PRODUCT DESIGN FOR SUSTAINABILITY – GUIDELINES FOR THE LIFE CYCLE DESIGN OF OFFICE FURNITURE

Lena Plaschke
Politecnico di Milano – Design Department, Via Durando 38/A, 20158 Milan, lenamaria.plaschke@mail.polimi.it
Carlo Vezzoli
Politecnico di Milano – Design Department, Via Durando 38/A, 20158 Milan, carlo.vezzoli@polimi.it
Francesco Scullica
Politecnico di Milano – Design Department, Via Durando 38/A, 20158 Milan, francesco.scullica@polimi.it

ABSTRACT

Competitiveness of the office furniture industry on the global market is strongly affected by an ever-increasing focus on environmental performance of products. Hence, verifiable information of the environmental compliance of products throughout their whole life cycle is demanded from stakeholders of the furniture industry, which needs to be based on scientific proposition. This paper investigates how to support companies in designing environmentally sustainable office furniture, considering all phases of the life cycle. It deals with the identification of the environmental profile and main environmental impact potential of the office furniture product group aiming to develop an instrument which orients towards sustainable design.

A Life Cycle Assessment (LCA) has been conducted to evaluate the environmental profile of five different office furniture product categories. Data drawn from publicly available Environmental Product Declarations have been evaluated with the software programme SimaPro. Furthermore, a system to prioritise Life Cycle Design (LCD) strategies for environmental sustainability has been adopted and a workshop for generating ideas for an LCD tool related to the design of office furniture has been carried out.

An important factor is that the majority of environmental burdens is significantly linked to the pre-production stage which implies that environmental impacts related to the furniture derive mostly from raw materials extraction and its processing. The final outcome of the research is a handbook and a tool with product type specific guidelines which assists in the product design process and addresses companies, i.e. engineers and designers.

Keywords: Life Cycle Design; Design guidelines; Office furniture; Environmentally sustainable design

1. INTRODUCTION

The debate on the environmental concern has reached high strength nowadays. Regarding the office furniture market, which is focused in this research, growing environmental consciousness increases influence on the furniture industry. Accordingly, many market participants demand verifiable documentation of the environmental performance of products throughout their entire life cycle, which needs to be found on scientific methods (The Norwegian EPD Foundation, 2018).

Today, the office furniture product group confront new and competing claims and significant challenges are faced by manufacturers in the marketplace (Luccitti, 2005; Smieja & Babcock, 2017). Regarding this issue, supporting methods referring to design for environmental sustainability has been evolved. Even though, developed methodologies and tools for design for eco-efficiency are limited due to critical issues related to difficulties of examine complex systems, some sustainability research centres provide consultancy for companies and manufacturers by developing specific tools for furniture industries in order to foster and support the environmental compliance of products. The objective is to offer organisations a tool for the development of a culture and design practice by guiding them towards new technical and strategic knowledge which promotes the emerging generation of products with high eco-efficiency combined with economic and competitive value (Vezzoli, 2018).

According to Vezzoli (2018) there is an explicit need to establish a more consistent approach to design methods for the implementation of low environmental impacting design in real company practices and culture. This can be achieved not only through a wider diffusion of supporting instruments and methods and operative expertise but also through practice of a *functional* and *life cycle thinking* approach.

This research investigated how to support companies, i.e. engineers and designers, in developing environmentally sustainable office furniture, considering all phases of the life cycle which are: pre-production, production, distribution, use and disposal. The aim was to develop an assisting instrument which orients towards environmental sustainability in the office furniture sector and specifically support designers in the development of low impacting furniture products.

1. GUIDELINES FOR LIFE CYCLE DESIGN

The development of product type specific guidelines can further the aims of sustainable development by supporting the design process in reducing environmental impacts (as e.g. global warming, ozone layer depletion, acidification, eutrophication and abiotic depletion potentials), taking into account all phases of the life cycle (Vezzoli & Sciama, 2006). Specific objectives of such kind of consultancy for companies is to identify environmental impacts as well as assessing design priorities which are necessary to improve product's environmental quality. In addition, it aims to promote diffusion of a new design culture as well as to develop a tool including a set of environmentally sustainable guidelines, strategies and design advisements for organisation's internal use which addresses designers and engineers who deal with product development (Vezzoli, 2018).

