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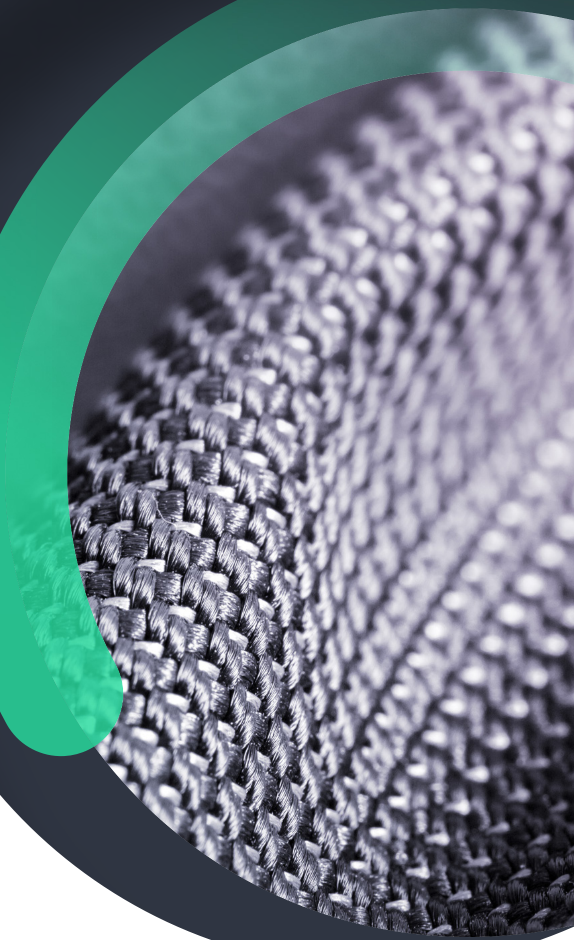

Circular Economy in the Technical Textile Sector

A pathway towards a sustainable future

The SWITCH-Asia Programme

Launched in 2007, the SWITCH-Asia programme is the largest European Union-funded programme promoting Sustainable Consumption and Production (SCP) supporting so far 24 countries in Central, South, Southeast and East Asia. Nearly EUR 300 million have been invested towards promoting sustainable consumption and production practices along value chains and micro, small and medium-sized enterprises (MSMEs) in the region. The programme has funded around 130 projects in the region over a period of 15 years, supporting over 500 Asian and European non-for-profit partners, about 100 private sector associations and 80.000 Asian MSMEs.

SWITCH-Asia is currently implemented through three components, the Grants programme, the Sustainable Consumption and Production Facility (SCP Facility), and the Regional Policy Advocacy Component (RPAC). The SCP Facility aims at strengthening the implementation of SCP policies at the national level. It also facilitates coordination of all components of the programme through information sharing. In addition, it carries out analyses on the results of the pilot projects and supports dialogue with stakeholders.

Acknowledgements

Author: Saengroj Srisawaskraisorn, Sustainable Consumption and Production Advisor (Textile Sector)

Contributors: Zinaida Fadeeva, Team Leader, SCP Facility; Rene van Berkel, Head of the Regional Office of the United Nations Industrial Development Organization (UNIDO) in India; Katharine Thoday, Principal Environment Specialist, Asian Development Bank

Supervisory: Zinaida Fadeeva, Team Leader, SCP Facility

Special thanks to all industry leaders and experts who were engaged in the consultation session and webinar for their expert insights into the technical textile sector.

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Table of Contents

List of Abbreviations

ACFTU	All-China Federation of Trade Unions
APAC	Asia Pacific Region
CAGR	compound annual growth rate
CE	Circular Economy
COVID-19	Coronavirus disease 2019
DMC	domestic material consumption
EU	European Union
FSC	Forest Stewardship Council
GHGs	Greenhouse Gases
GRS	Global Recycle Standard
ISO	International Organization for Standardization
MT	metric tonne; see t
OEKO-TEX	Sustainable textile production certification
PET	polyethylene terephthalate
PLA	polylactic acid
PPE	personal protective equipment
rPET	recycled polyethylene terephthalate
SCP	Sustainable consumption and production
SDGs	Sustainable Development Goals
SMEs	Small and medium-sized enterprises
SPP	Sustainable Public Procurement
t	metric tonne
USD	United States Dollar ($)
UV	Ultraviolet

Executive Summary

Technical textiles play an important role in our daily lives; they can be found in our homes, hospitals, sportswear, vehicles, buildings, infrastructure, and farms, among other places. A combination of technology and modern materials have made technical textiles a viable option for a wide range of specialist and high-performance applications.

The global consumption of technical textiles was approximately 42 million t in 2021 and is expected to reach 67 million t by 2032, an increase of 59%. Consumption has increased by approximately 4.8% over the past five years (Fact.MR, 2022). The technical textile market size is projected to grow from USD 164.6 billion in 2020 to USD 222.4 billion by 2025, at a compound annual growth rate of 6.2% between 2020 and 2025 (Markets and Markets, 2021).

However, the industry also has a negative social and environmental impact. The textile industry, including both technical textiles and apparel, contributes roughly one-fifth of global industrial water pollution, employs a wide range of hazardous chemicals, and emits significant greenhouse gas emissions (GHGs), particularly during the manufacturing, finishing and use stages. While the effects of the fashion industry are well documented, little is known about the estimated magnitude of the negative environmental and human consequences caused by technical textiles, resulting from a lack of awareness among supply chain stakeholders and the general public.

There are policy directives and regulations aimed at making the fashion and apparel industries more sustainable or circular, but none exist for technical textiles. As technical textiles are also less visible in the consumer markets, media and policymakers have not yet sufficiently addressed the negative effects of the technical textiles industry. No harmonised standards or guidelines are available for technical textile supply chains, and no roadmaps have been developed to indicate the transition from a linear to a circular economy in the sector. The absence of ‘design-for-recycling’ concept, regulations to control the use and release of toxic chemicals by the sector, and the collection and disposal systems for technical textile products after use, as well as advocacy campaigns to drive circular and sustainable agenda, are indicative of the limited attention to this sector.

This policy paper provides an initial review of the impact of the technical textiles sector on the environment, economy, and society from a circular economy and sustainable consumption and production perspective. It depicts the sector’s transition to circular textiles in response to growing international regulatory and policy developments, such as EU directives, and identifies emerging innovations and best practices that can help mitigate externalities.

In this paper, circular economy (CE) refers to a system driven by interconnected **innovations** and **strategies** that are aligned with the objectives of sustainable consumption and production (SCP). This includes using renewable and/or less harmful materials (‘resource switching’); working toward the continuous use and re-use of materials, products, and their components (‘circularity of resources’); and reducing waste through improved design and increased production and utilisation efficiencies (‘resource efficiency’). Innovations in materials, technologies, business models, and consumption patterns are needed to implement circular textile strategies (including consumption by private consumers as well as public and business organisations). CE strategies and innovations must be considered throughout a **product’s life cycle**, which includes materials, design, distribution, use, and end-of-life management. CE implementation requires public policies, functional markets, education, and capacity building (i.e., **enablers**).

Certain CE aspects[1] are already being practised by select industry players in the technical textile sector, for example in home textiles, sport textiles, medical textiles, and even geotextiles. Home and sport textiles are leaders in implementing circular practices in material selection, production, and post-consumption stages of the life cycle, but CE and SCP principles are not being fully or consistently implemented everywhere in the value chain. Technical textile applications have in common their specific, unique and high-performance specifications which, if compromised through applications of CE/SCP techniques during manufacturing, would result in functional losses that would give rise to a less sustainable use (reduced lifetime, etc.)

1 Circular strategies, innovations, enablers.

The EU's directives and regulations are helping member countries to transition to SCP. These requirements are creating indirect effects on countries that manufacture technical textiles, particularly in Asia, requiring them to implement CE and SCP practices. Many countries are developing CE and SCP strategies and action plans, but gaps are often identified before they can be successfully implemented.

Industry leaders are adopting innovative approaches to reduce the use of virgin resources and harmful materials. For instance, PET bottles are collected and recycled into polyester fibre, which is then used to make sportswear or PPE suits. Sustainable home furnishings are made from materials recovered from old, used materials. Harvested pineapple leaves are reprocessed into new fibres for use in apparel and technical textile applications. However, and despite these achievements, industry experts admit that the technical textile sector does not yet have a unified view nor incentive towards CE. Progress is witnessed unevenly across the supply chain. While sustainable materials are being targeted by many industry leaders, much more work will need to be done in the processing stag, because the same conventional processes continue to dominate the textile industry. A cleaner and more efficient manufacturing system must be vigorously promoted.

Innovative technologies are available, but they are being applied by only a small group of industry leaders and innovators. Mainstream manufacturers have not widely adopted them because of their perceived high investment costa. Small and medium-sized enterprises (SMEs), which make up the majority of the textile value chain, find it difficult to access innovations as a result of lack of resources for new technology and adaptation, as well as technical capability.

Low-interest financing and technical capacity would help accelerate the circularity and sustainability transition for the technical textile sector. Government incentives and requirements are expected to help unlock this barrier. Public procurement, which has a large budget and market influence, can promote sustainable and circular technical textiles. Private sector associations may also enhance the trend to promote sustainable products, thus creating the market demand.

This paper highlights several issues that prevent this sector from becoming more circular, including the absence of a baseline data and impact measurement system, limited information sharing (both within and between the private and public sectors), low market demand for sustainable products, lack of sector-specific requirements/guidelines, lack of consumer awareness, lack of good quality secondary materials and a take-back system, and finally weak compliance and enforcement capabilities within countries.

In conclusion, circularity and sustainable practices can be found at various stages of the technical textile life cycle. However, there is no coherent ecosystem that connects them and scales them to become the industry's new norm. Because they are employed in a wide range of applications, from home furniture to sports equipment and apparel, autos, and medical products, sustainable technical textiles can also be introduced and encouraged via numerous industries.

Two interconnected strategies are expected to create a shift toward circular technical textiles: (i) creating a coherent policy portfolio encouraging circularity at different stages of technical textile production – from yarn to materials and to product manufacturing, and (ii) disrupting the current linear practices. With stronger enablers coming in a form of regulations, economic and informational instruments, industry players will be more inclined to adopt CE/SCP practices, making the sustainable pathway a reality.

1. Introduction

Technical textiles have a significant role to play in virtually every social and economic activity. A combination of technology and textile materials provides a vast array of options for numerous sectors. Thus, technical textiles are those textile materials that meet the primary criterion of delivering functionality or conforming to specified performance parameters.

The market for technical textiles is expanding rapidly as a result of rising demand from both developed and developing countries, technological advances, and government investments. Global consumption of technical textiles was approximately 42 million t in 2021 and is expected to reach 67 million t by 2032, an increase of 59%. The global technical textile market size is projected to grow from USD 164.6 billion in 2020 to USD 222.4 billion by 2025, at a compound annual growth rate (CAGR) of 6.2% between 2020 and 2025.[2] Technical textiles are projected to account for about 43% of global textile sales by the end of this decade.

Europe is the largest consumer of technical textiles, followed by North America, while consumption in large Asian markets, such as China and India, is primarily for medical, infrastructure, and construction applications (The Textile Magazine, 2019). Medical applications are one of the primary drivers of demand and consumption of these textiles in the European Union countries and the Asia-Pacific Region (Grand View Research, 2021).

Consumption of technical textiles has increased by approximately 4.8% over the past five years, with the transportation industry leading the way.[3] Industry-specific textiles are used in a variety of transport applications (Mobiltech), such as seat belts, seat covers, airbags, and tyre fabrics in automotive, aerospace, railways, and marine vehicles. Other leading specialty textiles (by popularity) include medical textiles (Medtech), sports textiles (Sportech), protective textiles (Protech), and electronic textiles (Electrotech). The majority of technical textiles are made in the Asia Pacific Region. China is the largest producer of both woven and non-woven technical textiles in this region and is currently responsible for 30% of global production, followed by the Americas (19%), India (18%), EU (16%), and the rest of the world (17%) (Business Wire, 2017). China's lead is supported by a large number of suppliers, access to advanced technology, and experiences, coupled with steady domestic demand. Governments of countries in the EU and APAC are also supporting the development and manufacturing of technical textiles, which will allow both regions to increase production as well as give them access to more advanced technology and practices.

The COVID-19 pandemic has affected the textile industry's demand and supply. The chemical industry supply chain has been severely disrupted, which has had a significant effect on the procurement of raw materials for technical textiles. Hygiene is anticipated to be the largest application segment in the technical textile market over the coming years.

Improved technologies in the spinning, weaving, and knitting processes, such as melt thermo-forming, three-dimensional weaving, and knitting wet spinning, have made it possible to produce technical textile fibres with the functional properties required. High-performance fibre production is widely established in technologically advanced countries such as the United States, Japan, Canada, and a few European countries, and is expanding in developing countries such as India, China, and South Korea.

Technical textiles are made for specialised applications, and as a result, they are typically manufactured using complex processes and a variation of resources and materials to ensure high-performance quality (e.g., strength, durability, flexibility, comfort). But they also contribute significantly to pollution, high energy intensity, and greenhouse gas emissions because of the nature of these complex processes. Recycling and disposal of used technical textile products are also technically difficult and costly processes, with incineration and landfill disposal as the most common options.

2 www.marketsandmarkets.com

3 www.factmr.com

As a result of increasing pressure from the EU parliament and the governments of North American countries, stricter regulations are being imposed to reduce high environmental impact, inefficient resource consumption and health hazards for textile sector workers throughout the supply chain of technical textiles. Increasing consumer awareness of the environmental impact of products and health concerns will also contribute to the environmental and social responsibility of technical textile manufacturers.

In response, leading manufacturers in the United States, Germany, Japan, and France have introduced technological innovations to enable more versatile varieties of technical textiles that are more responsive to various applications and needs. However, more research is required to better understand the effects of these technological innovations throughout the supply chain.

Given the anticipated rapid increase in demand for technical textile products over the next decade, it is crucial to implement transformative sustainable consumption and production models and circular business methods and technologies in the non-apparel and technical textile industry.

