Life Cycle Assessment Prognosis for Sustainability
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Abstract

Today, along with the increasing environmental awareness in the politic, public and industries, the demand on environmentally friendly products and technologies has been increasing.
Therefore within the research and development of a product or technology in industries as well as in national or international funded R&D activities the method of **Life Cycle Assessment** (LCA) is often implemented in order to evaluate the potential environmental performance of a product or a technical system. At an early stage of a development a LCA analysis enables a cost and time effective improvement of environmental performances (so called "Design for Environment"– DfE).
Although LCA is a well established method, there are still aspects, which should be discussed further on. Especially in the context of the process development questions arise: does the LCA result based on a pilot plant represent that of a large scale plant? If not, how large is the potential derivation between the process plants at different stage of development?
Today, there has been no systematic procedure established which answers these questions. Hence a systematic integration of the aspects of process development in LCA were not conducted so far. A method, which is currently on development at the LBP (Chair of Building Physics) of University of Stuttgart, will establish a systematic procedure for a LCA prognosis, adapted to chemical engineering processes. This method considers the relevant development factors affecting significantly the LCA results of the considered process. For this purpose those relevant factors will be identified based on the principals of LCA and process development. The experiences and LCA analyses carried out at LBP enable the introduction of general assumption for chemical processes.

Keywords: scale up, life cycle assessment, method, laboratory, pilot plant

1. Introduction

There is an upward trend in the industries to integrate the environmental issue in the process development. Design for Environment (DfE) is an approach which is implemented in this context in different industrial fields e.g. automotive field, electronic field etc.. In this context Life Cycle Assessment (LCA) is a suitable method, on which many DfE procedures base.
LCA is a widely used and an internationally accepted method, which enables the analysis of environmental performance of products or process systems. According to ISO 14040 ff the procedure of LCA is standardized. LCA considers the potential environmental impact caused by a product or a process system during its entire life cycle – production, use and End of Life phase. Whereas the "production" begins at the "cradle" of a product (e.g. extraction of crude oil, mining of minerals and metal ores etc.) and the End of Life ends at the "grave" (e.g. waste disposal).
The result of a LCA analysis is usually presented as "impact potentials" for various impact categories such as Global Warming Potential (GWP), Summer Smog Potential (POCP), Acidification Potential (AP) etc. depending on the goal of the study.
The essential base of LCA analyses is the "inventory data", such as type and amount of energy and material consumption, wastes, emissions etc.. Directly collected data present the actual state of the process and accordingly that of the product under consideration at the stage of the data collection. As theoretically data collection can be carried out at any stage of a development, LCA can be applied for processes at any stage of the development as far as the study fulfil the aim of the study. Accordingly, the data source can be:

- laboratory experiments,
- pilot plant,
- mini plant,
- small scale plant or
- large scale plant.

In comparative LCA analyses, in which a comparison of the focused system (product or process) with another system is intended, the latter one can already be at an advanced level of process development e.g. already implemented as large scale plant. This means, that systems at different development stages are involved and compared to each other.
The fact is the derivation between the process at different development stages cannot be estimated systematically yet. The difference which occurs due to the process development is not clear and cannot be prognosed systematically due to lack of a systematic method for this purpose.
There are two questions, which LCA experts as well as manufactures want to have answered:

- Does the LCA result based on a pilot plant represent that of a large scale plant?
- How can a LCA prognosis for a large scale plant be carried out?

In order to answer these questions, LBP is currently working on the development of a prognosis method. The approach and the basic idea is presented in the following.

2. Methodological approach

The development of a plant encompasses from the process idea to the implementation of a large scale plant. In between, various technical changes and details are implemented. Not every single development step is of interest. As the first approach of such a prognosis the following method concentrates only on those relevant development aspects concerning environmental impact. Considering environmental impact, the most relevant technical changes are: the scale up (size) of the plant and their optimization from economic and environmental point of view due to their potential impact on inventory data. It is conceivable that the inventory data are affected by such technical aspects. As a consequence, the environmental performances of the systems are affected by the process development as well.

In order to integrate these two development aspects into LCA, a structure must be established which bases on LCA elements but which is close to the process engineers thinking (see figure 1) and integrated the above mentioned aspects.

