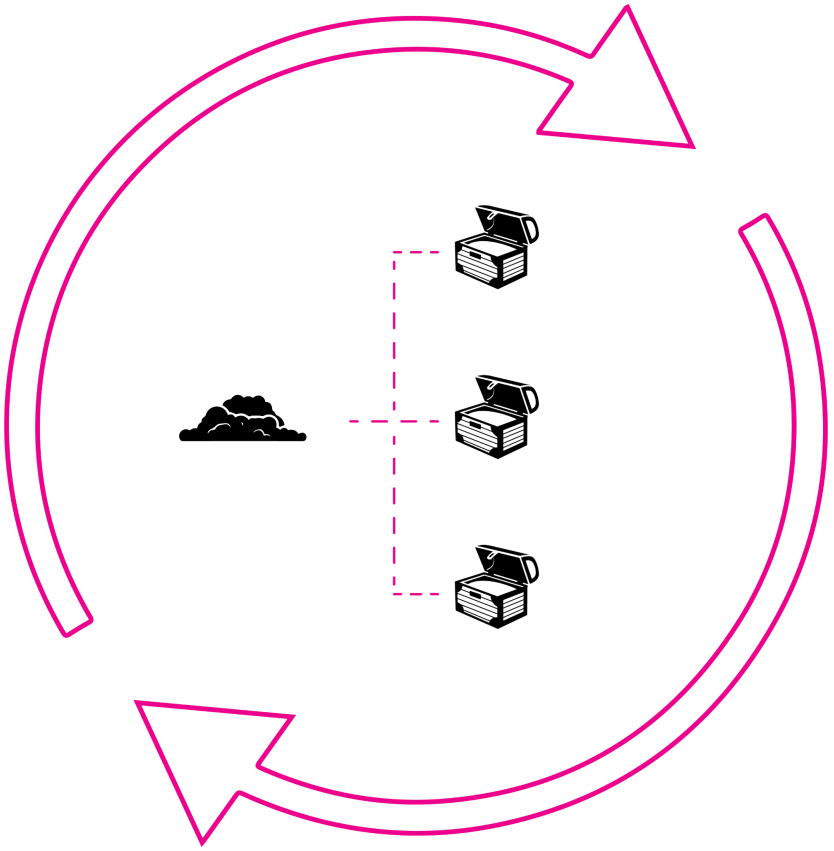
Reassessment of the Norwegian wool value chain

using circular economic principles



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Summary

In this thesis we have followed Norwegian wool from extraction and throughout the current value chain. This includes a farmer, wool stations, and wool refineries. In addition, we have sourced empirical data from key stakeholders. This consists of a representative from Norilia and a researcher that has contributed greatly to the theme of Norwegian wool. Through an exploratory research design, we have been able to enter a field of study without prior knowledge. This has also allowed for incremental implementation of knowledge towards later empirical sourcing.

The theory in the thesis concerns wool as a material, focusing mainly on Norwegian low-category wool, but also includes global perspectives. It also provides theory on circular economy concerning definitions, circular economy perspectives in value chains and the applicability of circular economy.

We have applied the 4Rs of circular economy to reassess the value chain, as a means to uncover potential alternatives to the current system. We believe that circular economy principles can contribute to increased value creation for low-category wool. This entails innovative measures that prevent waste, secure valuable resources inherent in the wool and plan for future use.

The thesis contains examples on alternative uses and processing techniques. These examples explain how conventional methods can be challenged in new ways with improved results. Rather than an addition to the theory of circular economy, this is an attempt to use aspects of circular economy to add to the field that concerns Norwegian low-category wool. The thesis attempts to shine a new light on an established system and challenge its ways. The degree of transferability to other fields is therefore present. We have built upon the work, but not limited to, by Kirchherr on the circular economy, and the work that has been conducted in KRUS and VerdifULL. The process has been an eye opener for us as wool has such a broad range of applicabilities. The same can be said for the circular economy principles.

We hope that this thesis is of interest and gives you, the reader, fruitful takeaways.

Sammendrag

I denne avhandlingen har vi fulgt materialet norsk ull fra ekstraksjon og gjennom den nåværende verdikjeden. Vi har vært i kontakt med en bonde, ullstasjoner og ullraffinerier. I tillegg har vi generert data fra nøkkelinformanter: en representant fra Norilia, og en forsker som har bidratt til vitenskap om norsk ull i stor grad. Gjennom et eksplorativt forskningsdesign, har vi gått inn i et felt uten forkunnskap. Dette har muliggjort en inkrementell implementasjon av kunnskap gjennom den empiriske utviklingen. Teorigrunnlaget for avhandlingen handler om ull som materiale, med særlig fokus på norsk ull av lavere kategorier, men vi inkluderer også et globalt perspektiv. Det inneholder også teori om sirkulærøkonomi, dets definisjoner, sirkulære verdikjeder, og praktisk anvendelse.

Vi har brukt de fire R-ene i sirkulærøkonomi som rammeverk i vår gjennomgang av ullas verdikjede, for å avdekke potensielle alternativer til det nåværende systemet. Vi mener at sirkulærøkonomiske prinsipper kan bidra til økt verdiskapning for lav-kategorisk ull. Dette innbefatter innovative tiltak som reduserer avfall, sikrer verdifulle ressurser i ulla, og en bedre planlegging for fremtidig bruk.

Avhandlingen inneholder eksempler på alternativ bruk av lav-kategori ull og ulike prosesseringsteknikker. Disse eksemplene forklarer hvordan konvensjonelle metoder kan bli utfordret på nye måter, og gi bedre resultater. Heller enn å være et tilskudd til teorien om sirkulærøkonomi, er dette et forsøk på benytte aspekter innen sirkulærøkonomi for å bidra til feltet som handler om norsk ull av lavere kategorier.

Avhandlingen forsøker å kaste nytt lys på et etablert system, og utfordre det. Graden av overførbarhet til andre felt er til stede. Vi har bygget på arbeidet til, men ikke begrenset til, Kirchherr på sirkulærøkonomi, samt arbeidet som er gjort i prosjektene KRUS og VerdifUll. Prosessen har vært en øyeåpner når det gjelder kartlegging av de mange anvendelsesmulighetene for ull. Det samme kan hevdes når det gjelder å bruke sirkulærøkonomiske prinsipper for å gjennomgå etablerte verdikjeder.

Vi håper denne avhandlingen er interessant, og gir deg, leseren, nyttig læring.

Foreword

This thesis concludes the two-year master's programme Shift - Entrepreneurship and Innovation at the School of Business and Law, University of Agder.

Our motivation for this thesis has been to gain expertise that will be useful for the current and future shift in perspective toward a green, clean and sustainable world. Changes in society and the environment are changing rapidly, and we need new ways of conducting business. A circular economy might accelerate our understanding of how we can decouple economic growth from resource depletion.

Our data comes from interviews with professionals in the field we studied, and we would like to thank them for sharing their knowledge and showing us how their work is conducted. Our informants represented Norilia, Nortura, Fatland, Sandnes Garn and Sjølingstad, and we appreciate being able to visit your facilities and watch the machines process the raw wool. We will also give our appreciation to the small-scale farmer, Stian, who took us out on the grazing field on a cold morning in February so that we could meet and greet the sheep. We give thanks to researcher Ingun Grimstad Klepp for an informative interview and all the useful literature on the subject.

Gratitude is given to Terje Nilsen for proofreading the document, providing helpful corrections and for raising Tobias.

We give thanks to our supervisor Professor Kalanit Efrat for guidance, advice and motivation. Your academic insights have been very valuable for us, and we have appreciated the opportunity to work with you.

Last but not least; we give our most humble gratitudes to our patient families that have given us valuable time to work on this thesis.

List of figures

Abbreviations

4R	Reduce, Reuse, Recycle, Recovery
CE	Circular Economy
EoL	End-of-Life
GHG	Greenhouse gas
HSC	Haworth Scouring Company
KRUS	Research project from OsloMet
LCA	Life cycle assessment
ScCO2	Supercritical CO2
SG	Sandnes Garn
SSB	Statistics Norway
VNW	Valuing Norwegian Wool

1.0 Introduction

Norwegian sheep wool is a natural resource with great properties. When you hear wool, you might think of garments and clothing, but it serves as a component in several other product groups. The Norwegian wool is recognised as too coarse for next-to-skin clothing, as it gives an itchy feeling. Instead of trying to soften the wool through breeding or chemical processing, we can instead focus on alternative uses that utilise its great properties.

Our current linear economic system needs to be replaced, where we extract resources, use them, and throw them away as trash. The circular economy challenges how we interact with materials and pushes our thinking to become more holistic. We need to design products for the future. This means that we should replace the product's end-of-life with recovery strategies like repairability, refurbishments, upcycling, or reusing. This keeps the material flow slower and longer and reduces the need to extract virgin materials.

According to the media, a large part of Norwegian wool is discarded as waste and never leaves the sheep farm, mainly because the prices are too low to justify the work of shearing and sending it to processing. The processing starts at the wool stations, where the wool is sorted into classes based on characteristics such as fibre length, fineness, elasticity, curliness, colour, pigmentation, and vegetable matter. The classification decides the price, which is a problem for the native Norwegian breeds of sheep with their colored and coarse wool. The wool gets shipped to England for scouring and washing. The scouring company, Curtis Wool Direct Ltd, is owned 87.5 % by the Norwegian industry actor Nortura, and yet the transparency of their processing is questioned by some researchers. This value chain problem inhibits the marketing of “Norwegian” as a trademark and the production of guaranteed sustainable and circular products with transparent processing.

We want to apply the principles of circular economy to improve the value chain of Norwegian wool. The properties of wool are well suited for a range of products, and can often replace plastic-based or mixed-material products which are impossible to recycle. In this thesis, we will explore how the current value chain for coarse Norwegian wool works and how it can be improved to become more circular and profitable. In this quest, we will keep the circular principles in the back of our minds and push ourselves to think ahead. Can we

avoid altering the wool to keep it recyclable? Can we make a product that can be upcycled without material degradation? How can coarse wool be used in product development to replace other materials? And how much value can really be extracted from Norwegian wool?

In addition to conducting a literature study that will give us an updated take on the theme, we will generate our own data by talking to key stakeholders, interviewing experts, and learning from watching the value chain in motion. We believe that Norwegian wool can be used innovatively within a sustainable value chain with a higher value for all involved entities.

1.1 Background and motivation for the theme

The linear economic system is outdated and needs to be replaced by alternative models that address the fact that nature has limits. We have become greedy in our perpetual economic growth. The linear system assumes that natural resources are infinite and that we can discard products in landfills after using them. These assumptions have grave consequences that often befall the global south, thus reproducing global unevenness. The problem is complex and will need several solutions on all fronts. The daunting size and complexity may leave us apathetic.

We know that understanding the circular economy is of great importance, and the shift towards circularity has already begun. We see this as a possible career path that aligns with our personal attitudes on how we perceive human impact in this world. We wanted to gain expertise in the field. We believe that applied knowledge will give a more profound understanding as the principles of circular economy can be operationalised in several ways. Clear examples of *how* to introduce circularity address the dauntiness and apathy.

Value chains are an important term here. Fragmentation, monopolisation, and globalisation might be obstacles to circular product development as the overview over material lifespan dissipates. Can we guarantee that a product is made without toxic materials that hinder recycling if the value chain stretches across countries with different toxicity regulations? Is it circular to ship natural resources at great distances to create products that *might* be recycled? There seem to be a lot of trade-offs that we need to be aware of when we introduce circularity, and we set out to identify some of these.

We selected a natural resource that we assume had untapped potential. We had recently read an article about how Norwegian wool had become a waste problem. Digging it into the ground or burning it had become some of the most attractive solutions. In addition, the main aim of product development was to try to force-fit the coarse Norwegian wool into the textile industry, even though it is unsuitable for next-to-skin garments due to its thick and itch-provoking fibres. By taking a step back and investigating what properties the wool has, we saw that the potential for other product groups could be much more attractive.

With circular principles fresh in mind, we set out to explore the value chain to identify its shortcomings and potentials. We were convinced that Norwegian wool can achieve a higher material status where future recovery is maintained.

1.2 Previous research on the theme

We began our thesis with a search in the scholarly database Oria and immediately found a research project from OsloMet called KRUS. The project's final report made a summary of the contributions (Klepp et al., 2019, pp. 129-137), which we used as a basis for sampling literature for our literature review. We found that KRUS was built on an earlier project about Norwegian wool, as follows in the next chapter. We also found that a key contributor had produced a considerable amount of text on the subject, namely Ingun Grimstad Klepp.

1.2.1 Valuing Norwegian Wool

One project was Valuing Norwegian Wool (VNW). This project lasted from March 2010 until the final report was published in September 2012, which stated that the project would continue for some time into the first quarter of 2013 (Hebrok et al., 2012, p. 5).

> The project's main focus is to contribute to an increased sustainable value creation from value chains based on natural resources, suggesting a fresh look at wool. It aims to map the value chain of Norwegian wool through its entire life cycle. It focuses especially on examining and describing the important links in the value chain and their relationships, to make visible the challenges and possibilities within the industry (Hebrok et al., 2012, p.19).

Key findings from the VNW final report:

- The sheep farmers need to be educated on the shearing and sorting process to deliver higher quality wool to sorting stations, thus getting better paid (Hebrok et al., 2012, p. 60).
- Products made from Norwegian wool are poorly marketed (Hebrok et al., 2012, p. 133).
- Scouring and washing of wool are done in England, which is unfortunate for the usage of Norwegian wool in Norway (Hebrok et al., 2012, p. 62). There is some uncertainty about whether the wool returned is exclusively Norwegian or if it is mixed with wool from other countries:

  > What seems to be a challenge is that the process of scouring now is almost monopolized by Haworth Scouring company (hereafter HSC) in the United Kingdom. Only the mills Sandnes Spinneri, Hoelfeldt Lund, and some other small-scale mills do their own scouring in Norway. Stakeholders have called for increased transparency regarding the origin of the wool returning from scouring in the UK, is it in fact the Norwegian wool? There is also little knowledge of the environmental impact of the scouring process and if it could be eco-certified according to the EU flower as the wool coming from New Zealand is (Hebrok et al., 2012, p. 132).

Another article from VNW, New Opportunities for Norwegian Wool: An Investigation of Product and Market Possibilities (Røsvik & Boks, 2012), focuses on "...other possibilities to utilize the Norwegian wool, and uncover new opportunities in the market.". We found this article to be aligned with our entrepreneurial thinking and saw that we had focused on similar research areas. The article is relatively short but includes important notes on material properties, like insulation, flame retardancy, moisture absorbance and sound absorption (Røsvik & Boks, 2012, pp. 4-5). In the article, the authors point out that the discourse around Norwegian wool seems to

> "…be locked within its own perceptions [...] which center on functional properties and how they are not ideal for clothing production. The use is connected to traditional aesthetics and handicraft and most existing research seems to only address how to adapt Norwegian wool to fit use in clothing, without looking for opportunities to open up for innovative thinking." (Røsvik & Boks, 2012, p. 3).

We found this statement to be very interesting, and in line with our own perceptions after reading up on KRUS and VNW. Røsvik & Boks (2012, p. 7) analysed the properties through a product development case, which resulted in designing an office space divider, and found that "...the most promising area of innovative use was to improve indoor air quality, exploiting and combining the ability of wool to regulate air humidity, absorb sound and thermally insulate". This is where we found the rationale of including as many of the properties as possible in order to fully utilise the material.

The KRUS final report sums up the findings from VNW as follows: "...the project Valuing Norwegian Wool (VNW) unearthed several gaps in the wool value chain: Lack of cooperation, transparency, product-development, quality development, and relevant origin labels.". In other words, the results from VNW are really more plentiful and complex than the findings we present here. We focus on the parts of the project that we find relevant for our thesis.

1.2.2 KRUS

The KRUS project lasted from March 2015 until December 2018 (OsloMet, 2015), and generated 40 chronicles, three books, 22 book chapters, 25 scientific articles, 4 reports, 60 popular scientific publications and over 140 lectures (OsloMet, 2019). We find this to be a credible source of information, and will mainly rely on the scientific articles as they adhere to a high level of reliability. The two main goals of KRUS was to "... å forbedre markedet for og verdien av norsk ull og kartlegge mulighetene for lokal produksjon som et skritt mot bærekraft i klesindustrien" [to improve the market for and value of Norwegian wool, and map the possibilities for local production as a step towards sustainability in the fashion industry] (Klepp et al., 2019).

The key findings from the KRUS final report:

- Norwegian wool captures little value in the large-scale value chains for wool; most of the Norwegian wool is used in floor carpets, while a smaller portion is spun into hand-knitting yarn and industrial yarn for knit and woven products (Hebrok 2012, cited in Klepp et al., 2019, p. 15).

- The removal of government subsidies on lower-grade wool has negative consequences for traditional Norwegian breeds. Making their wool unprofitable leads to farmers dumping or burning the wool, creating a waste issue. KRUS argues that this coarse wool can be key in high-quality product development. (Klepp et al., 2019, p. 18).
- Large-scale scouring occurs in England, where the wool gets sold on the world market. “Several actors have expressed a wish for a scouring plant in Norway…” (Klepp et al., 2019, p. 20).
- “ Due to extremely low prices and lack of industrial up-take, wool from older sheep varieties is burned, thrown in the sea, dug down in the earth or in other manners disposed of. This is waste of resources and affects animal welfare” (Klepp et al., 2019, p. 49). “... the farmers think it is terrible that such a good resource is not used” (Klepp et al., 2019, p. 51).
- Old Norwegian Sheep have a high lanolin content, which is underutilised and seen as waste rather than a resource. (Klepp et al., 2019, p. 51).
- Old Norse Sheep produces around 600 tonnes of wool each year. Fatland and Nortura collect some, and we do not know how much is discarded as waste (Klepp et al., 2019, p. 51).
- Wool is not wool. There are significant variations in the properties (lanolin content, coarseness, kemping, etc.) in wool between herds and even individuals. This is primarily due to selective breeding, age, health, and climatic conditions. (Klepp et al., 2019, pp. 62, 77).
- “Increasing demand for Old Norse Sheep wool is the best way to increase finances. The goal is to increase the quantity of both large-scale products and niche products from wool, focusing on all the good qualities of wool. With 60.0000 winter grazing sheep there is a potential.” (Klepp et al., 2019, p. 68).

The most significant difference between VNW and KRUS is that the latter mostly consider wool as textile, emphasising yarn, knitting, and fashion, while VNW focuses on wool as a resource and thus opens for more alternative uses. Both research projects have given us an insight into Norwegian wool and provided us with up-to-date information on central actors, the wool's attributes, the value chain and its contents, and how the wool is and can be used in product development. Our key takeaways from the literature review are:

- Branding wool as Norwegian is disrupted by the Curtis Wool Direct Ltd. scouring facility in England. This facility is 87,5%[1] owned by the Norwegian industry group Nortura, which in turn is owned by Norwegian farmers.
- The different classifications yield different potential for use in products. Focusing on next-to-skin garments might not be a very fruitful endeavour. The coarseness of the wool can be of advantage in other types of products.
- Lanolin is discarded, which we find odd given the market opportunity. In Norwegian mills it ends up in the sewer, and HSC in England only extracts around 20% of the total amount.
- There seems to be both will and motivation to cooperate for the increased use of wool in the Norwegian industry.

