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LIFE CYCLE DESIGN (LCD) GUIDELINES FOR ENVIRONMENTALLY SUSTAINABLE CLOTHING CARE SYSTEMS: AN OPEN AND OPERATIVE TOOL FOR DESIGNERS

Diana Giannone
Via Durando 38/a, 20158 Milan, Italy, Politecnico di Milano, diana.giannone@outlook.com
Carlo Vezzoli
Via Durando 38/a, 20158 Milan, Italy, Politecnico di Milano, carlo.vezzoli@polimi.it
Giovanni Maria Conti
Via Durando 38/a, 20158 Milan, Italy, Politecnico di Milano, giovanni.conti@polimi.it

ABSTRACT

This paper presents a set of Life Cycle Design (LCD) guidelines to operatively support fashion companies to design low-environmental impact cloth. The LCD guidelines for environmentally sustainable clothing care systems has been developed with the following process adopted since several years in company/organization consultancy by the LeNSlab of Politecnico di Milano: desk research of the fashion system and its environmental impacts and sustainable best practices analysis; identification of the environmental design strategy priorities; definition of cloth-specific guidelines. i.e. a process of specifying the general LCD strategies: material minimization, energy minimization, non-toxic harmful resources selection, renewable and biocompatible resources selection, product life optimization, material life extension, design for disassembly; tool development both as a handbook and a digital tool. The result is both an open access handbook and a digital tool of LCD clothing care guidelines and checklist to support and orientate the future designers and companies to an environmentally sustainable design of clothing for fashion.

Key Words: Design for Sustainability, Life Cycle Design, Sustainable clothing; Fashion system

