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LCA applied to the Printing Industry

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EA (Environmental Audit) - a site specific tool typically used to assess an existing facility. It generally includes consideration of the communication and management of environmentally related information.

RA (Risk assessment) - this considers the risk presented by a material or facility and includes consideration of both the potential hazard and its likelihood of occurring. (Some RA is generally included in both EA and EIA)

All the mentioned methods differ from LCA in that they do not attempt to cover the whole picture. However they all include consideration of temporal aspects and tend to consider the concentrations/rates of production of any emissions.

Fig.1 The relationship between LCA & EIA

The diagram above shows the way in which LCA encompasses many sites but excludes temporal consideration whereas EIA covers a single site and includes temporal consideration.

The structure of LCA

LCA's are composed of four inter-related components:

- goal and scope definition
- inventory analysis
- impact assessment
- interpretation
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1. Introduction

In this paper I will present a simplified LCA study investigating a range of methods of improving environmental performance of a Litho press Magazine printing operation. This study has used indicative and approximated data and is designed to demonstrate the application of LCA rather than to provide information on methods of environmental improvement. The results data contained in this study should therefore not be quoted or reproduced.

2. Introduction To LCA

The definition of LCA

Life cycle assessment (LCA) is defined by the Society of Environmental Toxicology and Chemistry (SETAC)\(^1\) as 'a process to evaluate the environmental burdens associated with a product, process or activity by identifying and quantifying energy and materials used and wastes released to the environment; to assess the impact of those energy and material uses and releases to the environment; and to identify and evaluate opportunities to affect environmental improvements'.

The assessment includes the entire life cycle of the product, process or activity, encompassing extracting and processing raw materials; manufacturing, transportation and distribution; use, re-use, maintenance; recycling and final disposal. In general LCAs then aggregate the burdens of processes over all sites and over all time (i.e. both spatially and temporally). This spatial and temporal blindness places obvious restrictions on the types of impact assessment that can be attempted\(^2\).

Where does LCA Fit in among other environmental tools?

LCA is one of a number of methods used as decision support tools. These tools include :-

EIA (Environmental Impact Assessment) - a site specific tool typically used to assess the environmental impact of a planned investment/facility.
3. **Goal and scope definition**

It is important to note that an LCA is an iterative process and the subsequent stages frequently require that the scope and sometimes even some aspects of the goal be revisited.

**Goal definition**

The goal is the purpose or intended application of the study. Defining clearly the goal of the study at the outset is very important as it will determine decisions made in setting scenarios, the scope and all subsequent stages of the study.

*Within this study the goal is to perform a screening LCA to discover where in the present scenario the greatest environmental impacts are taking place. Other scenarios will then be modelled to suggest areas where changes would yield significant environmental improvement. The results of the study will be used as one of the inputs into a decision to be made by the board on investment to improve the environmental performance in line with the companies environmental policy.*

**Scoping**

Defining the scope of the study involves identifying the following:

- the scenarios (options) to be studied
- the environmental problem areas to be considered
the functional unit or unit of comparison to be used
the system and system boundaries to be applied and
data quality considerations.

Scenarios to be studied
The scenarios chosen for the study should be consistent and capable of
addressing the stated goal of the study.

In this case the base scenario will be the present situation, with the litho
print press operating under current conditions. Other scenarios include
the installation of a new print press with reduced energy and material
wastage
a new IT network distribution system which is expected to reduce returns
from 30 to 25% (encourages greater newsagent subscriptions)
participation in supermarket recycling schemes designed to increase the
consumer recycling rate by 10%

Environmental problem areas
It is important to decide early in the study which problem areas are of
interest. This will define the data to be collected.

For this study global and regional problems will be considered. Factors
such as workplace safety will be considered elsewhere.

Functional unit
This is the point of reference for the study and the unit of comparison. All
inputs and outputs into the individual processes within the system are
normalised to the functional unit. The functional unit must be clearly defined
and measurable. In comparative studies, it is essential that the systems are
compared on the basis of equivalent function.

The functional unit in this study will be a number of magazines delivered to
the consumer. This excludes from the functional unit any magazines
returned by the retailer.

System boundaries
Defining the system boundary addresses what is to be included and
excluded from the system defined in the study. Decisions regarding the
burdens to be evaluated and data to be collected should be included within
the system boundary definition. The first stage in system boundary
definition is usually definition of a system flow diagram as shown in Fig 3
below.
Data quality considerations

There are various issues which need to be addressed under the heading of data quality. These include issues such as the age of the data, the geographic area (local, regional, global etc.), technology used e.g. current, old, variability, representativeness and reproducibility. The types of data collected include material and energy inputs and outputs to air, water and land. The level of detail required will depend on the goal of the study.

The validity and credibility of the results of any LCA study are dependent on the availability and quality of the data.

