Interreg Alpine Space | Co-funded by the European Union | Woolshed

D.2.1.2 Portfolio of Demands for Wool-Derived Materials

Connecting Wool Resources with New Market Opportunities

WOOLSHED ALPINE SPACE

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Abstract (for public dissemination only)	A snapshot of emerging uses for wool in fashion, design, architecture and agriculture, revealing where creativity meets circular economy.
Keywords	Market trends, Circular design, Wool applications, Creative industries

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Executive Abstract

This portfolio presents a comprehensive overview of the demand for wool-derived end products, compiled to support the development of a practical and effective resource-matching optimization model within the wool industry. Its primary objective is to document, categorize, and clearly articulate the performance and specification requirements of wool-based products across diverse sectors. This structured approach enables more informed decision-making and facilitates efficient alignment between supply and demand throughout the wool value chain.

Drawing on data from sectors such as fashion, construction, agriculture, and beyond, the portfolio offers a detailed catalogue of end-use applications. This information serves as a foundational input for the matching software tool, which connects specific product demands with the appropriate processing pathways that convert raw and semi-processed wool into market-ready goods. By organizing this data systematically, the portfolio ensures that the optimization model can accurately align available wool resources with tangible product opportunities.

The optimization model leverages the insights from this portfolio to enhance economic outcomes while minimizing environmental impacts. It incorporates key constraints such as demand thresholds, quality standards, and sustainability certifications. As such, the portfolio functions as the demand-side counterpart to the wool resource catalogue, forming a critical basis for strategic decision-making within the optimization framework. It supports stakeholders in navigating the complex interdependencies between material availability, processing capabilities, and product specifications.

Through regular updates, this portfolio will continue to serve designers, SMEs, processors, sustainability experts, and policymakers, empowering them to make informed, strategic choices that drive profitability, competitiveness, and sustainability across the wool industry.

Scope and Analytical Approach

The development of this portfolio follows the methodological framework outlined in Deliverable D1.1.1, which details the systematic documentation and characterization of product requirements, transformation processes specifications, and market expectations across the wool value chain. To support the creation of a robust optimization model, the portfolio organizes comprehensive information from all relevant application sectors, ultimately defining the key characteristics required for wool-based end products.

Each demand entry in the portfolio includes detailed descriptions of attributes essential for effective resource matching and optimization. These attributes encompass fibre quality ranges, colour specifications, acceptable lanolin content, mechanical performance criteria, certification requirements, and minimum lot sizes. By indexing and linking these parameters to the corresponding processes and raw or semi-processed inputs documented in the companion resource catalogue, the framework ensures seamless integration of demand-side data into the optimization model.

