



**STRENGTHENING THE RESILIENCE OF
TEXTILE, AEROSPACE, AND CONSTRUCTION
SMES TO TRANSITION TOWARDS GREENER
AND MORE DIGITAL SECTORS WITH SOCIAL
AND BUSINESS INNOVATION**

Grant Agreement number 101091494

***Deliverable D1.1 – Report on preparatory activities including mapping, need
analysis and tools developed***

Lead partner: CCS

Project acronym:	In Transit
Project full title:	Strengthening the resilience of textile, aerospace, and construction SMEs to transition towards greener and more digital sectors with social and business innovation
Grant agreement no.:	101091494
Author(s):	CCS
Reviewer(s):	ATEVAL, POLIMI, TUS
Nature:	Report
Dissemination level:	PUBLIC
Total number of pages:	70
Version:	1.0
Publication date:	31/05/2023

IN TRANSIT has received funding from the European Health and Digital Executive Agency (HADEA) under grant agreement no. 101091494

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1 EXECUTIVE SUMMARY

In Transit aims to strengthen the resilience of textile, aerospace and construction SMEs towards greener and more digital sectors with social and business model, with a mixed support mechanism including individual assessment support and a lump sum and coaching to ensure their consolidation and sustainability. In Transit will provide an open online collaborative platform involving innovation actors from the aerospace, construction, and textile sectors that will serve as a space for sharing best practices and as a matchmaking system for new ideas for innovation and circular economy and new collaboration partnerships.

WP1 aims to establish a comprehensive framework that enables SMEs to overcome technological barriers and foster the development of innovative business models in line with the principles of the circular economy.

The key role of WP1 is to devise effective tools and methodologies that provide a clear roadmap for companies to design, validate, and implement circular ecosystems. These ecosystems are characterized by sustainable solutions facilitated by the integration of digitalization tools. By leveraging these tools, SMEs can create business models that align with circular principles and promote long-term environmental sustainability.

The present document compiles the main outcomes regarding:

- Assess industry needs and offers: Surveys conducted among European SMEs to identify areas for improvement and tangible targets for circular, digitalization, and sustainability
- Engage citizens, public authorities, and academia. Analyse perceptions and motivations related to sustainability and circular economy. Identify good practices for accelerating circular economy implementation
- Develop diagnostic tools to help companies understand digital priorities and starting points. Explore how digital technologies contribute to economic growth and employment.

These tasks aim to assess industry needs, involve stakeholders, and provide tools for companies to enhance circularity, digitalization, and sustainability in their operations.

The deliverable presents a mapping of four sectors with basic insights in the future developments and action's needs. Sectoral reports integrated the results of the survey and desk Studies for the addressed sectors.

The present deliverable is developed within the framework of the Work Package 1 – Framework set-up and preparatory activities with CCS as Work Package leader.

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1 INTRODUCTION

1.1 In Transit Project summary

European construction and textile industries are seeking to embrace new market opportunities to grow and increase their competitiveness through the creation of high-added value products, which is particularly relevant in this unprecedented time.

In Transit will provide dedicated support to SMEs through a combination of different mechanisms to enable cross-sectoral and cross-border innovative activities. In Transit will facilitate the uptake of advanced manufacturing technologies as part of the digital transition of the textile construction and aerospace industries.

The consortium partners that bring this cross-regional partnership to life have an extended network, which comprises seven innovation clusters from advanced manufacturing, construction, and textile industries, one business incubator and accelerator, one university and one research centre.

In TransitIn TransitIn TransitIn Transit

Participant Organization Name	Country
ATEVAL - Asociación De Empresarios Textiles de La Región Valenciana	Spain
AEI Tèxtils - Associació Agrupació d'Empreses Innovadores Tèxtils	Spain
CSS – Slovenski Gradbeni Grozd, Gospodarsko Interesno Zdruzenje	Slovenia
ATHENA/CORALLIA - Athina-Erevnitiko Kentro Kainotomias Stis Technologies Tis Pliroforias, Ton Epikoinonion Kai Tis Gnosis	Greece
FCTA - Fundación Corporación Tecnológica de Andalucía	Spain
TUS – Technological University of the Shannon: Midlands Midwest	Ireland
POLIMI – Politecnico di Milano	Italy
SPG - Science Park Graz GmbH	Austria
PRODUTECH - Associação Para As Tecnologias De Produção Sustentável	Portugal
IRT JULES VERNE – Institut de Recherche Technologique Jules Verne	France

The consortium will capitalize on their ecosystems and their strong networks and partnerships across Europe and their participation in other European projects.

The In Transit project enables SMEs to benefit from the rise of sustainable and innovative business models and practices. The Project can significantly disrupt business practices by merging advanced technologies and contributing to a more sustainable eco-system. In Transit offers services leading to digital uptake towards more sustainable production patterns, connecting SMEs with innovation networks and digital solutions providers to assess them about the system that better suits their circular business model. The Project will collaborate with SMEs, connecting them with innovation, knowledge networks, and digital solutions providers with a multi-sectoral approach.

In Transit members can offer cross-border high-level expertise in various domains of competence. Moreover, In Transit is a bridge to connect SMEs with other relevant stakeholders in Europe (technology clusters, digital innovation hubs, open innovation test-beds) with whom close connections are already established.

2 ASSESSMENT OF INDUSTRY NEEDS AND OFFERS

2.1 Survey design

Within the In Transit project, we launched a [Industrial Survey](#) within clusters' members to identify the main needs of each sector in order to better design the project activities, support mechanisms and services that will be supported via In Transit calls. In this chapter we present the outcomes and conclusions from the survey.

2.1.1 General statistics: participants of the survey

We received responses from 8 EU countries, with 96% being SMEs,

With the majority of participants being SMEs (under the terms of the EU definition), but mainly cluster members, active in innovation, we can assume they are aware of the challenges for all four addressed sectors. Since the respondents are SMEs active in innovation, the survey among general “population” of businesses in these sectors would probably show different picture, even having a challenge of addressing particular questions. This is the reason that we have taken into account also answers from other surveys, to more clearly define the needs and challenges of three sectors.

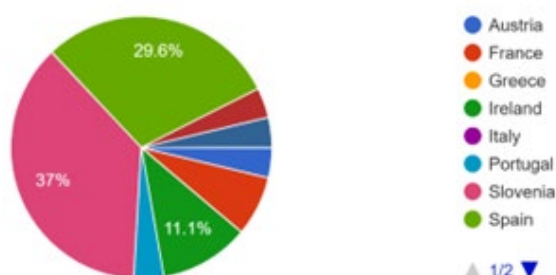


Figure 1: Countries of respondents

Responding SMEs are active in textile, construction, aerospace or providing advanced manufacturing technologies or other solutions for these three sectors.

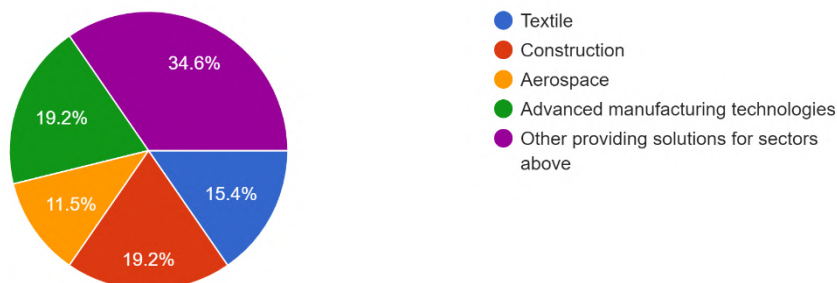


Figure 2: Main activities of respondents

2.1.2 Mapping of need and expectations for circularity, digitalization, and sustainability

The respondents were asked to map how they address in general the circularity, digitalization, and sustainability, which were described as follows:

Indicate the progress in three domains indicated



Figure 3: Progress toward circularity, digitalisation and sustainability

The responses show that digitalisation is already being implemented or it is core of the business strategy (81%), which can be expected due to fact that many supporting organisations for textile, construction and aerospace are from IT field, or their technologies are IT supported. The same percentage of respondents are also planning and implementing activities in regard the sustainability. The SMEs address the circularity in planning and implementation in a few processes. Just 11% are putting this in the core of their business.

The answers for pains and gaps on circularity show that all listed pains and gaps are moderate to very strong, with knowledge/skills, financing, innovation/technologies, and regulation to be more challenging. In other pains/gaps the Chinese low-cost competition, eco-design, regulations and practical steps to implement circularity were mentioned.

Indicate the level of gaps and pains for circularity in specific internal and external domains

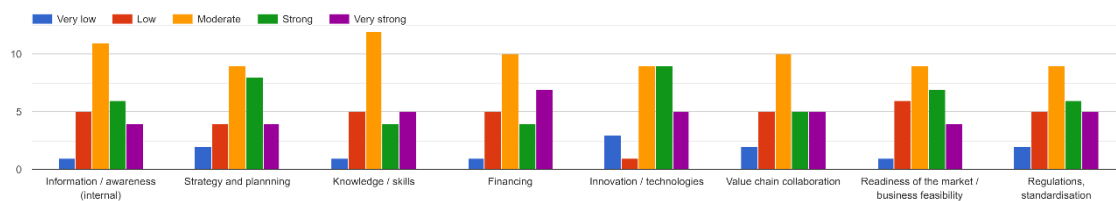


Figure 4: Pains and gaps on circularity

The answers for pains and gaps in digital transition show that all listed pains and gaps are moderate to very strong. Knowledge/skills was indicated as low and moderate (60%), financing being moderate to very strong (85%), and market readiness/business feasibility as strong (40%) to very strong gap (11%). Value chain collaboration was also indicated as low and moderate, so this is the field to leverage in next innovation steps.

Indicate the level of gap and pains in digital transition in specific internal and external domains

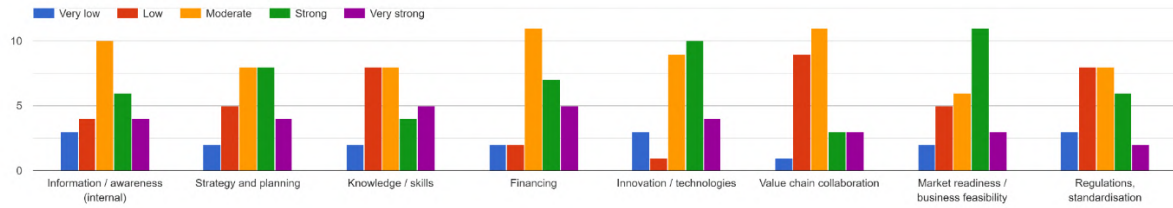


Figure 5: Pains and gaps in digital transition

For sustainability, the financing is moderate to very strong pain (81%), and the innovation/technologies being even more challenging. Readiness of the market and business feasibility was for half of the respondents a moderate gap, and for 33% of them strong to very strong challenge. This indicates that a promotion of best practices in sustainability is needed. Market growth, and digital platforms for making businesses aware of available circular and sustainable solutions are needed, too.

Indicate the level of gap and pains in sustainability in specific internal and external domains

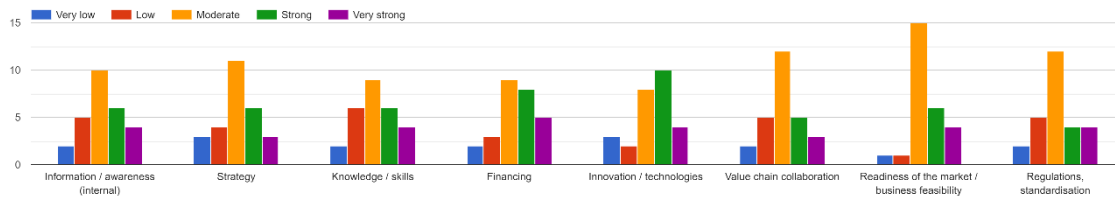


Figure 6: Pains and gaps in sustainability

2.1.3 Relevance of In Transit support services

The second group of questions was about the planned services within In Transit project, in different schemes of the support.

For the In Transit support services being foreseen in INCUBATE – joint services for incubating cross-sectoral innovation - open cross-sectoral innovation space (OIS) and learning expeditions (LE)), a strong and very strong relevance was on SMEs profile promotion and networking, learning expedition to view used case, and for matchmaking and related travel voucher to support these actions. We can conclude that SMEs are highly interested to meet, network and exchange best practices, to learn on relevant real-life application of circularity, sustainability and digital transition. This also reflects the gaps and pains in the market development, which was the question in previous series of questions, Additionally, among missing services, the development of new sales channels (market development for circular, sustainable solutions) was mentioned by respondents.

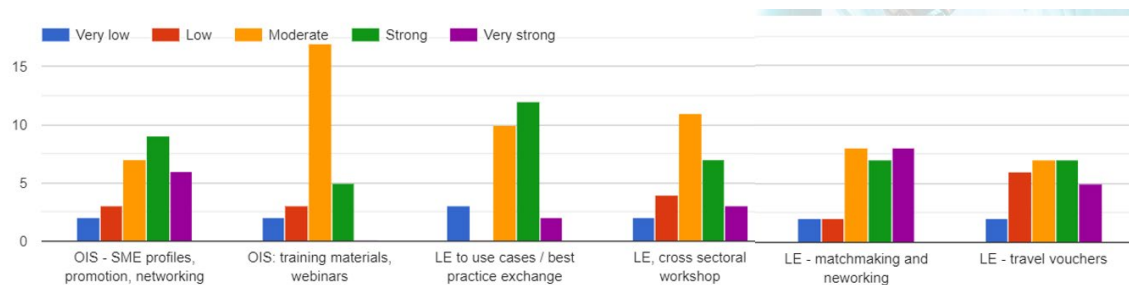


Figure 7: Relevance of the In Transit support services in INCUBATE

The main In Transit services provided via open calls will be within the INNOVATE call - customized advisory services to participant SMEs, helping them analyse their lineal business model, and identifying new market opportunities provided by digitalization and circular solutions.

Funding – leveraging public in private funding was the main service on the list, being indicated as strong or very strong by 65% of respondents. The second field of relevant services are related to technology identification and search of partners to support the SMEs. And the third most relevant services are the learning/adopting from digital and circular case studies, and related manufacturing and process optimisation.

Indicate the level of relevance of listed INNOVATE call support services: Customized advisory services to participant SMEs, helping them analyse their lineal business model, and identifying new market opportunities provided by digitalization and circular solutions

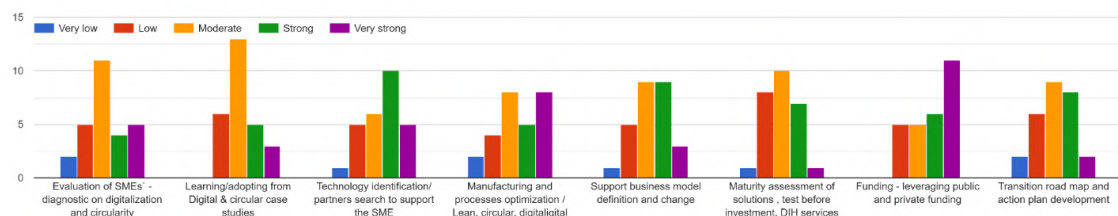


Figure 8: Relevance of In Transit support services in INNOVATE call

For the question “Indicate the level of relevance of listed consultancy support services in addition to direct funding of SME projects (DEVELOP call)” the most relevant services are support to open innovation models,

which is continuity of answer fostering the collaborative innovation which was highly ranked in previous questions.

To promote the In Transit services linked to DEVELOP call, the list of foreseen services is provided, indicating the most interesting in bold, e.g. where more than 50% indicated this as strong or very strong relevance:

1.Support to Open Innovation models (52%)

2.Digital Evaluation and Mentoring - explore real-life case examples

3.Become digital/circular champions for SMEs – guidance

4. New Business Modelling. Approach towards resilience and growth through digitalization and sustainable practices- (52%)

5. Green and digital academy to continue to support SME evolution

6.New commercialization opportunities (59%)

7.Adopt space technologies in non-space markets

8.Identification and specification of technologies to be exploited (as products and/or services), customers/users' implementation, and adoption.

9.Description of a value proposition (targeted customers, price, market entry barriers, competitive advantage)

10.Price & cost analysis (investments, resources, partnerships, structures, etc.)

11.Management risks assessment

12.Access to partners testing facilities to demonstrate concepts and impacts

13.Access to partners testing facilities to experiment with new materials and technologies

The same pattern appears, e.g., searching for partners and open innovation opportunities, defining the business models for commercialization of developed solutions, and fostering the market for these novel circular, digital and sustainable solutions.

Among the listed services in SCALE-UP support services, the most interesting (strong and very strong relevance beyond 40%), are

1.Mentoring for the large-scale demonstration and plan the needed tools, pilots and network towards scale-up tools and network towards scale-up

2.Tools and network towards scale-up

3.Coaching on investment and fundraising with private investors for funded projects

4.Coaching to foster cross-border networking among beneficiaries

5.Leveraging the different regional and European funds (ESIF, HE, COSME, LIFE)

6.Internationalisation - scale up to global markets

7.PiTextileh to share best practices and success stories at the In Transit final event.

The results show great interest for mentoring to scale and large-scale demonstration, and to bring solution to new markets, also on global market, including third countries.

The next question was addressing capacity building - specific joint webinars and trainings to be implemented. Since skills gaps were identified in different studies presented in the next chapters of this deliverable, a special question was devoted to this topic. This refers also to mapping, planning and implementing the capacity building activities as one of the key elements of resilience and recovery plans of industries in addressed sectors of In Transit project. **This is the reason we are presenting and promoting the list of services and activities relevant for SMEs and other businesses in textile, aerospace, construction and advanced manufacturing sectors.**

The respondents indicated strong very strong relevance of the following training fields:

- Advanced Technologies for specific sectors: applicable technologies examples
- Lean management and manufacturing
- Identifying Sources of Funding

The results show that training should be more oriented to industry specific technologies, lean management, and of course to learn how to find the appropriate sources of funding for innovation.

2.2 Relevance for development and market application in textile, construction, aerospace and advanced manufacturing

Within the next questions respondents were asked to indicate the level of relevance for development and market application in textile, construction, aerospace and advanced manufacturing. They were also asked to write any other topic of their interest beside the ones suggested by In Transit. To use this document to promote topics of green and digital transition, important in the resilience and recovery plans of SMEs in addressed sectors, the topics listed in the call are presented below.

TEXTILE circularity, digitalisation and sustainability - innovation and solutions

The topics indicated High, or Very High) are highlighted in bold text.

1. **Longevity and durability: selling durable textile products, focused on delivering longer product lives, for example, by using sturdy, high quality materials and repairable designs**
2. Access-based models, based on renting and leasing (business-to-business/business- to-consumer) or sharing (mostly consumer-to-consumer)
3. Textile collection and resale
4. **Recycling and material reuse**
5. 3D virtual fabric and fashion design (3/8)
6. **Remote monitoring and assisted maintenance, IoT and digital twins (4/8)**
7. **Supply-chain data integration**
8. Virtual showrooms, direct-to-consumer made-to-measure, and made-to-order business models
9. **Big data analytics and machine learning, extended reality, blockchain for supply-chain trustful interactions, NFTs, and other distributed security systems (5/7)**
10. Extended reality
11. Blockchain for supply-chain trustful interactions, NFTs, and other distributed security systems (3/7)
12. Buildtech
13. Geotextile: is a synthetic permeable textile material used to improve the soil characteristics
14. Nano-tex

Because of small sample of respondents, and the fact that SMEs in digital domain contributed to answers on IT support, it is clear, that topic were very concrete and the interest was narrowed to fields which are directly interesting for particular company. There were just to additional topic suggested, that is sustainable pharmaceutical, and sustainable chemicals to be research in textile sector.