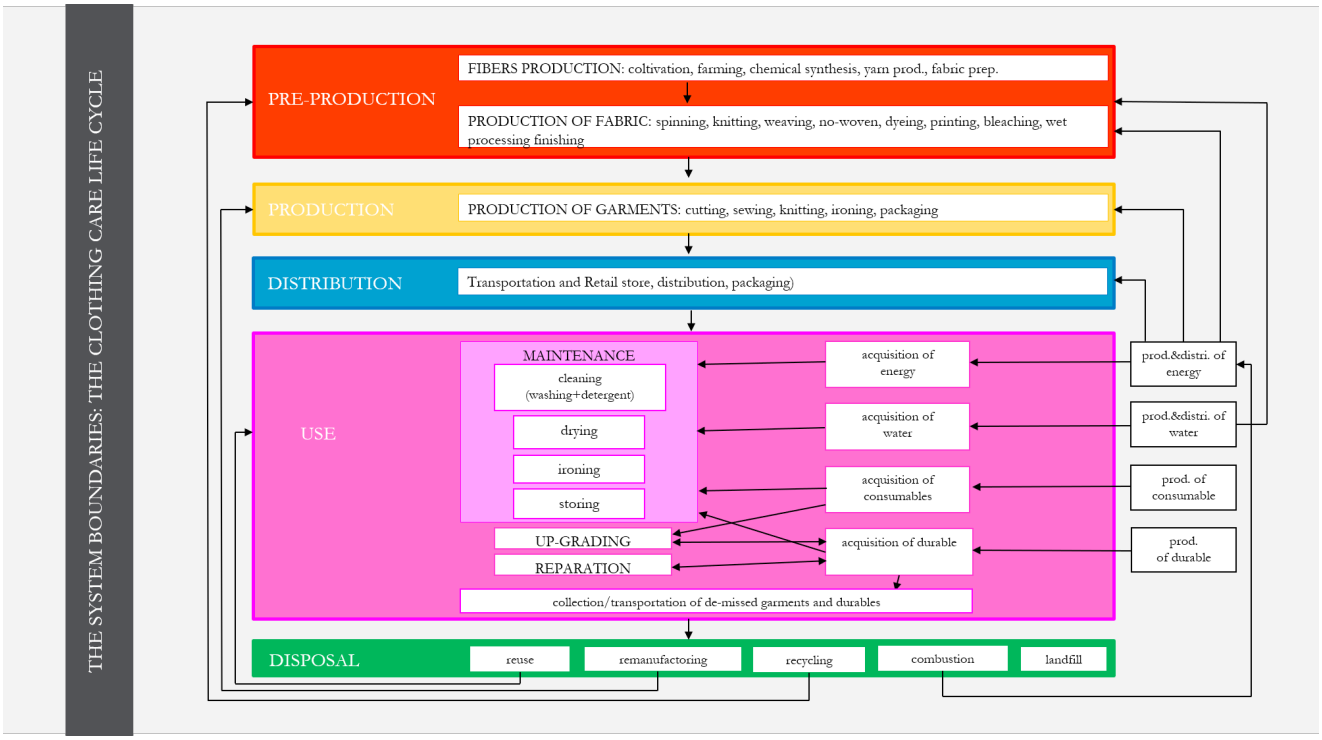
1. INTRODUCTION

The fashion industry is one of the industrial systems that contributes the most for global growth and development, but at the same time the industry has a very high environmental impact, that increase year by year, due to the industry's continuing growth. The apparel industry is the second highest user of water worldwide, producing 20 percent of global water waste, the 10 percent of the global carbon emissions and cotton farming is responsible for 24 percent of insecticides and 11 percent of pesticides despite using only 3 percent of the world's arable land (United Nations Economic Commission for Europe 2018). Most of the companies, design without thinking about the consequences of the clothing care life cycle and as a result the impact of their products on the environmental is very high. On the other hand, the demand for clothes are every day higher, consumers aren't getting enough to own useful products because they are driven by trends which follow fast marketing and therefore each product is often use just half long as their real life. The main goal of this project is to inform companies and designer regarding the importance of sensibilities and furthermore to give them an instrument to contribute to have less polluting world, through the realization of a handbook and a digital tool of LCD clothing care guidelines and checklist.

2. THE CLOTHING CARE ENVIRONMENTAL IMPACT

2.1. Environmental Analysis: system boundaries and the satisfaction unit

The environmental analysis is necessary to define the clothing care environmental impact and to discover and analyse the best practices. At the begging, the system boundaries need to be defined based on the product life cycle phases. Taking under analysis the clothing care system, the product life cycle phases are pre-production, production, distribution, use and disposal (Fig.1). Then, as the satisfaction unit (or functional unit), has been designated the use of a garment for one year.

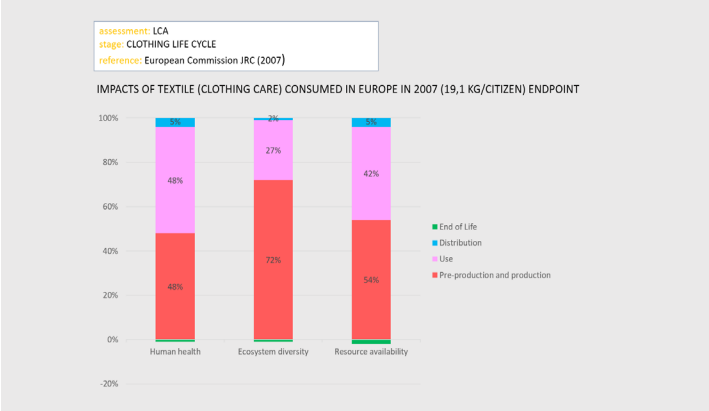


[Figure 1] The system boundaries: the clothing care life cycle

Each phases of the clothing care life cycle have been deeply analysed through desk researches. As shown in the following graph (Fig. 2) re-elaborated from the European Commission JRC (2007), considering the impacts that have been clothing care consumed in Europe in 2007 (19,1 kg/citizen) on Human Health, Ecosystem diversity and resource availability, the phases that impact the most are pre-production and production and use. In the following paragraph, each of the life cycle phases have been explicated.

2.2. Pre-production and production phase

The first phase is the pre-production phase which includes the fibres production and the production of fabric. Analysing the fibres production, first it is necessary to know that fibres can be divided into natural fibres (that has origin from living organism) and synthetic fibres (that has origin by chemical synthesis made by human), consequently different methods of fabric production are use, based on the materials. For example, a process that concern natural fibres might be the cultivation, whilst a process that affect the synthetic fibres might be chemical synthesis. Then these fibres, both natural or synthetic, turn into a yarn.



[Figure 2] Impact of textile (clothing care) consumed in Europe in 2007 (19,1 kg/citizen) endpoint. Authors re-elaborated from European Commission JRC (2007)

In the same way fabric production could involve different process, depending on the fabric, if it is knitted or woven. Different processes such as dyeing, printing, bleaching and finishing, have a very high impact on the environment due to the high requirement of water, energy and chemical treatment done to obtain the desired results. At last there is the production phase, which consist of garment production; this phase includes processes such as cutting, sewing, knitting, ironing and packaging. Analysing the pre-production, the environmental impact depends mainly on fibre type and technological approaches (Wiklund S, 1984). Based on a carbon footprint comparison of different fibres in pre-production and production from Wrap (2009) we can assume that the high carbon footprint level during pre-production and production phases is given by the fabric production; in addition, it is shows that natural fibres impact more on the environment, compared to synthetic fibres.

