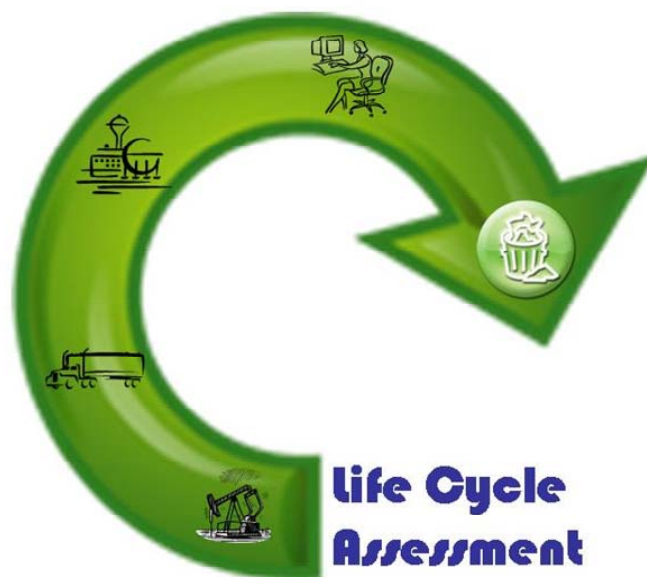


A Short Guide to Life Cycle Assessment



Scottish Environment Protection Agency

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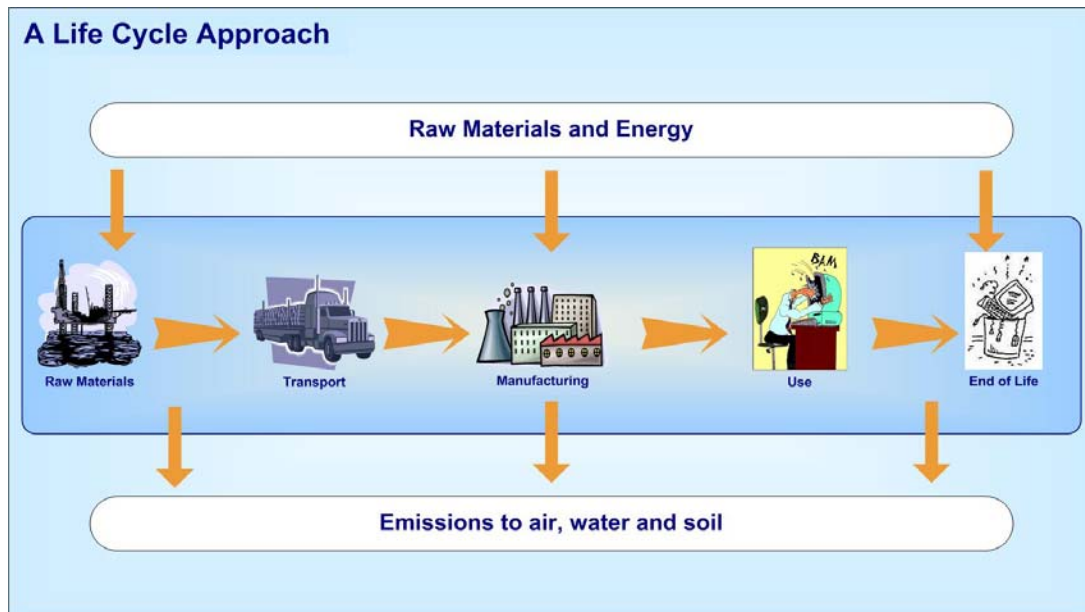
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1. Introduction

1.1. Life Cycle Assessment

Life cycle assessment (LCA) is a methodology for assessing the potential environmental impacts of a product or service across its entire life cycle, or cradle to grave, Figure 1.

Figure 1.



An LCA looks at the movement of materials and energy through the system from the time you extract the raw materials from the environment, through the manufacture, use, and final disposal. Following the mass and energy flows, this should tell you what burdens the product or service place on the environment. Only those impacts which cannot be readily quantified, such as biodiversity, or odour, cannot be assessed using LCA.