The European Union has already begun investigating the issue by introducing a series of directives, strategies, and guidelines to assist EU bloc members in achieving carbon neutrality by mid-century. Specifically, the EU Strategy for Circular and Sustainable Textiles provides guidance on how the textile industry, the fourth largest contributor to greenhouse gas emissions worldwide, can better respond to the situation. The strategy will inevitably affect countries that manufacture textile products for the EU market. In addition, national government policies and regulations play a crucial role in levelling the playing field and facilitating manufacturer compliance with social and environmental standards while remaining competitive in the global market.

The circular economy (CE) model along with the sustainable production and consumption (SCP) concept are viewed as stepping stones for the textile industry to transform into a sustainable sector. Companies that can maintain their sustainability programmes and commitments while managing the COVID-19 crisis will gain a long-lasting competitive advantage and be able to rebuild a more sustainable textile and apparel industry afterwards. CE, which necessitates new relationships among natural resources, customers, and markets, paves the way for the development of new business models and technologies. Policy frameworks that facilitate business innovation are required as well.

2. Scope, Objectives and Methodology

2.1 Scope and Objectives

This policy paper examines the effects of the technical textiles sector on the environment, economy, and society through the perspective of the circular economy (CE) and sustainable consumption and production (SCP). It also captures changing market and industry trends and depicts the sector's transition to circular textiles in light of stricter international regulatory frameworks, such as those required by the EU. It identifies emerging innovations and best practices that are anticipated to help address externalities and mitigate their impact.

Specific objectives of the paper are to contribute to:

- *Analysing of* the impact of the technical textiles sector on the environment, economy, and society throughout the life cycle through the lens of CE and SCP
- *Identifying* progress made by the technical textile industry and switching to circular and sustainable textiles
- *Highlighting* key industry players and enabling factors (e.g., regulatory frameworks, consumers demand, business models) in the technical textiles sector
- *Identifying* existing gaps of the sector and *highlighting* trigger points (e.g., emerging innovations or game changers) that are expected to help narrow the gaps and accelerate the sector's transition toward circularity

Three key questions are explored by this paper:

a) At what stage is the technical textile industry in its transition to a circular and sustainable textile industry? What are the differences in practices of different 'segments', e.g., differences between home textile practices and those of geotextile?

b) Where do the **points in the technical textile value chain** (such as primary production, processing, logistics, consumption, and utilisation of secondary materials) **present the most opportunities** for efficiently implementing circular practices to improve overall environmental performance and resource efficiencies? What are the critical factors that would make it possible to seize these opportunities?

c) What are the **most recent emerging trends** (such as enabling policy, investments, technologies and innovations, changing relations along the technical textile supply chains, innovative business models, growing demands for sustainable products, etc.)**? How can they contribute to making this sector become more circular/sustainable?**

It is anticipated that the findings of this paper will be presented to European Commission delegations, national government agencies, industry experts, international development agencies, and interested members of the public in an effort to inform new policies and actions that will bring the technical textiles sector closer to being circular and sustainable.

2.2 Methodology

This paper is based on published information, statistics, and business insights from targeted literature, as well as on insights gleaned from an expert consultation and a public webinar that included industry leaders and experts. Technical reports from international development partners and industry analyses were reviewed to provide a comprehensive view of the textile sector, albeit primarily focused on fashion textile, and the linkages with the CE principle. Online research was conducted to understand the latest sector developments and emerging innovations, be they technological advancements, business models, or financial solutions, to prepare the sector to become more sustainable and circular.

Finally, an interactive expert consultation meeting was held online to gain further insights into the issues, challenges, solutions, and most recent advancements of this sector. A total of 11 experts participated in the consultation meeting and shared their insights, which informed the writing of this paper. Further insights from the public webinar held on the same topic, comprising seven experts and industry leaders, were also used to guide the development of this paper.

3. Overview and Trends

Technical textiles are textile materials and products that are manufactured for their technical and performance characteristics rather than for their aesthetic or decorative qualities.[4] They are utilised in numerous industries, including agriculture, automotive, aviation, maritime, construction, medical health, and sports. Depending on their applications, these textiles are designed to have enhanced filtration, flexibility, lightness, durability, resistance, and strength properties, among others.

Technical textiles are made from various fibres: natural fibre, regenerated fibre, polymer, metal, and others (minerals, composites, etc.). The market is segmented based on application and end-user industry, and is mainly comprised of construction textiles (Buildtech), clothing textiles (Clothtech), geo-textiles (Geotech), domestic textiles (Hometech), industrial textiles (Indutech), medical textiles (Meditech), sports textiles (Sportech), and protective textiles (Protech).

Some specialised properties of technical textiles include risk reduction (e.g., antibacterial, mite-proof, insect-proof, odourless, flame retardant, soil-resistant, anti-UV, anti-electromagnetic radiation, etc.), enhanced functionality (e.g., heat-regulating, with new visual features, providing cosmetic-medical effects, etc.). Figure 1 shows a schematic diagram of various applications of technical textiles and their applications.

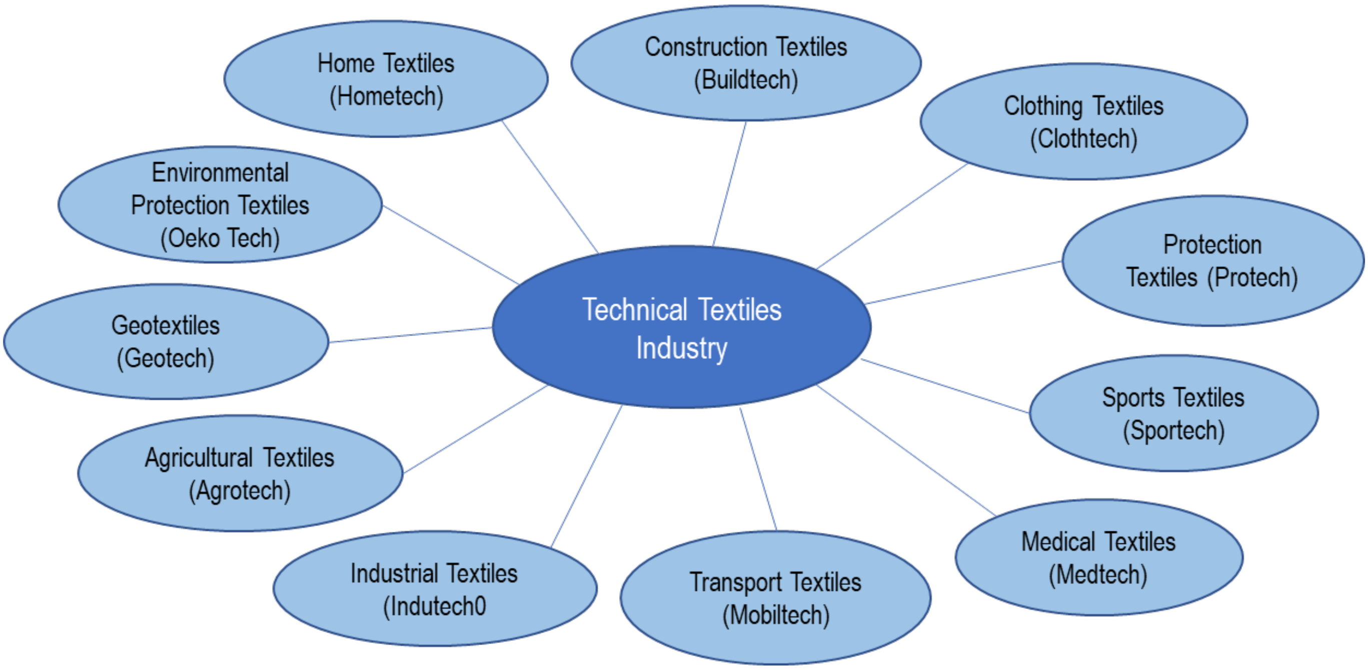

Figure 1. Schematic diagram of various technical textiles and their applications

Different Types of Technical Textiles

a. **Home Textiles (Hometech)** are utilised in the interiors of homes and transportation systems such as automobiles, buses, trains, cruise ships, and airplanes. They serve three basic purposes: *Decoration* (carpets, wall coverings, curtains & draperies, tablecloths, etc.); *Comfort* (upholstery, seat covers, mattresses, bed sheets, blankets, carpets, etc.); and *Safety* (safety belts and nets, airbags). Increased user and regulatory requirements have already rendered interior textiles more complex, multifunctional, and even ‘intelligent.’

4 Some yarn and fabric manufacturers supply both to apparel and technical textile product manufacturers.

b. **Construction Textiles (Buildtech)** - Due to their superior performance characteristics in terms of strength-to-weight ratio, durability, flexibility, insulating and absorption properties, and fire and heat resistance, construction textiles can replace more conventional construction materials such as steel and other metals, wood, and plastics. Examples of innovative textile applications include textile-reinforced concrete, fibre- and textile-based interconnecting cables and components, systems for erosion and landslide protection, reinforcement of dikes and other water management systems with textiles, and lightweight, flexible and durable fibre-based piping and canalisation.

c. **Clothing Textiles (Clothtech)** are technical textile components used primarily in clothing and footwear. Clothtech consists mainly of some textile materials for specific functional applications in addition to fabrics for making garments (shirts, pants, jackets, etc.) and shoes. These textile components include sewing thread, shoelaces, lining and interlining, labels, hooks, and loop fasteners (zippers, Velcro), narrow fabric, etc. Umbrella or similar textile materials are also classified under the Clothtech category.

d. **Protection Textile (Protech)** covers garments and accessories intended to protect the wearer against impact, contamination, temperature, and ultraviolet exposure. Protech also encompasses garments intended to protect products, the workplace, or the environment from people. The main end-use segments include particulate protection (clean room), chemical protection, flame retardant, cut resistance, and outdoor protection/hi-visibility. Some of these products are firefighting suits, swimwear, and special outfits for riot police or military to protect the wearer from explosion, shooting, or stabbing.

e. **Sports Textiles (Sportech)** has some special features, which have been made possible by the use of high-tech and smart textile technology. They are adaptive, easy to wear, fast drying, electrically conductive, anti-static, anti-microbial, and UV protective. The use of more expensive, branded specialty fibres and other materials is currently driven by the pursuit of even greater end-user safety and performance. Sportswear, boat covers, tents, and high-performance composites are just a few examples of the incredibly varied textile uses for sport and leisure.

f. **Medical Textiles (Medtech)** are various fibre-based materials intended for medical purposes. Medical textiles focus on fibre-based products used in health care applications such as prevention, care, and hygiene. Medical textile applications span from simple cotton bandages to sophisticated tissue engineering. Dressings, implants, surgical sutures, certain medical devices, healthcare textiles, diapers, menstrual pads, wipes, and barrier fabrics are examples of common medical textile products.

g. **Transport Textiles (Mobiltech)** are utilised in the construction of automobiles, trains, ships, aircraft, and spacecraft, among other things. They represent roughly 23% of the total market for technical textiles. Transport textiles are classified as technical due to their extremely high-performance specifications and special properties. Examples of Mobiltech include seat coverings in cars, trains, aircraft, and passenger vessels. Seats in public vehicles are subjected to significantly more rigorous use than household furnishings and must withstand a greater exposure to sunlight and ultraviolet (UV) radiation, and because they are intended for public use, they must meet stringent safety requirements such as flame retardancy.

h. **Textiles for Industry (Indutech)** are (unconventional) textiles designed specifically for use in industrial processes, goods, and services. Industrial textiles can be used as a component to reinforce other products, as a tool similar to filtration, or as a product (independently) with several uses. In addition to filtration, cleaning, chemical industry/electrical applications, and mechanical engineering, Indutech offers numerous applications including conveyor belts, drive belts, ropes and cordages, filtration products, glass battery separators, decatising and bolting cloth, AGM (absorption glass mat) plasma screens, coated abrasives, composite materials, printed circuit boards, printer ribbon, seals, gaskets, and paper-making fabrics.

i. **Textiles for Agriculture (Agrotech)** are used in agriculture, horticulture, and fishing for the cultivation, protection, and harvesting of plants and animals, as well as for the collection and storage of agricultural products. For the latter purposes, these textiles may overlap with Protech, Indutech, Geotech, and Buildtech in their applications. Examples of their applications are packaging agricultural products, accelerating the growth process of plants, protecting crops from UV rays, disinfecting agricultural areas, preventing the growth of weeds, agricultural drainage and erosion control, and protecting animals from weather conditions (livestock breeding and fish). Fishing nets, ropes, sacks, sun protection shades, greenhouses, heat insulation, wind/hail protection tarps, seed protection, soil support, protective clothing, hoses, conveyor belts, and filters are other types of Agrotech.

j. **Geotextiles (Geotech)** are synthetic, permeable textiles applied with soil, rock, or any other material connected to geotechnical engineering to provide a range of functions such as support, drainage, and separation at or below ground level. They are made from synthetic fibres that are woven, loosely nonwoven, or knitted. Geotech is used in a wide range of applications, including the construction of buildings, bridges, dams, roads, railways, and paths as well as embankments, cuttings, dykes, and sub-sea coastal engineering projects. For these benefits, Geotech is increasingly used to reinforce hard infrastructure (e.g., bridges, roads) so as to withstand natural disasters.

k. **Environmental Protection Textiles (Oeko-Tech)** are used for safety and environmental protection, and applications include air and water filtration systems, erosion prote00ctors, oil spill management, floor sealing, and waste management. These textiles have overlaps with many other sectors of high-performance textiles, including Indu-Tech textiles in filters, Geo-Tech textiles in erosion protection and sealing of toxic wastes, and Agro-Tech textiles in reducing water loss in soil and decreasing the need for herbicides by providing mulch for plants.

Primary materials used in technical textiles

Fibres used in technical textiles range from natural, regenerated and synthetic fibres to mineral and metal fibres, as well as certain speciality fibres. Technical textiles rely heavily on synthetic raw materials, such as viscose, nylon, acrylic/modacrylic, high-density fibres, and polymers, which cater to labour-intensive manufacturing processes.

