WP T2 – INNOVATION ON TEXTILE WASTE MANAGEMENT

ACTIVITY A.T2.3 PILOT CASES

D.T2.3.4 PILOT CASES FEASIBILITY STUDY

Version 1
12/2019

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This document has been issued within the project ENTeR (CE 1136) thanks to the funding received from the European Union under the Interreg Central Europe Programme (2nd call 2016)

ENTeR - Expert Network on Textile Recycling

ENTeR works in five central European countries that are involved in the textile business, to promote innovative solutions for waste management that will result in a circular economy approach to making textiles.

The project will help to accelerate collaboration among the involved textile territories, promoting a joint offer of innovative services by the main local research centres and business associations ("virtual centre"), involving also public stakeholders in defining a strategic agenda and related action plan, in order to link and drive the circular economy consideration and strategic actions.

The approach of the proposal and the cooperation between the partners is oriented to the management and optimization of waste, in a Life Cycle Design (or Ecodesign) perspective.

CONTENT

1. Pilot case description – aim and scope

1.1. Introduction

“Reduction of the waste generation through prolongation of the service life of textile products”

The pilot case aims to compare the length of the service life of textiles from 100% cotton and from the cotton/PES blends used for hospital service textiles which are designed for the repeated washing. The aim is to demonstrate the prolongation of the service life in case of textiles made from blends and therefore the reduction of raw materials consumption and thereby reduction of amount of generated textile waste (end-of-life textile products).

Relating to the large-scale use of these textiles for medical facilities, there is an opportunity to reuse and recycle these relatively well-defined materials after their physical lifetime. For pilot verification of this direction, it is necessary to create mutual coordination between producers (textiles and protective clothing or bedding), users and, increasingly, industrial laundries offering the rental of these products. Besides the ecological effect and the step towards the sustainability of the material resources, this cooperation may bring additional economic effects; instead of the upcoming landfill and liquidation charges, to create prerequisite for partial compensation of acquisition costs through the recovery of waste in the circulating economy.

1.2. Aims of the study

The main aim of this study is to map the issue of textile waste from industrial laundries processing the linen from healthcare sector. The partial aims that will help to achieve the main aim will be:

- formulation of a questionnaire and completing it by industrial laundries, which will allow input of the information for the study. In order for laundries to be able to objectively fill out the questionnaires, only those who provide leasing of healthcare linen and thus they have the necessary data will be addressed.
- analysis of the quantity and fibre composition of textile waste from laundries processing linen from healthcare facilities
- discussion of the influence of fibre composition and type of linen from healthcare facilities on the amount of waste (or on the lifetime of linen)
- discussion of the influence of technology that processes linen from healthcare facilities on the amount of waste (or on the lifetime of linen)
- comparison of lifetime of 100 % cotton and blended fabrics (cotton / polyester at different percentages)
- a description of the criteria and system for the disposal of linen and methods of textile waste disposal.

Because the laundry sector is a little bit far from the textile technology industry, the study also includes a basic introduction to laundry processing and technical equipment.

2. Recycling of textile waste in the pilot case company - state of art

In most cases, laundries have contractually covered disposal conditions for discarded textiles. In two cases the conditions are set the same for all clients, in two cases the conditions differ individually. In one case the disposal of discarded textiles is not dealt with by the laundry.

There are several parameters for discarding textiles from the use cycle. The most important are the holes, change of colour shade and possible stains. It is also important parameter the reduction the basis weight. Less significant is the number of repairs or the achievement of usage cycles expected.

Decommissioning of textiles is always done in laundries.

Four out of five laundries provide laundry repairs. The vast majority (three of the four answers) of the laundries provide repairs by their staff. In one case they use an external company for repairs.

Discarded linen from one customer or department can be used at about five percent for another customer or department.

The respondents to this questionnaire survey discard nearly 70,000 pieces of medical textiles annually. According to expert estimates it is about 35 tons. This textile forms from 5 - 100% of the total discarded laundry. The share depends on the product portfolio of the laundry.