1.3 Research problem statement

The insight we had gathered made us curious about what the value chain for Norwegian wool really looked like and if it really is on its way to becoming a waste problem. We wanted to explore it further to identify activities and processes that might be altered, modified, or changed towards circularity. Our main research problem statement is:

How can we use circular economic principles to reassess the value chain of Norwegian wool?

By reassessing all the stages in the value chain, from extraction of the material, through collection and sorting, refinement and distribution, we have created an overview that lets us explore the advantages and disadvantages. A point is made by assessing all stages in chronological order, as our experience with the material builds in the order of the value chain.

Why is this important to explore? We argue that the shift towards circular economic principles will be relevant for all business life, and that we need to familiarise ourselves with the necessary changes in current value chains. In our experience, there is great potential for a higher economic rationality and environmental soundness in designing products that last longer, with higher material purity, enabling future recycling, and overall reducing our extraction of virgin materials. For our own sake, we want to create and sustain transferable

[1] Owner share gathered from Norturas webpage: https://www.nortura.no/om/datterselskaper

knowledge, experience and up-to-date awareness of circular economy so that we might be part of the change and drive it forward. In addition, we know that policy changes on international and national levels will alter the way we relate to materials. Our second research problem statement is:

What is the current and potential future situation for wool?

This thesis contributes in two ways. We want to demonstrate how an existing value chain might be revisited through a circular economic perspective. As stated in the theory chapter on CE, Norway has a significant gap with a great deal of potential to increase its actualisation through the implementation of circular thinking. When it comes to the existing research on Norwegian wool, we contribute to the focus on product development aside from clothing and garments. We strive to include as many of the material properties as possible to utilise a fuller potential. Our focus on the business rationale of extracting lanolin is surprisingly absent in other business cases that we have reviewed during the thesis work.

Why focus on wool? By choosing to follow a raw material we knew that we would encounter several value chain stages. We chose wool from Norwegian sheep as we knew that the material was accessible to us, enabling empirical work at sites where the wool was present and visual. The complexity of the industry was deemed fairly overcoming due to the semi-monopolisation of industry actors, which enabled in- depth interviews with professionals that possessed overview over the whole value chain. We started out with the assumption that Norwegian wool was underutilised in product development, which is an assumption stemming from the literature study on the KRUS project, as well as KRUS-related news articles on wool being discarded.

1.4 Research methods

We read up on the two subjects, circular economy and Norwegian wool, in our preliminary literature study to get an overview over previous research. After the literature study, we had gained sufficient basic knowledge, where we discovered some ambiguities, unanswered questions, and potential research fields. We made an overview over the researchers and experts in the field, and made interview guides that would allow us to explore further by empirical data collecting.

1.5 Structure of the thesis

In order to gather the theoretical information that we needed to answer the research questions, we conducted a literature study in two parts. In the first part, an academic exploration of wool was conducted. By using previous research and other available sources, we mapped out the quantities of wool, the wool classification system, how wool is used today, innovative uses and processing of wool, and the economic factors involved. In the second part, we deep dived into CE, both as a holistic system and as an operational way of thinking that challenges us to rethink business models and resource management. In this part, we explored the definition of CE in a broad sense. Further, we focused on parts of the definition that we deemed relevant to the thesis. The methodology chapter will explain the research design that we found to be most appropriate for this thesis. There, we will present our methods for gathering and analysing data and justify our sampling. In this chapter, we will also account for the reliability and validity of our data and analysis and assess ethical concerns and considerations throughout the process. In the findings chapter we will present our results from the data collection in a summarised way, using the chronology of the existing value chain. We will only present the findings that are relevant to answer our research problem, even though it might be hard to delimit the boundaries of a value chain. In the discussion chapter we will use the 4Rs framework to process our findings and tie them to the theory. The conclusion will summarise the most relevant results of the thesis. In addition, we will suggest further research that we have encountered during our process.

2.0 Theory

This chapter will be divided into two parts. First, we look into wool. This will include different aspects of the value chain, greenhouse gas emissions, and environmental impact. Then, we seek Norwegian wool in relation to waste. Following, we map out some alternative uses of wool besides garments to illustrate how the material's properties may be utilised. Then, two of the main components are treated, namely keratin and lanolin, to show the potential for innovation and product development stemming from sheep wool. Lastly, we look at different ways of processing wool besides traditional scouring. The second chapter is about the circular economy. We start by looking into definitions before moving to the status for CE in Norway. Then, we focus closer on the value chain aspect of CE, as this is relevant

for our case. Further, we investigate the 4Rs, reduce, reuse, recycle and recover, to ensure that we gain sufficient knowledge about circularity in praxis. Lastly, we map out important critiques of CE.

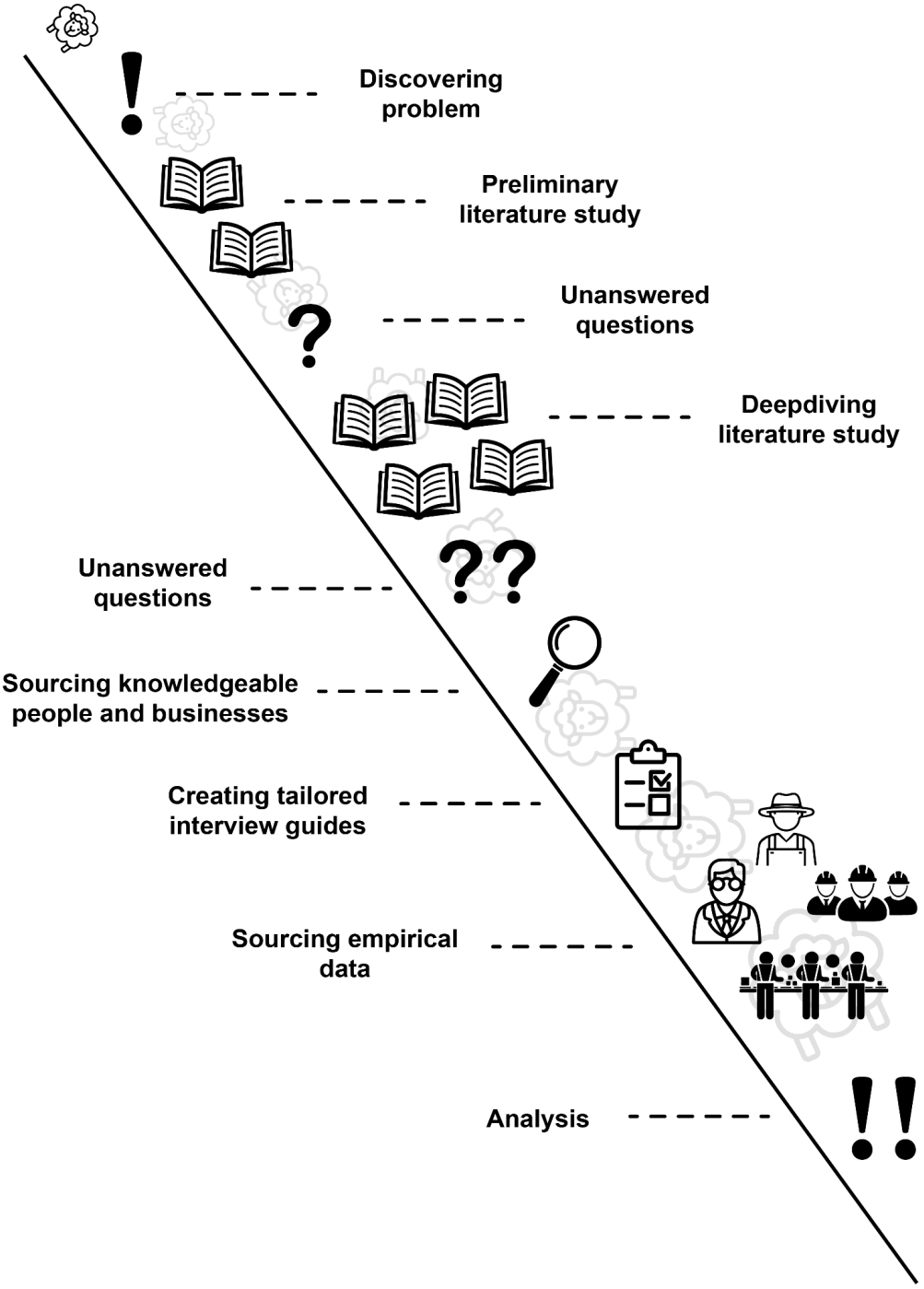


Figure 1. Structure of the thesis.

2.1 Wool

This chapter includes wool production internationally and nationally, alternative uses of wool, processing methods, and issues relating to wool production.

2.1.1 Global wool

According to the statistics reported by the International Sheep Wool Organisation, the worldwide production of clean sheep wool was estimated at 1.155 million kg in 2018 (IWTO, 2019). Generally, sheep wool is collected by trimming wool from sheep once a year during summer or spring. Australia produced the highest amount of clean sheep wool, i.e., 23.4% of worldwide production in 2018. Other major sheep-wool-producing countries are China (15.5%), Russia (11.4%), New Zealand (9.1%), Argentina (2.3%), South Africa (2.2%), the UK (2.2%), and Uruguay (1.6%). Clean sheep wool can be categorised according to the average diameter of the wool fibre into fine wool (≤24.5 μm), medium wool (24.6–32.5 μm), and coarse wool (>32.5 μm) fibres (Salem Allafi et al., 2021, p. 3).

According to Townsend and Sette (2016) global clean wool production was estimated at 1.2 million tonnes, valued at 8-9 billion dollars in 2013. The clothing industry accounts for 51% of the usage, where Australia, China, and New Zealand are the main producers. In Australia, concerning sheep farming, wool is the primary product and 270.610 tonnes of clean wool was produced and distributed across 25.000 wool producers. The wool is mainly produced for export purposes. In the US, where meat is the primary product, 79.500 sheep producers end up with 90 kg of clean wool from each producer, totalling 7155 tonnes. This may suggest that there is a difference in reporting systems, low or high emphasis on export and domestic sales, varying qualities of wool or differences in price for wool.

2.1.2 Norwegian wool

SSB (2021a) estimates there are just below one million winter-fed sheep in Norway, distributed across 13533 sheep farmers[2]. This amounts to just over 4000 tonnes of wool produced annually (Vičiūnaitė, 2020, p. 13) and an average of 295 kg of wool per producer

[2] Companies that are registered in this sector.

annually. According to Klepp et al. (2019, p. 18), the main driver for wool production in Norway is tied to meat production, thus making wool a by-product. Following this factor, the amount of wool that is produced is not pushed by a demand in the market. Klepp et al. (2019, p. 18) and Hebrok (2012, pp. 41, 48, 59) argue that increased value of wool (including governmental subsidies) can motivate farmers and linked entities to result in better refinement of wool and the development of the market.

The yearly report from Animalia (2020b), Sauekontrollen, concludes that the most common species of sheep in Norway in 2020 are Norwegian White sheep (67,4%), Norwegian White Spæl Sheep (9,5%), Norwegian Old Spæl Sheep (5,7%), Colored Spæl Sheep (3,1%) and Old Norse Sheep (2,4%). The wool is taken to one of the 11 wool stations in Norway (Animalia, 2020a). In the wool stations, the wool is classified into 16 different categories based on different attributes relating to, but not limited to, length of fibres, pigmentation, and vegetable matter (Animalia, 2021). 80% of the wool is sold in international auctions, and most are used in carpet production (Vičiūnaitė, 2020).

According to Hebrok et al. (2012, p. 12) the activity of sheep helps maintain the cultural landscapes associated with grasslands. Other factors such as tradition, employment, and economic value creation may also be tied to the activity. Hebrok et al. (2012, p. 12) also mention a point of interest regarding sheep activity as a matter of self-sufficiency concerning food access.

2.1.3 Issues concerning Norwegian wool

In a report by Klepp et al. (2019, pp. 58-59) on sheep farming in Norway farmers with less than 50 sheep, 70% replied that they deliver the wool to a wool station, to spinneries or use the wool themselves. Farmers with more than 50 sheep replied that 38% are delivered to a wool station, to spinning or use the wool themselves. Farmers with <50 sheep replied that they throw away wool as waste, and for farmers with >50 sheep, this number increased to 50%. The farmers in both categories report that they store wool for later use (11-13%), but Klepp et al. (2019, p. 58) speculate that this can be a mode to suspend the action of throwing it away, which farmers reluctantly want to do. All the farmers replied that they wanted to make good use of the wool (Klepp et al., 2019, p. 59; McKinnon et al., 2019, p. 6).

An incentive to use the wool is that greasy sheep wool has expensive disposal costs. This is due to its high bacterial load, thus carrying the label of special waste (Parlato & Porto, 2020, p. 2). Parlato & Porto (2020, p. 1) notes that "wool is often burned or buried, with serious consequences for the environment." Klepp (2016) states that: "wool decomposes slowly and hardly burns." Getting rid of wool is thus not entirely straightforward because if it is delivered to a landfill, you have to pay for it. The low price is already leading many heavy-hearted farmers to dump wool illegally. If the price becomes even lower, the risk of large-scale dumping in the cultural landscape is great. In contrast to the view that large amounts of wool are being discarded, Fatland Ull AS and Norilia estimate that only 0,16 % of raw wool, with contaminants, moisture, and vegetable matter, is discarded every year (Hebrok et al., 2012, p. 53). These numbers are from before the subsidies from the government were taken away.

Farmers choose to dispose of the wool in mentioned manners because the government has haltered subsidies on specific wool categories (Klepp et al., 2019, p. 18). The government has limited the subsidies on the categories C2S, G, V, H2 & H3 because the governing instances in this sector (the government, Norges Bondelag og Norsk Bonde- og Småbrukarlag) want to increase the quality of the wool being produced. Specific categories of wool have gained higher subsidies as a motivator to increase the focus on the production of these (Landbruksdirektoratet, 2015, p. 5).

Another reason is that the price of wool has decreased over time due to global competition posed by cotton and synthetic fibres (Røsvik & Boks, 2012, p. 2). At the time of writing this document, the prices of wool are historically low due to the impacts of Covid-19 with decreased demand for wool (Norilia, 2021, Nortura, 2021, Fatland, 2021). In September 2021, the price of wool was set to zero due to low demand and diminishing storage capacity (Norilia, 2021). Current prices can be found on Fatland's and Nortura's homepages.

The yearly production of sheep wool in the EU is mainly coarse and low-category and approximately amounts to above 200.000 tonnes. According to Petek & Marinšek Logar (2020, p. 45), this leads farmers to discard significant volumes of wool as waste.

2.1.4 Greenhouse gas emissions and wool

According to the Higgs Material Sustainability Index[3], wool ranks at number 18 of 22 materials analysed (Vičiūnaitė, 2020, p. 13). This is mainly due to the greenhouse gases (GHG) emitted during the sheep life. These GHGs include methane at a rate of 10-16 kg per year. In perspective, a cow emits from 60 to 160 kg per year on average, depending on the type, location, and feed (Soren et al., 2017, p. 213). Soren et al. (2017, p. 209) also inform that methane is a potent GHG that contributes to global warming and that it is approximately 23 times more potent than carbon dioxide. According to Nisbet et al. (2016, cited in Prajapati & Santos, 2019, p1427), methane, as an anthropogenic GHG emission, is responsible for approximately 20% of global warming caused by humans. In the US, about 35% of the total anthropogenic GHG emission derives from enteric fermentation in the households of animals (Gerber et al., 2013; Knapp et al., 2014; USEPA, 2017, cited in Prajapati & Santos, 2019, p. 1427). A Life Cycle Assessment (LCA) done in 3 different regions in Australia, the world's largest exporter of greasy wool, shows that emissions and water usage depend highly on geography and location (Wiedemann, 2016).

2.1.5 Alternative uses of wool

This section seeks to explore how wool can be used in other ways than textiles. This is a response to the findings from the literature review, where the intended purposes of wool seem overly attached to garments. Below are some examples that cover the use of different properties of wool.

Alternative uses

Lavalan is a German-based company that focuses on the insulative properties of wool concerning lifestyle garments and bedding. According to their website, they offer: “continuous improvement and innovations, customised product development, and a preferentially regional sourcing of wool – underlined by a ‘zero-waste’ philosophy” (Lavalan, 2022).

[3] The Higgs Material Sustainability index measures an entity’s or resource’s social and environmental performance.

Greenfibres offer duvets filled with wool and wool plush pads and use wool as a material due to its temperature regulating and moisture-absorbent traits (Greenfibres, 2022).

Norsk Ullsåle makes sleeping pads for e.g. trekking, and shoe soles (Fredriksen Fabrikk, 2022).

Havelock Wool, Sheep Wool Insulation, and *Thermafleece* are companies that focus on distributing wool plates and rolls for insulating houses. According to their websites, wool is an excellent alternative for insulation due to its temperature- and sound-insulating traits and its moisture-absorbent and fire-retardant traits (Havelock Wool, 2022, Sheep Wool Insulation, 2022, Thermafleece, 2022).

WoolCool also provides wool for insulation, but has tailored its product lines towards: ”Superior insulated packaging for the transportation of temperature sensitive goods” (WoolCool, 2022). The company's business model is tailored towards the transportation of fresh food (warm and cold) and pharmaceuticals.

Rom & Tonik focuses on the insulative aspects of wool (in certain product lines), but resides to the sound absorbent qualities of wool. Rom & Toniks slogan is: “Reduce echo and unwind: with good looking sound absorbers ” and intends to do so with a circular take with the use of a material called *Really”* (Rom & Tonik, 2022).

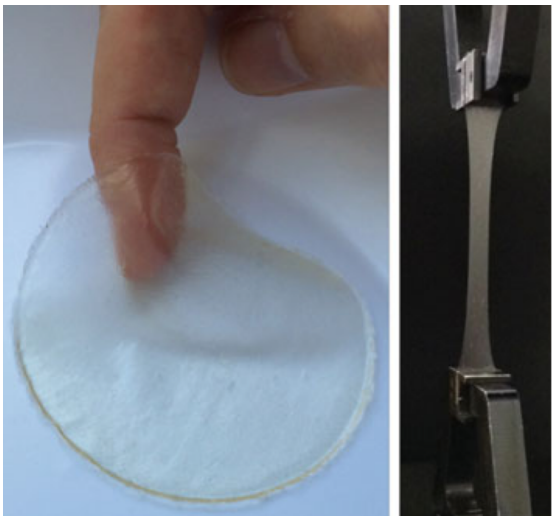
Kvadrat is a Danish company that delivers the material Really, or rather an array of materials. According to their website, Really is recycled textiles, mainly cotton and wool, upcycled to other materials. These materials can be porous, which makes them fit for sound absorption or be compressed with the use of polymers into solid materials coated with melanin, fit for interior construction (Kvadrat, 2022).

