CLOTHING DESIGN FOR SUSTAINABLE USE:

Social and technical durability

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Abstract

Many life cycle assessment studies document that the most resource demanding phase during the clothing life cycle is the use period. This paper discusses how to reduce the environmental impacts of clothing use by improved design. Complete systems thinking is required, evaluating contributions by all the actors in the clothes' life cycle chain. The use phase should not merely be the consumers' responsibility. Instead, this should be shared and taken into account already in the design and production phase. The improved design could lead to better quality products that also promote more sustainable use, for example by having longer use periods and broader use areas. The design should meet social challenges such as fear of stigmatisation due to using the same clothes several days in a row, or profuse anxiety of body odours, which both may lead to redundant laundering. Some design solutions may involve just providing information, putting the user in control, other design directions may focus on making undesirable behaviour impossible.

The analysis is based on a quantitative consumer survey and qualitative interviews of a strategic selection of households in order to investigate the motives behind clothing disposal, acquisition practices and maintenance habits. From these households, all clothing that would have been disposed has been collected and subsequently analysed in a textile laboratory. This way, information on both the social and technical aspects of disposal has been obtained.

Keywords

Clothing use, Design for sustainability, Systems thinking, Durability.

1 Introduction

In literature, several life cycle assessment (LCA) studies on textiles and clothing have been reported on (Dahllöf, 2004; Madsen et al., 2007). These studies evaluate the total environmental impact of specific products, taking the complete life cycle from cradle to grave into account. Most of these studies show that the use phase is the most energy-demanding stage of clothing items' life cycle. Depending on the energy source, it may also be the most polluting phase. However, when discussing designers' possibilities to increase sustainability, the focus is usually on the production phase. If the use period is considered, the attention is drawn to maintenance, mainly washing and drying. In addition to the maintenance methods, consumers' decisions during use determine the lifetime of clothing. Short lifetime increases the need for products to be replaced faster, thus increasing the environmental load from production and disposal phases. Therefore, in this paper the designers' possibilities for improving the durability of clothing will be discussed, thereby reducing the total environmental impacts. For longevity, both social and technical aspects are of importance.

The first part of the paper discusses the clothing's negative contribution to the environment, concentrating on the specific issues related to clothing use. Related to clothing use, some principles of ecodesign are presented. The following section discusses the research methods applied to get more information of consumer behaviour and which design aspects affect it. Chapter 4 discusses a number of possibilities the designers have for increasing the durability and clothing and thereby reducing the environmental impact. In the final chapter, conclusions are drawn, and recommendations for further research are given.

This paper is a part of an ongoing research project "From textile waste to material resources in a grave to cradle perspective", which financed by the Norwegian Research Council and Orkla ASA. The four-year project was started in 2009 and includes a PhD project for the first author. Project is lead by National Institute for Consumer Research in Norway (SIFO) and it has relevant textile chain stakeholders as partners, including textile recycling companies (Fretex and UFF), clothing and detergent producers (Norrøna Sport and Lilleborg), Nordic Fashion Association's project for Clean & Ethical Fashion (NICE), Department of Product Design of Norwegian University of Science and Technology, and three design schools (University of the Arts London, Oslo National Academy of the Arts and the Swedish School of Textiles). Some of the initial results are presented here.

2 Clothes' environmental contribution

Several LCA studies document the environmental contribution of clothing during the different life stages. However, these analyses on complex textile products often lack specified data, and estimates and generalisations have to be used. Therefore, it is possible that two LCA studies on the same product can have significantly different outcomes (Madsen et al., 2007). One severe uncertainty of LCA studies on clothing is all the assumptions that are made concerning the use phase. For example, in two studies the estimated lifetime varies from less than 10 times use to 104 washes (Bristwistle and Moore, 2007; Collins and Aumônier, 2002). Even if the same lifetime is assumed, the selection of maintenance methods may have significant effect on the results. A LCA study that compared a cotton t-shirt with a viscose blouse showed very different results for these two similar products during the use phase. This study assumed the life time to include 25 washes for both of the products, but estimated that they would be maintained completely differently, thus causing the use phase to be most important for cotton products, but only the third important for the viscose blouse (Allwood et al., 2006). Primary energy profile results from this study combined with another LCA are shown in Figure 1. Only a few extensive real life studies on clothes' lifetime measurements have been made. A Dutch study showed that an average piece of clothing was used about 44 days and washed around 20 times during its lifetime, but that large variations exist; for example the lifetime of skirts was estimated to be twice as long as that of trousers (Uitdenbogerd, 2007). A Norwegian study of 40-year old women's' disposed clothing showed that the garments' lifetime was in average 7 years, but this time includes periods when the clothing has not been in active use (Klepp, 2001).

LCA studies usually document the environmental contribution per product or per weight of products. When reading such results, one has to take into account that the shorter the assumed use phase, the higher the relative impacts from production and disposal periods. Therefore, depending on the length of use period as well as on the assumptions regarding applied maintenance methods, the contribution from the use phase has enormous variations. This indicates that the use phase is of considerable importance, suggesting the need for more knowledge on consumer behaviour concerning clothes acquisition, maintenance and disposal patterns. Such insight will be instrumental for assessing the redesign potential and providing methods to do so.