CONSTRUCTION: circularity, digitalisation and sustainability - innovation and solutions

1. **Circular design solutions for future disassembly, reuse, flexibility, adaptability...)**
2. **Reuse, recycle waste from construction, demolition, other waste**

3. Advanced building materials to improve the performances and offset the non-circular performances
- 4. Nature based materials and solutions, biobased materials**
- 5. Circular business models / value chain, including cross sectoral ones**
6. Offsite Construction (e.g. prefabrication or modular systems)
- 7. Digitalisation of processes and virtualisation (building as data base, digital twins, BIM)**
8. Construction Robotics
9. 3D Printing / additive manufacturing
- 10. Net zero buildings / decarbonisation fostering circularity**

AEROSPACE: circularity, digitalisation and sustainability - innovation and solutions

- 1. Advanced design technologies**
2. Digital assistants
3. Augmented reality (AR) and virtual reality (VR)
- 4. New manufacturing materials**
- 5. Collaborative robots**
- 6. Advanced computing capabilities**
- 7. Zero-Fuel Aircraft**
- 8. Structural Health Monitoring (SHM)**
9. Additive Manufacturing (3D Printing)
10. Utilizing Internet of Things (IoT) to Anticipate Maintenance Issues

The responses in aerospace show higher relevance of innovation related to advance technologies compared to textile and construction. This can be used as a basis for fostering exchange of best practices from aerospace to textile and construction as this is one of the aims of the In Transit project.

ADVANCED MANUFACTURING: circularity, digitalisation and sustainability - innovation and solutions

All suggested topic in this field were indicated as relevant. The most relevant (high, very high relevance) are the following (marked bold):

1. Integrated Supply-Chain
- 2. Digital twin (Product and Process)**
- 3. Robotics and automation**
4. Artificial Intelligence
5. Extended Reality

At the conclusion, all respondents provided their contact data to be informed about the future steps in In Transit project.

2.3 CONCLUSION, OPPORTUNITIES, BARRIERS, RECOMMENDATIONS

Summing up the survey results and the market studies, it became clear, that there are several potential cross-sectoral collaboration opportunities, and many within the target sectors.

The responses show that digitalisation is already being implemented or it is core of the business strategy (81%), which can be expected due to fact that many supporting organisations for textile, construction and aerospace are from IT field, or their technologies are IT supported. The same percentage of respondents are also planning and implementing activities in regard the sustainability. SMEs are less active in the circularity, e.g., circular transition.

The main pains in digital and circular transition are related to skills and financing, whereas low market readiness is also indicated as a challenge.

In regard to relevance of In Transit support services in INCUBATE, we can conclude that SMEs are highly interested to meet, network and exchange best practices, to learn on relevant real-life application of circularity, sustainability and digital transition, and in any actions supporting market development and options to foster commercialisation of solutions.

In regard to main In Transit services provided via open call INNOVATE, some of them were indicated as highly relevant: Funding – leveraging public in private funding was the main service on the list, being indicated as strong or very strong by 65% of respondents. The second field of relevant services are related to technology identification and search of partners to support the SMEs, which is well correlated with previous answers.

For the question “Indicate the level of relevance of listed consultancy support services in addition to direct funding of SME projects (DEVELOP call)” the most relevant services are support to open innovation models, which is continuity of answer fostering the collaborative innovation which was highly ranked in previous questions.

Among the listed services in SCALE-UP support services, the most interesting (strong and very strong relevance beyond 40%, are:

- Mentoring for the large-scale demonstration and plan the needed tools, pilots and network towards scale-up tools and network towards scale-up
- Internationalisation - scale up to global markets.

The results show that training should be more oriented to industry specific technologies, lean management, and of course to learn how to find the appropriate sources of funding for innovation.

In regard to the relevance for development and market application in textile, construction, aerospace and advanced manufacturing, some of the topics we more interesting that the others, depending on the person answering. Similarly, as for capacity building, the topics suggested are the ones seen as important in the resilience and recovery plans of SMEs in addressed sectors. The answers indicate where we can expect more applications for the DEVELOP call.

3 SECTORAL REPORTS

3.1 Overview

It is of crucial importance to understand the changes that the industry is facing as well as the impact of information on the readiness of the business to move to a new economic and business model. In Transit compiled information from survey conducted, and from other resources into sectoral reports that could serve as a gateway to green and digital transition, to enhance the circularity of products and associated value chains thanks to the identification of hotspots and areas for improvement and defining tangible targets for circular, digitalization, and sustainability.

3.2 Textile

3.2.1 Textile sector overview

The European twin transition (green and digital) involves opportunities and challenges that Europe will face in the near future. Especially for what concern textile (TEXTILE) sector, EU recognized the strategic role of this specific economic field. Indeed, EU has the ambition to stand as a leader in sustainable textiles; especially by focusing on innovation, quality and sustainability of the material used. Another aspect to be taken into account is the importance of European competitiveness through a more efficient EU textile industry. This means improving the green and digital skills of the workforce. The main goal is to make growth the EU global market share, pushing the open markets, with the aim of promoting a free and fair competition, where the EU companies will have comparative advantage.

3.2.2 Challenges and needs of textile sector

As pointed out in the results of the In Transit survey among SME, the textile sector shares the challenges of green and circular transition, skills and human resources, need for innovation and collaboration, and more market opportunities for sustainable solutions. In addition, results of survey within the textile show the challenges in the following fields:

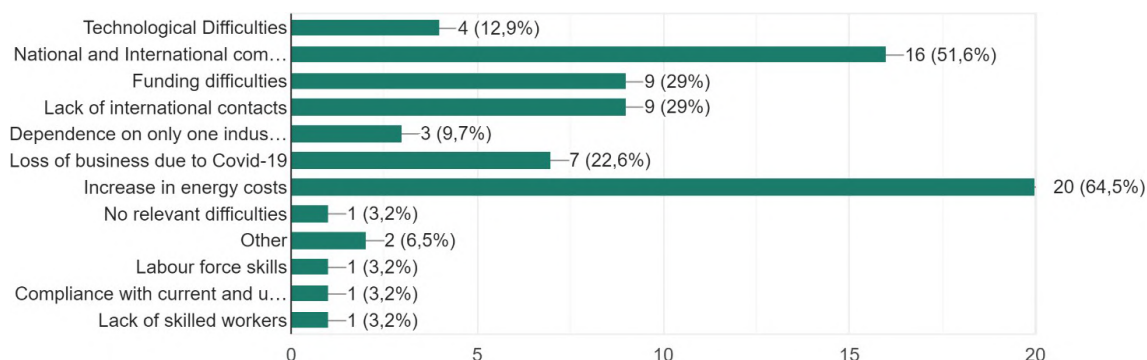


Figure 9: Current major pain points, from textile sector

Companies are facing constant and unplanned increase of the energy costs, with consequences that fall also on the costs of raw materials. It is currently impossible to foresee how soon prices will stabilize and return to their initial levels.

Overcoming such unpredictable task related to the energy costs, companies are also facing an increasing national and (mainly) international competition.

EU companies are threatened by the entry of new players and new countries that joined such an attractive market. In this sense, chronic problems have been brought to light: limited supply network, lack of international contacts, exports focused mainly on EU and lack of attractiveness by youth.

All companies aware of the opportunities that the global market can offer, but the most important gap for them is to find the best way to join. The gap is not only related in how to enter, but also in what to do when they are in. Experts highlighted the need to facilitate the access in new markets and broader contact to new suppliers and customers. In this sense it is important for companies not to play autonomously, but act as network and cluster. Cluster can offer a customized service to facilitate the access of EU companies in these markets, providing also qualified contacts and relevant market information, and report about financial and technical opportunities within European project.

The first step, and maybe the most difficult, is to start a pathway to change the mindset and prepare companies to embrace the new concept of textile industry.

In respect to the needs, such activities may range from technologies and IT solutions, to green transition and circular economy, passing through scouting of public fund, legislation and standards for new products.

It is important provide companies digital solutions, eco-design skills and circular economy practices to make more resilient, unlock new business opportunities and drive them into a new phase of textile industry.

In order to overcome such obstacles and turn into opportunities, EU companies would need marketing and financial support to set up a roadmap and explore the chance offered by the global scenario. This support could enable EU companies also to overcome current challenges namely the entrance to new market sectors, the needs of new advanced manufacturing methods and enhanced customer's requirements.

Finally, it is important to consider the general obstacles and the difficulties that companies are experiencing. The sector faced several challenges over the recent years and even tougher challenges are already coming.

The results of survey within the textile show some sector specific challenges.

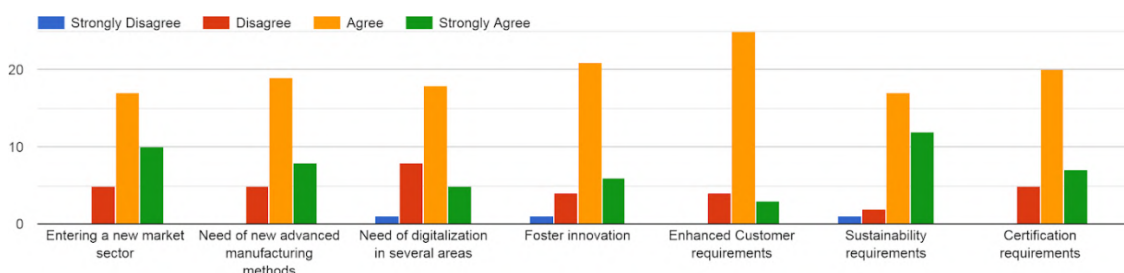


Figure 10: Challenges SMEs face in the near future

According to the graph, the areas in which companies will find greatest challenges concerns with the new customer requirements and consequently, with foster innovation. Other challenges deal with the definition of new manufacturing methods, digitalization, green and sustainability requirements.

Legal difficulties and Bureaucracy

Inefficient bureaucracy and legal technical aspects create a high-cost economy and decrease investment in which eventually it may obstruct the economic growth. Constraints really emerged during the recovery measures, but the problem is structural and affect both daily activities and planning investments. SMEs cannot manage internally such effort and legal obstacles risk outweighing the opportunity offered.

3.2.3 Textile - digital transition

The primary driver of growth in the coming year for Textile sector will continue to be the digital solutions for new models in manufacturing and logistics processes, in the supply chain management and in selling channels.

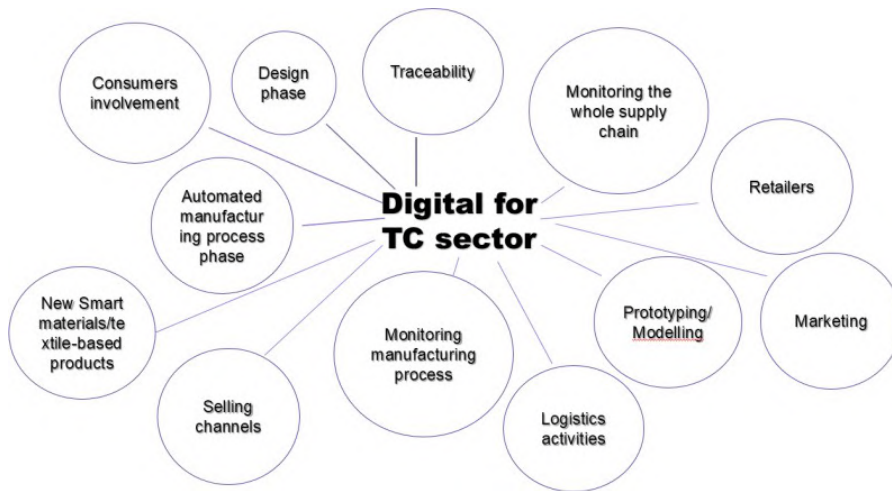


Figure 11– Opportunities of digital for TEXTILE sector

The digital transition in Textile means working on advanced technology innovation to make production more precise, as well as more local and sustainable, combining production automation, product technology, big data, AI and machine learning as the main innovative tools. Potential benefits include higher speed, faster delivery times and lower costs, thanks to reduced shipping time and inventory, as well as better waste management and reduced production defects¹

The following advanced technological solutions are already entered in the market, but they need to be implemented in the next years.

Artificial Intelligence (AI) spending is expected to increase by 33% over the next five years, reflecting the growing recognition of AI's potential. While AI and automation have been seen as short-term solutions, they also offer long-term benefits. Companies that previously may not have considered adopting AI are now investing in these innovative systems to stay competitive. Machine learning algorithms are being widely adopted for real-time quality checks and accurate defect detection.

Technology for sustainability is nowadays particularly relevant for European Textile companies, which are looking for materials, fibres and techniques that are sustainable and functional. The biggest challenge should be the shifting to a circular supply chain, involving a recycling model where unused items re-enter in the supply chain to reduce waste. Furthermore, a variety of textile recycling technologies are under development, and they typically fall into two broad categories: mechanical recycling technologies (cutting, tearing and needling to remove non-textile components and recover material, fibres or fabrics) and chemical recycling (chemical treatments to dissolve and reduce textiles to their base and extract the useful components). Some advanced manufacturing technologies are already available to make the garment life

¹ "Updating the 2020 New Industrial Strategy: Building a stronger Single Market for Europe's recovery", European Commission, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, 2021

cycle more sustainable. Other alternatives include eco-friendly textile products, as for example recycled fibres and fibres extracted from agricultural waste products.

Wearable technologies are personal garments and accessories that incorporate advanced computer and electronic technologies and can therefore connect to the Internet. These products have found numerous applications in sportswear and in the health and wellness sector, driven by the ageing population and the increased focus on health and wellness. It's one of the main applications of the Internet of Thing (IoT). These innovation trends require collaboration, some major Textile companies have started collaborative projects with high-tech companies to develop new wearables. This is an important market that boosted competition from two main sources: market leaders interested in these products and high-tech and electronic giants have also plans in this field, but also new start-ups, operating in different fields such as clothing, digital technologies, and IoT.

The use of blockchain technology is already changing the apparel industry, offering new ways of implementing transparency in a supply chain. The main application in Textile sector is in the product traceability process and in preventing the sale of counterfeit goods. With blockchain, consumers would be more aware of the entire product's value chain, from the origin of the raw materials until the product on sale. This also means the removal of imitation products and a major concern about the environmental impact. Moreover, transparency and traceability help to build trust both for relations between company and consumers and between companies and their suppliers and/or distributors.

Nanotechnology is widely used in the textile industry in order to enhance textile attributes, such as fabric softness, durability and breathability, water repellence, fire retardancy, antimicrobial properties, etc.. in fibres, yarns and fabrics. Nanoengineered textiles are enabling the industry to give new functions to textiles and clothes.

Nevertheless, the digital revolution is also providing new solutions and innovations to the industry, as well as interrupting traditional business models. The convergence of **ICT and digital technologies, artificial intelligence, virtual, augmented, and mixed reality and 3D/4D printing** is set to interrupt the fashion industry. This trend is making textile interactive, changing consumer habits, and forcing companies to acquire new skills. So, the smart technologies and wearable apparel need good and attractive designs in the future years. Thus, this field represent a concrete business opportunity for European companies.

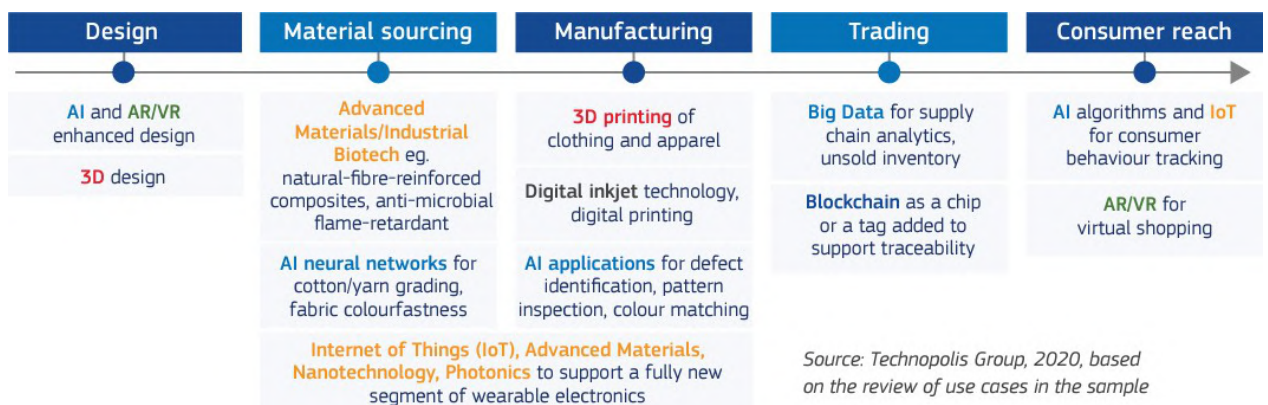


Figure 12– Use of advanced technologies throughout the textile industry value chain

The interaction of textile with the other fields of engineering is already leading to an increase in demand for new products and applications. Some examples are:

- High-Performance fibres are developed with unique properties to protect the body. Protection and survival in hostile environment can be linked to highly innovative and smart textiles. They usually have very high levels of at least one of the following properties: tensile strength, operating temperature, thermal stability at high temperature, flame retardancy or chemical and solvent resistance. These new fibres are a key player in several emerging markets for technical textiles and fibre-reinforced thermoplastic composites. Lightweight, high-strength and high-stiffness composite materials have been identified as a key cross-technology between the textile sector and several large industrial sectors aerospace, biomedical, civil engineering, construction, protective apparel, geotextiles and electronic areas.
- Functional solutions: processing fibres and textiles in specific ways to reach a highly purpose-targeted material property and new material functions are now one the main target of the innovative segment of textile sector.
- Smart materials and products: Sensing, actuation, power generation or storage, communication and a host of other functions have already been successfully integrated into many textile materials and products. The addition of intelligence to a textile-based product can start at fibre level and also at any subsequent stage of processing, manufacturing or assembly of the final product.

3.2.4 Green transition and circular economy in textile

Aligned with EU policy, many countries have committed to a sustainable recovery from the crisis and have included “green” initiatives in their stimulus packages. Although the green transition represents a substantial opportunity, the ecosystem consists mainly of SMEs, which need concrete support to comply with sustainability requirements. As mentioned, achieving sustainable textile will require new business models and approaches.

Recent reports from European Environment Agency and World Economic Forum identifies new circular economy business models for textile products.

Longevity and durability. The first rule of good waste management and the circular economy is preventing waste in the first place. Clothes need to be designed with the circular economy in mind, to make them more durable in terms of physical and emotional durability (e.g. through timeless design), to allow for greater use and cleanliness. This means use of robust, high-quality materials and repairable designs for products, often combined with offering consumers maintenance and repair services. As part of these models, some companies offer long-term warranties that include free repair or replacement of a product, or instructions for repair or recycling. The key is to offer products that are physically durable and timeless in design, so that they are not dependent on the fashion of the moment.