2. METHODS

For the identification of the environmental impacts of office furniture which is the objective of this study, different research methods have been conducted. The first research carried out was a desk research. Environmental Product declarations (EPD) of current existing office furniture have been investigated in order to identify the life cycle stages with the highest environmental impact. All EPD's which are involved are type III environmental declarations which provide quantified environmental data and accord to ISO 14025. The parameters are based on ISO 14040 and ISO 14044. Data of office furniture of five different product categories as task chairs, visitor chairs, office desks, (conference) tables and storage furniture has been examined. These EPD data which provided necessary information about the product's life cycle impacts has been drawn from documents which are publicly available on the internet. Data examined were drawn from *The Norwegian EPD Foundation,* as well as from the company and office furniture manufacturer *Wiesner-Hager Möbel GmbH*.

After the definition of the main impacting life cycle stages, a Life Cycle Assessment (LCA) has been carried out in order to provide specific information about those stages and to define the environmental impact of each single life cycle stage in a more detailed manner. Data drawn from publicly available EPD studies have been evaluated with the LCA software programme SimaPro which contains the latest databases.

In a further step, a tool for Environmental Design Priority Indicators (IPSA) has been applied in order to define the priorities of general Life Cycle Design (LCD) strategies[1] for the furniture products. The application of IPSA encompasses calculation tables with algorithms that use the results of the LCA's for the determination of potentials for reducing the environmental impact for each strategy, as well as for comparison between each other. The objective was to evaluate which LCD strategies are more relevant for a certain type of furniture. Additionally, a workshop about Life Cycle Design specification for office furniture has been conducted in order to define product type specific guidelines for office furniture. The participants of the workshop were composed by professors (Prof. Vezzoli and

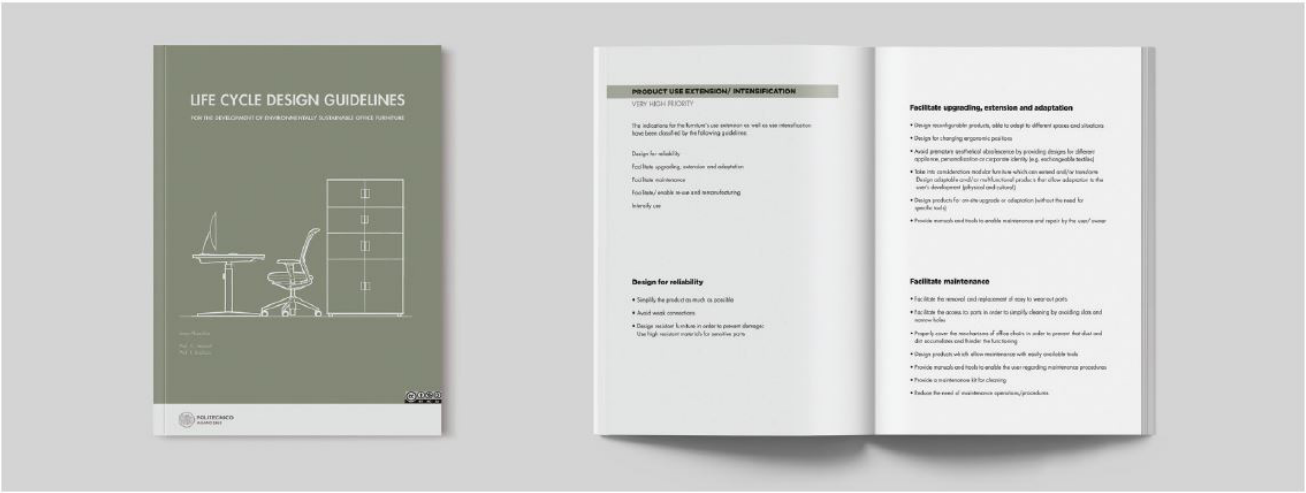
[1] General guidelines for environmentally sustainable design are available in 'Design for Environmental Sustainability', (Vezzoli, 2018).

Prof. Scullica) and two design students from the Department of Design of the Politecnico di Milano. General LCD strategies for environmental sustainability have been considered as a basis for the development of specific guidelines for the different office furniture products. The Brainstorming technique has been used to generate a draft of those guidelines which thereupon has been further elaborated.

