Designers' requirements of lifecycle sustainability management tools

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Abstract To date, responsibility for managing product-related environmental sustainability issues has generally been held within a centralised team of experts. However, the environmental sustainability pressures that companies are now facing mean that these issues must now be addressed in every new design project. For many companies these new pressures will require a new approach to life cycle management activities that will involve a more significant role for designers and engineers. The main focus of the paper is a discussion of the requirements that engineers and designers tasked with addressing environmental sustainability issues have for LCSM tools. A list of generic LCSM tools requirements for designers is presented and the implications for LCSM tool developers are discussed.

1 The changing nature of eco design activities

For many companies understanding the environmental impacts of their products and operations is rising up the business agenda. There are many drivers behind this such as:

- Product marketing, brand value and Corporate Social Responsibility
- Legislation on energy consumption and hazardous substances
- Cost and supply-chain management
- Stimulus for product innovation

The consequence of this is that the points of interaction between issues of environmental sustainability and product development are increasing in number. Specifically there are:

- More pieces of environmental legislation affecting more phases of the product lifecycle and covering a wider range of environmental impacts.
- More eco labels that can be used to report environmental performance.

- More customers demanding information on the environmental performance of the products they purchase and expecting information on a wider range of issues.
- Increasing number of substances restricted by legislation.
- Increasingly frequent updates to restricted substance (i.e. roughly quarterly updates to REACH SVHC list).
- Legislation looking at whole life cycle rather than specific phases (WEEE Directive vs ErP Directive).
- More customers requesting environmental performance information.

As these drivers become more intense and diverse, there is a need for companies to change the way in which they respond.

To date, eco design has generally been the preserve of a small number of experts within an organisation e.g. Compliance Manager responsible for restricted substances, LCA expert responsible for carbon footprinting etc. The advantage of this type of organisational structure is that environmentally sustainability is a complex, multi-faceted topic that generally requires a significant amount of knowledge and training for staff to be able to make informed decisions on business issues. Hence it is logical that a small group of experts deal with these issues. Unfortunately, the increased scale and frequency of environmental issues that occur during product design means that it is increasingly difficult for a small team of environmental experts to manage all of these issues across all product lines at all stages of the New Product Development (NPD) process. Companies are therefore faced with the problem of having limited eco design capacity but rapidly increasing demand for eco design resource.

One possible solution to this problem is to devolve certain eco design tasks from the expert team to the wider engineering and design personnel within the organisation. It should be noted at this point that environmental experts will still play a very important role within an organisation. For instance, completing an ISO 14040-compliant LCA study for an Environmental Product Declaration or to guide corporate technology strategy are both activities that require expert practitioners to undertake them in order to obtain a high level of rigour and accuracy and for the expert knowledge required to interpret and communicate the results. These are also examples of activities that can be conducted ‘offline’ from the core NPD process which is often highly time and resource constrained.

There are however a number of strong arguments for devolving ‘routine’ eco design activities from expert users to designers and engineers. First, eco design activities need to be undertaken during the early stages of the NPD process. It is widely claimed that 80% of a product’s environmental impact and economic cost is fixed by the end of the conceptual design phase [1-3]. Hence, eco design activities must be undertaken in the early stages when there is maximum potential

for improving environmental performance and when changes to the product design are easier and cheaper to implement. Secondly, it allows the environmental experts to focus on the more complex eco design activities such as obtaining EPDs for products and informing technology strategy. Thirdly, it may foster greater enthusiasm amongst designers and engineers for environmentally sustainability issues and generate greater interest in the work of environmental experts which may otherwise go unnoticed or be poorly understood. Finally, by getting designers and engineers involved in addressing environmental issues early in the product development process there is a greater chance of actually improving the environmental performance of the products delivered to market.