Keratin

Sheep wool consists of 80-90% keratin fibres with a high presence of cysteine (around 17%) (Fernández-d’Arlas, 2019, p. 2, Shah et al., 2018, p. 29). Keratin is one of the most abundant proteins found in reptiles, birds, and mammals (Sharma & Kumar, 2019, p. 2). Keratin is a by-product that is underutilised and may be hazardous to the environment (Cavello et al., 2012; Park et al., 2013, cited in Sharma & Kumar, 2019, p. 2). According to Sharma &

Kumar (2019, p. 3): ”Keratin is a useful product in the medical, pharmaceutical, cosmetic, and biotechnological industry. Materials obtained from keratin may be converted into porous foam of different sponges, shapes, coatings, mats, microfibers, gels, and materials of high molecular weight.”.

Keratin can be utilised as a strong biopolymer as the molecular structure forms at a nanoscale giving it strong walls that are neither soluble in hot or cold water and providing protection against heat stress, pathogens, and damages relating to pressure and rupture (Shah et al., 2018, p. 19). Petek & Marinšek Logar (2020, p. 46) notes that: “According to the great interest for different industrially applicable keratinases waste wool represents a useful and cheap substrate for production of these enzymes as products with high-added value.”.



.Figure 2. “Picture of wool keratin film: before (left) and during (right) tensile strength test”, 2018, by Sanchez Ramirez et al (https://link.springer.com/chapter/10.1007/978-3-030-02901-2_4)

Lanolin

Wool wax is a by-product of the sheep industry, is often disposed of as waste (Hassan et al., 2015, pp. 249-250), but it can be purified into lanolin which is a substance composed of oil and fat. Sheared sheep wool consists of 10-25% of this substance (Khattab et al., 2019, p. 9362), but the content varies between breeds. “Wool from Old Norse Sheep has a high content of lanolin which acts as a natural impregnation and is known to provide good heat” (Klepp et al., 2019, p. 51). “Bio-based products are gaining popularity because of their eco-friendliness, sustainability and low environmental impact“ (Hassan et al., 2015, p. 249). Lanolin is “..biodegradable, nontoxic, biocompatible and has a potential alternative to mineral oil” (Salem Allafi et al., 2021, p. 2).

> “Lanolin is considered a pure and safe intervention (containing no preservatives, additives, water, chemicals or perfume), aimed at creating a moist healing environment for nipple trauma, and providing a semi occlusive barrier that promotes

retention of internal moisture and prevents dryness" (Martin 2000, cited in Jackson & Dennis, 2017, p. 2).

"The hydrophobic nature of lanolin makes it valuable in various industrial fields, such as lubricants, plastics, rustproof coatings, paints, and inks. It can easily combine with a variety of materials to be employed for cosmetics and pharmaceuticals due to its strong emulsification and penetration properties. Its adhesion nature makes it an excellent substance to be applied as a plasticizer in adhesives and resins." (Edman and Möller 1989, cited in Khattab et al., 2019, p. 9362).

According to a report by Grand View Research (2019), the lanolin market size is expected to expand at a compound annual growth rate of 6% and reach 334 million USD by 2025. Lanolin is sold for up to 1000 NOK/kg (Cabell, 2021, p. 43).

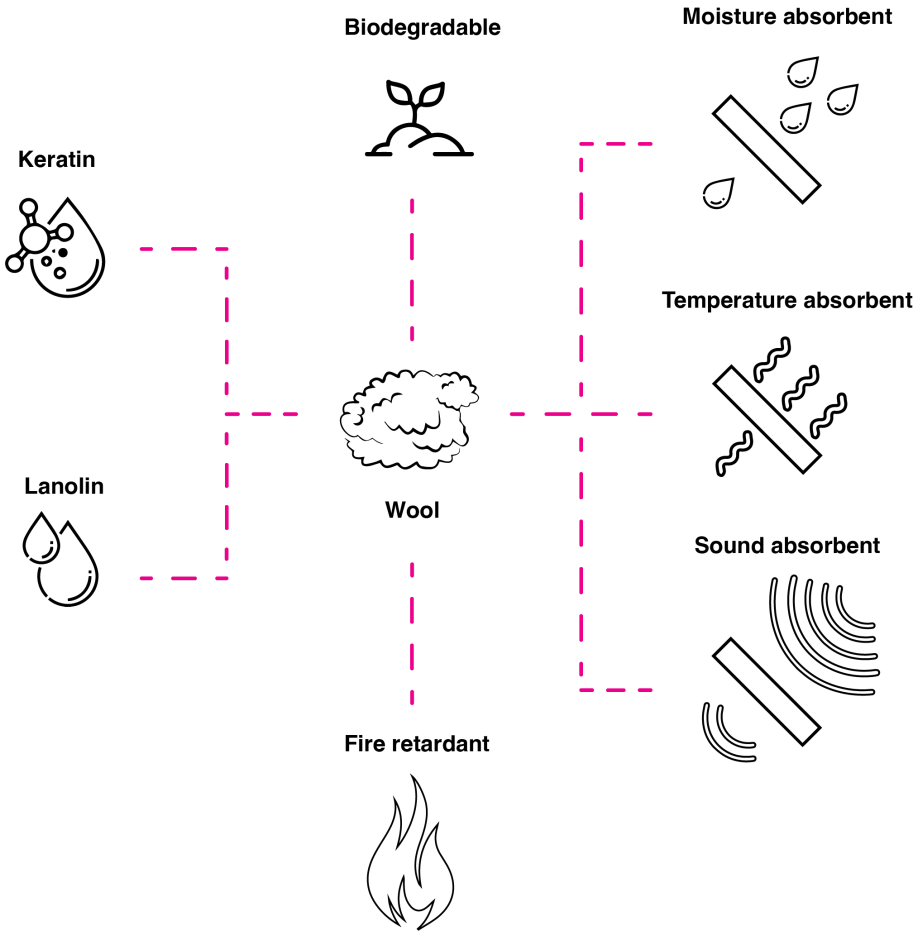


Figure 3. Properties of wool.

Processing

Raw or unprocessed wool mainly contains three contaminants: grease/lanolin, suint, and mineral dirt. The suint is soluble in water, whereas the two other contaminants need other modes of removal (Dominguez, 2003, p. 233). The conventional way of cleaning out these impurities is through scouring. This process requires much water, and accordingly, creates high amounts of wastewater with pollutants that need effective treatment before disposal (Holkar et al., 2016, cited in Salem Allafi et al., 2021, p. 2). The process also has certain drawbacks such as the minimisation of wool fibre strength, and that the separation of lanolin and drying requires further processing (Bhavasar et al., 2017; Gutarowska et al., 2017; Zhang et al., 2016, cited in Salem Allafi et al., 2021, p. 8).

However, alternative processing techniques can offer enhanced results with a smaller input concerning the usage of water and chemicals (Salem Allafi et al., 2021, p. 2). According to Salem Allafi et al. (2021, pp. 7-8), such technologies include:

- Pulsed electrohydraulic discharge
- Ultrasonic-assisted industrial wool scouring
- Enzymatic treatment with subtilizing
- Alkaline wool scouring
- Soap scouring
- Carbonising
- Oxidation with hydrogen peroxide
- Superheated water
- High-pressure water
- Microwave radiation
- Plasma
- Supercritical CO2

Salem Allafi et al. (2021, p. 12) and El-Sayed et al. (2018, p. 1154) argues that the process of applying scCO2 (supercritical CO2) offers many advantages compared to the other methods. Some of the arguments being that it does no generate toxic wastewater, the extraction of lanolin can be combined with other processes, the ability to dye the wool increase, the wool output is of higher quality, the process avoids the use of toxic volatile organic compounds and when implemented the process can save energy and time compared to conventional approaches. Two of the major drawbacks of this technique are the processing plant requires a

significant capital investment and that the process is at an infant stage concerning the processing of sheep wool (Salem Allafi et al., 2021, p. 8). A great advantage of this processing technique that supersedes the processing of sheep wool is that the parameters of the scCO2 are adjustable (pressure and temperature) allowing for extraction, separation, and cleaning/sterilisation of other matters. (Salem Allafi et al., 2021, p. 9). Hence, making it a dynamic processing technology.

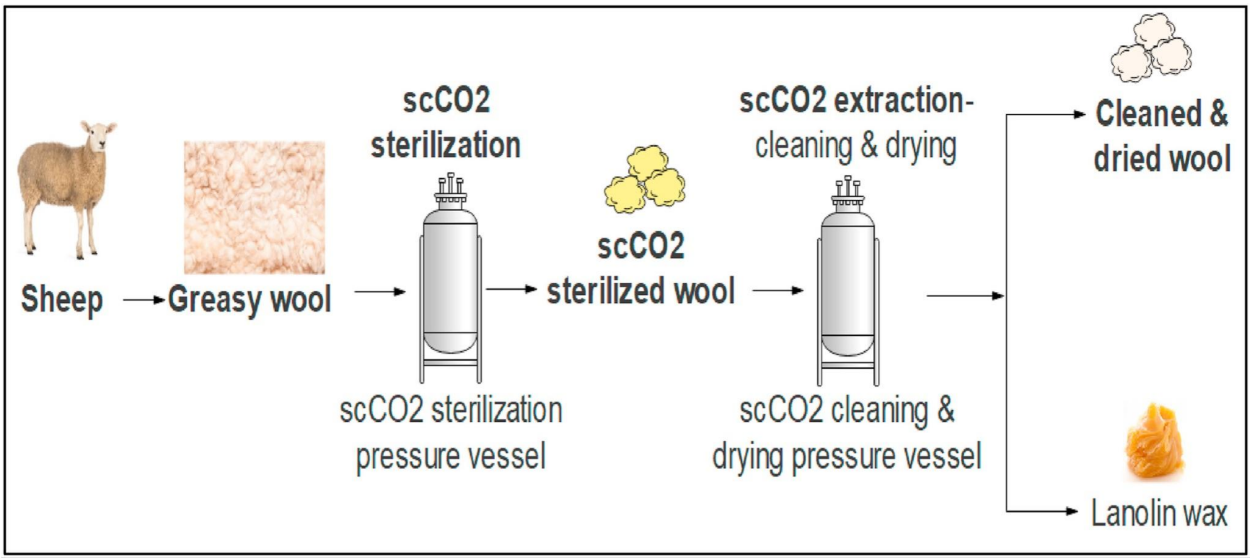


Figure 4. "Implementation of the scCO2 technology in sheep wool processing", 2021, by Salem Allafi et al. (https://doi.org/10.1016/j.jclepro.2020.124819).

2.3 Circular economy

The question might be what circular economy *does*, instead of discussing what it *is*, as a way to encapsulate the action-based aim of the concept. Ghisellini et al. researched the term by analysing 155 sources and found that "The ultimate goal of promoting CE is the decoupling of environmental pressure from economic growth" (2016, p. 11). Kirchherr et al. (2017, p. 221) argue that the concept of circular economy requires a coherent definition, as too great variations from too many authors may "result in the collapse of the concept". CE as an umbrella concept may be able to encompass

> "[...]a plurality of definitions, a lack of tools, and the existence of different indicators [...] raising questions regarding the nature of the binding capacity of the umbrella concept. This leads to further work in the form of additional theoretical development,

> which ultimately causes the concept to either cohere (theoretical challenges are resolved), collapse (construct demise), or persist as a contention (agree to disagree)" (Hirsch and Levin 1999, cited in Blomsma & Brennan, 2017, p. 606).

When a discipline lacks theoretical frameworks an umbrella can "[...] act as a catalyst in filling this knowledge gap by creating a new encompassing cognitive unit as well as a new discursive space" (Blomsma & Brennan, 2017, p. 606). In the metastudy by Kirchherr et al. (2017) they reference authors that have made the same argument regarding the term 'sustainable', with critique ranging from its lack of clarity in how it should be implemented, to its perceived connotations (van den Brande et al., 2011; Peltonen 2017, p. 2 ff.; Naudé, 2011, p. 352; Engelman, 2013, p. 3, cited in Kirchherr et al., 2017, p. 221). The lack of a unified definition prompted Kirchherr et al. (2017) to explore the term through a meta-analysis of 114 definitions, including 54[4] of the sources from the mentioned article by Ghisellini et al. (2016).

Ghisellini et al. (2016, p. 15) reference several authors (Feng and Yan, 2007, Ren, 2007, Sakai et al., 2011, Preston, 2012, Reh, 2013, Su et al., 2013, Lett, 2014) in stating that CE "...mainly emerges in the literature through three main "actions", i.e the so-called 3Rs Principles: Reduction, Reuse and Recycle". Kirchherr et al. (2017, p. 223) include an additional R in their framework for understanding the concept, Recover. The Recovery-dimension was added by the EU Waste Framework Directive and was found relevant for the metastudy as several definitions touched upon material recovery as an CE activity (Kirchherr et al., 2017, p. 223).

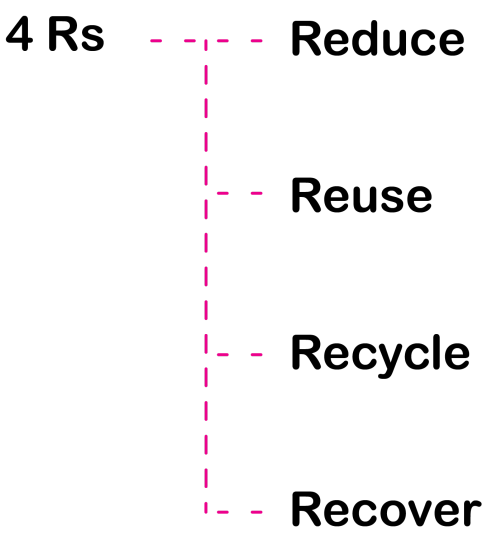


Figure 5. The 4Rs.

In addition to the 4R-framework, Kirchherr et al. (2017, p. 224) outline a system framework, where the concept is seen through macro-, meso- and micro-perspectives, with references to how other contributors define the levels:

[4] Out of the 155 sources analysed by Ghisellini, only 54 included a definition of the term.

> While the macro-systems perspective highlights the need to adjust industrial composition and structure of the entire economy, the meso-systems perspective usually focuses on eco-industrial parks as systems (on these parks: Heeres et al. (2004), Shi et al. (2010)) and this level is also called the 'regional level' at times, e. g. By Li et al. (2010, p. 4274) or Geng et al. (2009, p. 16). Meanwhile, the micro-systems perspective usually considers products, individual enterprises, and what needs to happen to increase their circularity as well as consumers (Jackson et al., 2014; Sakr et al., 2011).

In their metastudy, Kirchherr et al. (2017, pp. 223-224, 227) found that few sources mention all three systems and that most authors focus on the macro-system. "Those mentioning it [system perspective] highlight that CE requires a fundamental shift instead of incremental twisting of the current system."

With these two ways of framing the concept, Kirchherr et al. (2017) coded the 114 contributions by manually sorting along these dimensions, aiming for a synthesised definition. The suggested definition of CE after the meta analysis is:

> "A circular economy describes an economic system that is based on business models which replace the 'end-of-life' concept with reducing, alternatively reusing, recycling and recovering materials in production/distribution and consumption processes, thus operating at the micro level (products, companies, consumers), meso level (eco-industrial parks) and macro level (city, region, nation and beyond), with the aim to accomplish sustainable development, which implies creating environmental quality, economic prosperity and social equity, to the benefit of current and future generations." (Kirchherr et al. (2017, p. 224-225).

Kirchherr et al. (2017, p. 224) disclaim that this is a summary of their coding, stemming from their partially subjective understanding, not a definitive CE definition. Defining the term in an exact way might be futile, as the term is "constructed" through a "multi-stakeholder discourse" (Berger and Luckmann, 1966; Dahlsrud, 2008, cited in Kirchherr et al., 2017, p. 224).

We see the definition and the process leading up to it as relevant and valid due to its methodological convincing processing, and will rely on Kircherr et al.'s definition on CE. However, we find the systems framework to be hard to operationalise in our analysis due to our relatively small sampling size. Instead, we have chosen the framework from Korhonen et al. (2017), where the CE is seen in the perspective of the triple bottom line. The focus on social, economic, and environmental consequences makes it easier to view the CE principles in relation to sustainability. The triple bottom line is a well-accepted framework that may enable comparison with other text that uses the same framework.

> In sum, in our definition of CE for sustainable development, the environmental objective of CE is to reduce the production-consumption system virgin material and energy inputs and waste and emissions outputs (physical throughput) by application of material cycles and renewables-based energy cascades. The economic objective of CE is to reduce the economic production-consumption system's raw material and energy costs, waste management and emissions control costs, risks from (environmental) legislation/taxation and public image, and innovate new product designs and market opportunities for businesses. The social objective is the sharing economy, increased employment, participative democratic decision-making, and more efficient use of the existing physical material capacity through a cooperative and community user (user groups using the value, service, and function) as opposed to a consumer (individuals consuming physical products) culture. (Korhonen et al., 2017, p. 41).

2.3.1 Circular economy in Norway

The Circularity Gap Report was made by the organisations Circle Economy and Circular Norway, both organisational promoters of increased circularity. The report looked at all the inputs from the country's production and imported goods and found that our level of circularity is at 2,4% (Circular Economy & Circular Norway, 2020), leaving considerable room for improvement. In comparison, the global average is at 8,6% (Circle Economy, 2021), and the Netherlands can boast the highest number at 24,5%. The EU has set a target to become *fully* circular by 2050 (European Parliament, 2021).

The Circularity Gap Report: Norway states that the total amount of waste generated is 14.6 million tonnes, while 10.3 million tonnes are lost and landfilled. In Norway, there are well-functioning systems for recycling specific streams of resources, like metals, glass, paper, and organic waste, but this is a small volume of the total amount. We lag behind in general waste recycling, like mixed household waste, construction waste, oils, hazardous waste, and contaminated soils, which accounts for two-thirds of all waste (Circular Economy & Circular Norway, 2020, p. 27). The waste picture is quite complex as the Norwegian economy is based on the import of goods and has relatively little waste. This is because the waste generated in the production of the imported goods is generated in the country of origin on paper (Circular Economy & Circular Norway, 2020, p. 27).

To shift towards a higher rate of circularity, the authors propose actions in the sectors with the highest potential. For the consumer goods section, which includes textiles, these actions are summarised (Circular Economy & Circular Norway, 2020, pp. 42-43):

- Slow use - keeping products in use for longer.
  - Enabling a right to repair.
  - Designing products modular, allowing easy replacement.
- Cycle flows - reuse.
  - Using economic incentives to increase recycling.
  - Creating mono-material products for easier recycling with high material purity.
  - Creating deposit return schemes for a broad range of products, like we successfully did with plastic bottles.

Further, the report emphasises how Norway's resource use is extraordinarily high and that the concept of circularity is largely unknown[5]. This is regarded as a problem by Corvellec et al. (2021, p. 425), as the consumers might not be willing to pay a price premium or even equal price for a circular product because they are unfamiliar with the concept. In addition to using recycled or recovered materials the product needs to perform on par or better than its linear alternative. This can be an issue because the factor of material degradation will influence these capabilities.

[5] "Half of consumers (51%) are unfamiliar with the term 'circular economy', and only 12% know the meaning of the term" (Circular Economy & Circular Norway, 2020, p. 49).