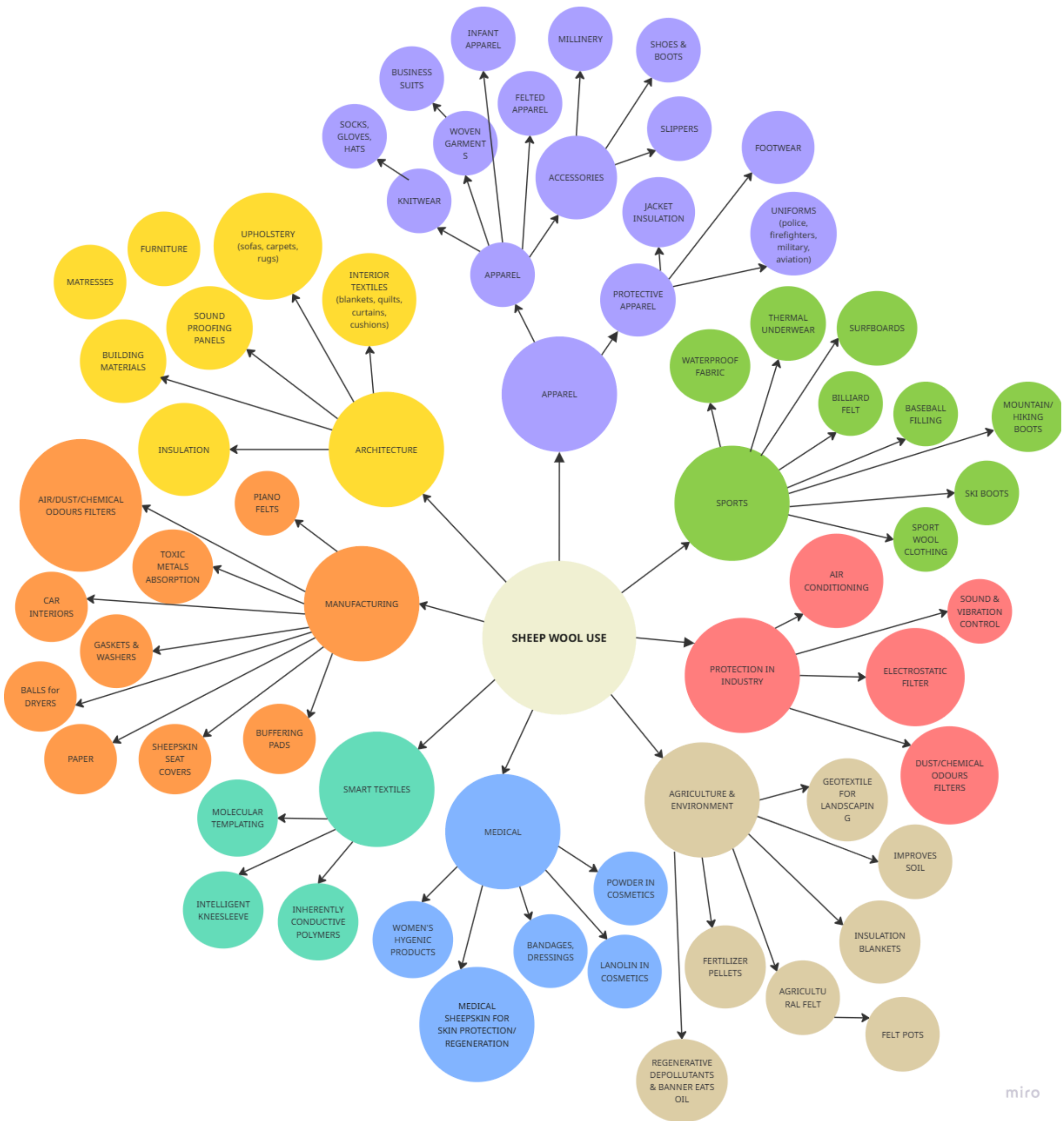


Figure 1 Some examples of the sheep wool use for production of goods in diverse sectors.

Figure 1 illustrates the various segments within the wool value chain where product demand originates, as identified in the collaborative mapping exercise executed in collaboration with WOOLSHED project partners.

The structured demand data compiled in this portfolio serves as the basis for generating input data rows for the optimization model. These data rows encapsulate the critical requirements of each product type, enabling precise matching of available wool resources to specific product demands.

Figure 2 presents an example of a demand data row, populated with placeholder values. This format captures the essential characteristics of a wool-derived product, including technical specifications, processing needs, and associated economic and environmental considerations. Such structured data is vital for identifying optimal valorisation pathways and ensuring that each wool resource is directed toward its most suitable and sustainable end use.

Index	Product	Input From	Applications	Price (€/kg)	al Impact	Required (	arket Dem
P1	Worsted Yarn Textiles	Co1	Suits, knitwear	40	10	1.2	5000
P2	Woollen Yarn Textiles & Felts	Co2	Tweeds, blankets, felts	30	8	1.3	7000
P3	Building Insulation	NW1	Wall insulation	12	4	1.1	12000
P4	Technical Felts	NW2	Industrial applications	20	3	1.15	6000

Figure 2 Example demand data row required for the optimization model that should be filled in with placeholder values

By integrating the resource and transformation processes datasets (Deliverable 2.1.1) with the demand-dataset (Deliverable 2.1.2), the optimization tool will be equipped to enhance supply-demand compatibility. This integration supports the strategic allocation of wool resources, maximizing value creation while promoting environmental sustainability across the industry.

Final Product Block definition

The optimization software tool for the wool value chain is built on a modular structure composed of interconnected blocks, each representing different stakeholders and stages within the value chain. As outlined in Deliverable 2.1.1, the Final Product Block defines the desired characteristics of the end product to be created using wool or its derivatives.

Unlike the Raw Wool Characterization and Process and Transformation Blocks, the Final Product Block does not receive a Specific Input (SI). Instead, it functions as a target configuration, specifying the desired characteristics of the Specific Output (SO) from the final process block in a given value chain. This relationship is illustrated in Figure 3, where the direction of the arrows is reversed compared to the preceding blocks. The data structure mirrors that of the SO but is defined as Expected Properties (EP).

The EPs play a critical role in shaping the architecture of the entire transformation pathway. They guide production planning and ensure alignment with the capabilities of the supply chain. The detailed configuration of EPs is influenced by several key factors, including:

- Market-driven demand for the product
- Expected form of the resource (e.g., packaging, fragmentation)
- Desired final product quality
- Required quality characteristics of intermediate products
- Acceptable cost levels for resources, raw materials, and components
- Desired environmental, social, and economic attributes
- (Optional) Traceability and certification of origin and processing stages

By defining these parameters, the Final Product Block ensures that the optimization model can effectively align production outputs with market expectations and sustainability goals.

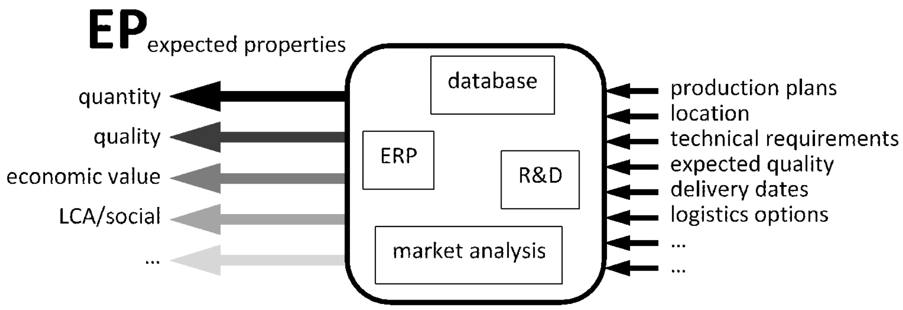


Figure 3 Final product block

Definition of wool quality in the context of WOOLSHED optimization software

An optimal value chain can only be achieved when suitable resources are directed into appropriate downstream conversion processes. The WOOLSHED optimization software enables a truly quality-driven value chain definition by integrating data on location, availability, quantity, and quality of wool resources, alongside other relevant factors such as environmental and social impact, and cost analysis. A key challenge lies in embedding quality information into the description of each batch of wool entering the value chain. The preferred methodology should be simple, low-cost (or cost-free), automated, and fully integrated with the IT system.