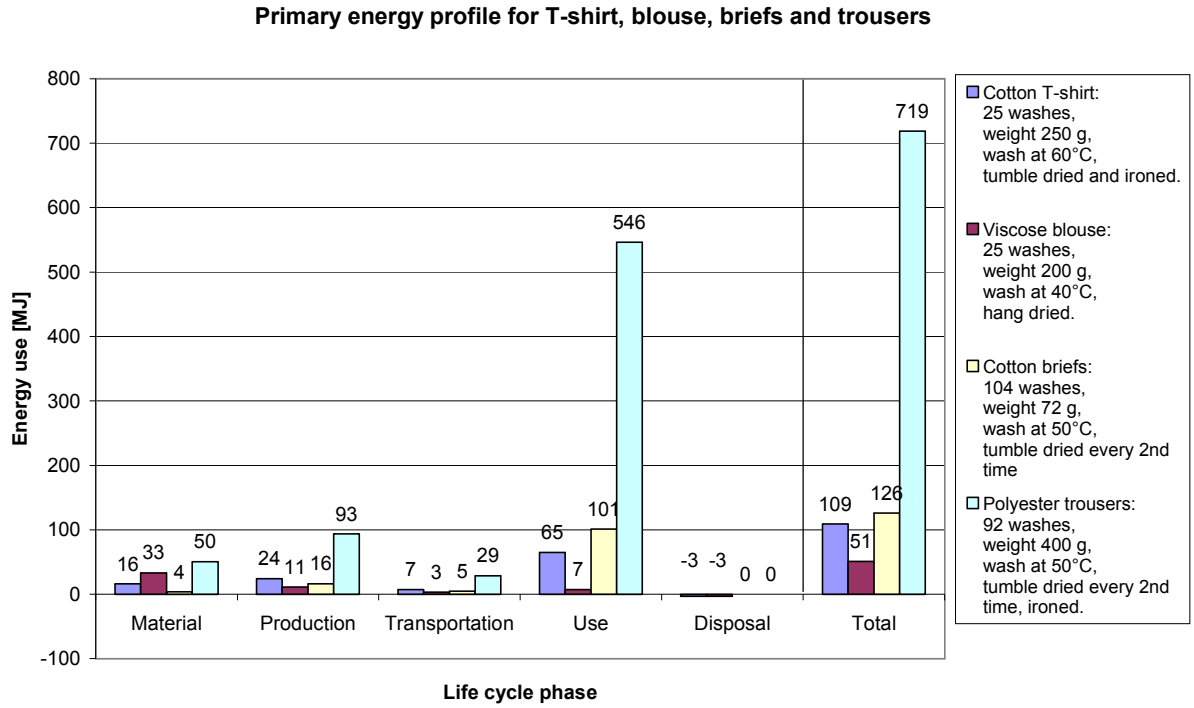

Figure 1: Primary energy profiles for a cotton T-shirt, viscose blouse, cotton briefs and polyester trousers (Allwood et al., 2006; Collins and Aumônier, 2002)

2.1 Clothing stock – acquisition, storage and disposal

One of the possible ways of increasing sustainability within the field of textiles and clothing is to prolong the use period (Fletcher, 2008; Klepp, 2001). Theoretically, if the use period could be doubled and one garment less would be produced, the reduction in the environmental effects from production and discarding phases could be reduced significantly both in absolute and relative terms. This could be valid under the assumptions that necessary changes in production methods would not increase the environmental burden, that the longer active use of that specific product would prevent another product from being manufactured, and that the longer use period would not increase the environmental effects from repair or additional washing, as well as that there would be no other rebound effects. The relative impact of production and discard phases from energy consumption is relatively low for most clothing products, but potentially more intensive in terms of chemicals use and emissions to air and water. Increasing the lifetime of clothing may therefore result in a meaningful contribution to lower environmental impacts.

In Norway, the price of clothing has fallen since the 1995. As a matter of fact, last time the clothing was on the same price level as today was in the 1984 (Andersen, 2007). At the same time the relative income has increased, thus enabling higher purchase power. Part of the higher purchase power is used on buying more clothing, which can be seen in the increased import statistics, see Figure 2. The statistics for year 2007 shows that the imported amount of clothes corresponds to 16.5 kg of clothes per person.

Corresponding to the increased import, the amount of textile waste disposed of in Norway is increasing as well, as shown in Figure 3. In Norway nearly 130 000 tonnes of textile waste are generated annually, which is in total 26.8 kg per person, out of which 10.5 kg per person are coming from households (SFT, 2008). The rest of the textile waste is coming mainly from the service sector and different industries. Charity organisations are doing a good job in collecting clothing for reuse. Fretex (The Norwegian Salvation Army) is Norway's largest collector of second-hand textiles. Together with UFF (Humana People to People) they collect approximately 13 500 tons of clothes every year (Germiso and Tajet, 2007). Twenty percent of Fretex's collected clothes are sold in Norway, while 60 percent is exported and sold abroad, mainly to Asia and Africa. About 4% of collected materials are used as shoddy and rags, and the remaining 16% is thrown away as waste (Fretex, 2009; Hansen, 2000). However, the garments that are unsuitable for reuse lack collection systems, in contrast to the other big waste fractions like glass, paper and wet organic materials. This is a result of the textile fraction being complex and composed of products that are quite heterogeneous and consist of cellulose, synthetic fibres, protein fibres and a range of different chemicals, plastic materials, metals etc, which makes material recycling more complicated.

Clothing recycling instead of throwing away is mainly positive, but in the view of complete life cycle thinking, using the clothing longer and not buying new may be better under the aforementioned assumptions. Other arguments in favour of extending lifetimes of clothing are that recycling has some environmental contributions caused by transport, sorting and selling stages. It has also been argued that the export of used clothing to the third world competes with the local production (Baden and Barber, 2005; Germiso and Tajet, 2007). However, a clear picture taking into account quantified assessments of all types of sustainability related effects (both environmental, economical and social) is not available yet.

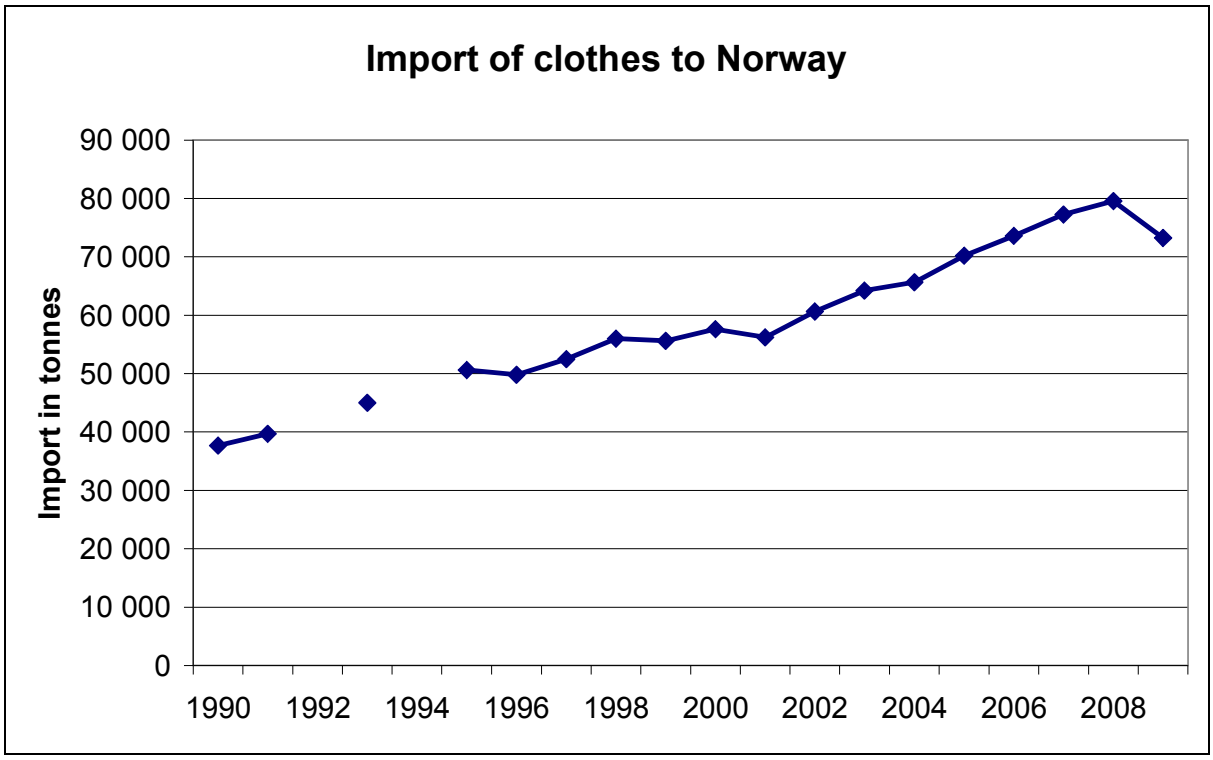

Figure 2: Textile import statistics to Norway (Statistics Norway, 2010a)

