WP T2 – INNOVATION ON TEXTILE WASTE MANAGEMENT

ACTIVITY A.T2.3 PILOT CASES

D.T2.3.4 PILOT CASES FEASIBILITY STUDY

Version 1

Partner:

December 2019

Innovatext - Multifelt Factory

(Hungary)

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)

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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.

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1. Pilot case description – aim and scope

The stakeholder of the pilot case is the Multifelt Factory, which is the only felt producing company in Hungary. The present - new - the owner is highly committed to environmentally friendly solutions, including waste management of quality guaranteeing a win-win position benefiting both the company and the environment.

"Felt" is a term that can be used to describe a variety of different textiles included felted woven wools, synthetics, and industrial felts. Traditionally, felt is a nonwoven textile composed of loose fibres which are matted together to form a coherent material. [1]There are two types of preparation, the needle felting and the wet felting. Multifelt Factory uses the wet felting technology only and produces 100% wool and wool-viscose mixture felts. The felts are manufactured from Merino wool that is typically sourced primarily from Hungary and Australia.

Currently, their waste is generated in the production of industrial and decorative materials, mainly in the form of cut off material edges. Most of them consist of only 100% wool, but the decorative materials contain viscose, and most of them painted. Their paintings meet the STANDARD 100 by OEKO-TEX requirements. The cut edges of the wool felt are too small to sell as felt for decoration and industrial use, so they are out of their business scope. The company needs to find another way to use these raw materials. These smaller parts contain the same good quality wool, so they are potential raw materials for another type of usage. It could be an extra profit if company could find new features of this form of wool. Wool is particularly well suited for felting and is superior to synthetic fibres. Characteristics include inherent durability and resilience as the crimp or bend in the fibres give it natural elasticity. Such flexibility makes it durable and the outer skin of the fiber acts as a protective film, providing abrasion resistance. Lanolin, the thin waxy coating on wool fibres, makes wool naturally resistant to water and soil. Wool readily accepts natural dyes as they can penetrate the core of the fiber and undergo a chemical reaction making the colour change permanent and intensely saturated. In addition, because wool retains moisture in every fiber, it resists flame without chemical treatment. Instead of burning when touched by flame, wool chars and self-extinguishes when removed. Due to these natural characteristics of wool, Wool Design Felt is high quality, sustainable comes in highly saturated colours and is perfect for demanding design applications. Today felt becomes very popular again. The Do It Yourself activities are very trendy and exercised by many people. Lot of them prepare handmade felts, but the machine-felted materials are also popular. Felt is a versatile textile; industrial, home decoration and fashion designers use it, too.

[1] Felts of the nonwoven class are considered to be the first textile goods produced, and many references may be found to felts and their uses in the histories of ancient civilizations. The nomadic tribes of north central Asia still produce felts for clothing and shelter, utilizing the primitive methods handed down from antiquity. Source. https://www.britannica.com/topic/textile/Braiding-or-plaiting#ref359481

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

Multifelt Factory predominantly uses wool, which is particularly well suited for felting and is superior to synthetic fibres. Because of the natural characteristics of wool[2], the Wool Design Felt is of high quality; it is sustainable and comes in highly saturated colours. It suits to demanding design applications too.

The products of Multifelt Factory are highly recyclable. As the felt is made from wool, the resulting waste or the used or worn-out product has also the unique and natural characteristics of the wool.
A fine wool like merino may have up to a hundred crimps per inch. Wool straight off a sheep is highly water-resistant; it retains heat better than most fabrics when wet.

Multifelt Factory uses also environmentally friendly paint (Oekotex). It means that the waste produced at the factory can be utilised in an environmentally friendly way from all points of view.

The two different types of waste generated in the Multifelt factory and their annual volume

In the Multifelt factory, the waste generates from cutting off the edges of felt produced by the factory. Two types of waste predominate the waste from cutting the edges of felt with decoration/design purposes and felt with industrial purposes.

- The quantity of the waste from the felt with decoration/design purposes is around 1 ton/year
- The quantity of waste from felt with industrial purposes is around 300 kg/year.

Different characteristics of the two types of waste in Multifelt factory – determining their reuse

The characteristics of the two types of felt highly differ and so the possibility of their further use varies.

