 1, overleaf).

Drivers

End-of-life waste management regulations and market competition have been the main drivers of LCA in Europe and America.

Much industrial interest in the subject has been motivated by public and regulatory pressure to act on the issue of waste packaging in municipal solid waste (MSW), and by the development of ecolabelling schemes for specific product groups.



Germany and Denmark have used LCA to resist challenges that their national waste packaging requirements violate European free trade rules. Refillable glass and plastic bottles appeared environmentally superior to recyclable glass bottles, aluminium and steel cans, according to an LCA published by the Danish Environment Protection Agency. A number of studies were undertaken for the German Federal Environmental Agency, comparing waste management options for a range of materials, including:

- *scrap tyres*
- *used refrigerators*
- *waste paper*

Regulatory agencies have turned to LCAs. The Environment Agency for England and Wales developed Wisard, a tool for waste management planning. The Agency's programme helps those concerned with waste management policy, mainly to compare alternative waste strategies and analyse particular strategies.

Manufacturers have sought to influence regulations in the market using LCA-based claims. These claims have also been used in cross-sectoral competition between substitute products (eg steel and aluminium or paper and plastics).

An LCA study claimed to show that re-treading is a better option for old truck tyres in Denmark than pyrolysis or as a fuel in cement plants. Another study in Germany found that energy recovery from waste plastics can compare favourably with feedstock recycling. In 1994, the Fraunhofer Institute in Germany was commis sioned

Information Sheet

INTERNATIONAL METHODOLOGY STANDARDS FOR LCA

ISO14040: lifecycle assessment principles and framework . The goal and scope should state the intended application, the reason for the study, the intended audience and the function of the system being studied.

ISO14041: lifecycle inventory assessment . The inventory data for all inputs and outputs are collected. The system is investigated from cradle to grave taking into account all environmental aspects from raw material acquisition through production, use and disposal.

ISO14042: lifecycle impact assessment . The above data are used in the impact assessment which investigates potential environmental impacts. The methodology for this stage is still being developed.

ISO14043: lifecycle interpretation assessment . The interpretation phase draws conclusions from the results of the inventory and the impact assessment.

to prepare LCA studies for 32 different floor-covering systems. The study also examined opportunities for environmental improvements relating to floor-coverings. Experts investigated 500 processes and concluded that:

- *end users should select a longer lasting product*
- *manufacturers should consider all opportunities for improvement (new formulations, latest technologies and use of recycled materials)*
- *the retail trade, waste managers and manufacturers should recover materials or energy from used floor-coverings*

An LCA carried out for the city of Vienna concluded that reusable glass is a slightly better packaging material than PET plastic. Disposable glass bottles were significantly poorer.

Limitations

Most of the difficulties surrounding LCA are concerned with the acquisition of accurate data. In addition, LCA does not include economic or social aspects.

LCA has a limited ability to measure local impacts such as toxicity. Another obstacle is the fact that the results are usually disputable.

Decisions without scientific basis, such as whether three tonnes of emitted sulphur are more or less harmful than the emission of just a few pounds of a more toxic pollutant, are inevitably subjective.

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 try to combine the aggregated figures into a single score for the product or process being evaluated. It is doubtful whether such simplification is of general benefit.

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

Comparisons are rarely easy because of the different underlying assumptions. For example, in the case of packaging, the size and form of container, the production and distribution systems used, and energy consumed, all have a bearing on the overall impact. 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 small truck, or a large one, whether it used diesel or petrol, and ran on congested city centre roads or motorways.

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

Preserving the confidentiality of commercially-sensitive raw data without reducing the credibility of LCAs is also a 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.

