VTT Technical Research Centre of Finland

Finland as a forerunner in sustainable and knowledge-based textile industry - Roadmap for 2035

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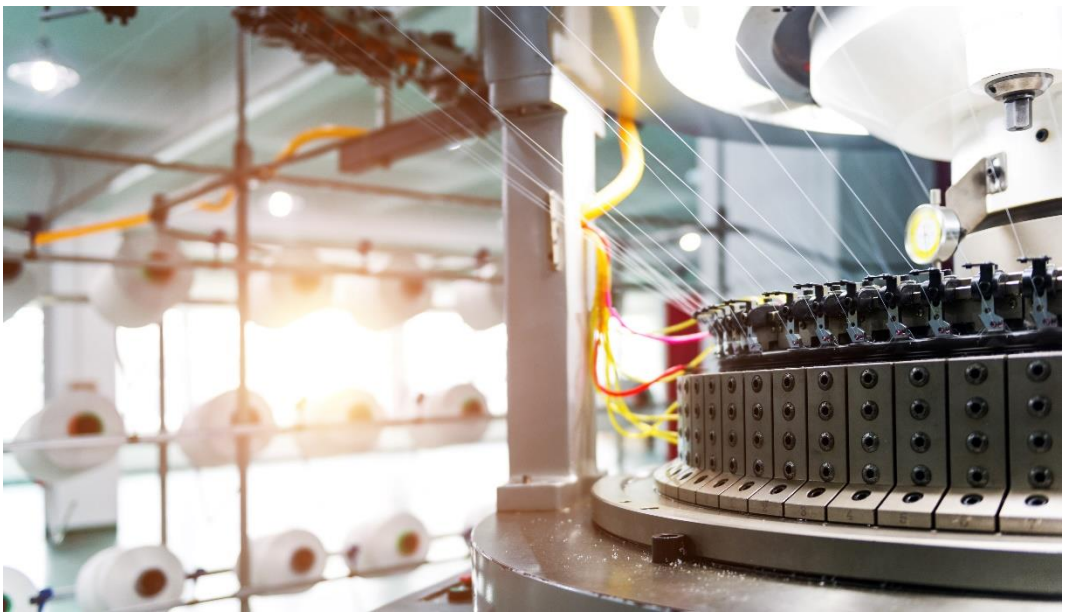
Published: 18/08/2021

Document Version
Publisher's final version

RESEARCH REPORT

VTT-R-00684-21



Finland as a forerunner in sustainable and knowledge-based textile industry - Roadmap for 2035

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Confidentiality: Public

Report's title

Finland as a forerunner in sustainable and knowledge-based textile industry - Roadmap for 2035

Customer, contact person, address	**Order reference**
Project name	**Project number/Short name**
Tekstiiliteollisuuden roadmap	130088 RoadTex
Author(s)	**Pages**
Taina Kamppuri, Katri Kallio, Satu-Marja Mäkelä, Ali Harlin	30/
Keywords	**Report identification code**
textile and fashion, sustainability, digital solutions	VTT-R-00684-21

Summary

On the one hand, the textile and fashion industry in Finland is currently going through a transition period. On the other hand, Finland has excellent preconditions for transforming the textile industry as part of an international network. There are several interesting pilot projects and industrial production investment projects going on around the new and ecological textile fibres as well as recycled textile fibres in Finland.

The aim of this work was first to identify the themes around which the roadmap was built. Secondly, the vision as well as the enablers and barriers were recognised. The data was collected in two workshops and in couple of individual interviews.

Finland will become as a forerunner in sustainable and knowledge-based textile industry by 2035. In practice, the first step to push the transformation is the building of *Future proof loop pilot* and ecosystem around the pilot, where different actors could demonstrate and verify sustainability and responsibility as well as business potential of novel solutions. *Designed for sustainability* will be operating model in the pilot. It will be developed and implemented within *Future proof loop pilot*. Later on, this operating model is extended into an international *Designed for sustainability standard* that will give globally common tools to verify sustainability.

For Finland, a renewed textile industry would mean an estimated one billion euros investments and almost 17 000 new jobs by 2035, and a strengthened global reputation as a leader in the circular economy and sustainable development.

Confidentiality	Public

Tampere 17.8.2021

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Distribution (customer and VTT)

VTT, STJM

Preface

This is the report of the VTT's self-financed Road*Tex project.* The project was carried out during May - September 2021. RoadTex was about building of roadmap for textile and fashion industry in Finland towards more sustainable and responsible future. The content of the report is based on discussions during two workshops and individual interviews. We had over 100 participants from the textile and fashion sector involved in the workshops. The authors would like to acknowledge all the stakeholders that actively contributed the discussions during the work.

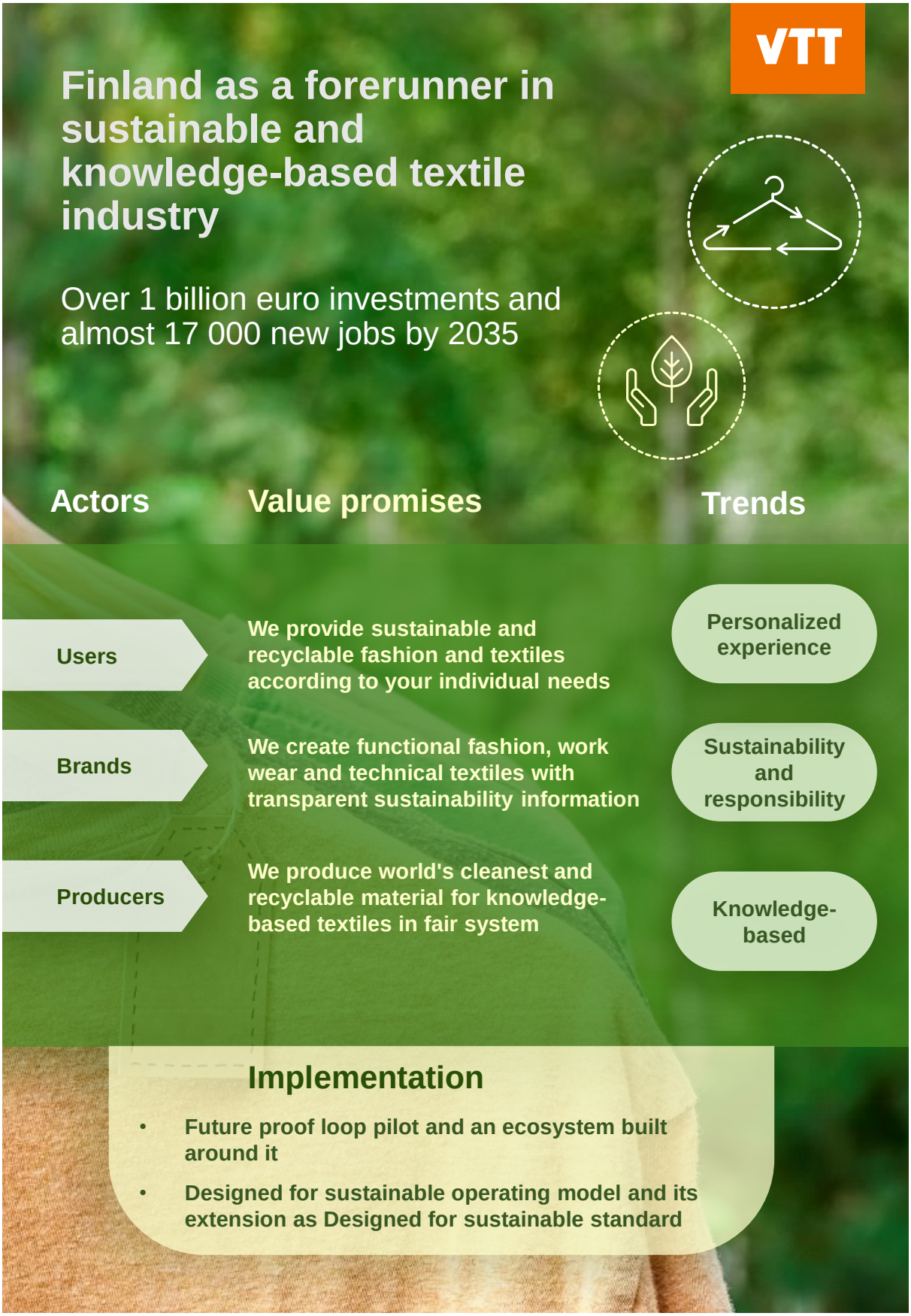
Many thanks to steering group members Managing Director of Finnish Textile and Fashion Marja-Liisa Niinikoski, Advisor International Business and Finance Anne Ruokamo and VTT's Executive Vice President Tua Huomo, Research Professor Ali Harlin and Professor of Practice Riikka Virkkunen.