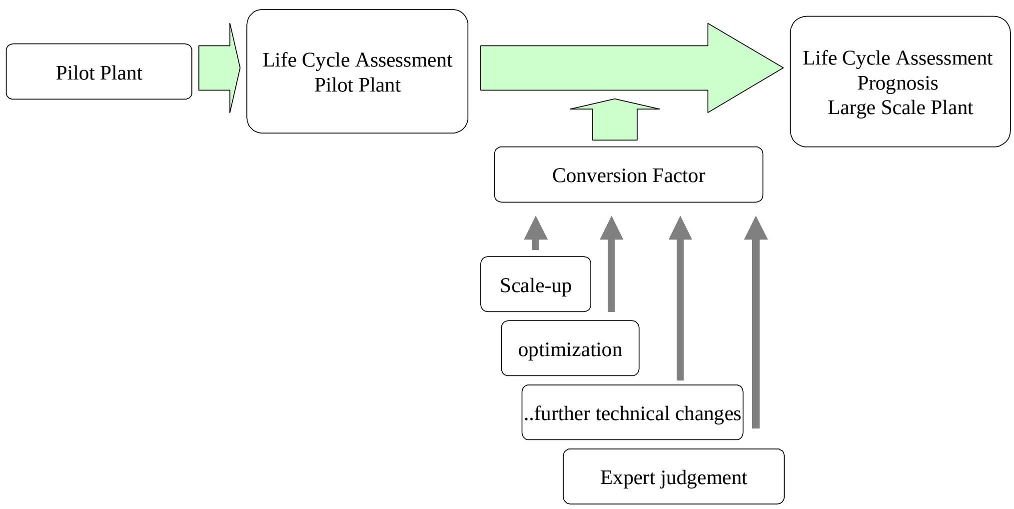

Figure 1: Principle method of LCA prognosis of a large scale plant based on pilot plant

As shown in figure 1, firstly, the influencing aspects are to be classified in a LCA conformable structure, in so called “stages” with respect to the different system boundaries:

- process step,
- process complex and
- value chain,

whereas the process step considers the scale up, the process complex the optimization within the process complex (plant and/or apparatus) and the value chain such as optimization which affect the up- and/or down stream of the process.
Secondary, a structure must be created in the LCA model itself. A structure enables the analysis of the influence of the above mentioned stages. The LCA structure is composed of so called “LCA components”:

- Upstream (material),

- Upstream (energy),
- Downstream and
- Process.

A correlation between the environmental performance of processes and the mentioned relevant factors will be established. Along this correlation and either expert estimation or rough plan of the large scale plant enables the estimation of the environmental performance of a large scale plant – based on the pilot plant.

3. Integration of the structure in chemical organic processes

The above mentioned structures (or the matrix consisting of both structures) shall be adapted to chemical organic processes. LBP of University of Stuttgart has examined about 40 chemical organic processes, such as processes for production of ethanol, glycerine, styrene etc.. For each of these processes, respectively for the products manufactured by these processes, a LCA analysis will be carried out with respect to the introduced LCA components.

Although the relevance of each LCA component depends theoretically on process and the position of the considered process within the value chain, if there is a common tendency, this will be screened. This leads to

- analysis of relevance of certain LCA component and
- analysis of the influencing character of the development stages

of chemical organic processes. These analyses enables to determine, which information is essential and which is negligible in order to make a LCA prognosis. The required information will be extracted, which can be provided by the plant manufacture. Beside the fact, that the implementation of a prognosis will be possible along with this method, the effort for an up date of a LCA reduces clearly.

4. Conclusion

The established structure and systematic procedure gives the basis of a LCA prognosis. There are two structures, which will be created. These structures, the one created in order to classify the influencing technical aspects, the other one created within the LCA model presents a matrix – the relevance of each components is to be examined. The inductive procedure using various numbers from various LCA analyses enables the determination of relevant factors, which should be integrated in the matrix.

LCA analyses for some processes of a common industrial field will deriver a tendency for the relevance of each influencing factors will be identified.

This prognosis can be implemented as a part of Design for Environment in industries, in order to enable cost effective increase of environmental performance of products or processes. The publication of the developed method is planned for 2007.

References

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