*Due to restraints of time and money this study will use readily available data.*

4. **Inventory analysis**

The inventory analysis component of an LCA quantifies the environmental burdens associated with a product, process or activity. The goal and scope defined for the study provide the framework around which the inventory analysis is conducted.

The production of the inventory table itself requires that several issues be considered. These include issues such as allocation and validation of data. It is important to note that once the data collection exercise gets under way, it may become apparent that the available data does not correspond to the...
goal outlined at the beginning of the study. The goal and or scope may therefore have to be refined in light of the available data.

**Inventory tables**

The final inventory tables produced illustrate all of the quantified inputs and outputs associated with each stage or process within each system or scenario. The quantity of material flowing through each unit process is determined by the functional unit. The results for the total raw material, energy requirements and environmental emissions for the entire life cycle system are calculated by the summation of the results of the relevant unit processes.

**Burdens or interventions recorded**

Early LCIs had a tendency to aggregate related emissions into groups like VOCs (volatile organic compounds) or TDS (total dissolved solids). With the development of impact assessment methods however it became clear that this form of aggregation imposed significant inaccuracies and uncertainties on the results of an LCA. As a result more recent data collection exercises and inventory studies have presented data in much more detail often with as many as 360 separate interventions recorded. An example of this more complex burden listing is given in Appendix 1. This increase in complexity has placed significant requirements on the software used for inventory analysis and often reduced the apparent transparency of the inventory. It is however a natural and necessary development.

**General allocation**

Allocation is the process of assigning burdens between products or functions. Frequently in compilation of the inventory, it will be discovered that more than one useful output/product is produced from individual processes and that these additional 'functions' are not required by the system. The key allocation issues surround the allocation of burden between the primary function (the one required by the system) and any supplementary functions. This has to be done in a comparative LCA in order to provide a fair comparison between the full systems compared.

As is defined in the Draft ISO Guidelines, April 1996\(^6\), wherever possible, allocation should be avoided or minimised. This may be achieved by considering the process in more detail. It may then be possible to split out the parts of the process that are connected to the other function. For systems where splitting is not possible then it is suggested that allocation be avoided by expanding the system boundaries in order that the additional inputs or outputs remain within the system boundary.
Where allocation cannot be avoided, it is suggested that the system inputs and outputs should be partitioned between its different functions in such way that the underlying physical relationships between them are reflected.

The third recommendation suggested in the ISO Guidelines is that where physical relationships cannot be established or used as a basis for allocation, the inputs should be allocated between the products and functions in such a way that the economic relationships between them are reflected.

Validation

Where there is uncertainty regarding data values or where there are data gaps, sensitivity analysis can be used to determine the significance of decisions made. Any data omissions should however be clearly stated and justified.

5. Impact assessment

The impact assessment component seeks to relate the environmental burdens quantified in the inventory analysis to measures of environmental concerns.

The methodology for impact assessment is currently under development and several approaches are available. Probably the most widely accepted approach is the multi-step problem oriented method. This method, as defined by SETAC\textsuperscript{11}, consists of three steps - classification, characterisation and valuation.

Classification groups the data listed in the inventory into a number of relevant impact categories such as global warming and acidification.

Characterisation assesses the relative contribution of the individual environmental burdens to each impact category.

Valuation is a much more subjective stage where the contributions of the different impact categories are weighted against each other. The relative importance of the impact categories to each other will reflect political and social issues and preferences. One technique does this by calculating the external costs which will be incurred by society as a result of the pollution incurred.
6. **Results & Conclusions**

Using the EPS Valuation method usage of paper was found to be the most significant step in the system (see Fig 4). The landfailing step and usage of energy in recycling were also found to be important areas.

Fig 4 Valuation graph showing the relative environmental significance of the stages within the life cycle. (Using the EPS Valuation method*)

*Please note that different valuation method may give slightly different results.

When the inventories of the four scenarios were compared (see fig 5 and 6) although it was clear that all three scenarios represented an improvement over the initial base case, it was difficult to rank the improvement options.
Fig 5. Inventory Results - Summary of inputs in kg/functional unit

Fig 6. Inventory Results - Summary of outputs in kg/functional unit

Where:
- Scenario 0 - Base case
- Scenario 1 - Base case + inclusion of new Litho print press
- Scenario 2 - Base case + improved distribution
- Scenario 3 - Base case + improved post-consumer recycling rate
Impact assessment clarifies the position slightly scenario 2 (new distribution system) being marginally better than scenario 1 (print press replacement). Scenario 3 scored better than the base case in all categories but against the scenario 2 it was worse in four impact categories and better in two - its relative position was therefore dependent on the weighting given to the different impact areas.

Fig 7 Impact assessment comparison of scenarios

References


2. Anon DIS ISO 14040