Due to their strength and durability, polymer composites account for the vast majority of the market share for technical textile products. Different end-use industries have proven and evaluated polymer composites, identifying them as the strongest material in terms of technical aspects because of their superior mechanical properties, durability and sustainability. In addition, polymers can be combined with various non-polymeric technical fibres, thereby enhancing the properties of technical textiles for a variety of applications. Technical textile yarns are composed of both natural and synthetic fibres.

NATURAL	SYNTHETIC	REGENERATED	MINERAL	METAL
• Cotton • Wool • Sisal • Hemp • Jute • Bamboo • Flax • Ramie • Kenaf • Abaca • Protein fibre	• Polyester • Polyolefin • Polyamide • Aramid • Carbon • Acrylic	• Viscose Rayon • Acetate Rayon	• Glass • Ceramic • Asbestos	• Silver • Steel • Aluminum • Gold • Metal coated fibres

Figure 2. Materials used for technical textiles.

Synthetic textiles can be made either from plastics such as polyester, polyamide and acrylic, or from plant materials that are chemically dissolved and then spun into fibres, such as rayon, viscose, lyocell, modal and cupro. The plastic most commonly used in textiles is polyethylene terephthalate, known as PET when used for plastic bottles, and polyester when used as a fibre.[5]

The majority of technical textiles are made in the Asia-Pacific (APAC) region. China is the largest producer of both woven and non-woven technical textiles in this region and is currently responsible for 30% of global production, followed by the Americas (19%), India (18%), EU (16%), and the rest of the world (17%). China's lead is maintained by a large number of suppliers, access to advanced technology, and experience coupled with steady domestic demand. Governments of countries in the EU and APAC are also supporting the development and manufacturing of technical textiles which will allow both regions to increase production and give them access to more advanced technology and practices.

5 OECOTEXTILES, as cited the UK House of Commons (2019).

Technical Challenges of Materials Recycling

One of the main obstacles to the development of a more circular textiles sector is the lack of technology and a market for recycled fibres due to the nature of input materials. There are few textiles that can be recycled into high-end new products. Current mechanical recycling techniques shorten and degrade the original fibre's length. This restricts the options and variety of markets for recycled fibres, and in most cases, they can only be recycled once. Existing markets have a limited level of demand, and as a result, recycled textiles have a low value.[6]

There are initiatives within industry to increase the use of recycled fibre. The world's largest textile, apparel, and retail companies, including Adidas, Dibella, Eileen Fisher, Gap Inc., H&M, IKEA, Lindex, MetaWear, Target, and Timberland, have committed to increase their use of recycled polyester (rPET) by at least 25% by 2020. Currently, most plastic recycling infrastructure is established for PET bottles, while the technology for recycling old synthetic fabrics into new ones is in its infancy.

Major Players

The market for technical textiles is advancing rapidly as a result of fluctuating consumer preferences and fashion trends. In addition, a number of market players are concentrating on the development of consumer and commercial textiles that are suitable for a vast array of industrial applications. The market is competitive as a result of the presence of major product manufacturers. Principal competitors have benchmarked their products based on geographical presence, distribution network, product portfolio, operational capabilities, and innovation.

Leading players in technical textiles

- 3M Company
- Dow
- Fibertex Nonwovens A/S
- Low & Bonar PLC
- Freudenberg Group
- Berry Global Group, Inc.
- Ahlstrom-Munksjo
- Asahi Kasei Advance Corporation
- Kimberly-Clark Corporation
- Mitsui Chemicals, Inc.
- Huntsman International LLC
- Berry Global Group, Inc.
- Toray Industries, Inc.
- Milliken & Company

6 UK House of Commons (2019).

3.1 Environmental, Social, and Governance Issues[7]

The textile industry is one of the primary contributors to the global crisis of environmental degradation, pollution, and depletion of natural resources. The production and consumption of textiles has a significant impact on the environment and on climate change. The production, dyeing/colouring and finishing steps in the textile industry, and the circulation of fibres, yarns, and fabrics in the sector is accomplished with massive, complex, and expensive machine systems.

Environmental degradation in the production phase results from the cultivation and production of natural fibres such as cotton, hemp and linen (e.g., use of land and water, inputs of fertilisers and pesticides) and from the production of synthetic fibres such as polyester and elastane (e.g., energy use, chemical feedstock). The manufacturing of textiles requires large amounts of energy and water and uses a variety of chemicals across various production processes. Distribution and retail are responsible for transport emissions and packaging waste.

The textile sector accounts for roughly one-fifth of global industrial water pollution and uses a vast array of chemicals, many of which are carcinogenic. Numerous toxic chemicals, including heavy metals and formaldehyde, are released into water streams and soil, and in addition, toxic gases, including suspended particulate matter and sulphur dioxide, are emitted in the atmosphere. These hazardous wastes can potentially cause diseases and severe health problems, such as respiratory and cardiovascular problems. Approximately 3500 chemical substances used in textile production have been identified (UNEP, 2021).

FACTS ABOUT TEXTILES

- The textile industry produces an estimated 1.2 billion t of CO_2 equivalent (CO_2e) per year - more than international flights and maritime shipping combined.
- 20% of industrial water pollution globally comes from the dyeing and treatment of textiles.
- 0.5 million t of microfibres from washing synthetics are released into the oceans every year, accounting for 35% microplastics released into the environment.

There are thus numerous opportunities for materials such as textile components or processing reagents to escape from textile machine systems and cause environmental contamination. In addition, efforts to produce technical textile products result in the release of impurities into the air, water, and soil, as well as the production of unwanted noise and unpleasant sights.

Air Pollution

Air pollution can occur during and after the use of technical textiles. For instance, the pollution of home textile furnishings may be caused by construction materials, whereas the back coatings of furniture, rugs, and curtains may contain excessive formaldehyde or other volatile organic compounds. The extensive use of fossil-fuel energy primarily in the production and finishing stages also contributes to the increase of GHG emissions into the atmosphere.

It is suspected that microplastic pollution probably begins during the manufacturing phase. When synthetic fibres are produced, combined into yarn and woven into fabrics, it is possible that fibres are released into the air and environment. There is emerging evidence that this may pose a health and safety risk for textile factory workers.[8] Occupational health hazards have also been linked to natural fibres. Byssinosis, also known as brown lung disease, is caused by cotton dust exposure in poorly ventilated workplaces.[9]

7 This section outlines the environmental and social concerns associated primarily with the upstream and midstream stages of the textile life cycle, many of which also have an impact on the technical textile supply chain.

8 UK House of Commons (2019).

9 ibid.

Water Pollution and Consumption

Water pollution is perhaps the most visible pollution caused by the textile industry because it can change the water's colour, smell, and appearance. Abnormal pH levels of water streams can be observed near or around textile production facilities. Sizing materials and starch are common pollutant by-products of finishing processes. Other finishing by-products include flame-retardant, softeners, antistatic agents, stain-resistant agents, and waterproofing and oil-repellent agents. Loss of lubricants or spinning oil from machines can lead to unintended discharges of harmful substances. These polluting by-products have toxic effects on aquatic organisms or species, e.g., algae that eutrophicate aquatic habitats (they remove oxygen from bodies of water), causing harm to aquatic organisms. Additionally, aquatic organisms can occasionally survive when feeding on plants or other animals contaminated with dangerous pollutants, which then move up the food chain and affect people.

It is estimated that textiles are the largest source of synthetic fibres in the oceans, with washing releasing microplastics into the water system. According to the evidence, when synthetic textiles are discarded or burned, they can also release microfibres into the environment.[10] Synthetic cellulosic-fibres – made from plant matter rather than plastic – are sometimes said to be biodegradable, but there is evidence that they also persist in the environment.[11]

In addition to direct pollution of water by the textile industry, a substantial amount of water is used in the textile manufacturing process itself. Annually, the fashion industry consumes approximately 79 billion m^3 of fresh water on a global scale.[12] The process of growing and producing fibres consumes the largest quantities of water of all. Water is also used when dyeing, finishing and washing clothes. Cotton is one of the thirstiest fibres in fashion. According to WRAP, cotton production accounts for 69% of the water footprint of fibre production for textiles. One kilogram of cotton – equivalent to the weight of a shirt and pair of jeans – can take as much as 10,000–20,000 litres to produce, depending on where it is grown. The Aral Sea, formerly one of the four largest inland bodies of water in the world, has almost entirely dried up, in large part due to intensive industrial cotton farming in Central Asia.[13]

Water scarcity exacerbated by cotton production in arid regions has an impact on local communities, especially in low-income countries. Major cotton producing countries such as China and India are already suffering from medium to high levels of water stress in certain areas.[14]

Soil Pollution

When fibres or chemicals degrade under the influence of air, water, or sunlight, they may generate toxic agents. If textiles made from nylon, polyester, or other polymeric materials are dumped in landfills, they can contaminate the soil. Similarly, the same contamination may be observed if they are discarded in water streams and ultimately end up in landfills. Polymeric materials (e.g., microbeads) will likely remain in the environment for hundreds of years, despite the fact that sunlight, water, and air actually serve as a catalyst for their chemical breakdown and decomposition.

The increased demand for the production of textile products results in higher resource consumption (e.g., water, land, electricity, fossil fuels) throughout the supply chain, as well as increased chemical and effluent discharges into public waters, as well as CO_2 emissions. Synthetic textile materials, particularly those comprised of fibres derived from petroleum, also contribute to an increase in greenhouse gas emissions and the unintentional release of microplastics into the ocean. This pattern is exacerbated by the extremely low reuse and recycling rates for the whole textile sector, which is even lower for technical textiles, resulting in a large quantity of used or worn-out textiles to be dumped in landfills or incinerated which in turn causes a substantial loss of material value and significant environmental degradation as described above.

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10 Fashion Revolution, as cited by the UK House of Commons (2019).

11 ibid.

12 No specific statistic for technical textiles is available.

13 ibid.

14 WRAP as cited by the UK House of Commons (2019).

Plastic Pollution

Microplastics, which are composed of petroleum-based synthetic fibres, are released into the environment throughout a textile product's life cycle, from production and use to end-of-life disposal. Estimating and measuring the quantity of microplastics discharged into the environment is challenging. However, research studies have estimated that over 14 million t of microplastics have accumulated on the ocean floor worldwide and an additional 1.5 million t enter the oceans annually.[15] These quantities increase annually, causing harm to ecosystems, animals, and people.[16]

It is possible to minimise or eliminate the release of microplastics from textiles through sustainable design and production techniques, as well as caretaking practices that manage microplastic emissions during use, and by enhancing disposal and end-of-life processing. Providing washing instructions on a product's label is a standard method used by many textile firms to educate their customers on how to care for their products. However, the majority of consumers neither read nor follow these recommendations. Measures to curb excessive release of microplastics during other life cycle stages are not yet widely practised.

Gender Issues and Worker's Rights

Labour and gender issues in the textile supply chain are of concern, particularly in developing countries where environmental and social law and enforcement capacity are weak but where the majority of textile products are produced.[17] It is common for workers to describe long working hours, low earnings, absence of regular contracts, and conditions that are inherently dangerous. Trade unions, when given the opportunity, are unable to safeguard employees. The 'Fundamental' International Labour Organization treaties have not been ratified by all of the Asian nations that export textiles and garments to the EU, and their actual application is far from the norm. OECD Guidelines for Corporate Social Responsibility, United Nations Guiding Principles on Business and Human Rights Multinational corporations set high expectations of corporate social responsibility for its suppliers. Western brands that are active in such nations, but do not make any guarantees or are not legally binding if the punishments are not implemented. In actuality, they have not done much to defend the rights of employees.[18]

Oxfam's Trading Away Our Rights study for China found that women garment workers had 150 hours of overtime per month, sometimes 10–12 hours a day, sometimes 15–16, with one or two days off a month the standard. ACFTU[19] reported 62% of workers worked 7 days a week and 25% were paid late. Some 60% had no formal contract, and 90% had no social insurance. Toxic chemicals, fire dangers, and industrial accidents are common in textile factories. Most migrant employees are not insured for maternity, illness, or work injury pay. Non-payment of wages and withheld wages are serious issues in China and cause many labour disputes.

Table 1. An illustration of the social and environmental issues associated with the textile sector at different stages of the supply chain

Fibre Production	• **High use of fossil fuels** to produce synthetic fibres (resulting in climate, human health, and degradation of ecosystem quality) • **High use of agricultural land and water** to produce natural fibres, especially cotton (leading to biodiversity and ecosystem degradation and loss) • **Unsafe working conditions** and fragility of the legal system (leading to human health problems and social risks)

15 European Environment Agency, 17 March 2022.

16 ibid.

17 This is not explicitly mentioned in relation to technical textile manufacturers but can be inferred to as these issues are generally discovered within the manufacturers of yarn and fabrics in developing countries.

18 European Parliament, August 2014.

19 All-China Federation of Trade Unions.

Yarn & Fabric Production	• **Data gap** regarding the polluting effects of yarn and fabric production
Textile Production	• **High use of fossil fuels for heat and electricity generation** in the production processes (which involves climate, human health, and degradation of ecosystem quality) • **Use of hazardous chemicals** (leading to high human health and degradation of ecosystem quality, particularly via water pollution) • **Release of microfibres from petroleum-based synthetic fibres** (leading to degradation of ecosystem quality and potential impact on human health) • **Unsafe working conditions and fragility of the legal system** (leading to human health problems and social risks)
Consumption or Use	• **High electricity consumption in the care of certain technical textiles** (e.g., bedding, clothes) over their lifetime (fossil fuels used for energy production, leading to climate, human health, and degradation of ecosystem quality) • **High consumption of water and releases of microfibres in washing textiles** over their lifetime (leading respectively to water scarcity, ecosystem quality and potential impact on human health)
End-of-Life	• **Low recovery rates of technical textiles** at the end of their life leading to high material value loss and non-renewable resource depletion.