- 90 % of the waste from felt with decoration/design purposes is thin and consists of 60% wool and 40% viscose. It is easy to tear and grind. However, 10% of the décor/design felt consists of 100% wool.
- The waste from felt with industrial purposes is thick and hard. It consists of 100% wool.

2.1. Waste management in Multifelt Factory

2.1.1. Nature of present use of waste in Multifelt Factory

- *Storing*

[2] Natural characteristics of wool are: a) durability; b)

Multifelt Factory has not any mean to use the waste from felt production with industrial purposes. It is put in bags and stored in storehouse within the factory. There is no problem with storing. The factory has enough storing capacity.

- *Previous practice – reusing waste as hobby felt*

Previously the dry felting technique gave the possibility to reprocess the ripped, less fibrous material to reuse as hobby felt. Actually, the stapling machine is lacking and the waste could be only ground. The result would be a powdery material.

- *The present practice of utilisation of waste from decor/design felt*

At present, the waste from décor/design felt is used for art and decoration purposes (like carpet) with manual technique. The available labour force capacity is not enough to elaborate all available waste. It means that also part of the waste derived from décor/design felt is simply put in bags and stored.

2.1.2. The planned waste solution for the company and its benefits

The felt factory was established in 1895 by Kamill Eisner, and since then it has been producing felt continuously. Following a period of nationalisation, since 1990 the factory was privatised in 1990. Since the last year, it has a new owner. The new owner has decided to not only develop the production but also consider doing it in environmentally friendly way, including the best use of waste. So, actually Multifelt Company has to find a proper way to use its waste. The presently planned solution would result the reuse of the valuable material, which is the wool, but at the same time, it should be a product with added value.

However, the first step is the conversion of the waste at disposal presently at the factory, into reusable raw material. The aim of the present pilot project is to find a proper way, methodology and technology to do it. With the help of the Italian company, Cormatex, the present pilot project looks for solutions. Cormatex, elaborating a small amount a waste sample (10-50 kg) in its experimental plant would suggest how to proceed with the waste in concern, what kind of equipment would the factory need for it, etc…

The preliminary idea and target of Multifelt factory are to produce from the waste acoustic panel and sell it. The purpose to reach the needed acoustic characters of the product first would need the proper milling and the casting of the waste at disposal. There is also another idea to prepare from the felt-waste equestrian pavement. It is moulded from a mix of wool and rubber.

The planned solutions would certainly require the acquisition of equipment. If the factory could find the financial means to do so, they would put on the agenda of the day the purchasing of additional waste as well.

In case of eventual highly increased demand for these products factory would use for their production not only the waste but also primary raw material. Hopefully, it would result the increase of the factory's turnover.

3. Feasibility study

3.1. Use of wool waste emerging at the Multifelt Factory Kft.

'The wool supply chain produces huge amounts of pre-consumer and post-consumer woolen wastes, which have found valuable applications in the textile sector. …Valorization of raw wool for non-clothing applications have been developed in two main ranges: (1) applications that exploit the properties of natural wool fiber, subjected to non-destructive pretreatments, and (2) applications that exploit the properties of the keratin biopolymer, which involve fiber solubilization and keratin extraction'…. 'Valorization of wool as a renewable and biodegradable resource has social, economic and environmental benefits, and can contribute to the sustainable development concept.' (Hossein, Rajabinejad - Ingrid-Ioana, Bucişcanu - Stelian Sergiu, Maier (2018), p. 1443 and p. 1452)

Multifelt factory plans to use the insulation properties of its wool waste. According to a source from 2014 (Corscadden et al. (2014)) the manufacturing cost per unit(cost/m2) was around 7, 75 USD.

Table 1 Significant properties of wool insulation materials

Property / Behavior / Characteristic	***Values / Description***
Sound absorption coefficient (500 -2000 Hz frequency range, 60 mm thick)	0.572 at 500 Hz; 0.966 at 2500 Hz
K value - thermal conductivity (W/mK)	0.034 – 0.067 0.034 – 0.048
R value - thermal resistance, 82 mm thick, 17% moisture content (m2K/W)	1.68 horizontal; 1.70 vertical
Embodied energy **(**GJ/m3**)**	0.11
Health hazards	Organic dust release during manufacture, presence of toxic anti-moth agents Growth of mould strains
Health benefits	Improvement of indoor air quality by sorption of VOCs
Environmental impact	Global warming potential LCA profile and biodegradability
Cost per unit – manufacturing cost ($/m2)	7.75