The surgical laundry care cycles are 100 % monitored by one laundry, three laundries monitor this parameter partially; one laundry does not monitor usage cycles at all. Two laundries discard surgical fabrics when the recommended cycle limits are reached. However, two Laundries continue to use these textiles, provided the surgical fabric does not show any signs of damage.

Laundry employees are partly experienced in the disposal of infectious textiles as hazardous waste. Two of five laundries have already solved this situation. Two Laundries also encountered this problem, but the disposal was resolved by the hospital.

Storage, removal and disposal of discarded textiles

The discarded linen is transported as needed depending on the requirements of the discarded linen customer or the storage capacity. In some cases, 200 kg is carried away, in others 1000 or 2000 kg. The pick-up interval is also different - in some operations every couple of weeks, sometimes 5 weeks, and sometimes every two months.

Only one laundry was able to quantify the exact annual costs. Other companies do not monitor the disposal costs of discarded textiles separately. In addition, the sale of discarded textiles generates revenue in some cases.

There are basically three ways to dispose of laundry:

- pass to landfill (in one case)
- sale for further processing. The discarded textile is used as a starting material for the production of polishing wheels, cleaning rags for industrial operations (engineering, car service, tool shop…), or for the production of non-woven textiles.

- handing over textiles, for example to maintenance department for use in the machinery repairs, or handing over to a hospital that also uses textiles for the maintenance or cleaning purposes.

In many cases, discarded textile is used as secondary raw materials for the production of other technical applications - polishing discs, cleaning cloths, cleaning fabrics, textiles for the furniture industry and many other technical applications.

3. Feasibility study

3.1. Medical textiles market

Global medical textiles market was valued at USD 16,686.6 million in 2018 and is projected to grow at a CAGR of 4.9% to reach USD 23.3 billion by 2025, according to a new report conducted by Grand View Research, Inc. Non-woven segment dominated the medical textiles industry, accounting for 64.29% of global market volume in 2018 and is projected to grow at a fastest CAGR of 5.0% over the forecast period. Woven fabric segment was the second largest fabric segment accounting for 15.38% of the global market volume in 2018 and is anticipated to reach 491.8 Kilo Tons by 2025. In terms of revenue, knitted fabric segment was valued at USD 2,130.1 million in 2018 and is expected to grow at a significant rate over the forecast period. (1)

Based on application, market is segmented as implantable goods, non-implantable goods, healthcare & hygiene products, and others. Non-implantable goods segment is the largest and fastest growing application of medical textiles.

