



100% EU Wool innovative car mats

Waste prevention, High Performances and.... Fashion

EU SHEEP POPULATION

EU-27 has the second world sheep population, numbered about 90 million heads.



EU-28:

90 M sheep

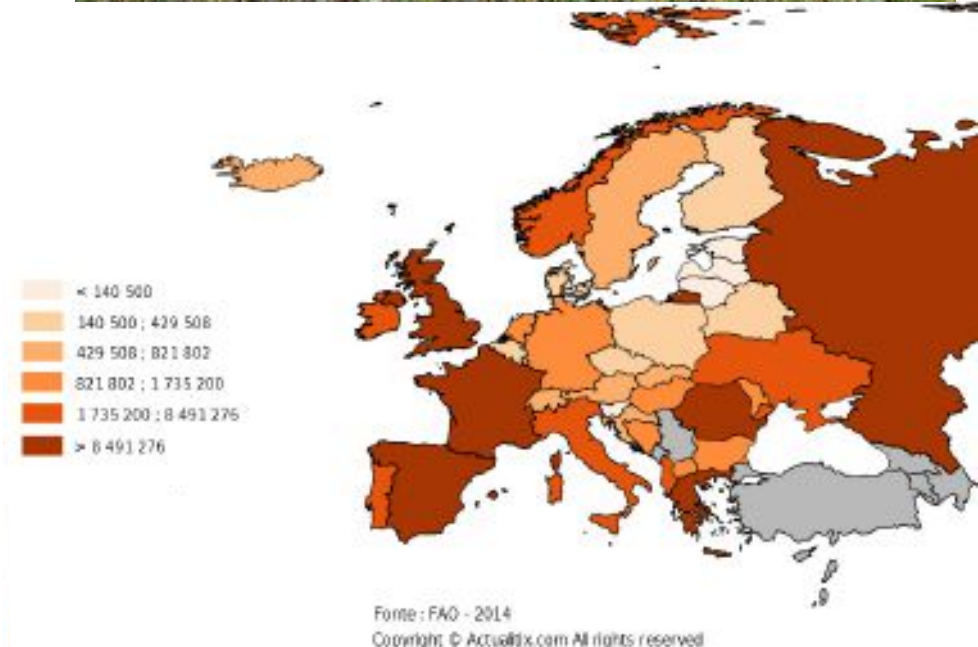
82,5% in seven Countries: UK (25 %), Spain (16%), Romania (11%), Greece (10%), Italy (8%), France (8 %) and Ireland (4,5%)

(Source EU-Eurostat 2018)

Italy:

70% in 4 Regions:

Sardinia, Sicily, Lazio and Tuscany



PRIMARY ROLE OF SHEEP HUSBANDRY IN EU

EU sheep are generally not graded for fine wool production, since they are prevalently bred for **meat** and **milk**. These kind of sheep produce **low quality wool**, in contrast to wool from sheep selected and bred for fiber.

Europe is **not self-sufficient** for sheep meat. Finding application and profit for low quality wools may help to **increase EU sheep breeding**, reducing meat import from overseas.

Meat: 1 Mt (80 % self-sufficient in 2018)

20% import from New Zealand and Australia

(Source: EU- CMO Management Committee, *EU SHEEP and GOATS Meat Market Situation, 2018*)

Milk: about 5 Mt (Southern EU)

EU WOOL

Most EU wool, which is generally coarse and heavily contaminated by dead fibres (kemps), is practically unserviceable for the textile industry. The traditional use for filling mattresses has been actually outclassed by synthetic materials, so that the market for EU wool is currently confined to local handicraft niches, carpeting or insulation boards for green architecture, which absorb about 20-30 % of the total annual clip.

Nevertheless, annual shearing, necessary for the animal welfare, produces 1,5-3 kg/head of coarse wool.

**EU Wool is a by-product of sheep farming
> 200 000 t/y in EU (14-16 000 t/y in Italy)**



EU WOOL USES



Best quality (25%)



Clothes & carpets

Best quality wool, which accounts for only 25% of total EU wool, is used for conventional clothing or for carpets manufacturing.



Low quality (75%)

WOOL WASTES

Cat. 3 waste

(EU Comm. Regulation n.142/2011)

Shearing, storage, transportation and disposal of waste wool (in accordance with the current EU Reg. N° 142/2011 for Class 3 Materials), heavily weigh on the profit of sheep farming. Poor quality wool is a large volume solid waste which is mostly disposed in landfill, or illegally thrown over, with ambient threat and infections risks.



