PROPOSAL OF RECOMMENDATIONS FOR DESIGN UNDER A SUSTAINABLE APPROACH: LCA CASE.

Bonifaz Ramírez Adonis Wenceslao
Javier Rojo Gómez Street, #27, México City, Centro de Diseño Mecánico e Innovación Tecnológica (CDMIT), Centro de Ingeniería Avanzada, Facultad de Ingeniería, Universidad Nacional Autónoma de México. adonis-hp@hotmail.com
González Leopoldo Adrián
Eje 10 sur, México City, Centro de Diseño Mecánico e Innovación Tecnológica (CDMIT), Centro de Ingeniería Avanzada, Facultad de Ingeniería, Universidad Nacional Autónoma de México. pologlez@unam.m

ABSTRACT

A scientific literature review was carried out in relation to the topics of mechanical design, sustainability, product design, sustainable design, making a list of tools to design with sustainable approach; the information was analysed and diagrams and tables are presented Bonifaz Adonis, González Leopoldo | Proposal of recommendations for design under sustainable approach: LCA case. | 2 indicating: considerations, recommendations, and tools to design, methodologies and conclusions. The main topic that has been investigated is Life Cycle Analysis (LCA), so we have focused the work on it. The purpose of this work is that people who are involved in the field of design have an approach to sustainable approaches and can apply the tools making use of the recommendations to obtain better results.

Key Words: Mechanical design, sustainability, sustainable approach

1. INTRODUCTION

Sustainable development is one that meets the needs of the present without compromising the ability of future generations to meet their own needs [1]. Sustainable approach is gaining ground in the field of mechanical design; sustainability has become a global mega trend under the pressure of climate change. Designers are increasingly concerned with integrating sustainable objectives into their projects and products; organizations tend to increase their commitment to move towards more sustainable products and services; governments are also following the sustainability trend highlighting sustainable procurement policies; the world is changing towards the thought of social responsibility [1]. That is why, thinking about a revision of the current sustainable design tools and approaches is of vital importance, especially for design professionals.

As a concept, design for sustainability contributes to environmental, social and economic advantages throughout the entire life cycle of a product, while at the same time supporting health and well-being, as well as environmental conservation [2].

This study aims to help mechanical design professionals to include the sustainable approach in their daily professional practice, as well as to guide designers in the selection and implementation of sustainability tools, synthesized by means of tables, matrices and diagrams, to increase the solidity of sustainable approaches thanks to the implementation of the proposed recommendations and suggestions.

2. SELECTED TOOLS

In the literature review, several important tools were found for the deployment and implementation of design under a sustainable approach, we selected one of them to focus on it, because it has a lot of information and its deployment involves a great impact on sustainable topics related to political governments and international standards.

2.1. Life Cycle Assessment

It is an analytical tool that captures the general environmental impacts of a product, process or human activity from the acquisition of the raw material, through production and use, to the management of waste. This comprehensive vision makes LCA unique in the set of environmental management tools. It has become a standardized method to provide a solid scientific basis for environmental sustainability in industry and government. LCA provides a comprehensive view of the environmental aspects of the alteration or selection of products or processes and presents an accurate picture of possible environmental compensation [3].

The current practice of LCA, regulated by the international standard ISO 14040 [4], follows four interrelated phases:

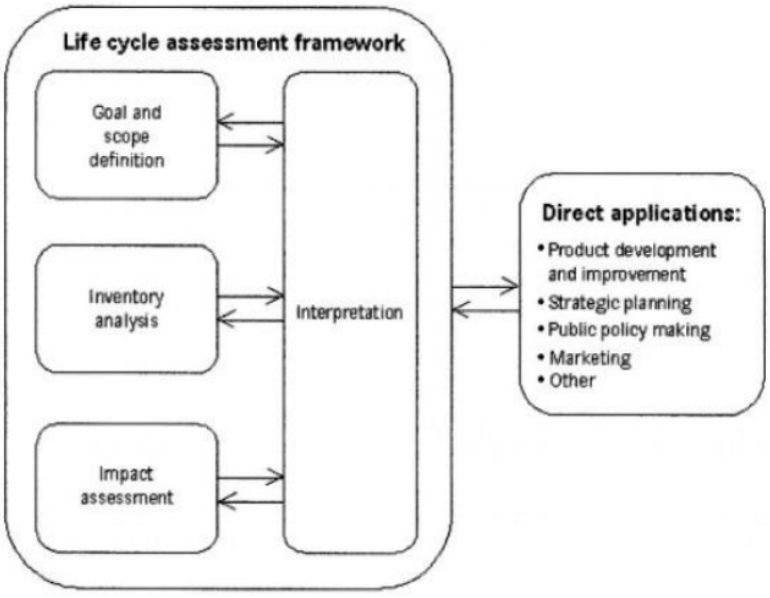
Clearly define the objective and scope of the study (including the selection of a functional unit).