Source: UNEP, 2019

3.2 A Challenging Reality

Global consumption of technical textiles was approximately 42 million t in 2021 and is expected to reach 67 million t by 2032, an increase of 59%. Consumption has increased by approximately 4.8% over the past five years. The technical textile market size is projected to grow from USD 164.6 billion in 2020 to USD 222.4 billion by 2025, at a CAGR of 6.2% between 2020 and 2025 (Market and Market, 2021). It has been projected that technical textile will account for about 43% of global textile sales by the end of this decade.

Regarding sustainability, little is known about the estimated magnitude of the environmental and human health impact caused by the manufacturing of technical textiles (i.e., amount of chemicals used and released; the amount of toxic fumes emitted; energy usage; and area of land required to produce plant fibres). An absence of data has impeded the environmental and sustainability promotion of the technical textile industry, resulting in a lack of awareness among supply chain stakeholders and general consumers.

While there are specific policy directives and regulations aimed at making the fashion and apparel industries more sustainable or circular, there are no comparable frameworks aimed at preventing or mitigating the negative effects of technical textiles. In addition, the negative effects of the technical textiles industry appear to be not attended by the media and policymakers.

Therefore, no harmonised standards or guidelines are required for the supply chains of technical textiles to transition from the current linear economy model of 'take-make-waste' to a circular economy model. A lack of 'design-for-recycling' concepts, absence of regulations to control the use and release of toxic chemicals by the sector, the absence of collection and disposal systems for technical textile products after their use, and the absence of advocacy campaigns to drive the circular and sustainable agenda is indicative of the lack of standards.

Where there are laws regulating the environmental quality of natural resources and efforts to address labour and gender issues in some countries, the effectiveness of their enforcement varies significantly from country to country. In addition, environmental laws in most countries are primarily concerned with the end-of-pipe quality of water, air, and land, but they lack a focus on the upstream processes, such as materials sourcing and design, that will determine how effectively technical textiles will be handled/treated after their useful life.

In view of this situation, more sustainable practices and textile products are forced to compete with lower-priced and wastefully produced mainstream products on the market, making sustainable textile solutions the economically unviable options for most buyers and sellers.

However, in spite of these challenges, some companies are now investing more in technological solutions in an effort to mitigate the negative impact this industry has caused, thanks to the recent rise in global corporate consciousness and commitments to sustainability and climate change issues. This will be discussed in more detail in Section 5.

3.3 Global Trends

The global market size for technical textiles is projected to increase at a CAGR of 5.3% over the next ten years, from a valuation of USD 220 Billion in 2022 to USD 370 Billion by 2032 (PR Newswire, 2022). In 2021, the global market for technical textiles was valued at USD 180.9 billion and is projected to rise at a CAGR of 4.7% between 2022 and 2030. Over the projected period, it is anticipated that the market will be driven by an increase in end-user industries' knowledge of the advantages of technical textiles (Grand View Research, 2021). As a result of the economic downturn brought on by the Covid-19 crisis, the global technical textiles market has encountered sluggish expansion, with the exception of certain specific technical textile products (e.g., PPEs, masks). During the initial phase of the pandemic, industrial activity encountered setbacks, after which the entire market experienced catastrophic setbacks.

Europe represents the largest regional market for Technical Textiles, accounting for an estimated 28.8% share of the global total. The market is projected to reach USD 58.5 Billion by 2024. Asia-Pacific is forecast to emerge as the fastest growing regional market with a CAGR of 7.7% over the period (Business Wire, 2022).

Figure 3. Global technical textile market outlook for 2021 Source: Grand View Research

In 2021, Hometech technical textiles dominated the market for technical textiles and accounted for a revenue share of more than 19.4%, owing to the rising demand for the product in the household sector, which includes cushioning materials, furniture, and floor and wall coverings as well as fireproofing. With an increase in residential development, particularly in emerging countries, this segment of the industry is projected to undergo a positive trend in the next years. Demand for Indutech technical textiles is projected to increase at a substantial pace of 5.5% from 2021–2025 on account of its excellent features for industrial applications, such as durability and strength. Increasing need for decatising cloth, bolting cloth, drive belts, printed circuit boards, and other industrial textiles in a variety of application industries is anticipated to raise demand for industrial textiles over the coming years.

Rapid population growth in emerging countries, along with increased birth rates and an aging population, is expected to fuel demand for sanitary and personal care medical equipment over the next few years. This is anticipated to contribute positively to the market for MedTech textiles, consequently contributing significantly to the total market for technical textiles. Positive growth is anticipated for the *Agritech* and *Buildtech* end-use segments, respectively, as a result of the rising use of advanced technology in agriculture for high crop production as well as the rising construction activities for residential and commercial segments (GlobeNewswire, 2021; Grand View Research, 2021).

Increasing customer preference for protective gear and current fashion trends are inducing large technical textiles companies to restructure their businesses by incorporating new engineering technologies, such as smart textiles and nanotechnology. This is expected to increase the overall cost of products, hence serving as a market restraint. The bulk of market participants are emphasising efficient and effective distribution channels by constructing new production facilities and forming partnerships and agreements with several e-commerce websites to assure a steady supply of items. However, the market experienced sluggish growth in 2020 because of COVID-19, which is anticipated to cause weak market growth for the next several years.[20]

Regional Perspectives

In 2021 Asia-Pacific dominated the technical textiles market, accounting for over 46.6% of global revenue in that year, and the region is expected to lead the market through the end of this decade. Demand for apparel and functional, industrial, and protective clothing is expected to drive market growth over this period. The expansion of China's residential, commercial, and industrial sectors, combined with favourable government policies to support India's overall textile market, is expected to boost market growth prospects. The direct involvement of India's prime minister with the Cabinet Committee on Economic Affairs (CCEA) aims to increase the domestic technical textile market size from USD 40 billion to 50 billion by 2024 (Daily Update, 2022).

Clothing and household textiles are driving product demand in Europe, and this trend is expected to continue in the coming years. Furthermore, an increase in tourism, healthcare activities, and automotive is expected to add significant growth to various end-use technical textiles segments, thus fuelling the growth of the market.

20 https://www.grandviewresearch.com/industry-analysis/technical-textiles-market

4. Circular Economy: A new opportunity for textile industry transformation

An increase in the consumption of resources is leading to a rapidly escalating crisis situation where pollution is uncontrolled, biodiversity and ecosystem loss and degradation are accelerating, and the disastrous effects of climate change are increasingly pronounced around the world. It is time for a shift away from the linear ('extract-make-use-dispose') models of development toward the circular ('extract-make-use-reuse/recycle/remake/recover') models. This shift is becoming ever more essential in order to decouple economic growth from the deterioration of the environment and the excessive consumption of resources.

4.1 Principles of Circular Economy and Sustainable Consumption and Production

The circular economy (CE) offers a framework in which the value of materials, parts, and products remains for as long as possible within the production and consumption system. The CE model provides an invigorating alternative to our current 'take-make-dispose' extractive industrial model, which is not sustainable. The CE model seeks to rethink our conventional growth patterns by focusing on the positive common benefits for the entire society on the planet. The overarching strategy of CE is to decouple economic activity from the consumption of finite resources while simultaneously designing waste out of the system. The model seeks to rebuild economic, environmental, and social capital, by relying on sources of renewable energy.

Figure 4. Circular economy flow diagram

The CE model follows three basic principles:

- ***Design out waste:*** One of the primary goals of a circular economy is to eliminate all forms of waste as well as the adverse effects of economic activity that are harmful to human health and the natural environment. This includes the emission of greenhouse gases (GHGs) and hazardous substances, the pollution of air, land, and water, and structural waste such as clogged roads and other forms of urban congestion.

- ***Keep products and materials in use:*** A circular economy favours activities that preserve more value in the form of energy, labour, and materials. These include keeping products and materials in use as long as possible, which necessitates designing products with longevity, reusability, re-manufacturability, and recycling in mind in order to keep goods, components, and materials in circulation within the economy. Circular systems make efficient use of renewable materials by promoting a wide variety of uses for the materials before recycling the organic components safely back into the natural environment.

- ***Rejuvenate natural systems:*** A CE avoids the use of non-renewable resources and preserves renewable ones, for example, by returning valuable components to the soil to support regeneration or by using renewable energy as an alternative to fossil fuels as the primary source of energy.

The transition from a linear to a circular economy has benefits that extend well beyond merely mitigating the adverse effects of the linear economy. This switch in economies implies a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides benefits to society as well as the environment.

A 'Cradle-to-Cradle' way of thinking, which differentiates between technical cycles and biological cycles, is a significant source of inspiration for the model. Consumption can take place only within the context of biological cycles, which are situations in which food and materials with a biological basis (e.g., cotton or wood) are intended to feed back into the system through processes such as composting and anaerobic digestion. These cycles are responsible for the regeneration of living systems such as the soil, which in turn supplies the economy with renewable resources. Reusing, repairing, remanufacturing/refurbishing, and recycling are all strategies that can be used during the technical cycle to recover and restore products, components, and materials. Recycling is a strategy to be used as the last resort.

4.2 Circular Economy (CE) and Sustainable Consumption & Production (SCP) in Practice

In the context of textile industry, **Circular Economy** refers to a system that is driven by interconnected ***innovations*** and ***strategies*** (Figure 5). It is accomplished through the implementation of circular strategies that are aligned with the objectives of SCP. This involves shifting to the use of materials that are renewable and/or less harmful (known as 'resource switching'), working toward the continuous use and re-use of materials, products, and their components within the context of consumption and production systems ('circularity of resources'), and reducing the amount of waste generated through improved design and increased production and utilisation efficiencies ('resource efficiency').

The implementation of circular textile strategies is dependent on innovations in areas such as materials, technologies, business models, and consumption patterns (including consumption by private consumers, and public and business organisations). When moving through the various stages of a product's life cycle, it is imperative that all circular economy strategies and innovations be taken into account. This includes everything from the selection of materials and the design of the product or service to its distribution, use, and management at the end of its useful life. In conclusion, the uptake and implementation of the Circular Economy will require ***enablers***, which include appropriate public policies, functional markets, as well as education and capacity development.

CIRCULAR ECONOMY DIMENSIONS

Circular Strategies

- Resource Circularity
- Resource Efficiency
- Resource Switch

Innovation

- Products, Materials & Technologies
- Business Models
- Consumption Patterns / Lifestyle

Lifecycle Stages

- Materials
- Design
- Production & Distribution
- Use
- End of Life

Enablers

- Education & Behavioural Change
- Public Policy
- Markets

Adapted from Van Berkel, R. 2021. 'Building a Circular Manufacturing Economy', presentation at CII GreenCo 2021 Summit, 7 October 2021. https://greenco.in/grncosummit/

Figure 5. Key components of circular industrial economy

Sustainable consumption and production (SCP) refers to 'the use of services and related products, which respond to basic needs and bring a better quality of life while minimising the use of natural resources and toxic materials as well as the emissions of waste and pollutants over the life cycle of the service or product so as not to jeopardise the needs of future generations' (UNEP, 2010).[21]

21 https://www.unep.org/explore-topics/resource-efficiency/what-we-do/sustainable-consumption-and-production-policies

In a nutshell, SCP aims at increasing resource efficiency while simultaneously promoting sustainable lifestyles, decoupling economic growth from environmental degradation, and doing more with fewer resources. SCP is the principle behind SDG 12: Ensure sustainable consumption and production patterns.

SCP emphasises the holistic approach to bring about systemic change. It is built around three main objectives:

- **Decoupling environmental degradation from economic growth**. This refers to doing more and better with less, increasing net welfare gains from economic activities by reducing resource consumption, degradation and pollution throughout the entire life cycle, while improving the quality of life. 'More' goods and services are delivered with 'less' resource consumption, environmental degradation, waste and pollution.

- **Applying life-cycle thinking.** This refers to enhancing the sustainable management of resources and achieving resource efficiency throughout both the production and consumption phases of a product's life cycle, including resource extraction, the production of intermediate inputs, distribution, marketing, use, waste disposal, and re-use of products and services.

- **Seizing opportunities for developing countries and 'leapfrogging'.** SCP contributes to the eradication of poverty and the attainment of the Sustainable Development Goals (SDGs). For developing countries, SCP offers opportunities such as the creation of new markets, green and decent jobs, and a more effective, welfare-generating management of natural resources. It is an opportunity to 'leapfrog' to more resource-efficient, environmentally responsible, and competitive technologies, bypassing the inefficient, polluting, and ultimately expensive stages of development experienced by developed economies in the past.

CE and SCP models share many underlying principles in common in that they promote resource efficiency and perpetual use within the life cycle of products throughout the production and consumption of goods or services to prevent unmanageable consequences for the environment and people.

5. Progression and Prospects

5.1 Progression outlook

While the sustainable consumption and production (SCP) concept has existed for decades, and circular economy (CE) has moved from the fringes to the mainstream for about a decade, there is nonetheless little observable progress on how the world is becoming either more circular or more sustainable. The 'linear economy' model remains the predominant economic model in most, if not all, countries.

> When it comes to a circular economy, we are all developing countries. No country, as of yet, satisfies the basic needs of its citizens within the ecological boundaries of the planet, warns Circle Economy.