Thanks to VTT's working group Petri Rouvinen, Eetta Saarimäki, Rosa Palmgren, Ville Hinkka, Vafa Järnefelt, Pirjo Heikkilä and Anastasia Ivanova. Many thanks to Satumaija Levón and Katri Pylkkänen from Finnish Textile and Fashion for their valuable contribution.

Tampere 16.8.2021

Authors

Summary


VTT
Finland as a forerunner in sustainable and knowledge-based textile industry
Over 1 billion euro investments and almost 17 000 new jobs by 2035
Actors
Value promises
Trends
Users
We provide sustainable and recyclable fashion and textiles according to your individual needs
Brands
We create functional fashion, work wear and technical textiles with transparent sustainability information
Producers
We produce world's cleanest and recyclable material for knowledge-based textiles in fair system
Personalized experience
Sustainability and responsibility
Knowledge-based
Implementation
Future proof loop pilot and an ecosystem built around it
Designed for sustainable operating model and its extension as Designed for sustainable standard

Finland has excellent preconditions for transforming the textile industry as part of an international network. A **responsible and knowledge-based textile industry** emerges in Finland, which enables **individual solutions of the digital age**. Sustainability and responsibility are transforming from noteworthy values into key criteria that guide user behaviour as well as decisions regarding purchases and cooperation. Tightening EU legislation is accelerating the transition to bio-based and recycled raw materials as well as textile and fashion designed to be durable and recyclable. At the same time, the desire to create and use individual fashion is growing.

The knowledge-based technology takes into account the customer orientation, personalization, and prediction of needs. Finnish excellence in design, digitalisation, circular economy and industrial production provides excellent conditions for the creation and mass customization of next-generation, high-value-added textile solutions. Finland's special opportunity is in the sustainability and **knowledge-based functionality** of textiles and fashion. The know-how of bio-based raw materials and smart technologies is among the best in the world in Finland.

Finnish know-how **gets its value when it is in use**. Right now is the right time to invest and put into practice the world's smartest and most agile production infrastructure for textile industry to Finland. In the **Future proof loop pilot** actors could test sustainable and responsible solutions in design, manufacturing and recycling. The promising applications to start with are work wear and other professional textiles, maternity package textiles, as well as apparel and home textiles based on distinctive patterns and prints. Additionally, the pilot would also support and make it possible to test an industry-wide Designed for Sustainability operating model. This operating model is translated into an international **Designed for Sustainability standard**. The standard could increase and harmonize the ambition of sustainable practices in the field. A digital product passport, the extension of the eco-design directive to textiles and the extension of taxonomic criteria are already under way at EU level. These contribute to guiding the development of the standard as part of piloting. For Finland, a renewed textile industry would mean investments worth over one billion euro and almost 17 000 new jobs by 2035, and a strengthened global reputation as a leader in the circular economy and sustainable development.

Yhteenveto


VTT
Suomesta vastuullisen ja tietämyspohjaisen tekstiiliteollisuuden mallimaa
Miljardiluokan investoinnit ja lähes 17 000 uutta työpaikkaa vuoteen 2035 mennessä
Toimijat
Arvolupaukset
Trendit
Käyttäjät
Tarjoamme maailman puhtainta ja täysin kierrätettävää materiaalia, tekstiilejä ja muotia yksilöllisiin tarpeisiin
Brändit
Luomme puhdasta ja toimivaa muotia, työvaatteita ja teknisiä tekstiilejä sekä todennamme niiden vastuullisuus- ja kestävyystiedot
Tuottajat
Tuotamme vastuullisesti maailman puhtainta ja kierrätettävää materiaalia tekstiileiksi, joissa on vahva tietämyspohja
Personoitu kokemus
Kestävyys ja vastuullisuus
Tietämys-pohjaisuus
Toimeenpano
Vastuullinen ja todennettu suljetun kierron pilotti ja sen ympärille rakentuva ekosysteemi
Suunniteltu kestäväksi toimintatapa, joka laajentuu Suunniteltu kestäväksi standardiksi

Suomella on erinomaiset edellytykset uudistaa tekstiiliteollisuutta osana kansainvälistä verkostoa. Suomeen nousee **vastuullinen ja tietämyspohjainen tekstiiliteollisuus**, joka mahdollistaa **digitaalisen ajan yksilölliset ratkaisut. Kestävyys ja vastuullisuus** eivät ole tulevaisuudessa pelkkää puhetta, vaan keskeisiä käyttäytymistä, yhteistyö- ja ostopäätöksiä ohjaavia kriteereitä. Euroopan unionin tiukkeneva lainsäädäntö vauhdittaa siirtymää biopohjaisiin ja kierrätettyihin raaka-aineisiin, sekä kestäviksi ja kierrätettäviksi suunniteltuihin tekstiilituotteisiin. Samanaikaisesti halu luoda ja käyttää **personoituja tuotteita ja yksilöllistä muotia** kasvaa.

Uusi tietopohjainen teknologia ottaa huomion asiakaslähtöisyyden, personoinnin ja tarpeiden ennakoinnin, joita se toteuttaa mallintavan suunnittelun, automaation, robotiikan, keinoälyn, tietoturvallisuuden ja tunnistusteknologioiden keinoin. **Suomalainen suunnittelu-, digitalisaatio-, kiertotalous- ja teollisen tuotannon huippuosaaminen antavat erinomaiset edellytykset seuraavan sukupolven, korkean jalostusarvon tekstiiliratkaisuiden luomiseen ja massakustomointiin.** Näissä Suomen erityisenä mahdollisuutena korostuvat kestävien ratkaisujen ja materiaalien **tietopohjainen toimivuus.** Biopohjaisten raaka-aineiden ja älykkäiden teknologioiden osaaminen ovat Suomessa maailman huippua.

Suomalainen **osaaminen** on käytännöllistä ja se **saa arvonsa, kun se on käytössä**. Juuri nyt on oikea hetki investoida ja viedä käytäntöön Suomessa maailman älykkäin ja joustavin tuotantoinfrastruktuuri tekstiiliteollisuuteen. **Vastuullisen ja todennetun suljetun kierron pilotissa** voitaisiin testata täysin kestävää ja vastuullista suunnittelua, valmistusta ja kierrättämistä lupaavien sovellusalueiden, kuten äitiyspakkauksen tekstiilituotteiden, työvaatteiden ja muiden ammatilliseen käyttöön tarkoitettujen tekstiilien sekä omaleimaisiin kuoseihin ja printteihin perustuvien vaatteiden ja kodintekstiilien avulla. Pilotti mahdollistaisi myös koko alan edun mukaisen Suunniteltu kestäväksi -toimintatavan testaamisen. Toimintatapa kääntyy kansainväliseksi **Suunniteltu kestäväksi -standardiksi.** Standardin avulla alan kestävien käytäntöjen kunnianhimoisuutta voitaisiin nostaa ja yhtenäistää. EU-tasolla on jo tekeillä digitaalinen tuotepassi, ekosuunnitteludirektiivin laajennus tekstiileille sekä taksonomiakriteerien laajennus. Nämä ohjaavat standardikehitystä osana pilotointia. Suomelle uudistunut tekstiiliteollisuus tarkoittaisi arviolta miljardiluokan investoinnit ja lähes 17 000 uutta työpaikkaa vuoteen 2035 mennessä sekä maailmanlaajuisesti vahvistunutta mainetta kiertotalouden ja kestävän kehityksen johtavana maana.

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1. Introduction and framework for the roadmap

The textile and fashion industry in Finland is currently going through a transition period. There are several interesting pilot projects and industrial production investment projects going on around the new and more ecological textile fibres as well as recycled textile fibres in Finland. The innovations and investments around novel cellulose-based and recycled textile fibres provide a basis for the building of a textile cluster, which has links to the forest industry, digitalization and software development as well as other technology industries in Finland.

The formation of a textile cluster requires investments to Finland. In addition to investing in production, we need to strengthen international trade, especially in the consumer business, so that excellent Finnish products and innovations produce sustainable growth in Finland. For the transformation of the Finnish textile industry, we need increased understanding of opportunities that lies in the data economy, robotics and automation in order to produce and deliver sustainable, personalised and high-quality products to the global market.