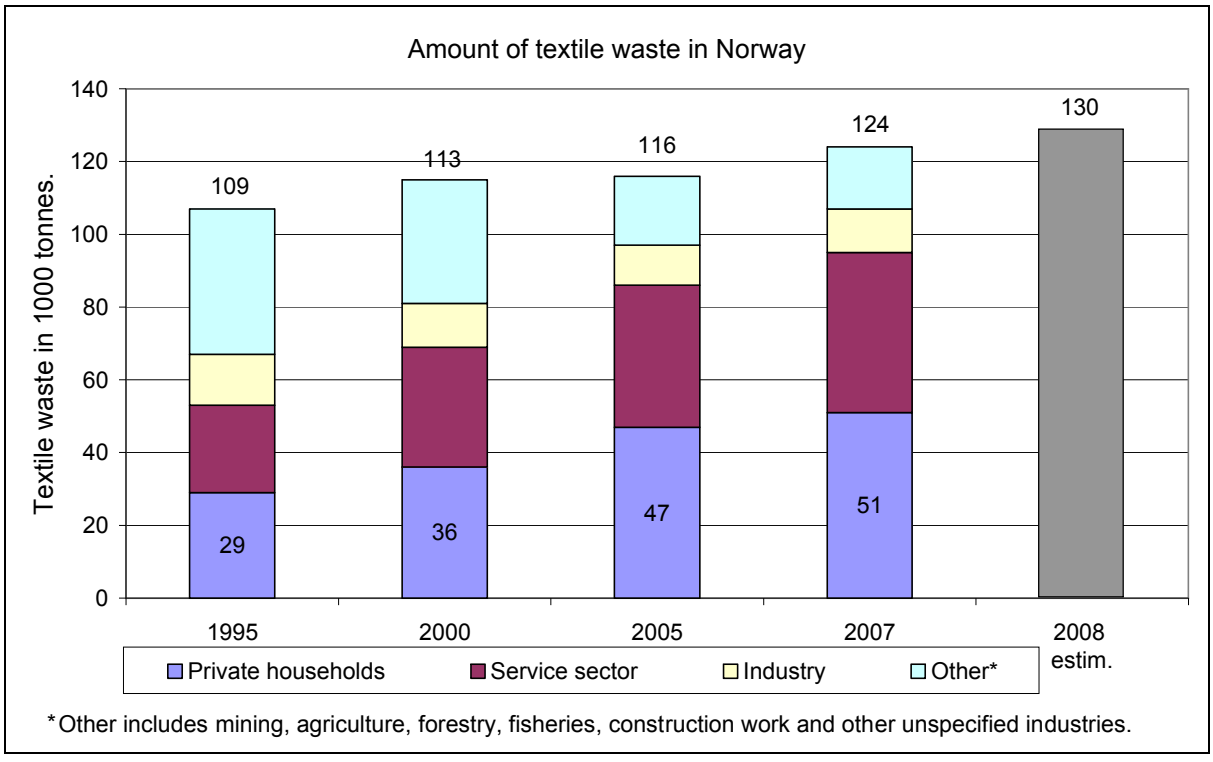

Figure 3: Textile waste statistics (Statistics Norway, 2010b)

2.2 Consumers' clothing use and disposal habits

Some studies have discussed the clothing use phase, both concerning the maintenance habits and disposal patterns. One of the first published models for clothing consumption was developed by Winakor (1969). She described the different stages from clothing acquisition to disposal, including use, care and active and inactive storages. According to her, the inactive storage is a kind of limbo between inventory and discard. This model has been used and developed further by other researches when studying clothing consumption. VeVerka (1974) showed that garments are discarded from the inactive storage when the current use value provided by the garment is less than the current costs of the garment and when the cost of keeping the garment exceeds the costs of disposing of the garment. Cluver (2008) has studied this further in her dissertation, concentrating especially on the complex decision making process between storage and disposal, and why clothes are kept in storage even though they are no longer used. According to her study, several factors exist which prompt disposal versus storage at decision making, including calls from charitable organisations, seasonal changes, need of storage space, changes in life, and identification of suitable recipients.

Klepp (2001) has studied women's clothing habits and reasons for clothing disposal. In her studies se identified several reasons for clothing disposal, and divided the reasons for discarding clothes in six main categories. These categories are a further development of studies made by Packard (1960) and Strandbakken (1997) concerning consumers' product disposal patterns. The division found in Klepp's material is presented in Table 1.

In this study, the informants could give several reasons for disposing each garment. The results show that technical or quality related obsolescence is given as most common reason for clothes disposal, even though a large amount is discarded due to psychological reasons. One of the psychological reasons mentioned is that the owner is tired of the product and wants something new. Another high percentage of disposed clothing is within the sector "never used". Some explanations to this could be unsuitable design (fit, use properties) or mistake purchases such as wrong size.

Table 1: Reasons for disposal of clothes in study of 24 Norwegian women (Klepp, 2001)

Type of obsolescence	**Percentage of total number of registered reasons**
1. Situational (The owner has developed new consumer needs, such as changed body size, has other similar clothes and not enough of closet space, or that the clothes have too narrow use area)	19%
2. Functional (New and better products have come to the market)	1%
3. Technical or quality related (The product is worn out, ruined or is uncomfortable in use.)	35%
4. Psychological (The owner is tired of the product and wants something new, does not use that style anymore, or clothes do not seem modern)	31%
5. Never worn (Product not suitable for purpose. Often bought on impulse or received as present)	13%
6. Museal (The owner takes the product out of use and keeps it for other purpose, does not want to use it in order to not to ruin it)	1%
Total	100%

Similar research was done by Koch & Domina (Domina and Koch, 1999; Koch and Domina, 1999) in Michigan, where they studied which different textiles disposal methods were used, and why clothes were discarded. The five most common reasons for each disposal method are presented in Figure 4. This study had a very different method compared to Klepp's study (2001), as it is based on a quantitative questionnaire with ready made answering options. The answering options for clothes disposal include both why the clothes are given away (did not fit, out of style, damaged or tired/bored) as well as why clothes are given away to specific place (valuable, convenience, helps needy) Due to the difference in focus, the results from these two studies cannot be readily compared.