The Circularity Gap Report 2022 reveals the harsh reality of where the world stands in terms of CE. About half a trillion t of virgin materials have been used over the past six years to make products and services that we all rely on, but less than 10% are retrieved and fed back into the economy. And it's getting worse: in only two years, global circularity dropped from 9.1% in 2018 to 8.6% in 2020.[22]

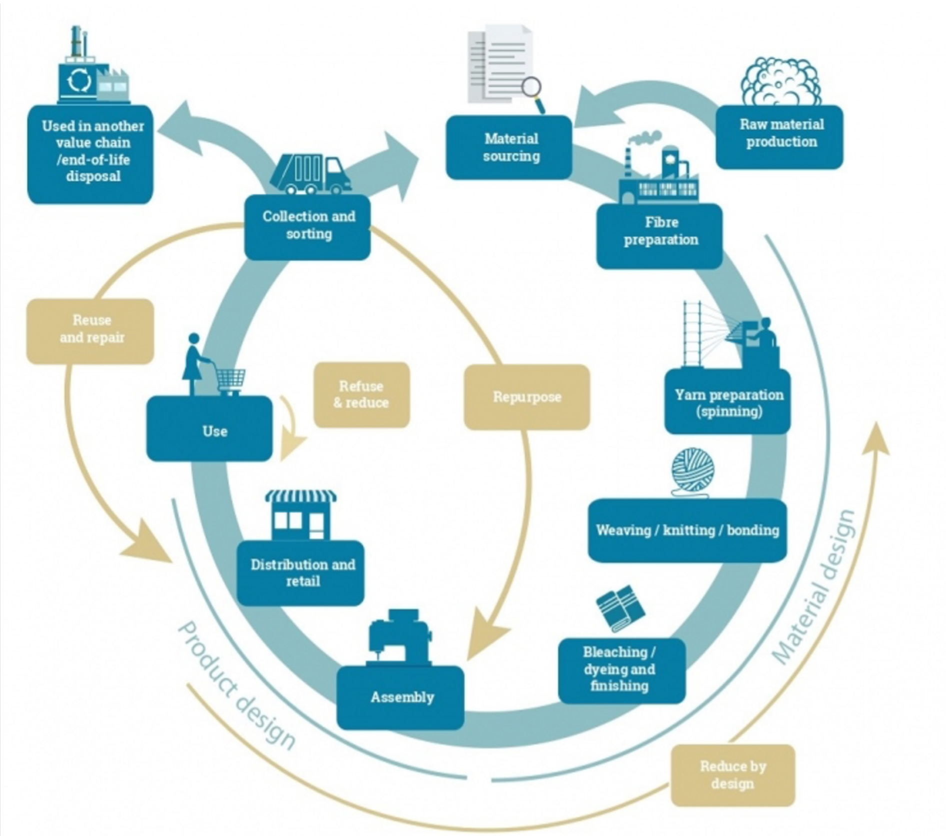

Figure 6. A schematic diagram of a circular textiles industry

22 Circle Economy (2022).

Our 'take-make-waste' economy consumes 100 billion t of materials (e.g., minerals, ores, fossil fuels and biomass) a year and wastes over 90%, and the trend continues to grow.[23] These enormous volumes of materials – by and large wasted after use – are climbing year after year. Ultimately, waste is connected to most environmental problems, from biodiversity loss, global warming and air pollution to 'plastic soup'. In only 50 years, global use of materials has nearly quadrupled – outpacing population growth.

Similar narratives about SCP can be found. According to the 2022 Sustainable Development Goals Report, total Domestic Material Consumption (DMC)[24] rose by more than 65% globally, amounting to 95.1 billion t in 2019. That translates to 12.3 t per person. About 70% of the global DMC are in Asia, Europe, and North America with East and South-East Asia experiencing the steepest growth from 31% in 2000 to 43% in 2019. Renewable energy is growing in developing countries overall, but the poorest countries lag behind. Fossil fuel subsidies remain alarmingly high, despite a temporary drop in 2020.

In spite of this, awareness of sustainability and circularity issues, as well as the need for change in the textile industry, have never been greater than they are now. Several initiatives, including the development of transparency standards, cotton cultivation guidelines, and restricted substances lists, have made progress in addressing the most pressing social and environmental issues. Most of these initiatives, however, are focused on the apparel and garment sector while technical textiles currently receive little attention. Several policy directives and regulatory frameworks have also been introduced to regulate the textile industry, with the EU being the most pro-active and ambitious in reducing the externalities toward circularity from this sector.

It is clear that much more needs to be done, and that environmental and social improvements must become mainstream – as opposed to niche – pursuits among luxury brands and major players. Changing the current linear model to a circular model will require systemic change and a mental shift on the part of supply chain stakeholders. Emerging innovations that are anticipated to turn the textile industry toward circularity will be discussed in Section 5.4.

5.2 Sector circularity in progress

As stated in Section 4.2, a pathway to a successful circular textiles industry must be based on circular 'strategies and innovations' along the entire supply chain and supported by key enablers (such as public policies, education, consumer behaviour, and markets). This section will investigate the circularity and/or sustainability of the industry.

Circular Strategies

Circular strategies can be implemented through many interventions throughout the life cycle of textile products, from raw material selection to production, consumption, and post-consumer waste management. In the technical textiles sector, energy and waste reduction, as well as the substitution of fossil fuels with renewable energy (e.g., solar, biomass) are practised by select industry leaders. Additionally, some manufacturers have emphasised the recycling of textile and non-textile materials to create new products. Selected home textile products, such as curtains, carpets, and rugs, contain regenerated materials.

Recycled polyester and nylon are the most common fibres produced from pre- or post-consumer- or pre- or post-industrial waste materials such as PET plastic bottles, clothes, or nylon fishing nets – material that would otherwise have been sent to landfill or for incineration. Cotton is another typical fibre type that has been regenerated to make new textile products.

India and China are good examples of countries where fuel choice switching is evident, albeit more so in the garment industry than in the fibre manufacturing industry. The rising cost of fossil fuels resulting from the Russia–Ukraine conflict also acts as a catalyst for change among these manufacturers. Listed below are some examples.

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23 ibid.

24 Domestic material consumption (DMC) measures the total amount of materials directly used by an economy to meet the demands for goods and services from within and outside a country.

A Closed-loop Circularity Model

EgeCarpets is a good example of companies where circular strategies are implemented in a full cycle. Materials selection, processes, and working conditions are taken into account throughout its carpets-making processes. Based on the full closed-loop recycling model, it recycles abandoned nylon fishing nets, old carpets, and clothing to make regenerated nylon which is then woven to be new regenerated carpet products. Ege's REFORM or RAWLINE's carpet backings are created 100% with recycled PET bottles, yarns are made from regenerated fishing nets, electricity is derived from renewable energy sources, used surplus heat from the backside of the oven is provided for district heating, and reused water from the dyeing process for re-dyeing the carpets, saving 88% of water usage during the process. Ege also uses old carpets and industrial scraps to make new carpets, and they take old carpets back from consumers for recycling. Ege Carpets is so far the only carpet maker in the industry that receives the cradle-to-cradle certification.

Home Textiles

Numerous manufacturers of home textiles (e.g., carpets, rugs, bedding products, furniture) are turning to using sustainable materials, such as recycled PET plastic bottles, abandoned fishing nets, organically grown cotton, recycled furniture fabrics/clothes, minimising/avoiding the use of harmful chemicals, and taking better care of workers' rights, in response to environmental and climate change impact responses among consumers and the business community.

- Carpets Inter makes modular carpets from PET bottles. Since 2004, it has recycled over three-quarters of a billion single-use plastic PET bottles, capturing over 50% of the carbon content in its EcoSoft® modular backing to support the ocean clean-up program. It strives for Zero waste to landfill, self-sufficient water supply and treatment. The company also donates 100% of the sediment from its on-site wastewater and sewerage treatment plant to the leading Thai organic agricultural fertiliser brand. This company is Thailand's largest carpet manufacturer with 40 years of global experience.
- Mohawk's *EverStrand™* carpet combines up to 100% recycled PET fibre, odour-reducing technology and enhanced softness for superior comfort and performance. The *airo* carpet is hypoallergenic, easy to clean and volatile organic compound (VOC)-free. Since 2008, Mohawk has turned more than 900,000 t (50 million bottles) of PET bottles into fibre make new carpets.
- Alma Green Design makes eco-friendly bedding in Spain. Each step of the creation process was rethought, and raw materials were recycled with care. No dyeing or harmful chemicals are used. Organic and recycled cotton are used to make the materials, resulting in a saving of about 10,000 l of water per sheet, and with a softer colour design without using dyes.
- The US home furniture maker Sabai makes furniture by order using Forest Stewardship Council (FSC)-certified sustainable and recycled materials, eco-friendly packaging, and a carbon-neutral shipping option. This company also offers a second-hand collection of well-conditioned furniture at discount prices.
- Burrow produces responsibly sourced furniture made of upcycled materials that are lead-free, formaldehyde-free, and flame retardant, and shipped in 100% recycled cardboard boxes.

Sports Textiles

- Licia Florio pairs sustainability and local manufacturing with a sleek aesthetic. Its stretchy **fabrics are made from 100% recycled yarns**. The colour-block collection uses nylon and elastane recycled from industrial waste. All orders are shipped in recycled cotton bags.
- Plant Athletic uses a **batch-manufacturing model**, producing multiple units of one design at a time. The goal is to streamline the resources required to produce each piece. **Made from recycled materials**, the jerseys are light, sweat-wicking, and highly breathable. Every order is sent in a compostable bag.
- The yoga brand From focuses on using the softest and most environmentally friendly materials for

its collections. It produces its designs **using organic cotton and Lenzing Tencel**, a fibre made from the pulp of eucalyptus wood, **which grows quickly without artificial irrigation**. The textiles are created **using a closed-loop process that recovers, recycles or decomposes all solvents and emissions.**

- League Collective makes activewears (e.g., for running, biking, yoga) from **100% recycled fabric** that is designed to perform at the same standard as non-recycled fabric.
- Sundried focuses on sustainable and ethical performance wear at an affordable price. The brand claims its Ecotech range of fitness T-shirts uses the world's only **biodegradable polyamide yarn**. Sundried also makes use of other recycled materials, such as **coffee grounds and plastic bottles**.
- Born in Sweden, Icebug became one of **the first climate-positive footwear brands** in the world by offsetting and reducing its emissions as much as possible. Its running shoes are made almost entirely of recycled materials, **from fishnets to polyester to rubber**. The shoes are precision-engineered for every kind of runner and terrain (yes, including ice).
- Giesswein incorporates Merino wool into its sustainable running shoes. This Austrian family-owned business sources wool responsibly due to its antibacterial, heat-resistant, and odourless properties. **Zero waste is produced during production, and 90% of the water used is recycled**. The unique 3D stretch technology renders these running shoes extremely lightweight and flexible.
- Brooks is focused on mindful sourcing, net-zero carbon emissions by 2040 and transitioning to circular products. It **uses recycled polyester and biodegradable compounds in EVA soles** with a **take-back program**.
- Adidas has committed to shifting to 100% recycled polyester by 2024. Many of its shoes are already made with **recycled plastics and/or vegan-friendly materials.**

Geotextiles

- Wallbarn supply a large, recycled geotextile membrane range in a number of different densities and materials. This geotextile fabric range is absolutely ideal for a many different uses, including protection, drainage, filtration, soil stabilisation & green roofing, and horticulture.
- The Bidim Green geotextile, from Geofabrics Australia, is **made from recycled plastic bottles**, **sourced from Australian recycling bins**. It is designed to be used in infrastructure projects, including rails, roads, and waste.
- Kaytech, a South African geotextile company, has been **using PET recycled drink bottles to make regenerated geotextiles, geogrids, staple fibres, and geosynthetic clay liners**. Since the early 2000s, the company has completely stopped using virgin polymer in the production of geotextiles. It is now **starting to increase the use of solar energy** to offset its carbon footprint.
- Re-Gen Enterprises is a niche player who together with its recycling partner **transforms containment liners into recycled plastic products** (e.g., garbage bin, vacuum cleaner parts).

Circular Innovations

Circular innovations put emphases on (i) products, materials & technologies, (ii) business models, and (iii) consumption patterns and lifestyle. Examples of interventions may include eco-design, recycling technologies, use of eco-friendly/recyclable materials, take-back programmes, reselling, renting, repairing, improving product quality, and promoting a low carbon lifestyle, among others. Various approaches are undertaken to implement incremental (e.g., process-related, campaigns, etc.) or disruptive innovations (e.g., new business models).

Home Textiles

- AlmaGreen Design, a Spanish bedroom textiles maker, introduces a take-back program that allows customers to return their old bed linens in exchange for points for purchasing new products. Used cotton textiles are sorted, cut, shredded, and spun into new and recycled yarn to create bed linens with a durable and high-quality fabric. *Recover Fiber* is a soft, durable material that can be turned into three textiles using recycled cotton yarn and unique colours and designs, made with cutting-edge technology and supra-recycled premium textile yarns. Alma Green's Recover Fiber home textiles are GRS, OEKO-TEX, and Organic Blend-certified. They have obtained the sector's lowest Higg Index.[25]

- Piñatex® is the fabric made of fibre from the waste leaves of the pineapple plant. The leaves are mixed with a corn-based polylactic acid (PLA) and then undergo a mechanical process to create Piñafelt, a non-woven mesh that forms the base of all Piñatex collections. Piñafelt is then shipped by boat from the Philippines to Spain or Italy for specialised finishing that gives the materials more strength, durability, and water resistance. Piñatex is used across the fashion, accessories and upholstery industries, and has been used by over 1,000 brands worldwide including Hugo Boss, H&M and the Hilton Hotel Bankside.

Sports Textiles

- Prism creates multifunctional mix-and-match pieces for all shapes and sizes that are intended for use as activewear, daywear and swimwear. Made in Italy, the styles are produced using a 3D-knitting process that minimises waste. They are dyed according to Greenpeace's detox protocol.

- Picture has been creating technical clothing from recycled bottles since 2008 and has always offered a repair service for any piece of clothing. It is now focusing on bio-sourcing and the development of plant-based fabrics.

- Organic Basics activewear is treated with a safe, permanent, recycled silver salt called Polygiene. This stops odours – and bacteria – from developing on the fabric, meaning you can wash your kit less often. Organic Basics also give shoppers the option of using a lower-impact website that reduces data transfer by up to 70%, thereby saving electricity.

- Mandala's bio-polyamide collection comes from Italian castor bean plants. Its production is water-saving and sustainable. The company claims bio-polyamide is perfect for activewear because it enables effective moisture management, even in hotter temperatures. Mandala uses no plastic in any of its packaging, either.

- Allbirds, a certified B Corporation,[26] makes running shoes and sneakers with tree fibres and wool, sugarcane for midsole, and castor oil for insoles. The brand is fully carbon-neutral and ships its shoes in recycled packaging. *Allbirds ReRun* is a marketplace that keeps gently used or slightly imperfect products out of the landfill and puts them to new uses.

