International Journal for Research in Engineering Application & Management (IJREAM)
ISSN : 2454-9150 Vol-04, Issue-09, Dec 2018

A bird's eye view of Life Cycle assessment – An effective tool to evaluate environmental effects of a process or a product throughout its life cycle.

Chandraprakash G. Bhagchandani, PhD Scholar, Gujarat Technological University, Ahmedabad, India. cgbhagchandani@gmail.com

Dr. S. A. Puranik, PhD Supervisor, Gujarat Technological University, Ahmedabad, India, Emeritus Fellow & Director, Atmiya Institute of Science & Technology, Rajkot sapuranik@aits.edu.in

Abstract: The life cycle assessment (LCA) is an effective tool to assess environment effects of a process or a product throughout its entire life cycle. An LCA examines the product from the extraction of raw materials for the manufacturing process, the production process and use of the item, to its final disposal. The paper discusses the bird's eye view of the LCA studies broadly considering Goal, Scope, purpose, stages. Process steps, Impact indicators, interpretation etc. of LCA studies in brief.

Keywords – LCA, Bird's eye view, environmental effect.

I. INTRODUCTION

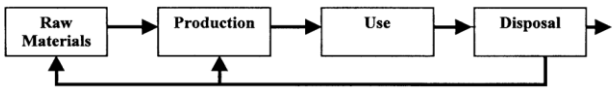
The butterfly's genesis from egg to larva to caterpillar to chrysalis to butterfly; the path of water from precipitation into bodies of water, then evaporation or transpiration back into the air. Each individual stage along the cycle is given a distinct term to distinguish it from the others, yet each stage flows seamlessly into the next often with no clear breaks. The common theme is a continuous stepwise path, one stage morphing into the next, where after some time period we are back to the initial starting point. A dictionary definition of life cycle might be "a series of stages or changes in the life of an organism". Here we consider this definition for products, physical processes, or systems.

It is often taught or considered life cycles as existing in the natural world, we can just as easily apply the concept to manmade products or constructs: Aluminium's journey from beverage can to recycle bin back to beverage can; a cell phone we use for our 2-year contract period then hold onto (because it must have some value) before donating to a good cause where it is used again before…being recycled? or being thrown away? The same common theme – a continuous stepwise path, one stage morphing into the next, where after some time we are (or may be) back to the initial starting point.

The entire life cycle for a manmade product goes from obtaining everything needed to make the product, through manufacturing it, using it, and then deciding what to do with it once it is no longer being used. Returning to the natural life cycles described above this means going from the birth of the product to its death. As such, this kind of view is often called a "cradle to grave" Some life cycles may focus on the process of making the product (up to the point of leaving the factory) and have a "cradle to gate" view? The recycling of some sort, or taking back the product and using it again. Building on this alternative terminology, proponents have also referred to the complete recycling of products as going from "cradle to cradle".

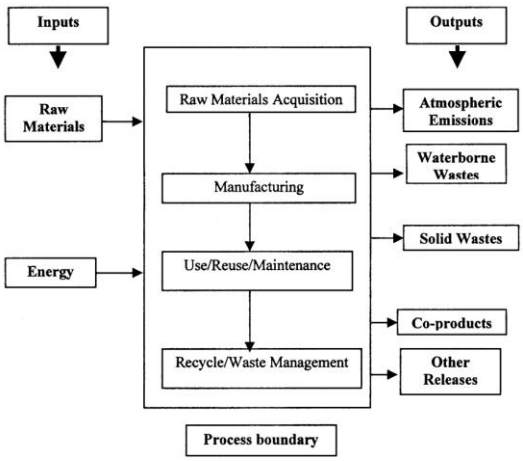
II. PURPOSE OF LCA

Life cycle assessment (LCA) is a tool to evaluate the environmental effects of a product or process throughout its entire life cycle. An LCA entails examining the product from the extraction of raw materials for the manufacturing process, through the production and use of the item, to its final disposal, and thus encompassing the entire product system. The schematic diagram is as follows.