Koch & Domina's results show that one of the most common reasons for finding a new use area for clothing after the use period is "not to waste it", showing that respondents do not want to throw away clothing when there is an alternative. One of the most common reasons for giving away clothing seems to be fitting problems. Damaged clothing is usually either used as rags or modified and reused.

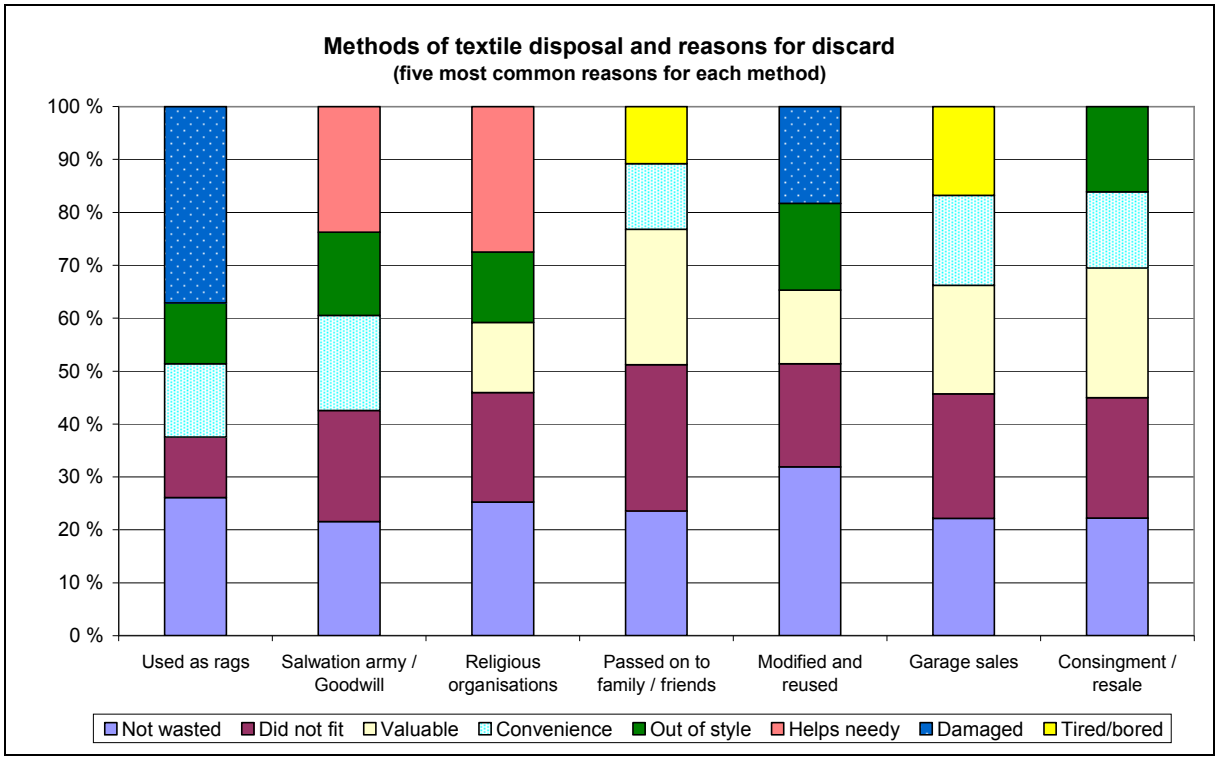

Figure 4: Methods of textile disposal and reasons for discard (Domina & Koch 1999b)

Another study, which included focus group studies and interviews on younger female fashion consumers, revealed that most respondents did not have a specific idea of how long they would keep the clothing (Bristwistle and Moore, 2007). Most kept items as long as they were wearable and said that they stopped wearing clothing acquired from cheaper mainstream outlets, for three main reasons: lower quality, new fashion trend or clothes were bought for one specific occasion. They were more likely to retain expensive clothing, even if they no longer wore it.

Several studies on clothing recycling have concentrated on environmental behaviour and attitudes of consumers, recycling habits and hindrances for environmentally friendly behaviour (Daneshvary et al., 1998; Domina and Koch, 2002; Ha-Brookshire and Hodges, 2009; Shim, 1995). These studies showed that some specific consumer groups are more likely to recycle, and that convenience of recycling plays a central role.

Correct maintenance is crucial for keeping the clothing functional in terms of cleanliness, comfort and aesthetics. In addition to energy, water and chemical usage, the washing also contributes to wear of clothing. Some clothes are not abraded that much due to use, but

more because of frequent washing where the mechanical action, heat and detergents have an effect. Both washing and tumble drying can damage fibres. A scanning electron-microscope (SEM) study of cotton fibres showed that the damages from these two treatments are different. Washing causes fibrils from cotton fibres to separate resulting in reductions in the fibres' diameter, and the fibres appear stringy and peeled. Tumble drying and specially over-drying causes embrittlement and that fibres can snap due to deep cracks (Goynes and Rollins, 1971). Therefore, another motivation to reduce washing and tumble-drying, besides saving energy, is the possibility to save clothing.

2.3 Ecodesign

Ecodesign (also called green design or sustainable design) takes life cycle considerations into account in the design process, trying to systematically reduce the environmental impact (see discussion of these terms in Madge, 1997). Fletcher and Goggin (2001) criticise that ecodesign has been too concentrated on resource use in production instead of concentrating on human choices and actions during use. However, some researchers and designers have started to look into this. Lockton et al. (2010) have introduced some tools for design for sustainable behaviour, which they refer to as "Design with Intent" (DwI). These tools include different "lenses" that the designer can use for opening the view of thinking outside the immediate frames. Some examples of the techniques used for leading the users are choice editing, warnings, portion control, feedback, rewards, colour associations, positioning, and even threatening. The direction, be it through providing information, feedback or through "force" of users, has initiated some ethical questions of limiting the individual freedom, demographic rights or quality of life. Pettersen and Boks (2008) discuss how to balance between the control applied in leading the users towards more sustainable behaviour with the users' rights and free will, and suggest that designers should apply a reflective approach towards the ethical consequences.

In ecodesign literature, several examples can be found in the design of washing machines and detergents that guide the users for more sustainable behaviour, such as the use of eco-buttons or detergent tablets that should secure optimal dosage in wash (Lilley et al., 2005). However, the design of clothing for sustainable behaviour has not been addressed to a large extent in literature yet.