- Hylo Athletic makes vegan running sneakers with corn fibres, natural rubber, algae, and organic cotton. Hylo has a take-back program where customers will be given a $10 credit if they return their old shoes to the stores after use.

25 The Higg Index is an apparel and footwear industry self-assessment standard to rate environmental and social sustainability throughout the supply chain.

26 B Corp Certification is a designation that a business is meeting high standards of verified performance, accountability, and transparency on factors from employee benefits and charitable giving to supply chain practices and input materials.

Other technical textiles

- 3M Thinsulate technology uses 60% post-consumer recycled material to make high-performance materials.
- The Recaro Aircraft Seating manufactures completely biodegradable Airbus A380 seat covers that are converted into a nutrient source for cotton plants, which are then used to produce new seat covers
- Faurecia's BioMat project creates a spray-formed material with a matrix consisting entirely of organic fibres, which is ousting materials based on mineral (petroleum) oil from the marketplace. To make this new material, polybutylene succinate (PBS) is combined with hemp-based fibres to create a material consisting entirely of natural substances. This technology has been used in cars beginning in 2016, and represents an important milestone on the way to using natural materials in the automotive market. BioMat reduces the industry's dependence on the price of oil and helps to reduce greenhouse gas (GHG) emissions.
- Asahi Kasei Fibres & Textiles expanded its capacity to produce Lamous, a high-quality microfibre suede. It is used in a wide variety of applications such as furniture upholstery, automotive interiors, IT accessories, apparel, and industrial materials.

Circular Enablers

Public Policies & Regulations: From the global level down to regional and national levels, policy and regulatory frameworks have been put in place to enable the textile industry to become more circular and sustainable. These frameworks are applied to various stakeholders in the textile industry's supply chain, from materials selection to fibre preparation, yarn production, weaving/knitting/bonding, bleaching/dyeing/finishing, assembly, distribution, and including waste collection, sorting and recycling for use.

The EU is by far the most proactive regional group with ambitious goals to turn Europe into a carbon-neutral region. For more than a decade, the bloc has issued circular/sustainable policies and regulations (as well as updated ones) that require member states to comply and to put more pressure on the textile industry's supply chain players – most of whom are in Asia – to change the way they do their business. Key regulations are summarised below.

Table 2. List of relevant EU policy frameworks and regulations for the textile industry

Framework/Regulation	Description
European Green Deal	A set of policy initiatives by the European Commission with the overarching aim of making the European Union (EU) climate neutral by 2050.
2020 Circular Economy Action Plan	Provides a plan for a cleaner and more competitive Europe that was made with the help of business, consumer, citizen, and civil society organisations. It aims to speed up the changes needed by the European Green Deal while building on actions taken since 2015 in the area of the circular economy. This plan will make sure that the regulatory framework is streamlined and made ready for a sustainable future. It will also make sure that the new opportunities that come with the transition are taken full advantage of and that people and businesses do not have to deal with too much extra work.

2021 EU Industrial Strategy	Ensures EU's industrial ambition takes account of the circumstances following the COVID-19 crisis, while leading the way in transitioning to a green, digital and resilient economy. It supports the EU 2020 Industrial Policy's twin green and digital transitions, makes EU industry more competitive globally, and enhances Europe's open strategic autonomy.
EU Strategy for Sustainable and Circular Textiles	Provides a coherent framework and a vision for the transition of the textiles sector towards a sustainable and circular industry by: • Establishing eco-design • Incentivising circular business models • Enabling better materials recycling and improved production processes • Ensuring increased transparency for consumers • Managing social impact and responsibility, including labour conditions • Ensuring post-consumer waste management
Regulation N°1007/2011 on textile fibre names and the marketing of the fibre composition of textile products	Establishes common rules for fabric names and compositions, as well as labelling standards. For instance, the label must include the fibre content in the official language of the country where the product is sold. In addition, the regulation specifies how national authorities should approach compliance controls with these various rules.
Best Available Techniques (BAT) Reference Document for the Tanning of Hides and Skins	Regulates tanning practices in the European Union.
Industrial Emissions Directive 2010/75	Specifies the most effective and currently available technologies for integrated pollution prevention and control. This regulation pertains to the textile industry's environmental practices.
General Product Safety Directive (2001/95/EC)	In general, this directive applies to all consumer goods, including textiles. It specifies which products should be classified as safe and which types of unsafe products should not be sold within the European Union. In this regard, the Directive also establishes the European alert system RAPEX, which contains a list of all products recalled by national authorities.

REACH Regulation 1907/2006	A chemical regulation that has established and continually updates an EU-wide list of regulated substances. Annex XVII contains a list of chemicals related to textile manufacturing: • Certain flame retardants in textiles • Chromium VI in leather • Azo colourants and dyes • Polycyclic aromatic hydrocarbons (PAHs; derivatives of coal, crude oil, petrol/fuels) in rubber and plastics • Cadmium in plastics, coated materials • NPEO in washable textiles (as of February 2021) • 33 CMR substances in textile consumer goods (as of November 2020) • PFOA, except textiles for protection of workers (as of July 2020), via the POPs Directive

In addition, there are international trade and labour standards as well as other sectoral guidelines and tools to ensure safe working conditions for textile workers and fair trade for small and medium-sized businesses to remain competitive on the market.

Education: For all participants in the textile life cycle, the concepts of sustainability and circularity must be integrated into teaching in a multi- and interdisciplinary manner in schools, training centres, and universities. In April 2020, the 'Clean and Innovative Textiles Strategy for Circular Economy' – the CLEANTEX project – was launched to promote the adoption of circular economy and eco-design to improve the skills of textile engineering students and the workforce in the sector through cross-sectoral cooperation with higher education institutions to address the main pollution problem and achieve a more sustainable textile industry. This is a strategic partnership with higher education, co-funded by the European Commission via the Erasmus+ program. The partnership is made up of eight institutions (including universities, non-profit institutions, technological centres and clusters) from six European countries. CLEANTEX offers a range of training options:

- A virtual training programme (MOOC, Massive Open Online Course) with open educational resources on circular economy and eco-design with a focus on the textile industry
- An industrial 'clean textiles' bootcamp training with innovative materials and methodologies
- An e-book with examples on how to apply life cycle assessment and eco-design in the advanced textile manufacturing industry
- An intensive training summer course to be organised using the bootcamp methodologies

The Sustainable Textile School, established in 2017 by TU Chemnitz and Gherzi Group, conducts additional focused educational activities. The textile school, which is held annually, focuses on five circularity-related topics (such as resources, fabric production, chemistry, supply chains, and policies) and aims to provide a global platform for sustainable textile engineering.

Consumers' Behavioural Campaigns: Finally, although there are public initiatives to increase consumer knowledge of the social and environmental repercussions from the textile and fashion sector, there is a glaring lack of public efforts that specifically target the various categories of technical textiles. This lack of awareness is observed both in consumers and supply chain actors.

5.3 Linkage with SWITCH-Asia Grants

Since 2007, SWITCH-Asia has helped 24 Asian countries, as well as small and medium-sized enterprises (SMEs) and businesses make the transition to the CE and SCP by offering technical assistance and grants. Grant projects are clustered into four project types, namely cleaner production, value chains, sector formalisation, and sustainable consumption, involving sectors that include agri-food, sustainable building & housing, waste management, tourism, plastics, transport and logistics, electrical & electronics, multi-industry, and textile & leather. While not directly targeted at the technical textiles sector per se, the practices and policies implemented through the SWITCH-Asia grants are synonymous to those highlighted above; therefore, contributing to the transition toward circular and sustainable technical textiles.

6. Transition Challenges

As previously discussed, the circular economy model and the principle of sustainable consumption and production have demonstrable benefits for people, the environment, and economic growth, and they should be the development models pursued by all countries. In reality, the linear economy model has dominated the global economy for generations, establishing complex take-make-waste supply chains. Transitioning from a linear economy to a circular economy will take time, resources, and collaboration from the government, businesses, and civil society, as well as a shift in consumer behaviour. This section will discuss the primary barriers to implementing circular economy (CE) and/or sustainable consumption and production (SCP) in the real world, as well as trigger points. The barriers are grouped by the three circular economy dimensions as described in Section 2 (see above). While discussing the barriers to circular transition, it is important to remember that some of the products in the category of technical textile will be better addressed through certain SCP strategies, but not the others, e.g., geotextiles are be designed, not with an eye on circularity, but rather on efficiency.

6.1 Circular strategy barriers

Barriers related to implementing circular strategies include:

- **Lack of baseline data on the negative impact from technical textiles sector –** The absence of specific data related to impact on the environment, human health, and workers makes constructing narratives for awareness raising (for consumers, policymakers, media, etc.) and advocacy campaigns difficult.
- **Lack of specific regulations/guidelines for the sector –** Without a clear policy, guidelines, standards (such as design-for-recycling), companies may not find a motivation to change for fear of market disadvantage as there are substantial costs involved.

6.2 Circular innovation barriers

Although circular innovations have been identified at various stages of the textile life cycle, there are some barriers that prevent circular innovations from becoming mainstream.

- **Perceived low(er) quality of recycled, repurposed products by consumers:** such perceptions can be formed by deliberate actions of competitors and lobbyists, or come as a genuine concern about the quality of unfamiliar material. A different but similar challenge is the potential **absence of the standard for the alternative input material or design** in the situations where the quality of a technical textile is of critical importance, e.g., medical (medtech) or geotextiles (geotech).
- **Challenges associated with inputs**: the scarcity of alternative input materials and energy, their uneven supply or cost makes sustainable textile products more costly to produce, or compromises the consistency of its supply to the market.
- **Lack of the collection system at post-consumer stage**: the absence of a common take-back program makes sourcing of recyclable materials difficult and expensive, thereby causing the prices of products made from recycled materials to be higher than conventional materials.

6.3 Circular enablers barriers

Following the example of the EU, international standards (e.g., ISO) are beginning to focus on the circular economy, and some countries have adopted and/or implemented CE/SCP national action plans. While these appear to be a good foundation for carrying out the plans, there are some obstacles that must be overcome.

- **Lack of sector-specific policy, regulations, and standards for SCP and CE.** Most countries have committed to the SDGs and SCP, but there are few sector-specific SCP/CE policies, despite the importance of the textile sector for some countries' economies. Current environmental regulations focus more on outputs than inputs (e.g. water use and cleaner production, that is, effluents and energy reduction). Some countries have implemented Green Public Procurement/SPP, but have not always provided guidance for textiles.
- **Low consumer interest/awareness.** The experts participating in consultations shared the view that the main interest for more sustainable technical textile products comes from institutional rather than private consumers, which is natural for most of the products using technical textile. For products with a greater visibility in the private consumer market, consumer awareness of the impact of technical textiles is still lacking, in contrast to their awareness of the impact of the apparel sector.
- **Weak compliance and enforcement capacity.** Compliance with social and environmental laws is difficult because country-to-country enforcement power varies. Meanwhile, there is a fear that stricter legal enforcement (as in China) may encourage businesses to move abroad.
- **Financial burdens, technical support and market for CE/SCP transitioning.** Changing to a circular economy model will require up-front investment in new textile recycling equipment, or resetting/restructuring factory manufacturing systems to be more energy efficient, emit less or no carbon, and/or be compatible with renewable energy. Manufacturers (especially SMEs) are hesitant to change due to a lack of finance, policies, and markets for sustainable products. This situation is exacerbated by the lack of understanding and technical support, provided in a convenient and accessible manner, for SMEs.

6.4 Trigger Points

Circular/sustainable practices can be found at various stages of the textile life cycle. However, a cohesive ecosystem that would bring them together and scales them to become the industry's new norm is completely lacking. Sustainable technical textiles can also be encouraged through various industries because they are used in a wide range of applications, from home furniture to sports equipment and clothing, automobiles, and medical products. Some elements, whether existing or emerging, must be given support, while others must be provided in order to create an enabling ecosystem for circular technical textiles. These elements are:

a. <u>Technological advancements:</u> Textile manufacturers, such as Dupont or CORDURA, have continued to improve textile/fabric quality (e.g. lighter weight, faster drying, more durable, high performance) in order to meet the varying demands of various applications. Typical industries that utilise these textiles include the military, construction, aviation sports, and agriculture. The sustainability of the technical textiles industry will be enhanced by the development of technologies (e.g. water, electricity) that reduce resource consumption and pollution during production. To enable a more effective and cost-effective post-consumer recycling process, fibres or blends that maintain the same or higher quality of technical textiles will be required. More advanced or different recycling technologies, such as chemical recycling, will be essential for closing material loops.

b. <u>Market forces:</u> The technical textile industry is heavily influenced by market leaders. As a leading consumer market for technical textile products, the EU is well-positioned to influence the sustainable production of technical textile supply chains. Consistent enforcement of previously issued sustainable policies and regulations will enable global supply chains to comply, thereby accelerating the EU Green Deal targets. In addition, established and functional carbon trading markets might contribute to incentivising businesses to pursue sustainability initiatives and accelerating their achievement of their objectives.

c. <u>Digital transformation:</u> Bringing together digital, virtual and physical systems encourages manufacturing practices that secure quality and innovation while minimising losses. The Internet and smartphones have also increased the accessibility of sellers and buyers and made it much easier to conduct business transactions for products. There are digital platforms for second-hand items; it may be beneficial for technical textile supply chains to utilise these platforms to implement circular strategies (i.e., for reuse, recycling, materials sourcing). Digital platforms can also help buyers trace the sustainability supply chain (i.e., buyers can check whether their products are truly sustainable across the supply chain), and connect buyers and sellers of sustainable products thereby expanding the unique market.

d. Climate change impact: Rising temperatures, extreme floods and droughts, and rapid glacier melting are increasing consumers awareness of climate change. As a result, businesses now have a strong incentive to rethink their business models in order to meet the evolving needs and intentions of consumers. The government must enact policies and economic incentives that respond to these evolving needs/intentions to encourage the transition to sustainability.