While natural fibres such as conventional cotton have a critical environmental impact for the large consume of water, fertilizers and pesticides during the cultivation, hem, flax and organic cotton, could be valid alternative. Considering the high use of pesticides in pre-production, it is important to know that organic cotton is made avoiding the use of pesticides and chemical fertilizers and hemp and flax do not need pesticides for their nature, since their fibers are not made from the plant flower but from the wood-like part of the plant. Considering that natural fibres impact more than synthetics one, analysing toxicity we can observe that the situation changes (Fig.4). In this case comparing different fibres during pre-production, synthetic fibres such as acrylic, has the highest impact. Different regulation for harmful substances has been instituted for different countries. In Europe, there is the REACH (Registration, Evaluation, Authorization and Restriction of Chemicals) the European Union regulation for harmful substances created to protect human health and the environment from the risks caused by chemicals harmful substances.

2.3. Distribution phase

Distribution phase considers both transportation during pre-production, production and post production phase. Even more often, clothing companies move to countries with a cheaper manufacture cost like Bangladesh, Vietnam and Philippines, shipping from countries like India and China the raw materials needed. When the garments are ready, they are sent to retail by rail, ships and trucks in shipping container. It is fundamental to know the impact of different transportation methods and to try to reduce the environmental impact through conscious decisions like maximize transport, utilizing transport solutions with minimum pollution and try to work as much as possible with local companies, to be eco-friendlier. However, in life cycle phases, the distribution phase does not have a very relevant environmental impact, compared to the other phases, like the use and the production one.

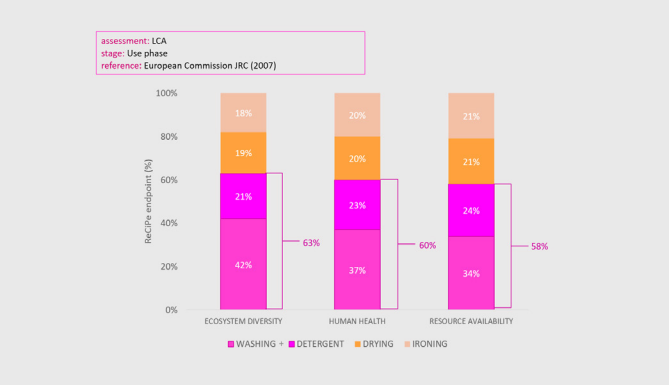
2.4. Use phase

From an accurate analysis, we can assume that strong environmental impacts are caused by the consumers during the use phase. The maintenance activity that affects the environment the most is the cleaning, which include washing and the use of detergents (Fig. 5). Washing and drying clothing alone are estimated to account for 120 million tonnes of CO2 equivalent (Ellen MacArthur Foundation, 2017). Consumers most of the time wash their garment too often and at high temperatures. Unfortunately, most of the energy used for washing clothes goes into heating the water, for this reason encouraging consumers to wash at low temperatures could reduce water and energy use. Commonly it is used too much detergent without the correct dose and some detergents could be dangerous and harmful. Even through there are people that still prefer line drying and increasing number of consumers use tumble dryers without thinking that it is a high consuming method that could easily be avoided. Customers need to be informed about the consequences of their actions and at the same time need to be encouraging to do the right choices concerning the maintenance routine. At the same time, it is essentials that companies start to design also thinking about the use phase, in order to reduce the high environmental impact of this phase.

2.5. Disposal phase

At the end of life of a garment, the product could be reuse it (starting a new use phase), remanufacturing (being part of a new production of garment), recycling (being part of a new production of fibres), combustion (produc-

ing new energy) or send it to incineration and landfill. Analysing the textile industry in Europe about 15-20% of disposed textiles are collected (the rest is landfilled or incinerated), where of about 50% is downcycled and 50% is reused, mainly through exporting to developing countries (Textile Recycling Association, 2005). Increasing the practice of textile reuse, remanufacturing and recycling could potentially decrease the production of new textile fibres and therefore reduce environmental impact. WRAP has developed a specific methodology for quantifying the benefits of reusing products. For example, analysing the reuse of 120 million T-shirts (ca 30,000 tonnes) in the UK every year, it is possible to avoid 450,000 tonnes CO2-eq per year.