When discussing sustainable clothing, fast fashion and design for durability are two trends worth noting. The former is a defining characteristic of today's textile and clothing industry. It

is a combination of high speed and low-cost production with high speed and volume consumption, which puts pressure on working conditions and environmental standards (Fletcher, 2008). Lee (2003) has given a new term for this trend, calling it McFashion, referring to the similarity to fast-food chain McDonalds because of its global uniformity and predictability, as well as low price. Design for durability, on the other hand, is often seen as a sustainable approach, an antidote to fashion change. The design process consists of improving physical and technical robustness of garments in addition to addressing the emotional and expressive qualities that they can provide for consumers. This may lead to extended use and a longer functioning cycle, thus harvesting environmental benefits (Fletcher, 2008; Hethorn and Ulasewicz, 2008; Klepp, 2001). Tham (2010) describes how fashion and sustainability are often perceived to form opposites, such as fast vs. slow, creative vs. reactive and egoistic vs. altruistic. The neutral ground in between these is often left out in discussions, where a strict division between “the good” and “the bad” is created.

User oriented design is one of the tools that can be used for designing products that will be attractive to the end-users, thus potentially increasing the lifespan. Rosenblad-Wallin (1985) discusses three successful user oriented clothing design projects, and she distinguishes between functional values and symbolic values. Functional values are formed between the user, the product and the actual environment, and include themes such as protection and physical comfort. Symbolic values arise between the user, the product and the socio-cultural environment, such as “belonging to” or “distinguishing from” fellow humans. In addition to these user requirements, external general or superior demands exist, such as legislation, economical, normative and political demands, and so on. The same point of departure is used in a clothing design framework created by Lamb & Kallal (1992). In their model, consumers are in the centre, and clothing design will have to take into account Functional, Expressive and Aesthetic consumer needs (FEA model). In user oriented design, customer involvement can be divided in three different levels, as done by Kaulio (1998):

1. Design for: based on data of users and theories of customer behaviour. Includes often interviews and focus groups.
2. Design with: As the first one, but in addition the customer can react on different proposed design solutions.
3. Design by: Customers actively design their own products with the help of designers.

For further evolution of innovative design, the innovation process should be continuous and feedback from users should be received even after the new products are taken into use. Stewart & Williams (2005) call this innofusion.

The symbolic and aesthetic values of clothing are of great importance for the wearer to be able to function in social settings (Kaiser, 1997). Being inappropriately dressed for an occasion can cause feelings of awkwardness and vulnerability (Entwistle, 2000). These values affect the feelings of self-esteem, respectability, group membership, fashion consciousness, decorativeness, and so on. If some of these principles are not addressed correctly in the design, the clothes often remain unused.

A condition for durability of clothing is that it fulfils the user's needs over time. For this, good design is needed. Unsuitable fit is one of the common functional demands that is problematic and causes clothing to be disposed of before it is worn out. Before the industrial revolution and the mass production of ready-to-wear clothing, clothes were individually tailored according to the user's wishes, thus having a high user involvement in the design process. Today, the mass producing clothing companies usually have confidence in their own internal knowledge and competence, and seldom involve regular users in the product development and design process (Rosenblad-Wallin, 1985). The fashion information is often received from trend forecasting companies, fashion shows and media (Priest, 2005). However, there is a recent movement towards product customisation within mass production, which does give the users an option to be involved in the design process, at least to some degree (for example Nike iD shoes). This may be a useful tool when designing within the terms of mass production but still having possibility to focus on individualisation and user oriented design.

Studies on clothing sizes and fit have shown that the designers and pattern makers do not always have the average consumers in mind when designing their fashion items. When ready-to-wear garments are made, a size sample is often made in a small size (European 36 or 38 for women) and then scaled up to the larger sizes. This process is not very easy, and it has been shown that the variation in large women's sizes are greater than at small sizes and that large women report more problems with fit (Laitala et al., 2009). Consumers with special needs such as disabled users have also severe problems at finding clothing that fits (Thorén, 1996). This indicates that the clothing design process is not always a user-oriented product development, but includes other goals such as fashionable image creation and designing clothes that only fit to population with ideal body size. Of course, there is great diversity in clothes designers' focus, some being more mass marked oriented and others being more concentrated on high fashion or creating own label. Some designers and engineers consider

themselves as users and relay on their personal experiences to be representative for average users. Oudshoorn & Pinch (2003) call this I-methodology, and claim this is an important constraint in the development of technologies that aim to reach users in all their variety. This is also valid for clothes design, where there is a vast diversity of users.

Functional material demands of clothing address basic needs such as physical durability, temperature regulation, wearing comfort and ease of maintenance. Technical material quality is essential for potential long lifespan of clothing. In addition to that, LCA studies emphasise that a certain high quality is needed even to enhance clothing repair, recycling of textile and reuse (Madsen et al., 2007). There exist standards with suggested minimum requirements for durability of some textile products such as upholstery materials (EN 14465, 2003) and personal protective equipment (EN 340, 2003), but there are no requirements available for everyday wear. Most of the international clothing companies have their own quality handbooks where they specify the minimum requirements for their products, but it is uncertain whether these requirements are based on realistic demands. In general, there is a lack of knowledge concerning the relation between laboratory based test results and the real use. Some large test laboratories have possibilities for performing tests with real users, for example concerning temperature and moisture transportation comfort during use, but such tests are very expensive, and cannot really be used for simulation wear and tear in real use.

More information of consumer habits and clothing is required in order to study the possibilities for more sustainable clothing use, and to know more of the designers' option for improving the durability of clothing. The next section presents the research methods this paper is based on.

3 Methods

Due to the interdisciplinary nature of the project and the large number of research themes, different types of data are needed, requiring different methods, including quantitative survey, qualitative interviews as well as laboratory tests.

3.1 Quantitative questionnaire.

Quantitative information of consumers' experiences and opinions concerning clothing use, maintenance and disposal habits was collected through a survey in Norway. The questionnaire included questions of respondents' social background, clothes disposal habits, maintenance routines (washing, drying and ironing), and environmental attitudes. All of the

questions had alternative answers that the respondent could tick off, and in most questions a comment field was included. Each quotation from the survey is presented with a code that gives the gender and age of the respondent.

Questionnaires were sent to 1300 Norwegian households. The addresses were selected randomly from the phone catalogue, but in a matter that the different counties were presented equally based on the number of inhabitants. 60% of questionnaires were sent to men, as from earlier experience we know that men have a lower response percentage. As the response percentage was very low, further respondents were recruited to answer a web-based questionnaire through publicity in various media, including personal, university and work related networks. The questionnaire was available on the net from July 2009 to October 2010. The questionnaire was programmed with PHP and MySQL. The received data was analysed with the help of SPSS software.