Our common aim is to find ways to create new investments in the textile industry as well as international business in Finland. Instead of exporting dissolving pulp from Finland Finnish companies could export textile fibres, yarn, fabrics, knits, nonwovens and finished products, such as apparel, work wear and home textiles. The value of finished products is much higher than dissolving pulp[1].

The different European level action plans, strategies and directives have created pressure for the transformation of textile industry. The European Commission has identified textiles as one of the priority product categories for the circular economy in the 2020 EU Action plan for circularity[2]. The EU strategy for sustainable textiles are being prepared and it will help textile industry to shift to a climate-neutral and circular economy[3]. In addition the single-used plastic directive[4], The EU initiatives on Sustainable Product Policy[5] and on Sustainable Corporate Governance[6], the European Strategy for Plastics in a Circular Economy[7] will have impact on textile sector. Globally, the UN Sustainable development goals are driving the action towards more sustainable world from social, economic and ecological perspectives[8].

Finnish textile industry is in the midst of a transition towards sustainability in raw materials, production processes, design and the whole life cycle of textiles. In general, this transition has created a need to identify the possibilities for further development needs, investments and business opportunities for the textile industry in Finland. The first step was to formulate together a vision, especially from the point of view of digitalised and sustainable textile production, for Finnish textile industry for 2035. In practice, the work started by identifying the themes around which the roadmap was built. The main focus was on reforming the production processes towards sustainable, responsible and digital production. The identified themes important for the transition period were Finnish textile value chain, digitalization, future consumer and international partnerships. This roadmap is linked to Finnish Textile and

[1] Tahvanainen, Antti-Jussi, Pajarinen, Mika (2014).
Älykankaita ja kukkamekkoja. Suomalainen tekstiiliteollisuus globalisaation ristiaallokossa. Helsinki: Taloustieto Oy (ETLA B265) available https://www.etla.fi/wp-content/uploads/alykankaita__kukkamekkoja_ETLA_B265_kansilla.pdf
[2] EU Action plan for the circular economy (2019) https://ec.europa.eu/environment/circular-economy/
[3] EU strategy for sustainable textiles (in preparation 2021) https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12822-EU-strategy-for-sustainable-textiles_en
[4] Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment https://eur-lex.europa.eu/eli/dir/2019/904/oj
[5] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12567-Sustainable-products-initiative_en
[6] https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12548-Sustainable-corporate-governance_en
[7] EC (2019) European Strategy for Plastics https://ec.europa.eu/environment/waste/plastic_waste.htm
[8] The 17 goals https://sdgs.un.org/goals

Fashion's Carbon Neutral Textile Industry roadmap[9] and to Telaketju roadmap that deals with circular textile economy and recycling of textiles.

The vision for the Finnish future textile industry was built in close collaboration with the Finnish textile industry, Finnish Textile and Fashion and VTT's experts. The industry and other interested stakeholders were invited to two workshops, where first step was to identify the themes around which the roadmap was then focused. In the second workshop, the attendees were discussing the vision for the sustainable transition of Finnish textile industry as well as enablers and barriers at the present time. The roadmap was geographically limited to Finland, even though the textile industry is global. The international partnerships were identifying the important cooperation and international links for Finnish textile industry. In addition, the workshops were intended to Finnish textile actors, but the cross-industry collaboration is needed to combine knowledge-based textiles to smart production and data driven solutions for transparency.

In the workshops, three global trends driving the change of the textile industry were identified and they are discussed in chapter two. Third chapter focuses on the first ambitious implementation actions that could pave the way towards the change in Finland. Chapter four summarizes the economic value of the transformation. The collection of data for this report is explained in chapter five and the workshop discussions are opened in chapter six. At the end of the report, in chapter seven, there are conclusions.

[9] Hiilineutraali tekstiiliala -tiekartta. Loppuraportti (2020) https://stjm.s3.eu-west-1.amazonaws.com/uploads/20200610133352/STJM-Hiilineutraali-tekstiiliala-tiekartta_FINAL.pdf

2. Global trends for the vision and opportunities in Finland

2.1 Sustainability

Sustainability and responsibility are growing trends and these values are transforming into behaviour, purchasing and cooperation trends. Behaviour are catching up the values. In addition to the growing consumer awareness, textile producers and brand owners emphasize the importance of sustainability and responsibility. Tightening legislation in the EU is accelerating the transition to transparency and bio-based and recyclable raw materials and textiles.

In the production of textiles, bio-based materials and novel production methods of bio-based and recyclable textile fibres will enable the shift towards sustainable textile industry. The material base for the Finnish novel cellulosic textile fibres is certified. The certificates of forest industry, FSC and PEFC, promote ecologically, socially and economically sustainable forest management. The novel cellulosic fibers shall have their own branded certificates, and these should be referred to in the final product. ”Intel inside” and Gore-Tex could act as successful branding references for the Finnish actors. Alongside the development of bio-based materials their recyclability must be taken into account. In addition, a certified method is required to verify recyclability.

Increased recycled content in clothing inventory will be enabled through reusing, recycling and refining innovations, emphasizing quality. There is a need for certificate for recycled fibres that verifies the recycled material content in the product and gives the promise of recycling. The certificate will enable the branding of recycled materials and facilitate their marketing.

Designers have strong responsibility in their work. In this frontline work, they need modern tools and concepts. Simple digital tools are not enough, but designer needs product modeling and supportive intelligence to hit the most functional and sustainable design. The training of designers should emphasize the sustainable design solutions and there is a need for a design guide to help them to check the sustainability of materials using available life cycle analysis (LCA) tools and versatile data sources for the review of impacts of their choices. The development of the certification of materials helps the sustainable design. The extension of the Ecodesign Directive to textiles is currently being discussed in the EU. In addition, the Product Environmental Footprint (PEF) Method for textile products is nearing completion by the end of 2022. These are sure to become requirements and tools that will guide product design in the future and help make consistent LCA calculations.

Consumers need a simple and standardized sustainability label, which will indicate all the core aspects of sustainability in an understandable manner. For this simple label, there is a need for the development of a more complex indicator for sustainability with a comprehensive LCA view on circularity and sustainability. The indicator is data-intensive and needs support from digital platforms. There are already some efforts towards sustainability verification, such as Rank a Brand and Higg Index, but more research and development is needed to give consumers a simple way to verify the sustainability. The EU's Initiative on Sustainable Product Policy is currently addressing these issues. For example, in the future, environmental claims for products should be based on LCA calculations according to the PEF method, and a digital product passport is being developed to ensure the availability of product-related information throughout the product life cycle. Consideration is also given to the changes of the consumer protection legislation with regard to green claims. There is a desire to protect consumers from greenwashing, and the need for legislative reform in this area is also being assessed in various countries and within the EU.

2.2 Personalized experience

Fashion and clothing are a way to express oneself and feelings. A person becomes a brand and influencers have strong impact on style. The desire to create and use personal solutions in fashion is growing. At its simplest, the personalization helps shoppers navigate e-commerce offerings and get to the purchase decision faster. This requires AI solutions and data which reflects consumers' habits and predicts their future buying behaviour. Virtual fitting of clothing enables consumers find the right size and well-fitting garment according to their actual body measurements, body shape and style. Future digital experience is allowing a user to select and preview 3D photorealistic design before production. Extended reality with AR and VR solutions, not only in the consumer business but in the fashion industry more general including virtual fashion shows and digital/virtual collections. The aim is to create digital, immersive experiences besides physical experiences. In this respect similarities between gaming industry and fashion industry can be identified in the near future.

In addition to personalized shopping experience, personalized fashion covers unique, made to measure and made to order clothing. Key for individual fashion lies in mass-customization near the consumer. The reaction time from the purchase decision to ready product creates advantage to Finnish actors and Finnish companies focus more on personalizing semi-finished products. Different additive manufacturing methods and micro factories will enable made to measure clothing and personalized fashion.

Finnish excellence in design, digitalisation and industrial production provides excellent preconditions for the creation and mass customization of next-generation, high-value-added textile solutions. Big data and AI are the key to use the data for nearly perfect prediction. These together lead not only to maximum end user satisfaction and profits, but also minimal environmental impact. However, design, digitalisation and production know-how alone are not enough in creating significant growth for Finnish textile industry. The growth requires strengthening international consumer trade from these points of views.