2.3.2 Circular value chains

We recognise the linear supply chain as a “take-make-waste”-model, as illustrated below by Wautelet (2018, p. 18; see also Korhonen et al., 2017, p. 37). The implications are obvious, with consequences ranging from resource depletion, emissions, environmental degradation, and massive landfill areas of waste seeping into soil, water and biomass (Korhonen et al., 2017, p. 38).

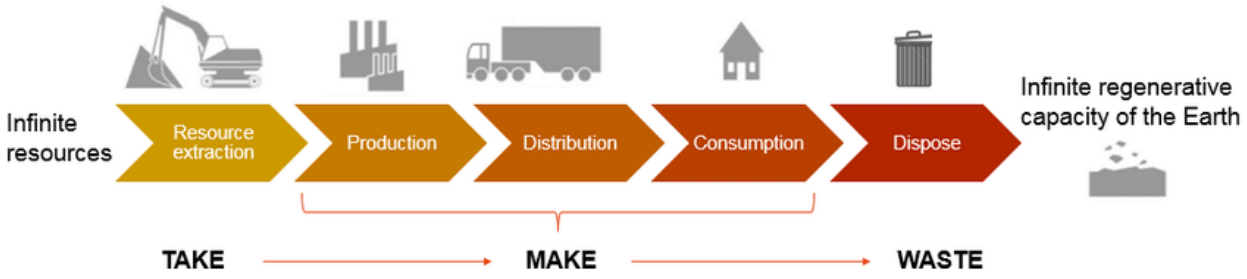


Figure 6. “The linear economy - The 'take, make and waste' approach of production”, 2018, by Wautelet. (https://www.researchgate.net/figure/The-linear-economy-The-take-make-and-waste-approach-of-production_fig2_323809440)

As Wautelet explains, this current economic model is constructed upon two assumptions: that we can extract resources indefinitely, and that the earth will have a limitless regenerative capacity (2018, p. 18). These assumptions are, of course, constantly falsified by empirical evidence. Wautelet argues that the take-make-waste model is unsustainable and that it increases the exposure to the risk of resource supply disruptions (World Economic Forum The circular economy 20, 2014, cited in Wautelet, 2018). The need for another model is evident and has led to the emergence of a circular economy.

The United Nations Industrial Development Organisation has summarised the difference between a linear and a circular value chain as illustrated:

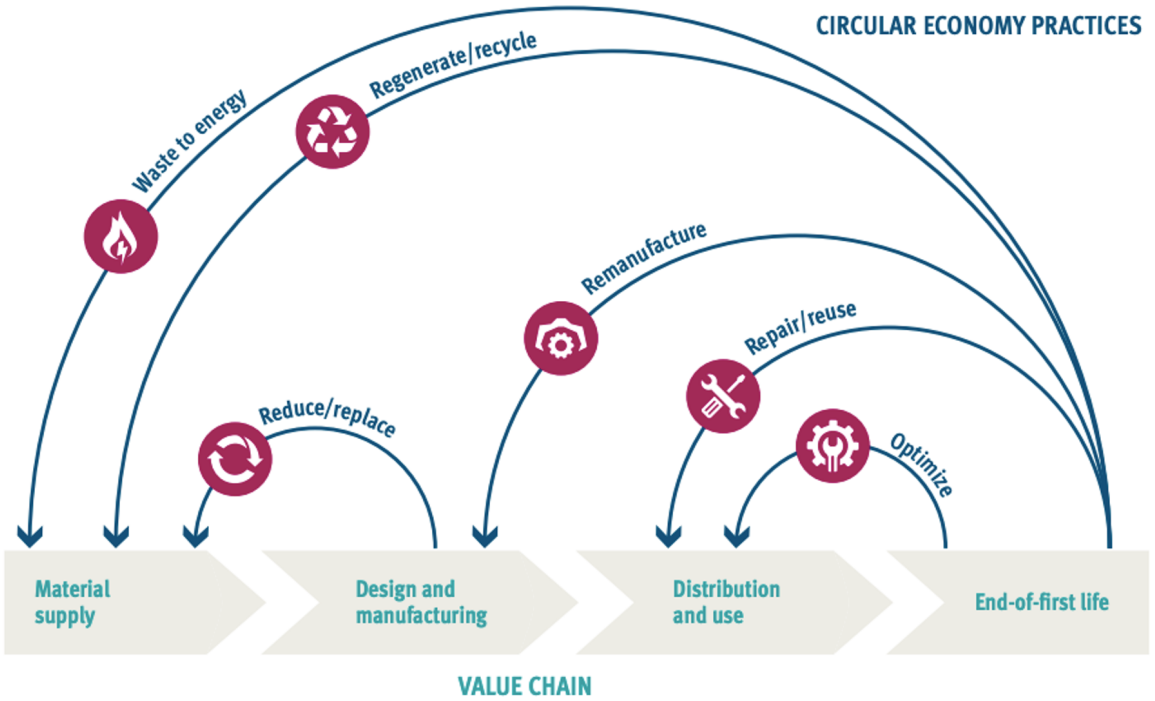


Figure 7. "Illustration of linear and circular value chains.", 2020, by UNIDO. (https://www.unido.org/our-focus-cross-cutting-services/circular-economy)

In this model, we recognise the 4Rs previously mentioned and how they fit in a production chain. We note that this model illustrates a company-level or micro-level process description. Compared with the take-make-waste model, this model starts at *material supply* instead of *resource extraction*, thereby leaving out discussions on themes like sustainable resource management and mono-materialism, enabling future recycling.

Global value chains, where the production of goods is dispersed in several locations, are complex. While the adverse effects of transport lead to high climate gas emissions, global value chains create job opportunities for people in the global south (Dollar, 2021). Corvellec et al. (2021, pp. 5-6) argue that

> few products are remanufactured, purchased, disposed of, and recycled in the same geographic location, thus leading to vast transfers of resources across the globe (Skene, 2018). Therefore, using waste in new activities would require a challenging global reorganization of consumption and production (Savini, 2019). Consequently, it is not clear how a circular economy can deliver a globally sustainable satisfaction of human needs within the planetary boundaries (Schröderetal., 2019).

We understand these as trade-offs that need to be addressed in the transition toward a circular economy. By localising a value chain, we need to understand the social implications of the jobs that disappear in the existing global chain and account for the positive factors like CO2 reduction, local job creation, and a tighter value chain that might be better suited for recovery strategies.

2.3.3 Reduce

Circularity implies reducing the extraction of virgin materials. This can be done by recovering existing materials, but also for materials overall. Many strategies could reduce demand, like prolonging product lifespan, making modular products, sharing-economy business models and customer awareness.

> The Reduction principle aims to minimize the input of primary energy, raw materials and waste through the improvement of efficiency in production (so called eco-efficiency) and consumption processes e.g. introducing better technologies, or more compact and lightweight products, simplified packaging, more efficient household appliances, a simpler lifestyle, etc. (Feng and Yan, 2007; Su et al., 2013, cited in Ghisellini, 2015, p. 15).

This can happen through "[...]keep or increase the value of products whilst also reducing their environmental impacts … by using fewer resources per unit of value produced and by replacing more harmful substances in favour of less harmful ones per unit of value produced" (Ghisellini, 2015, p. 15). However, Kirchherr points out that "Practitioners frequently neglect 'reduce' in their CE definitions, though, assumingly since this may imply curbing consumption and economic growth." (Kirchherr et al., 2017, p. 229).

So, by reducing demand for materials, through lighter packaging, smarter design or customer awareness, less material extraction is necessary. Extraction, processing and distribution are usually energy intensive and create emissions. If we include extended factors, like the extractions of raw material to make the machines that process other raw materials, or the material footprint of the oil industry that makes the diesel for the trucks involved in distribution, the argument for reduction is severely reinforced.

We need less of everything. When materials are turned into products and distributed, the next circular action according to the 4R hierarchy is to reuse what already exists to put less pressure on material demand and keep products and materials in use for as long as possible.

2.3.4 Reuse

The European Union defines reuse as “any operation by which products or components that are not waste are used again for the same purpose for which they were conceived” (Directive 2008/98/EC, 2008, article 3).

According to Castellani et al. (2015, p. 374), reuse of resources may have socioeconomic benefits by e.g., providing disadvantaged demographics with less costly resources than new ones. Reuse may also benefit environmental factors as it entails lower requirements of energy, labour, or the use of virgin materials. LCA approaches have revealed that reuse can prevent emissions of noxious emissions and have other positive environmental impacts when compared to conventional linear methods (Castellani et al., 2015, p. 379). Before something is reused it may have to undergo preperment for a reuse process which is defined as the means of “checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing” (Directive 2008/98/EC, 2008, article 3). Resources can be exchanged in various modes, through an increasing amount of informal, e.g., direct encounters, and formal channels, e.g., third parties (Castellani et al., 2015, p. 373, Delanoeije, & Bachus, 2020, pp. 13-16). Delanoeije, & Bachus (2020, pp. 16-18) highlights some of the issues related to reuse of resources;

- the receiving part require a particular function of the good
- reusable resources may be collected effectively, but are not reused successfully
- there is a risk that the replacement rate exceed the reuse rate, which can lead to a surplus stock
- goods can be used in other ways than intended and therefore preparation for reuse can entail that the function of that good is different than the requirement of the new user
- if the value chain of reuse is global the tradeoff is less sustainable practices

2.3.5 Recycle

The European Union defines recycling as “any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.” (Directive 2008/98/EC).

An interesting discussion on recycling revolves around the law of entropy. In the views of Georgescu-Roegen (1971), the second law of thermodynamics makes complete recycling theoretically impossible, due to the fact that recycling will demand energy, generate waste and dissipate materials. This has been contested by arguing that

> “ …earth is an open system receiving the flow of infinite solar energy that could, in theory, be harnessed and utilised for materials collection, recovery, shorting and other recycling and CE-type processes (see e.g. Ayres, 1999; Graig, 2001; Converse, 1997; 1996). [...] Hence, in theory, actually it is possible to recycle everything by using the incoming renewable (infinite) energy from the sun. This would require a lot of work, e.g. for tracking, finding, recovering and processing the dissipated materials and nutrients. But in theory, this is possible.” (Korhonen et al., 2017, p. 42).

This is a powerful statement, implying that circularity depends on renewable energy sources to be fully implemented. Circular practices must therefore be scrutinised to avoid using fossil energy in every stage of production, use, and End-of-life strategy (hereafter EoL). The contours of magnitude prove that the 4Rs are arranged in a hierarchy, where reduction is the overall better solution, reuse renders less energy use and product tampering, and recycling is hard to perform at a high level. However, when products and materials reach their perceived end-of-life, the last strategy is to recover the material. According to Blomsma & Brennan (2017) strategies with this capacity can be called resource life-extending strategies (RLESs).

2.3.6 Recover

The European Union defines recovery as:

> “‘any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy” (Directive 2008/98/EC, 2008, article 3).

The EoL recovery dimension includes recovery strategies such as remanufacturing, repairing, reconditioning, cannibalization, redesigning, refurbishing, upgrading, and recycling. The EoL strategy is applied when the resource is no longer satisfactory for the last user. Three main criterias should be fulfilled to apply a recovery strategy as an EoL option; sourcing of second-hand resources, refinement of a recovered resource, and the redistribution of the refined resource. New governmental legislations push original equipment manufacturers to handle their products at an EoL stage through an extended producer responsibility (Alamerew & Brissaud, 2018). Alamerew & Brissaud (2018, p. 176) define the different recovery strategies as follows:

> **Remanufacture** is an end-of-life product recovery strategy whereby used products are restored to the original equipment manufacturer standard and receive a warranty at least equal to a newly manufactured product.
>
> **Recondition** involves returning the quality of a product to a satisfactory state level (typically less than a virgin standard/new product) giving the resultant product a warranty less than of a newly manufactured equivalent.
>
> **Refurbishing** involves returning products to a specific quality level, usually less than that of a new product. Reconditioned products have gone through extensive testing and repair than refurbished products.
>
> **Cannibalization** is an activity of recovering parts from returned products. Recovered parts are used in repair, refurbishing, reconditioning and remanufacturing of other products.
>
> **Repair** is an activity of returning a used product into "working order" by fixing/replacing specified faults in a product using service parts.
>
> **Recycle** is an activity where discarded materials are collected, processed and used in the production of new materials or products.

2.3.7 Critiques of circular economy

Kirchherr & van Santen (2019) offers a brief summary of critical observations stemming from previous analysis on the concept of circular economy, like the aforementioned meta-analysis on how the term is defined. We hope to become aware of these pitfalls in our further work on the subject by leaning on their observations. The critique of the concept revolves around its lack of empirical evidence, its lack of large-scale case studies, its focus on the manufacturing industry (and lack of focus on the service industry), its adherence to developed economies, and its lack of practical advice (Kirchherr & van Santen, 2019, p. 151). For instance, the illustration of the difference between the circular- and the linear economy as presented above in figure 2, appears to be fitted for a micro-scale manufacturing company, proven by terms such as "material input" and "remanufacture". Corvellec et al. (2021, p. 3) offer additional critiques, stating that even closed-looped systems will cause emissions, material degradation, and eventually waste. Material degradation sets an upper limit on recyclability, and therefore a fully closed loop cannot be created.

Part of the critique addresses the implementation of circular policies' promotion of circularity "rather than to obstruct the legacy of the linear economy" (Corvellec et al., 2021, p. 4). Another similar statement points to the same: "Circular business models thus end up being not as radical as one might imagine; in particular, they fail to address the roots of the persistent resource problems that they are supposed to solve, in particular in globally fragmented and dispersed value creation networks" (Hoffmann, 2019, cited in Corvellec et al., 2021, p. 5).

3.0 Methodology

We consider our intended readers to be our peers, academics or professionals working in one of the two fields, CE or wool. This chapter will present the research design we see as best fitted to answer our research questions, our sampling of both literature and empirical evidence, and how we collect and process data. In the subchapter on ethics, we strive for transparency regarding our personal beliefs and convictions and the formalities tied to consent, referencing, information handling and the university's ethical standards. We aim to operationalise the ethical considerations and stances throughout the thesis and will make

disclaims where it is appropriate to do so. As all researchers have a bias to some extent, we believe that it is important to include this as it is deemed to influence the material. With that said, by being aware of one's perspectives relating to the data, the researchers will be able to stipulate questions, interact with informants and perform analysis on a somewhat neutral basis. This will also be helpful by not steering us into actualising preconceived beliefs, also known as confirmation bias.

3.1 Research design

The innate logic of our research design can be illustrated as below. Chronology matters, as the consecutive chapters lean on each other. In our research we went into a field of study with little prior knowledge. The previous studies in the literature review gave us a great introduction, but we needed to generate our own data to supplement and question the already existing data.

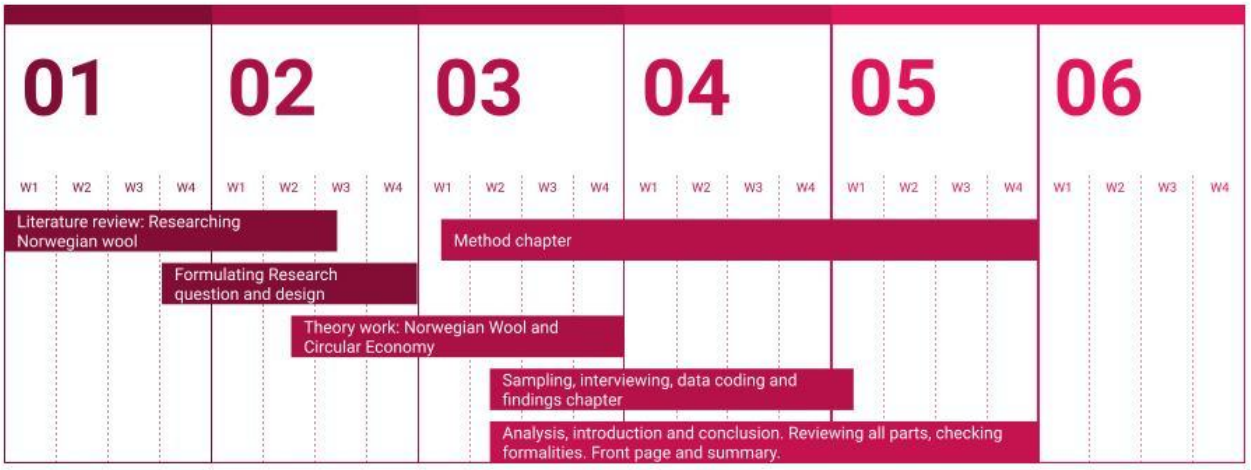


Figure 8. Research design.

Our research design includes flexibility by overlapping some of the processes because parts affect each other, which calls for revisiting. For instance, the methods chapter is under construction during the majority of the thesis, because it includes information on all parts. We went back and forth between literature review, theory work and the formulation of our research questions to situate our thesis in a practical manner. The “Sampling, interviewing, data coding and findings chapter” was the most challenging part. We needed time, guidance and reading to understand how to perform the activities fruitfully. To fully commit to discussing and writing up, we strived to complete most of the other chapters before April. The plan was sufficiently detailed and feasible, in our experience.

3.2 Sampling

Our sampling has been strategic, as we have approached people of interest that we assumed had knowledge about the theme we have explored (Thagaard, 2013, p. 60). Thagaard describes strategic sampling as when the participants represent relevant traits for the research problem (2013, p. 61). In this logic, the sampling was created based on the theory work, as people of interest emerged from the literature. This is in line with Marshall & Rossman, who argues that "purposive and theoretical sampling, which is guided by the theoretical framework and concerts, is often built into qualitative designs." (2006, p.70). We found the professionals that could be representatives from the industry actors we wanted to interview through online searching. and contacted them directly. The sample size was deemed feasible and sufficient related to our resources and the scope of the thesis. We believe that the interview guide was constructed in a manner that generated credible and reliable data for further analysis and discussion. In addition, it was shaped in a way that allowed for casual conversations relating to the theme.

3.2.1 Literature review and theory

To explore and understand the Norwegian value chain for wool, we performed a literature study on academic articles and reports on the subject. We found two resourceful research projects, KRUS and VerdifUll. The main objectives of this preliminary study were to get familiar with the terms, key people, existing uses, and suggested alternative uses. We read the abstracts of all the scientific articles from the two projects to get an overview of themes and sorted the articles after what we deemed relevant. The boundaries for our thesis were set to exclude the following themes: fashion, knitting, history, sheep farming, sheep breeding, ruralism/localism[6], food and clothing/garments. In order to do a narrow study within our time range, we selected articles with these themes for further review: value chains, wool sorting, business model innovation and business development, entrepreneurialism, alternative uses, and different qualities and attributes of wool.

The theory chapter is structured in two parts: Wool and Circular Economy. The theory subchapter on wool gives a contemporary overview of the situation for wool. As mentioned

[6] Globalism and localism will be mentioned in the theory chapter on value chains, but we will not venture far into this.

earlier we avoided including thematics such as the history of Norwegian wool, breeding and so forth. The reason is that we wished to funnel the data into concepts that can be tied up to CE principles. These thematics are also well covered in material such as the KRUS report, VerdifUll and others. The chapter investigates how the circumstances relate to wool production, on a global scale, down to wool on a national level. Then, issues relating to sheep wool, such as wool wastage and emissions are investigated. In the latter stage of the chapter, we explore the alternative use of wool and how keratin and lanolin, extracted from wool, can be used for many applications. We also included the different processing alternatives of wool, as innovative measures are motivated by offering more effective and sustainable means of refining the wool.