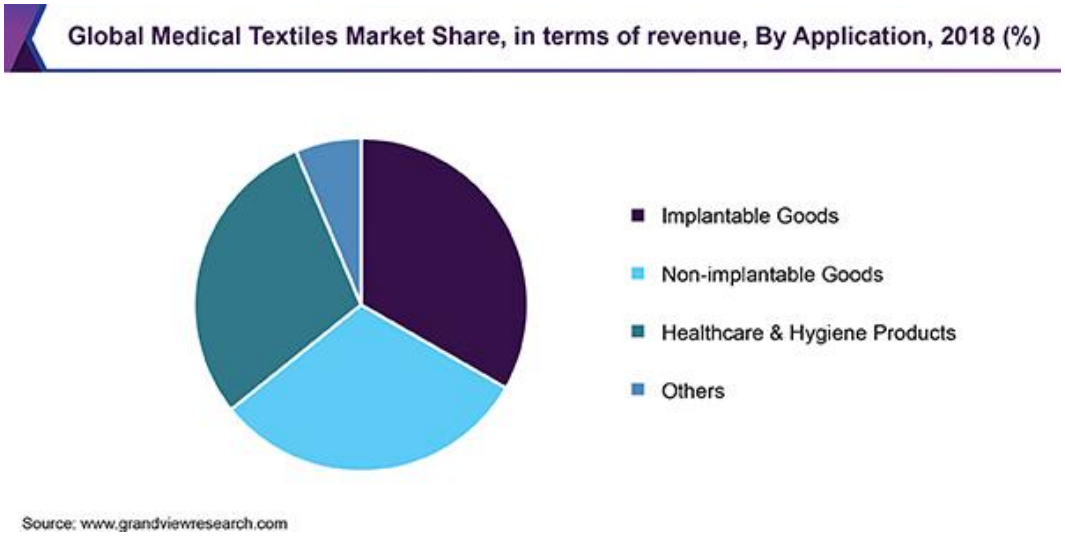

Figure 1: Global Medical Textiles Market Share in 2018 (source: www.grandviewresearch.com)

Rising awareness for better healthcare practices, ongoing technological advancements, regulatory framework mandating the usage of medical textiles, and rising geriatric population are expected to be the major growth drivers responsible for the growth of global market over the forecast period. (1)

In 2018, North America dominated the medical textiles sector with largest revenue share for 32,82 % of overall medical textiles industry. Europe represented the second-largest market share of the overall market; the European medical textiles market was dominated by implantable goods application segment, followed by healthcare & hygiene product. The third largest region in terms of revenue was Asia Pacific with 27,08% market share in 2018; non-woven fabric segment is expected to achieve highest gains over the forecast period in the region, on account of increasing penetration of disposable baby diapers and feminine hygiene products. (1)

In Czech Republic the turnover of the healthcare textiles industry is 268,59 million euros. In Czech market healthcare textiles from following fibers are realized: 100% mercerized cotton (36,9%), 100% PES (24,1%), blend PES/Cotton 65/35 (20,2%), blend Cotton/PES 50/50 (16,5%), other fibres (2,1%). **(2)**

3.2. Medical textiles from blended materials cotton/PES

The increasing percentage of a working clothes of medical staff and patients is made from mixed fabrics with varying proportions of man-made fiber. Improved fabric appearance & durability and ease in handling along with expansion in textile industry are the major properties propelling blended fibres demand. High strength & elasticity, tear-resistant and less prone to pilling & static are key properties supporting growth in this segment. Further, improved shelf-life, wrinkle free and ease in sewing are the other factors enhancing product scope. According to a new research report by Global Market Insights Inc. the b**lended fibres market** share is was over US$ 35 billion in 2016 and will exceed 18 million tons by 2024, estimated to hit USD 57 billion by 2024. **(3)**

Compared with pure cotton with the equal fabric construction, the blends cotton/polyester shows much better mechanical performance (strength, abrasion resistivity, lower pills formation) leading to their prolonged service in the long-term maintenance cycles which is important mainly in health-care sector, protective clothing utilizing leasing laundry maintenance (Fig.1).