While LCA has been more commonly applied to products, it also a very powerful tool for assessing the environmental impacts of services. It is in the field of waste management that SEPA have used LCA.

LCA is a technique to assess the environmental aspects and potential impacts associated with a product, process, or service, by:

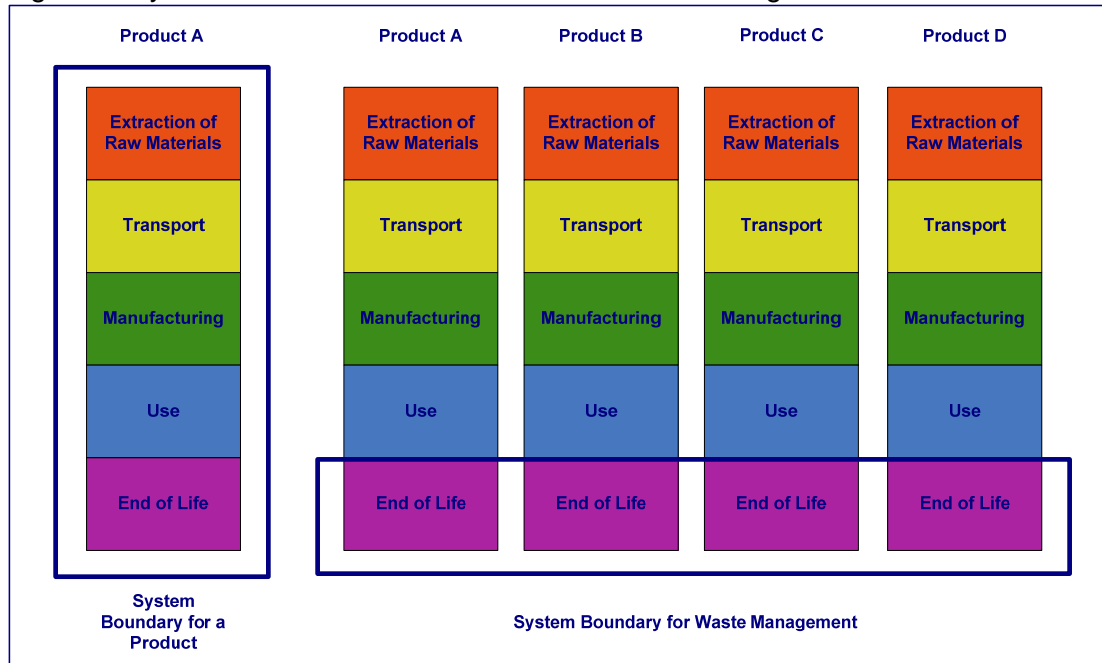
1. compiling an inventory of relevant energy and material inputs and outputs;
2. evaluating the potential environmental impacts associated with identified inputs and releases;
3. interpreting the results to help you make a more informed decision.

US EPA

An LCA of waste management systems varies from a product LCA in that the cradle-to-grave approach is applied to the waste management infrastructure. It is does not

include the life cycle of the products that are now being treated as waste; they are only included in the system once they become waste. The difference in the system boundaries for LCA for products and LCA for waste management is shown in Figure 2.

Figure 2. System Boundaries for Product and Waste Management LCA's



2. WRATE

The software SEPA uses to undertake the LCA of waste management options is called WRATE (Waste and Resource Assessment Tool for the Environment). WRATE was developed for the Environment Agency to replace the tool used to assess the Area Waste Plans when they were first developed, WISARD. While WISARD was at the time the best tool of its type available, upgrading it to take in up to date data and new technologies was not feasible.

WRATE is an immensely powerful tool which has new databases for all waste management process, and includes many new waste management technologies. It will also be routinely updated as new data becomes available.

3. Results

It must be made clear that that LCA is a tool to assist the decision, not make it, and it is unlikely that it will provide a clear result as to which option is the best on environmental grounds. This is because of the range of environmental impacts it takes into account and, in most cases, the options will be better for some impacts

and worse for others. It is therefore a matter of prioritising the impacts according to the local and national situation.