[Figure 4] Human toxicity and freshwater ecotoxicity. Re-elaborated from JRC (2007)

[Figure 5] Use phase environmental impact. Re-elaborated from JRC (2007)

3. ENVIRONMENTAL SUSTAINABILITY DESIGN STRATEGY PRIORITIES

At this stage, due to the previous analysis, the design guidelines' priorities were individuated. For every single design strategy, it was defined a priority indicator, based on their potential environmental development. Three main priorities are recognised: high priority, medium priority and low priority (Fig. 6) The design strategy with high priority are: Resources conservation which intent is the reduction of products environmental impact through the responsible use of earth's resources; Toxicity reduction which intent is the reduction of products environmental impact through the minimization of toxic emissions; Use extension/intensification which intent is the reduction of products environmental impact through the extension and/or intensification of the life span of the product or of a single part of it. The design strategy with a medium priority are: Energy consumption reduction which intent is the reduction of products environmental impact through the reduction of the use of energy consumption; Material consumption reduction which intent is the reduction of products environmental impact through the reduction of materials consumption. The design strategy with a low priority is Material life extension, which intent is the reduction of products environmental impact through the materials efficiency.

4.SUSTAINABLE BEST PRACTICES ANALYSIS

Various case studies of sustainable best practice examples, related to the fashion system, has been studied. The objective of this analysis is to learn from the cases the most excellent solutions and to use them as an incentive during generation of ideas for the workshop. This paper describes some of them. Timberland has created a boot builds with a 42% recycled rubber outsole, upper leather from greener tanneries and organic cotton shoelaces. Once you returned, Timberland will take the shoe apart and the soles will be send to a factory in Georgia to be made into new Timberland shoe outsoles; The leather's sent to the Dominican Republic to be refurbished, the metal hardware's either unscrewed and reused in new footwear, the polyester lining's recycled into new products in Japan. For this reason, is also in the interest of the company to have a Life Cycle Design strategy approach, based on extending the lifespan of materials. Threadmiths is another example, a technical apparel company based in Australia that design basics garments with high performance fabrics. They collaborate with a fabric technology company to make a durable stain-resistant technology that is naturally self-cleaning. The fabric can repeal water-based liquids, and this means durability, less washing and detergent and at lower temperatures making it more environmentally friendly. Their Life Cycle Design strategy approach is based on optimizing resources renewability and bio-compatibility.

5.METHOD OF DEFINITION OF SPECIFIC LCD CLOTHING CARE GUIDELINES

All the previous results were the solid basis for the definition of specific Life Cycle Clothing Care guidelines. In this section are described the main phases followed to obtain the tool development both as a handbook and a digital tool.

5.1. Workshop

A workshop was organized with the support of fashion system and design for sustainability specialists. The main purpose of the workshop was to delineate a draft of specific clothing care life cycle guidelines, supported by both, input for the desk research on environmental impact of clothing care, best practices of environmentally sustainable

cloths and the general LCD strategies and guidelines. In the first part of the workshop was made a presentation of the results of the strategic analysis and were discussed the best-case studies solutions; moreover, the definition of design strategic priorities was presented. Subsequently, the product life cycle design ICS qualitative toolkit (developed by the LeNSlab of Politecnico di Milano), has been used to work on the core part of the workshop, i.e. the guidelines specification. The qualitative tool orientates the design process thanks to the eco-ideas tables, with guidelines, which are a set of general design guidelines divided per priority. During this phase the following process has been adopted: specifying a guideline for any type, one or more clothes; erase a guideline for any type, one or more clothes; add a new guideline for any type, one or more clothes; add note/remainder for any type, one or more clothes. After the workshop, a draft of the guidelines was developed; then correctly reformulated and improved for the final handbook.