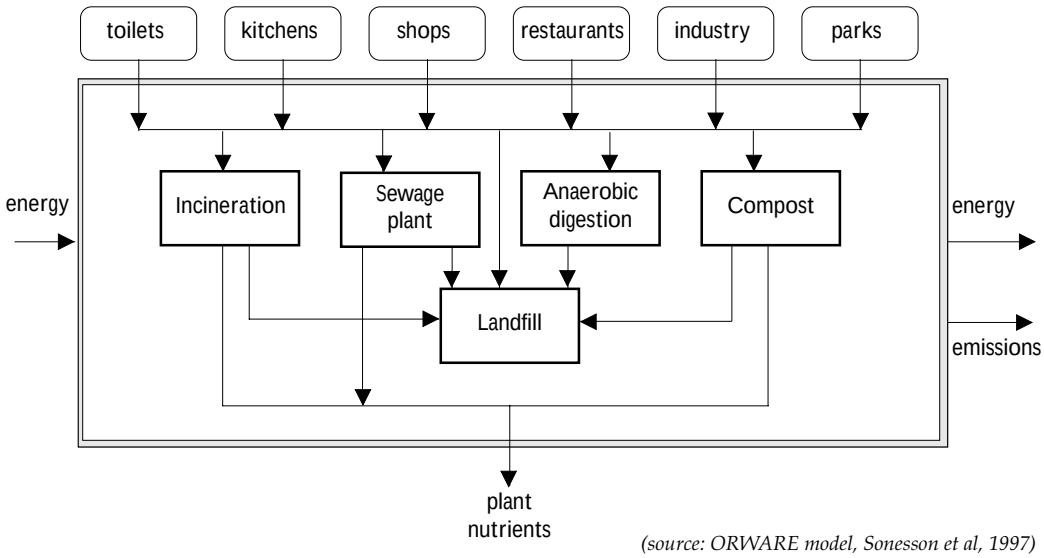
LCA can only aid, not make, decisions on the preferred environmental options for products or systems under consideration. It should be used in conjunction with other environmental management mechanisms such as risk assessment to make decisions affecting the environment.

Advantages

LCA gives a unique insight into the environmental effects of waste management strategies. It allows overall process systems to be evaluated rather than the single sites.

LCA can help reduce the likelihood of environmental burdens merely being shifted

Figure 1. Conceptual model of LCA for organic waste handling systems



(source: ORWARE model, Sonesson et al, 1997)

up or down the process chain. LCA can assist in comparing the environmental impacts of waste treatment systems. It also helps define optimisation potentials in identifying pollutants with the strongest potential impact. LCA is particularly good at detailing widespread issues, eg global warming.

Recycling

Recycling introduces a further difficulty into the calculations. In the case of materials like steel and aluminium which can be recycled more or less indefinitely, there is no longer a 'grave'.

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 associated environmental impacts.

An LCA which concludes that recycling 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

Many groups use LCA tools in helping make waste management decisions. Regional and local waste planners and consultants have used LCA tools to help them plan waste management strategies for regions including Gloucestershire and Hampshire in the UK, Barcelona and Pamplona in Spain and London, Ontario in Canada.

Two separate studies for the European Commission used an LCA approach to compare waste management options in order to produce a new (and controversial) hierarchy of preferred options.

LCA can address the environmental and resource impacts of alternative disposal processes, as well as other processes which are affected by waste strategies (eg different collection regimes for recyclables and altered transport patterns).

Why perform LCA?

LCAs might be conducted by an industry sector to help identify areas where environmental improvements can be made. Alternatively, the LCA may provide environmental data for the public or for government. 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 might 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

Information Sheet

the use of scarce resources, showing where a more sustainable product could be substituted.

Design

Most of a product's lifecycle impact on the environment is determined during the design stage. Design-for-environment (DfE) aims to address the environmental impacts of a product without compromising function, quality, cost and other considerations. LCA can form a useful part of such a system.

Barriers to the use of LCA

LCA studies are expensive and time-consuming. A large study conducted by a third-party consultant can take more than a year and cost up to one million Euros. LCA-based claims about the relative environmental performance of a product typically elicit counter-claims from competitors, and non-expert audiences are unable to make a judgement.

Companies undertaking LCAs need data on activities outside their own enterprise. Data now exist for major classes of materials (eg plastics, steel, aluminium and paper), industrial transport systems and for energy production and use. However, statistics are scarce for final products or industrial processes.

Future trends

It was once predicted that LCA would enable definitive judgements to be made, but is now used rather as one in a range of tools to assist in decision-making.

Once seen as unnecessarily complex, it is now accepted that LCA tools need to be easy to use, flexible, credible, easy to understand and communicate clearly to others. A 1997 survey of more than 400 companies in Germany revealed that almost half predicted LCA would play a bigger role in their future development of products and systems.

Another survey showed around 40 per cent of top UK companies were involved in some form of LCA activity.

Major European vehicle manufacturers agreed that LCA would play an increasing role in environmental optimisation of products and components; screening of new vehicle concepts; assessment of new process technologies; procurement standards for suppliers, and in providing environmental information to customers and the market.

Leading producers of personal products are using LCA on an increasingly routine basis. In the European electronics industry the use of LCA is seen to have the greatest potential as a research tool, and when incorporated into a company's design process. North American firms are interested in LCA, and there is evidence of growing interest in Asia.

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 very helpful tool. It must be used cautiously, and extreme care must be taken when making subjective judgements during the interpretation of results.

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