Access-based models, also referred to as “product as a service”. The customer purchases a service for a limited time while the provider maintains ownership of the product and remains incentivized for the product’s ongoing maintenance, durability, upgrade, and treatment at the end of its use. “Product as a service” shifts focus from volume to performance, thus maximizing the usage factor. These business models could increase the number of garments worn by renting, leasing, and sharing clothes. Some brands already offer clothes as a service, other companies offer clothing subscription services, where consumers pay a monthly fee to rent a fixed number of garments at a time, allowing them to change their wardrobe frequently without buying new clothes.

Collection and resale of textiles. In this specific case, companies can collect their own brand of clothes for resale in their shops and e-commerce (mainly) and ensure that they are recycled properly. Alternatively, they can organize the collection of used clothes, regardless of brand, to resell on global second-hand markets. The second-hand market is expected to hit \$64B in 2024, overtaking the tradition thrift and donation segment. Resale, vintage fashion, or the second-hand market are not new concepts, however, its hybrid

approach with technology certainly is. In the last decade several platforms and online consignments have grown a selective or massive clientele willing to buy, trade, or sell their clothing. In this context, with the ease of e-commerce, peer-to-peer exchanges, or even auction services, the consumer has found a valuable offer of clothing and accessories to buy compared to the full-price market. Additionally, when consuming second-hand, the customers are cultivating a responsible commitment to sustainability and curbing wasteful consumption.

Material recycling and reuse for remanufacturing (reuse of textiles to produce new items, also known as “upcycling”) or for recycling textile fibres. It focuses on the end stages of the usage cycle, namely the recovery of embedded materials, energy, and resources from products at the end of use that are no longer functional in their application. Several companies use these business models as a key component of their branding. Smooth C2C e-commerce services make it easy to give a new lease of life to products no longer needed. To support these companies, EPR (Extended Producer Responsibility) schemes can be introduced, which make manufacturers and importers legally responsible for ensuring that used clothing is reused or recycled, with companies organizing their own programs or contributing financially to an accredited collectively responsible organization.

Textile waste consortia-platform for the collection and treatment of pre and/or post consumption textile waste. Consortia may be representative by public authorities or also private companies including textile industry stakeholders, brands, manufactures, innovation. In both cases, actors will have the possibility to close the loop on textile waste giving the possibilities to waste to have a second-life. The consortium guarantees not only an efficient end-of-life product management service, but also solution, consultancy and training. With respect with the latter, educational activities are essential to drive companies and final consumers’ behaviour to correct handling and management textile waste.



Figure 13– Main technology groups across the textile value chain

Adopting these new business model and shifting to a circular economy the following benefits can be achieved:

- Transform current throwaway economy, eliminating waste and pollution, and circulating resources
- Tackles climate change and biodiversity loss simultaneously
- Separate the ability to achieve economic growth from the consumption of natural resources
- Create jobs, prosperity and resilience while cutting GHG emissions, waste and pollution
- Present a business case for each sector to be more sustainable while increasing competitiveness.

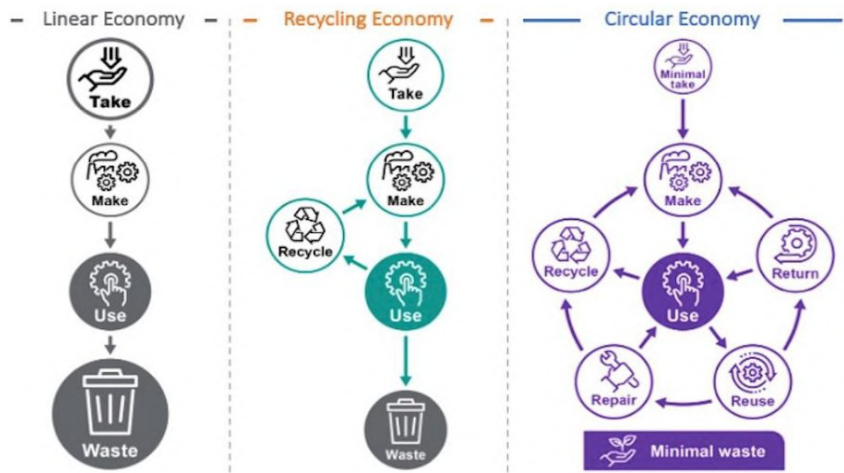


Figure 14: Transition from linear to circular economy

3.2.5 Priorities

The priorities regarding near-future are included in 3 main areas:

Industrial Transition

The IT solutions will be the core of the new industry, and this will help to accelerate and improve work processes and also to shift into a greener and more sustainable production. Companies cannot afford to lag behind and skip the “Digital and Green Revolution”. Become a leading and recognized Tech Company and shift into environmental pioneer of textile industry are the core element to become and remain competitive.

Training and Upskilling

Companies must become more attractive and hiring qualified profiles with targeted knowledge. In parallel, priority for companies is also to enhance internal resources. This implies significant investment in training and upskilling initiative. A relevant aspect is the adequacy of the training to the current reality of the sector, mobilizing the various national and international agents of the innovation system (public administration, universities, research centres, business associations and companies), to establish and execute the envisaged strategies, to allow the Textile sector competing in the global market. The technical and cultural refresh must involve all the internal resources, with particular focus on management and leader position.

Synergies and Cooperation

In analysing the European Textile sector, we cannot disregard its main structural feature: the prevalence of SMEs. If this was one the elements that allowed EU companies to become leader the global context, now it can be an obstacle and some corrective measures must be implemented. Companies cannot afford to act independently, no more, not only. A key priority in the globalized market is the synergy between companies. Each company can adequately develop its knowledge, products and/or services with the contribution of the knowledge and services and products of the other companies. To this end, it is very important to replace relationships based solely on empathy and/or the economic advantages of the moment, to partnership and network with supplier, technician and all operators of the value chain in general. Thus, the priority for companies becomes to fit into a structured network being part of clusters and bridge the gaps that internally and independently they would not be able to overcome: access to new markets, innovative solutions, qualified stakeholders, funding opportunities, cross-sectoral collaboration, marketing support.

3.2.6 Overview of the Aerospace sector

Civil aeronautics has been defined by the Aerospace and Defence Industries Association of Europe (2020) as “the civil aeronautics sector includes all certified flying objects, manned and unmanned, along the life-cycle, i.e. the complete range of categories of commercial aircraft, business jets, regional jets, general aviation, [...], as well as a broad range of transport aircraft and rotor-wings, training and simulation services, Maintenance Repair & Overhaul (MRO) and air traffic management ground systems [1].

Hardly any other industry has been as severely affected by the COVID-19 pandemic as the aerospace industry. The unprecedented crisis has led to a sharp downturn of the world economy and especially the aeronautics sector is affected because global and regional air travel restrictions lead to an almost stop of the passenger air transportation. Besides the COVID-19 crisis the recent climate change discussion created enormous pressure on all air traffic participants. It became clear, that aircraft must become more climate friendly and therefore more fuel-efficient and lighter. However, the current situation offers the opportunity to explore new smart industrial innovations and to accelerate the development towards sustainable green technologies.

Due to the COVID-19-epidemic and the associated global and regional air travel restrictions, a decline of 59% in world total passengers transport can be witnessed in the year 2020 [2]. Within Europe, the domestic and international passenger & cargo flights were reduced by 51,88 % (in high times even by around 90%), corresponding to a reduction of approximately 4. Mio flights compared to 2019 [3].

While some European airlines went bankrupt, others are restructuring their fleet by reducing aircrafts or by replacing old aircraft by new and more fuel-efficient ones. Airlines ground a high percentage of their fleet and still suffer dramatic losses of revenue. As a consequence, many airlines either cancel or postpone orders, with an immediate effect on the entire civil aviation industry value chain. Experts preview a drop of aircraft deliveries within the next years. Until September 2020, Airbus has delivered a total of 341 aircraft, which is a reduction of around 40% compared to the same period in 2019 and still has the comfort of a huge backlog (7,441 aircraft) [4]. Particularly suppliers with high dependency on aircraft manufacturers are struggling under these circumstances. Government policies and support as well as national funding programs might support suppliers in short term, but the risk not to survive this crisis due to a weak financial situation, or by losing critical workforce of highly skilled employees, is real. This may cause severe problems for the whole supply chain, offering on the other hand opportunities for companies entering new in the sector. Present forecasts predict a full recovery of the sector (in best case) by end of 2023.

The European civil aeronautics sector

During the last decade, the rush for increasing production rates has been in the focus of aircraft manufacturers and the whole supply chain within the aeronautics sector. It became apparent that the civil aeronautics sector should invest more in areas like full deployment of digitalization or smart automation technology. As aircraft manufacturers and suppliers have temporarily reduced production rates to adapt to the lower market demand, this situation now offers the possibility to take a breath in the race for production, to rethink their business model and to use their personnel for other activities [5]. The current situation should represent an opportunity for the sector to invest in the future, by pushing innovation and by using advanced and smart technologies.

Aeronautics value chain

The civil aeronautics industry can be characterized as one of the EU's key high-tech sectors on the global market [6]. In 2019, more than 405.000 highly qualified employees have been working across Europe in the

sector, making the civil aeronautics sector one of the world leading industries in providing employment, innovation and economic growth [6]. In 2019 the growth trend of recent years within the sector has continued. The annual revenue in 2019 generated by European companies within the civil aeronautics industry has increased by approximately 40% in comparison to 2010 - generating EUR 178 billion in revenue [7].

The exports of the civil aeronautics industry provide an important net trade balance to the European economy. In 2019 the export share of the whole European aeronautics sector increased to 83%, generating around EUR 109 billion [6].

Europe is home of some of the largest companies within the industry. Particularly, it is home of one of the two leading aircraft manufacturers worldwide – AIRBUS. In 2019, the company generated more than EUR 70,5 billion in total revenue out of all European production sites with a global order book value of EUR 471 billion [8].

Europe is also home of some of the biggest companies within the supply chain including ROLLS-ROYCE PLC, SAFRAN AIRCRAFT ENGINES, Thales and LEONARDO S.P.A.,

DASSAULT AVIATION, LIEBHERR. with main concentration in France, Germany, Italy, UK, Spain, Poland and Sweden. This makes Europe world leader in the production of civil aircraft, including helicopters, aircraft engines, parts and components. Beside the big companies, the civil aeronautics sector consists of a great variety of small and medium-sized enterprises (SMEs), which are spread across Europe and contribute to a huge spectrum of technologies, integrated capabilities, and innovative potential.

The aerospace sector has a specific supply structure. Scientifically, the ideal tier structure can be described within the form of a pyramid of supplier relationships (Tiers). The supplier interrelationships start with the manufacturer (Original equipment manufacturer (OEM), which is supplied by a system manufacturer (Tier 1), whereas the components of a system are ordered from component manufacturers (Tier 2) and their suppliers (Tier 3) [9].

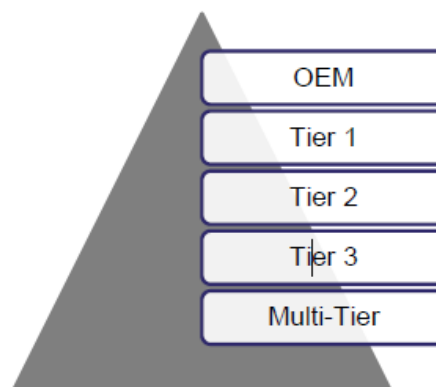


Figure 15: Schematic representation of the aerospace supply chain Source Supply Chain Excellence Initiative 2016

Therefore, the affiliation to the value chain and industry segments can vary. Within the supply chain, the ideal-typical form of a pyramid is more characterized with many overlaps and intersections between the different relationships. Belonging to a tier level can differ between the industry segments in which a company is active. A direct supplier to an OEM for a certain product can also be categorized as Tier 2 or 3 in other

product segments. With the interlinking of delivery also comes a responsibility, which is assumed at each individual level of the value chain. Especially legal and certification requirements can be a challenge for suppliers of lower tiers (see chapter 2.5). Most SMEs within the supply chain are mostly anchored into the lower tier structure, a high dependency on other tier-suppliers can be identified. In the current situation, balancing supply-side over- capacity with reduced order books faces most suppliers with new risks, challenges but also opportunities. The crisis leads to re-evaluate existing product portfolio and breadth of operational as well as manufacturing capabilities [10].

3.2.7 Challenges and needs

Aviation is one of the fastest-growing sources of greenhouse gas emissions [11]. In 2019, more than 915 million tons of carbon dioxide (CO₂) worldwide were produced by flights. The global aviation industry therefore produces around 2% of all human-induced CO₂ emissions [12]. Due to the increasing global demand for mobility, the demand for a more sustainable aviation is growing. While airlines reduce their fleet to optimize costs and try to optimize economical and efficiency aspects, the demand for green technologies in civil aviation increases. The civil aviation industry is strongly aware of the need to decarbonize. Before COVID-19, the International Civil Aviation Organization (ICAO) forecasted that by 2050 international aviation emissions could have tripled compared to 2015 if the industry is not taking counter measures [11].

Even though the COVID-crisis has reduced the enormous growth of this industry, the recovery to pre-COVID-19 levels is expected by 2023. Therefore, investments in cleaner aircrafts and fossil fuel alternatives and sustainable solutions to reduce emissions drastically can contribute to long-term resilience and new revealed markets for the civil aeronautics industry [12]. To achieve climate neutrality, the European Green Deal sets out the objective to reduce transport emissions by 90% by 2050 (compared to 1990- levels). The aviation sector will contribute to this reduction. That's why in the last years the main focus in R&D was directed towards the reduction of emissions. The European aviation ecosystem recently announced a joint commitment to work with policy makers to achieve net zero CO₂ emissions by 2050. [13]. One possibility to contribute to this objective is to decrease weight. Here a window of opportunity opens for textile industry through the development of light and load-bearing material.

Regarding innovation the COVID-19 crisis revealed the necessity to develop new hygienic solution and concepts especially for the cabin sector. On one hand these concepts are needed urgently to enable safe flying right now, on the other hand this aspect will be in general focus for the future, as other diseases or pandemics will occur. Here arises an opportunity for innovation and products coming from textile sector.

Another area in aeronautics with potential for innovation and intersectoral ideas is the field of unmanned air vehicles (UAV). The kind of activities comprises a manifold of commercial application for small drones (octocopters and fixed wing) in the short and medium range up to larger UAV able to transport people and cargo over short and medium distances. As this area is still in a development phase and regulation is just underway, new business models still have to be created. This area is considered to have a huge growth potential in the near and middle future.

3.2.8 Future development toward circularity and resilience

Research, development and innovation ability

The time span from the first research and development activities to the decommissioning of an aircraft type is in general several decades. Technological innovations can therefore in general only be introduced with relatively long lead times. Companies invest primarily in further development of already established products and in highly application-oriented research projects.

Investment in research, development, and innovation (RDI) are vital for the development and competitiveness of the civil aeronautics industry in Europe. RDI expenditures represent 10% of industry turnover, one third of which being financed by the public sector [6]. In 2019, an estimated amount of EUR 8 billion was invested in civil aeronautics R&D activities by private and public stakeholders [1]. According to the European Commission, every Euro invested in aeronautics R&D creates an equivalent additional value in the economy annually thereafter [6]. New technologies and innovations must comply with a large number of safety regulations and comply with existing patents. Therefore, RDI activities within the civil aeronautics sector can be characterized as highly complex and competitive. However, this competitiveness is also the key driver for new, innovative, and sustainable solutions.

The number of patent applications of EU companies also testifies the EU's dynamism in the sector, and its developing role in the world's aerospace industry. Based on the International patent classification system, between 2002 and 2016, the growth in patent applications in the field of 'Aircraft; aviation; cosmonautics' addressed to the European Patent Organization (EPO) grew by 162 %, compared with just 46 % in manufacturing on average. When examining the country origin of approximately 428 patent applications in the EU-27 in 2016, two Member States accounted for over 70 % of total patent applications: Germany recorded the highest share with 36 %, ahead of France (35 %) and Spain (9 %) [14]

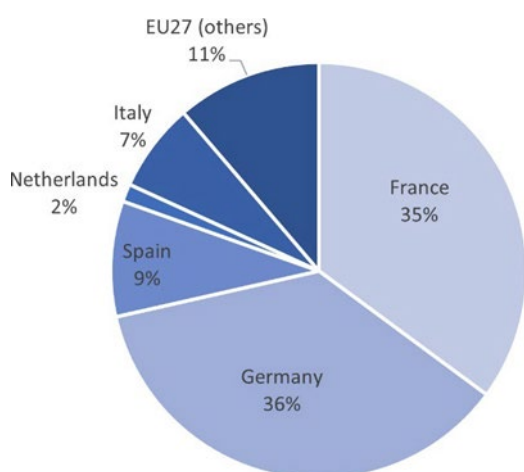


Figure 16: Breakdown of patent applications made to the EPO in aerospace equipment by country origin, EU-27, 2016

Within the last years, there has been a significant increase in the pace of development and application of new technologies and concepts of operation within the civil aeronautics sector. Public funding, research cooperation and joint projects are still of great importance as research institutions act as a bridge between research and industrial application and work closely with companies in the civil aeronautics industry.

3.2.9 Textile used in aerospace

Textiles have been an important material since the beginning of aerospace. Lightweight materials like silk or canvas were some of the initial materials used in the first aircrafts and gave the pioneers the possibility to make their dream of flying reality. Nowadays high-performance textiles are used in aircraft and spacecraft because of their efficiency and flexibility while reducing costs. Highly developed special textiles have become an essential component of the manufacturing process and have a high potential for future development. [15] [13]

General requirements for textiles in aerospace:

- Safety
- Lightweight
- Resistance to water, fuels, fire, high temperatures
- Provide advanced insulation
- Easy maintenance
- Durability
- Enhance of comfort and design
- Hygiene and Infection Control
- Recyclable

Technically the main challenges are safety (mainly flame retardancy) and weight reduction. It is estimated that for every 1 kg of weight saved in an aircraft, yearly 80€/ per aircraft seat is saved in fuel costs, whilst a 100 kg lighter load can increase the range by 100km. The same challenges occur in the space sector where extra weight in a spacecraft increases fuel consumption and costs significantly. New technologies and today common textile materials have been developed in the space sector because reliability, safety and comfort have high priority [17].