Despite the above, some challenges remain and must be addressed throughout the life cycle. The small and medium-sized enterprises (SMEs) that comprise a large portion of the textile supply chain are crucial stakeholders. They require technical and financial assistance to become more sustainable, without which circular technical textiles will remain a pipe dream. Technological advances are almost always available to large industry players, whereas SMEs frequently lack financial access to such technologies, as well as the technical capacity to use them.

SMEs that develop technologies frequently face a lack of financial capital to commercialise them. Both CE and SCP are still viewed by financers as mere concepts that do not result in tangible and financially viable gains. At the same time, sustainable products remain significantly more expensive than conventional products, making them less likely to be adopted by mainstream consumers. There is still a need to motivate and encourage consumers to move towards sustainable/circular products and lifestyles while also making these products and lifestyles affordable – hence the crucial importance of a circular economy ecosystem.

7. Conclusion and Way Forward

A systemic shift is needed across the entire life cycle of technical textiles, from materials selection to processing, marketing, consumption, and post-consumption, in order to achieve a circular economy (CE) and sustainable consumption and production (SCP) in the technical textile industry. There are implementation challenges that must be overcome and opportunities that must be seized to achieve sustainable outcomes. Different SCP strategies have different potentials for improvement, and for different technical textile products – this understanding should guide their application. Circular strategies, innovations, and enablers provide a crucial framework for the technical textile sector to become more circular and sustainable.

The European Union is paving the way for its member countries to transition to sustainable consumption and production by developing directives, strategies, and regulations. These requirements are being extended to countries where technical textiles products are manufactured, requiring many countries to pay closer attention to CE and SCP principles. As a result, countries have begun developing CE and/or SCP strategies and action plans, although there are still many gaps that must be closed before they can be successfully implemented.

On the private sector side, select industry leaders have already adopted circular strategies (e.g., energy efficiency/renewable energy promotion) to achieve cost savings and sustainability goals. Innovative approaches are being used in the manufacturing process to reduce the use of virgin resources and harmful materials. PET bottles, for example, are collected and recycled into polyester fibre, which is then used to make sportswear or PPE suits. Pineapple leaves are harvested and reprocessed into new fibres for use in apparel and technical textile applications. By-product CO2 is used to replace water in the waterless dyeing process, reducing both water consumption and GHG emissions in the manufacturing process.

Despite these accomplishments, industry experts admit that the technical textile sector is making slow progress toward the circular economy. Progress is observed unevenly across the supply chain. For example, in the material selection stage, producers of some products look for more sustainable inputs to make textile products (e.g., recycled polyester, cotton, etc.). Yet there is still an enormous potential to reach efficiency at the processing stage – this is especially important for the sectors in which changes in the material composition, and thus in the selection of the input materials, is limited. A cleaner and more efficient manufacturing system must be vigorously promoted.

While innovative technologies are available, they are concentrated within a small group of industry leaders and innovators and have not yet been widely adopted by mainstream manufacturers due to the perceived (and actual) higher investment costs of making the change. Small and medium-sized enterprises (SMEs), which make up the vast majority of the textile value chain, are also finding it difficult to access innovations due to a lack of resources for new technology and adaptation, as well as their lack of technical capability.

However, there are some underlying issues that must be addressed. The absence of a baseline data and impact measurement system make convincing and informative discussions for both producers and consumers on the benefits of CE/SCP difficult. Lack of information sharing (both within and between the private and public sectors) makes learning and scaling up difficult. Low market demand for sustainable products, a lack of sector-specific requirements/guidelines, a lack of consumer awareness, and a lack of good quality secondary materials and a take-back system, combined with weak compliance and enforcement capabilities within countries, have been identified by industry and technical experts as the remaining challenges for technical textiles to become more circular and sustainable.

Furthermore, despite the fact that the principles of circular economy and sustainable consumption and production have been around for more than a decade and have recently shifted from the margins to mainstream discussions, they are still only vaguely understood by the private sector players, particularly SMEs. More work is needed to translate these principles into practical, real-world terms.

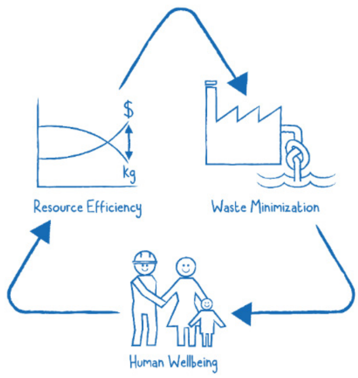
In conclusion, circularity and sustainable practices can be found at various stages of the textile life cycle.

However, at present there is no coherent ecosystem that connects them and scales them to become the industry's new norm. Because they are employed in a wide range of applications, from home furniture to sports equipment and apparel, autos, and medical products, sustainable technical textiles can also be promoted and encouraged through numerous industries. Some elements must be supported, be they existent or emerging, while others must be created and supported in order to build an enabling environment for circular technical textiles. These elements include technological advancements, market forces, digital transformation, consumer behaviour, and recognition of the devastating impact of climate change.

A transformative move towards CE is possible by encouraging circular solutions and disrupting 'linear' practices leading to loss of resources, growing pollution, and accelerated climate-related disasters. External factors (e.g., Covid-19 pandemic) may strengthen the requirements for resilience in supply chains, but this will become possible only when stronger incentives – e.g., policy packages – and solid support from key stakeholders are firmly in place.

Annex 1 – Resource Efficiency and Cleaner Production Principle

The **Resource efficiency and cleaner production (RECP)** concept refers to the continuous application of preventive environmental strategies regarding processes, products and services in order to increase the efficiency with which materials, water and energy are used so as to improve productivity and thus competitiveness. The application of RECP leads to a reduction in the amount of pollution and waste generated and reduces threats and risks for humans and the environment.[27]



RECP addresses three sustainability dimensions individually and synergistically:

- heightened economic performance through improved productive and efficient use of resources
- environmental protection by conserving resources and minimising industrial impact on the natural environment
- social enhancement by providing jobs and protecting the wellbeing of workers and local communities

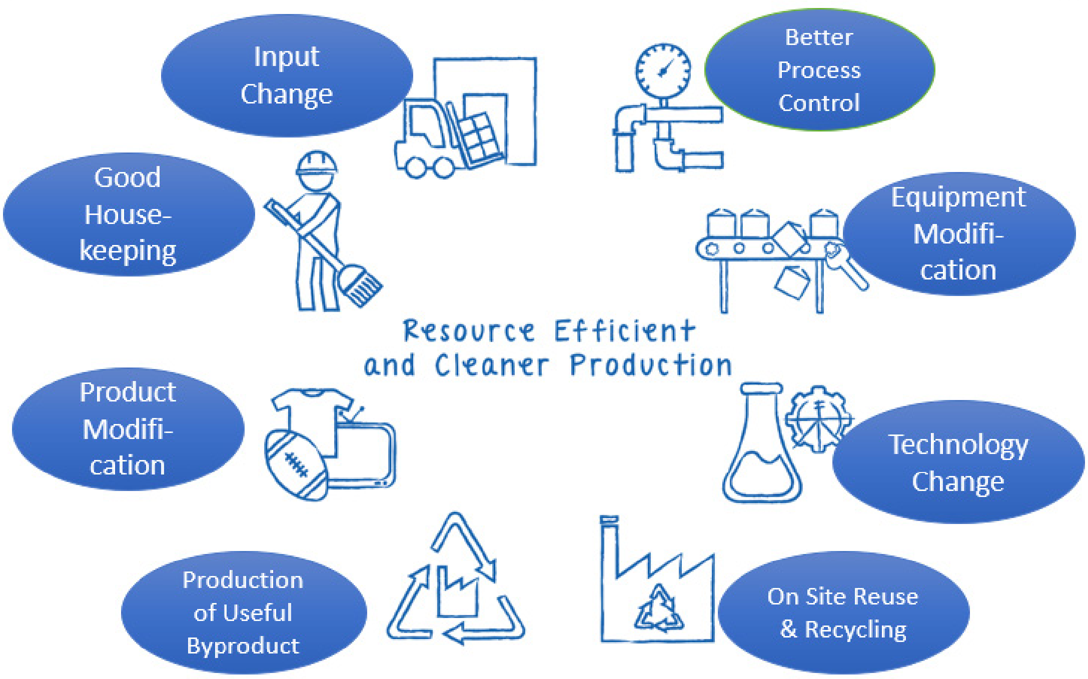
RECP can be applied to a variety of industries. For example, in the technical textile sector, RECP may be applied to increase resource productivity as well as pollution intensity reduction using different means[28]:

INCREASE Resource Productivity		DECREASE Pollution Intensity	
Material productivity	Selection and efficient use of materials, including chemicals	Solid waste	Reduction and environmentally sound recovery, treatment, and disposal of waste
Water productivity	Selection of sustainable sources for and efficient use of water	Wastewater	Reduction and environmentally sound recovery, treatment, and disposal of wastewater
Energy productivity	Selection of sources and efficient use of energy	Emissions	Reduction and environmentally sound discharge of emissions

Solutions: To implement the RECP approach, various practices can be used, ranging from simple practices like good housekeeping and input change to better process control, equipment modification, technology change, on-site reuse & recycling, and the production of useful by-products, as well as product modification.

27 *Van Berkel, R. (2018),* Scaling up and Mainstreaming Resource Efficient and Cleaner Production (RECP) in Small and Medium Enterprises (SMEs): achievements and lessons learned in the European Union's Eastern Partnership Region, *Sixth GGKP Annual Conference/2018 OECD Green Growth and Sustainable Development Forum, 27-29 November 2018, Paris*

28 *Van Berkel, R. (2018),* Scaling up and Mainstreaming Resource Efficient and Cleaner Production (RECP) in Small and Medium Enterprises (SMEs): achievements and lessons learned in the European Union's Eastern Partnership Region, *Sixth GGKP Annual Conference/2018 OECD Green Growth and Sustainable Development Forum, 27-29 November 2018, Paris*



RECP practices illustrated[29]

More information on these practices is provided below along with common applications in textile wet processing sector[30].

RECP Practice	Description	Common Water-Related Textile Example
Good Housekeeping	Maintain a clean, organized and productive ('neat') workplace to eliminate avoidable 'wastage'	• Switch off what is not in use (e.g., taps) • Repair what is broken or leaking (e.g., pipes) • Remove dry debris before factory wash down
Input Change	Choose inputs that are efficient, effective and/or pose minimum harm to the environment and health	• Use secondary, recovered water • Use less harmful chemical substances (dyes, detergents, etc.) • Use enzyme-enhanced bleaching, scouring
Better Process Control	Monitor and control processes and equipment so that they always run at highest efficiency and with lowest waste	• Establish and follow Standard Operating Procedures (SOP) • Submeter use of water • Install automatic shut-off and overflow prevention valves
Equipment Modification	Make existing equipment more efficient and less wasteful	• Align and debottleneck production line • Close, hot and cold process equipment
Technology Change	Change to new technology that is more efficient or produces less waste	• Waterless dyeing • Additive, 3D printing

29 *Van Berkel, R. (2018),* Scaling up and Mainstreaming Resource Efficient and Cleaner Production (RECP) in Small and Medium Enterprises (SMEs): achievements and lessons learned in the European Union's Eastern Partnership Region, *Sixth GGKP Annual Conference/2018 OECD Green Growth and Sustainable Development Forum, 27-29 November 2018, Paris*

30 Van Berkel, R (2017), *Water Efficiency in Textile Processing: good practices and emerging opportunities*, July 2017 Conference: Roundtable on Waterless Processing, Textile 2017 Gandhinagar, Iindia

On-Site Reuse & Recycling	Use previous ‘waste’ for similar or alternative purpose in company	• Counter-current or cascaded use of water • Condensate recovery
Production of Useful By-Product	Convert a previous ’waste’ for use elsewhere	• Provide used cooling water for external heating or cooling purposes
Product Modification	Redesign product to reduce its environmental impact during production, use and/or disposal	• Produce easy-care textiles that will require minimal water use by consumers

Source: A presentation by Rene van Berkel at the webinar on the ‘Achieving circularity and sustainability in the technical textile sector’, organised by the SWITCH-Asia Programme on 17 October 2022.

Annex 2 – The Expert Consultation Meeting (3 October 2022)

INFORMATIVE NOTE

Funded by the European Union

Expert Consultation For the Circular and Sustainable Technical Textiles in Asia

Date: 3 October 2022
Time: 14.00 - 16:00 hours (ICT)

INTRODUCTION

Technical textiles have a significant part in virtually every social and economic activity. A combination of technology and textile materials provides a vast array of options for numerous applications. The textile sector, however, accounts for roughly one-fifth of global industrial water pollution, uses a vast array of hazardous chemicals, and emits substantial greenhouse gas emissions, especially during the production and finishing stages. While these impacts are well documented for the fashion industry, much less attention has been given to the technical textiles for which demand is increasing rapidly in recent years.

A need to transition to a circular production and consumption system for technical textiles is clear. And partnerships play a crucial role in developing more resilient technical textile supply chains in Asia. This proposed expert consultation session, jointly organized by the Asian Development Bank (ADB) and the EU SWITCH-Asia SCP Facility, will examine the current trends, challenges, opportunities, and game changers to move the technical textiles industry toward a circular and sustainable value chain, with a particular focus on identifying leverages and trigger points for transformative change of the sector.

OBJECTIVES

The expert consultation aims to contribute to a deeper understanding of critical factors facilitating circularity of the technical textile sector in Asia. It will focus on the discussion of (a) circular-economy-related practices that contribute to the sustainability of materials and used in the region and (b) critical factors that influence the development of circular supply chains.

TENTATIVE AGENDA

Agenda	Programme
14:00 (GMT+7)	Introduction & Welcome Remarks
14:05 (10 min)	Presentation on the draft policy paper on "**Achieving a circular economy and sustainable consumption and production in the non-apparel technical textiles sector**"
14:20 (10 min)	Circularity Economy and Sustainable Production and Consumption Models
14:30 (30 min)	Exploring critical factors in technological innovations and business models toward the circular and sustainable technical textiles sector
15:00 (30 min)	Defining policy framework and innovation ecosystems to optimize circular and sustainable textiles
15:30 (15 min)	Final Thoughts
15:45 (15 min)	Wrap and closing remarks
16.00	Event closes

TECHNICAL BACKGROUND

Technical textiles often have greater performance characteristics than conventional textiles[1]. They are made from synthetic and natural fibers. The synthetic fibers used in these applications are produced by combining various natural fibers with special chemical processes to impart their new properties. These fibres have greater or different qualities than regular fibres, and as a result, they are widely used not only for clothing, but also for medical, automotive, home furnishings, construction, agriculture, and other applications.