3. RESULTS

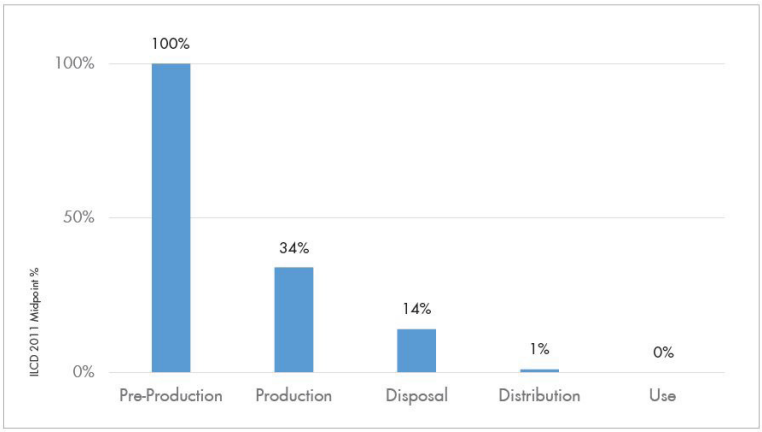
The final result of the research are product type specific guidelines and a digital tool for the sustainable development of office furniture that assists in the product design process and addresses companies, i.e. engineers and designer. The guidelines refer to a handbook which has been developed in the framework of the research and is available as free open source at www.lens-international.org (see Fig.1).

Guidelines presented in the handbook provide a set of procedures and tools to orient the decision-making process (i.e. the design process) towards the objective of reducing environmental burdens. The developed digital tool includes the compiled guidelines and provides an idea board which can be used from designers to generate specific and explicit ideas that aim to achieve the development of low environmental impacting office furniture products. For this purpose, easily upgradable idea boards as shown in Fig. 2 can be used in workshops or meetings where a team of experts practise brainstorming. Both, the handbook with office furniture specific guidelines and the related tool are available under copyleft for everyone who is interested in the development of environmentally sustainable office furniture.



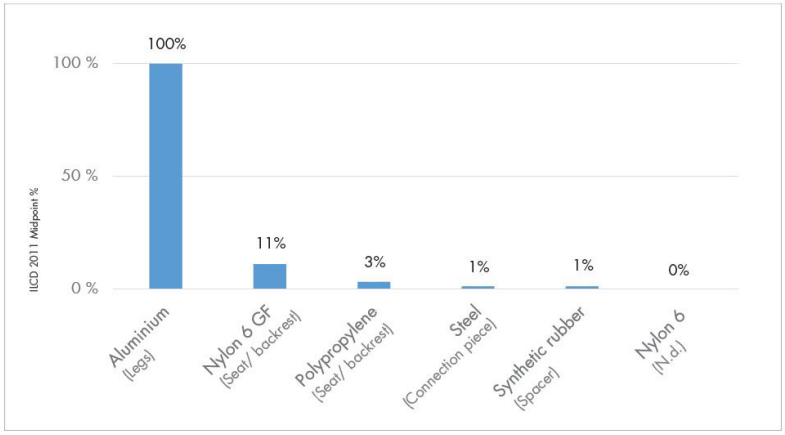
[Figure 1] Handbook with product type specific guidelines, 2019 (Personal collection).

Results of the Life Cycle Assessment which has been carried out on different office furniture products has been a very crucial part of the process of the development of office furniture specific guidelines. They reveal the most impacting life cycle stages, materials and production processes as well as impact potentials of the distribution, use and disposal stage referring to different office furniture products. Key findings of the performed LCA support that the majority of environmental burdens of all assessed office furniture products is significantly linked to the pre-production stage which implies that environmental impacts related to the furniture derive mostly from raw materials extraction and its processing. The second main impacting stage is the production stage, which refers to the production of components, assembly and final making of the product. Another fact is that the source with the lowest environmental impact potential is the use stage. Environmental impacts of the life cycle of a task chair are presented in Fig. 2 (The Norwegian EPD Foundation, 2016) as a representative example. All assessed products of the five office furniture categories provided very similar results as those illustrated below.



[Figure 2] Environmental impact of life cycle stages of a visitor chair, LCA results, (The Norwegian EPD Foundation, 2016).