Application of textiles in aerospace

- Wings, Body parts.
- Curtains.
- Wall covers.
- Seat covers.
- Furnishing fabrics
- Fibre-reinforced composites
- Technical fabrics
- Nylon tyre cord
- Seat belt Webbing
- Air bags
- Floor carpet/covering
- Rotor blades
- Circuit boards
- Webbing for aircraft
- Aircraft upholstery
- Fly-Bag
- Parachutes
- Space shuttle

- Space suits and clothes
- Tyres

Raw materials and essential properties

Common raw materials in aerospace are Carbon fibres, Kevlar fibre, E- Glass fibre and numerous other textile fibres e.g.: Poly fibre, Boron fibre, Acrylic, Nylon, Polyurethane, Vinyl ester, Alumina-boria-silica fibres. [18] [15]

The essential properties of textile composites in aerospace applications are:

Aircraft interior designing

The modern interior of an aircraft uses many different textile developments. The industry develops e.g., higher quality and more robust cables which, unlike rubber or plastics, are coated with resistant specific textiles. The target is to provide higher levels of durability and resilience. Many parts primarily made of rubber or flexible plastic in the past are replaced by textile mixtures that have

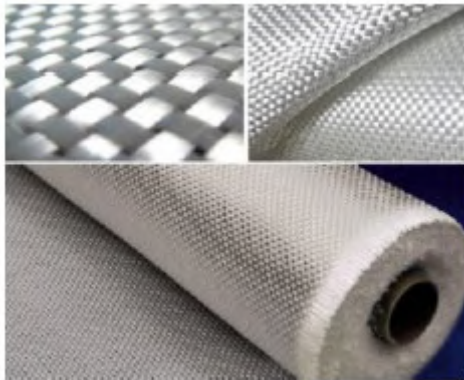


Figure 17: E-glass [15]



Figure 18: Cabin interior [18]

demonstrated durability in many applications. Since cabin design exist, fabrics have been involved. Here hard-wearing, comfortable and safe fabrics are required for covering seats. They must demonstrate properties for everyday use: easy to clean, be fire- resistant and free of pollutants that could evaporate and pollute the air. Modern materials such as microfibers, nanotechnology, new plastics, artificial leather, fillings

made of sustainable materials such as hemp for the upholstery and linings have revolutionized the use of textiles in interiors. [15] [19] Specific maintainability properties required for aerospace interior textiles:

- Washable.
- Abrasion resistance.
- Tear resistance.
- Moisture resistance.
- UV stabilization.
- Material standardization.
- Hygiene and Infection Control.

Future developments

New developments of textiles in the aerospace sector are vital for the future development of high-performance air- and spacecraft. Low weight, high strength, cost efficiency, ease of working with the materials, and safety are all parameters that can only be achieved using new materials. Intelligent or “smart” textiles with additional functions are particularly interesting. Work is currently being carried out on self-luminous textiles with incorporated metal threads that can emit light when stimulated by electricity (e.g., for cabin interior ceiling). Innovations, such as incorporating bionics into the development of new textile solutions, will open completely new solutions for engineers and scientists. Thinkable e.g., is a versatile spider silk, which is considerably more resilient and at the same time elastic in comparison to steel threads of the same thickness. The main aim is always to lower the weight and raise efficiency. A key topic is the implementation of sustainable textiles and the opportunity to recycle materials. E.g., future targets foresee to have a 100% recyclable aircraft. What remains to implement new textiles, is the challenge of developing efficient production processes.

3.2.10 Advanced manufacturing technologies in aerospace

Aerospace has always been at the forefront and a leading industry in the use of advanced manufacturing technologies. Because of the unique challenges and high product complexity that exist for designing air- and spacecraft under extreme environmental conditions, materials must be strong, lightweight, and resistant to temperature and corrosion. Further the process complexity with a demand on fine, tight-tolerance features that require micro- and nano-machining methods, including laser machining and welding. Aerospace often comes up first with innovative advanced manufacturing approaches, which later are implemented in other industries. [20] [21]

Additive manufacturing (AM) and 3D design

The term AM encompasses many technologies including subsets like 3D Printing, Rapid Prototyping, Direct Digital Manufacturing, layered manufacturing and additive fabrication with a number of benefits that help the aerospace industry to improve its production process and efficiency with advanced materials and unique geometries. The scope of AM ranges from preproduction visualization models, lattice structures, to a creation of single replacement parts. This reduces the number of possible failure points and simplifies assembly. AM is also moving toward building large parts up to two meters in size. [22] [20]

Need: As in 3D metal printing porosity issues, fissures, cracks, and poor fusion between the metal layers in the finished product can occur, there is a need of developing reliable standards. This is possible by generating materials big data to have a good understanding of all components. [23]

New 3D design solutions like Virtual Reality, Mixed Reality and Augmented Reality not only help to realize precision manufacturing but also strengthen the respect of safety regulations. In general, there is still a serious skill shortage in the industry. [24]

Robotics and precision manufacturing

Numerous improvements in the manufacturing machinery have already reached the aerospace manufacturing plants: Special software advances for machine control and simulation, assembly processes, and inspection; Robots for lifting and handling. Robotics and automation in the factories of the future will lead to less labour-intensive processes. Robot tasks include inspection, drilling and fastening, welding, sealing and dispensing. Large, fixed auto-riveting robots and laser machining are used to connect aircraft sections. In general Robotics take over more and more hazardous work, such as welding, coating or painting, and help to produce more cost-effective.

Industry 4.0 - IOT applications

The radical transformation of the manufacturing processes in the aerospace sector through Internet of Things (IoT) is already ongoing. The Trend of using Big Data, Artificial Intelligence, and of digital practices: cooperation, mobility, open innovation, will modify not only production infrastructures, but also the development of products and services and even the customer relationship. Beyond the before mentioned new tools, the “Smart Factory” is a key element of the Industry 4.0 trend. The aerospace sector strives for lower production cost and significant increase in manufacturing efficiency through the analysis of production data. The aerospace industry and its supply chain, relying on a large network of suppliers will highly benefit from this increase in flexibility and digital integration. [25]

3.3 Construction

3.3.1 Construction sector overview

The industrial construction ecosystem employs approximately 24.9 million people in the EU and provides a value added of EUR 1.158 billion (9.6% of the EU total). In terms of employment and value added, this ecosystem is the second most important of the 14 identified Blueprint ecosystems, with retail as the only ecosystem with higher employment (29.8 million) and value added (11.5%). The ecosystem is dominated by micro and small enterprises. With a total of 5.3 million firms, 99.9% companies of the ecosystem are SMEs, which represent 90% of employment and 83% of the total value added. The fragmentation of the ecosystem is accentuated by the fact, that around 90% of the companies are microenterprises, standing for 45% of employment and 32% of the total value added. About 52% of the employment can be allocated to the sector construction and demolition activities' (NACE F), which accounts for 55% of the added value.

The European construction sector was highly impacted by Covid-19 crisis and Ukraine war during and after which a stronger recovery for the sector started in summer 2021, when FIEC – the European Construction Industry Federation forecasted an increase in investment of 4.2%. Total investment in construction increased by 5.2% in 2021 and amounted to €1.6 trillion, corresponding to 11.1% of EU GDP. Italy (+16.4%) registered the largest increase in investment, followed by Estonia (+10.7%), Greece (+10.6%) and France (+10.5%). While a majority of countries experienced a growth in investment in construction, Spain experienced a slight decline (-0.9%). However, Bulgaria is the country hit the hardest as investment went down by 19.2% compared to the previous year

3.3.2 Challenges and needs

The updated EU industrial strategy highlights the need to accelerate the green and digital transition of EU industry and its ecosystems. To that end, it proposes working together with industry, public authorities, social partners and other stakeholders. This co-creation process will lead to the publication of transition pathways for each core ecosystem, including Construction that is actually considered as one of the EU industrial ecosystems that is the most heavily affected by the COVID-19 crisis and the war in Ukraine, and face the most important challenges as a result by heavily suffering from shifts in supply and demand for materials, finished products and skilled workforce.

While the effects of Covid on the economy have waned, several problems affecting the construction industry still persist. In several Member States there is a lack of skilled construction workers. In Germany, for example, roughly a quarter of construction companies consider this to be a major issue of concern. Another major concern is the supply and prices of construction materials. The ongoing war in Ukraine has further disrupted supply chains and prices of raw materials continue to rise. Energy prices have also gone up significantly. These developments have the potential to slow down construction activity this year and the first signs of this are already visible.

There are several critical inputs and technologies for the construction sector in Europe, including:

- Sustainable materials: With growing concerns about climate change and environmental sustainability, there is an increasing demand for construction materials that are eco-friendly and have a low carbon footprint. Materials such as recycled concrete, sustainable timber, and low-carbon cement are becoming more popular.
- Building Information Modelling (BIM): BIM is a technology that enables architects, engineers, and construction professionals to create and manage digital representations of buildings and infrastructure. BIM can improve project efficiency, reduce errors, and help to ensure that projects are completed on time and within budget.

- Energy efficiency technologies: Energy-efficient technologies, such as insulation, smart heating and lighting systems, and renewable energy sources, are becoming increasingly important in the construction sector. These technologies can help to reduce energy consumption and greenhouse gas emissions.
- Modular construction: Modular construction involves building sections of a building off-site in a factory, which are then transported to the construction site and assembled. This approach can reduce construction time and costs, while also reducing waste.
- Digitalisation and automation: Digitalisation and automation technologies are becoming more prevalent in the construction sector, including 3D printing, robotics, and drones. These technologies can improve efficiency, reduce costs, and improve safety.
- Overall, the European construction sector is becoming more focused on sustainability, innovation, and efficiency, with a growing emphasis on using technology to drive progress in these areas.

In terms of critical supplies main ones are summed up in:

- Cement: Cement is one of the most critical materials used in the construction industry. It is a binding agent that is used to hold together the various components of concrete, which is the most widely used construction material in the world.
- Steel: Steel is a versatile material that is used in construction for various purposes, including structural support, framing, and reinforcement.
- Timber: Timber is used extensively in the construction of buildings, especially in Europe, where it is a traditional and popular material for constructing houses.
- Aggregates: Aggregates, such as sand, gravel, and crushed stone, are used as a base material for constructing roads and buildings.
- Insulation materials: Insulation materials, such as fiberglass, mineral wool, and polystyrene, are used to regulate the temperature and soundproof buildings.
- Electrical and plumbing supplies: Electrical and plumbing supplies are essential for the construction of buildings. They include wiring, pipes, valves, and fittings.
- Glass: Glass is used in the construction of windows, doors, and other building components.
- Roofing materials: Roofing materials, such as tiles, shingles, and metal sheets, are used to provide protection against weather elements.
- Paint and coatings: Paint and coatings are used to protect building surfaces and enhance their appearance.

3.3.3 Future development toward circularity and resilience -circular construction

We refer to circular construction as implementation of circular economy in building and construction sector, using also circular transition of shortly circularity in buildings/construction.

As indicated in the survey (see In Transit SME survey results), the circular construction is less clear, that is there is lower understanding and awareness compare to high relevance in different European policy documents such as Green Deal, but also forthcoming directive such as new Energy performance of building directive.

The construction is highly regulated, so someone can say that if not in the regulation and codes (for example building design codes) – the “circular construction” doesn’t exist – for majority of business stakeholders in this sector.

Thereof, it is highly important to promote and explain the background, basic principle and key fields of application of circular construction, as core part of resilience and recovery plans in the sector,

e.g. promoting fields of capacity building, skills development, innovation action, development, value chain collaboration, expansion and development of market for circular solutions.

The construction industry accounts for about 50% of our total use of raw materials. Furthermore, the built environment is responsible for 40% of CO2 emissions and 36% of energy consumption. Addressing these impacts through circular and climate neutral development is thus crucial.

According to the circular economy principles for buildings design, prepared by the EC, the principles are divided on:

1. Overall principles

- a. Design principles of circular economy and sustainable buildings are applicable to all actors along the value chain.**
 - i. Engage with all actors along the value chain, including building users, investors and regulators.
 - ii. Promote understanding and use of existing standards, schemes and examples that enable a more holistic design and adjust business models for including circularity in construction;
 - iii. Apply ISO standards for DfD/A (ISO20887) and Levels(s), as well as pre - development audits and other guidance.
- b. Sustainable choices must take into account total life cycle costs, financial and non-financial return on investments.**
 - i. Actors along the value chain respond above all to financial incentives and these need to be tailored to each situation.
 - ii. Look at the financial aspects through a whole life cycle perspective and therefore do a cumulative cost calculation taking into account costs, revenues and residual value;
 - iii. Consider scenarios in which estimated costs for new materials, furniture and waste elimination are significantly higher than the actual costs, and in which certain elements could be sold for reuse and/or recycling.
- c. Viable business models must exist or be developed for each economic operator in the supply or value chain.**
 - i. A reliable marketplace for used products and materials must exist or be created.
 - ii. A favourable legislative environment, incentives from public decision-makers (e.g., public procurement), innovative and circular businesses as well as financial models, must be put in place to ensure a long-term vision and support building owners' decision-making;
 - iii. Innovative circular business models such as "take -back" business models or "product as a service" business models can offer interesting solutions for some products and systems.
- d. Principles need to be applied taking into account proportionality - benefits should outweigh the costs.**
 - i. It is important to consider the burden and costs for operators to follow these principles.
 - ii. Operators should prioritise those principles which are most relevant and generate the highest benefits and lowest costs;
 - iii. Externalities should be taken into account when assessing costs and benefits.
- e. Better knowledge is needed about construction techniques to facilitate deconstruction and to enhance durability and adaptability of a building.**
 - i. In all parts of the value chain, workers need to have the right skills and incentives to apply this knowledge and use the appropriate tools.

- ii. Designers and project managers should ensure safety and consider the feasibility of demolition/renovation for the workers;
 - iii. Allocate specific funds for the upskilling of workers;
 - iv. Integrate deconstruction techniques into apprenticeship schemes.
- 2. **Durability**
 - a. **Durability of buildings depends on better design, improved performance of construction products and information sharing.**
 - i. Structural elements should last as long as the building does, whenever possible. If it is not possible because of intrinsic obsolescence or anticipated change in requirements (e.g., IT infrastructure), they should be reusable, recyclable or dismantlable.
 - ii. Favour construction systems that incorporate circular economy thinking. For instance, enable systems to be easily maintained, repaired and replaced as this will prolong the life cycle of buildings;
 - iii. Ask for detailed information from providers and designers on products, materials and the design of the buildings. Conserve, update and share the information so that it can remain valid and relevant during the whole life cycle of the building.
- 3. **Adaptability**
 - a. **Prevent premature building demolition by developing a new design culture.**
 - i. Anticipate changes in requirements;
 - ii. Enable adaptations and transformations of the building for better use and reuse, new ways of using it, and prepare for the end-of-life and future lives of the building and its components.
- 4. **Reduce waste and facilitate high-quality waste management**
 - a. **Design products and systems so that they can be easily reused, repaired, recycled or recovered.**
 - i. When recycling, it is preferable that products and systems should be upcycled, too.
 - ii. Make use of easy to dismount elements and products;
 - iii. Prescribe in procurement contracts that waste should be separated on site to facilitate recycling;
 - iv. Use simple and recyclable products.

According to the circular economy principles for buildings design, prepared by the EC, all participants (target groups) in the building value chain must take those principles into account. Target groups in the value chain are defined as:

- Target group 1: Building users, facility managers and owners
- Target group 2: Design teams (engineering & architecture of buildings)
- Target group 3: Contractors and builders
- Target group 4: Manufacturers of construction products
- Target group 5: Deconstruction and demolition team
- Target group 6: Investors, developers and insurance providers
- Target group 7: Government / Regulators / Local authorities

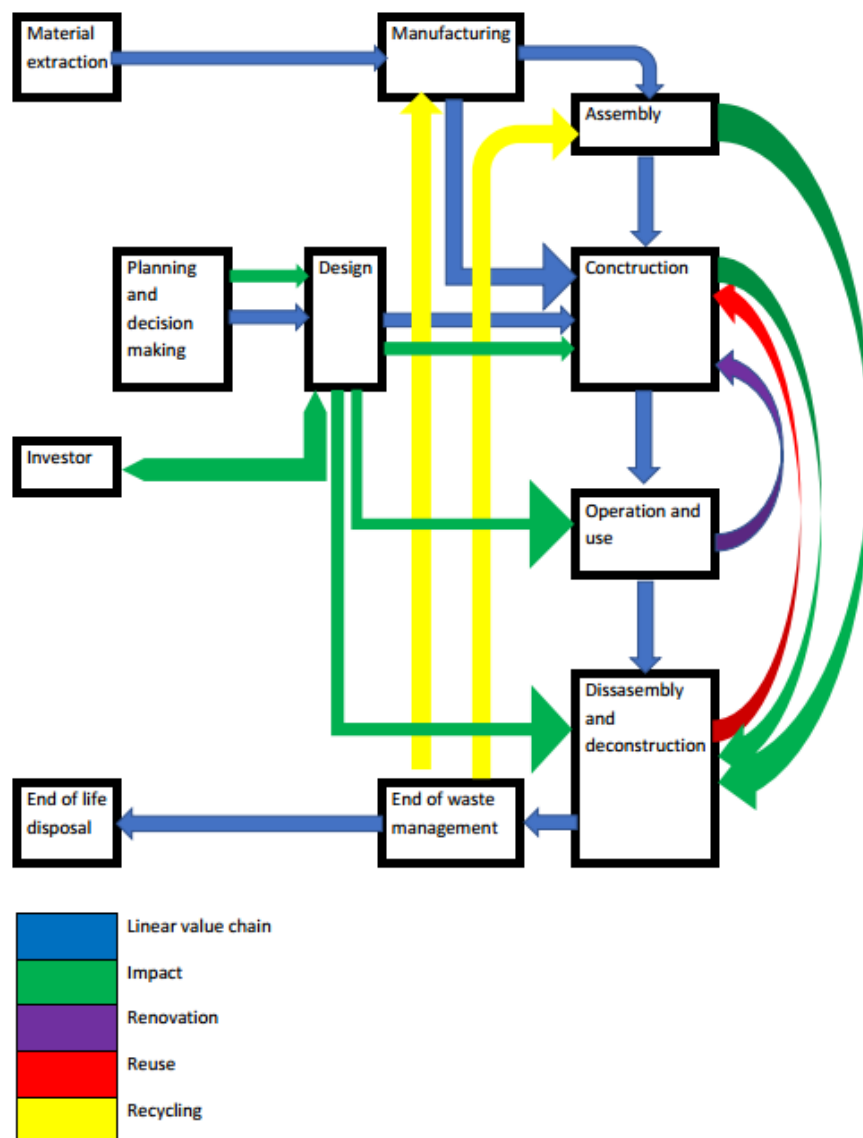


Figure 19: Circular economy value chain in construction sector

3.3.4 Circular construction design and business models

In order to better understand the principles of circularity in circular design, it is necessary to know the principles of circular design in relation to the technological and biological cycle.

Circular design strategies

1. Technical cycles
 - a. Slowing flow
 - i. Design for maintenance
 - ii. Design for reuse
 - iii. Design for refurbishing
 - iv. Design for remanufacturing

- b. Closing flow
 - i. Design for upcycling
 - ii. Design for recycling
 - c. Narrowing flow
 - i. Design for resource efficiency (material)
 - ii. Design for resource efficiency (energy)
- 2. Biological cycles
 - i. Design for cascade use
 - ii. Design for biodegradation

in connection with circularity, it is also necessary to know various circular business models, such as:

1. Access and performance model
2. Extending product value
3. Classic long-life model
4. Encouraging sufficiency
5. Extending resource value
6. Industrial symbiosis

3.3.5 Circular construction technologies and solutions

Advanced building materials

A series of innovative materials play now a key role in the construction sector taking step by step the place of more **traditional** ones such as wood, concrete, and bricks, which of course **are not being replaced but made more circular**, for example by cement decarbonisation.

Advanced materials offer different advantages from eco-friendly manufacturing to sleek contemporary designs.

A list of most known advanced materials follows:

3D Printed Graphene

Graphene is a strong, lightweight material used often in microchips and sensors. Several researches have also proved that adding graphene can enhance the strength of a material. Unfortunately, it is expensive and hence, it has not been widely used despite its capabilities. However, researchers have now managed to develop 3D-printed graphene using graphene oxide hydrogel as the resin for the printer. This, however, is not a final product. 3D-printed graphene can be used to reinforce concrete.