While several standardized quality determination routines are well established within the broader industry, they are often highly technical and require access to sophisticated laboratory equipment. Moreover, the resulting quality descriptions can be complex and not always practical for everyday use by stakeholders. Therefore, the most critical features determining the suitability of raw wool for downstream conversion have been identified and categorized. As part of the WOOLSHED solution, alternative in-field methods for quality assessment are proposed to complement laboratory-based approaches. Four key quality descriptors for wool have been selected and are briefly presented below. Proposed methodology for the quality feature assessment as well as discrete categories or quality classes are also explicitly defined.

Fineness: fibre diameter (micron count)

Method: to be measured with portable microscope connected to cellular phone or laptop computer. The average dimeter of fibre is determined by image analysis where each pixel corresponds to known distance.

Discrete categories of wool fineness (value in bracket corresponds to the fibre diameter):

- Ultrafine Wool (< 17 µm)
- Fine Wool (17–20 µm)
- Medium Wool (20–25 µm)
- Strong Wool (25–30 µm)
- Coarse Wool (> 30 µm)

Colour

Method: measure the colour by comparing the wool with dedicated colour checker. As an alternative, the image of the wool batch is taken with cell phone together that is later colour corrected with paper printed colour checker. The result of colour can be expressed as a member of quality categories or represented as RAL or CIE Lab colour coordinates.

Discrete categories of wool colour:

- White
- Cream
- Pale
- Grey
- Brown
- Black
- Alternative CIE Lab (?)

Staple Length (indirectly related to crimp, Strength and Elasticity)

Method: a randomly selected staple is measured manually with a simple measuring tape or reference scale integrated with the WOOLSHED-defined colour chacker.

Discrete categories of staple length:

- Very Short Wool (< 4 cm)
- Short Wool (4–7 cm
- Medium Wool (7–10 cm)
- Long Wool 10–15 cm
- Very Long Wool (> 15 cm)

Scouring yield

Method: a batch of wool is measured manually with portable NIR spectrometer. At least five randomly selected places are assessed and average spectrum determined. The spectrum is then pre-processed by the proprietary software and the scouring yield value predicted thank to chemometric model. The same NIR spectrum can be used for determination of the grease content (Lanolin), vegetable matter (VM) and wool moisture content

Discrete categories for the wool scouring yield:

- Very Low Yield (< 40%)
- Low Yield (40–50%)
- Medium Yield (50–65%)
- High Yield (65–80%)
- Very High Yield (> 80%)

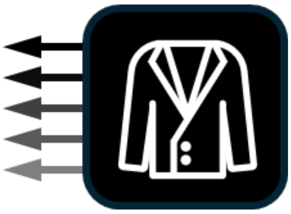
Specification of wool characteristics for representative final product blocks

The detailed specifications of wool-derived products vary depending on the intended market application, the production capabilities of a specific facility, or even the subjective preferences of the artisan. These specifications are provided individually to the WOOLSHED optimization software by each stakeholder seeking specific quantities of wool semi-products. The input process is straightforward and follows the data structure outlined in the template presented in Figure 2. The following section presents an example of a general "demand sheet," tailored to the needs of a typical industrial stakeholder or production process.

The most relevant wool specifications typically include desired fibre fineness range, colour requirements, mechanical performance characteristics, permissible residual lanolin content, certification and compliance expectations as well as minimum viable lot size, among others.

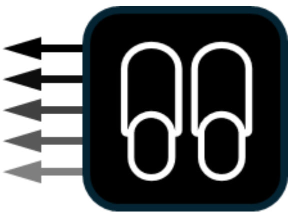
Additional wool-derived products are listed in Appendix 3, that can serve as a starting point for developing other final product blocs.

Apparel (clothing, accessories, felted goods)



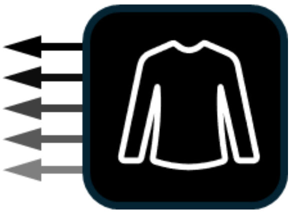
- **Fibre fineness:** Fine to very fine (below ~25 microns) for knitwear, suits, infant wear; coarser (25–32 microns) acceptable for felt hats or outerwear.
- **Colour requirements:** Preference for white or light fibres for dyeing; natural greys and browns valued in niche artisanal fashion.
- **Mechanical characteristics:** Soft handle, good elasticity, resistance to felting for woven goods; controlled felting ability for hats and accessories.
- **Permissible lanolin:** Must be fully scoured; <0.5% residual fat acceptable.
- **Certification expectations:** Oeko-Tex, GOTS (organic), fair-trade, traceability labels.
- **Minimum viable lot size:** Fashion houses can work with <100 kg specialty lots; mills generally require 500–1000 kg consistent lots.

Footwear (slippers, shoes, insulation for jackets/boots)



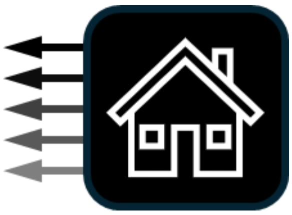
- **Fibre fineness:** Medium (~28–34 microns); coarser fibres desirable for durability.
- **Colour requirements:** White, grey, brown acceptable; darker natural shades attractive for rustic footwear.
- **Mechanical characteristics:** Strong, resilient fibres that felt and insulate; resistance to wear and compression.
- **Permissible lanolin:** Moderate scouring sufficient (<1%), as softness is less critical.
- **Certification expectations:** EU footwear standards, eco-labelling for natural products.
- **Minimum viable lot size:** 200–500 kg, depending on slipper/boot manufacturers' runs.