The initial output from any LCA is the inventory. This produces a large data which is simply the compilation and quantification of inputs and outputs, for a given product or service throughout its life cycle.

One point to remember when looking at the results is that, the lower, or more negative the number, the better in environmental terms the result.

3.1. Impact Assessment

To make this data more useable impact assessment models are applied which convert the data into environmental indicators, e.g. climate change emissions, or human toxicity. WRATE is capable of applying a wide range of environmental impacts models. In order to keep the assessment as simple as is reasonably possible it has been decided to assess six headline indicators which are stated below:

- **Climate Change Emissions**
- **Non-Renewable Resource Depletion (reported in WRATE as Abiotic Resource depletion)**
- **Eutrophication**
- **Acidification**
- **Human Toxicity**
- **Aquatic Ecotoxicity**

If considered necessary due to local circumstances, or where requested, other assessments will be carried out.

a) Climate Change Emissions

Climate change emissions are reported as carbon dioxide (CO₂) equivalents. This means that the quantity of each emission that will contribute to global warming is converted to the equivalent quantity of CO₂ according to its global warming potential.

For example: Methane (CH₄) has approximately 20 times the global warming potential of CO₂. So if 50 tonnes of CH₄ are emitted the CO₂ equivalent is calculated as:

$$50 \times 20 = 1000 \text{ tonnes CO}_2 \text{ equiv.}$$

b) Non-Renewable Resource Depletion

This impact category indicator is related to extraction of scarce minerals and fossil fuels. The Abiotic Depletion Factor (ADF) is determined for each extraction of minerals and fossil fuels based on the remaining reserves and rate of extraction. It is based on using the equation, $\text{Production} / (\text{Ultimate Reserve})^2$ and comparing this to the result for Antimony (Sb), which is used as the reference case. The reference unit for abiotic depletion is therefore kg Sb equivalent.

c) Eutrophication

While eutrophication is a natural process, in relation to human impacts on the environment it is defined as the nutrient enrichment of waters.

Human activities have dramatically accelerated the natural process of eutrophication by releasing phosphorus compounds (such as fertilizers and detergents), nitrogen compounds (fertilizers) and organic matter (urban and industrial effluents) into the water. This causes excess growth of plant matter and the depletion of oxygen levels in the water.

It is expressed as phosphate equivalents.

d) Acidification

Emissions to air, water and land of acidifying compounds such as sulphur dioxide (SO₂) and nitrogen oxides (NO_x) can contribute to the destruction of plants and acidify the soil, which can result in changes to ecosystems.

Acidification Potential (AP) is expressed using the reference unit, kg SO₂ equivalent.

e) Human Toxicity and Aquatic Ecotoxicity

Human toxicity and aquatic ecotoxicity are expressed in kilogram (kg) equivalents of 1-4-dichlorobenzene. This is a common substance; it gives mothballs their distinctive smell, which is harmless at low concentrations. At higher concentrations it can cause giddiness, headaches and liver problems. In animals it has been shown to cause tumors at high concentrations.

Toxicity is problematical in LCA due to the relative lack of data on the impacts of many of the substances assessed. The outputs are not as accurate as other environmental impacts and should be treated with some caution.

3.2. Avoided Impacts

For a scenario, negative numbers mean that the burden of waste management system is effectively avoided. This is because an environmental benefit of equal or greater magnitude to the impact of the operation of waste management processes occurs elsewhere in the life cycle.

Where different scenarios are compared, lower (or more negative) numbers mean that the environmental burden of the system is smaller than the alternative.

Avoided Impacts

When a waste management process generates a useable output, such as recycling or energy from waste, it not only causes environmental impacts. It also saves impacts as the requirement for the production of energy or material from more conventional sources is avoided.

This is accounted for in LCA by subtracting the impacts of, for example energy from waste, from the impacts of energy generation from other sources, for example coal or gas.

Where the result is a negative figure some of the impacts of energy generation by conventional means have been avoided, hence the term avoided impacts.

Where the results are positive there is an actual impact.