INNOVATIVE WOOL MATS FOR CAR CARPETING

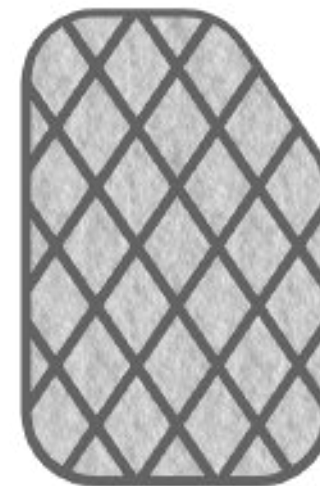
Currently, car mats are the most consumed car components. They typically consists of one or more layer of backing (mostly **polypropylene fabrics**), joined by CaCO_3 filled styrene-butadiene **latex rubber** (SBR), and face fibers (majority being **nylon 6** and **nylon 6,6** textured yarns) tufted into the primary backing.

The project idea is to develop innovative car mats made of 100% coarse wool from EU sheep farming.

The upper layer is made of 100% wool felt, and the lower layer is made of protein adesive made of partially hydrolysed wool that stick the fibres replacing rubber latex. Silica form carbonised rice husk is used as fillers to impart both abrasion resistance and black decorative patterns.



Current car mat (polypropylene, nylon, dyes, filled latex backing)



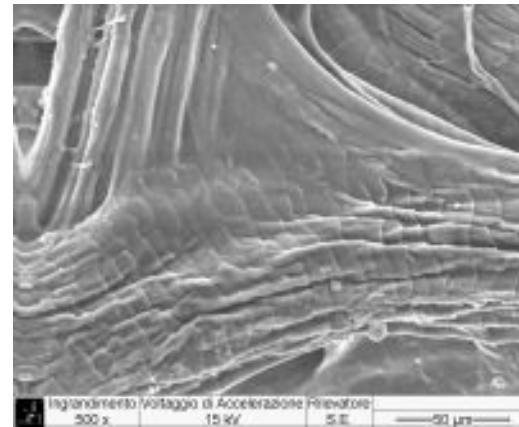
Innovative wool car mat (waste wool, wool protein layer, filled with silica from carbonised husk)

THE BASIS OF THE PROCESS: WOOL IN ALKALI

Wool is made of keratin, a natural protein which is stable in neutral and acidic media. To the contrary, wool fibers in mild alkali solutions and controlled conditions (temperature and time) undergo a partial disruption producing a protein glue that sticks the remaining fibers each other. This reaction will be applied for the production of the innovative 100% wool car carpeting.



Alkali



SEM 500x (source: CNR- BI)

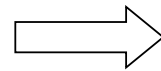
- Partial protein hydrolysis
- Partial disruption of fiber structure resulting in the adhesive matrix

FILLER: SILICA FROM CARBONISED RICE HUSK

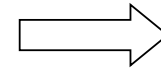
Rice husk is the hard protecting covering of grains of rice and represents an organic waste produced in large amount. It's the major by-product of the rice milling and agro-based biomass industry. Rice husk is a cellulose-based material which is burnt for fuel, producing energy and ashes with approximately 90% silica.