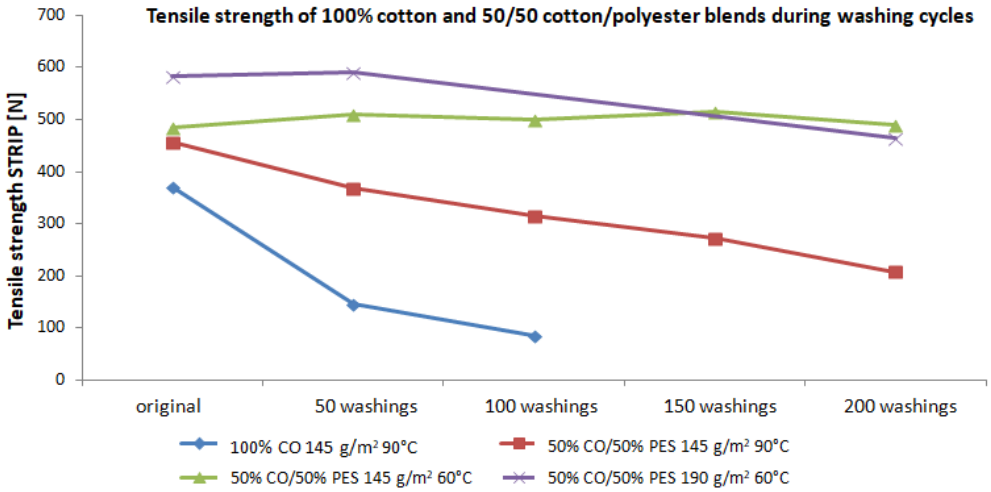

Fig. 1: Tensile strength (STRIP EN ISO 13934-1) of 100% cotton and blend cotton/polyester 50/50 in during repeated washings at 60°C (+ chemothermo-disinfection) and 90°C (harsh maintenance regimes for health care sector) **(4)**

The cotton/polyester blends physiological parameters are also advantageous: the cotton part maintains the high hydrophilicity of the fabric; the polyester part ensures the quick sweat

transport resulting in moisture management properties and quick drying effect which are the basic condition of the wearing comfort.

3.3. Economic evaluation of medical textiles from blended materials cotton/PES - example from the Zdratex project (5)

Within the ***Zdratex*** project (2007 - 2009, the CZ "TANDEM" program) the development of new medical materials for the production of surgical gowns and surgical drapes, bedding and clothing for personnel and patients and functional underwear for medical staff was solved. The research was focused on the development of new constructions and finishing systems. In case of bedding and clothing for staff and patients, the development focused on the replacing of 100% cotton fabrics with blends of PES/cotton (50/50) aiming to increase their durability while maximizing the physiological properties. At the same time was also studied the economic effect of prolonged lifetime, supported also by the reduction of energy costs by the possibility of switching to low temperature washing technology.

The long-term stress tests in participating healthcare facilities confirmed that PES/cotton blended textiles (containing 50%, respectively 55% PES) met all the requirements in terms of comfort and ease of handling. The optimized blended PES/cotton (50/50) construction has shown significantly higher durability of its mechanical-physical parameters in real-life and washing cycles. The mechanical-physical damage values of 100% cotton measured after the 80th cycle of use-maintenance were not achieved in case of the blends even after 200 cycles of comparable washing. The results showed that 100% cotton fabric has a significantly lower durability (at least 2.5 times at washing at boiling (90 °C)) than the blended textiles. This significantly supports the overall economy of focusing on the development standars 50/50. Although its purchase price will be higher, a significantly longer life span plays in its favor.

Within the project, also the economic evaluation of products made of blended materials was provided. The basis for the calculation was a consideration based on at least 2,5 times longer lifetime of the blended products compared to pure cotton, which was experimentally confirmed (see Fig. 1).

Examples of the economic benefits of innovations of medical products solved within the ***Zdratex*** project:

1. *set of clothing of medical staff* (tunic and pants) of PES /cotton (50/50) with antibacterial treatment:
   purchase price: 100% cotton 244 CZK
   for 1 pc of the set PES/co 50/50 284 CZK
   service life 100% cotton 80 wearing - washing cycles
   of the product: PES/co 50/50 200 wearing - washing cycles
   (= 2,5x longer than 100% cotton)

   The purchase cost difference over the service life of 200 wear-wash cycles is 326 CZK per set.

2. *sheets for the medici sector* of PES/cotton (50/50) with antibacterial finishing
   purchase price: 100% cotton 109 CZK
   for 1 pc of sheet PES/co 50/50 159 CZK

service life of the product: 100% cotton 80 wearing - washing cycles
PES/co 50/50 200 wearing - washing cycles
(= 2,5x longer than 100% cotton)

The purchase cost difference over the service life of 200 wear-wash cycles is 113 CZK per 1 sheet.

The economy is an important part of the tenders which are a mandatory condition of supply contracts for health facilities directly financed by health insurance companies. The results show unambiguously that the often prioritized simple purchase price does not indicate the actual effectiveness of the selection. It is therefore advisable to consider the possibility of replacing the criterion for the tenders of healthcare facilities by the parameter "cost per 1 cycle of use". In addition, the new constructions and their functional parameters, in addition to economic viability and profitability, provide scope for meeting the increasing demands of the stricter EU legislation for this product category.