By the date of this analysis, a total of 412 people have responded to the questionnaire. The background variables for the respondents are presented in Table 2. Due to the selected recruitment methods, the received data is not representative for the whole population. All of the respondents volunteered to take part in the research, and assumingly often participated because they are at least partly interested in the subject. In addition to that, the second recruitment method excluded respondents that do not have access to the internet due to the web-based questionnaire. The distribution of respondents is uneven with evident female domination (80%) despite the precaution taken. The age group 25-39 is overrepresented in comparison to the average of the adult population, and the oldest age group 60+ is underrepresented. The respondents have higher education than the average Norwegian population.

As the sample is not representative for the population, it has been taken that into account when conclusions are drawn. The cases are not weighted. The results cannot be used for generalizations for the Norwegian population as a whole. However, we still have a large number of respondents that can be compared with each other in the sample, and we can use the sample as an example of consumers in Norway.

Table 2: Respondents divided by background variables and compared to Norwegian population (15 years and older) (Nordic Council of Ministers, 2007)

BACKGROUND VARIABLES	**Sample [%]**	***Population [%]***
GENDER		
Male	20	*49*
Female	80	*51*
	100	*100*
AGE GROUP		
15-24 years	9	*16*
25-39 years	50	*26*
40-59 years	31	*33*
>60 years	10	*25*
	100	*100*
EDUCATION		
Primary and lower secondary school	18	*28*
Upper secondary education	34	*43*
Higher education (university or college)	44	*26*
Other	4	*4*
	100	*100*
EMPLOYMENT STATUS		
Employed (full or part time)	74	*75* [1]
Unemployed	2	*3* [1]
Non working (retired, homemaker etc)	13	-
Student	8	*15* [2]
Other	3	-
	100	-

1) Figure gives percent of employment status of total population aged 16-64 years.

2) Figure gives percent of students of total population aged 15-74 years

3.2 Qualitative consumer interviews and clothes collection:

A strategic sample of 16 households was selected for a qualitative study to collect more detailed information of households' clothing material flow through in-depth interviews. In addition to the interviews, these households collected all clothes taken out of use and filled

in a list of their clothing acquisitions during a period of six months. The informants were interviewed a second time to find out the specific reasons for disposal of each clothing item. These respondents were selected from volunteers that had agreed to be contacted after the quantitative survey. The intention was to interview people with different life situations, age, gender, civil status, children and so on. A semi-structured interview guide was used, where the topics were fixed, but not the exact order or wording of the questions. The questions were formulated in a manner that made the informants describe and reflect on their experiences in a form of a conversation. The interviews were recorded, transcribed, coded and analysed with ATLAS.ti software.

3.3 Laboratory tests on used clothing:

The clothing that was collected from the 16 households was studied further in the textile laboratory of the National Institute for Consumer Research in Oslo. The products taken out of use due to technical reasons such as wear and tear or changes in appearance were analysed in order to see which test methods could reveal these weaknesses and to quantify the technical quality. Based on these results, it will be possible to suggest minimum limits for these properties, which will be useful in the selection of materials for production. By combining the interviews with laboratory tests, information on both the social and technical aspects of clothes can be revealed. The focus is on the reasons for the disposal decisions, and what could be done to increase the lifespan of the products. The laboratory tests are based on standardised test methods and are performed in an accredited laboratory.

4 Results

In the following, the first results from survey, interviews and laboratory studies concerning the durability are presented. The survey respondents were asked for their opinion on what would need to be different in their clothing in general for them to use them longer. Several readymade answering options were given and the respondents could either agree or disagree with them, or suggest other alternative answers. The division of answers is given in Figure 5.

Figure 5: Survey results of agreement on different statements of "I would use my clothes longer if..." N=412

In line with earlier research results as presented in 2.1.2, some of the main reasons for clothes disposal are a combination of technical and quality related aspects, unsuitable fit and the situational/psychological/social reasons (Bristwistle and Moore, 2007; Domina and Koch, 1999; Klepp, 2001; Koch and Domina, 1999). In the following, the durability is divided between technical and social aspects. Issues related to repair are discussed separately.

4.1 Technical robustness and fit

Technical quality issues were the most popular answers among survey respondents' opinions on what would need to be solved in their clothing so that they could be used longer. The most popular answer, better quality in general, was often commented with wish of better material strength. This was followed by problems of clothing changing shape or size, pilling, fit issues and poor colourfastness. Strength, dimensional changes in washing, pilling and poor colourfastness are typical problems that can be prevented by selecting quality controlled materials.

The same problems recognised by survey respondents could be seen in the examination of disposed clothing. Typical problem areas were:

- Pilling and fuzzing
- Colour changes
- Unstable dimensions (especially on knitted clothing)
- Abrasion damages. Typical abrasion areas varied between different types of clothing:
    - Trousers: at lower legs (if too long), between thighs, around pockets and knees (different typical abrasion areas on different users).
    - Jackets: lining seams, elbows, hanging loop.
    - Socks: Heels, sometimes toes
    - Shirts: Collar, cuffs, elbows

These kinds of problems can be solved by material selections, proper sewing and quality control. They could also be taken into account in design, for example by using reinforcements or detachable parts placed on the areas that are most exposed to wear and tear. If the designer does not want the reinforcements to be visible, they could be placed inside the clothing.

Naturally, users are different and their clothing use, habits, background and use situations vary greatly. For example, examination of disposed clothing showed that there is a great difference in opinions on when the clothing is too worn out to be used. These norms are depended on cultural and personal preferences, and therefore, it will not be possible to suggest a technical quality level that will apply for everybody. However, different levels could be suggested for these properties in order to secure minimum durability in use, and increased values for clothing that requires higher durability, such as children's clothing for playing outdoors.

On some types of clothing the wear and tear is more accepted than others, and can even be intentional in the original design. For example, visible changes on jeans are more accepted than on dress pants, and wrinkles on linen clothing more accepted than wrinkles in similar clothing of other materials. This depends on the materials and on the occasions that the clothing will be used. Favourite items are kept longer even if they are worn out, but then used mainly at home, cabin or other private occasions.

In addition to physical durability, other problems that can be solved by design and material choice are for example pressure on body, difficulty of movement and static electricity. These problems were also given as reasons for clothing disposal in the interviews.

Fitting and size problems are one of the main issues designers and pattern makers could address more in order to increase the use period and lifespan of clothing, and to avoid production of clothing that does not get sold due to fitting problems. One solution to this problem is increasing the user involvement in design and trying on sample patterns on different sized bodies instead of only concentrating on small fit model sizes. This could contribute to better-suited clothing for users in different sizes and figure types. For the users to recognise clothing that will fit their bodies, the size labelling could be expanded to include more information, such as figure type or length.