Light Generating Concrete

Light-generating concrete or cement is non-flammable and able to reflect light, hence the name. This material is also known to absorb solar energy to 'charge' and emit light in the dark. Proven to be energy efficient, it has been used to illuminate bicycle lanes and roads in Mexico, where its research took place. As it is quite similar to the regular cement already in use, it can find application in the construction of many other structures like facades and parking lots.

Cross-laminated timber

Cross-laminated timber is a type of mass timber (man-made or engineered wood) that is connected in layers. As the name suggests, cross-laminated timber is developed in planks by gluing timber pieces in layers, each layer being perpendicular to the previous. CLT is known for its strength as well as for being lightweight. It is easy and quick to construct with CLT since it can be manufactured off-site and assembled on-site. Using

CLT alongside technology that provides precise drawings and models, like [BIM \(Building Information Modelling\)](#), can reduce waste and labour needed for construction.

Self-healing materials

We have evolved from using traditional materials such as timber to using concrete as a construction material so frequently that we now live in a concrete jungle. Researchers have been developing the next stage of concrete for construction to counter its vulnerability to cracks. Yes, nothing lasts forever, but with the right materials, we may just be able to extend the lifespan of our built environments. That is, indirectly speaking, the purpose of self-healing materials including concrete; fibres or natural capsules that release an adhesive substance are added to the concrete mix, which then heals the cracks.

Strand rods

Strand rods are manufactured using carbon fibre composites in both synthetic and inorganic fibres and thermoplastic resin. It has been developed and tested in Japan to create a lightweight seismic reinforcement system. It is much lighter than metal rods of the same length and strength while being equally effective. As the lightest seismic reinforcement, it has high tensile strength and is also aesthetically pleasing. The first use of such material can be seen in the facade of Kengo Kuma's work for Komatsu Seiren's head office.

Carbon fibre

Made of thin carbon strands woven together for a fabric-like composition, carbon fibre is generally considered to be an alternative to steel that is lighter and stronger.

Some of these fabrication techniques rely on generative design methodology and tools.

Translucent wood

Through research and innovation, we now have translucent wood that is almost 90% clear. The wood is made translucent with the aid of a chemical that strips away its colour while keeping many of its natural properties intact. It is said to be energy efficient and has the potential to be a good alternative to glass and plastic as it is renewable and has low thermal conductivity.

Transparent aluminium

This material has been hailed as a material of the future, having been featured in the 1986 Star Trek movie! The difference between the movie version and the real material we have now is that in the movie, transparent aluminium is made of pure elemental aluminium while in the real-world transparent aluminium is a ceramic alloy. Extremely durable and believed to be resistant to corrosion and oxidation, it is already in use as bulletproof glass and in other security systems. The downside is that it is expensive, much more than normal bulletproof glass. However, when the price drops, we can expect a far wider use of this wonder material for windows, facades, or even underwater structures. It may just turn out to be the cost-effective and long-lasting material our construction industry needs today.

Bio-based materials

Besides its significant demand for energy, the built environment is also a large consumer of material resources.

These are mostly minerals (rocks, gravel, and sand), metals, and fossil oils used for plastic manufacturing. In developed economies such as the EU27, the construction sector is the largest single consumer of metals and uses more minerals than all other industrial sectors combined. Indeed, minerals are essential for the modern building: from concrete, to bricks and stones, to glass, plaster and ceramics. But although they are abundant materials, they are not renewable and often require invasive and polluting processes for their extraction.

The term biomaterials is used to describe building materials derived from living organisms including plants, animals and fungi. Plant-based materials are becoming increasingly popular among designers and architects due to their environmental performance.

In the effort to reduce the environmental impact of construction, **researchers and designers have turned their attention to biobased alternatives**. Biobased materials are organic resources produced by plants and animals, such as timber or sheep's wool. In the context of construction, biobased materials can have several benefits over conventional ones:

- They are renewable and can be sustainably produced over the long-term
- They can naturally absorb carbon from the atmosphere during cultivation, thus positively contributing to climate change mitigation
- They promise performance gains in terms of moisture absorption and breathability
- They are generally less harmful to people and the natural environment in terms of pollutant emissions
- They can be disposed of more easily and sustainably at their end of life
- They offer cruelty-free production, are usually biodegradable and store CO₂ during their useful lifetime, thereby lowering the embodied carbon footprint of buildings and products.

Traditional and vernacular architecture across the world has always made large use of biobased materials available in the local environment.

Some, like wood and hemp, can be used in their raw state while others such as algae, mycelium and food waste are generally mixed with other materials to be turned into useful composites. The following biobased materials can be used in construction and buildings:

The main material in this field is wood. Wood is a renewable material that offers a low-carbon alternative to concrete and steel. Due to its highly machinable, lightweight structural tissue, which is strong yet flexible, wood has historically been used to construct furniture and products as well as small houses. The other biobased materials are: ***Hemp, Mycelium***

Algae, Chitin, Bioplastics (polymers derived from biological and renewable sources as opposed to plastics made from fossil fuels), ***Linoleum , Cork, Straw, Cellulose***.

3.3.6 Advanced manufacturing technologies in buildings and construction

3D printing

The beginning of the use of 3D printing in construction can be traced back to the experiment of Professor Behrokh Khoshnevis of the University of South Carolina who, in 2004, attempted to 3D print a wall for the first time. Since then, this innovation has exploded and it is now possible to build a house in as little as 20 hours! The professor has developed an FDM 3D printer, mounted on a robotic arm, that extrudes layers of concrete instead of layers of plastic to create a 3D model.

Contour Crafting technology has proven to have all the qualities needed for the use of additive manufacturing on construction sites: reduced costs and waste, increased construction speed, reduced accidents, complex architectural shapes and much more. His discovery marked the beginning of 3D printing in construction. However, it remains much less used than certain sectors such as aeronautics or medical.

Construction giants are rapidly realizing the potential of 3D technologies and their possible impact on the future of construction. The concrete 3D printing market is projected to reach \$56.4m in 2021, and for good reason. More and more companies are stepping up in the industry to create new innovative designs. Some are more futuristic, others are very concrete in the present, like the 3D printed house by [Apis Cor](#) in 24 hours. 3D printing for concrete is developing rapidly and relies on different technologies and materials, offering numerous advantages to its users. However, the technology is still in its infancy and is forced to respect its current limits.

Major technologies used

Robotic arms

The Contour Crafting method involves depositing the build material to create a large-scale 3D model with a smooth surface finish. Rails are installed around the building area which will act as a structure to direct the robotic arm. The latter moves back and forth to extrude the concrete, layer by layer. Trowels placed on the side and above the nozzle to flatten the extruded layers and ensure the strength of the model.

Conventional concrete cannot be used in this process as it would need to harden before continuing in the process. If it were 3D printed, therefore, it wouldn't be able to support its own weight. Then, a quick-setting cement is used.

Contour Crafting (a company of the same name as the method) is very discreet about its progress. However, Chinese construction company WinSun Decoration Engineering Co describes it as capable of "stealing the show". These machines are huge (32m long, 10m wide and 6.6m high). This allows them to 3D print entire structures and assemble them on site. To do this, concrete and fiberglass are mixed on site and then printed. This introduced additive manufacturing to many builders and construction workers.

The different players on the market have developed machines that employ various different technologies for 3D printing concrete. French firm Constructions-3D has created a polar 3D printer that prints inside the construction site and walks out the front door of the building once construction is finished. It consists of a mechanical base and a robotic arm with a nozzle for extruding material at one end. This arm offers a printable area of more than 250 m² and more than 8 meters in height.

Cazza Construction's robot looks something like this, with a mobile crane system that allows it to 3D print a much larger area and create bigger and taller structures. This is evidenced by past prints from companies like Apis Cor and XtreeE, which quickly create entire houses.

Other companies have specialized in the extrusion of materials other than concrete with this technology. The patented process of BatiPrint 3D is an obvious example: the University of Nantes, Bouygues Construction and Lafarge Holcim have joined forces to develop an industrial robot that prints 3 layers of material at a time. Two of these layers are a polymeric foam and the third is concrete. Benoit Furet, professor

at the University of Nantes explains "the foam guarantees internal and external insulation, the concrete and the reinforcement the anti-seismic load-bearing structure".

An easy to use 3D printing, a multi size and mobile 3D House concrete printers using Fused Deposition Modelling (FDM) are being developed by Interlab d.o.o. under the trade mark BetAbram (<https://www.youtube.com/waTextileh?v=q0QbyW7xCZw>) in Slovenia. Different sizes of printers can be developed, from 3x4 m to 9x16m or larger on request.



Figure 20: BetAbram 3D House printer demonstration at the construction trade fair MEGRA, March 2023

Layers of sand

Italian architect Enrico Dini first made headlines as "the man who 3D prints houses". He recently showcased an interesting 3D printing process with his "D-Shape" 3D printer. This machine relies on powder binding which makes it possible to solidify a layer of material with a binder. Layers of sand are deposited to the desired thickness before a print head pour drops (the binder) to harden the sand. This 4 x 4 meter machine is capable of creating large structures up to 6 cubic meters in size.

Solid metal structures

DuTextileh company MX3D has developed a unique construction method called WAAM (Wire Arc Additive Manufacturing), which allows you to 3D print metal structures with a 6-axis robot that lays down 2 kilos of material per hour.

This robot is the result of collaboration with Air Liquide and ArcelorMittal and is equipped with a welder and a nozzle to weld metal rods layer by layer. This process is also compatible with other metal alloys such as stainless steel, bronze, aluminum and Inconel. The machine may resemble some kind of gigantic soldering iron. The team commented: "We combined an industrial robot and a welding machine to turn them into a 3D printer that runs on our software."

Advantages of 3D printing in construction

In terms of material usage, 3D printing is cost effective with additive rather than subtractive processes, using fewer materials than traditional manufacturing processes. This reduces the environmental impact, as less waste is produced. Romain Duballet, one of the co-founders of XtreeE, explains, "with a greater mastery of the geometries, we can build shapes optimized to limit the number of materials used".

However, there are still reserves to the dream of 3D printing houses, bridges and skyscrapers. Axel Th  ry of Constructions-3D explains that "the main difficulties arise from the fact that the process of 3D printing buildings is not currently a construction method recognized by many codes and standardization bodies. Because printed structures are non-traditional, strength and durability calculations are difficult to make. This

is why the housing solutions created will have to be tested on a case-by-case basis at the outset". Standards bodies are concerned that these structures are really robust and able to withstand their environments.

Because printed structures are non-traditional, strength, durability, and also earthquake resistance calculations are difficult to make. This is why the 3D housing solutions created will have to be tested on a case-by-case basis at the outset and number of R&D projects need to be done, in collaboration with research institutes, testing and certification bodies. The standards and technical specifications for this technology have to be prepared on EU and national level, framing the fields of use and implementation. Besides printing house, there are numerous other applications for built environment, such as urban furniture, and different options for material use, including secondary raw materials, including recycles waste for other industrial sectors.

3D Printed Houses: A Sustainable Solution?

Some construction companies are heading into additive manufacturing. Among these, the Italian company WASP which aims to build a more sustainable world through 3D printing. He developed one of the world's largest 3D printers, capable of building houses from locally sourced materials using solar, wind or hydroelectric power. This allows regions that do not yet have access to electricity to 3D print environmentally friendly structures using local resources.

Similarly, in Brazil, Anielle Guedes founded Urban3D to respond to the Brazilian housing crisis. Her company 3D prints parts of buildings in a dedicated factory before assembling them on site. This allows her to create buildings of a height that would not be possible if 3D printing was done on site. The company is currently testing several prototypes and hopes to offer a solution to the development of Brazilian slums.

The Russian company Apis Cor is also convinced of the positive impact that 3D printing can have on homes. Founder and CEO Nikita Chen-iun-tai explains, "we believe that additive manufacturing is an effective solution against the housing crisis and that is why we developed our project. We hope that in a few years this approach will be thoroughly tested in various parts of the world to demonstrate its feasibility. We believe that more and more construction companies will adopt this technology, as some of them already do today".

Construction monitoring and construction robotics

Nowadays, in many construction sites, progress monitoring still requires an inspector to walk through the site and visually assess the project's progress. However, this method is considered inefficient and imprecise. The answer to this challenge can be the integration of construction robotics and construction monitoring. Through the integration of both, the accuracy and efficiency of construction projects are considerably improved while also ensuring that the required quality and safety standards are met. Both can be connected in several ways, as shown below.

1. Through the use of site robots, the process of data capture scalability is automated, which means it automatically analyses and shares all data. Consequently, project managers are able to successfully scale up data analytics initiatives of multi-site projects within the monitoring and site safety domains.
2. Construction monitoring involves the use of various sensors and monitoring systems to track the progress of a construction project and ensure that it is meeting the required quality and safety standards. These monitoring systems can also be used to collect data on the performance of construction robotics, such as how quickly and accurately they are able to perform tasks.
3. Construction robotics can assist with construction monitoring by providing a more efficient and accurate way to collect data on the progress of a project. For example, drones equipped with cameras can be used to capture aerial images of a construction site, providing a detailed overview of the progress and identifying any potential issues.
4. Robotic systems can be used to collect data on materials and structures, such as measuring the strength of concrete or detecting cracks in walls.

5. Through the use of site robots, assessments can be visually performed with reparation strategies developed immediately. This means that connected software solutions offer built-in image analysis and data interpretation tools for significantly faster technical auditing of visual data captured.

The above-mentioned examples portray that the incorporation of robotics technology in construction facilitates construction professionals with quality-assured outcomes and reduced human errors. In other words, the implementation of combined technological solutions, such as construction monitoring and construction robotics, clearly improves accuracy and diminishes construction time, saves money and other resources.

The construction industry is of paramount importance to the European economy, as it provides 18 million direct jobs and contributes to almost 10% of the EU's GDP. In this context, there has been a considerable interest in construction robotics since the 1960s, which in following decades was accompanied by a significant increase in investment, research and real-world uses. As a consequence, robots are noticeably improving at performing complex tasks and becoming increasingly autonomous. The effectiveness of robotic systems and automation can be seen in reduced labour costs, improved quality, increased productivity, efficiency and flexibility in manufacturing. Additionally, it is generally known that it contributes to reducing injuries since it takes over dangerous tasks from workers. In recent years, there has been more and more developments in this field, as the trends below show:

1. On-site construction robots. A number of prototypes have been developed for various applications of on-site construction, such as masonry robots. They can build walls independently from bricks. Another trend is the robo-welder, which can handle a variety of welding tasks. Also, on the rise are robots that erect objects or parts of buildings using 3D printing.
2. Robots in machine prefabrication. Robotic arms and machines have been used in factory production lines for decades, but now there is a growing market for prefabricated homes also using this technology.
3. Humanoid robots in construction. This robot at the construction site is primarily intended to support the construction process where stationary or large machines cannot be used.
4. Autonomous vehicles. From excavators to bulldozers, there are numerous construction vehicles that are suitable for automation in construction. As a consequence, construction and clearing work can be carried out nonstop.
5. Inspections by robots on the construction site. Such inspection tasks usually require time and energy; therefore, number of robots are being developed to handle this task more efficiently.
6. Exoskeletons. These are worn by construction site workers and support them with robotic functions for various activities and robots can help reduce the risk to workers.

The advantages of using the above-mentioned technologies are others are obvious, for example, robotic automation can help reduce waste by improving quality and consistency. This can be of utmost importance in times of increasingly stringent environmental regulations in the industry, as well as rising demand for cost-efficient buildings. Another factor that it is related to cost and time savings is that robots can work around the clock. This means that certain phases of projects can be completed at a much lower cost than usual and significantly faster. Another point worth mentioning is that there are several construction work-related injuries, more specifically, around 30 percent of occupational accidents occur in construction. At the same time, the risk of being involved in a fatal accident in construction is four times higher than in other industries. This can be significantly reduced with the use of exoskeletons or autonomous inspection robots. Additionally, there is shortage of skilled workers in this sector. In the EU, more than 200,000 low- and high-skilled construction jobs were unfilled in the second quarter of 2020 alone. This means that nine out of ten

construction companies will expect a shortage of skilled workers by 2030. This gap can be filled with the introduction of robots. This is in line with the results from the ABB (a leading global technology company) commissioned global survey of 1,900 construction companies in Europe, the USA and China, which shows that 81 percent of those surveyed want to introduce robots in the next ten years.

Still, the use of robots in construction is considered to be in its infancy. Proof for this was also identified in the ABB survey, where only 55 percent of the companies surveyed already use robots - compared with 84 percent in the automotive industry and 79 percent in manufacturing. The reasons for the challenging implementation of construction robots are several. For instance, robots are most successfully used in mass production lines, where they perform the same tasks repetitively. In contrast, each construction site is unique and the situation on site makes a very challenging places for robots. Furthermore, investments in robotics come with high upfront costs, such as research and development. In a sector where most companies are small subcontractors operating on low profit margins due to widely used “lowest price practices” in tendering, the needed capital investments are still considered significantly high (for example, top 100 UK construction companies had an average profit margin of just 1.5% in 2017). Therefore, only a few big construction firms can allocate resources to test new technologies. There are also safety and regulatory issues related to the risks of an unmanned, autonomous robot going to work on a busy construction site, which becomes another barrier to the use of robots in construction. Finally, weak innovation culture prevalent in the construction industry, skill gaps of construction workers and a common aversion to perform tasks alongside robots are disadvantageous for successful adoption of robotic technologies in this sector.

Although current studies identified concerns from industry players regarding the readiness and effectiveness of robotic technology to be adopted in construction, the level of innovation expected in this field in the next few years is considerably promising, and in the coming years, it is expected to see more companies using this technology as part of their daily business. According to ABB Robotics' internal analyses of the market potential for robotic automation, there will be double-digit growth rates in key construction sectors, including precast and 3D printing, over the next decade.

3.4 Advanced manufacturing

3.4.1 Advanced manufacturing overview

The vision for the future of Europe is for a more competitive, smarter low carbon economy, with a sustainable enterprise base that provides quality jobs and enables a high quality of life. An inclusive society at the heart of an outward-looking, dynamic and successful EU, that provides the conditions for organisations and individuals to adapt to technological change and reach their full potential.

Around one in ten (9.8 %) of all enterprises in the EU-27's non-financial business economy was classified as manufacturing in 2009, a total of 2 million enterprises. The manufacturing sector employed 31 million persons in 2009, generating EUR 5 812 billion of turnover and EUR 1,400 billion of value-added. The sectors' turnover grew from 2009 to 2010 by EUR 600 billion, up to EUR 6,400 billion (EU Commission, Factories of the Future Report, 2018).

The application of advanced manufacturing technologies textile, aerospace and construction sectors has been presented in previous chapters. This chapter focuses on digital technologies in manufacturing.

Digital technologies are profoundly changing our daily life, our way of working and doing business, and the way people travel, communicate and relate with each other. Digital communication, social media interaction, e-commerce, and digital enterprises are steadily transforming our world. They are generating an ever-increasing amount of data, which, if pooled and used, can lead to completely new means and levels of value creation. It is a transformation as fundamental as that caused by the industrial revolution (Shaping Europe's Digital Future, 2020).