Compilation of an inventory of the relevant energy and material inputs and environmental releases (analysis of the Life Cycle Inventory (LCI)).

Evaluate the possible environmental impacts associated with the inputs and emissions identified (Life Cycle Impact Assessment (LCIA)).

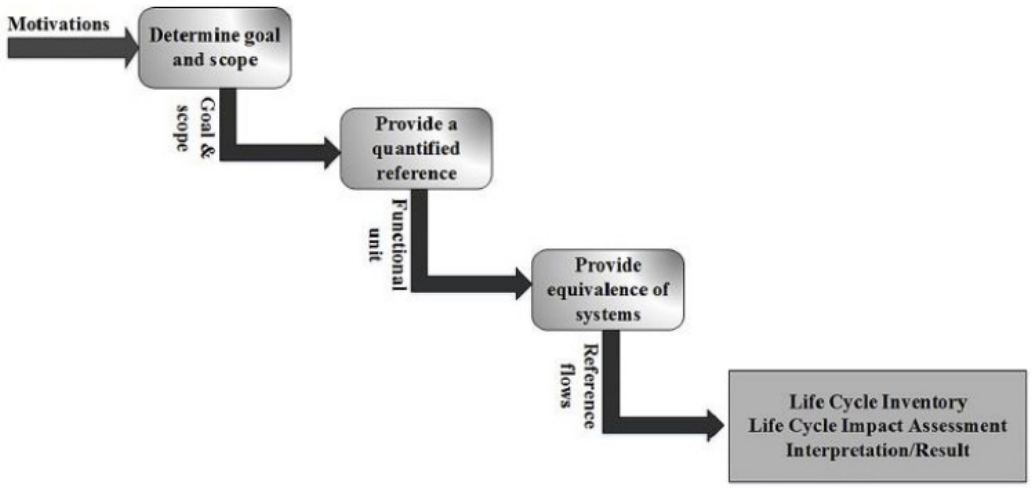
Interpret the results to help make a more informed decision.

The LCA evaluation framework is defined as shown in figure 1:



[Figure 1] LCA evaluation framework [5].

The objective and scope of each LCA study should be reviewed in great detail, using the interconnected step diagram as shown in figure 2.



[Figure 2] Steps in the goal and scope of an LCA study [2].

2.1.1. Important recommendations for LCA.

Although the ISO standard defines LCA and provides a general framework for carrying out an evaluation, it leaves much to be interpreted for the professional. There is much confusion about what the LCA can and cannot do, and how it fits into a strategic level approach to sustainability.

Below are ten important aspects of the LCA methodology shown in table 1. It describes each aspect and what users should keep in mind when preparing to perform an LCA or when reviewing an LCA made by another person.

Attribute	Explanation	Recommendations
Setting objectives and functional unit	A clearly stated objective will simplify the scope of thestudy limits and guide the data collection effort. The functional unit is defined by the service provided by the system under study and is given additional form according to the objective of the study. A functional unit is a quantified description of the performance of the product system.	et objectives clearly. Set correctly the scale of the functional unit.
Assign environmental charges to the co products of a process	The ISO standard requires professionals to avoid assignment, although it cannot always be avoided, especially if the data for the sub processes or for the expanded system cannot be easily acquired.	Model threads Expand the system
Credit per load avoided	In a system expansion approach, limits are expanded to include the alternative production of exported functions. While the concept of system expansion seems reasonable on the surface, it can be problematic. Not only does it require the identification of a way of producing an alternative by-product, which in turn requires additional market and other data, it can generate negative emissions when the system is credited with avoided charges compensated elsewhere.	System expansion Consecutive LCA
Consecutive LCA	It consists of extending the limits of the study to cover the probable consequences of a decision. A consequential LCA is conceptually complex because it includes additional economic concepts, such as marginal production costs, the elasticity of supply and demand, and so on.	Make sure that the various results with respect to the different consequences can be explained using plausible arguments.