3.4. Dematerialisation as a feasible way towards reduction of textile waste production

Together with rise of the raw materials prices and minimizing of the environmental footprint of products and technologies, there is an increasing pressure to product life prolongation, including optimizing maintenance service. With an increasinf pressure on dematerialisation, it means reduction of a raw materials consumption and products life cycles prolongation, the importance of extending the life of products for PPE (PPE) is also increasing. As a result, the set of steps that include optimizing the choice of fiber compositions and structures used in conjunction with research into optimized (multi) functional adjustments as well as gentle maintenance processes and eventual reactivation of functions during use become part of the innovative solutions. The criteria of cleaner production and the focus on renewable resources also become inseparable. **(6)**

According to Research and Markets, the global PPE market will reach US $ 74.78 bn by 2025 with a CAGR of 7.5% between 2016-2015. Main areas: construction, manufacturing, healthcare. Among the functional treatment for this market segment, which is often the subject of public procurement, are the prevailing demand for flamme-retardant treatments, weather protection; important in terms of volume are also textiles for clothing of medical staff and patients, where not only functionality (protection against nosocomial infections) also the lifetime prolongation is expected. It can be achieved by using blended structures, if the requirements on utility comfort are met. **(6)**

Textiles for the living comfort of an aging population are becoming a new market segment, bringing demand for new functional parameters for long-term home care, ensuring safety and monitoring. Medical disciplines thus bring new requirements also to other special functions - for example, blankets against the effects of laser radiation. **(6)**

According to Transparency Market Research, the global hospital linen market at CAGR will reach 2.4% over the period 2016-2024 of US $ 1bn (Transparency Market Research). Of this, bedding made up 34.4% in 2015. Europe is a leader in the field of medical textiles with a market share of over 40% in 2015. An aging population, changing customer approach to health and hygiene, and the availability of health technologies will have a further stimulating effect on the demand for functional health textiles in the coming period. This will affect the expansion of laundry services in social care services. **(6)**

With the development of tourism, also the volume of hotel laundry increases. According to Czech Tourism statistics, the number of foreign visitors to the Czech Republic increased by more than 10 million persons - ie by + 9.2% compared to 2016. With respect to sustainable growth in countries with growing populations and new mobility opportunities (China, Japan, Russia, Korea,...), the sustained growth is expected – the last numbers are confirming an increase of 5.4% over the first half of 2018 (i.e. 4.8 mil. attendance) of users of accommodation services. **(6)**

Both in terms of sustainable resource availability and in view of the need to eliminate environmental impacts, systematic work on the transition to a circular economy must be launched. Logically, one of the ways is the "dematerialization" of product cycles, which can be achieved by extending the service life of products. The solution shall be on the side of the input textiles as well as in the optimization of long-term maintenance and the reactivation of the most frequently required functional parameters for selected textile categories. Targeting to the protective, professional textiles and ready-made garments, as well as to the volume needs and maintenance of hotel linen products is more feasible than in case of small-consumers products. The benefit of these system solutions is not only a localizable cycle of use and maintenance, but also well predictable material composition and functionalization of products as a prerequisite for the organization of a new waste treatment system. **(6)**

Another factor leading to a significant increase in the durability of clothing and its resistance to mechanical stress in use and maintenance will also be the replacement of 100% cotton structures with cotton / polyester blends using the properties of both types of fibers: the cellulosic component ensures a physiological wearing comfort and the polyester part provides higher strength, durability and faster sweat removal. Prolongation of the fabric lifespan by reactivating functional treatments, milder maintenance regimes (reduced dirtiness), reactivating functional effects and increased application of blended structures in leasing laundries will lead to significant cost savings in terms of the cost of owning goods due to dematerialization and extending the lifetime (it means longer interval of replacement of textiles with high added value) as well as in the costs of laundry maintenance (reduction of maintenance conditions, shortening of maintenance cycles). From the perspective of potential manufacturers, the feasibility of implementation using existing production technologies is also important in order to minimize needed investments. **(6)**