If, based on the case outlined above, we assume that in the future an increasing number of companies will seek to devolve routine eco design activities to designers and engineers, the question of how to support these activities arises. The majority of LCSM tools, and in particular LCA tools, have been developed for use by environmental experts. Unfortunately these tools are not suitable for use by designers for reasons that are discussed in the following section. There is therefore an urgent need for a new generation of LCSM tools that can be used by designers, engineers and other users within an organisation beyond the conventional group of environmental experts. This represents a significant challenge for LCSM tool developers. The aim of this paper is to begin to address this challenge by sharing some insights into the requirements of designers for LCSM tools and promoting further discussion of this topic.

In summary, eco design has until recently been the preserve of a small group of environmental experts within an organisation but as the number of environmental touchpoints to design has increased the demand for eco design resource has increased to an extent that it now makes sense for certain eco design activities to be devolved to the wider design and engineering community within an organisation. In the following section we move on to the main focus of this paper which is understanding the requirements of the designers and engineers for LCSM tools and why conventional LCSM struggle to become adopted by these users.

2 Understanding why LCSM tools struggle to become adopted by designers

For many years, developers of LCSM tools have seen their tools struggle to become adopted by significant numbers of designers and engineers. Certainly within the academic community this has been recognised as a significant problem and a barrier to the development of eco design as a discipline [4]. Today, tThe

increased scale and frequency of environmental issues that occur during product design means that many organisations that currently have a central team of environmental experts managing all product environmental issues will soon need to consider devolving responsibility for some routine eco design activities to engineers and designers if they are to avoid these central teams becoming overburdened. Hence, it is more important than ever to understand why existing LCSM have struggled to to become adopted by designers and engineers. Here, some of the reasons identified in the literature for the generally poor uptake of LCSM tools are presented:

No systematic introduction process – Tools are often introduced within a company without any formal analysis of the need that the tool is intended to fulfil, with choices about the type of tool and how and when it should be introduced often done on an ad-hoc basis [5-6].

Tool not customised to the specific application – There are many variations in NPD activities between companies related to organisational, cultural, process and product differences. These differences may require the tool to be customised to the specific application but this is not normally considered [5-7].

No demand – If there are no environmental criteria in the product requirements specification then quite simply there is no need for eco-design tools [8-9].

No time - Environmental impacts are just one of many constraints a designer must consider during product development and hence only a very limited amount of time and effort can be spent on them [8,10].

Designers' requirements not considered – Tool developers have lacked a thorough understanding of how designers use tools and their main considerations when choosing whether or not to use a tool [11]. Also, the outputs from tools, such as LCA tools, often require further analysis which requires a certain level of environmental science or eco design knowledge in order to draw useful and sensible conclusions. Unfortunately, design teams, particularly in SMEs, do not have access to this type of expertise [5].

'Human factors' not considered – when a new working practice is introduced into an organisation, including the use of eco-innovation tools, there is always a risk that the change will face resistance, at an organisational or individual level [12-13]. This resistance may be due to socio-cultural or psychological reasons rather than technical reasons.

Too difficult to understand or apply – some LCSM tools are perceived to be difficult to understand or apply[7,10].

Too many tools – the vast multitude of tools now available makes the process selecting an appropriate tool a complicated and time-consuming task. Designers do not have time to go through such a process and so end up using inappropriate tools, or none at all [14-15].

Poor integration – when LCSM activities are treated as a separate stream of activity, distinct from the mainstream product development activities, they struggle to gain acceptance and quickly become marginalised [16].
Lack of commitment – design teams are sometimes reluctant to use LCSMtools because they believe that their company's rhetoric about wanting to improving environmental performance lacks sincere commitment [10].
Reviewing the list above, it is possible to categorise the causes of poor tool adoption into those that are related to implementation and integration of LCSM tool and those that are related to the nature and design of the LCSM tools themselves. LCSM tool implementation and integration issues have been focus of several recent research studies [12,15,17] but the target audience for this paper is people involved in the development of LCSM tools. The remainder of this paper therefore focuses on the design of LCSM tools, and specifically designers' requirements of LCSM tools, as with a better understanding of these requirements LCSM tool developers should be able to deliver tools that better respond to these requirements.