2.3 Knowledge-based textiles

Knowledge-based is the essential information content of a product that can be used to create a successful customer experience, social acceptability and reduce the burden on the environment. Information includes the sustainability and acceptability of production, traceability of the origin of products, suitability for customer use, maintenance, repair and recycling. Data can be collected, stored and shared across multiple technologies on different material and product platforms. Data, extensive information related to a product, is available from an open source throughout its lifecycle.

Knowledge-based textiles emphasise the value of the material and data the material is carrying. This stands for clever business models and technical solutions where value is related to material properties so that the inherent and improved material properties determine the functionality of end-application. In addition, the value of the textile product is partially based on the data it carries. On the one hand, the material is selected to applications where it has the best performance. On the other hand, the recyclability of the material is prerequisite for all textiles and fashion. At the same time, material and textile product carries its story, for example data about its origin, usage and end-of-life options.

Additionally, clever and knowledge-based textiles will have high resale value. Consumers value their clothing and when making the purchase decision they take not only the price into account but also estimate the resale value of the clothing. The story behind the garment can be stored to the product, so that the story and information of the usage of the product is available for the next user. EU's Initiative on Sustainable Product Policy is currently promoting

the use of digital product passports. Digital passport could carry information that may with the product throughout its life cycle. The accompanying knowledge that the textile product carries will promote traceability that in turn could be a significant competitive advantage for new Finnish fibers and products processed from them.

The production and product transactions are optimized to make full use of advanced manufacturing technologies. Data are gathered during the production steps. New capabilities for processing sensor data, along with big data, machine learning and artificial intelligence are the keys to process the data and finally reach intelligent manufacturing.

The intelligence and functionality of sustainable solutions and materials are emphasized as a special opportunity for Finland. The know-how of bio-based raw materials and smart technologies is among the best in the world in Finland.

For improving the customer experience in fashion and textiles, we will need more transparent information and data from the whole textile lifecycle. Data should include many details from whole lifecycle starting from origin of the raw material ending to the point where the textile is the source of the new fibers or otherwise handled in its end-of-life.

Currently textile industry is trying to support gathering all the information relating to final product including the raw material and processing information, factories and even who has made the product and the packaging & the logistics information. As the level of digitalization increases and the design process is digital, this information will be also included as data source. We can say that we are quite close of having digital model of the textile having all the information collected from the production phase of the end product. Digitalization creates platform for real personalized and tailored products with ability to object oriented material and product history opening viable reuse and recycle markets.

In the world of Internet of things (IoT) digital twin means a counterpart of the physical entity that has real time connection to it. When we get to the point that the information of the textile is updated in real time from different phases including sales and customer behavior in digital platforms, we will have the digital twin of the textile. Increased access to garment user data and improved quality enable substantial improvements of product sustainability as well new services in reusability and circularity.

In near future the same product will also gather (real time) information of its usage and maintenance. This will support new type of services for sustainable shopping behavior relating to purchase decision, rental services, second hand shopping etc. allowing the life as a textile as long as possible before serving as a new fiber source.

Digital twin of the textile with intelligent analytics provides the brand tools to reach the sustainability goals and also new possibilities to satisfy the new era customer urging sustainability information of the textile. This data can transform design and selling process especially in terms of sustainability but also improve the recycling of textiles. As the usage data from the customer increases, the feedback loop for the brands allow the design process to improve for more sustainable design by increasing the quality and durability of products.

Already existing data and efficient analytics would provide completely new insight to the product. The digital twin of the textile will require a platform for information that is maintained for long time. All the essential content will be stored systematically in digital form and updated during the life cycle of the textile product. Innovation driven partnerships will enable the use of technical offerings in new and interesting ways while supporting the creatives that transform industries for a more disruptive and sustainable future. One challenge will lie on this; who will maintain the platform and information as many businesses will utilise the data. Will we face challenges relating to GDPR (*General Data Protection Regulation)* and privacy. How we can tag the textile so that it will be identified even after the 10 year. In addition, it is essential is to understand the real need of connectivity and risk related to the personal data safety where the

consumer benefits exceed hazards and user experience may become new standard. There are many challenges on a way, but already the research is looking for solutions and if viable new business is born, it will find solutions to some of the technical issues by its nature.

Main probable solutions are to be found in commitments in customer relations, rental textiles and consumer recovery applications, where it is possible to create a positive and both benefiting agreement between vendor and customer. These represent up to 30% of clothing markets, and expected to grow. RFID is reality in rental clothing already, and the concept can extend to individual consumer products, at least in special cases, e.g. children and sport clothing. In addition, the concept could extend to the return of used textiles especially if deposit fee will be accepted.

3. Implementation of needed actions in Finland

Textile industry is global and the oldest industry branch. Textile industry have adopted many technical solutions and scaled up them to industrial scale. This offers a potential for the global textile industry to lead the way once more and turn the production into intelligent and data driven.

Certain production steps in the textile and fashion value chain, such as yarn spinning and weaving, are labour intensive. Finland will not compete with the traditional mass production in textile assembly in future either. Finnish excellence in business models, design, digitalisation and industrial production provides excellent preconditions for the sustainable transition of textile industry. The know-how of bio-based raw materials is among the best in the world in Finland. Additionally, the Finnish know-how in smart technologies should be transferred to textile industry as well.

Future prospects of Finland's textile sector relying especially on bio-based and circular economy have been evaluated and the timeline sketched in Figure 1. The phases from the development to emerge of industrial scale plants for cellulose based regenerated fibres, chemically and mechanically recycled fibres are plotted in the timeline. The processes for converting the fibres to textiles are indicated and the needed timeline for them indicated in Figure 1.

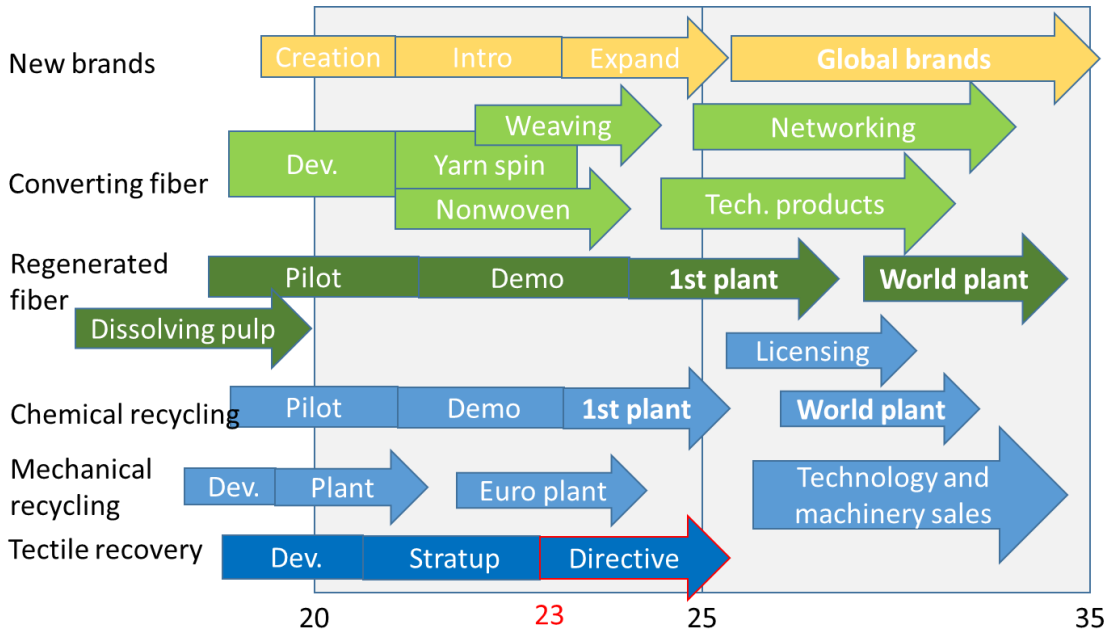

Figure 1. Timeline for the future prospects of textile sector in Finland

The first steps to implement the sustainable textile industry could be *Future proof loop pilot* that can be used to demonstrate and verify the sustainability of the value chain. The sustainability can be based on EU's Product Environmental Footprint calculation and additionally EU's planned digital product pass and the extension of the Ecodesign Directive can guide the sustainability assessment. Finnish actors could involve more actively in the development of a Designed for sustainability standard that ensures the sustainability in wide context and emphasises the Finnish perspective. Digitalisation, data and AI are closely connected to *Future proof loop pilot* and additionally different digital platforms plays a central role. In addition, it is important to harmonize and standardize the various durability requirements and, in particular, to establish a general classification for recycled materials and reusable textiles.