Source: Hossein, Rajabinejad - Ingrid-Ioana, Bucişcanu - Stelian Sergiu, Maier (2018) p. 1444

3.1.1. The present use of wool waste at the Multifelt Factory

Actually, there is produced 1,3 - 1,5 tonnes felt waste yearly. This felt waste, generated from cutting the edges, is put in bags and stored in the storeroom of the factory. Actually, the majority of the waste is not reused or recycled within the factory, it is simply stored. Only a small part of the decoration felt waste is reused for decoration purposes. There are prepared in a small quantity some decorations, rugs with hand technique. There is not available capacity (including human capacity) and/or proper equipment to reuse the waste in a bigger quantity.

The unit price (unit energy cost, any device capacity requirement) of reuse or simply handling of the available felt waste is insignificant and it includes mostly the cost of labour force only used to prepare the products of decoration. As the storage of the major part of felt waste is in own premises within the factory, we can consider it almost at no cost (only insignificant costs are incurred, like of bags, some energy cost, etc.).

The new owner of Multifelt firmly decided to boost the reuse and/or recycling of the felt waste generated at the factory. The owner is looking for good opportunities, products with high value-added. Market research indicates at first place the concrete demand for acoustic panels and at second place the demand for floor panels of horse tracks from mixture of minced wool and rubber. In case of finding the right way and technology the owner of Multifelt is willing to increase the actual producing capacity of the factory and even to buy more waste and/or use regular raw material for these purposes.

Table 2 Indicators – cost and benefits

	Actual situation	The situation in case of eventual capacity increase
Costs	The full cost of waste use (equipment, energy, labour, waste cost)/ /1 m3	Full cost of waste use (including the cost of new equipment, energy, labour, waste cost, including the cost of bought extra waste)/1 m3
Benefits	Income derived from selling the product created from the felt waste	Income derived from selling the product created from the felt waste

Multifelt plans to convert its felt waste in a product with high value added, using first of all a specific property – the sound-proofing/insulation - of the non-woven wool (or mixed) felt.

3.1.2. Recycling Multifelt waste by Cormatex - Running trials with Multifelt material on Cormatex pilot line

- *Creating the prototype of a new product from the wool waste in partnership*

- *Developing an on-line database on the emerging wool waste to sold on the market*
- *To develop more efficient recycling of the wool waste to the production*
- *To develop a more efficient sorting of waste*
- *A generalisation of experiences and lessons gained during the process – to raise knowledge*
- *Creating a widely applicable method and methodology in the re-use of the waste of wool*

The Italian company, Cormatex is approached by Multifelt to help fiberize waste materials to achieve a quality that can be reused in the current process, first to produce acoustic felt. Cormatex elaborated their Airlay Technology. **he advantage of our Airlay Technology** called "lap formair H" (see at https://www.cormatex.it/en/portfolio/lap-formair-h/) compared to conventional carding and cross lapping technologies as well as to other airlay systems **is to be able of processing a huge variety of materials**, including non-fibrous ones. This allows approaching the recycling process of various wastes in an unconventional way. As per the wool felt waste they have already tested with success an approach consisting of a grinding process of the waste to reduce it into granules and then produce a thermo-bonded nonwoven product out of it by using our Airlay technology. The application for the resulting products could be thermal and acoustic insulation, automotive or furniture, as interior design product.

Photo 1 Recycled waste - this is the waste material after grinding

Photo 2 Recycled product - this is a nonwoven product achieved with airlay technology by using up to 85% of the waste shown in the picture above

Stiff products for interior design - these are examples of interior design products that could be achieved with the above shown recycled product. Other applications are automotive or building *construction*.

Photo 3 Stiff products from felt

There is also a solution to integrate Airlay machine into existing nonwoven lines: this could be a way of widening the recycling capabilities of one of the existing lines by reducing the capital investment required.

As part of the pilot project, Cormatex runs trials with Multifelt's waste material on their pilot line. Multifelt collected and sent Cormatex a sample of their waste materials (10 /20 kg) to touch it and run a preliminary test on some of the opening and grinding machine to confirm which approach is applicable to Multifelt's waste.

We have to note, that Cormatex is a textile machinery manufacturer and not just a Research Center, therefore, their R&D activity focuses on real opportunities of selling a machine or a line to the final customer. Whether or not it is worth to purchase machinery is up to how much waste, Multifelt produces (per day, month or year).