Physical and data infrastructure are key enablers in helping governments, businesses and individuals access the opportunities offered by AI and digital automation. Ireland can be categorized as an ideal testbed for further digital transformation because of its collaborative nature, innate technology base and the natural proximity afforded by the size and infrastructure of the country. To enable a competitive economy for a smarter world, it can be argued that the nation must further develop its AI ecosystem. This means enabling investment and collaboration in AI research and an enhanced environment that supports research and innovation in AI applications. Irish business already competes in an increasingly digitalised world. It is important to realise that it is in the implementation of AI-based solutions across all sectors that the real economic benefits will be found. The focus should be on enhancing comparative strengths and the conditions that enable every organisation to embrace innovation, better understand opportunities and adopt technologies, including AI. Enterprises must be encouraged in developing, adopting and deploying AI applications. Different sectors, organisations and individuals may be at different stages in their understanding and adoption of AI. Some may lack awareness of the opportunities of AI, while others may require support in the development and deployment of AI applications. Arguably, without enterprise-driven AI, Ireland will not be able to add value to ongoing research in AI and lose out to competitors. Enable everyone to reach their potential and succeed in an era of further innovation and technological change. Build an indigenous pipeline of AI talent and practitioners. Encourage digital inclusion and diversity and intensify investment in education and develop relevant skills. Build external partnerships and attract mobile AI talent to augment this pipeline (IBEC, 2020).

3.4.2 Major trends in Advanced Technologies

Integrated Supply-Chain

The growing importance of global supply chains has fundamentally changed the way the global economy and goods manufacturing are organised. While trade conducted through global supply chains has fallen

somewhat as a share of total trade since the 2008-2010 global financial and economic crisis, more than two-thirds of international trade still involves transactions made possible by such chains. The EU is profoundly involved in these production chains, more so than most other countries, and significantly more than both the United States and China (Szczepański, 2021). Smart manufacturing is the process of using digital technologies to create novel solutions, data business processes, culture, and customer experiences to meet the ever-demanding and changing economic landscape. Considering these supply chains, logistics and business process movement will undoubtedly become more competitive, productive, internationalized and efficient. Therefore, improving the overall effectiveness of how the business model evolves and having a greater impact on society. This reimagining of business in the digital age and on the manufacturing production line is the art of smart manufacturing.

The art of digitalisation can help your firm with the (1) reduction of time to market, (2) improvement of manufacturing/production processes, (3) reduction of non-quality supply chains, (4) reduction of stress and increase in attractiveness, (5) development of partnerships in the supply chain and (6) increase knowledge of the supply chain to identify new partners capable of providing rapid and agile skills development. However, to take full advantage of this technological advantage, companies must now focus on new skills and training.

Digital Twin (Product and Process)

Digital twinning can be defined as a virtual representation of a physical asset enabled through data and simulators for real-time prediction, optimization, monitoring, controlling, and improved decision-making. Recent advances in data processing and management tools bring the promise of digital twins and their impact on society closer to reality. Digital twinning is now an important and emerging trend in many applications. It can be said that there can be no doubt that a digital twin plays a transformative role not only in how we design and operate cyber-physical intelligent systems, but also in how we advance the modularity of multi-disciplinary systems to tackle fundamental barriers not addressed by the current, evolutionary modelling practices. A Digital Twin needs data collected from its real-world asset over its full lifecycle. In a standalone Digital Twin solution these data include:

- Design data pertaining to the real-world asset that include design specifications, process, and engineering data
- Manufacturing data including production equipment, material, method, process, quality assurance and operators
- Operational data including configurations of both hardware and software, telemetry and real-time and historic usage data, and maintenance records of the real-world counterpart (Boss, et al., 2020).

Digital Twin is an advanced digitisation trend that promises to deliver great value in and across many application domains. However, organisations must overcome many organisational and technological barriers to achieve a feasible solution that brings the value they seek. This represents a challenge for Small and Medium Enterprises (SMEs), as Digital Twin solutions can be quite costly and time-consuming to develop, use and maintain.

A Digital Twin is a digital replica of an artefact, process, or service sufficient to be the basis for making decisions. The digital replica and physical world are often connected by streams of data. The concept of the Digital Twin is by no means new. Cutting-edge and emerging technologies have made it possible to realise a Digital Twin solution capable of much more than previously possible. However, before the term was coined, the concept might have been referred to as an advanced version of a computational mega-model, a synchronised virtual prototype, or a device shadow. More generally, it may have been defined as an adaptive model used in an operating stage of a physical system for some specific purpose (Rasheed, San, & Kvamsdal, 2019). Moreover, the Digital Twin is considered revolutionary because it reaches across different Industry domains. The underlying simulation models are becoming increasingly complex with time, mirroring the complexity of the physical processes they represent (Boschert & Rosen, 2016). This generates the need

for new techniques in managing model complexities to operationalise the solution for the business process – a further complication to delivering an efficient and effective solution.

Robotics and Automation

Europe is a world-leader in the production of robots. This industry is a key element of the digital transformation of our societies and economies that, combined with Artificial Intelligence (AI), will likely have tremendous disruptive potential. Robotics, a domain of technology that produces programmable machines, is pushing the bounds of technology as we know it. Recent advances in Artificial Intelligence (AI) and related technologies have enlarged the scope of what can be disrupted by robots, inducing important socio-economic changes.

Since the COVID-19 crisis, we are witnessing how the use of robots can bring significant efficiency improvements in protecting the health and guaranteeing security. However, there have also been concerns about the potential for cheaper and more efficient robots to replace humans in the workplace, linked to the emergence of the so-called “service robots”. It can be said that robots represent both a challenge and an opportunity for human society in general and for Europe in particular. Robots can be used to support humans in the performance of tedious, dangerous or hazardous tasks; they can improve efficiency and productivity, especially if combined with AI; they can help us increase our societal welfare and enhance the way we learn, allowing us to develop our potential to the maximum (Torrecilla-Salinas, 2021).

Artificial Intelligence

Under the right conditions, Artificial Intelligence (AI) are a suite of transformative technologies that can enable that future. Ireland has a positive baseline in certain aspects of digital development, but our economy and society must be prepared to work and compete in a world that is subject to further technological change. Artificial intelligence (AI) can be described as a suite of technologies or systems aimed at reproducing certain human cognitive processes – technologies that can be combined to sense, comprehend, act and learn. Current AI, although it can equal or surpass human capabilities in certain domains, is still narrow. The development of an ‘Artificial General Intelligence’ – one that could compete or surpass all human capacities, appears distant at present. Examples of current domain-specific AI applications include natural-language processing, image understanding, text understanding and generation, voice recognition, robotic process automation (RPA) and autonomous cars. AI is not new. AI development is iterative and has sometimes gone unnoticed. However, while sometimes misunderstood or misrepresented, there has been significant recent progress in AI development through a combination of technical progress and increased volumes of computing power and data. The World Intellectual Property Organisation (WIPO) report that there have been 1.6 million scientific papers and 40,000 AI-related patent applications since the 1950s, with the majority (more than half) of all AI-related patent filings published since 2013.

AI is a transformative technology that can bring social and economic benefits for example through better healthcare, more efficient public administration, safer transport, a more competitive industry and sustainable farming. AI has seen unprecedented levels of investment – funding of AI start-ups jumped to \$1.73 billion in Q1, 2017 up 84% on the previous year. AI is estimated to have the potential to double the annual economic growth rates of developed economies and increase labour productivity by 40% by 2035. Ireland is ranked in a cluster of EU states who are high performers in digital progress. Ireland’s AI ecosystem is characterised by a strong mix of both multinational and indigenous firms, 25 years of AI research, a variety of research centres focussing on different aspects of AI; and strong industry-academic collaboration. Government can play a key leadership role in preparing organisations and individuals for technological change. It can shape the emerging governance of AI, both at home and with its international partners. It can act as a catalyst by

enhancing conditions for AI awareness and adoption and lead by embracing technological change in government and enhanced public service delivery. Irish business already competes in an increasingly digitalised world. It is important to realise that it is in the implementation of AI-based solutions across all sectors that the real economic benefits will be found. Further digital transformation of the economy could benefit practically every sector, building on those where Ireland already has comparative strengths, including information, communication technology (ICT); biopharmaceuticals and medical technology; financial and business services; agriculture and advanced food production. For that reason, Ireland needs to enable every business, and not just in the technology sector, to understand and embrace AI, where appropriate, as a key driver in the next round of technological change. We should focus on enhancing our comparative strengths and the conditions that enable every business to embrace innovation, better understand opportunities and adopt technologies, in particular AI.

Extended Reality

The European Commission is supporting research and innovation into a European XR ecosystem ensuring that our European values are upheld. The development of technologies such as 5G/6G, data, artificial intelligence, edge and cloud computing offers new powerful means to XR. The European Commission is also encouraging cross-fertilisation between disciplines and domains, with a special focus on industry and SMEs, which will support Europe to become a force in XR. Extended reality is a mix of virtual reality (VR), augmented reality (AR) and mixed reality (MR). These technologies are used for much more than gamification (Shaping Europe's Digital Future, 2020).

The introduction of Smart Manufacturing deliverables with a focus on extended reality and full Industry 4.0 integration, implementation and buy-in, arguably, will lead to the disappearance of some jobs, but also the emergence and transformation of many others. When advanced technologies are implemented, most job positions at all functional levels will be affected, some of them are expected to disappear and others are expected to undergo important changes, or even merge with other job positions. Therefore, the digital transformation will require a thorough assessment of the transformation and recycling capacity of each of these job positions. Smart Industry (SI) stands for three main transitions:

- 1) Radical digitisation
- 2) Connecting products, machines, and people
- 3) Use of new production technology

The DuTextileh SI program, for example, has eight focus areas surrounding these transitions, namely Smart Products, Servitisation, Digital Factory, Connected Factories, Sustainable Factory, Smart Working, Advanced Manufacturing, and Flexible Manufacturing. To provide an insight into the Irish context, business priorities for a national AI strategy are fundamental to the future of industry sectors moving forward to be competitive, productive and achieve growth (IBEC, 2020).

3.5 In Transit services and drivers for innovation, collaboration, and growth with target industries

3.5.1 In Transit services and future activities

In regard to relevance of In Transit support services in INCUBATE, we can conclude that SMEs are highly interested to meet, network and exchange best practices, to learn on relevant real-life application of circularity, sustainability and digital transition, and in any actions supporting market development and options to foster commercialisation of solutions.

In regard to main In Transit services provided via open call INNOVATE, some of the them were indicated as highly relevant: Funding – leveraging public in private funding was the main service on the list, being indicated as strong or very strong by 65% of respondents. The second field of relevant services are related to technology identification and search of partners to support the SMEs, which is well correlated with previous answers.

For the question “Indicate the level of relevance of listed consultancy support services in addition to direct funding of SME projects (DEVELOP call)” the most relevant services are support to open innovation models, which is continuity of answer fostering the collaborative innovation which was highly ranked in previous questions.

Among the listed services in SCALE-UP support services, the most interesting (strong and very strong relevance beyond 40%, are

Mentoring for the large-scale demonstration and plan the needed tools, pilots and network towards scale-up tools and network towards scale-up and Internationalisation - scale up to global markets.

The results show that training should be more oriented to industry specific technologies, lean management, and of course to learn how to find the appropriate sources of funding for innovation. Training and Up / re-skilling need to respond to the new business models and the market expectations, the project will arrange workshops and webinars targeted on the topics mentioned in the previous chapters.

In regard to the relevance for development and market application in textile, construction, aerospace and advanced manufacturing, some of the topics we more interesting that the others, depending on the person answering. Similarly, as for capacity building, the topics suggested are the ones seen as important in the resilience and recovery plans of SMEs in addressed sectors. The answers indicate where we can expect more applications for the DEVELOP call.

4 EUROPEAN CITIZENS' BEHAVIORS, ATTITUDES, PERCEPTIONS, AND MOTIVATIONS REGARDING SUSTAINABILITY AND THE ADOPTION OF CIRCULAR ECONOMY PRACTICES

4.1 Objectives and survey design

In Transit invites Citizens/consumers and other entities, such as Research Centres and Policymakers, which are believed to be key in developing business models and reorientating demand. With this work, produced by POLIMI, the Project aims to implement a co-creation process to understand and analyse European citizens' behaviours, attitudes, perceptions, and motivations regarding sustainability and the adoption of circular economy practices, identify good local and international practices to accelerate the circular economy's implementation.

Three main reservoirs of civil identities addressed by D 1.2 were European Citizens, Research Centres and Policymakers. These groups were enquired because of their three diverse perspectives of the general perception regarding Sustainability, Circularity and Digitalisation depending on the civil and cultural role these cover within the European society.

4.1.1 European citizens' perspective on sustainability and circular economy

The [Survey for Citizens](#)² was released the 2nd May 2023 and has been closed the 26th May 2023 after **24 days**. The total number of **interactions** is **108** completed fillings, of which the majority is from Italy, followed by Slovenia, and Spain.

Questions on the general background of citizens show that the majority are younger than 25 years old and an equivalent percentage between 25 and 35. The results of the survey make believe that the great majority of the interviewees belongs to a generation with a high level of environmental awareness and sensitivity to related themes of circularity and digitalisation. Most represented country are Italy and Slovenia, almost in equal numbers, and Spain with 14% representation rate. 56.5% identify as female, 41.7% as male, and 1.9% as non-binary. 34.3% is a student, 19.4% works in Education and Research, lower numbers (13.9 and 11.1%) belong to the Business and Management and Engineering fields.

When defining the concept of **circularity**, the great majority (88%) knows the significance.

The questionnaire is structured per sectors: Textile, Construction (also addressed as Built Environment), and Advanced Manufacturing, excluding the Aerospace sector because of its structural distance with the civil environment.

Regarding the **Textile sector**, 83.3% of citizens state to undertake sustainable behaviours when interacting with textile items, mostly through practices of donation to charities and resale through service providers (mostly 'Vinted', very popular in Italy among young people, coherently with the main background of the citizens). Second most answered actions are *maintenance and repair* through personal and private tailoring, then *recycle* through major brands' recycling campaigns and charities' programmes, *swapping* among family and friends and *reconditioning*, even though when asking through which service provider, it appears that this action is mistaken with *resale*. All practices are related to life extension and are perceived to have a medium range of difficulty in the implementation (See Fig. n°21).

² The link sends to a .pdf file, where it is possible to consult the questions proposed in the Citizens' survey.

3. How difficult or challenging is it for you to adopt the above-mentioned strategies on a scale from 0 (not at all difficult) to 5 (very difficult)?

108 risposte

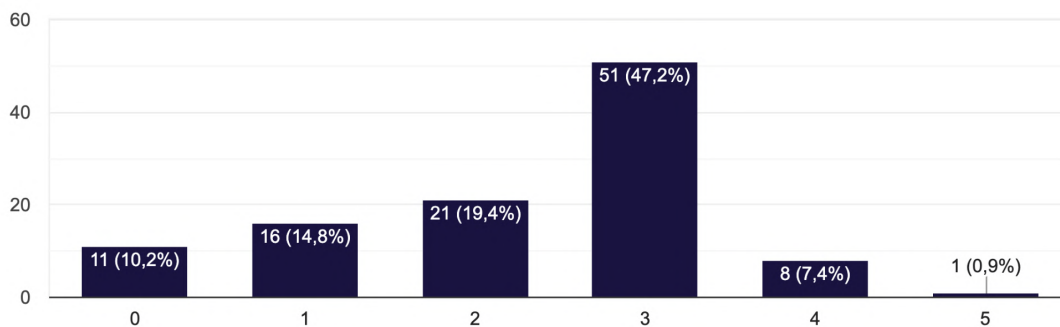


Figure 21: Citizen's survey: how challenging is to undertake sustainable behaviour using textile

66.7% of the interviewees believes the previous practices of Life Cycle Design (LCD) are applicable to the **Built Environment** (Construction sector), especially for the items related to wood flooring which is believed to be the category with the highest degree of intervention through *repurposing*, *reuse* and *recycling*. Also, walling, wall finishings, and plaster are considered recyclable, and in fact, processes for the reprocessing of plaster exist. Piping (both plastic and metal) along with structural metals are considered suitable for recycling.

Almost 3/4 of the citizens interviewed state they are aware of the possibility to extend the life of products and upgrade their performance through **Advanced Manufacturing**, but only 33.3% of the total has ever used the technologies, even though they are aware that it can be leveraged to apply CE strategies. Always 3/4 of the interviewees discloses that, despite being aware of the potential benefit to apply Advanced Manufacturing for circular solutions, they have never resorted to it, not for the textile nor for the built environment sectors.

Similarly, to the case of Circularity, 82.4% is aware of the given definitions of **Sustainability**:

- 1) "Sustainability is meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Source [UN](#)).
- 2) "The application of sustainability in overall business strategy, actions, processes and products, for example addressing SDGs (Sustainable Development Goals), ESGs (environmental, social and governance) () investing, addressing sustainability criteria for buildings, products solutions, addressing decarbonisation" (Source Results of the In Transit survey for companies).

72.2% of citizens believes to undertake sustainable choices when buying **textile** items. In particular, the great majority wants to choose items made of durable and sustainable materials. Of the processes related to the textile sector, the interviewees strongly believe that fair working conditions, toxicity of materials and processes, along with water exploitation and pollution, followed by deforestation are the most important themes to address, showing a gradual increase of interest from themes related to the natural environment, quality of natural environment related to human health, human health and quality of life (See Fig. n°22). In fact, the highest interest that citizens show is to have more information and transparency related to material sourcing, production processes and end of life.

3. In terms of Sustainability, in a scale from 0 (not important) to 5 (very important), how much do you rate the following factors when buying textile items:

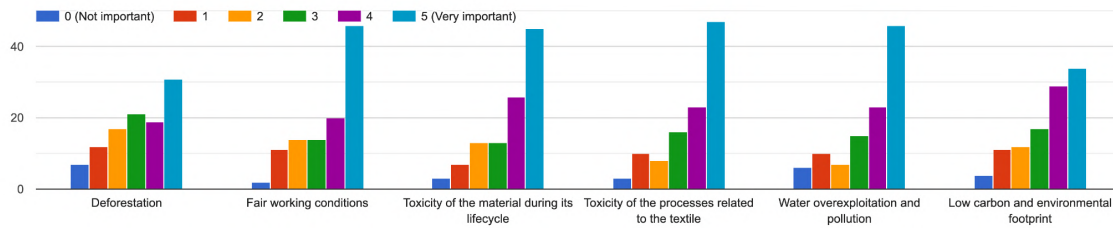


Figure 22: Citizen's survey: importance of processes in textile sector related to sustainability

Interesting are the results related to Sustainability in the **Construction** sector, which show an almost even score, revealing that 40.7% believes it does not undertake sustainable choices when choosing items related to the built environment. This result might be justified by the young age rate and the provenance from a country with a low range of purchasing power in young citizens. The prioritised strategies for reaching sustainability in the construction sector are identified in sourcing sustainable long-lasting materials, particularly biomaterial, and only after that compostable ones are chosen. Coherently, when asked to rate what they believe to be the most important factors for sustainability in construction, citizens showed a strong preference for materials' toxicity during their lifecycle and toxicity of processes together with water exploitation, followed then by fair working conditions and deforestation. The trend here shows that a strong attention is directed towards materials' sourcing, processing and disposing, no major insights are detected regarding the end-of-life phase and that of transportation that could also be considered of great impact (See Fig. n°23).