Sports (thermal underwear, ski wear, uniforms, equipment)



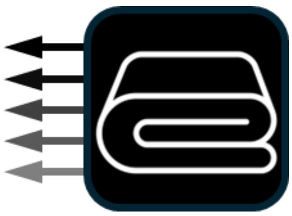
- **Fibre fineness:** Fine (18–24 microns) for next-to-skin comfort; medium fibres (24–30) for outer layers and equipment felts.
- **Colour requirements:** White/light preferred for performance textiles; darker shades possible for boots/felts.
- **Mechanical characteristics:** Moisture-wicking, thermal regulation, elasticity, high resilience to abrasion for sports felts (e.g., billiards).
- **Permissible lanolin:** Near-zero residual lanolin; must not impede breathability.
- **Certification expectations:** ISO textile performance standards, GOTS, bluesign®.
- **Minimum viable lot size:** 500–2000 kg for continuous runs of sports fabrics.

Architecture & Interior Textiles (insulation, furniture, carpets, mattresses)



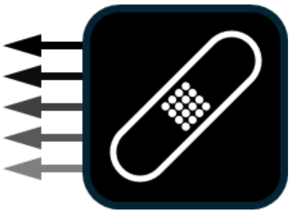
- **Fibre fineness:** Broad tolerance; medium to coarse (30–40 microns).
- **Colour requirements:** Natural shades (white, grey, brown) acceptable; no bleaching required.
- **Mechanical characteristics:** Loft, bulk, flame resistance, sound absorption; durability for upholstery and carpets.
- **Permissible lanolin:** Residual lanolin tolerated (1–3%); contributes to hydrophobic properties.
- **Certification expectations:** Fire resistance (EN ISO 9239-1), building material safety, eco-certifications.
- **Minimum viable lot size:** 1000–5000 kg, given bulk insulation markets.

Manufacturing & Industry (filters, gaskets, absorption pads, transport belts)



- **Fibre fineness:** Coarse fibres (>35 microns) ideal for strength and resilience.
- **Colour requirements:** Neutral; colour irrelevant.
- **Mechanical characteristics:** High tensile strength, resistance to tearing, excellent absorbency, insulation.
- **Permissible lanolin:** Higher tolerance (up to 5%) depending on lubrication uses.
- **Certification expectations:** Industrial textile compliance (ISO 9073 for filtration media).
- **Minimum viable lot size:** 500–2000 kg, depending on industrial processor.

Medical (bandages, dressings, sheepskin, lanolin-based cosmetics)

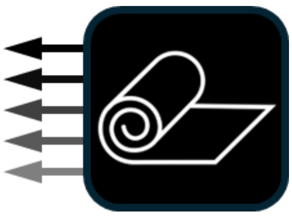


- **Fibre fineness:** Fine (≤21 microns) for direct skin contact; coarse acceptable only for non-contact medical absorbents.
- **Colour requirements:** White/off-white, must be sterilizable.
- **Mechanical characteristics:** Hypoallergenic, highly absorbent, breathable, soft.
- **Permissible lanolin:** Must be fully removed for medical textiles; lanolin is separately extracted for cosmetics (must be ultra-purified, pharmaceutical grade).
- **Certification expectations:** CE marking, ISO 13485, dermatological safety certification.
- **Minimum viable lot size:** 50–200 kg for specialty medical supplies; higher for lanolin extraction.

Agriculture & Environment (fertilizer pellets, soil improvers, geotextiles, erosion blankets)

- **Fibre fineness:** Coarse (>35 microns) and short staple, including waste wool.
- **Colour requirements:** Irrelevant.
- **Mechanical characteristics:** Slow biodegradation, nitrogen release, water retention, bulk for soil aeration.
- **Permissible lanolin:** No scouring required; lanolin can be beneficial for hydrophobic balance.
- **Certification expectations:** Organic farming approval, EU fertilizer regulations.
- **Minimum viable lot size:** Flexible, from 100 kg for local farms to >5000 kg for industrial soil amendments.

Smart Textiles (conductive polymers, sensors, intelligent fabrics)



- **Fibre fineness:** Fine (≤24 microns) for integration into wearable sensors; technical fibres for composites.
- **Colour requirements:** White or light preferred for processing into conductive or functionalized fibres.
- **Mechanical characteristics:** Flexibility, compatibility with coatings, stability under electronic integration.
- **Permissible lanolin:** Must be completely scoured, as chemical treatments require clean fibre.
- **Certification expectations:** Emerging standards (ISO/IEC for e-textiles), safety testing for wearables.
- **Minimum viable lot size:** Small R&D lots (10–100 kg); scaling later to 500+ kg for pilot production.

Quantitative Demand Analysis

Accurate data on wool supply and demand are essential for ensuring reliable optimization of the value chain, as envisioned in the WOOLSHED project. The following analysis is based on publicly available sources, primarily from the ALPTEXTYLES project, co-financed by the Alpine Space programme. The values presented should be interpreted as order-of-magnitude estimates, rather than definitive figures. It is important to note, however, that the WOOLSHED value chain model is designed to enable more realistic analysis and simulation. Each module (or model block) represents a specific stakeholder, contributing highly detailed and context-specific data. As a result, every point on the wool map is directly linked to the simulation software, allowing for dynamic updates that reflect the most current status of the system.