Availability of inventory data and transparency	The lack of easily available inventory data remains a major obstacle to the practice of LCA. Often assumptions about the data must be made to sum them up to represent a sector of the industry.	Use of commercial software tools in conjunction with publicly available government databases.
Identifying data uncertainty	The uncertainty in the form of variability can be attributed to errors or fluctuations in the data. The uncertainty analysis is the process to determine the variability of the data and the impact on the final results.	Perform data uncertainty analysis for processes.
Differentiate the evaluation of the impact of the life cycle and the evaluation of risk	Risk assessment is a complex process that requires the integration of data and information in a wide range of activities and disciplines, including characterization of source, destination and transport, modelling, exposure assessment and response evaluation. LCA, on the other hand, expands the roduct system in space and time.	The LCIA models and the LCA results are adequate to evaluate relative comparisons.
Report qualitative and quantitative information	It is not possible to quantify all the environmentally relevant information, not all the impact data are available to model certain inventory data. When performing the LCA, it is necessary to apply several assumptions of modelling and engineering estimates. Sometimes, these choices are based on the values held by the modeller or the person who commissioned the study.	All options must be established and the impact on the decision must be clearly communicated within the final results in order to fully explain the conclusions drawn from the data.
LCA not always (usually) declares a 'winner'	The LCA interpretation phase involves the evaluation of the results of the inventory analysis along with the results of the impact evaluation to assist in the decision-making process, with a clear understanding of the uncertainty and the assumptions used to generate the results. Very rarely will the results of an LCA identify a clear 'winner' among the alternatives. In some cases, it may not be possible to affirm that one alternative is better than the others due to uncertainty in the final results.	LCA improves understanding of the environmental and health impacts associated with each alternative, revealing more fully the pros and cons of each alternative.
LCA is an iterative process	The interpretation of the findings is to compare the data and results with previous findings, and put them in the proper context of decision making and limitations. It is especially important to determine whether the results of the impact assessment or the underlying inventory data are incomplete or unacceptable to draw conclusions and make recommendations, then the previous steps should be repeated until the results can support the original objectives of the study.	If the uncertainties are too high, you can go back to collect better data. If the sensitivity analysis shows that some decisions are crucial, you can go back and do a more refined analysis.

[Table 1] Important recommendations for LCA.

It is necessary to complement LCA with other tools or methods to provide a basis for decision making. These tools include risk assessment, site-specific environmental assessment, cost evaluation and others. As part of the scope determination process, it is useful to identify where and how these other tools will be used to increase the LCA findings [3]. Given that there is no correct way to carry out any of the modelling options found in LCA, the practice would benefit from the development of a harmonized guide and a global agreement on the part of LCA professionals and modellers.

3. RESULTS

A review of the state of the art of sustainable design was carried out, and what was found is that, although there is no specific and sustainable methodology for sustainable design, there are approaches and tools that help the designer mainly to evaluate the environmental impact of products during all its useful life and even after it. Such tools are implemented from early stages in the design process and can evaluate modelling and simulation, projections of the behaviour and performance of the products or systems to which they are being applied.However, these approaches are applied most of the time in isolation. The professionals working in the branches of LCA already present some recommendations and suggestions to delve into the implementation of several tools that complement each other. Recommendations that were collected and expanded are presented in this paper in such a way that the design professional who decides to implement them has sufficient bases to carry out sustainable approaches and obtain better results in practice.

4. CONCLUSIONS

There are several tools that help design professionals to apply a sustainable approach, such tools are responsible for guiding the analysis and studies on the ecological implications of carrying out a design, either of a product or a service. These approaches are being implemented in isolation, oriented to very specific design objectives, so it can be concluded that there is no guide that combines sustainability tools.

By combining design strategies with sustainable approach tools, better solutions are obtained to environmental issues, such as appropriate end-of-life treatments and an extended product life cycle.

However, one of the difficulties in applying sustainable tools is that they are complex when they are not carried out adequately or crucial steps are omitted during their implementation, so the search for recommendations towards the deployment of the approaches sustainable is of great value to the design community.

Since there is no correct way to implement any of the sustainable design tools, the practice would benefit from the development of a harmonized and complementary guide.

BIBLIOGRAPHY

1. 1.Riel, A., Lelah, A., Mandil, G., Rio, M., Tichkiewitch, S., Zhang, F. & Zwolinski, P. (2015). *An Innovative Approach to Teaching Sustainable Design and Management.* Procedia CIRP, Volume 36, Pages 29-34. 2018, March 10. From SpringerLink.
2. Suhariyanto, T., Wahab, D., & Rahman, M. (2017). *Multi-Life Cycle Assessment for sustainable products: A systematic review Lifetime Product Example.* Journal of Cleaner Production, Volume 165, Pages 677–696. 2018, March 10. From SpringerLink.
3. Curran, M. (2013). *Life Cycle Assessment: a review of the methodology and its application to sustainability.* Chemical Engineering, Volume 2, Issue 3, Pages 273-277. 2018, March 10. From SpringerLink.
4. International Standards Organization. (2006). ISO: Environmental Management - Life Cycle Assessment -Requirements and Guidelines: ISO 14044.
5. Krasowski, H. (2002). *Life Cycle Engineering. Environmental Management Accounting: Informational and Institutional Developments*. Eco-Efficiency in Industry and Science, vol 9. Springer, Dordrecht.