The subchapter on CE starts with defining the term by drawing on a well-cited meta-analysis. By clarifying the definition from the start, we wanted to avoid discussing contested definitions later on, possibly obstructing our focus. Further, we narrowed our theoretical focus on CE value chains to highlight some pros and cons of CE and illustrate the difference between a linear and a circular way of thinking. The following subchapter, CE in Norway, builds on country-specific data on how we perform now and where our potential for improvement lies. This specification is needed because different countries have different levels of self-sufficiency, import- and export rates, purchase power and waste facilities. We saw it as relevant to understand the Norwegian situation, as our theme revolved around a Norwegian resource. Finally, we included some academic articles with critiques of the concept of CE, as a way to understand it more profoundly and become aware of how we might reproduce or reject the common errors. This forced our thinking to become more generalised. Throughout this part, we have chosen peer-reviewed academic articles or well-renowned reports, with attention to publishing dates, to lean on the latest research with high validity.

We felt that further empirical work might be conducted more efficiently by starting our thesis with a literature review. For instance, getting to know the classification system through literature enabled us to plan and perform more proficient interviews when visiting the wool stations. Our first step in the literature review was a simple search in the university database Oria, using the keywords “Norwegian wool” and “Norsk ull” [Norwegian wool]. The articles from KRUS were among the first results. We used the snowball method to find adjacent articles and reports by reviewing the references from the most relevant articles in the KRUS

project. By focusing on written articles, we found that the key authors had produced many scholarly and popular articles on the subject of wool. We wanted to read up on their work that was relevant to our project so that we could contact them later in the process for interviews.

3.2.2 Empirical sampling

After a systematic review of our theoretical findings, we made an overview of the people we wanted to interview:

- Local sheep farmer - to see different breeds of sheep and listen to the farmer's insights and perspectives on wool.
- Wool sorting stations, both Fatland and Nortura. We wanted to have a walk-through of the whole process line from raw wool intake to readily sorted bags ready for shipping to HSC. We wanted to plan this as a walk-and-talk unstructured interview, to learn about the process.
- Sjølingstad Uldvarefabrik - a local small-scale mill that does the whole process from raw wool to end products. The plant is run as a living museum now. We wanted to watch the process, and ask questions through an unstructured interview.
- Norilia - a subsidiary company of Nortura that deals with the wool generated through Nortura.
- Ingun Grimstad Klepp[7], author from the KRUS and VerdifUll projects. Her insight about the theme has been very valuable, and we humbly build on the knowledge we gained from the reports.

The parties were contacted by mail or phone at the start of our thesis, with the aim of planning for face-to-face meetings. Researcher Ingun Grimstad Klepp and the representative from Norilia were interviewed digitally due to long distances. We sorted the parties after their appearance in the value chain, which allowed us to ask how they relate to the stages before and after in the chain. This gave us insight about fragmentation and coherence. Our sampling consists of parties in our geographical proximity, as we wanted to meet people face-to-face and visit physical places to get an impression of how the value chain works. The maximum driving distance was 2-3 hours from our university. Interviewing in the local setting of the participants was a strategic choice to ensure that the people we talked to felt safe, and to even

[7] Ingun Grimstad Klepp requested that we used her full name when referencing her, which we respect.

out the asymmetricality of the situation (Thagaard, 2013, p. 66). Several participants had been interviewed by students before and were thus familiar with the situation. Our experience was that all participants "had nothing to hide", spoke their opinions and were excited that the theme was given attention. Our access to the field came without barriers and gatekeepers. The only exception to this was the English scouring facility at HSC, where contact with the sister facility Norilia acted as a gate opener[8].

As researchers in a field setting, we needed to discuss and become aware of our boundaries before the interviews. Due to the theme centred thesis design (Thagaard, 2013, pp. 157-158), we felt that we could be open about our intentions, and explained to the participants what we studied, how we studied it, and how their contribution would be used. This is in line with Marshall & Rossman's explanation of the level of *revealedness*, in which the researcher varies in disclosure of their intentions (2006, p. 73). We interviewed the participants, but did not participate in their daily tasks. We did not see this as necessary to build trust or to enter the field. Our presence was experienced as welcomed, and we felt that brief and effective interviews were the most respectful way to conduct our fieldwork.

3.3 Data collecting methods

An exploratory research design allowed us to gather data without having a precise aim (Thagaard, 2013, p. 16). We knew we needed to explore, but were uncertain of what data would be uncovered and how this would lead to further sampling, empirical gathering and analysis. In that sense, the data collection method of semi- or unstructured interviews created that flexibility. Our roles as researchers can be described as "acceptably incompetent persons" (Thagaard, 2013, p. 72). Thagaard describes this as being "new in the field", where the participants "train us in their ways".

When planning our empirical work, we agreed to refrain from conducting interviews with voice recorders as we did not want to spend the great amount of time it takes to transcribe it afterwards. We decided that jotting notes would be sufficient. Being two interviewers, we saw it as feasible that one of us would do the talking while the other one took notes. We saw this as in line with Thagaard (2013, p. 90), who states that the research situation decides

[8] Unfortunately they did not respond once the contact was established.

whether or not to take notes during the interviews. She argues that the presence of a notepad or a recorder may disturb the contact between the researcher and the participant. We felt that our situation allowed a notepad present since we sought perspectives that were tied to the theme and not the persons.

Before the interviews, we ensured that the subjects had been informed about the study and how their data would be used, stored and deleted afterwards. This was formalised in a consent form which can be read in the appendix. We scheduled the interviews as physical meetings whenever possible. This was a conscious choice as we wanted to observe the activities in the value chain and interviewees in their natural settings. The observations added thickness to our data collection. Observing the machinery, the people and the places gave us audiovisual insight that we would not get if we had conducted the interviews by phone, mail or video chat.
We made separate reports after the interviews where we wrote up what we had heard and learned to include as much as possible. This proved very valuable, as we focused on different aspects. Then, by conjoining the two reports, we had a better and more detailed material.

In our data collection, we differed in techniques to gain relevant data and, at the same time, create flexibility. These included

- Asking open-ended questions
- Probing for further explanations
- Providing statements about a situation, and asking about the interviewee's opinions
- Reassuring that we understand what the interviewees were talking about
- Responding to what's being said by asking follow-up questions
- Using terms related to the theme

We learned these techniques from Thagaard (2013, pp. 95-106), and were satisfied with the outcome. As stated, we had fruitful interviews that gave insight into what we asked about and beyond.

3.3.1 Interview guides

We created separate interview guides for each sector containing our main themes, but avoided direct questions to create the space we felt was natural for a semi-structured or unstructured interview. The different sectors were: the sheep farmers, wool stations, industry actors (Sandnes Garn and Sjølingstad) and the researcher. We wanted to interview each sector in a chronological order according to where they are situated in the value chain. By doing so, we thought that we would be able to source incremental data, which could be beneficial for the next stage. The design of the interview guides was an iterative process as each of the respondents gave us insights that touched on several stages in the value chain.

By starting with the literature review, we had learned terms that proved advantageous in the interviews. For instance, at the wool stations, we reassured our guides/interviewees that we were familiar with terms and concepts, and that they could use them without explaining too much. They responded positively to this. In another setting, with researcher Ingun Grimstad Klepp, we conducted this interview on purpose at the very end of the data empirical phase, to have as much insight as possible so our questions were more direct. By gaining insight in every interview, we evolved from being acceptably incompetent persons, to becoming quite familiar with how the system worked. The accumulated knowledge affected the data gathering technique, from open-ended questions to increasing the focus on details that interested us. For instance, representatives from both wool stations stated that the lanolin was discarded as waste, and it seemed like there was little knowledge about potential uses. This insight was included in designing the interview guides for Norilia and Ingun Grimstad Klepp, where we could ask why lanolin was underutilised as a natural resource.

3.3.1 Informal conversational interviewing

The informal conversational interviewing is one of three interview techniques described by Patton (2002, pp. 341-347, cited in Marshall & Rossman, 2006, p. 101). “The researchers explores a few general topics to help uncover the participant’s view but otherwise respects how the participants frame and structures responses” (Marshall & Rossman, 2006, p. 101). This can be exemplified by how our participants jumped back and forth between arguments and stories during our interview, or refuted the validity of some questions overall. In our

experience, the informal conversational interview seemed fitted to the setting, where we were outsiders in the field, seeking knowledge and perspective from professionals.

3.4 Data analysis methods

Thagaard states that the analysis starts in the field, as our understanding evolves during the interviews (2013, p. 120). But, as we leave the field and go back to our desks, we must also be aware that the participants lose their ability to influence the analysis. This leaves us with the responsibility of preserving their perspectives (Thagaard, 2013, pp. 120-121).
As mentioned, we made notes from the data collection where we included as much of the relevant information as possible. After the interviews, we read through the notes and marked interesting contributions. Our analysis method is *theme centred*, as opposed to *person centred*, which means that we focus on *what's being said* instead of *who says it and how* (Thagaard, 2013, p. 157-158). The interviews were processed by removing information that we deemed irrelevant to our research question. This left us with a malleable amount of text.

This was then processed through coding, where we abstracted the notes into *first order concepts*. We had predefined that the analytical framework in the analysis would be the 4Rs of CE. The *first order concepts* were tied to the 4Rs, reduce, reuse, recycle and recovery in the discussion. We included a chapter on additional findings that were related to the theme, to ensure that we could display knowledge that did not fit into the framework we decided upon.

3.5 Ethics

An important consideration is to acknowledge the previous work on the subject, as presented in our literature review and theory chapters. The groundwork laid by the authors has enabled us to enter the field of study swiftly and effectively, leaving more time for empirical work and discussion.

None of us has worked on the subject of wool before, and we both have mixed feelings about it. Our personal conviction is that animals like sheep should not be raised, slaughtered and sold for profit, but that they are sentient beings that should be respected. We considered this in our discussions on how sheep wool could be the main element in new product

development, as the demand for wool might rise. We also state that meat production is unsustainable and that the industrialisation of meat and its by-products maintains a sector that should be downsized. With that said we were very conscious of our preconceived ideas about the industry. This enabled us to steer away from existing biases, enabling us to meet our sources of information on a relatively neutral ground.

We believe that the role of the researcher is to gather data that are as uncolored by biases as possible. Though it must be said that the snowball method we applied shaped future interview guides as a result of findings in the process. Even though our beliefs about the meat and wool industry are somewhat pessimistic, we never put that blame on any of the respondents. We treated them as proud workers who did their tasks at hand. That is also the impression we gained from interacting with the respondents.

All the respondents were given a document that informed them about the study and that they can at any time withdraw their cooperative insights from the study. However, Thagaard points out that complete openness is not possible in a study that relies on flexibility (2013, p. 91). This is due to the fact that the thesis is under constant revision. The form included information on the thesis itself, how we would collect, process and store data, and that the raw material would be deleted after the thesis was turned in.

Thagaard highlights three stances the researcher can take concerning the participants: neutral, critical and advocacy (2013, pp. 230-231). She states that critical researchers investigate groups with values or perspectives of which the researcher disagree, which can be problematic for the relationship. In the advocacy stance, the researcher promotes the views and perspectives of the group they investigate, which negatively affects the researcher's credibility. Thagaard recommends refraining from both extreme points, and aiming for the golden mean (2013, p. 231). In our fieldwork, we experienced all three stances, but had discussions on our appearance in advance of the interviews. This enabled us to act neutral and pose open-ended questions, and it is an example of the value of reflection on ethics.

3.5.1 The limitations of the design and methods

Our sampling size is too small to be representative, and therefore our data will be the basis of an analysis that lacks full perspective and representation. The implications are that the investigation might be too weak for policy implications, or that critical views are overlooked.

Semi- or unstructured interviews leave more room for the subject to formulate the terms and definitions, making it harder to compare answers from different people. When we sorted the *first order themes* into the framework in the discussion, we had some difficulties deciding whether different terms could be understood as similar enough to go into the same categories without tweaking the respondents' contributions, or whether or not we were force-fitting.

Marshall & Rossman (2006, p. 102) points to the weakness of solely relying on interview as data, but includes that "[the researcher may] demonstrate through the conceptual framework that the purpose of the study is to uncover and describe the participant's perspective on events - that is, that it is the subjective view that matters.". We focused on the value chain aspect of wool processing, in which observation would be futile as the distances and timing would not allow us to follow the material from farm, to stations, to HSC, and the world market. To strengthen our data, we included desk research whenever we encountered ambiguous perspectives or when the participants' versions of reality contested each other. For instance, different perspectives on the toxic wastewater emissions related to scouring led us to check permits and reports that provided official information.

In our field observations and on-site interviews we were aware that our presence might affect the behaviour and answers of the people we interviewed. We refrained from asking controversial questions, or in other ways challenging the subjects, in case we made them uncomfortable or defensive. But a researcher's presence will, to some degree, cause people to act somewhat differently. We dressed casually, and left some room for small-talk whenever it felt natural to create and maintain a relaxed setting. We also assume that the absence of digital recording devices had a positive effect.

Another weakness is that our lack of knowledge in the field may have influenced how we gathered data and how this data was used in the analysis. As a researcher, you have to select what information is important and what information that is deemed less important. As

opposed to quantitative methods, where the data speaks for itself, qualitative methods are filtered and refined through the minds of the researchers. This calls for a process where calculated choices will affect the final result. This is especially true concerning the iterative snowball method, where the information gradually appears. A slope in the wrong direction may give the snowball a different form or even size that will affect the project as a whole.

Thagaard (2013, p. 191) lays out the specific ethical dilemma related to theme centred analysis: the information provided from the interviews are removed from their context and divided into parts that we, as authors, have predefined. This disrupts the flow of the arguments, and might alter the respondents perception of reality. In our consent form to the interview subjects, we informed them on how they could contact us if they wanted to read the thesis to give an opportunity to correct any potential misunderstandings or miscommunications.

3.5.2 Validity

Marshall & Rossman (2006, p. 201) highlight the importance of validity in qualitative studies, stating that the study can heighten its believability by overtly discussing the "boundaries around and limitations to the study".

Our sampling consists of parties of interest in the value chain, which we have deducted from the literature review and snowball-method. The interviews have given us depth information, but the lack of larger-scale inclusion renders the data quite person specific. This is a trade-off that we cannot overcome in the span of this thesis. But, to improve the situation, we have relied on information that draws on broad sets of data, such as the meta-analysis on CE and statistics on Norwegian sheep farmers from the previous research project KRUS.

We also know that our interview subjects might have business related interests that might affect the answers in the semi-structured interviews. Fatland, Nortura/Norilia are private businesses and compete with each other. Norilia is the sister company of HSC, the company that performs the scouring and washing in England. Ownership and relations are important, since this thesis focuses on the value chain of the wool. In general, we assume our interview subjects to be trustworthy. The persons we have interviewed have been in positions where

their knowledge areas fit our data focus. Our experience is that the data has been beyond expectancy regarding depth and complexity.

Interestingly, we saw that the literature study had colored our assumptions in a significant manner, as we had largely adopted the views of the authors. This became clear to us after conducting interviews that had opposing views, and we were able to readjust our critical sense before the analysis and discussion.

We also saw that the interview with the sheep farmer was too unrepresentative of reality. The flock was small, and there was no system present for collecting and selling the wool. To get a better representation we should have interviewed several farmers with flocks of different sizes. But, as the thesis developed, we saw that the information from the farmer served as background information, but was not necessary to answer the research problem.

At Sjølingstad, we gathered data on the history of wool, facts on wool itself, and followed the process from raw wool to ready-made yarn. Sjølingstad is a living museum, and the machines are mostly for demonstration purposes. It was valuable to listen to the museum host, and to see the machinery in work, but we assume that the reality of processing wool occurs in more modern facilities. To gain a higher validity, we also visited Sandnes Garn (hereafter SG), where we could follow the same process in a more modern and commercialised setting.

We assumed that the persons we contacted were knowledgeable on the subject, and that the information they provided was a good representation of reality. Marshall & Rossman (2006, p. 202) discuss *external validity*, where the findings are transferred to another sample, as problematic in qualitative research. However, if the researcher succeeds in relating the findings to a body of theory, other researchers may revise the validity of the text by basing their work on the same theory. This might be a way of enabling generalisation. Thagaard (2013, p. 205) draws on Seale (2007, pp. 384-387), and argues that the level of transferability depends on how well the researcher provides qualified decisions for the arguments and conclusions, and by critically assessing their own analysis.

3.5.3 Reliability

We chose an exploratory research design, where we research a field without prior personal knowledge and with limited general knowledge The flexibility that we facilitated through semi-structured interviews enabled knowledge creation that was constructed through accumulation. However, a flexible design with open-ended interview guides may be hard to replicate for other researchers. Thagaard (2013, p. 202) draws on Holstein & Gubrium (2004, 2004, 149), and argues that constructionist research will be based on qualitative data generated between the researchers and their respondents, and therefore the question on replicability is invalid. We have increased the reliability of the data collection by writing separate notes. By doing this, we overcame the variable of "different researchers, different data", as we were in the field setting together. Our experience is that this strengthened our field notes, and thereby enhancing the basis for data analysis.

Is the data relevant to the research question? In our experience we gained sufficient knowledge on the value chain of wool, so that we could make statements based on the data gathered. The interviews included questions that provided knowledge on both research questions. We have been open with regards to how we collected the data, and how we abstracted the data to first order themes, and further to analyse said themes. The overview of this analysis is available in appendix C.

4.0 Findings

In this part of the thesis we present the data material from the interviews through a categorical presentation. The categories have been prepared to provide a rich and in-depth understanding of the dissertation's theme and problems:

- How can we use circular economic principles to reassess the value chain of Norwegian wool?
- What is the current and potential future situation for wool?

We have focused this chapter on findings that are relevant to answer the research problem statement. In excluding what we deem to be irrelevant, one can say that the analysis starts here, as Thagaard argued in the methods chapter.

4.1 Wool value chain

Norilia stated that 90-95% of all Norwegian wool is collected and sold to HSC for scouring and washing, before it is sold in the world market. In comparison, around 40% is collected in Sweden. In the interviews we conducted with Sjølingsstad, Fatland, Norilia and Nortura, we found that the current solution of transporting the wool to HSC was seen as practical, efficient and economically rational.

Wool stations are situated where there is a larger population of sheep (see figure 11). At the wool stations the wool is sorted into the aforementioned classes, and core samples are sent to Wales for testing. If the core samples do not match the stated category of the wool, the wool station will be fined.

After sorting, the wool is compressed into wool bales with a weight ranging from 350 to 400kg. Containers with a payload of approximately 25 tonnes are shipped from the Norwegian sorting stations to HSC, according to Norilia and Fatland. The wool bales are tracked with a lot number, and Fatland states that it is possible to track the wool from the wool station and throughout the whole scouring- and washing process, as the lot numbers are treated separately. In this way, the Norwegian wool can be traced back to the wool station of origin.