Rice husk



Carbonized rice husk ash



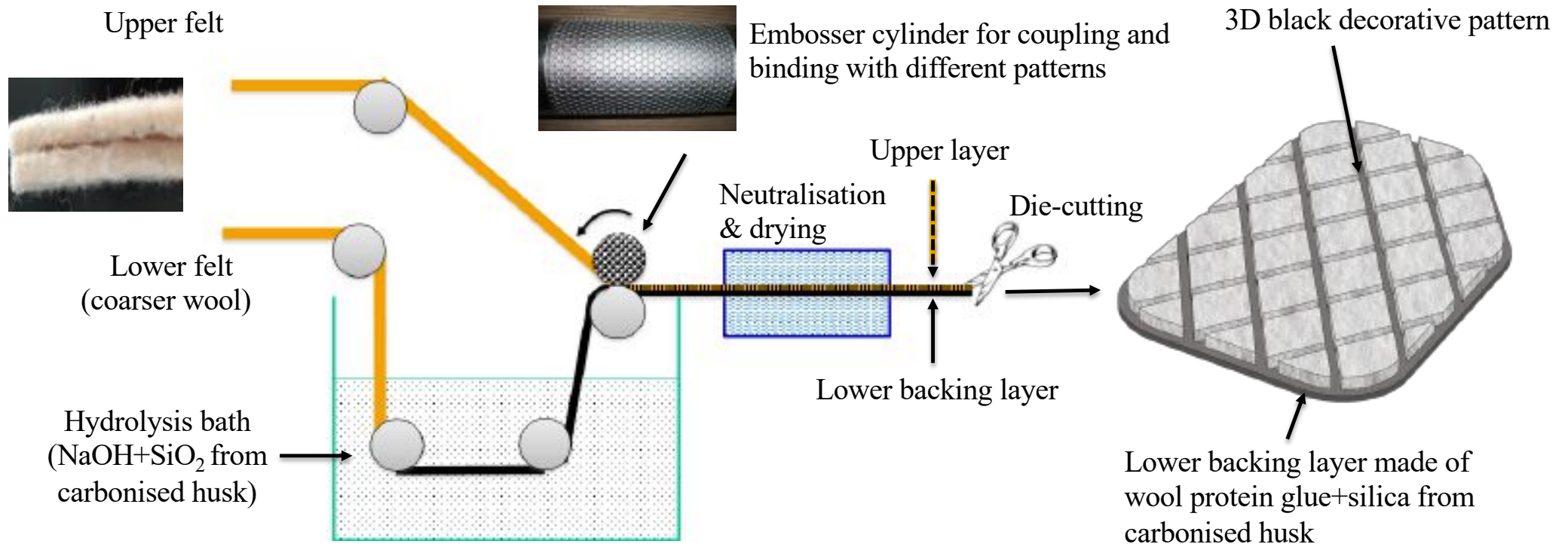
Tyres

Silica is already used in tyre manufacturing: it increases tyre's wet grip and cuts its rolling resistance by around 30%, that translates into a 5-7% reduction in fuel consumption.

Some of the most important companies, already use silica from rice husk ashes as filler for rubber compounding, reducing the use of "carbon black". They verified several benefits like more grip and abrasion resistance.

Added to the innovative car mats, silica is expected to improve abrasion resistance in addition to impart black decorative patterns.

PROCESS LAYOUT

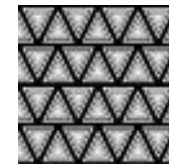
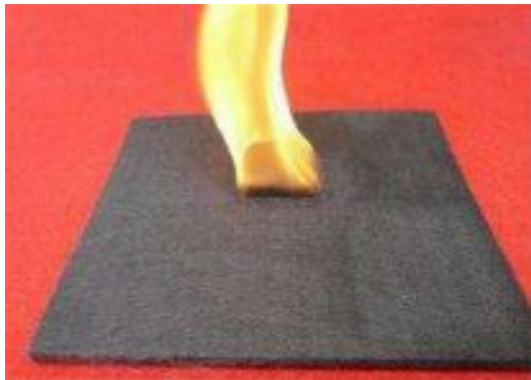


The lower felt is treated with a mild alkali solution to produce the protein adhesive by partial hydrolysis of the wool fibres. The adhesive laminates, penetrates and binds the upper felt to the lower one by compression of the embosser cylinder. Patterns are made by the black protein glue that stick the fibers from the two felts each other. As with conventional latex, lamination is improved by small amount of mineral fillers such as silica from carbonised husk which also give black decorative patterns and resistance to abrasion. After coupling the mat is neutralised, dried and die-cut.

EXPECTED PERFORMANCES AND BENEFITS



Since wool is self-extinguishing (LOI > 25) and silica improves flame resistance it is expected that the carpets will be **flame-retardant**.



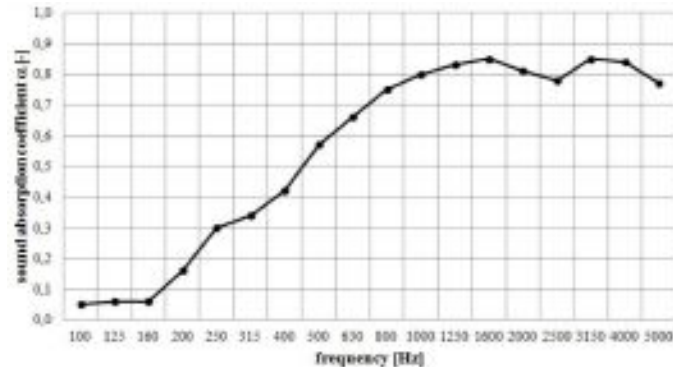
Silica from carbonised husk impart better **mechanical properties and haesthetic effects** so that dyeing is not needed.