3.1 Future proof loop pilot

It was identified that for the implementation of the needed actions in Finland, an ecosystem for piloting the textile value chain, is needed. *Future proof loop pilot* would be a platform to demonstrate the sustainability of the Finnish textile value chain. It will be used to demonstrate different processing concepts, but also to develop different data driven systems throughout the steps as well as demonstrate the data collection to enable transparent value chain for textile materials and fashion. In addition, it will be a tool to develop the criteria and measures for the designed for sustainability operating model to be translated later on into a standard. The actors of *Future proof loop pilot* will form an ecosystem that will actively take part on the development of the designed for sustainability standard.

At the moment, the environmental and social impact is often difficult to assess in practice. *Future proof loop pilot* will develop practical measures for the assessment of these impacts of different concepts. Digital tool, AI and big data concepts are included to the piloted systems to find the full potential of data collection and analysis in different phases of the developed concepts. There is also an urgent need for a globally available textile information platform. The owner of the Finnish platform is a state-funded organization or research institute to guarantee open access to SMEs, also.

Finnish actors have know-how and true willingness to participate in the *Future proof loop pilot*. Several companies, research institutes and Business Finland are already expressed their interest towards the pilot. The ecosystem pilot will be used to outline concepts, roles and competencies of different actors. The missing processes currently identified are related to yarn spinning and yarn and fabric dyeing. Weaving also requires know-how and agile piloting opportunities. *Future proof loop pilot* will be used to identify the needs and development opportunities in the digitalization. In addition, digitalization and data driven smart production concepts will be developed. Platforms to share data and knowledge demonstrates alongside the development of the processing.

In addition, *Future proof loop pilot* will enable modelling of the demand. *Future proof loop pilot* will enable a new piloted system to grow into business. It demonstrates that business is possible and is on the path towards the growth of business. The pilot demonstrates and tests the created system. It serves as a first step on the path towards sustainability and provides valuable insights to reshape the markets.

Link to recycling of textiles

Without the extension of the value chain beyond the country's borders, Finland will not be able to achieve a significant textile recycling system. The value chain for recycling of textiles is truly international and we lack certain parts of the recycling chain. Main missing links in the value chain are those, where manual work is dominant, mainly yarn spinning, cloth weaving and actual assembly including sewing. In addition, the Finnish raw material base is very limited, domestic raw material for textile fiber is just forest based cellulose, missing natural fibers like wool and linen. Additionally, the domestic amount of end-of-life textiles is limited and availability of recycled textile materials is partially unknown.

The closed loop recycling system should aim for a significant size range in a chosen area, such as work and rental clothing. In addition Finland has opportunities to grow in nonwovens that supports the closed loop recycling. Sharing sustainability data is becoming threshold to achieve transparency to the whole textile value chain. However, Finnish actors in closed loop recycling have the opportunity to guarantee transparency with regard to recycling. In addition, the aim of the textile recycling is to keep the quality of the materials and textiles from recycled materials high. This requires networks and cooperation in different markets.

In order to create a significant export-oriented industrial and commercial activity, we need to be involved in supplying recycled materials, textiles from recycled materials and supplying technologies related to recycling. Finland can be significant supplier of recycled textile materials, if we import a significant amount of used textiles and if we blend recycled textiles fibres with novel cellulosic based fibres, for example in yarn spinning. Finland will be a major supplier of recycled textiles, however we need to create a European or global value chain in selected market areas. For Finland to become a technology leader in recycling of textiles, the technology for automated sorting of textiles is the key. The automation in sorting and identification of textile materials is currently studied and developed in Finland. The sorting system should be analogous to bottle deposit system, so that the materials are sorted and classified as they are entered to the collecting point. The key to keep the technology solution in Finland is that technical components are designed for smart production.

3.2 Designed for sustainability

A Designed for sustainability standard will give criteria for actions in the whole textile value chain. There is clear need to have such standard, and Finland could take ambitious lead and participate actively in the ongoing activities in the development of a deigned for sustainability so the standard will encompass comprehensively and universally the sustainability for textiles and fashion. The designed for sustainability standard will take into account environmental, social and economic sustainability. Additionally, the standard will be the touchstone of technologies used through the value chain and ensures their interoperability and eventually leads to sustainable end product. The standard will be effective tool in marketing as it improves the product, ensures interoperability of the actors along the value chain and opens up markets in different points along the value chain. The Finnish work towards the standard starts by developing a designed for sustainability operating model in *Future proof loop pilot* that will be translated as an international standard.

There are different certification possibilities that represent different parts of ethical, sustainable, and transparent fashion manufacturing. For example, there are certificates that are used to verify input material in the product[10], Cradle-to-Cradle certificate[11] provides an approach to product design, Higg-Index[12] gives tools to assess the current sustainability situation in a company and Rank a Brand[13] helps assessing company responsibility by giving criteria for assessing the responsibility raised by companies themselves. EU is actively developing and initiatives for more sustainable production, digital passport and criteria for product environment footprint. Additionally, a European standardization working group (CEN / TC 248 / WG 39) has started work, which focuses on textiles and their circular economy.

The development of the designed for sustainability standard needs international cooperation. However, for Finnish actors, it is important the standard includes and emphases the use of bio-based material whenever possible. Finnish actors have the will to be the forerunners in the introduction of the technical specifications to be included in the standard. The designed for sustainability standard is closely connected to the digital solutions, from the collection and processing of data to digital platforms to share information, so that compatible solutions are implemented through the international value network.

The first steps towards the designed for sustainability standard are the development of the assessment methods and measures. For example, these could rely on the principals of PEF.

[10] For example certificates to verify the recycled materials content are reviewed https://telaketju.turkuamk.fi/uploads/2020/12/e9e1655f-sertifikaatit-selvitys.pdf
[11] https://www.c2ccertified.org/
[12] https://apparelcoalition.org/the-higg-index/
[13] https://www.close-the-loop.be/en/case/62/rank-a-brand

Finland has aspirations to be the key player in the development and testing of the measures for sustainable textiles and fashion in the *Future proof loop pilot*.

4. Economic value

The manufacturing of textiles and clothing is the core of the Finnish textile industry. Broadly speaking, however, the textile and fashion sector in Finland covers a number of different actors and activities. In addition, the textile and fashion sector includes retail and wholesale of textiles and fashion, maintenance of textiles and fashion, and other manufacturing related to the industry, including shoes, leather goods, fiberglass and mattress. In 2019, the turnover of the whole textile sector was EUR 4.4 billion.[14] The turnover of selected subsectors of the Finnish textile industry is shown in Figure 2.

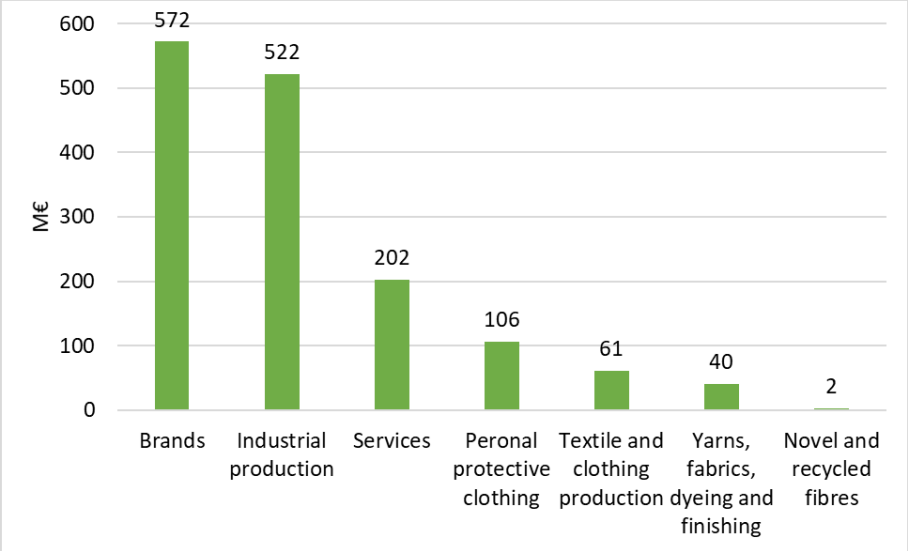

Figure 2. Turnover of different subsectors of Finnish textile industry. (Brands includes manufacturers of clothing, accessories and interior and home textiles, such as fashion brands that do not have their own production in Finland; Industrial production includes nonwovens, hygiene products, medical textile products and other technical textiles; Services includes rental, laundry and second-hand platforms; Personal protective clothing includes manufacture, wholesale and retail[9].