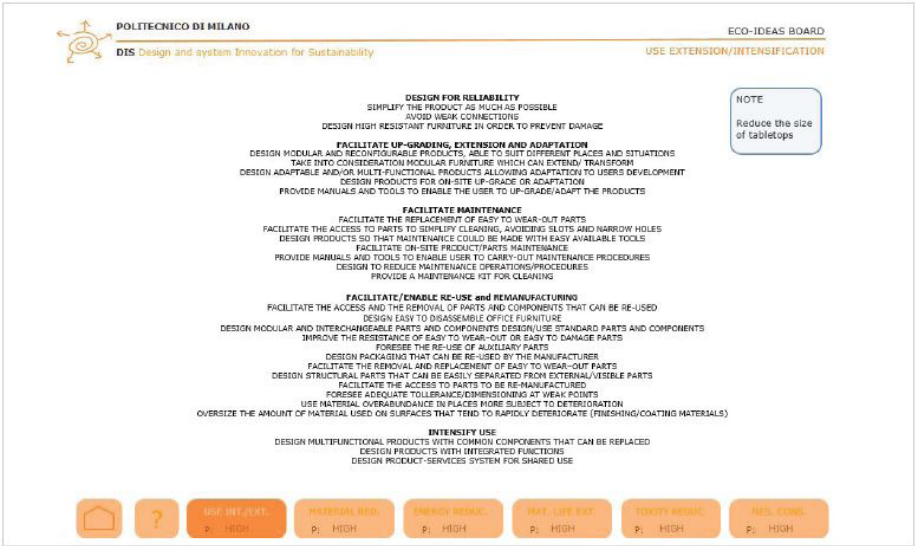
Figure 3 (The Norwegian EPD Foundation, 2016; European Commission, Joint Research Centre, 2012) illustrates the environmental impact potentials of the task chair's pre-production stage. Each material has a different contribution to environmental burdens. The materials have been assessed with respect to their weight that appears in the assessed product. It is to point out that primary aluminium shows very high impact potentials compared to other common materials used in office furniture. Overall, metals revealed generally more impact potentials than materials as plastics and wood. In addition, results of the Environmental Design Priority Indicators (IPSA), which have been applied to determine the priorities of LCD strategies, showed that the LCD strategy of *Product use extension* has the highest priority regarding office furniture production. This is followed by the strategy of *Material reduction*, which has been defined as a strategy with high relevance.



[Figure 3] Environmental impact of the pre-production stage of a visitor chair, LCA results, (The Norwegian EPD Foundation, 2016; European Commission, Joint Research Centre, 2012).

4. DISCUSSION

The conducted study investigated the environmental profile of office furniture in order to develop an assisting instrument which orients towards environmental sustainability in the office furniture sector and support companies, i.e. engineers and designers, in developing environmentally sustainable office furniture, considering all phases of the life cycle. The Desk research as well as the Life Cycle Assessment revealed valuable insights that have been thoroughly considered for the development of specific guidelines for the design of office furniture. The LCD guidelines are designated to be incorporated into the design process, where they foster the integration of environmental requirements in product development. They offer an assisting instrument for designing low environmentally impacting office furniture and support the designer in orientating design decisions towards an effective implementation of sustainability. However, due to the fact that technologies evolve over time, some limitations can appear and certain issues might be unpredictable during the design process. Considering that an office furniture product has a lifetime of several years[2], it could be the case that, e.g. technologies of recycling or other disposal processes are different than meant to be when the product has initially been designed. That means that design guidelines run the risk to become partly obsolete over time. Not only technological and economical changes, but also changes in office and workplace needs to be considered as an important factor. Our working environment is changing constantly and increasingly faster. Tech-



[Figure 4] Digital tool with specific LCD guidelines, 2019 (Personal collection).

[2] EPD's of office furniture products which has been assessed considered a product lifetime of 15 years.

nological progress, globalisation, flexibilisation and demographic change, are drivers and indicators of the evolving working environment.

Those changes in office environment and new ways of working can strongly relate to the sustainability and requirements of designing office furniture. Thus, guidelines for the development of environmentally sustainable office furniture need to adapt to new circumstances and new situations in which office furniture will be used in the future. For instance, office furniture has to meet new requirements in terms of utility value, stability, maintenance and longevity regarding emerging hot desking approaches and prevalent coworking spaces where one desk is assigned to many different employees i.e. users. Another example is that furniture consistently has to adapt to new needs of the future of work which is driven by effective communication, collaboration, employee experience and flexibility. In the case of fast-changing office structures, it should be avoided that furniture become obsolete prematurely regarding its function. Consequently, it is important to emphasize that the developed guidelines are no rigid rules and need to be understood as indications and advises which can be updated and extend over time. To enable adaptation of guidelines to those previous described changes, it is necessary to design flexible solutions. The issue of upgradability of the design guidelines has been considered in the research project by providing a modifiable digital tool which enables their constant update.

On the other hand, referring to the overall concept of sustainable office furniture including its real application, it is important to indicate and advise that measures aiming at sustainability should not only be taken regarding the production of office furniture but also regarding its use and maintenance. Insight of the research revealed that high attention should be paid to the strategy and the related design guidelines that deals with the office furniture product's use extension. Consequently, it is very crucial as well to pay attention to the use phase and the relation between the office furniture products and those who use and maintain them.

According to Vezzoli and Manzini (2008), 'the impact during the stage of usage is more of a socio-cultural phenomenon, since this request, to a different extend, changes in the way products … are utilised' (p. 65). In other words, in order to aim entirely and with a widespread approach at life time extension of office furniture, not only instructions should be provided aiming at sustainable office furniture production but also to those who use, buy and maintain the furniture.

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