EXPECTED PERFORMANCES AND BENEFITS



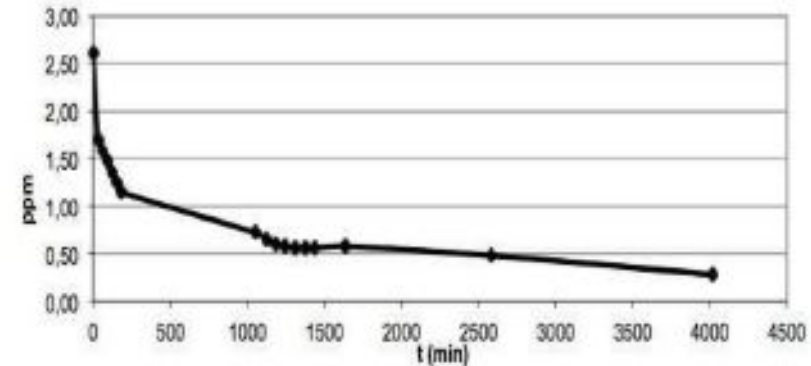
Wool displays excellent **acoustic properties** at high frequencies **reducing noise**.



Sound absorption properties of wool



Wool absorbs formaldehyde and other volatile organic compounds (VOCs) contained in car exhaust gases thus **improving the quality of the car interior air**. Wool permanently bound formaldehyde which is not released anymore.



Absorption of formaldehyde by wool vs time

ESTIMATED COSTS



Raw materials

EU wool is essentially perceived as a by-product to be disposed of. Therefore, the cost of 1 Kg fiber should be estimated as follow:

- sheep shearing: 1 euro
- wool scouring: 0,7 euro

Process

The fabrication of the wool felt and the process to produce the innovative car mat is expected to be not higher than 2 euro/Kg due to the easy process and low costs of the ingredients.

Yield

Since the weight of a single mat should be about 500 g, the estimated cost should be lower than 2 euro.

END-OF-LIFE

The innovative wool mats may be recycled and valorised at the end of their life. Indeed, they are made with materials suitable to be recycled or transformed into amendment-fertiliser for agriculture.

Wool has already been transformed into organic nitrogen fertiliser by green hydrolysis conversion with superheated water (LIFE 12 ENV/IT000439 GreenWoolF project-<http://www.pdc.minambiente.it/en/node/1722>).



WOOL AND SILICA FOR AGRICULTURE

Properties of wool hydrolysates

- Protein hydrolysates (amino-acids and low molecular weight peptides) are permitted in biological agriculture;
- N release (and other nutrients to plants) can be tailored;
- Protein hydrolysates display bio-stimulant properties (soil microbic activity) and are suitable for foliar-feeding;
- Protein hydrolysates display chelating properties for micro-elements (Fe, Cu, Zn) and may reduce the use of chemical fertilisers and complexing agents such as EDTA.

	N (%)	C (%)	C/N (%)	S (%)	K (%)	P (ppm)	Microelements
Raw wool	8	32,5	4,27	3	2,33	491	(Cu, Zn Mn)

Chemical composition of carbonized rice husk ash (RHA)

Oxide	RHA (%)
SiO ₂	91.40
Al ₂ O ₃	0.48
TiO ₂	0.00
Fe ₂ O ₃	0.02
MnO	0.37
MgO	0.35
CaO	0.50
Na ₂ O	0.00
K ₂ O	1.50
P ₂ O ₅	0.18
H ₂ O	5.63
Total	100.40

Source: J. Agron., 10 (3) : 99-104, 2011

Source: Dep. of Agricultural Science, University of Turin

IN CONCLUSION

Wool is a traditional fibre used for high quality, conventional garments, but coarse wool from EU sheep farming is unsuitable for clothing.

Nevertheless, coarse wool has excellent technical properties suitable for non-clothing applications such as components for car's interiors.

This proposal describes an innovative car mats made of 100% replacing both synthetic fibres, dyes and SBR latex.

The innovative car mat will be flame retardant, resistant to abrasion, will improve car interior air absorbing VOCs and reduce noise. New fashion effects may be imparted by Silica from carbonised husk applied by embosser cylinder so that dyeing is not needed.

The composition of the innovative car mat make it suitable to be recycled or transformed into amendment-fertiliser for agriculture.

This technology will enable to produce car mats that are even more environmentally friendly and better performing than those currently produced and recyclable at the end of their life.