In 2018, there were about 3 300 companies operating in the Finnish textile sector. Most companies operated in textiles and fashion retail (43%) and textile and fashion wholesale (24%). The textile sector employed a total about 21 000 people in 2019[14].

The value of textile exports in 2019 was 695M €, the main export countries being Sweden, Germany and Estonia. Of these, 40% are clothing (233M€) and 26% technical textiles (181M€)[15]. The share of clothing export can be strengthened and there are signs of growth, i.e. by 2035 the export potential could be increased to 550 M€.

The global consumption of textile fibres is dominated by polyester and cotton. The consumption of cotton will decline due to the environmental concern and additionally, the land use for cotton cultivation cannot grow indefinitely. This creates an opportunity to other cellulose-based textile fibres to reach the market. This increases the need for dissolving grade pulp. Globally, the share of pulp is expected to increase by about 5-10Mton. Additionally, the market share for cellulose based textile fibres will increase and the Finnish novel cellulosic textile fibres will increase the growth of Finnish textile export potential.

Currently nonwovens are mainly synthetic over 80% of the materials is based on synthetic fibres, i.e. polypropylene, polyester and polyamide. This is an interesting opportunity for

[14] Tilastokeskus / Yritysten rakenne- ja tilinpäätöstilasto & suhdannetilastot.
[15] https://tulli.fi/-/suomen-tevanake-kauppa

Finland, because Finland's nonwoven capacities are large and transition from synthetic fibres to bio-based fibres will create markets for cellulosic fibres. Dry paper type wiping and hygiene nonwovens could increase export potential of technical textiles.

In addition to innovative Finnish cellulose based fibres, wool, hemp and linen can be reinvented. These are ecological natural fibres, who once were industrially relevant, but the discovery of synthetic fibres drove past these fibres. Now, there could be potential for these to increase their market shares, but for that research and development is needed.

The recycling activities could open up new possibilities to Finnish actors. If the estimated amount of imported textile waste from other EU countries to Finland was 20% from the total amount of waste textiles in Europe, it would be about 1.5 - 2 Mt. The economic added value of receiving, treating and recycling such amount of textile waste into new fibres could translate to 1.2 - 1.8 billion €. Further if the amount of recycled fibres was processed to customer products, the value could be 3 - 5 billion € annually.

Textile raw materials are particularly important when assessing the export potential. The production of dissolving grade pulp is currently 500kta (equal to 450 M€). The estimated increase in the production of dissolving grade pulp will be in the forest industry, but the market size could be in level 855M €. The production of regenerated textile fibers could reach the market share of 360 M€, all of which belongs to the textile sector. in addition, the development of recycling technologies will increase the markets for recycled fibres. The estimated annual production of recycled textile fibres in 50 kt and estimated value is 80 M€.

According to the above estimated values, the value of the Finnish textile industry could be in 2035 1540 M€ (without dissolving grade pulp) and when dissolving grade pulps is included the value is increased to 2395 M€. The share of bio-economy for the whole area is estimated to be 2332 M€.[16]

For Finland, the renewed textile industry would mean an estimated 1210 M€ investments 16900 new jobs and a strengthened global reputation as the leading country in sustainable development. The estimation is based on the current size of Finnish textile industry with net turnover 3.95mrd € and 3 180 employees[17]. In the manufacturing industry one job costs about 150 000 € when the estimated new turnover with a mean repayment is up to 3 years. The amount of new jobs in textile industry is estimated to be over 8000 new jobs. This in turn leads to the need of 1210 M€ investments. With the increased net turnover and new jobs in textile industry, the value chain all together will create 16 900 new jobs in total.[17]

[16] Harlin Ali, VTT's research professor, private conversation 23.6.2021
[17] Tekstiili ja muotiala Suomessa, STJM (2020) https://stjm.s3.eu-west-1.amazonaws.com/uploads/20210528095105/stjm.fi-Yritystilastot-28.5.2021.pdf

5. Methodology

The work was carried out during April - August 2021. Textile companies and other interested stakeholders were involved in the roadmap work in two public on-line workshops. The invitations were sent to the Finnish Textile and Fashion member companies and additionally, we utilized social media for inviting other stakeholders. We had over 50 participants in both of the workshops. After both workshops, on-line questionnaires were sent to the participants that allowed them to make additional comments and give further information. Additionally, both questionnaires were publicly open.

In the first workshop, we discussed and clarified the themes and agreed the timeframe for the roadmap. The themes for this roadmap were:

a) Finnish textile value chain

b) Digitalization

c) Future consumer

d) International partnerships

In the second workshop, the aim was to discuss the vision for Finnish textile industry transformation around the identified themes for 2035. In addition to the vision for 2035, we mapped the drivers, current enablers and barriers, as well as the actions for reaching the vison. In addition to the workshop discussions and questionnaire answers, VTT expertise and interviews were used to gather further data and insights.

6. Dismantling the workshop discussions

6.1 Finnish textile value chain

Vision 2035

Finland is globally the leading country in the development of cellulosic textile fibres. The consumption of materials has turned from fossil-based fibres towards bio-based fibres. The use of recycled fibres is more common and they are available in industrial relevant scale. In addition, to novel cellulosic fibres, Finland has started to develop the production and use of flax, hemp and wool fibres in industrial scale. Different business models have enabled that the materials are not only sold but also loaned and there is return system for materials. This is analogous of material leasing, meaning that there is an agreement where material user will commit to return equal amount of used textiles and will compensate the value loss respectively. The transparency of the value chain starts from the fibres and reaches the whole value chain and the essential material and production information is clearly and comprehensibly available to the consumers.

The Finnish textile value chain has gained kwon-how in yarn spinning and dyeing of yarns and textiles. The processing of fibres to yarns has enabled the medium scale production of textiles and fashion in Finland. Finland is known to be a forerunner in sustainable textiles and fashion.

Different brands are working together. There are several different paths for collaboration at the national level and the collaboration is cross-sectorial and extending the value network from linear to multiple business. The international cooperation is common with actors in Nordic and Baltic countries and expanding to Europe.

The textile education is based on cooperation with international partners with high know-how in textile education, for example Turkey is a key player in education cooperation. The education anticipates future needs and, when implemented in a modular way, can be agilely changed.

Present 2021 - main challenges

The Finnish textile industry have lost know-how and related machinery for yarn production. Additionally, yarn spinning is labour-intensive step in the production. It is difficult to find investors to invest in labour-intensive production steps in Finland. In addition, the textile education is almost disappeared and a skilled workforce is needed for a variety of tasks. The return of the textile value chain to Finland takes place from two directions: the direction of fibre production and the direction of clothing design and branding. This highlights that there may be a gap in the middle of the value chain.

Finland is small country and the national market size is limited. Additionally, the Finnish consumer brands are not so large that the demand would cover the upstream supply of the value chain. International markets and exports are needed to keep the business in Finland and the Finnish textile industry is only possible through international networking. The know-how and marketing of Finnish brand is behind from Nordic countries. In addition, for industrial scale recycling of textiles, the amount of domestic end-of-life textiles is limited. The amount of textile waste generated in Finland may not be sufficient for the required profitable production volume of chemical recycling without the import of textile waste. For mechanical recycling, the requirement is lower and possibly relevant scale is achieved without import of textile waste. Finland do not produce recyclable materials in relevant scale.

Cooperation is needed with Nordic and Baltic countries to have business potential of recycling companies. In addition, Finland could become one of the recycling hubs in Europe. Finnish Textile and Fashion, its four European sister organizations and Euratex, the umbrella organization for textile and fashion, have been suggested Finland to as a recycling hub to

coordinate recycling activities in Europe. Recycling Hubs promote textile recycling throughout Europe and support the European Commission's circular economy action plan. The aim of the hubs is to develop an EU level system for waste textiles in order to recover and recycle as much of the valuable textile materials as possible. In addition to Finland, Belgium, Germany, Italy and Spain are interested in operating as textile recycling hubs. Finland is a natural place for the hub, as we already are a forerunner in the circular economy of textiles, and we have well-functioning cooperation networks between companies, authorities and educational and research institutions.

How to reach the vison?