The assessment process includes identifying and quantifying energy and materials used and wastes released to the environment, assessing their environmental impact and evaluating opportunities for improvement as illustrated in following figure

 DOI : 10.18231/2454-9150.2018.1189



III. STAGES IN PRODUCT LCA

LCA is split into five stages that include:

1. **Planning**: Includes Statement of objectives, Definition of the product and its alternatives, Choice of system boundaries, Choice of environmental parameters, Choice of aggregation and evaluation method and Strategy for data collection

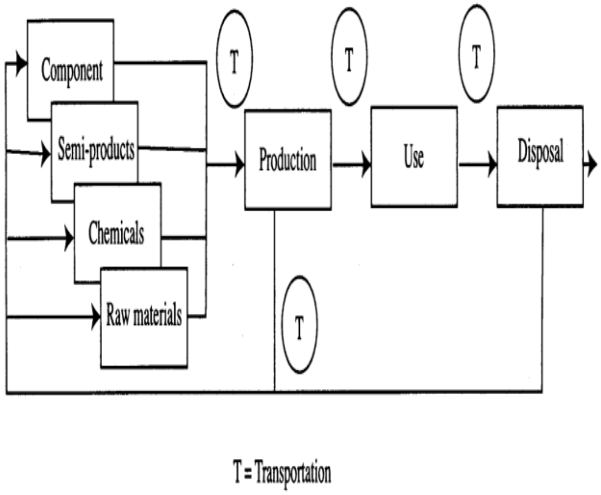
2. **Screening**: Includes preliminary execution of LCA and adjustment of plan

3. **Data collection and treatment**: Includes measurements, interviews, literature search, theoretical calculations, database search, qualified guessing and also computation of the inventory table

4. **Evaluation**: Includes classification of inventory table into impact categories, aggregation within category, normalization and weighting of different categories

5. **Improvement assessment**: Includes sensitivity analysis and improvement priority and feasibility assessment

It is generally recognized that the first stage is extremely important. The result of the LCA is heavily dependent on the decisions taken in this phase.



Product Life Cycle Stages

IV. PROCEDURE FOR LCA

Four steps are involved in carrying out an LCA, and these are:

(i) Definition of scope, goals, and delimitation of the life cycle.

(ii) Preparation of an inventory.

(iii) Assessment of impact of environmental loadings in terms of environmental profiles.

(iv) Evaluation of environmental profiles according to the defined goals.

(i) Defining the goal and scope

The goal of an LCA study must definitely state the intended application, including the reasons for carrying out the study and the intended audience. The statement of goal must also indicate the intended use of the results and users of the results. The practitioner, who has to reach the goal, needs to understand the detailed purpose of the study in order to make proper decisions

(ii) Analysing the inventory

Inventory analysis is the second phase in an LCA, consisting of issues such as data collection, refining system boundaries, calculation, verification of data, relating data to the specific system and allocation.

(iii) Assessing environmental impact

Impact assessment involves category definition, classification, characterisation, and valuation/ weighting.

Category definition: The life cycle assessment involves, as a first element, the definition of the impact categories to be considered. This is a follow-up of the decisions made in the goal and scoping phase. Based on the type of information collected in the inventory phase, however, the boundaries defined in the goal and scoping may be redefined. The impact categories are selected in order to describe the impacts caused by the products or product systems considered. The issues that need to be considered when selecting impact categories include the following:

Completeness: This means that all environmental problems of relevance should be covered by the list.

Practicality: This means that the list should not contain too many categories.

Independence: This means that double counting should be avoided by choosing mutually independent impact categories.

Relation to the characterisation step: This means that the chosen impact categories should be related to available characterisation methods

The life cycle impact assessment includes, as a third element, the characterisation of the inventory data.

 DOI : 10.18231/2454-9150.2018.1189

Characterisation is mainly a quantitative step, based on scientific analyses of the relevant environmental processes. It has to assign the relative contribution of each input and output to the selected impact categories. The potential contribution of each input and output to the environmental impacts has to be estimated. For some of the environmental impact categories, there is consensus about equivalency factors to be used in the estimation of the total impact (e.g., global warming potentials, ozone depletion potentials etc.) while for some others there may not be any consensus (e.g., biotic resources, land uses, etc.).