Estimates of annual wool uptake by different industries in the Alpine Region

In the Alpine region, annual wool uptake varies significantly across sectors. The fashion & apparel industry is the largest consumer, using an estimated 10,000 to 20,000 tonnes of wool annually, driven by regional textile traditions and tourism. Home textiles follow with approximately 3,000 to 5,000 tonnes, primarily for carpets, blankets, and upholstery. The construction sector, particularly in insulation and acoustic applications, consumes around 1,000–3,000 tonnes per year, reflecting growing interest in sustainable building materials. Agricultural uses, such as mulch mats and erosion control textiles, account for roughly 500 to 1,000 tonnes annually. Meanwhile, the cosmetics sector, focused on lanolin extraction, represents a niche but high-value segment, with an estimated uptake of 100–300 tonnes per year.

Estimates of price for wool and wool-derived semi-products in the industrial sector of Alpine Region

In the Alpine region, raw wool prices vary significantly depending on fibre quality, ranging from approximately €2 to €6 per kilogram for coarse wool used in insulation and geotextiles, up to €18 to €35 per kilogram for fine Merino wool destined for high-end fashion. Wool-derived semi-products also show a broad price spectrum. Wool insulation typically costs from €15 to €35 per square metre depending on thickness and thermal performance of the panel. Cost of felt sheets range from €10 to €25 per square metre. The yarn prices span for €8 up to €60 per kilogram of wool, based on fineness and processing method. Lanolin, a by-product used in cosmetics, is valued at €25 to €60 per kilogram, with slight seasonal variation.

Seasonality of Wool supply in the Alpine Region

The highest availability of raw wool is in the period from April to June due to the main shearing season. Similarly, the secondary or optional shearing season starts in September and ends in October, resulting in moderate availability of raw wool. Occasional post-shearing activities are performed in July and August, but the relative amounts of wool are rather low. Wool is usually not produced during the winter season (November to March), as shearing operations are not practiced. During this period, only wool from storage can be processed. The visual presentation of the seasonality of wool supply is presented in Figure 4.

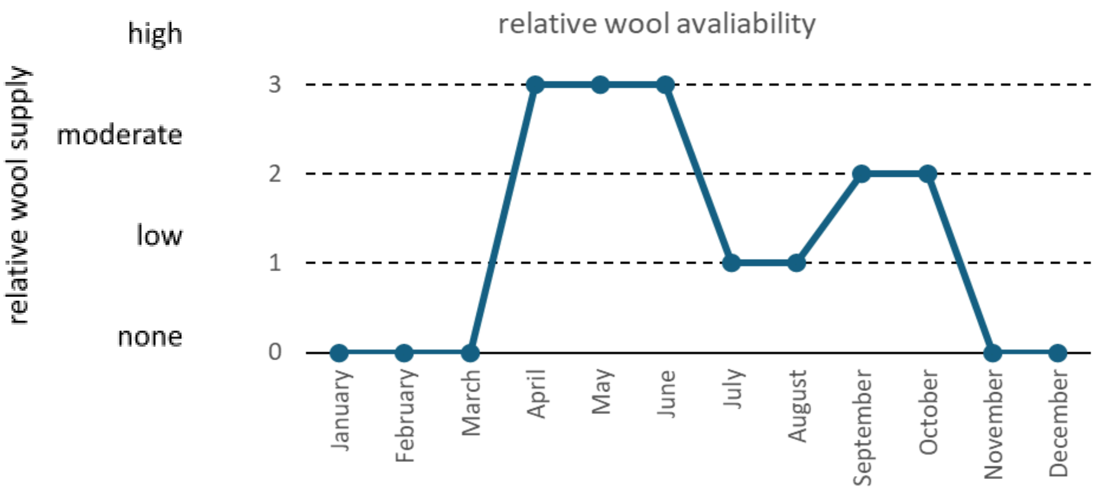


Figure 4 Seasonality of wool supply in Alpine regions

The estimated total availability of greasy wool in Alpine regions is more than 330 thousand tonnes per year. However, only 139 thousand tonnes of this wool were cleaned.

Seasonality of Wool Demand in the Alpine Region

The usual production of goods based on the transformation of wool is seasonal. The fashion & apparel sector notices peak in autumn and winter (quarter 3 and 4). It is aligned with autumn/winter collections and tourism-driven demand for local wool products. The latter is especially relevant in the context of Alpine regions.

Conversely, spring planting and land management activities typically occur in the agriculture sector, resulting in peaks of wool product-derived demand during quarter 1 and quarter 2. Other seasonal variation can be observed in the construction sector, particularly for insulation materials. Most of such activities are executed from early spring till late autumn (quarter 2 and 3). This corresponds to the typical building season when relatively high temperatures in Alpine climates allow execution of construction activities.

It must be mentioned that several wool transformation industries present a relatively stable demand for wool fibres. This is especially noticeable for products such as home textiles, which only show slight increases in colder months. Similarly, cosmetics based on lanolin are produced year-round, with minor winter peaks due to increased demand for skincare products.

The visual representation of wool demand seasonality is presented in Figure 5. The graph is a rough simulation and does not include verified values. It was created assuming that 130k tones of clean wool is produced in Alpine regions each year, while estimated demand for listed sectors is approximately 22k tones/year. The gap reflects structural inefficiencies, market fragmentation, and underutilization of local wool resources.