Investments are needed to bring the novel cellulose based textile fibres into industrial scale. National investments are not enough alone and international investments are needed. International investors value stability in the operating environment and predictable regulation. The market for new cellulose-based fibres in Finland and globally appears to be promising and this increases the interest towards investing in Finnish innovative textile fibres. The willingness of companies to look new solutions and to bring new products form novel fibres to consumers is needed. The advantage of the novel cellulose textile fibres is that the raw material base is versatile, in addition to dissolving pulp the raw material can be agricultural by-products, recycled cardboard and cellulose based recycled textiles such as cotton. The price of the cellulose based novel fibres will be competitive when the production capacity is increased. Brands are needed to bring the fashion products to market.

The availability of recycled textile fibres is a challenge: supply is not as extensive as virgin fibres. The improvement of the availability requires increased collection rates, recycling options and development of a network of actors. Partnership networks in the value chain are required to meet the demand and supply of recycled fibres. Turning the use of recycled fibres profitable requires policy guidance. The increased supply of recycled fibres increases the profitability of the using of the recycled fibres.

The increased production capacity of novel cellulose based fibres and recycled fibres is ensured by investing in education of technical experts in textile sector. The material and processing engineers with understanding from textile sector are needed when the production volumes of textile fibres is increased in Finland.

Enablers	Barriers
Textiles are part of Finnish bio-economy strategy. Three test-scale industrial cellulose-based fibre spinning factors in Finland. New cellulose based textile fibre manufacturing expertise is available in Finland There is strong will to establish new spinning factories in Finland. Two pilot-scale plants starting production of mechanically recycled fibres in Finland.	Finnish brands that are needed to bring the products from novel fibres to consumer markets are small. Finnish textile value chain is lacking yarn spinning, weaving as well as finish such as dyeing that are needed for production of clothing. Compared to the foreign counterparts, Finnish brands are small and international competition is hard for small brands. Sufficiently large investments are hard to obtain in start-ups.

Enablers	Barriers
Finnish industry has strong know-how and machinery for knitted textiles.	Textile education has been almost disappeared from Finland Technical knowledge about the needed finishing processes, such as dyeing of different types of textile material, are lacking. The machinery for different processes is old or completely lacking making the processes economically unprofitable.

6.2 Digitalisation

Vision 2035

Digital platforms for shopping of clothing are commonly used and the virtual fitting of clothing is widely used. Consumers find the right size and well-fitting garment according to their actual body measurements, body shape and style. One of the selling points of digital fashion is in environmental savings that consumer is increasingly valuing. Materials are needed only after design and virtual fitting phases. Digital shopping has elevated on-demand production and local customization services. Digital twins are already in use. The digital twin is following the purchased garment and is carrying with it all the information about the production of the garment from the source of fibres to the use and end of life instructions. The digital twin has a consumer interface allowing the collection of usage history of the garment.

The individualized user experience is deepened through digitization. Garment has a virtual story. Textile production is returned closer to customers, the production series are small and customization is common.

The use of artificial intelligence in the production and all along the value chain to the marketing has become more common. Data on design, sales and marketing are utilized in production, but also to understand the market and to predict the customer behaviour and customer experience. AI is harnessed to steer consumption in a more sustainable direction. Designers have switched over to 3D design, which is utilized in consumer applications, also. Salesman samples are no longer produced, 3D designs are used instead.

Data providers, data management and data users have active connections. Common rules have been adopted for data collection, validation, refining and utilization.

Present 2021 - main challenges

The textile value chain is long and branched. This leads to challenges in the traceability if tracing begins from the end of the value chain and strives for the beginning. Currently textile industry is trying to support gathering all the information relating to final product including the raw material and processing information, factories and even who has made the product and the packaging & the logistics information. As the level of digitalization increases the design process will be digital this information will be also included as data source. For enabling the new service we will need more transparent information and data from the whole textile lifecycle. In addition, the determination of confidential and open data is challenging.

How to reach the vision?

There is a need for investing and adapting on digital technologies, development of digital platforms, especially compatibility between different platforms and technical possibility for exchange of information between platforms. To deepen the digitalisation and information exchange there is a need to advance integration are within company systems as well as between different companies in value chain. Additionally, development of standard APIs (*Application Programming Interface)* are needed.

Consumer experience in e-commerce stores is developing with fast pace. There is digital dressing rooms for finding the right size and suitable garments. These are improving consumer experience as well as increasing the sustainability of e-commerce. The consumer returns are often causing challenges. Second hand clothing sales in digital platforms is trending and have even more challenges to solve for example trust and quality issues.

AI helps in turning large and diverse data sets into enriched information to improve the whole textile value chain. Big data and AI utilises heterogeneous data from design, production, sales, customer behaviour and demand and social media sources. Data Science can provides actionable insight for the business, but it can also help the fashion industry with various predictive algorithms to help fashion companies make wiser business decisions. AI and big data are identified as one of the key enablers for shifting e-commerce into personalized experience.

Closer integration of digital solutions in production and in e-commerce platforms is needed to support customisation of the production. From the consumer perspective, user interfaces and applications are needed that allow the consumer to track the purchased product while the product is being customized. However, alongside of digitalization, there is a need to develop customization services and production technologies that allow for the production of small series and individual products and repair services to support longer life of the textile. For example of such are digital printing of single products, microfactories, mall knitting services, repair and refurbishing services call for cross-sector collaborations and partnerships. Development of new customization and production technologies should include additionally 3D-printing for accessories and garments. The application of these technologies enables shorter value chains that are identified as one of the key aspects in enabling customization.

Enablers	Barriers
Co-development of ecommerce platforms with different partners in value chain. Adoption of new technologies available. Utilising Open API' and known protocols in platforms allow different partners easily deploy technologies. Global standardisation initiatives along the value chain to support development. Trustable and certified partners in business that support transparency. Utilising technologies such as block chain. Future local domestic value chains in production would give beneficial transparency. The digital product passport under development promotes traceability.	Existing technical solutions for virtual dressing rooms are patented which may prohibit development without additional licensing fees Different players along the value chain do not cooperate and used digital platforms are not compatible Partnerships for collecting and sharing data remain local and there is no access to global data Digitalization expertise in the beginning of the value chain can be in low level. Energy consumption and data security of block chain solutions may be challenging.

Enablers	Barriers
Finnish know-how and understanding on digitalization, data handling and AI Good IT education in Finland	Relatively big gap between the possibilities and the current level of digitalization in Finnish textile companies. Start-up companies that links digitalization and textile industry and allows small scale initial trials are missing Digitally skilled workforce for textile sector is challenging. Digital second-hand shopping in similar platforms than e-commerce of clothing is hard to make economically viable.

6.3 Future consumer

Vision 2035

Consumers' own choices and the impact of their actions has emphasized. The corona pandemic has accelerated the change in consumer behaviour in a more responsible direction. Behaviour is are catching up with values. Consumers commonly choose high-quality, local products and services. Consumers expect to receive transparent information on the life cycle effects of the products. Products are ready for maintenance and recycling. Ownership is no longer an absolute value, but the portability of the product and the preservation of value raise their heads. This requires nearby and easy-to-use recycling services. The price, appearance and comfort of the product remain important criteria.

The textile industry has put sustainable operations into practice. The Finnish textile industry has started to stand out from the mass by moving to fully sustainable operations. The responsibility for producing sustainable solutions is in the producers' value network. The Finnish textile industry is commonly experimenting the sustainable operations in practice from the perspectives of the environment, people and the economy. Consumers can make quick and personal decisions, as products are fully recyclable and serve as raw materials for new products.

Present 2021 - main challenges

Textile consumption is mostly price oriented and quantity dominates over quality. Sustainability and durability information is lacking from clothing, which makes consumer's sustainable choices and actions difficult. It is still suspected that the consumer will not accept higher prices, even if she knows more about the estimated durability and resale value of the product. Recycling of textiles is becoming more common, but at present, there are few collection points for end-of-life clothing and extra efforts are required from consumers to reach the collection point.

How to reach the vison?

Systemic change to turn the textile value chain to sustainable and transparent is needed. This change is predominantly required in the upstream of the textile sector. Transparency is possible only if brands use the same communication method. EU's PEF and digital product pass that are under development and the coming extension of the Ecodesign Directive are

providing tools to boost the transparency. For consumers this is one of the enablers for the development of an easy scale for assessing sustainability and durability of clothing. Garments are designed and manufactured so that they are easily recyclable and materials reusable. Textile industry takes the responsibility for the sustainable design and production, so that customers are offered sustainable and durable garments.

Closed loop pilot environment is needed in operation in Finland to verify sustainability and durability. For the development of the closed loop pilot environment, the understanding of the needs of the different consumer groups is essential. The high-end customers and B2B sector are good groups to start. The network of local micro-enterprises produces customized garments for the consumer close to the consumer, so that an order from the brand can come to micro-entrepreneurs in small series or in individual pieces.