4.2 Social robustness and fashion

Large portion of clothing is disposed due to other than technical reasons, such as social, psychological or other situational reasons. These garments are usually given away to friends, family or charity organisations instead of throwing it out as waste. The respondents often have problems verbalizing the reasons for disposing these items, telling for example “I just don’t use it” or “I don’t like it anymore”. When pushed further, the reasons are varying, for example that clothing feels unflattering to the user, is difficult to combine with other garments, feels outdated or has a colour or print that does not fit the owner’s taste. The latter was often the case when the respondent in the purchase situation had thought they should try some new style or colour they don’t usually use. These items were very little used but stored for a long time before given away.

Washing is related to use even beyond the purpose of cleaning dirty clothes. The results indicate that clean clothing is sometimes washed, because the user feels that it cannot be used again due to social reasons, such as that one cannot go to work in same clothing several days in a row, or that the clothing only could be used in some specific occasions such as formal parties. Many respondents did not want to store used clothing in the wardrobe without washing it first, even if it was only used for some hours and would not have any odour or visible stains. This problem could be solved at least by two different design solutions, either by addressing the storage need for keeping “half-used” clothing neatly and separated from the clean clothes, or by addressing the clothing problem of not being able to use the same clothing several days in a row or at different occasions. Designing solutions

addressing the later challenge could include making adjustments and changes on the clothing possible in order to get variation, to make it look new or to fit different use situations, for example with the aid of styling and accessories. This might even enable smaller number of clothing items to be used for creating several outfit combinations. In the survey, 40% of respondents agreed that they would keep their clothes longer if they would feel less need for having something new. Possibilities to change the clothing could even help to meet this challenge, at least to some degree.

To reduce the need for washing, the garments can be designed with common dirt-exposed areas in mind. Some materials such as wool are naturally more dirt-repellent than others, and wool can also be washed in low temperature. Different repelling treatments could also be used, but then one has to take into account the environmental effects of these materials. The form of clothing is also essential, for example having extra space around armholes can help to avoid the smell of sweat. Another option of designing clothing for durability is to meet the challenge of stains that sometimes are not removed in washing. If the stains are not visible, or if the material would look like the stains belonged to it, the garment could be used longer. A lot of children's clothing thrown away by the families had stains. Even though clothing was often used further within the family when it had some stains, it would not get inherited further to friends or charity when the child had out-grown it, as the parents felt that they could not give away stained clothing.

The results confirm that it may be challenging to design socially durable clothing for mass-market that meets the symbolic and aesthetic demands, as there are so many personal variations in preferences. In this matter, individual tailoring has several advantages. Focus on user oriented design and maybe customisation can offer some solutions to this challenge.

4.3 Mending and repair

The survey results indicate that a large part of the respondents do repair their clothing at least sometimes (figure 6). The same was seen in the interviews, where all of the informants would do the most simple repairs. Different considerations play a role when deciding to repair the clothing or not. The value of a garment is considered important. With value we do not mean only the purchase value, but also functional, symbolic, aesthetic, and exchange values. Therefore, favourite items and expensive clothing are often considered more valuable than other items and therefore are more likely to be repaired, if broken. Type of clothing and its use areas are important as well. For example, holes in sportswear or

children's wear are more often repaired than on more formal clothing. In this evaluation, the visibility of mending is of importance. Very few informants used the repair as a decorative element, which is also a possibility. The designer could also think of the possibilities for planning the garments in a way that the visibility of repair would not matter or could be part of the decorative element.

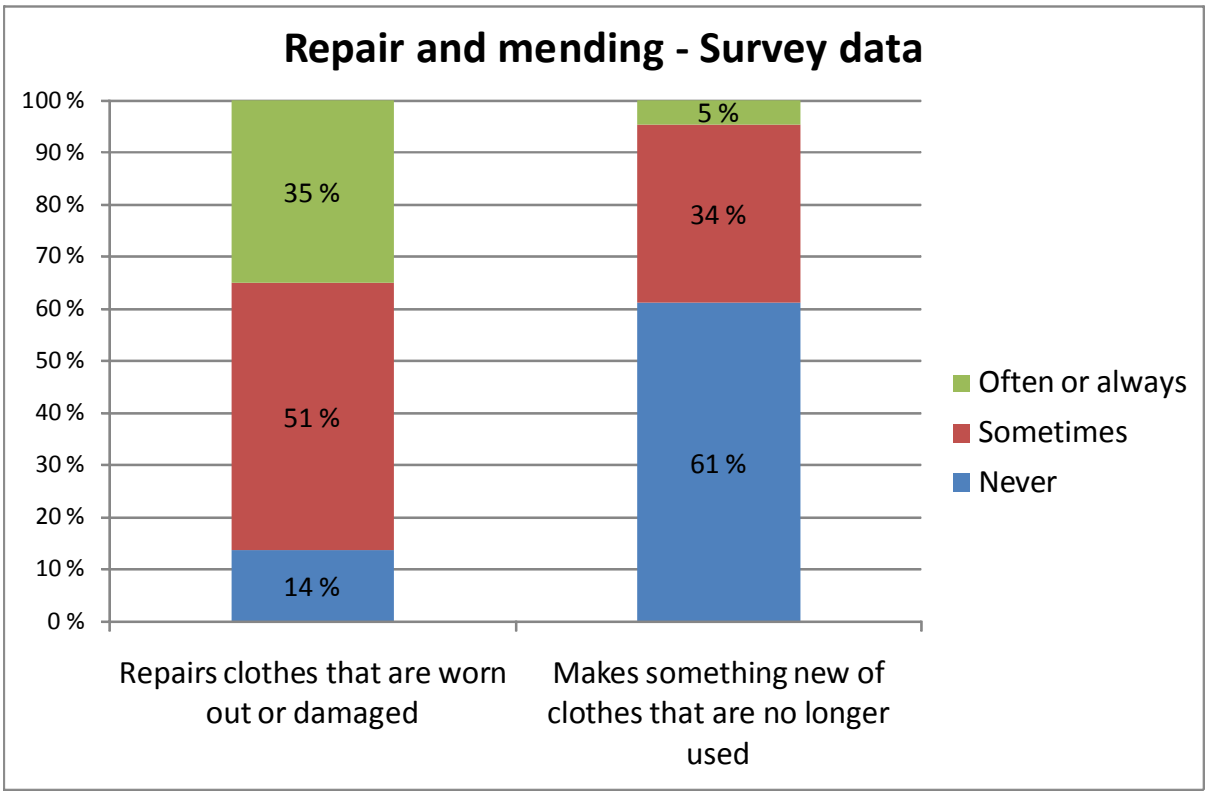

Figure 6: Repair and mending statistics. N=412

The respondents' competence in handicrafts and sewing is affecting partly on whether they decide to repair, and usually easy reparations such as sewing on a button or repairing a seam that has unravelled are most commonly reported to be done. This is followed by mending holes or tears on clothing either by patching or darning. Zipper replacement is more demanding, and most of informants did not try to do it themselves. If the zipper gets broken, the garment is often thrown away unless it is considered to be very valuable. In that case the zippers may be taken to be replaced by professional tailors or by family or friends with more sewing competence, usually mothers. Amending clothing is not that common; some female informants had done it sometimes, but found it often too difficult. Based on the survey, a large portion of respondents had either repaired or had reparations done to their clothing

during the past year. These results are presented in Figure 7, and reflect findings very similar to the interview findings.