6. In terms of Sustainability, in a scale from 0 (not important) to 5 (very important), how much do you rate the following factors when choosing items for construction:

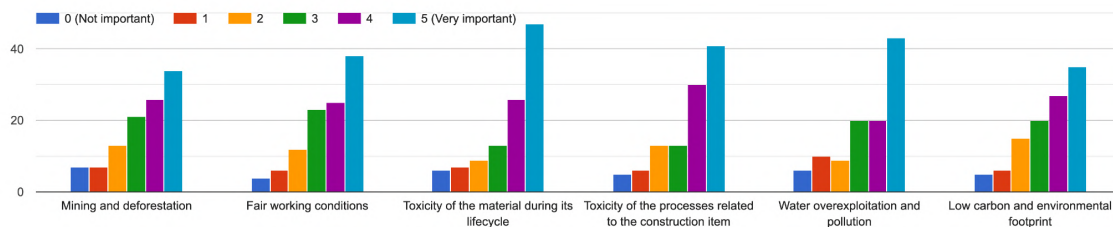


Figure 23: Citizens' survey: evaluation of importance of sustainability of construction processes

As well as for Circularity, also in the case of Sustainability, more information and transparency related to material sourcing, production processes and end of life are requested (See Fig. n°24).

7. Would you like to receive a more transparent communication from SMEs about (Multiple choice):

108 risposte

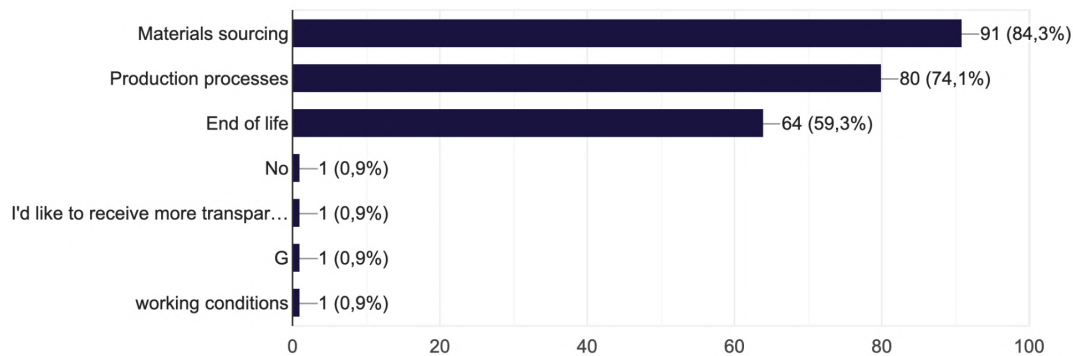


Figure 24: Citizens' survey: expectation for communication with clients on sustainability

The section of the questionnaire, dedicated to extract info about **Digitalisation**, confirms that citizens are well aware of what all the three themes (Sustainability, Circularity, Digitalisation) are about. When asked about what assets digitalisation help save the most, the interviewees believed that digitalisation can equally help in saving water, human labour, electric energy, and fossil fuel, all assets related to the physical running of processes and machineries. As it is possible to see in the figure below, in a second instance arrive issues like vegetal and animal life impoverishment, and material sourcing (polymers and minerals).

2. By using digital tools, which materials, processes, or labour do you think you are saving the most? (e.g., Using emails saves paper, using online drives ... making of the physical object...) (Multiple choice)

108 risposte

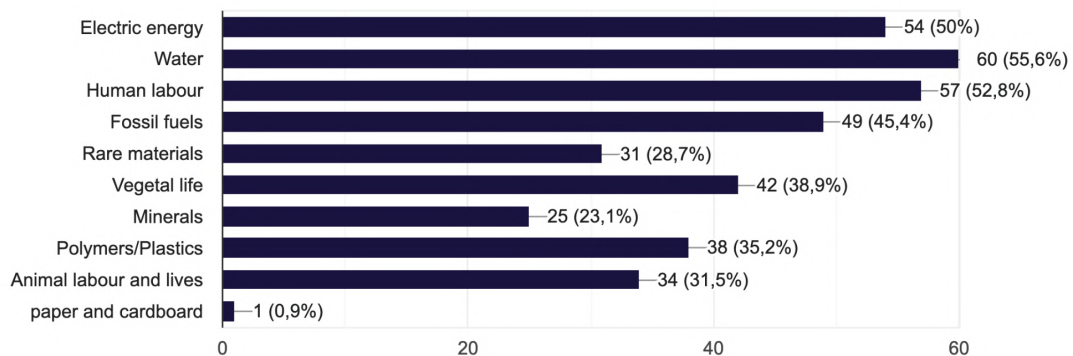


Figure 25: Citizens' survey: what assets digitalisation helps saving the most

The majority of citizens stated that they use online platforms to buy items from all the four sectors addressed within In Transit. The results show, in an extremely consistent gradual decreasing, that the highest rate of online purchasing goes to the textile sector, then construction, aerospace and advanced manufacturing as a last (See Fig. n°26). The most used platform is Amazon.

3.1 If yes, which sectors? (Multiple choice)

84 risposte

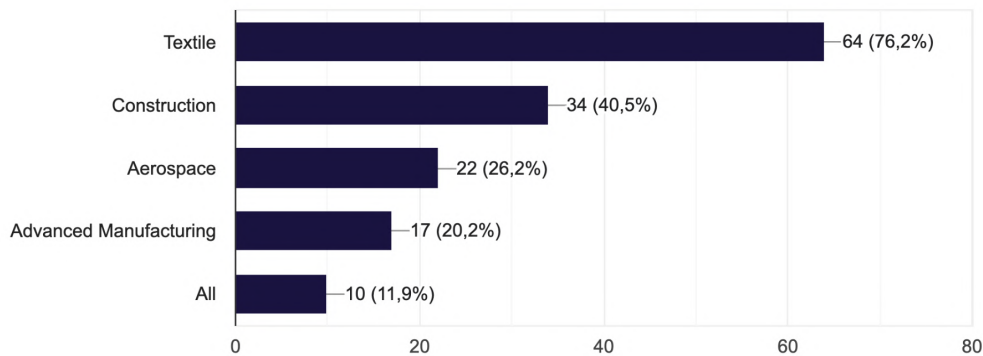


Figure 26: Citizens' survey: use of online platforms to purchase from sectors

36.1% of the interviewees uses AI and AR platforms to experience the item before shopping, the major reasons are to get a preview of the aesthetic features, of the use modalities, and for emotional experience. 64.8% of citizens is familiar with AI, only half of that has used AI to customise their wanted items, the most used AIs are Midjourney and Chat GTP, even though this last one is mostly used to generate textual responses.

1.1.1 European Research Centres' perspective on sustainability and circular economy

The [Survey for Research Centres](#)³ was released the 2nd May 2023 and has been closed the 26th May 2023 after **24 days**. The total number of **interactions** is **25** completed fillings, of which the majority is from Italy, followed by Spain and Ireland equally, and Portugal.

The gender proportion is 6 to 4, Female to Male. 64% is a PhD graduate, 32% Master Level.

The majority of experts works in the field of Materials, followed by Engineering, Science and Tech and then the Creative Industries, where they mostly study for a PhD, have a research fellowship or are Associate Professor. Even though, there is a stronger academic presence, a more entrepreneurial/managerial presence is detected through the participation of project manager figures and Principal investigators equally.

Entering the queries of the main sections, the experts are interviewed on best practices to put in place when entering a collaboration with SMEs. The most effective practices for leading SMEs to pathways of circular transition are considered by experts to be Life Cycle Assessment (LCA) and Life Cycle Design (LCD) equally, the use of materials that prevent toxicity and harmfulness. 40% of them believes in Sustainability Roadmaps as interventions toward circularity, and then, evenly distributed, LCD strategies like: the use of production processes that minimise Energy consumption, Advanced Manufacturing tools to extend lifespans of technology, products, services, and design to achieve industrial symbiosis (towards complex strategies and 'closed loop' solutions), (See Fig. n°27).

³ The link sends to a .pdf file, where it is possible to consult the questions proposed in the Research Centres' survey.

1. Highlight which, in your opinion, is the best practice/most effective activity toward Circularity to put in place when conducting applied research for SMEs (Multiple choices):

25 risposte

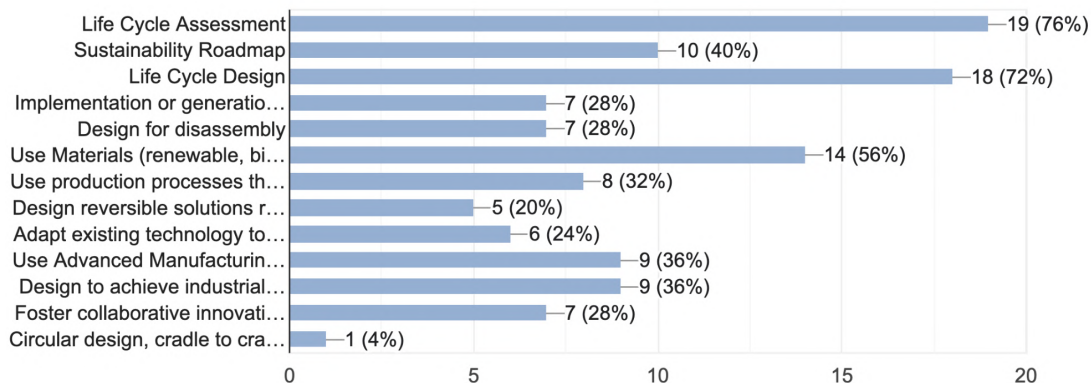


Figure 27: Research Centres' survey: best practices towards circularity

The survey presents a series of ranking questions dedicated to detect which are in the experts' opinion the best practices to implement when creating collaborative opportunities between SMEs and the research field, specifically per each sector addressed within In Transit. For the **Textile sector**, extending lifespans of technology/products/services, minimisation of materials' toxic and harmful effects, recycle materials to be used in a 'closed loop' cycle, are believed to be the most relevant topics to address, minimisation of energy consumption when using machinery is also widely considered to be of medium relevance. The less effective activities to achieve sustainability in collaborations between academia and SMEs for the textile sector are considered to be to stop exploitation of human labour implementing ethical human work practices and, equally, to Implementing pre-consumer and post-consumer material batch within production; in general, most interviewees believe the design for a facilitated implementation of all the mentioned practices to be the most relevant trajectory. In the **Construction sector**, the results are showing that the most effective practice is believed to be that of choosing renewable and biocompatible materials, also designing and building structures for longevity, consistently with using minimisation of energy consumption when using machinery and during transportation. The **Advanced Manufacturing sector** collects positive feedback related to the practice of recovering materials waste when operating subtractive manufacturing techniques, extending lifespans of technology, products, services, and designing to arrange reversible solution to make a service up to date. Minimisation of energy consumption during use and transportation are also concerning issue that experts believe to be relevant to address in the advanced manufacturing sector. The results of feedback for the **Aerospace sector** are more evenly distributed. Optimisation of energy consumption during the use phase of aerospace products is considered to be by the interviewed experts the most effective practice towards sustainability in collaborative projects. Minimisation of risks related to the controlled or uncontrolled release of space debris is a concern that is widely believed important to address, consistently to a trend that shows alarm for the end of life of spatial objects also designing lifespans appropriate to the spatial context is considered crucial.

For all the sectors, the trend shows that life extension strategies along with energy conservation and reasoned consumption are those believed to be more relevant to address in collaborative projects of research centres with SMEs to achieve sustainability.

When undertaking collaborative pathways for fostering innovation, often some boundaries have to be challenged and crossed. For this reason, it has been enquired in this survey which would be, in the researchers' experience, the departments within SMEs most resistant to change and what could be the collateral obstacles. Respectively, 76% and 60% state the departments less open to change are Economic and Financial and Management, the issues that prevent a smooth transition to sustainability are stated to be mostly related to management and system rigidity (76%). 64% of the interviewees believes the gap between existing regulation and new ones implemented generates a void that makes unclear on how to proceed, in fact, 60% identifies the Economics and financial department reluctance to be also an obstacle. (See Fig. n°28).

3. Which department within companies is, in your opinion, the most resistant towards CE (Multiple choices)?

25 risposte

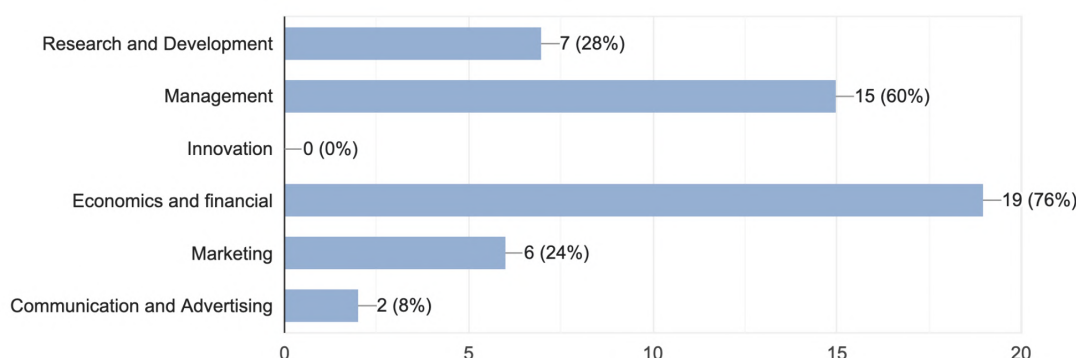


Figure 28: Research Centres' survey: which departments in companies contribute to CE

Experts believe that to drive SMEs toward more innovative, circular, sustainable products and processes, it is wiser to boost life extension strategies (durability, reusability, upgradability, repairability and recycling) and knowledge-building (Knowledge transfer, cross-fertilisation and Sustainability literacy). 24% chose 'Social readiness for circular practices implementation' and when asked to elaborate on what they meant by that, all answered giving solutions related to educative pathways, such as marketing and awareness campaigns, and educational spaces like makerspaces.

The experts believe that the research related to the circularity of products and processes is mostly heading towards strategies of life extension (such as durability, reusability, upgradability and repairability and recycling), 40% reports of product-service systems, 32% digitalisation. The results show that according to research centres, these strategies are moderately often applied, the ranking is positioned at a medium range: 3 to 5, (See Fig. n°29).

7. How often do you see any of these strategies being applied by companies on a scale from 0 (never) to 5 (always)?

25 risposte

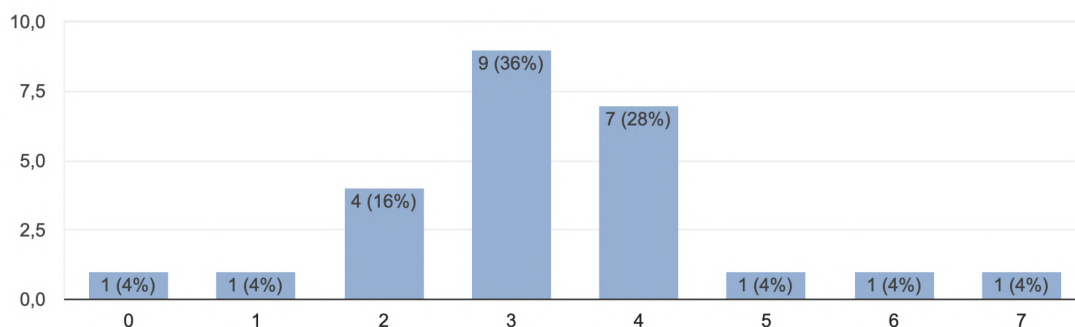


Figure 29: Research Centres' survey: how often transition to sustainability and CE is actually applied

Lastly, the survey poses questions related to the strategies that researchers and their institution put in place when fostering fruitful collaborations with SMEs. 76% listen to potential partners' needs and internal challenges to identify possible solutions that might be of interest, 56% engages in bi-lateral conversations regarding shared interests and opportunities, 52% opens up to the co-design of new products/service or processes. The obstacles that rise when establishing collaboration with companies are the difficulty to find relevant companies willing to go through a knowledge transfer process (48%) and the 'lost-in-translation' problem: 40% believes the academic language is too distant from the industry language (See Fig. n°30).

9. What are the troubles you face in establishing collaborations with companies/ third parties?

25 risposte

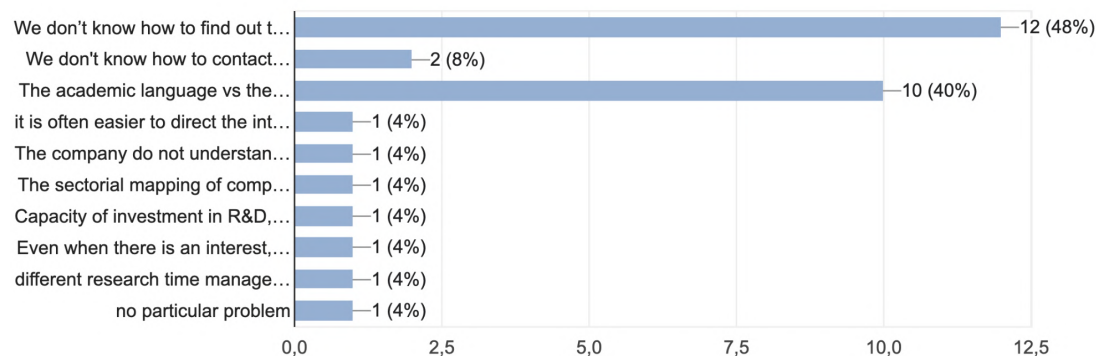


Figure 30: Research Centres' survey: obstacles at establishing collaboration with companies to foster green transition

According to the experts' opinion, the innovation most widely implemented by companies are: 3D printing and Biomaterial (both at 52%), AI and Machine Learning at 44%. Advanced Manufacturing, Furniture, Digital and Health, are in a decrescent order the sectors recognised as the most open to the implementation of innovative processes. In fact, Furniture, Textile, Ad. Manufacturing, Home appliances, are evenly the sector for which research centres work the most.

1.1.2 European Policymakers' perspective on sustainability and circular economy

The [Survey for Policymakers](#)⁴ was released the 2nd May 2023 and has been closed the 26th May 2023 after **24 days**. The total number of **interactions** is **8** completed fillings, of which the majority is from Slovenia, followed by Portugal, and Italy, Austria, Bulgaria equally. 75% of the users are **female**. 50% of the total works for the municipality, followed by regions, and ministry and chamber of commerce equally.

To set a general background, from the interpretation of the collected data, it is possible to observe that the majority of the interviewees operate at a **local level** (See Fig. n°31), intervening mostly on **sustainability**, specifically trying to have an impact on Construction, Textile and Advanced Manufacturing in a decreasing order. Reasonably, in fact, themes of circularity and digitalisation, along with other capillary ones, consistently follow the most chosen field, for they are indeed conceptually contained within the realm of sustainability.

