REALIZATION OF LCA IN BUSINESS – LIFE CYCLE SIMULATION MODELS FOR PRODUCT OR TECHNOLOGY DESIGN

Julian Maruschke, Matthias Harsch, Judith Schnaiter, LCS Life Cycle Simulation GmbH.*
**Aspacher Str. 9, D-71522 Backnang, Germany; julian.maruschke@lcslcs.de*

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ABSTRACT

The life cycle of products or technologies can be very complex and therefore the LCA approach is comprehensive. Hence, it is still a challenge to make LCA accessible to a broader range of practitioners in industry in order to integrate sustainable thinking in product development. Experience shows two main obstacles that prevent companies from applying LCA internally: the cost for specific software and the almost permanent demand of human resources. This paper describes how LCA can successfully be realized in any business by using life cycle simulation models based on spreadsheet software. Detailed life cycle models allow the ISO compliant calculation of a product LCA but can also be used to compare technologies or monitor and optimize processes.

INTRODUCTION

It is always emphasized that the LCA method is a scientific tool. Taking shortcuts must not dilute the high representativeness and robustness of results. Similarly, it has always been a vision to make LCA accessible to a broad range of practitioners in the industry. However, todays' business reality shows that it often takes profoundly trained and experienced experts and professional software tools to execute high quality LCA studies and establish life cycle thinking in business processes in a meaningful and profitable way. High cost for software and databases as well as the lack of capable in-house specialists are considered to be the main barriers for LCA to be a steadily integrated part of product development and design.

As a solution, the LCA community is discussing streamline LCA approaches for years and consultants are offering simplified LCA tools to be seamlessly integrated in product development processes. However, when applying such tools, it has to be guaranteed that simplification is not only realized at the expense of quality, transparency and meaningfulness of results. Beyond, streamline approaches must not simplify one part of the LCA but simultaneously adding complexity to another part of it. Practitioners still have to be able to sufficiently differentiate between alternatives (no over-generalization) and to trust in the comparability and appropriateness of used environmental background data (transparency).

This paper presents a solution that fulfills the high requirements of a scientific tool but still enables non-LCA-experts in companies to carry out LCA studies for their respective products, processes or technologies in reasonable expenditure of time and cost.

SPREADSHEET-BASED LIFE CYCLE SIMULATION MODELS

In order to come up with a practical solution for the above described situation it is crucial to recollect what is really essential to execute a high-quality LCA according to today's standards: The tool has to be flexible, transparent and easy to use in order to gain meaningful LCA results in adequate timeframe and at reasonable cost.

The execution of a LCA study is a well-structured and straightforward process. The essence always is a matrix, which combines the quantitative information of the life cycle inventory analysis with environmental impacts. The practitioner has to keep this matrix as small and transparent as possible. Most companies only produce few products or run only few processes, which are more or less comparable. This means that the matrix already is naturally limited. The solution is not a simplified general tool but a finite customized tool. Such a tool therefore can't cover anything, but if used for the target system, it guarantees highest transparency, representativeness, accuracy and quality. Spreadsheet-based life cycle simulation models represent successfully realized implementations of suchlike finite customized LCA tools.

The structure of spreadsheet models is kept simple and is strongly guided by the customers' needs. Depending on the scope, the system under study is categorized in reasonable subassemblies or subsections. For each of those there are reasonably parameterized product and/or process models created based on input-output analysis. This part of a spreadsheet model defines quantity and quality of involved materials, waste, emissions and kinds of energy and hence represents the life cycle inventory analysis. The information that feeds the quantitative life cycle inventory is primarily coming from bills of material, drawings, facility layouts, bills from the purchasing department and actual metering but also is extrapolated from external sources like patents and relevant literature. Raw data is reviewed according to goal and scope of the study and combined at the same level of detail and quality.

Then the resulting mass balance is linked to respective LCI datasets in order to calculate life cycle impacts. The chosen ecoprofiles originate from publicly available industry data, patents, literature, commercial and open source databases and internal calculations. If customers can provide specific datasets e.g. for onsite electricity generation, this will be preferred.

The interpretational part of the model usually consists of a spreadsheet summarizing the results and presenting customized charts for visualization. Optionally a normalization step can be included.

Using the capabilities of parameter variation, sensitivity analysis, scenario technique and dominance analysis, the models are fast and flexible tools for management and improvement decisions.