The economic situation of the household is also of importance, and more mending occurs in lower income families. However, even some of the high-income families do repair, at least if they have the competence and time. As one of the survey respondents put it: “I would use my clothes longer if I was better at repairing them” (Male, 49 years), indicating that higher competence in this area might help to increase the lifetime of clothing.

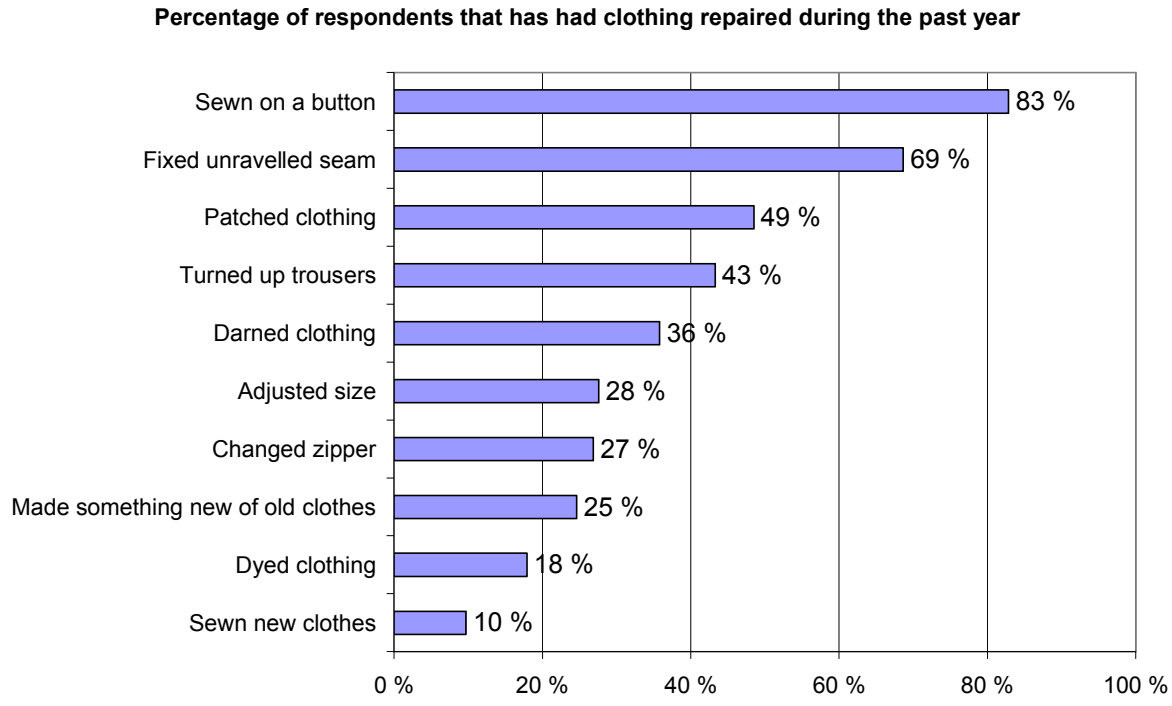

Figure 7: Percentage of respondents that have either repaired or had someone else to repair their clothing during the past year. N=134

It is often found to be a big threshold to start mending clothing, so the clothing often waits for a long time before it is fixed, and then often several products are sewn at the same time, when the sewing machine is finally taken out. Figure 8 shows patching done by one of the informants (female, 31). She said that she often has wear and tear on the trousers in the same area, and did this kind of repairs every now and then.

Figure 8: Patch repair on typical abrasion area of jeans

Designers can have the mending possibilities in mind already when designing the clothing. Seams are important, as there should be enough of allowance to permit adjustments and repair. This kind of techniques are used for example in national dresses in Norway, where the dresses are often used for decades, including the seam allowance for changes in the owner's body, as well as when inherited by a new owner.

5 Conclusions

In theory, designers can contribute a lot, and may positively influence environmental impacts in all stages of the clothing lifecycle. Complete systems-thinking would be required, where all the actors during clothes life cycle chain contribute. That way, the use phase would not just be the consumers' responsibility. Instead, it would be shared and taken into account already in the design and production phases. But even though the technical development within clothing production, washing machines and detergents is significant and very important, and can contribute to the designer's solution space, the consumer behaviour is still crucial. The study reported on in this paper makes clear that users will make the decisions concerning when clothing is purchased and disposed of, and when and how it is washed. Further research will have to contribute to a better understanding of attitudes, values and motives for behaviour, to make better informed design decisions. A number of studies have shown that changes in attitudes and values may have limited effect on everyday behaviour (Ajzen and

Fishbein, 1977; Ajzen and Fishbein, 1980) and that there are several barriers for change, including cultural-normative barriers such as the importance of cleanliness in the Western cultures, where individuals' fear of having a body odour that might be caused by unsatisfactory laundering result may inhibit the change to lower temperature. Other barriers may be individual-psychological and based on earlier experiences or upbringing (Throne-Holst et al., 2008). Therefore, understanding of barriers and designing around them rather than trying to change attitudes and values through design should also be considered as design directions, depending on the activity and behavioural pattern at hand. Some design solutions may involve just providing information, putting the user in control, other design directions may focus on making undesirable behaviour impossible. An additional strategy relevant under most conditions is the application of so-called linked-benefit design strategies. If information campaigns are used, they should consider all possible barriers for change and try to include them in the message. For example, when trying to convince the consumers to reduce the washing temperature, the message should emphasize the good cleaning effect in addition to environmental advantages.

In conclusion, the possibilities for designing more sustainable clothing are numerous. By utilising the information that is received from users and their disposed clothing, new knowledge was obtained on technical and social aspects of clothing that can in theory be used for improved design. In good clothing design, the demands for functional, symbolic and superior requirements have to be addressed. They vary depending on the user, and therefore taking users into account in innovation and product development is crucial. One could identify user groups that the design is aimed at, and include them in the process. However, such recommendations may not fit the reality of the bulk of today's clothing industry, and therefore design strategies aimed at reducing the environmental impacts during the life cycle of clothing need to be evaluated in this perspective as well. This will be part of future research by the authors, facilitated by the wide range of stakeholders in the project.

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