In our interview with Norilia, we also found that quantity matters, as the scouring-, washing- and purification facilities are expensive. They need to treat considerable tonnage to justify the investment. This can only be economically viable with a high volume of wool and efficient logistics. Norilia argues that the volumes in Norway are too small. The representative at Sjølingstad had a similar statement, claiming that scouring in Norway would be too expensive.

4.2 Emissions

Washing and scouring require detergents and results in various emissions depending on the facilities investigated. SG and Sjølingstad have permits from local governments to release limited amounts of toxins. These permits have to be renewed if changes in production occur.

SG washes the wool with fat-soluble soap. The representative that we interviewed showed us the machinery, but was not aware of the chemical content of the soap. He claimed that they used small amounts. The washing water and wool grease are later flushed into the sewage. The sewage is led to Mekjarvik cleaning station. SG states that the sewage water is transformed into a soil-improving medium. According to a respondent from Fatland, SG has been subject to criticism concerning their emissions.

Figure 9. Washing machines at SG.

Sjølingstad is under regulations concerning their scouring process, limiting their ability to wash larger quantities of wool. They have a treatment plant next to the factory, and release their wastewater in a small creek nearby. To bypass this capacity limitation, Sjølingsstad is buying their wool from HSC and only uses their own washing machines for demonstrative purposes, as seen in figure 10.

Most of the Norwegian wool is sent to HSC in England for scouring. The representatives at Fatland claimed that it would be hard to do the washing and scouring in Norway due to strict environmental laws.

Figure 10. Washing machines at Sjølingstad.

However, according to Norilia the environmental regulations in the UK are as strict as in Norway.

"Vi har fått svanemerke på vår vaskede ull. Det er en god bekreftelse på at den holder høye miljømessige krav."

[We have obtained the Nordic Swan label on the washed wool. This is a good confirmation that it meets strict environmental demands]

(Representative from Norilia, 01.04.2022).

Norilia points to the transportation from farms to sorting stations as one of the main disadvantages in their value chain, due to emissions from the diesel trucks. Local organisations of farmers can collect and store their wool, and pay a fee to Norilia to have the wool transported to the stations. It is also possible that the farmers can transport it themselves. Figure 11 shows where the sorting stations are located. Norilia explained that the stations are at the same locations as slaughterhouses, as the sheep wool gets sheared just before they are slaughtered.

Norilia states that people are generally concerned about animal welfare and the absence of chemicals in their products. We asked whether customers that buy Norwegian raw wool from England require information about ESG[9], and this was confirmed. Norilia claimed that the transport to England was effective since the containers are always packed to maximum capacity. The freight is by boat, trains and trucks. According to Norilia, the environmental disadvantage of transport to ESG for scouring in England is not necessarily worse than scouring in Norway, as we have great distances here as well. According to Norilia, HSC uses biodegradable soaps in their scouring. The sludge that remains in the water is clean enough to be used as soil improvement in farming fields[10].

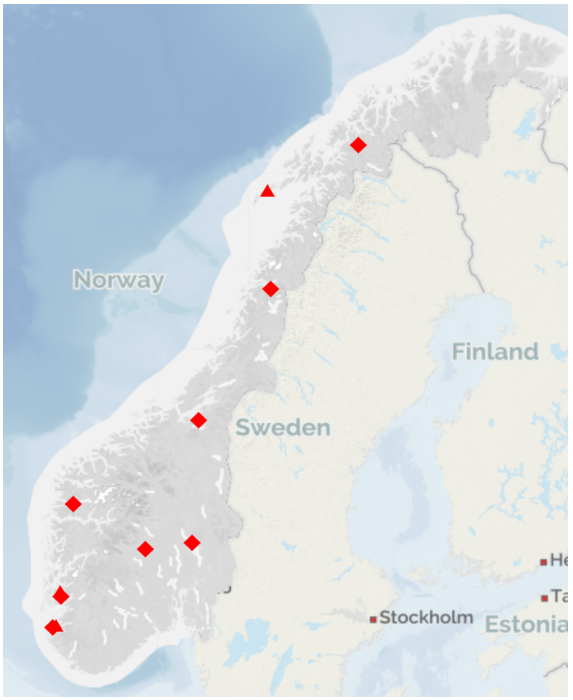


Figure 11. Location of Norwegian sorting stations.

[9] Environmental, social, and corporate governance.

[10]This claim is also expressed on their website https://haworthscouring.co.uk/environment/

4.3 Lanolin

From the literature review we gained insights related to wool grease and lanolin. We were under the impression that lanolin was an overlooked resource, even though it sells for a high price and has many uses. This led us to explore how our interview subjects related to this matter.

According to the staff at SG the wool they receive contains approximately 30% wool grease. This is flushed out in the sewage system. At Sjølingstad they made lanolin yarn in the past, but the production of this item has ceased. When the production at Sjølingstad was running it was not attempted to recover lanolin as an item of value. At HSC the recovered wool grease, which accounts for approximately 20%, is used as a soil improver in farming fields.

> "Du får myke hender, men ikke så mye annet"
> [You get soft hands, but not much else].
> (Representative from Nortura, 28.02.2022)

4.4 Government subsidy

> "Vil anta at mange bønder kaster ulla som de ikke får betalt for."
> [We assume that many farmers discard the wool that they do not get paid for.]
> (Representative from Nortura, 28.02.2022).

According to Norilia, the subsidy for the lower classes was taken away as a measure to stimulate a higher wool quality so that Norwegian wool could be part of the supply to an increasing international demand. Five categories were removed, and the prices for the remaining classes were increased. Several of our interviewees expressed that it was "a shame" and "sad" that the government subsidy for lower class wool was taken away since it had acted as a motivation for the farmer to deliver the wool to the sorting stations. A sheep farmer we interviewed, claimed that it forces farmers to operate on a large scale to be profitable. For small-scale farmers, like himself, the collection and delivery will be unprofitable and the wool is discarded.

The sheep farmer's subsidy is paid by the wool station, which later is reimbursed from the Norwegian government. To obtain the subsidy from the government, the wool has to be sorted by a certified wool sorter. If the wool is categorised wrong, the wool station will not receive the funds from the government, and in addition the station will receive fines from the testing facilities in Wales.

According to a farmer, the government has subsidised red-listed breeds, like Old Norse Sheep, in order to maintain a viable amount of individuals. In 2016 the subsidies for Old Norse Sheep were abolished.

Figure 12. Wool discarded as waste.

"Tilskudd er ryggraden i lønnsomhet for produsent. Uten det hadde det ikke vært økonomi for å ha system rundt innhenting av ull i Norge. Uten dette hadde vi hatt samme system som Sverige."

[Subsidies are the backbone of the value of the wool in Norway. Without it, it would not be economical to collect all the wool. Without the subsidies we would have had the same system as in Sweden]

(Representative from Norilia 01.04.22).

According to the same person only 40% of the wool in Sweden is collected, and this is done mainly in centralised areas.

4.5 Capacity

"Vi ønsker mer norsk ull, men har makset det vi kan få fra Fatland og Nortura"

[We want more Norwegian wool, but we are unable to get more from Fatland and Nortura.]

(Representative from Sandnes Garn, 28.02.2022)

SG claimed that they wanted to process and use more Norwegian wool in their production. Their facilities are running at roughly 25-40% capacity, and according to the production manager, they can at least receive another 80 tonnes yearly. SG washes approximately 260 tonnes of Norwegian wool annually. According to the staff at SG they had maxed their quota and neither Fatland nor Nortura would sell them more. According to the staff at Nortura wool sorting station, SG only buys the finest wool.The staff at Fatland said SG only wanted the very best wool and returned what they did not want to use. Norilia states that there simply are not sufficient amounts of wool in the desired class to sell. Ingun Grimstad Klepp notioned that SGs capacity for scouring may also be tied up to their wastewater emission permits given by the local government.

According to Norilia, 95% of all Norwegian wool is sent to the various wool stations, categorised, and sold. According to Norilia a somewhat different picture has been fronted in the media, where some media[11] claim that significant volumes of wool in Norway are burnt, tossed away or dug down. According to the respondent, this is due to the locations where the respondents to the reports were situated.

"Etterspurt ull, som C1, har høyere etterspørsel enn hva som kan leveres. Det denne ulla som det må ligge insentiv på å ta vare på."

[Demanded wool, like C1, has a higher demand than what we can supply. It is this wool that should be incentivised to be taken care of.]

(Representative from Norilia, 01.04.2022)

4.6 The future of wool

SG said that Norwegian wool is selling well and that demand is increasing, even though the market is fluctuating. Norilia supports this, but the demand is limited to certain wool categories, namely the same categories that are used in the process at SG. Norilia states that people are more aware of factors such as animal welfare, working conditions, how the wool is produced, its properties, and absence of chemicals. Animal welfare is a factor that is of the greatest importance these days. Norilia notes that in general people are positive towards Norwegian wool.

[11] https://www.nrk.no/rogaland/ull-fra-norske-sauer-blir-gravd-ned-i-jorda-eller-brent-i-fjaera-1.15482787

As stated by SG, an important step in enhancing the role of Norwegian wool is through a strong brand and good design. The future of wool is promising if the farmers are given suitable conditions, and it is produced in a sustainable way

Sjølingstad reports that they are approached by a new wave of entrepreneurs and researchers that want to investigate new uses of low-grade wool. SG and Norilia state that a process of innovation and product development is necessary to enhance the future of Norwegian wool. All respondents are optimistic about exploring new usages of wool.

> "Alle materialer har gode egenskaper, man må finne ut hva det egner seg til."
> [All materials have good properties, but you have to use them appropriately.]
> (Ingun Grimstad Klepp, 25.04.2022)

> "Ønsker at mere norsk ull skal brukes i Norge. Ideelt sett hadde det vært mer bruk av norsk ull i produkter."
> [We want an increased use of wool in Norway. Ideally there should be more use of Norwegian wool in products.]
> (Representative from Nortura, 28.02.2022)

> "Ulla vil alltid bestå. Jeg håper de kan bruke norsk ull til mye mer."
> [The wool will always be there. I hope Norwegian wool can be used for a lot more.]
> (Representative from Fatland, 29.02.2022)

4.7 EUs new directive for sorting textiles

A representative of Avfall Norge stated that they do not know what proportion of wasted textiles in Norway is wool. Ingun Grimstad Klepp informed that there is work in progress to quantify this proportion. A representative at Sjølingstad claimed that the Netherlands and Sweden have technologies that separate the different textiles after they are discarded. The representative also added that used wool is safe for further use, even if it is colored, due to the chemicals being washed out.

5.0 Discussion

The original aim of the study was to explore how one might use the principles of circular economy to reassess the value chain of Norwegian wool, with a special focus on low-category wool, and what the current and future situation for wool looks like? In this chapter we will discuss the findings from the empirical data through a CE framework driven by the 4Rs of CE; reduce, reuse, recycle and recover.

5.1 Reduce

As stated in the theory chapter, reduction is the most important step towards a circular economy. Norwegian wool is a by-product of meat production and is currently a material input in a value chain that utilises almost everything practically and efficiently. As presented in the findings, our interview subjects from the industry were all in favour of more product development to secure the future of Norwegian wool. To fulfil both of these necessities, the aspired product development needs to be well within the boundaries of the current available material quantity. If this is exceeded, the demand for wool might prompt an increase in sheep production. If this happens, the principle of reducing is overrun by business-as-usual resource extraction. This argument implies that sheep production is unsustainable.

Ingun Grimstad Klepp said it wisely when asked what we should do with the wool of lower quality categories. She stated that the question was part of creating an impression that finer wool was better than lower categorised coarser wool. Instead, she stated that coarse wool was very useful when used in products that enhanced the features and properties inherent in the material. This is important in relation to the increased governmental subsidies of the finer classes of wool and the fact that it has been removed from the coarser kinds. However, reducing governmental wool subsidies might increase the prices of meat, which could influence the demand for sheep meat. In this hypothesis, we assume that the overall production of sheep would decrease, and thus the amount of Norwegian wool too. This might have several implications.

- The current Ukrainian war and European conflict with Russia has disrupted and stalled crucial flows of resources, including food, with hitherto unknown ripple effects. We know that the national political focus on food security has been

revitalised, affecting this year's agricultural settlement. This could, in turn, be beneficial for Norwegian farmers through higher subsidies and better terms.

- The Norwegian-produced agricultural products would not be able to compete in the world market without subsidies, as labour is cheaper in other countries.
- With decreased or removed subsidies, the farmer would lose the incentive to deliver the wool to the sorting station, and it is likely that a larger amount would go to waste or be used at the farm.
- The import of finer wool, like merino wool from Australia and New Zealand, might increase, pushing the innovation potential around coarse wool of the picture all together.

Sustainability

Sheep wool is ranked low on environmental sustainability in a comparison made on 22 common textiles (Vičiūnaitė, 2020, p. 13). In Norway, with an abundance of natural feed and water, this is mainly tied to the methane emissions from the sheep themselves (Soren et al., 2017, p. 213). In a socioeconomic perspective sheep farming contributes to employment, preserves traditions, maintains food security, and helps maintain the cultural landscapes associated with grasslands (Hebrok et al.2012, p. 12). A positive notion of sheep wool concerning environmental sustainability is that it is a by-product of the meat industry. Thereby it becomes a matter of how this resource is handled after it is sheared.

According to our informant in Norilia most of the Norwegian wool is sent to England for refinement. An overseas value chain like this is at first glance unsustainable. Though, as reported from the wool stations, each of the containers is loaded with 25 tonnes of wool. These containers are shipped by boat to England and, according to Norilia, mainly transported by train in England. One may claim that it is more beneficial to have one large source of emission than several small ones in relation to emissions from wool treatment. When comparing HSC to e.g., SG, it is evident that HSC is relatively less polluting than SG. This is due to their ability to recycle washing water, recover wool grease from the washing water, their usage of biodegradable detergents, and how they make good use of the wastewater. If the transport and processing of wool are driven by non-fossil, renewable sources of energy, then it will be even less polluting than what it is today. However, the strongest argument that supports the current situation is that there are no facilities in Norway that can handle the quantities of wool generated in Norway.

5.2 Reuse

The European Union defines reuse as “any operation by which products or components that are not waste are used again for the same purpose for which they were conceived” (Directive 2008/98/EC, 2008, article 3). One issue that we are fronting in this thesis is that we are discussing a virgin material that, in essence, has yet to be used. Seen in a LCA perspective, however, a material should also be considered in regard to its potential future uses. Aspects to be considered in this context can be modular product design that enable easy replacement and create in-depth cycle flows. EoL strategies should also be considered. We believe that the definition stated by the EU is somewhat limiting. The reason being that products and components may have other uses beyond their initial intended purpose. To exemplify this: at Sjølingstad they make seating pads from material that was intended for blankets if errors occur. An alternative definition could be: “any operation by which products or components that should not be wasted are used again for the same or a different purpose of which they were conceived”.

5.3 Recycle

In 2025, the EU and Norway will introduce new laws concerning textiles. These laws state that textiles shall be sorted from the general waste.

> The aim of the initiative is to set in place a comprehensive framework to create conditions and incentives to boost the competitiveness, sustainability and resilience of the EU textile sector, taking into account its strengths and vulnerabilities, after a long period of restructuring and delocalisation, and addressing its environmental and social impacts. The initiative will propose actions to make the textile ecosystem fit for the circular economy, addressing weaknesses regarding sustainable production, sustainable lifestyles, presence of substances of concern, improving textile waste collection and recycling in the Member States as well as capacity building (also for skills). (EU strategy for textiles, 2021).

In Sweden, a facility called Siptex can even distinguish and sort textiles based on colour and fibre. One can only speculate that the result from the sorting process in this type of facilities

will result in considerable volumes of wool[12]. In the following figure we will show how circular wool can be.

- Wool are turned into e.g. clothing and used woollen garments are recovered from the waste by being collected and sorted.
- If the clothes are beyond repair, they can be shredded and remanufactured into insulation.
- When the insulation is changed or at the end of its lifetime due to other purposes it can be turned into bioplastics.
- The bioplastic can be used as soil improver.
- The soil improver will give higher yields of grazing grass for the sheep.
- Good grazing opportunities for sheep are good for sheep in the grazing period or a proactive strategy for higher yields of winter feed.
- The wool is sheared and ready for processing.

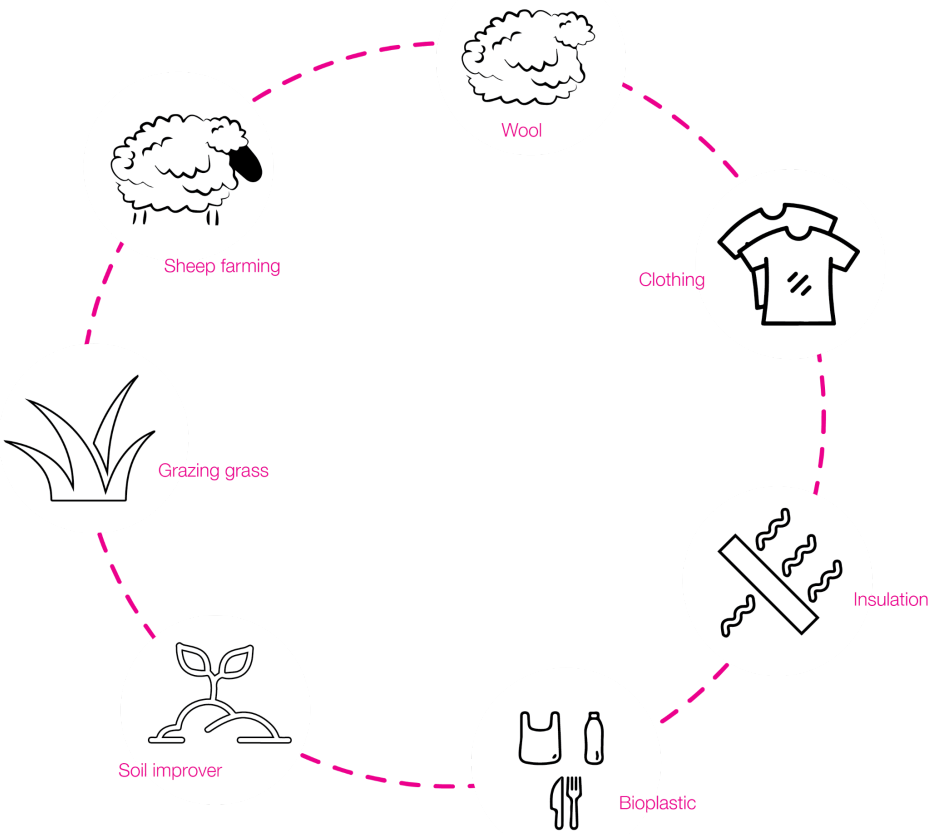


Figure 13. Circularity of wool.

[12] We have reached out to Avfall Norge [waste handling company], but they do not know how much wool that is thrown away in Norway.

An important factor in recycling wool, as for other materials, is that the different product modes are made with recyclability in mind. The material Really by Kvadrat is produced from recycled cotton and wool, but their interior products are coated with melamine (Kvadrat, 2022). The company does not state how the material can be recycled after its intended use. The problem with material composites is that their composition can affect recycling of many material categories ranging from plastics to wood (Yang et al., 2012, pp. 54-55). A way to combat this issue may be to create mono-material products for easier recycling with high material purity.