5.2. LCD specific guidelines

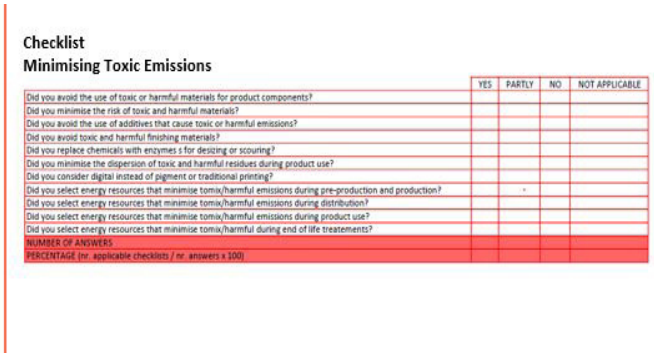
Based on the workshop, the final Life Cycle Design guidelines was been written and organized into a handbook (Fig. 7) and a digital tool (Fig. 8). The project starts with a short introduction on the clothing system and is followed by the environmental impact caused by products, how to evaluate it and the Life Cycle Design method.

The main part is composed by the guidelines, organized by environmental priority. The seven guidelines are the following: 1. Renewable and Bio-Compatible Resources; 2. Minimising Toxic Emissions; 3. Extension of Product Lifespan 4. Minimising Energy Consumption; 5. Minimise Materials Consumption; 6. Improve Lifespan of Materials; 7. Design for Disassembly. In each of the seven main guideline there are specific group of LCD strategies, supported by graphics and tables, that are useful to support the designers during the decision of design making process. Finally, for each guideline has been prepared a check lists, to help the designers and developers to verify to which level the given guidelines have been pursued.

Types of clothes: jackets and coats. trousers and shorts. underwear. skirts and dresses. shoes, sweaters and waistcoats. shirts, t-shirts and tops

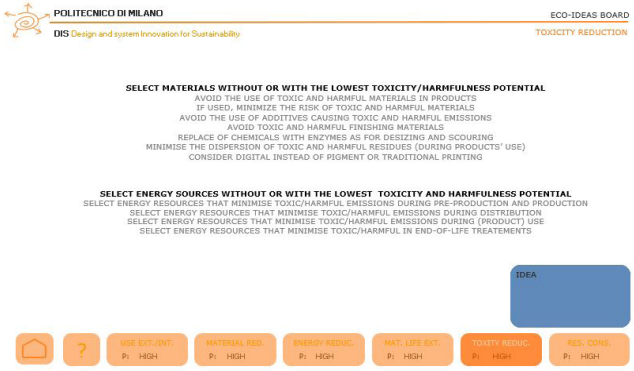
6. CONCLUSION

As discussed in the previous paragraphs, we can assume that the fashion system has a very high impact on the environment. This project is based on the studying of environmental impact caused by the clothing life cycle and outlines the efficacy to use the specific guidelines to support the most promising process to design clothing care with the lowest environmental impact. For the companies and the designer is essential to be consciousness about the envi-


Checklist
Minimising Toxic Emissions

	YES	PARTLY	NO	NOT APPLICABLE
Did you avoid the use of toxic or harmful materials for product components?				
Did you minimise the risk of toxic and harmful materials?				
Did you avoid the use of additives that cause toxic or harmful emissions?				
Did you avoid toxic and harmful finishing materials?				
Did you replace chemicals with enzymes s for desizing or scouring?				
Did you minimise the dispersion of toxic and harmful residues during product use?				
Did you consider digital instead of pigment or traditional printing?				
Did you select energy resources that minimise tomix/harmful emissions during pre-production and production?				
Did you select energy resources that minimise tomix/harmful emissions during distribution?				
Did you select energy resources that minimise tomix/harmful emissions during product use?				
Did you select energy resources that minimise tomix/harmful during end of life treatements?				
NUMBER OF ANSWERS				
PERCENTAGE (nr. applicable checklists / nr. answers x 100)				

[Figure 7] Handbook: a frame from the checklist chapter about minimising toxic emissions



[Figure 8] Digital tool: idea generation board with specific about minimising toxic emissions

ronmental impacts caused by the creation of its products and they have to be conscious regarding the importance of their role. The use of the Life Cycle Design cloth-specific guidelines and checklist tools, it is suggested to be adopted and eventually redefined by both fashion company's and fashion designer in their design and development processes. This project brings from general to product specific Life Cycle Design guidelines, offering a completely new tool for the fashion design system. This tool could be useful for fashion designers and companies to have a support to implement since from the earliest phase of the design process, the correct strategies and to avoid high environmental impacts. Working with this tool could help companies to be orientated and inspirited to develop and to choose design solutions that are environmentally friendly. Thinking about future step, it is important to know that the guidelines could evolve, based on the evolution of society, needs and new technologies solutions and this is facilitated by being the same guidelines and the two tools open access.

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