3 Designers requirements of LCSM tools

In Table 1. some of the general requirements that designers have for LCSM tools are provided. The requirements are based on a combination of: the results of a PhD research programme that investigated LCSM tool customisation and implementation based around eco innovation workshops and interviews with designers [18]; discussions with designers and engineers that occured as part of the author's role within a commercial LCSM tool-development organisation; and insights from working with leading engineering organisations as part of the collaborative Environmental Materials Information Technology (EMIT) consortium [19]. It should be noted that the requirements presented here are not exhaustive and will need to be further refined depending on a variety of factors such as the type of LCSM tool, the experience of the organisation in applying LCSM tools and principles, the industry sector etc. However, it is hoped that the list will provide a useful starting point for those involved in developing LCSM tools intended for use by designers.

Tab.1: A list of designers' generic LCSM tool requirements

Requirement	Comment
Environmental assessment with sufficient precision to allow design decisions to be made.	The level of precision required by a designer is lower than that for an LCA expert as for the purposes of eco design it is

	simply necessary to identify which life cycle phase contributes most to the product's life cycle environmental impacts.
Quick to use	To allow for repeated environmental assessments as part of fast iterations in the design and to fit with the short lead times of the product development process.
Easy to learn and use	Designers may use the tool infrequently and do not have time to be relearning how to use the tool every time the need arises.
Integrated with existing design workflows and available within their normal working environment (i.e. CAD, CAE software packages).	The workflow disruption required to use tools LCSM that are not available within the normal working environment is likely to cost the designer time.
Tools that do not require detailed information about the product.	which is often not available during the early stages of the produce development process
Minimal data collection activities required.	Designers do not have time to collect primary data and may not know where to look for suitable secondary data sources.
Minimal environmental expertise required.	Most designers will have a limited knowledge of topics such as LCA or restricted substances legislation.

4 Implications for LCSM tool developers

There are a number of implications, and opportunities, for LCSM tool developers that arise from the developments in industrial eco design practice outlined previously. It is suggested that there is a growing need for tools that can support routine eco design activities and can be used by people who do not have environmental expertise. The primary user group for such tools will be designers, and it is hoped that the LCSM tool requirements described in Section 3 will provide tool developers with some initial guidance on how to develop suitable tools for this user group. However, there are other user groups that do not have environmental expertise but will need to be involved in routine eco design tasks. The LCSM tool requirements of these other user groups may be quite different from those of the designer. For example, a purchasing manager who wants to check that the materials he/she is buying for a new product will comply with the

RoHS and REACH Directives would probably find a restricted substance management tool that interfaces with an Enterprise Resource Planning (ERP) or Product Lifecycle Management (PLM) system more useful than a tool that interfaces with a CAD system. Having different tools and interfaces that are adapted to the requirements of these different user groups will hopefully enable more actors across the organisation to participate in eco design activities in an effective and efficient manner. However, this will also create new challenges, such as: how to ensure that compatability of this increased number of tools; how to avoid work being repeated unecessarily in different tools/formats; and how to ensure that all users are accessing consistent and up to date information about products, materials and processes.

Another major issue for LCSM tool developers to consider is how Life Cycle Assessment and life cycle thinking approaches can be simplified for use by users without environmental expertise. For instance, should there be a greater use of aggregated score methods, such as ReCiPe, in tools intended for non-expert users as they may simplify the complexities of multiple impact categories down to a single score? It is not the intention of this paper to answer such questions, but it would seem that there is a strong need for more dialogue between the LCA community, who can provide insight into, amongst other things, the methodological pros and cons of aggregated score methods, and the engineering design community, who can offer insight into the practical time and cost constraints of the NPD process and the workflows of the designer.The LCM conference is one of the rare and important opportunities for this type of dialogue to occur.

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