The market for technical textiles is expanding rapidly as a result of rising demand from both developed and developing nations, technological advances, and government investments. Global consumption of technical textiles was approximately 42 million MT in 2021 and is expected to reach 67 million MT by 2032, an increase of 59%. The global technical textile market size is projected to grow from USD 164.6 billion in 2020 to USD 222.4 billion by 2025, at a Compound Annual Growth Rate (CAGR) of 6.2% between 2020 and 2025[2]. *Technical textiles are projected to account for about 43 percent of global textile sales by the end of this decade*.

Europe is the largest consumer of technical textiles, followed by North America, while consumption in large Asian markets, such as China and India, is primarily for medical, infrastructure, and construction applications. Medical applications are one of the primary drivers of demand and consumption of these textiles in the European Union countries and the Asia-Pacific Region. Since the onset of the Covid-19 pandemic, the demand for medical textiles has increased significantly, and this trend is anticipated to continue in the coming years (See Box 1).

Box 1. Impact of pandemic on growth in technical textile

The COVID-19 pandemic has affected the textile industry's demand and supply. The chemical industry supply chain has been severely disrupted, which has had a significant impact on the procurement of raw materials for technical textiles. However, the pandemic also caused a sudden increase in demand for gowns, masks, and others, which had a positive impact on the demand for medical textiles (Medtech). As a response to the pandemic, technical textile manufacturers around the world are increasing their production capacity and investing in machinery to produce healthcare essentials. Demand for disposable hospital supplies and nonwoven materials is projected to rise from 2020 to 2025 due to an increase in the number of cases worldwide and the need for more healthcare professionals. Hygiene is anticipated to be the largest application segment in the technical textile market over the coming years due to continuing COVID-19 spread. Nonwovens are used as an alternative to conventional textiles in hygiene products due to their superior absorbency, softness, smoothness, strength, comfort & fit, elasticity, and cost-effectiveness

The majority of technical textiles are made in the Asia Pacific Region. China is the largest producer of both woven and non-woven technical textiles in this region and is currently responsible for 30% of global production, followed by the Americas (19%), India (18%), EU (16%), and the rest of the world (17%). China's lead is supported by a large number of suppliers, access to advanced technology, and experiences, coupled with steady domestic demand.

1 Yet, with development of textile technologies in apparel sector, this difference might be minimal or non-existent. In some cases, it is reasonable to talk about application of textile materials to different areas rather than differentiating between technical and non-technical textile.

2 www.marketsandmarkets.com

Governments of countries in the European Union (EU) and the Asia Pacific are also supporting the development and manufacturing of technical textiles, which will allow both regions to increase production and give them access to more advanced technology and practices.

As a result of the sophisticated procedures used to manufacture technical textiles for specific purposes, post-consumer disposal and/or recycling are frequently viewed as highly difficult to almost impossible, leaving only incineration and landfill disposal as feasible possibilities. As a result of increasing pressure from the government and the society, including from the side of international buyers, stricter regulations are being imposed to reduce the high environmental impacts and resource consumption throughout the supply chain of technical textiles.

Given the anticipated rapid increase in demand for technical textile products over the next decade, it is crucial to implement transformative sustainable consumption and production models and circular business technologies in the non-apparel and technical textile industries. Sustainable Consumption and Production is viewed as a steppingstone for the transformation of the textile industry into a circular economy. Companies that are able to maintain their sustainability programs and commitments while managing the crisis will gain a long-lasting competitive advantage and be able to rebuild a more sustainable textile and apparel industry after COVID-19. The circular economy, which necessitates new relationships between natural resources, customers, and markets, paves the way for the development of new business models and technologies. Also required are policy frameworks that facilitate business innovation.

Box 2. Policy directions in the European Union

The European Union has already begun investigating the issue by introducing a series of directives, strategies, and guidelines to assist bloc members in achieving carbon neutrality by mid-century. Specifically, the EU Strategy for Circular and Sustainable Textiles provides guidance on how the textile industry, the fourth largest contributor to greenhouse gas emissions, can better respond to the situation. The strategy will inevitably affect countries that manufacture textile products for the European Union market. In addition, national government policies and regulations play a crucial role in leveling the playing field and facilitating manufacturers' compliance with social and environmental standards while remaining competitive on the global market.

SCOPE

The expert consultation aims to determine the extent to which 'circular strategies' (e.g., resource circularity, resource efficiency, and resource switch), 'innovation' (e.g., products, materials, technologies, business models, consumption patterns, and lifestyles), and 'enablers' (e.g., education/behavioral change, public policy, market) can facilitate development of the technical textile sector towards circularity.

Key initiatives supporting or strengthening circular strategies, innovation, and enablers in the sector will be discussed, especially in the following areas:

1. **Technology & Processing** including waterless dyeing, efficient dyeing solutions, circular textile (based on design of the fibre), less harmful dyes, recycling/upcycling, energy efficiency and switch, resource circularity, etc.
2. **Business models** including the exchange of used items, the sharing model, and the collection and sorting systems for recovered materials.
3. **Market & Behavioural Change** including awareness campaigns (for consumers and value change actors), market outlook, and sustainability trends.
4. **Policies & Regulations** including sustainable programmes, global ambitions & commitments, international and national regulations, etc.

OUTCOMES

Expected results of the expert consultation include:

- Better understanding of the critical factors and players facilitating circular technical textiles for Asian markets.
- Identified issues and factors for market transformation (policies, finance, technology development, etc.) towards sustainability and circularity in the technical textile value chain.
- Increased knowledge of key initiatives toward sustainable and circular value chain in the technical textile industry and understanding of how to scale up such initiatives through policy support and collaboration and partnerships.
- Increased collaboration between concerned partners.

TARGET PARTICIPANTS

Representatives from the manufacturers, brand owners, knowledge institutes, and development partners as well as respective staff of the Asian Development Bank and SWITCH-Asia Programme.

PANELIST PROFILES

Ms. Katharine Thoday
Principal Environment Specialist, ADB
Katharine is a principal environment specialist at the Asian Development Bank (ADB) who focuses on increasing public and private climate and nature positive investments in ADB operations. In support of ADB's Healthy Ocean Action Plan she has been developing opportunities in the regenerative aquaculture space as well as supporting the development of thematic bonds.

Dr. Sunita Dasman
Resource Efficient and Cleaner Production Specialist
An expert in textile quality, production, product development, R&D, and resource efficient and cleaner production (RECP) with years of management experience with the United Nations Industrial Development Organization (UNIDO) and the Indonesia Cleaner Production Center.

Ms. Piyaporn Phanachet
CEO, TCM Corp
TCMC is a global holding company investing in sustainable living related businesses, from upholstery (under Alexander & James, and Ashley Manor brands), carpeting and flooring (under the Royal Thai and Carpets Inter brands), acoustic surface, and automotive carpets and upholstery

Mr. Schle Wood
Founder, Pasaya
A socially and environmentally responsible Thai brand owner of healthy & green home textiles and lifestyle products with vertical inhouse R&D, manufacturing to marketing and retailing.

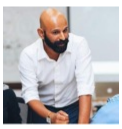
Mr. Chanchai Sirikasemlert
Executive Director, Thailand Textile Institute
Thailand Textile Institute (THTI) is a non-profit organization with a main duty to support and develop Thai textile and garment industries toward sustainable progress and competitiveness in the world market.

Mr. Supoj Chaiwilai
Executive Vice President, Thai Traffeta
Thai Traffeta is a vertical textile producer that employs eco-friendly business practices to make innovative fabrics for a variety of products (e.g., outdoor gears, sportwear, combat outfits, clean room outfits, life vests) for global brands.

Mr. Chaiyos Rungcharoenchai
CEO, Perma Corp.
Perma is a producer of functional fibers that have permanent anti-bacterial with environmentally friendly method for medical textile, hygienic wear, innovation home textile, and innovative food packing.

Dr. Raquel Prado
Head of Research and Sustainability, Ananas Anam
Ananas Anam manufactures and sells Piñatex. The company is orientated to ethical and responsible business practice. Ananas Anam meets the challenges of our times by developing products in which commercial success is integrated with, and promotes, social and cultural development.

Ms. Lei YAO (Gloria)
Director, Project Development, Hong Kong Research Institute of Textiles and Apparel
Hong Kong Research Institute of Textiles and Apparel conducts applied research to support the textile and apparel industry.



Mr. Venkat Kotamaraju
Director & Partner, Circular Apparel Innovation Factory (CAIF) and Climate Solutions, Intellecap
CAIF is an initiative that brings together a variety of stakeholders in the India's apparel industry to work toward a circular industry.

Ms. Thamonwan Virodchaiya (Amm)
Co-founder Moreloop Co.,Ltd.
A company with a vision to make circular economy a reality by managing industrial waste databased using digital platform as a tool. We curate quality surplus fabric from garments and textiles manufacturers, put them up online so others have chance to use an existing at it efficiency instead of producing new material.

Annex 3 – Details of the technical webinar on achieving circularity and sustainability in the technical textile sector

INFORMATIVE NOTE
Webinar

switchasia SCP FACILITY

Funded by the European Union

ADB

PROMOTING CIRCULAR ECONOMY AND SCP IN THE TECHNICAL TEXTILE SECTOR IN ASIA

17 OCTOBER 2022 | 14:00-16:00 (ICT) (GMT+7)

BACKGROUND

Technical textiles play an important role in our daily lives; they can be found in our homes, hospitals, sportswear, vehicles, buildings, and farms, among other places. A combination of technology and modern materials made technical textiles a viable option for a wide range of applications. However, the industry also has a negative social and environmental impact. The textile industry contributes roughly one-fifth of global industrial water pollution, employs a wide range of hazardous chemicals, and emits significant greenhouse gas emissions, particularly during the manufacturing and finishing stages. While the effects on the fashion industry are well documented, much less attention has been paid to technical textiles, which have seen rapid growth in recent years. This proposed webinar, co-hosted by the Asian Development Bank (ADB) and the EU SWITCH-Asia SCP Facility, will discuss current trends, drivers, challenges, and game changers for moving the technical textiles industry toward a circular and sustainable value chain, with a particular emphasis on identifying leverages and trigger points for sector-wide transformative change.

OBJECTIVES

The webinar aims to contribute to a deeper understanding of critical factors facilitating circularity of the technical textile sector in Asia. It will focus on the discussion of (a) circular-economy-related practices that contribute to the sustainability of materials and used in the region and (b) critical factors that influence the development of circular supply chains.

TECHNICAL BACKGROUND

Technical textiles often have greater performance characteristics than conventional textiles.[1] They are made from synthetic and natural fibers. The synthetic fibers used in these applications are produced by combining various natural fibers with special chemical processes to impart their new properties. These fibres have greater or different qualities than regular fibres, and as a result, they are widely used not only for clothing, but also for medical, automotive, home furnishings, construction, agriculture, and other applications.

1 Yet, with development of textile technologies in apparel sector, this difference might be minimal or non-existent. In some cases, it is reasonable to talk about application of textile materials to different areas rather than differentiating between technical and non-technical textile.

The market for technical textiles is expanding rapidly as a result of rising demand from both developed and developing nations, technological advances, and government investments. Global consumption of technical textiles was approximately 42 million MT in 2021 and is expected to reach 67 million MT by 2032, an increase of 59%. The global technical textile market size is projected to grow from USD 164.6 billion in 2020 to USD 222.4 billion by 2025, at a Compound Annual Growth Rate (CAGR) of 6.2% between 2020 and 2025.[2] *Technical textiles are projected to account for about 43 percent of global textile sales by the end of this decade.*

Europe is the largest consumer of technical textiles, followed by North America, while consumption in large Asian markets, such as China and India, is primarily for medical, infrastructure, and construction applications. Medical applications are one of the primary drivers of demand and consumption of these textiles in the European Union countries and the Asia-Pacific Region. Since the onset of the Covid-19 pandemic, the demand for medical textiles has increased significantly, and this trend is anticipated to continue in the coming years (See Box 1).

Box 1. Impact of pandemic on growth in technical textile

The COVID-19 pandemic has affected the textile industry's demand and supply. The chemical industry supply chain has been severely disrupted, which has had a significant impact on the procurement of raw materials for technical textiles. However, the pandemic also caused a sudden increase in demand for gowns, masks, and others, which had a positive impact on the demand for medical textiles (Medtech). As a response to the pandemic, technical textile manufacturers around the world are increasing their production capacity and investing in machinery to produce healthcare essentials. Demand for disposable hospital supplies and nonwoven materials is projected to rise from 2020 to 2025 due to an increase in the number of cases worldwide and the need for more healthcare professionals. Hygiene is anticipated to be the largest application segment in the technical textile market over the coming years due to continuing COVID-19 spread. Nonwovens are used as an alternative to conventional textiles in hygiene products due to their superior absorbency, softness, smoothness, strength, comfort & fit, elasticity, and cost-effectiveness

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2 www.marketsandmarkets.com

SCOPE

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AGENDA

Time	Programme
14:00 (GMT+7)	Welcome
14:05 (10 min)	Overview of the technical textiles sector
14:15 (10 min)	Challenges, drivers, and trend setters in the technical textile sector
14:25 (10 min)	Circularity economy and sustainable production and consumption concepts explained
14:35 (35 min)	**Panel Discussion I:** Critical factors in technological innovation and business approaches toward a sustainable and circular technical textiles industry
15:10 (35 min)	**Panel Discussion II:** Policy framework and innovation ecosystems for more circular and sustainable technical textiles
15:45 (5 min)	Final Thoughts
15:50 (10 min)	Wrap and closing remarks
16:00	Event closes

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