To motivate the consumer to reuse and recycle, a brand agreement on the return of reusable clothing would be needed. Consumer could return reusable clothing to any store, for example t-shirt bought from H&M can be returned to Marimekko store. Uber/ Wolt approach can be utilized as a two-way system: when one order food, at the same time, one can return garment for reuse or send it for repair. The separate collection of the end-of-life textiles will start in Finland 2023.

Enablers	Barriers
Increase of consumer awareness Getting familiar with and getting used to service models which are already available for other types of goods Promoting and advancing repair and customization services Education launched to train not only designers, but also consumers in circular and sustainable textiles Harnessing of AI, big data and block chains in textile value chain Emerging of business models for textiles as service and rental services for consumer clothing	Shifting the textile industry to sustainable is too slow. The upstream of textile sector are not sharing the sustainability values and transparency is not reached. No sufficient market incentives for sustainable production. Lack of repair and customization services and competence in general. Lack of information that supports consumer in making sustainable choices. It is difficult to compare the responsibility messages of textile companies, and assessment of the significance of the corporate actions is difficult for consumers

6.4 International partnerships

Vision 2035

International partnerships are essential, as the volume of Finnish brands, especially consumer brands, is not big enough for Finnish raw material and fibre producers. In international partnerships, interdisciplinarity and sustainability are mainstream in 2035. International partnerships are built not only across countries, but also across industries. The bioeconomy is part of the textile cluster, which is closely linked to technology, IT, process and mechanical engineering. The Nordic and Baltic countries form the Nordic8-ecosystem. The Finnish textile

ecosystem has built an industrial park, which has a closed loop pilot environment for the production of textiles and verification of their sustainability and durability.

Joint experiments are the new normal; information about the successes and failures of the experiments is shared. Active participation in international networks has increased expertise in technologies and business models. Cross-border cooperation is particularly emphasized in addressing and solving the challenges in the various parts of the textile value chain.

Finnish brands are forerunners in design, technology and sustainability. They actively leverage different kinds of collaborations with international giants. Finnish actors make many kinds of collaborations with international giants. Brands are not only related to the products but also the material, for example textile fibre, has become a brand. The "*Intel Inside*" branding, familiar from the world of information technology, has expanded into textiles.

In the production of textile fibres and textiles, the investment partners are international forest and textile companies, as well as technology developers and machinery producers, such as equipment manufacturers in the pulp industry. Asian investors have invested in the construction of intermediate production stages of textile value chain in Finland.

There is local textile production in Finland, but in addition, we still have production partnerships in the Far East and Europe. On the one hand, production is local in micro-factories that combine new technologies and production methods; and on the other hand, production is still in the Far East, but Finnish innovations is utilized with international partners. Sustainability and responsibility have been made available to the masses.

Present 2021 - main challenges

The textile value chain is long and branched. This leads to challenges in finding the right partners. It is important that the international players share the same values and reach towards sustainable materials and technologies. At the moment, especially for small actors in the value chain, the potential to have impact on the other players' sustainability and responsibility statements is very limited and even non-existent. The transparency of the value chain is limited, and it is difficult and even impossible to get needed data and information on the other actors in the value chain.

How to reach the vision?

Interdisciplinary collaboration to identify and form collaboration networks is needed for finding international partnerships. Through active searching of identified partnerships it is possible to open up new markets, also. It is important to find the right partnerships, but also to take into account the scalability of the processes and the capabilities of the partners for global business. The support of non-profit actors and for example UN's sustainability work is important alongside companies. Different funding options are needed to improve possibilities for all for development projects towards sustainable production of textiles.

Branding of textile fibres is necessary behind the transparency of the value chain. It is important to strengthen the brands around new fibers. In order to get the fibre brand visible in the ready garment, brands along the value chain need to share same sustainability values and to see the positive potential in showing the fibre brand in garment. It is important that brand take active part in demanding sustainable and recyclable textiles. The B2B sector, such as work wear, hotel and restaurant businesses, is leading the way towards sustainable textile industry, because business has enough volume for sufficient turnover and productivity. New models for co-production that aim for less inventory and generation of waste, are needed. For example, main collection is produced in Asia and as demand increases, rapid reproduction closer to the demand, in cooperation with Finnish and Baltic actors.

It is important to find investors who have confidence in the company's ability to grow into a global solutions provider. There is a need for an attractive investment environment for international investors in Finland. The review of taxation, predictability of regulation, streamlining of licensing processes and stability of the operating environment is required. In addition, turning Europe as a forerunner in sustainable textile industry, attracts investors from Asia to Europe. The stability of Finland's operating environment, predictable regulation and the smoothness of licensing processes are prerequisites for business operations, but also issues to which international investors pay special attention. Fair contract basis between the actors are needed to ensure security of companies business at every stage.

Enablers	Barriers
New cellulosic and recycled textile fibres developed and produced in Finland Emerge of own brands for new fibres attractive to fashion brands Finland's know-how in new bio-based fibres and circular solutions, and the best production processes make the cooperation interesting for global investments Finland is stable environment and follows EU's regulation. Investors value sustainability when making their investment decisions.	Lack of confidence between companies Lack of knowhow in marketing and branding, essential both in international B2C and B2B operations. Lack of domestic funding supporting Finnish actors in their transitions towards sustainable production. Finland's attractiveness as an investment environment. Inadequacy of own material flows for circular economy models.

7. Conclusions

The Finnish textile industry has strong will to transform the fashion and textile industry towards responsible and knowledge-based industry. This includes more sustainable materials, circularity, smart production and digital solutions. For the realization of the vision, *Future proof loop pilot* and ecosystem around it will be needed. In the ecosystem pilot actors can demonstrate different concepts in practise to evaluate their sustainability, and also, to test the business value of the concepts. For *Future proof loop pilot*, the identified lacking parts of the value chain of the Finnish textile industry are related to spinning of yarns, dyeing and production of fabrics. Traditionally, these parts are labour intensive and mass production of yarns and fabrics is not seen as profitable and possible option to Finland. However, the future proof ecosystem pilot will need these parts to be able to develop the measures for sustainability for the whole value chain. All the different actors would benefit from the designed for sustainability standard as long as it will cover the whole value chain. When the actors in the value chain share the same values and willingness to move towards more sustainable production of textiles and fashion, the designed for sustainability standard will expand globally.

Finland has excellent preconditions for transforming the textile industry as part of an international network. Additionally, partnerships, cooperation, research and development is needed to bring different industrial sectors together and finding the solutions towards sustainability and knowledge-based textiles and fashion. The strengths, weaknesses, opportunities and threats of this transformation is summarised in Figure 3.

Figure 3. SWOT-analysis of the transformation in Finnish textile and fashion industry

The novel cellulosic fibres is part of the renewing forest industry, but the forest industry is only a part of textile cluster by offering raw materials for the textile industry. The textile industry needs its own production structure in order to manage the whole value chain. Finland has strong competence in novel cellulosic textile fibres and their export potential will increase Finnish textile export significantly, but at the same time we need to further build the textile value chain in Finland in order to increase the added value of products. Compared to the market value of dissolving pulp, the added value is 6.5 times higher when it is sold as ready-made garments.

To become a forerunner, the first step is to select certain areas where to start the transformation. These areas could be work and rental clothing, as well as rental textiles, where the used business models enable the management of the material flows slightly easier

compared to the consumer fashion. However, at the same time attention should be paid to the development of more internationally recognised consumer brands in order to utilise the current Finnish strongholds to its full potential. Strong development is needed for the selected areas towards quality leadership. It is important to utilize domestic innovations, especially they will open new markets. Additionally, it is necessary to build a strong international partner network. Partners are needed in many parts of the value chain to make these innovations international success stories.

The individualized user experience is deepened through digitization. There is a need for investing and adapting on digital technologies, development of digital platforms, especially compatibility between different platforms and technical possibility for exchange of information between platforms. Platforms should allow user interfaces to consumers.

The use of artificial intelligence in the production and production management will be a game-changer for manufacturers. Data has an important role throughout the value chain. Data on design, sales and marketing are utilized in production, but also to understand the market and to predict the customer behaviour and customer experience. AI is harnessed to steer consumption in a more sustainable direction.

Textile industry is global and Finland need allies in textiles, in manufacturing and machinery. Finland has key competence in design, imaging, digital solutions, robotics and business models that will open up international cooperation.