3.1.3. Environmental assessment of the planned investment

The environmental assessments of textile reuse and recycling are steadily increasing. As concerns of the proposed project, we have to identify and evaluate its environmental impact. Are textile reuse and recycling always beneficial from point of view of environmental impact?

Authors most often assume that textiles sent to recycling are wastes free of environmental burden, and that reused products and products made from recycled materials replace products made from virgin fibres. But according to the findings of Gustav Sandin & Greg M. Peters (2018) not always. As "benefits mainly arise due to the avoided production of new products, benefits may not occur in cases with low replacement rates or if the avoided production processes are relatively clean. Also, for reuse, induced *customer transport* may cause an environmental impact that exceeds the benefits of avoided production, unless the use phase is sufficiently extended.

Environmental benefits of both reuse and recycling

- Reducing the need for landfill space (also counts when incinerated)
- Reducing pressure on virgin materials and non-renewable resources. (Here we have to mention that as every year a sheep produces at least one new fleece, *wool can be considered a renewable resource* (see: Hossein, Rajabinejad - Ingrid-Ioana, Bucişcanu - Stelian Sergiu, Maier (2018), p.1442)
- Usually resulting in less pollution and energy use than production from new raw materials

We have to answer to the question whether the Multifelt Factory's planned project helps to mitigate the relevant negative environmental effect of the waste?
What is the environmental burden of the product made from recycled waste wool? What is its replacement rate in concern of the same product prepared from the new material? How clean is the production process of the new product and/or the product made from recycled wool?

Measuring PCF and LCA

To measure the environmental impact of the planned investment in practice we have to calculate the product carbon footprint (PCF) and life cycle assessment (LCA) of the particular product. Carbon footprint is one of the most important environmental indicators to be measured in the life cycle assessment methodology.

'A comparative Life Cycle Assessment of different insulators - wool, hemp, mineral wool - showed that the wool-based insulator offered a net negative Global Warming Potential in 100 year timeframe (GWP100) of – 0.323 kg CO2-eq over its entire lifecycle, while the hemp had a GWP100 of 0.345 kg CO2-eq, and the mineral wool had a much higher value of GWP100, equal to 1.2 kg CO2-eq'. (Murphy and Norton, 2008), quoted by Hossein, Rajabinejad - Ingrid-Ioana, Bucişcanu - Stelian Sergiu, Maier (2018) (p. 1445)

3.1.4. Economical assessment

Economical assessment of the planned investment includes to take into consideration the following aspects:

- Quantity/year and quality of wool/felt waste
- Planned investments (equipment)
- Planned operational costs
- Summary of planned financial costs

- Payable demand for the planned product (according to the preliminary market research)
- Planned incomes – net total income (net return investment)
- Sustainability of the production on long run (resupply of raw material that is the wool/felt waste)

As concern Multifelt Factory, the felt waste (that ist he raw material for reuse or recycling) is available in low quantity. It means that economical use of waste (to have a net return on invesment in equipment and technology) requires the acquisition of further felt waste. The production of the products – demanded in the market, like the sound absorbic panels – require investments in machinery and technology. The return of this investment can be guaranteed only in case of a certain economics of scale. In case of Multifelt factory the main bottleneck – which must be observed – is not the market demand for the innovative and (in this specific case) the high value added product but the availability (that is scarcity) of the wool felt waste (the row material). It is aggraveted by the current situation in Hungary – that is there are very few and lately less and less undertakings dealing with wool processing. For example, the last wool washing company was closed at the end of 2003. The Hungarian sheeps' hair (wool) is shipped to countries like Italy, Germany, Austria, etc… Only some of the already processed wool returns to Hungary for further elaboration. Further, as concerns the (wool or mixed) felt, Multifelt is the only factory to deal with this material. It means that the first step for the company is to find the sources to get raw material (wool felt waste) in the needed quantity to guranatee the economics of scale of their future production, even from abroad (importing felt waste). Furthermore, there are some other difficulties to overcome, like being a small (micro) company, has to find the way to cover the investment into the needed equipment and technology. Also, Multifelt, has to find the way to have the adequate quantity and quality of labour force which is not easy during the present labour market conditions in hungary (skilled labour shortage and rising wages).

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