3.5. Public procurement for washing and renting of linen and clothes for medical facilities

The Association of Laundries and Dry Cleaners has developed a methodology for public procurements for washing and renting of linen for medical facilities. The methodology was approved by Czech Ministry for Regional Development. The methodology reccomends a method of awarding the public contract for rental of laundry, its complete maintenance (washing, ironing, repairs, replacement), washing and cleaning of the client's own laundry and logistics related to the laundry. **(7)**

The bids of the tenderers are evaluated according to their economic advantage. The economic profitability of bids shall be assessed on the basis of the most favorable price-quality ratio, including the life-cycle costs - quality ratio. Recommended evaluation criteria are: bidding price 80%, quality - aesthetic and functional properties of the laundry 20%. **(7)**

The best bid in the "Bidding price" criterion is the bid with the lowest bidding price. The aesthetic and functional properties are evaluated by the commission specified by the client in the following

parameters: wrinkles, brittleness and overall appearance of the laundry; material transparency of the laundry; touch sensation, touch and wearing comfort; cutt suitability of a evaluated laundry. **(7)**

The evaluation according to the described parameters on the set point scale (1-10 points) shall be carried out by the members of the commission. On the basis of the sum of the scores of the individual evaluation criteria for the individual tenders, the commission determines the ranking of the tenders so that the most successful bid is the one with the highest total score. **(7)**

It can be seen from the above that the bid price is the main evaluation criterion for public procurement; in contrast, the length of service life is not assessed. This is one of the factors that plays an important role in the fact that state health facilities prefer 100% cotton hospital textiles but having a shorter service life (number of washing cycles) and having more negative impact on waste production.

3.6. Conclusions and recommendations

A survey conducted in the field of medical textiles has shown that the textile renting companies for medical facilities use mixed materials in their practice. These fabrics, with a suitable material composition, provide both wear comfort and durability, which is represented here by the proportion of synthetic fibres. The survey clearly showed that textiles with a chemical fibre content have a life cycle up to a third longer than 100 % cotton products. The results (ENTeR pilot case, ZDRATEX project) show that the criterion “the lowest bidding price” prioritized in public procurements does not reflect the effectiveness of the final selection. Therefore, it seems to be advisable to consider the possibility of replacing this criterion for tenders by the prameter “cost per 1 cycle of use”. Changing the assessment criteria for public procurements to take into account the lifecycle of the used laundry can be an important factor in reducing environmental impacts.

The pilot case results showed that laundries have an efficient way of disposal of discarded textiles in the form of sale for further processing as secondary raw materials. Discarded textiles, after further processing, find use as cleaning cloths, insulating fabrics, cleaning fabrics, polishing wheels or fabrics for the furniture industry. Thus, the principles of circular economics are already applied in this sector - both for the used textile materials (a combination of synthetic and natural fibres and the use of their specific properties) and for the disposal of discarded textiles - the use as secondary raw materials.

The situation is different for hospitals that operate their own laundry. Here, the use of 100% cotton linen, which has clearly shorter lifespan than blended linen, still prevails. The question is also the quality of the purchased laundry, whose main parameter is mostly favourable price. The study provides strong arguments for the purchase of mixed textiles in hospitals. Here, it is necessary to educate the staff of the hospital laundry purchase department, who can prolong the life of medical textiles by appropriate selection of the material composition of the laundry and thus reduce the amount of waste generated.

The second area that offers the potential to extend the lifespan of textiles is the hotel sector. Hotels and other accommodation facilities generally have high demands on the look and handle of the textiles used. Usually it is bed linen and terry textiles made of 100% cotton. The use of blended materials with a predominant share of natural fibres could extend the service life of the material without noticing consumers. This would reduce the environmental impact not only of the textile waste generated but also of savings in the textile care process (lower water consumption).

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