Another alternative is to use economic incentives to increase recycling. This can e.g be done through deposit returns schemes for a broad range of products. An example of this can be the deposit scheme for drinking containers in Norway. Infinitum Limited established by the beverage producers and grocery chains in Norway claim in their yearly report (Infinitum Årsrapport, 2021) that 91,5% of sold cans and 92,8% of sold bottles are recovered through the scheme. 12.921 tonnes of aluminium derived from cans and 23.092 tonnes of plastic derived from bottles are recycled. This may suggest that similar schemes could have a positive effect.

5.4 Recover

How can the wool be kept in use as long as possible without deteriorating its qualities? Using the wool as fertiliser may be seen as a waste, as it can be used for several purposes before “ending” its life in the ground. In an optimised circularity, a product's qualities are maintained for each stage in its lifetime. However, this view is problematised by claiming that material degradation will occur according to the second law of thermodynamics. “... recycling will always require energy and will always be incomplete generating wastes and side-products (increasing entropy, decreasing exergy) of its own" (Georgescu-Roegen, 1971 cited in Korhonen et al, 2018, pp. 41-42).

This argument was refuted by Korhonen et al. (2018, p. 42; see also Corvellec et al., 2021, p. 423) as renewable energy, like solar power, can be used in the recycling process. We can recycle without causing further energy depletion, but some material loss or spoilage will

occur. However, the argument is interesting because it revolves around the theoretical possibility of complete close-looped schemes and what it takes to make it happen. Solar power, and other renewables, are not yet in surplus, as it will take a long time to meet the energy demand of the population. Theoretically, using clean energy to recycle materials will increase the demand for fossil energy for other needs.

However, we can overcome the problem with material degradation by viewing quality as a social construct instead of a physical property. To exemplify, many people find readily-ripped jeans to be more valuable than a new-looking pair. One representative at SG also stated that they sell less of the warmest wool because the climate is changing towards warmer winters and consumers want lighter yarn. And, without statistics to back up the argument, it seems like the second-hand market for clothes is expanding.

We can also create products with slower material degradation, as we will introduce later in the analysis.

5.4.1 Wool value chain

In the preliminary stages of this thesis we believed that there was a great problem linked to the wastage of wool. We can safely confirm that this is not the case in Norway. However, this is the case in other European countries, including our neighbours in Sweden. Even if this is what we have concluded, the problem in Norway relating to wool is presented in other ways in the media. In an news article by NRK (2021) the situation was fronted somewhat distorted. A farmer is interviewed and he claims that he digs down or burns his wool as this is the most economical alternative. The article states that only 25% of the wool is actually used here (in Norway). The wording in this article suggests that the wool that is not used *here* is wasted.

A combination of factors such as the 5-10% of the wool that does not find its way to the wool stations, combined with the withdrawal of government subsidies on specific categories and journalists having taken this situation to their hearts may have resulted in a projection of a problem that is larger than it really is. Nevertheless, 5-10% of the total national wool production equals approximately 200-400 tonnes of wool. In the final KRUS-report (Klepp et al. (2019, pp. 58-59), many of the farmers claim that their wool that does not go to wool

stations may be used for their own purposes, being spun to yarn or saved for later use. Some farmers also reply that they use it for soil improvement. Therefore, wool is not a wasted resource per se, but that the resource could have been better utilised from a CE perspective.

Another factor influencing the perceived situation is where the reported numbers originate from. A report conducted in Fosen showed that 24% of the wool is treated as waste (McKinnon et al., 2019, p. 13). As waste, the wool is tossed, burnt, dug down, or just left on the ground. They further estimate that if this wasted wool is low-category, then 3.133 out of 6.489 sheep fall into these low-categories. Certain regions, such as Fosen, have a majority of sheep from older breeds with low-categorised wool. The problem can be great if regions are seen in isolation, but the problems are more balanced on a national level.

It should be mentioned that the content of vegetable matter, and to what degree the wool is felted, if it contains residues of paint, or if the wool is permeated with faeces or urine, will affect the sellability of the wool. The content of vegetable matter may be a factor that is related to the local fauna. If the scenery is mostly grass or covered with forest, it will affect the amount of vegetable matter in the wool. An employee at Fatland reported that the content of thistles had increased over the years. Consequently, the wool with thistles was wasted as it is very hard to remove from the wool. The increase of thistles may result from a shift in climate or a biological change. He also stated that the landscape on the southwestern coast has lower vegetation, which in turn yields cleaner wool with less vegetable matter.

The degree of felting can be reduced by shearing the wool more often. Some sheep are sheared twice a year while others, often native breeds, are sheared once a year or not sheared at all as they drop the wool by themselves. Paint is often used to mark the sheep for different purposes, but some paint can be washed away so it does not affect the sellability. The last mentioned factor is related to hygiene. If hygienical procedures are lacking the wool will, especially in winter when most sheep are indoors, be affected by urine and faeces.

5.4.2 Lanolin

It is stated on the HSC webpage that they have the capacity to wash 1000 tonnes of wool per week (Haworth Scouring Company, 2022). According to an article by Norilia, a daughter

company of Nortura that owns 87,5% of HSC, 20% of the grease is recycled at HSC (Norilia, 2022). The recycled grease is used as a grease slurry applied to farming fields as a soil improver. As reported by a representative from Norilia, this activity does not generate much value. A calculation based on a 15-25% content of wool grease (Khattab et al., 2019, p. 9362), estimates that 6.240-10.400 tonnes of wool grease are wasted yearly. The calculation is based on 100% capacity and the recycled amounts are deducted from the calculation.

At SG the wool quantities are much lower and it is estimated that they waste 39-65 tonnes of grease yearly. Compared to HSC none of this is recycled by SG. All of this is sent to the local sewage purification plant, IVAR, along with other sewage[13]. If SG are able to purify and even recover some of the lanolin that goes into the sewage they may be able to scour beyond their permits of today as emissions drop accordingly. It may also be a profitable venture to pursue. The process of extracting lanolin from wool grease can be energy efficient, environmentally friendly, and efficient with the use of new technologies such as, but not limited to, scCO2 (Salem Allafi et al., 2021, p. 12).

With an annual growth rate of 6% for lanolin (Grand View Research, 2019) and prices up to 1000 NOK/kg, there should be an incentive to recover the wasted lanolin and bring it back into the value chain. The cost of investments to recover the lanolin will differ based on the size of installations and technologies. Nevertheless, taking a waste problem and turning it into a new business venture is at the heart of the CE mindset. It is also in tune with new regulations on emissions by the governing entities.

5.5 Reduce / reuse / recycle / recover

In essence, the 4Rs are overlapping, and no situation can be seen in isolation. A thorough analysis of a product's life will reveal that it is prone to intersect the different Rs throughout its life cycle. The following examples is an attempt to illustrate how wool can be processed without waste.

[13] We have tried to reach out to IVAR multiple times, but have not succeeded in gaining contact with people who have insight on this issue.

5.5.1 No waste processing

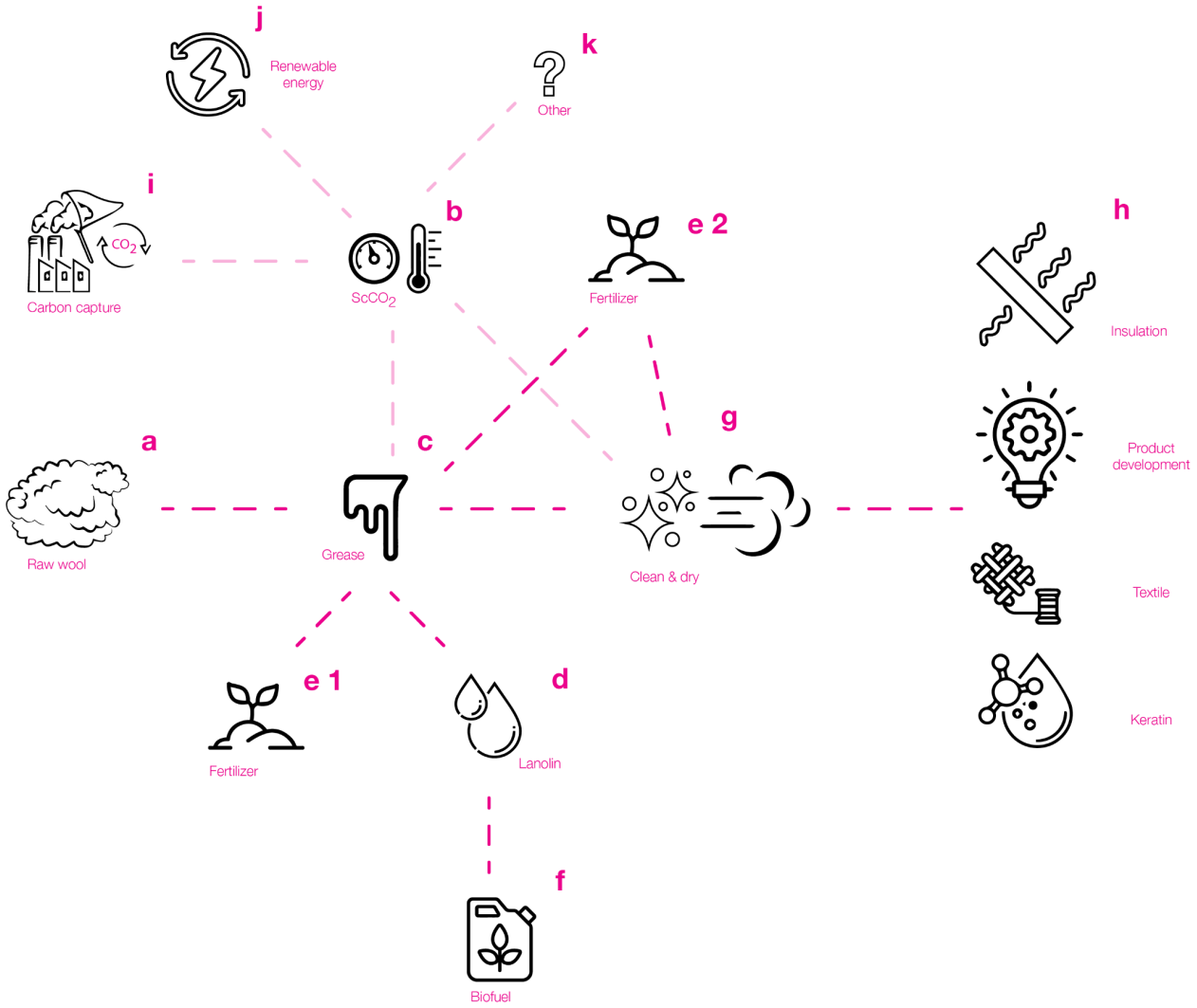


Figure 14. Wool processing plant using scCO2

Raw wool (**a**) is sourced from the wool stations and the category that is sourced is based on the intended usage (**h**). The processing technique used in this example is ScCO2 due to this being a superior refinement process (**b**) (see 2.2.3). In the first processing step the wool grease is separated from the wool (**c**). The wool grease is then refined to lanolin (**d**). The lanolin may be used as biofuel (**f**). The wool grease that is too crude, or for some reason cannot be refined to lanolin, can be used as fertiliser (**e1**). The wool that cannot be processed due to specific types of vegetable matter, felting, etc., can be mulched into fertiliser (**e2**). When the wool grease is separated from the wool, the wool undergoes another scCO2 treatment where the receding contaminants are removed (**g**). These contaminants can also be used as fertiliser (**e2**). When the wool is clean, it can be further processed into articles (**h**). By

having a varied product portfolio based on the same resource, the process has several options and can focus its efforts based on market demands. The CO2 that is used in the process can be sourced from carbon capture facilities. The CO2 is recycled for further usage (**i**). Energy comes from renewable sources (**j**). In sum the processing medium is reused for further processing, waste, time and energy are reduced, and valuable resources are recovered. Salem Allafi et al. (2021, p. 9) note that the scCO2 processing technique has many possible applications. Therefore the same facilities can be dynamic and allow for other processing ventures (**k**).

This can be a sound argument to defend the high investments to establish this process. Another factor that supports this notion is that woollen fleeces only are sheared twice every year, leading to a vacuum in supply in off-seasons.

5.5.2 From by-product to plus product

As shown in the theory chapter, wool has properties that have the potential to become other articles than just yarn. By basing the production of these articles on the availability of the resource and its properties we believe that the wool can be more circular than it is today. An employee from Nortura claimed that the average woollen fleece weighed roughly 3 kilos. This includes vegetable matter, but the employee said that the vegetable matter normally does not account for much of the weight. Therefore in the following example the vegetable matter is not subtracted. In this example we will use the wool for two purposes; extraction of lanolin and production of insulation for e.g. housing. Wool as insulation in housing allows for a slow material degradation as it is used passively and statically in the walls.

Given that these articles can be recovered from wool independent of the wool category, no pricing is mentioned for the first step (**1**) in the example. The wool grease content in Norwegian sheep wool is reported to be between 15-30% and this would equal to 450-900 grams per woollen fleece (**2a**). Based on online searches the lowest price for lanolin is 200 NOK/kg and the highest is 1250 NOK/kg (**3a**)[14]. The average of these prices are 652,5 NOK/kg (**4a**)[15]. Given that there are some expenses for investments, processing, salary,

[14] Prices are based on wholesale. Small quantities can be priced at over 3500 NOK/kg
[15] The average pricing of lanolin is based on a low price (90 NOK/kg) on a low content (15%) and a high price (1250 NOK/kg) on a high content (30%).

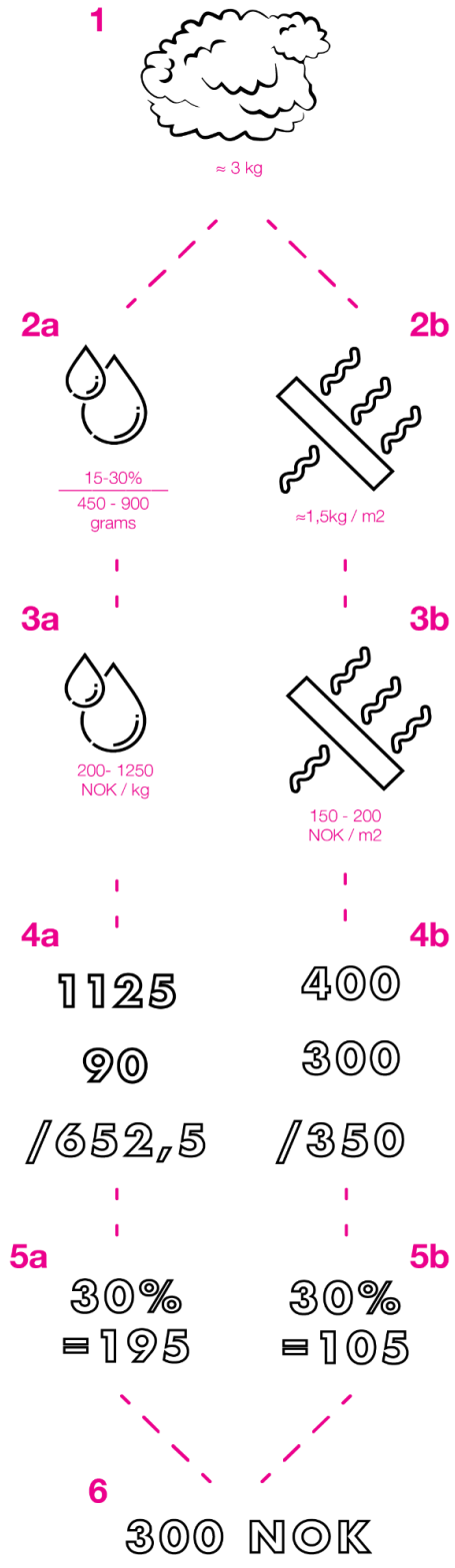


Figure 15. Revenue calculations.

transport, ect., 70% of the average price is subtracted to cover these costs. This number then accumulates to 195 NOK/kg (**5a**). There are different kinds of insulation in relation to density and thickness. On average one square metre of insulation contains 1,5 kg of wool (**2b**). Based on online searches the lowest price for insulation is 300 NOK/m2 and the highest is 400 NOK/m2 (**3b**). The average of these prices are 350 NOK/m2 (**4b**). Given the same factors as lanolin 70% of the amount is subtracted, which accumulates to 105 NOK/m2 (**5b**). The sum of 5a and 5b are 300 NOK per woollen fleece (**6**). An employee from Fatland reported that they have 24 bales of 350 kg that they struggle to sell. The employee said that these will be sold at 3 NOK/kg.

Wool that is hard to sell can be turned into two products that are highly sellable. If the wool can be bought for e.g. 3 NOK/kg and the profit is 100 NOK/kg then this may be a successful venture. If 10% of the yearly production of sheep wool in the EU was refined into insulation and lanolin we could produce more than 13 million square metres of insulation and 3 million tonnes of lanolin (15% lanolin content).

With an estimated average market value of more than six billion NOK it could create and maintain many jobs. In addition, the farmers can be paid a fair wage for the production of wool.

5.6 Additional findings

A factor that fits poorly within the framework of the 4Rs is the theme of government subsidies. However, it is a topic with interesting remarks that may influence wool production, which is why we include it in the thesis.

Government subsidy

As mentioned earlier in this document, the Norwegian government removed subsidies for specific wool categories. The reason being that this may motivate the farmers to produce wool of higher quality by changing breeds. The government has claimed that reinstatement of subsidies can be considered if there is enough value creation by using the categories of wool that are not subsidised. Paradoxically; if the prices of those categories increase, so will the subsidies. This is interesting as one might believe that the subsidies are there to prevent losses. Instead, it might be interpreted as the means of supporting products and services which cannot be self-supported.

The first step should be to utilise the wool that already exists as a by-product from the meat industry. This can be done through product development. Another key element is that this product development results in solutions that require viable quantities at predictable rates. This could result in a total recovery of all the wool, with its inherent properties, that is lost in the value chain. If the value creation is greater in new developed products, it may lead to a shift in breed priorities. The consequence of this could be that farmers choose native breeds that are more adapted to local surroundings leading to a lower necessity for imported fodder. This would give the wool a lower carbon footprint. However, by switching to natural grazing, instead of concentrated feed, the methane footprint can increase (Belanche et al., 2020).

Product development

All of our respondents called for more product development using Norwegian wool. There seems to be a positive will for entrepreneurial ventures with wool as the input material. Several respondents saw product development as crucial for the continuation of the Norwegian wool industry.

6.0 Conclusion

Diving into this thesis we were under the impression that large volumes of Norwegian wool were discarded and that many farmers turned to digging down or even burning the wool, and that wool was turning into a waste problem. It has been an interesting journey through the different stages of the value chain. The inductive nature of the thesis has allowed us to gain incremental knowledge about the current situation. The iterative process has given rise to many valuable insights. The greatest insight in relation to the situation for wool in Norway is that the system for collecting, transport, scouring and sales are actually very efficient compared to other European countries.