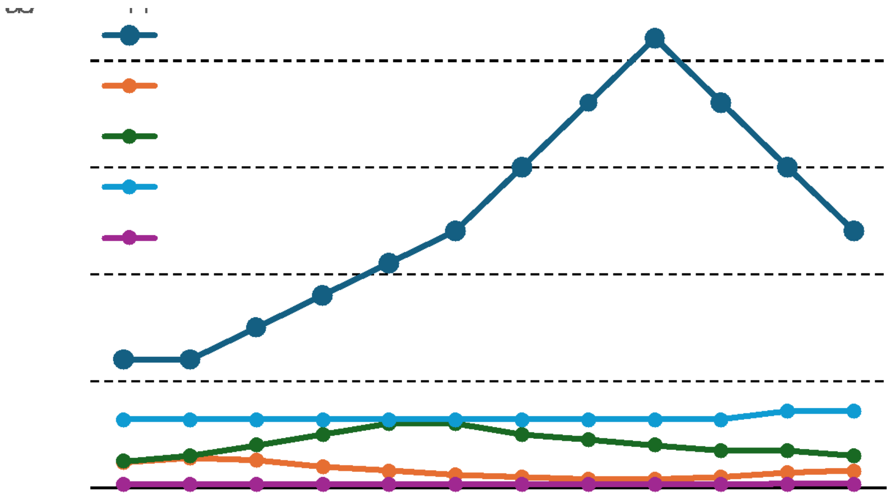


Figure 5 Simulated seasonality of demand for wool in Alpine regions including different industrial sectors

Unfortunately, only a fraction of the total wool is processed into high-value products. Large portions of Alpine wool are underutilized or wasted due to low market prices, fragmented supply chains and lack of processing infrastructure. An important factor is certification barrier as well as high import of wool from outside the Alpine region (e.g. Merino from Australia), reducing local wool uptake.

Gap Analysis and Compatibility Assessment

To ensure effective alignment between wool resources and product requirements, a cross-referencing exercise was conducted between the demand sheets (Deliverable 2.1.2) and the material classes catalogue (Deliverable 2.1.1). This assessment identified areas of full compatibility, partial compatibility, and substantive gaps. Direct matches were observed where wool types and processing capabilities fully met the specified product requirements. Partial matches highlighted cases where minor adjustments, such as fibre blending or mechanical restructuring, could bridge the gap. Substantive mismatches were observed where existing wool resources lacked the necessary properties for certain high-performance or specialized applications. In these cases, chemical functionalisation or advanced processing techniques may be required to meet demand specifications. All of these are implemented as dedicated process blocks that transform materials based on specific input (SI) and process parameters (PP). In addition, each block allows transformation of the resources fulfilling specification of the SI, enabling composition of out-of-the-box transformation flows or creation of innovative products from wool. This analysis supports the dynamic matching logic of the WOOLSHED optimization tool and informs strategic decisions on resource allocation, product development, and innovation pathways.

Each demand entry is compared against the catalogue’s material classes using key parameters such as fibre fineness and length, colour and cleanliness, mechanical properties (e.g., tensile strength and elasticity), lanolin content, certification and traceability requirements, and minimum viable lot sizes. The analysis reveals that direct matches are most common in traditional textile applications, such as knitwear and felted goods, where local wool types already meet the required specifications. Partial matches are observed in technical textiles and insulation products, where minor adjustments, such as blending with finer or coarser fibres, could bridge the gap.

Substantive gaps are expected in high-performance applications, including fire-retardant composites and medical textiles, where current wool resources lack the necessary functionalisation or purity levels. To address these gaps, several strategies are proposed to be tested during Design Marathons, such as:

- blending different wool types to achieve target properties
- mechanical restructuring techniques like carding or felting to modify fibre orientation and density
- chemical functionalisation methods such as lanolin removal
- antimicrobial treatments to enhance suitability for specialized applications
- process innovations like enzymatic scouring
- plasma treatment

All these processes (available as process blocks) may expand the range of achievable product specifications. To improve matching precision, stakeholders are encouraged to provide more detailed data on product requirements, determine resource quality at the single batch level, conduct pilot trials to test bridging strategies, and contribute to a feedback loop that continuously refines compatibility assessments within the optimization tool.

Innovation Frameworks

The further development of the wool sector in Alpine regions requires continuous innovation and evolution across the entire value chain. The WOOLSHED project aims to deliver a systematic solution to support this advancement by introducing new applications for wool and its derivatives. By combining a broad portfolio of diverse, high-value-added products with quality-driven value chain optimization, this goal can be achieved. At the same time, alternative innovation frameworks—such as circular economy models, regional clustering of SMEs, and digital traceability systems—are increasingly being adopted or show strong potential to transform the wool processing sector. These approaches promote resource efficiency, transparency, and collaboration among stakeholders, and are particularly well-suited to the fragmented and locally embedded nature of the Alpine wool ecosystem. Some of these initiatives as briefly mentioned below.

Stage-Gate (Cooper Model) **Resources:** https://www.stage-gate.com/blog/the-stage-gate-model-an-overview/ https://www.toolshero.com/innovation/stage-gate-process/	Stage-Gate provides a structured pathway from idea to launch, helping wool innovators filter out weak product ideas early and invest resources in those with the highest potential. For example, a new wool thermal jacket concept can be tested at multiple checkpoints like, material feasibility, prototype trials, and market validation before moving to production. This prevents costly failures and ensures each stage adds value.