The benefits are obvious:

- Common spreadsheet software, which usually is already available in any company, can be used. This highly contributes to the models' transparency, easiness of use and adjustability. Also there is no additional cost for purchasing special software.
- Employees do not need extra training but can just start working with the tools right away.
- Since the tools are not bound to a specific database, the most appropriate available

LCI datasets can be used. LCA experts just have to make sure that only comparable datasets (in terms of quality, cut-off criteria, representativeness, etc.) are combined in one tool.
- The spreadsheet-based LCA tools are in compliance with ISO14040/44. They meet the criteria of an external review by an expert panel.
- The tools are highly flexible and thus extensible. In case a model was initially created to only cover essential parts of a system, more detailed sub-models can easily be added after a hot spot analysis. Also, models can be equipped with any desired impact categories and even with life cycle cost or social aspects (depending on available LCI data)

Those simple yet powerful and accurate tools are applied to almost any system (product LCA, process LCA, production site LCA) and serve individual purposes (product comparison, holistic technology benchmark, scenario analysis, analysis of optimization potentials, etc.).

IMPLEMENTATION IN BUSINESS - CASE STUDIES

LCS Life Cycle Simulation GmbH was founded in 1999 due to the growing demand for innovative holistic service concepts. The methodology – life cycle simulation – combines holistic and sustainable thinking with transparent spreadsheet-based simulation tools and internationally accepted standards. It can be used for any kind of system and is not restricted to a specific industry sector. LCS serves to a wide base of national and international clients in large enterprises, small and medium enterprises, research institutes and associations.

Product LCA at BSH Bosch und Siemens Hausgeräte GmbH, Munich, Germany
In 2005 LCS developed the first product LCA tool for BSH Bosch und Siemens Hausgeräte GmbH (http://www.bshg.com). This tool comprises the four main lifecycle stages – production, transportation, use and end-of-life (Saunders, 2013). The tool consists of a manageable, flexible spreadsheet-based set of tables. BSH Bosch und Siemens Hausgeräte GmbH uses the tool for retrospective and descriptive LCAs of existing products but also for quick scenario analysis to estimate impacts of future products. Although the resulting data are not published, they are available on request for customers and retailers. Starting to work with the tool and creating more and more LCAs for various products the practitioners gained knowledge with regards to absolute greenhouse gas emissions as well as the relative contribution of the four main life cycle stages. This awareness is constantly influencing the company's sustainability strategy (BSH Bosch und Siemens Hausgeräte GmbH, 2012).

The tool is currently updated in order to allow for adjustments with respect to product technology, LCA databases, materials and production techniques.

Production-site LCA/Process-LCA at Richard Henkel GmbH, Forchtenberg, Germany
Within the scope of the BMBF-funded project "Ehoch3" LCS built-up a spreadsheet-based LCA tool for Richard Henkel GmbH (http://www.metall-pulverbeschichtung.de). The model covered the entire powder coating facility i.e. pretreatment, adhesive water dryer, cooling zone 1, top coat application, top coat oven, cooling zone 2. Crucial parameters are consumption of gas, electricity and powder coating. In this case the LCA tool was linked to a Life Cycle Costing analysis. Within the project several measures to enhance resource

efficiency have been evaluated with the tool. CO2 and cost savings as well as pay back periods for investments have been verified.

After finalization of the "Ehoch3" project, the tool now serves Richard Henkel GmbH to monitor energy and material consumption and can be the basis for the ISO 50001 certification.

Future Technology LCA/Technology benchmark for Innoshade Project, EU Com. - FP7
Innoshade (www.innoshade.eu) is concerned with an innovative, nanocomposite-based switchable light transmittance technology, applied in various technical environments (Posset et al., 2005). LCS investigated the LCA of five electrically controlled state-of-the-art transmittance modulation devices including their production routes, 'from cradle-to-gate'. Environmental strengths, weak points and optimization potentials in the industrial up-scaling process were identified. Ecoprofiles for relevant substances have been created from scratch with commercial LCA software and then implemented in spreadsheet-based LCA models for the various industrial applications. This allowed the entire project team to conduct an instant scenario analysis and to receive feedback of any changes in the environmental performance of the process after adjusting parameters.

CONCLUSIONS

Spreadsheet-based LCA tools include many advantages. However, the customization also bears a certain amount of limitation and rigidity. The initial effort of building the unique models has to be executed by experienced LCA experts before they are delivered to practitioners in companies. In terms of timeliness of LCI data the spreadsheet-based LCA tools are considered equal with commercial LCA software. The effort for model maintenance should be lower due to a limited scope and higher transparency.

The key to implement LCA in business is to recollect what is really essential to execute a high-quality LCA according to today's standards. Practitioners need a flexible, transparent and manageable tool to handle LCA in adequate timeframe and at reasonable cost. Spreadsheet-based, customized LCA tools represent a practicable, proven solution for any life cycle related investigation.

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