In relation to value creation and circularity, some factors can be changed. Wool as a material with its inherent properties, has a multitude of uses. The current system mainly focuses on wool as a textile material, where the higher categories go to garment production, whereas low categories are turned into carpets and similar low-status products. We believe that wool, regardless of category, has unique properties that should be utilised for what its properties deem it to be most appropriate for. Scoured coarse wool, that has been permeated with urine before the scouring process[16], hidden behind a wall panel has the same insulating properties as scoured coarse wool that is white as snow. Refined lanolin from a merino sheep in Australia has the same properties as refined lanolin from a native sheep in Norway. By investigating the by-products based on their properties and potential uses, something that was prior a waste issue can be turned into profitable ventures. These ventures should consider how the product or service should be used and should also account for EoL strategies. This will ensure that the wool as a virgin material or as used material will not end up as waste. Thorough LCAs should be established to function as guidelines for future applications of wool. Efforts should be made to develop new usages of wool and new modes of processing wool. We believe that wool has many undiscovered applications. Wool can reach a new era if enough attention is put into it.

In sum, wool wastage can be reduced, by increasing the value extracted. This can be done by recovering valuable resources from it and remanufacture/redesign it to other products. These products can be reused for the same or different purpose or be recycled to other products.

[16] The scouring process removes urine odour from wool

6.1 Further research

- The Norwegian system for collecting and refining wool leads to relatively little waste and high predictability for the producers. This could inspire other countries to systematise their value chains, and highlight business ventures related to scouring and refinement. As we have argued, product developers need predictability in material input. We believe that the Norwegian system for collecting and scouring wool gives the sheep farmer an income which upholds a stable production, and therefore enables the opportunity for product development. An interesting addition to this thesis would be to conduct a systematic overview containing accurate and contemporary data relating to how wool is handled in other European countries

- Half of the population is unfamiliar with circular economy. The authors of Circularity Gap Report: Norway state that circular agents, like a company with a circular business plan, will need to educate and introduce the concept to the population to achieve a better understanding (Circular Economy & Circular Norway, 2020, p. 51). Meanwhile, the shift towards circular economy is largely introduced through EU regulations. Does this top-down implementation lead to public resistance in non-EU countries?

- In the chapter on critiques of CE (2.3.7), we referenced (Kirchherr & van Santen, 2019, p. 151) on the lack of practical advice. An interesting further study would be to gather and compare data from businesses that claim to be circular, in order to deduct the activities tied to circularity. This could be used to make a feasible best-practice for other businesses to follow, and thus create an arena for learning and implementing.

- Evidence on circular economy in countries and cultures with less economic means or a different perspective on nature could inspire practices on reducing, reusing, recycling and recovering resources. Indigenous populations, slum settlers, street dwellers, hill people, tribes people and many more should be invited to define an economy that is in line with the circular mindset and within the boundaries of nature, so we refrain from creating another economic system based on westernism and developed economies with focus on manufacturing.

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Appendixes

All appendixes are translated from Norwegian. The interviews are in chronological order.

Appendix A Consent form

Do you wish to participate in the research project: ***Loops and curls*** ?

This is an invitation to you to participate in a research project where the aim is *to investigate the potential of Norwegian wool*. In this form we will give information on the aims of the project and what participation will mean to you.

Objective

This project is a part of a master thesis in relation to the study field entrepreneurship and innovation. The objective of the project is to explore alternative uses to wool (besides textiles for garments). The project will also focus on Norwegian wool in relation to circular economy. In the scope of the project we will contact actors like shearers, sheep farmers, wool sorting stations, researchers and companies.
We want to explore how low-category wool can be used.
We want to explore how we can make Norwegian wool circular.
The objective with the data gathering is to write a well-argued thesis that can be useful for actors in the wool industry and persons/businesses that focus on circular economy.

Who is responsible for the research project?
University of Agder is responsible for the project.

Why are you invited to participate?
You are invited to participate because you have a central part in the wool industry in Norway.

What does participation mean to you?

It is voluntary to participate.

It is voluntary to participate in the project. If you choose to participate, your consent can be withdrawn at any time and without explanation. All of your personal information will then be deleted. It will not have any negative consequences for you if you do not wish to participate or later choose to withdraw from the project.

Your privacy rights - how we store and use your information

We will only use the information we gather from you for the purposes described here. We will treat your information confidentiality and in compliance with privacy regulations.

Only the students and the supervisor that work on this project will have access to the information.

The name and personal information will be replaced with a code that is stored on a file separated from the belonging data set. With your consent, you will be recognised through direct citations that are relevant for the research.

What happens with the information you provide when we finish the project?

The name list will be anonymised after the thesis is delivered and is approved, which according to plan is 1. june, and after this the raw data and name list will be deleted.

What gives us the right to treat your personal information?

We treat your personal information based on your consent.

On behalf of *University of Agder*, NSD have concluded that the treatment of private information is in compliance with the relevant regulations.

Your rights

As long as you can be identified in the data material, you have the right to:

- access to what data we store and treat about you, and a copy of the data.
- to correct information about you that are wrong or misleading
- to have your data and personal information deleted
- to send a complaint to Datatilsynet about the treatment of your personal information

If you have questions about the study, or wish to know more about or invoke your rights, contact:

Tobias Ruben Moe (student), tobiasm17@uia.no (e-mail), +47 908 65 184 (mobil)
May Lis Furenes (student), maylf17@uia.no (e-mail), +47 950 02 507 (mobil)
Kalanit Efrat (supervisor), kalanit.efrat@uia.no (e-mail), +47 381 41 820 (telefon)

Our privacy representative: personvernombud@uia.no

If you have questions tied to privacy representative services' assessment of this project, you can contact:

Privacy services on email (personverntjenester@sikt.no) or phone: 53 21 15 00.

Best regards

Project responsible (supervisor) *student*

Declaration of consent

I have received and understood the information about the project, and have had the opportunity to ask questions. I consent to:

( ) Participation in interview
( ) that information about me is published in a way that I might be recognised.

I consent to the treatment of my information until the project is finished.

(Signed by project participator, date)

Appendix B Interview guides

[introduction where we inform about the thesis and go through the consent form.]

Interview guide for sheep farmer
Date: 16.02.2022
Setting: Grazing field with Old Norse sheep, Kristiansand

Can you tell us about your sheep farming?

What do you do with the wool? Can you store the raw wool after it is cut?

What usages are you aware of, besides clothing?

What are the advantages and disadvantages of having older breeds?

Can you tell us about the wool shearing process? How much does it cost?

What happens with the wool after the shearing? How is it processed?

Can you trace your own wool and buy it back?

Are you able to sell the wool afterwards? How do you market it?

What do you know about lanolin? How can it be used?

[introduction where we inform about the thesis and go through the consent form.]

Interview guide for Nortura and Fatland
Date: 28.02.2022 and 29.02.2022
Setting: Nortura Wool Station in Forus, Norway & Fatland Wool Station in Hommersåk, Norway.

(We are shown around the premises, where we learn about the process and the machines.)

How can the farmer deliver their wool to your station?

Are there many farmers that *do not* deliver the wool? What happens with the wool in those cases?

How much wool goes to waste from the station each year? What happens with it when it goes to waste?

How do you sort/classify the wool?

Can you tell us about your relationship with Fatland/Nortura? What is the difference between the two of you?

How much of the wool is sent to Haworth? And to other scouring facilities? Others?

How much would it cost to scour raw wool in X class?

What do they do with the wool in Sweden/Denmark/Iceland/England?

[introduction where we inform about the thesis and go through the consent form.]

Interview guide for Sandnes Garn
Date: 28.02.2022
Setting: Guided tour with the production manager at the factory in Sandnes

Can you tell us about the wool, and where you get it from? How much is Norwegian?

How do you tackle wool grease? What is the amount of grease in the wool you buy?

Do you perform the whole value chain in-house? What is your yearly capacity?

Can you take us through the washing process?
What kinds of soaps and chemical solutions do you use for cleaning the wool?

What happens to the wool grease?
Do you know of any alternative uses of lanolin?

What categories of Norwegian raw wool can you process here?
Is it possible to wash the lower classes here?

Would it be possible for a product developer to get raw wool washed here, and nothing else?

What is the advantage of washing it yourself instead of buying readily washed from England?

Can you tell us about the market development for wool through the years?

What is the future for wool?

[introduction where we inform about the thesis and go through the consent form.]

Interview guide for Sjølingstad

Date: 23.03.2022
Setting: Conversational interview in the factory store, followed by unstructured interview while shown around the factory.

What are the advantages of Norwegian wool?

How is the wool used?

We are looking into alternative uses for the wool, besides garments. Do you know of any particular product development that uses Norwegian wool?

Can you take us through the process from raw wool to spun yarn?

Our focus for the thesis is circular economy. Are you familiar with the concept?

How much waste is generated here, and what do you do with it?

Where do you get the raw wool from?

Most wool is shipped to England for scouring. Would it be possible to do this in Norway? Why/why not?

What categories of wool can you process here?

What is your experience with wool from lower categories?

Do you perform the whole process in-house?

Can you tell us about the advantages and disadvantages of this?

What is the future for wool?

Is it possible to recycle used wool garments and other products made from wool?

What can you tell us about lanolin? How do you process it?

Would it be possible for a product developer to wash the raw wool here?

[introduction where we inform about the thesis and go through the consent form.]

Interview guide for Norilia
Setting: Digital interview through Zoom.

Can you tell us about your value chain for Norwegian wool? Advantages and disadvantages?

How much wool is discarded as waste? What do Norilia think of discarded wool?

What do you think happens with the wool that is not collected?

In Norway there are great distances between the wool stations, especially in the north. Is proximity a problem when it comes to wool collecting?

Can you tell us about the relationship between Norilia and Fatland, in regards to wool?

We see different figures on the total amount of wool produced in Norway. How much do you estimate, including wool that is discarded?

We know that government subsidies are important. What would happen if it did not exist?
What is the consequence of removing subsidies for lower classes?
What would be the consequence of reinstating the subsidy for lower classes?
How much value creation is needed for the reinstatement of subsidies on lower classes?

We have read that most Norwegian wool is used for carpet production in England. Is this right?

Do you know of other product groups that use Norwegian wool?

Can you explain the process of when wool is sold at the world market? Can you talk about the demand for Norwegian wool at the world market? Has this developed over recent years?

Do the buyers request information on ESG and animal welfare?

We learned that there has been an increase in production of black sheep wool. Why?

In our interview with SG they told us that they wish to buy more wool, but are not able to get a hold of more. Why?

What is the future for wool?

Why are the majority of Norwegian wool sent to England? Can we not wash it here?

Can you tell us about the advantages and disadvantages of sending the wool to England?

Can Norwegian wool be traced and tracked?

What kinds of soaps and chemical solutions do you use for cleaning the wool?

Do you know of alternative ways of cleaning the wool?

What classes can be scoured at Haworth? Are there any limitations?

Is it possible to process wool from the lower categories at Haworth?

Do you know if there is a market or market demand for Norwegian wool from lower classes?

The wool contains wool grease, and we read that Haworth extracts approximately 20%. Can you tell us about the process?

What happens with the lanolin after it is extracted?
What happens with the lanolin that is *not* extracted?

Can you tell us about the amount of discarded waste at Haworth?

Can you tell us about the prices on Norwegian wool after the processing at Haworth?

We learned that the Brits sued the Norwegian government over the subsidy on wool, arguing that it tweaks the competition. Do you know what happened here, and how the lawsuit went? What do Norilia think of this?

[introduction where we inform about the thesis and go through the consent form.]

Interview guide for Ingun Grimstad Klepp
Setting: Digital interview through Zoom.

KRUS is largely about utilising Norwegian wool to a higher degree. Why is low-categorised wool worth focusing on?

Do low-categorised wool have properties that other categories lack? In case, which?

What are the market opportunities for Norwegian wool of lower categories?

We are looking into the extraction of keratin. How complicated is this process, in your opinion?

What about the extraction of wool grease and the refinement to lanolin? Do you have knowledge about this process?

In KRUS the focus is that a lot of the Norwegian wool is discarded or burned. Can you tell us more about this?

We have looked into product groups that use wool, besides garments. We found that two companies, Havelock and Thermafleece, make insulation for houses.
Is this something you have heard of?
What is your opinion on using wool for insulation?

In our understanding, the subsidy arrangement between the government and the farmers was made in 1952. Can you tell us about the consequences of this arrangement?

“The subsidies are the supporting beam of Norwegian wool”. What is your opinion on this statement?

Is the market large enough to scour wool in Norway?
Where do the barrieres lie, since it is not done today?

Sandnes Garn states that they have maximised their quota of the wool they may receive from the wool stations. What are your thoughts on this?

The Norwegian wool is scoured at Haworth in England. Do you know how this process takes place, and the advantages and disadvantages of this?

It seems like a lot of the wool grease is flushed into the sewer. How could we use this resource?
How might we gather and refine the wool grease?

Is wool sustainable? Why/why not?

Are you aware of alternative ways of cleaning the wool?

A new EU legislation is on the way, that will lead to a much higher degree of recycling. What can we do with used wool?

What can we do with the used wool that is sorted away from the general waste?

What is the future for wool?

Appendix C Data analysis

	1. order concepts	2. order themes	Reduce	Reuse	Recycle	Recover
Farmer	- Do not know what to do with the wool - Storage of wool is ruined - Perceive wool as valuable - Wool as a fertiliser that takes long time to decompose - Farmers have a big pile of soil mixed with wool - Wants to sell sustainable and short travelled product	- Improving value of wool - Discover usages for wasted wool - Lack of opportunities - Local and informal distribution	- Resource overshoot - Reduction through customer awareness - Reducing climate impact by selling locally - decomposition time - wool waste	- Wool as fertiliser	- Wool as fertiliser	- Recover wasted wool though product development
Wool stations	- Promising characteristics of Norwegian wool - Some increase of C1S - False marketing of what is “Norwegian” - moist, painted and wool with insects is wasted - Most of the wool is sold - poor categorising by farmer - a wish to find more areas of usage (in	- understanding how Norwegian wool can be utilised for value added activities - High efficacy - lacking knowledge in relation to categorising - supporting innovation	- Reduce environmental toxins by recovering lanolin - Reduce waste by having a high quality yield -Reduce need for other materials by utilising spens and durability in carpets.	- reuse wool locally	- use sorters in low season to train sorting AI (2025 textile law)	- rethink value based on properties of wool - recover value added activities and expertise locally/regionally

	Norway) - Efficient but long transport - Some local distribution - “The lanolin gets washed right out of the wool” -”lanolin gives you soft hands, but not much more” - Efficient collection from farmers - Very little plant matter in the west coast wool - Norwegian wool is used in carpets due to its spens - seasonal amounts of wool to be categorised - 3 kr/kg delivered H3 to England and same if we want to buy it - Lot of fuss around SG laterly due to emissions	- lanolin is wasted - high quality raw resource - Lasting product development - lack of knowledge on lanolin - processes in need of development - same price regardless of geography	- Reduce emissions - reduce transport			
SG	- unused capacity for scouring - wool grease is flushed into the gutter - Norwegian wool is gaining popularity - low value creation in scouring - in-house production benefits - much of Norwegian wool goes to industry yarn = low pay and high obligation to deliver, this has been	- transferrable value adding activities to other disciplines - processes in need of development - solidarity - in house production avoids transport emissions - Measurements	- Reduce import of foreign wool - Reduce capacity - Reduce environmental toxins by recovering lanolin - Reduce emissions - Inhouse production = reduced need for	- Rethink waste as lanolin - Reuse washing water - Reuse chemicals used in washing - Reuse yarn - Reuse recycled textiles	- Recycle lanolin for greasing machinery - Recycle washing water -Recycle chemicals used in washing - Recycle yarn - Recycle textiles	- Rethink grease as lanolin - Recover chemicals used for washing - Recover vegetable matter - Rethink low-cat as high value

	reduced - branding has given SG good yields - the future of wool is good if the farmers are given good terms - The whole production inhouse reduces risks and transport emissions - Buys readily washed wool without lanolin due to weight in transport - what they sell is based on the seasons	to reduce weight - Measurements to develop portfolio	transport/reduced energy need. - Reduce industry yarn - Reduced capacity - Measures to reduce seasonal changes in demand			
Sjølingstad	- Norwegian wool is desired due to sustainability and origin - entrepreneurs are approaching them for new usages of wool. Such experimentation can lead to future productions and are exciting activities to partake in. - When producing large blankets with faults, smaller pieces are cut out to make seat pads. - reduced capacity due to emission permits - The factory relies on fossil energy, when electric energy is pricy - Recyclability in the kratzerie, use everything	- desired qualities in Norwegian wool - increasing awareness of origin - will for change - fixed maximum amount of processing - Controlling waste emissions inhouse - awareness of resource management	- Reduced material input due to high efficacy - Reduced material input due to law against textile waste - Reduce waste in local environment - invest in new “kratser” to reduce waste	- invest in new “kratser” to reuse materials	- Recycling is done with fossil energy - Recycling of lanolin is not done - Onsite recycling of unused material - Recycling with shoddy in the past.(remanufacture?) - Recycle lanolin for greasing machinery - invest in new “kratser” to recycle materials	- Faulty products may be cannibalised into new products. (blanket to seat pad) - invest in new “kratser” to recover waste

	- Dependency on fibre length due to machinery - Used to be a shoddy-machine that recycled all materials, but its gone now - New govt policy will come in 2025, stating that all municipalities must recycle every textile - treatment plant at the factory - does not extract lanolin					
Norilia	- 95% of wool is collected and all of it is sold - in Sweden 40% is collected - Norwegian wool has good properties such as crimp, elasticity and shine - Norwegian wool is of relatively low value on the global market - customers are aware of how the wool is produced concerning animal welfare and use of chemicals - Norwegian customers are prioritised - media have exaggerated wool waste - subsidies are the backbone of wools value, both pricing and financing wool	- High resource allocation - increasing awareness of origin - desired qualities in Norwegian wool - sources with varying agendas - established value-chains - will for change	- reduce dependence on international value-chains			- rethink value based on properties of wool

	sorting stations - practical and economic incentives by sending wool to England - important to increase value of low-grade wool - innovation and product development					
Ingun Grimstad Klepp	- unwise to categorize materials. - all materials have good properties, find suitability - keratin from human hair should be used as well - research funding for new materials instead of improving known material. - political hangup to invent new things - lanolin extraction done at all the major laundries. - centralised large plants are better at extracting the lanolin - no shortage of things to use lanolin for - Norway is best in class along with Iceland and England - f-races; there is more wastage than there should be	- knowledge about resources - resource utilisation - resource recovery - centralisation - govermental schemes - lost resources - resource priotities - natural vs. synthetic - product development	- reduce wastage through utilisation of exisitng resources - reduce wasted wool through business ventures - reduce synthetic demand through utilisation of exisitng natural resources			- recover lanolin from scouring, small-scale to mid-scale - funding to improve utilisation of recovered resources - large-scale advantages - innovative recovery sources

	- when something costs to produce one must have good products that can sell, bear some of the cost - fine wool is very suitable for insulation - use the worst you have that is still suitable - the mainstay should be that we pay for the product we use - world trade has outcompeted local conditions. Raw materials are not taken care of - just produce what we need, and use what we have - more use of pure natural materials again. More excitement about what we get from nature - better use of resources