3. To what scale are you working in your role as Policy Maker?

8 risposte

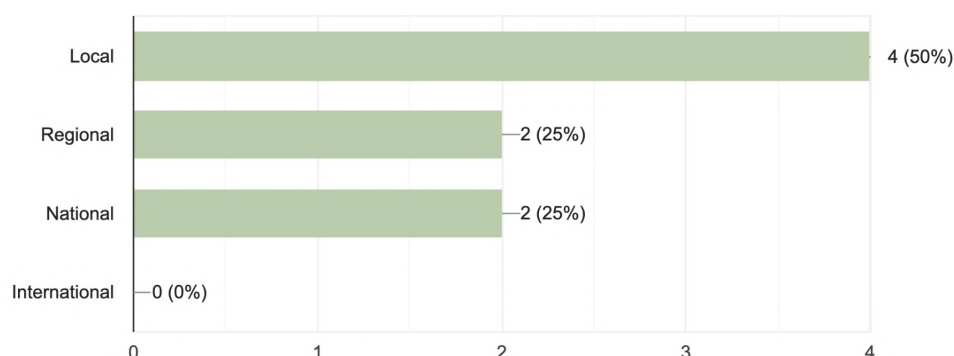


Figure 31: Policymakers' survey: field of activities of policy makers answering the survey

In the section of the survey dedicated to **Circularity**, 50% of the interviewees responded that they work to put in place the [Green Public Procurement](#) (GPP) also addresses as 'green purchasing'; second and third choices were respectively Sharing Services and Public Transport which in the essence can be also considered a sharing service but for the public sector: if the distinction between private and public service is overlooked Sharing Services outrun the GPP choice; a minority (25%, corresponding to 2 interactions) deal with certificate schemes for the reduction of CO2 emissions in the *Construction and Tourism* sectors (See Fig. n°32).

⁴ The link sends to a .pdf file, where it is possible to consult the questions proposed in the Policymakers' survey.

3. Do you work for carbon emission limitation in the form of a certificate scheme to support procurements?

8 risposte

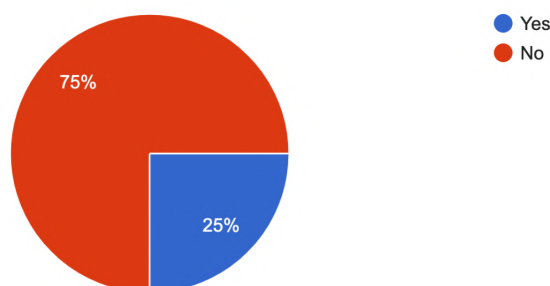


Figure 32: Policymakers' survey: working towards carbon emission

All interviewees state that their work brings together experts from financial institutions, the business community, government, innovators and civil society in order to generate attention and investment opportunities for the circular economy. Most interviewees (75%) work in European Projects, the same number stated that organizes platforms and network for knowledge exchange and innovation, 50% fosters private and public sector partnership, while the rest chooses 'Cross-sectoral projects connecting local SMEs with long-term investments in circularity' and 'Data collection across Europe to design new shared circular practices and regulations. It is, therefore, fair to say that most of the interviewees operate in a similar framework to that of IN TRANSIT.

When asking about tax incentives (See Fig. n°33), 62.5% stated that they are not working to create such tools, but the remaining 37.5% (2 interactions) that instead does design tax incentives addresses the sectors of construction and waste, specifically for life extension (recycling and repurposing) and material minimisation.

5. Does your policy making create tax incentives for the textile, construction, advanced manufacturing, aerospace sectors?

8 risposte

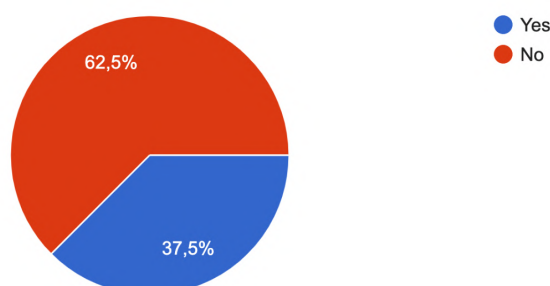


Figure 33: Policymakers' survey: working on tax incentives for sustainability and circularity

Even though, most interviewees don't work to generate tax incentives, they do create financial incentives for citizens devoted mostly to boost the use of sustainable means of transportation, management of construction waste, and recycling of textile materials. Only **half** of the policymakers interviewed states they

are currently working on policies for implementing circular practices within SMEs' framework, this 50% is equally distributed between Textile and Construction, which are also the sectors towards which previous interventions of the policymakers were destined to.

Currently, the focus of interviewed policymakers is increasingly directed towards fostering cross-sectoral waste management projects, recycling construction waste, reconditioning and repairing of goods using cross-sectoral knowledge and implementing cross-sectoral work-flows and mostly, pilot projects for cross-sectoral knowledge-building.

When addressing the theme of **Sustainability**, 87.5% of the interviewees states that s(h)e is working in the field of Sustainability Transition for SMEs. Most of the interactions show that the collaboration between private and public realities is found effective and productive, even though complex and challenging at times. Construction, Textile, and Advanced Manufacturing are the sectors to be believed more in need of urgent policies for sustainable practices. Reduction of CO₂ emissions, reduction of raw material extraction and waste, minimisation of water use are the actions taken more often by policymaker intervening on SME level. Textile, Construction, Advanced Manufacturing and Aerospace are seen to be most eligible for interventions connected to material innovation, especially through material flow and exchange, technology transfer and new flow-stream of energy. This trend shows that policymakers value initiatives towards circular logics of production where materials, energy, and knowledge flow from one field to the other (See Fig. n°34). This potential exchange requires a certain degree of security and protection when moving assets from one sector to the other, 87.5% of policymaker interviewed in this questionnaire state they are currently implementing digital solutions for transparency and governmental support toward cross-sectoral partnerships.

5. Partnerships and collaboration break down existing linear, siloed systems by offering collaboration among stakeholders from sectors th...onstruction, Advanced Manufacturing, Aerospace?

8 risposte

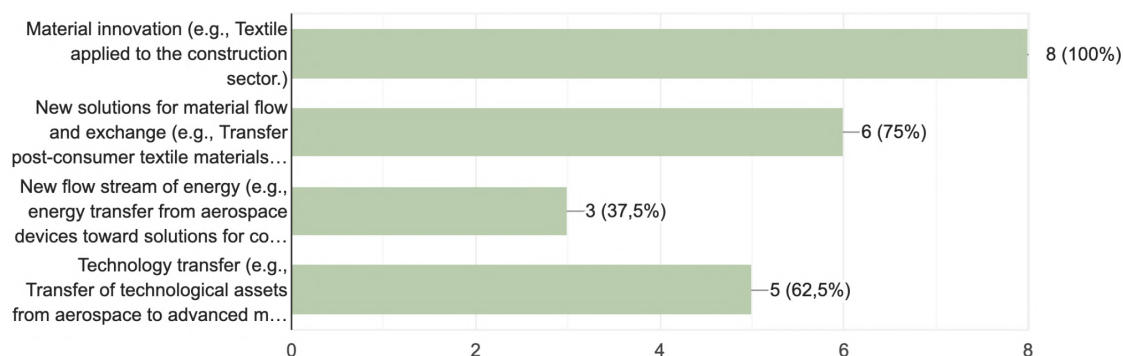


Figure 34: Policymakers' survey: supporting cross-sectoral solutions and collaboration

Compared to the two previous sections on Circularity and Sustainability, **Digitalisation** collects the lowest result (62.5%) when asking if related policies are being generated, nonetheless the **totality** of interviewees believes digitalisation to be functional to the sustainable transition, for, they believe, it facilitates solutions to increase the lifespan of products, reduces materials' exploitation, facilitates access to data and information (See Fig. n°35).

2.1 Why?

8 risposte

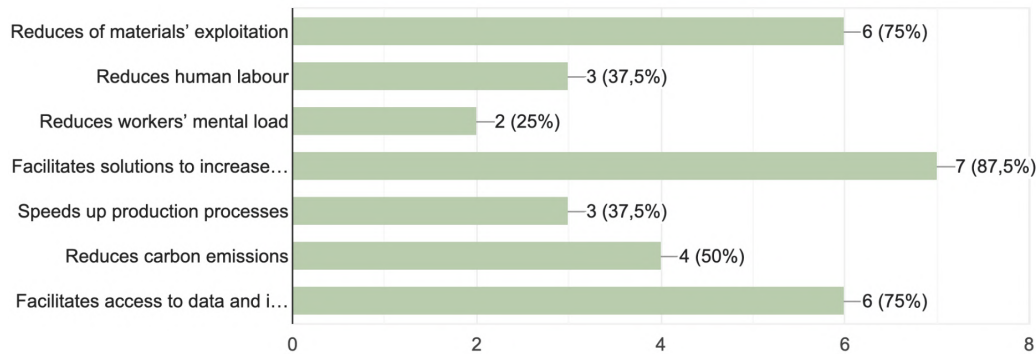


Figure 35: Policymakers' survey: how digitalisation supports sustainability and circularity

Despite that, only 62.5% of interactions show to have used dedicated platforms for governments to communicate with stakeholders, most of those who have, are from Construction and Textile sectors. Concerns arise related to cybersecurity and transparency when having to work on regulating online SMEs shopping services. In fact, Aerospace and Advanced Manufacturing, the two sectors already most digitalised, are believed to be more suited to incorporate digital technology and infrastructures compared to the other more traditional sectors. The total absence of action taken toward implementing either AI (Artificial Intelligence) or AR (Augmented Reality) within digital transition processes for SMEs enacted by policymakers shows a general slow grade of digital implementation within the addressed sectors (See Fig. n°36).

5. In a scale from 0 (not likely) to 5 (likely) how do you see digital technology and infrastructure to be incorporated within the:

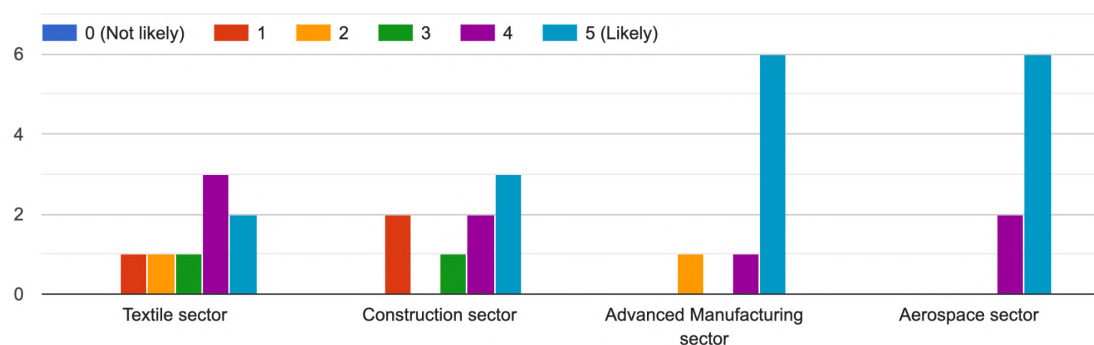


Figure 36: Policymakers' survey: importance of digitalisation for target sectors

4.1.2 Conclusions and main findings from the three surveys

Despite the diversity of sensitivity, awareness and knowledge backgrounds among all the interviewees, some consistencies between the three surveys, emerge and can be stressed to make some critical

considerations in order to lay the foundation for supporting SMEs toward innovation, cross-sectoral collaboration and improvement.

Considerations on the main findings will be here addressed, reasoning across surveys. The intent is to delineate the current state of the art by intersecting perceptions and beliefs extracted through the questionnaires of the three addressed social groups. This can help clearly visualise the contextual starting points, from a civil and social level, to designing, programming and developing interventions toward sustainability for SMEs participating in the In Transit project.

The three main findings resulting from the surveys can be classified as:

- focus on life cycles
- focus on materials
- focus on knowledge-building
- lack of focus on digitalisation

Focus on life cycles. The life cycle of products and services are considered, both by Citizens, Research Centres and Policymakers, a crucial point of intervention to undertake pathways toward a sustainable transition. Research Centres state that the most effective practices for leading SMEs to pathways of circular transition are considered by experts to be Life Cycle Assessment (LCA) and Life Cycle Design (LCD) equally. The design of extendable lifespan is strongly supported not only when designing products but also for technologies and services. In particular, strategies like durability, reusability, upgradability, repairability and recycling are firmly stressed, among these strategies, repurpose and recycle are those practices that Policymakers support the most with their protocols and incentives. Despite Citizens are aware of the importance of implementing these practices in their daily life and to govern their customer choices, they find the application of sustainable conducts moderately difficult to implement. These results show there is space for potential interventions in the gap between sustainability within SMEs and sustainability when their products land in the house of people, in the transitional space between the factory and citizens' homes. Most policymaking is currently devoted to life extension through transversal recycling policies, but a range of other strategies can be implemented towards reduction of toxicity of processes, deployment of energy not only during the use phase but also through the other stages of the lifecycle: pre-production, production, transportation and end of life, that currently, emerge to be less addressed.

Focus on Materials. It emerges from the three surveys a particular concern about materials exploitation, conservation and therefore minimisation. In the Citizens' survey, this preoccupation comes across through the attention towards extending the life of products, especially those from the textile industry, through practices of material recycling, reuse and repurposing. Researchers link the concern toward material exploitation to that of minimisation of energy exploitation and its reasoned consumption, a comprehensive vision that seems is missing from the perspective emerged from the policymaker's survey's results, who instead reason more with a sectorised vision of sustainability related to incremental actions e.g., CO2 minimisation, reduction of water use, reduction of raw material extraction etc. In fact, from the Research Centres' survey, it emerges that the second most pressing issue in the implementation of sustainable transition, after management rigidity, is the gap between existing regulation and new regulation with governmental legislation. To summarise, the normative structure at an internal and governmental level that exist feels to be not consistent with the complexity of the interconnectedness of the sustainable practices needed. A focus on 'materials', either material-based or energy-based, needs to be elevated to a further state of comprehension of the issue.

Focus on Knowledge-building. The theme of knowledge-building seems to be crucial for both Citizens, Research Centres, and Policymakers. Within the Citizens' results, it still emerges an anthropocentric view of the world which places humans' needs and their quality of life at the top of their concerns, then followed by concerns related to environmental issues as a consequential issue that could have an impact on the previous concern. Research experts stress the need of knowledge building activities, in the shape of

knowledge-transfer, cross-fertilisation and sustainability literacy. One of the main issues underlined is, in fact, a problem of communication between sustainability languages, that of the academic field and that of the industrial. Therefore, important is to foster a knowledge-flow that also policymakers value as compelling, when building cross-sectoral partnership. Another necessary intervention is that of sensibilisation of the Economic and Financial and Managerial departments which the surveys indicate as the most reluctant to implement practices of sustainability, to promote the involvement of the adverse sectors, researchers propose awareness campaigns and workshops along with spaces for incubation.

Lack of focus on Digitalisation. Throughout the three surveys emerges a certain distance to practices that lead to a digital transition. Citizens seem to have a degree of understanding on how digital tools could be implemented in their daily lives, the survey shows they already have had experience with digital interfaces related to customer services, especially from the textiles and clothes field. Researchers identify an increase in the implementation of innovation related to digital tools within companies, particularly connected to AI, Machine Learning and 3D printing employment. On the other hand, though, the policymakers show, through their survey, that incentives and policies leading and pushing towards the digital transition are consistently lacking in all the four sectors addressed within the In Transit project. Emerging is policymakers' concern regarding cybersecurity and transparency, which leads to a certain degree of reluctance toward digitalisation.

5 DIGITALIZATION & CE DIAGNOSTIC TOOL

5.1 Objectives

Developing a diagnostic tool for digitalization and circular economy (CE). This tool is designed to assist participant companies in evaluating their digital priorities and understanding where to begin their journey towards digital transformation. The diagnostic tool aims to provide insights into how digital technologies can contribute to economic growth and employment creation within the context of circular economy practices.

By utilizing this tool, companies will be able to assess their current digital capabilities and identify areas where digitalisation can be leveraged to drive circularity and sustainability in their operations. The diagnostic tool will help companies gain a comprehensive view of their digital landscape, enabling them to make informed decisions and prioritize actions that align with their goals for circular economy implementation.

Ultimately, the diagnostic tool will empower companies to navigate the complexities of digitalization and effectively integrate digital technologies into their processes, thereby fostering innovation, efficiency, and sustainability throughout their value chains.

The In Transit Diagnostic Tool is a self-assessment, created to provide an overview to industry and business in all sectors, where there are in their digitalisation journey and a summary of their circularity levels, in a combined two in one questionnaire. The engagement of clusters, SMEs, and other entities, on using this tool and providing us feedback, is crucial for the improvement deployment phase throughout following months after launch.

This digital tool has its main objective to support companies on implementing the digital technologies on increasing efficiency, security, productivity etc. Also linking the benefits of the available technologies and how they can be applied to foster and ignite circularity approaches such as reducing waste, electricity, raw materials usage, additionally, implementing practices of reuse, remanufacturing, redesigning, recycling among other.

Once the assessment is complete, a report is generated providing percentages and scores for questions covered in the Digital and Circular Economy sections. With these results a clear path for improvements is shown and what to do next. Moving forward, one of the next steps is getting in contact with local clusters, to address specific gaps and implement technologies specific for each sector.

The introduction to digital maturity and digital transformation methods might be the differential on optimising expenses and investments. Additionally, the access to alternative and ecological materials and smart technologies and how to implement them can be guided by your cluster sector experts.

The Diagnostic tool is allocated on the In Transit Project website <https://InTransitproject.eu/> under the subdomain <https://diagnostic.intransitproject.eu/>. Some preview of visual traits of the developed diagnostic tool can be seen in the Figure 3 and Figure 4 below. The visuals and contact might slightly differ from the final version.

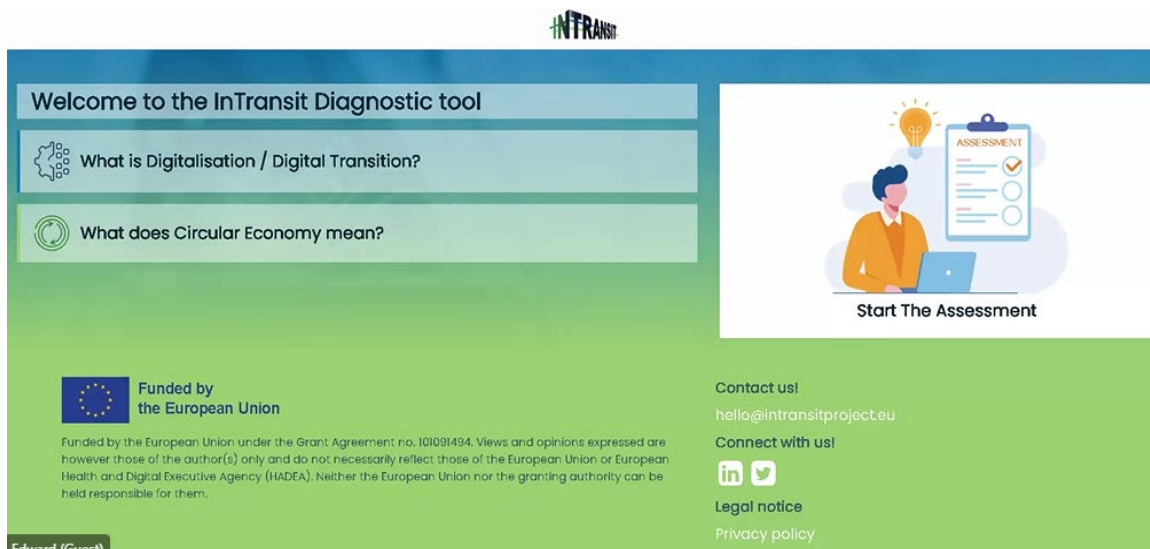


Figure 37: Diagnostic tool landing page: start the assessment

Figure 38: Diagnostic tool company details page

5.1.1 Digitalisation and CE diagnostic tools – pilot use

The In Transit Diagnostic tool official launch will happen on the 31st of May 2023 during the Matchmaking & Info- Day in Barcelona.

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