Quality Function Deployment (QFD / House of Quality) **Resources:** https://sixsigmastudyguide.com/house-of-quality-hoq/	QFD ensures that the voice of the customer is built into wool product development. It translates consumer needs — such as lightweight warmth for alpine hikers — into measurable specifications like fiber fineness, knit density, and moisture-wicking ability. This systematic alignment between user requirements and product features increases the chance of market acceptance.

Design for X (DfX) **Resources:** https://www.openaccesslibrary.com/vol12/6.pdf https://www.sciencedirect.com/topics/engineering/design-for-x	DfX ensures wool products are optimized for key factors such as durability, manufacturability, or sustainability. For example, hiking socks can be designed for extreme durability with reinforced knitting, while also considering recyclability by avoiding mixed fibers. This framework helps wool products perform well not just for customers, but across their entire lifecycle.

TRIZ (Inventive Problem Solving)	
Resources: https://humanskills.blog/triz-problem-solving/ https://spectrum.library.concordia.ca/id/eprint/36055/1/triz.pdf	TRIZ helps solve contradictions in wool product performance. Wool is naturally warm but can feel heavy when wet a classic conflict. TRIZ pushes innovators to find inventive solutions such as hydrophobic coatings or hybrid yarn structures. This framework drives breakthrough designs rather than incremental improvements.

Morphological Analysis	
Resources: https://www.swemorph.com/pdf/chapter2.pdf https://medium.com/lastbasic/morphological-analysis-67e9eb57aee0	Morphological analysis systematically explores all possible product variations by combining parameters such as wool type, knitting method, finishing treatment, and intended use. For example, fine merino × 3D knitting × water-repellent finish × sportswear could yield a unique alpine performance product. This method ensures no creative opportunity is overlooked.

Circular Product Design Framework	
Resources: https://repository.tudelft.nl/record/uuid:307f8b21-f24b-4ce1-ae45-85bdf1d4f471 https://www.kearney.com/service/sustainability/article/designing-beyond-less-bad-a-strategic-framework-for-circular-product-innovation	This framework integrates circular economy principles into wool products from the start. Instead of treating products as disposable, wool jackets or blankets can be designed for repair, reuse, or recycling. By embedding circularity into design, alpine wool producers can differentiate their products with a strong sustainability story.

Abernathy and Utterback Model	
Resources: https://www.researchgate.net/publication/271240447_Where_is_Abernathy_and_Utterback_Model	This model describes how product and process innovation evolve in three stages: fluid, transitional, and specific. In the fluid stage, wool products are experimental and diverse such as testing new felting methods or wool composites. In the transitional stage, dominant designs emerge, like standardized merino base layers, while process improvements gain importance. In the specific stage, the focus shifts to efficiency, cost reduction, and incremental improvements, such as refining knitting techniques. For the alpine wool industry, this framework helps producers understand when to prioritize radical product innovation and when to shift toward process optimization and scaling.

Booz, Allen & Hamilton (BAH) Model	
Resources: https://samples.jbpub.com/9780763782610/82610_ch02_pass02.pdf https://venngage.com/blog/product-development-process/	One of the earliest structured models of new product development. It breaks innovation into stages: new product strategy, idea generation, screening, business analysis, development, testing, and commercialization. For alpine wool, this ensures product ideas like eco-friendly wool ski gloves move through a disciplined process, minimizing risk.

Conclusions and Next Steps

The *Portfolio of Demands for Wool-Derived Materials* represents a pivotal step in the Woolshed project's trajectory towards a renewed and circular Alpine wool economy. By systematically mapping the needs, constraints and aspirations of multiple actors, it offers a comprehensive framework that connects the productive, creative, and scientific dimensions of wool valorisation. Conceived as both a knowledge repository and a design tool, the portfolio translates complex, often fragmented information into a coherent structure that can guide future experimentation, investment, and policy alignment.

For **wool breeders and raw wool producers**, the document provides a valuable insight into the types of material properties, certifications, and transformation pathways that are most sought after across innovative markets. It illustrates how raw and semi-processed fibres can meet emerging industrial and design requirements, allowing producers to orient their practices towards higher-value outputs and improved ecological standards.

For **innovators, designers, and creative professionals**, the portfolio constitutes a source of inspiration and a technical reference. It reveals new application domains where wool can serve as a functional and aesthetic component – from bio-based materials and circular textiles to acoustic solutions and eco-design composites. Its structured mapping of potential uses and functional criteria serves as a starting point for design marathons, pilot prototyping, and transdisciplinary collaborations.

For **entrepreneurs and industrial stakeholders** operating in sectors potentially interested in wool-derived materials – such as construction, packaging, fashion, interior design, or bio-composites – the portfolio functions as a bridge to innovation. It offers an overview of available materials, technical compatibilities, and demand trends, supporting business diversification and cross-sectoral innovation through the integration of natural, renewable resources.

For **researchers and scholars**, the document provides a structured baseline for further scientific and socio-economic investigation. It contributes to understanding how material innovation can foster territorial resilience, combining empirical observation with a systemic view of circular value chains and multi-actor cooperation in mountain economies.

Methodologically, the portfolio introduces a **systematic approach to demand mapping**, grounded in transdisciplinary inquiry and the logic of design-driven innovation. It integrates data collection, comparative analysis, and classification of material demands across multiple domains, establishing a shared vocabulary and interoperable criteria to connect the upcoming *Digital Alpine Wool Atlas* and the *Woolshed Optimisation Model*. This approach transcends the traditional divide between material producers and market users, enabling evidence-based matchmaking between supply and demand within a coherent digital and methodological framework.