Characterisation results in a quantitative statement on different impact categories (e.g., global warming, stratospheric ozone depletion, acidification potential, eutrophication potential, smog formation, water, resources, eco toxicological effects etc.) Comparison of these categories is not immediately possible. Therefore, the life cycle assessment includes, as a fourth element, a valuation/weighting of the impact categories against each other.

Weighting aims to rank, weight, or if possible, aggregate the results of different life cycle impact assessment categories in order to arrive at the relative importance of these different results. The weighting process is not technical, scientific or objective, as these various life cycle impact assessment results are not directly comparable (e.g., indicators for greenhouse gases or resource depletion.) However, applying scientifically based analytical techniques may assist in weighting

Calculation procedures No formal demand exists for calculation in life cycle assessment except the described demands for allocation procedures. Due to the amount of data, it is recommended, as a minimum, to develop a spreadsheet for the specific purpose. The appropriate programme or software can be chosen, depending on the kind and amount of data to be handled.

Use of online tools/software: Various online tools/calculators and software are available which assist in evaluating different impact indicators. The list includes GaBi software, Umberato NXT LCA, LCA calculator online design software, Open LCA, SALCA-tools, Sima Pro 7 etc. These tools play a vital role in the LCA studies and study of many products of general use are already conducted using these tools and based on the study innovative products have been developed having a minimal environment effects.

(iv) Interpretation

Interpretation is the fourth phase in life cycle assessment containing the following main issues:

• Identification of significant environmental issues

• Evaluation

• Conclusions and recommendations

The different elements are explained in relation to the ISO standard. Life cycle assessment interpretation is a systematic procedure to identify, qualify, check, and evaluate information from the conclusions of the inventory analysis and/or impact assessment of a system, and present them in order to meet the requirements of the application as described in the goal and scope of the study. This assists in preparing remedial plans, models, optimising etc based on results and conclusion and thus proposing a better appropriate option for the present product/process.

Life cycle interpretation is also a process of communication designed to give credibility to the results of the more technical phases of LCA, namely the inventory analysis and the impact assessment, in a form which is both comprehensible and useful to the decision maker.

Interpretation is performed in interaction with the three other phases of the life cycle assessment. If the results of the inventory analysis or the impact assessment is found not to fulfil the requirements defined in the goal and scoping phase, the inventory analysis must be improved by e.g. revising the system boundaries, further data collection etc. followed by an improved impact assessment. This iterative process must be repeated until the requirements in the goal and scoping phase are fulfilled.

V. CONCLUSION

The paper covers the important aspects of the LCA studies in a broader perspective. The authors have tried to cover the relevant topics for a beginner in the field. This will help the beginner to understand the subject from a bird's view point and apply the same to the desired process or a product to study environment effects of a process/product during its entire life cycle.

REFERENCES

[1] Life cycle assessment- A guide to approached, experience and information sources, Environment Issues series 6, European Environment Agency (1997)

[2] Life Cycle Assessment (LCA) Unit-6, Lecture Notes; NPTEL, A Project funded by MHRD, Govt. of India.

[3] Life Cycle Assessment: Quantitative Approaches for Decisions that Matter – lcatextbook.com, © 2015 by H. Scott Matthews, Chris T. Hendrickson and Deanna H. Matthews.

[4] Life cycle assessment student handbook- Edited by Mary Ann Curran, John Wiley & Sons Inc (2015)

[5] European Commission - Joint Research Centre - Institute for Environment and Sustainability: International Reference Life Cycle Data System (ILCD) Handbook - General guide for Life Cycle Assessment-Detailed guidance, First edition March 2010. EUR 24708 EN. Luxembourg. Publications Office of the European Union 2010.

[6] LIFE CYCLE ASSESSMENT: PRINCIPLES AND PRACTICE by Scientific Applications International Corporation (SAIC) 11251 Roger Bacon Drive Reston, VA 20190.

 DOI : 10.18231/2454-9150.2018.1189