In this sense, the *Portfolio of Demands* does not simply document existing needs; it anticipates and structures the conditions for their transformation into opportunities. Its innovative character lies in the convergence of data, design, and systemic thinking – offering a transnational, multi-sectoral platform for knowledge exchange and collaborative innovation. As the project advances towards the next phases, particularly the *Design Marathons* and market-testing activities, this document will serve as both compass and catalyst: a foundation for creative experimentation, entrepreneurial initiative, and scientific validation within the evolving ecosystem of the Alpine wool economy.

References

[1] **Bizjak, M., & Simčič, M. (2024).** Differences in body measurements, wool and semen quality traits between two Slovenian autochthonous sheep breeds. *Stočarstvo, 78*(1–2), 15–24. https://doi.org/10.33128/s.78.1-2.2

[2] **Cosgrove, A.** (2022). *A statistical analysis of New Zealand strong wool sold at auction between 2022 and 2024*. [Industry report].

[3] **Helena Hojnik**. (1999). *Analiza karakteristik volne domačih pasem ovac* [Bachelor thesis]. Naravoslovnotehniška fakulteta, Univerza v Ljubljani.

[4] **Kancler, K., et al.** (2014). *Tradicija in inovacije v uporabi živalskih materialov*. LANATURA cross-border project publication. Kmetijsko gozdarski zavod Nova Gorica.

[5] **Kobiela-Mendrek, K., et al.** (2022). Acoustic performance of sound-absorbing materials produced from wool of local mountain sheep. *Materials*, 15(9), 3139. https://doi.org/10.3390/ma15093139

[6] **Kromar, A.** (2020). *Ovčja volna za izolacijo zgradb in varnostnih oblačil – požarna varnost* [Diploma thesis]. Fakulteta za kemijo in kemijsko tehnologijo, Univerza v Ljubljani.

[7] **Mateja Medija**. (1998). *Analiza karakteristik izbranih vzorcev domače volne* [Diploma thesis]. Naravoslovnotehniška fakulteta, Univerza v Ljubljani.

[8] **Rijavec, T., & Vujasinović, E. (2002).** Volna – izziv tudi za jutri? *Tekstilec, 45*(11–12), 372–384-x.

[9] **Rosan, A.** (2019). *Adsorpcijska kapaciteta odpadne volne* [Diploma thesis]. Fakultet za geotehniku, Sveučilište u Zagrebu.

[10] **R.S. – Ricerche e Servizi srl**. (2023). *Laboratory analyses of Foza, Brogna, Lamon, and Transumante wool samples (PE2019–2020)*. Internal project reports.

Appendix 1: Processed Wool Products

Finished Product	Input Form	Manufacturing Process	Performance / Key Properties	Standards / Safety	Typical Markets & Applications	Source
Acoustic wall/ceiling panels	Needle-punched wool felt batts (coarse mountain wool)	Cut to panel size, framed or laminated; installed on walls/ceilings	NRC up to 0.4; sound absorption comparable to mineral fibre panels; moisture-buffering	Meets indoor acoustic treatment norms; low VOC; inherently FR	Office meeting rooms, classrooms, recording studios	[5]
Acoustic carpets/rugs	Tufted fabrics from ring-spun/core-rug wool yarn	Tufting machine, cut & loop piles; backing applied	NRC 0.4–0.42; improved with higher pile height; durable under foot traffic	Fire safety advantages over synthetics; low emissions	Hospitality, office, home interiors	[5]
Thermal & acoustic building insulation	Wool batts (needle-punched)	Cut, packaged; fitted into walls, ceilings, floors	Low thermal conductivity; absorbs sound; moisture-regulating; naturally flame-retardant	Meets EN fire reaction standards; safe to handle	Eco-building sector, heritage renovations	[6]
Fire-protective clothing layers	Woven or felted wool fabrics	Cut & sewn into PPE garments or integrated as liners	Heat resistance; no melt/drip; thermal insulation in flame exposure	EN ISO standards for PPE; tested for flame spread, afterflame	Firefighting suits, foundry wear, industrial PPE	[6]
Oil spill sorbent pads / booms	Washed coarse wool mats or loose fill	Encased in mesh or nonwoven covers; deployed on water surface	Adsorbs ~15 ml/g diesel; re-usable in some conditions; >90% removal efficiency	Safe disposal required after use; complies with local spill-response norms	Marine spill clean-up, harbour maintenance	[9]
Agricultural mulch mats	Needle-punched wool sheets	Cut to shape; placed around plants	Retains soil moisture; suppresses weeds; biodegrades to enrich soil	No harmful residues; safe for organic farming	Vineyards, orchards, landscaping	[4]
Apparel yarns	Carded/combed sliver from fine–medium wool (e.g., Lamon, Brogna, JSR)	Spun (woollen/worsted); dyed; packaged	Soft handle; even spinning; good dye uptake	Meets textile fastness & safety norms	Hand knitting, weaving for garments	[7], [1]
Rustic rugs / tapestry yarns	Sliver/yarn from coarse breeds (e.g., Istrska Pramenka, JS)	Spun into thick yarn; woven or knotted	Durable, textured surface; natural colours	Wears well under heavy use	Handwoven rugs, decorative wall hangings	[7], [3]