Mapping, gap analysis, and SME workshop to identify post-COVID situation and opportunities to build resilience

Project acronym:	xBUILD-EU
Project full title:	Cross-fertilization of industrial ecosystems in textile manufacturing and construction leveraging digital and advanced technologies to build up green and digital resilience in Europe
Grant agreement no.:	101074415
Author(s):	CITEVE
Nature:	Report
Dissemination level:	PUBLIC
Total number of pages:	29
Version:	2
Publication date:	23/12/2022

xBUILD-EU has received funding from the European Union's Single Market Programme under grant agreement no. 101074415

DISCLAIMER:

TABLE OF CONTENT

Executive summary

The aim of this report is to provide an analysis of the common gaps felt by the three activity sectors under the xBUILD-EU project, namely textile and clothing, construction and advanced manufacturing, when facing the challenges of the twin green and digital transitions, we then try to explore potential opportunities for cross-fertilisation initiatives between sectors, trying to open up new products or services, new markets and new open-to-innovation mindsets.

Firstly, the study provides an introduction to the recent and present status of each activity sector and the corresponding trends in business and technology.

Secondly, an exploration of potential opportunities for cross-sector initiatives leveraged by advanced technologies is presented.

In order to better understand their unique needs and objectives for overcoming present and upcoming difficulties, organizations have been requested to complete a survey. The second part of the document is dedicated to analysing the survey made to a sample of 27 companies of the mentioned sectors, in Ireland, Portugal, Slovenia and Spain.

Direct contributions from experts are gathered in the last part, in order to have a full perspective and concentrate on priority gaps and upcoming difficulties. The survey results have been combined with expert contributions, in order to draw some conclusions on the priorities of future xBUILD-EU training and funding initiatives.

Global Market Overview

Textile and Clothing Market

Global key facts

The textile industry is an ever-growing market, with key competitors being China, the European Union, the United States, and India. China is the world's leading producer and exporter of both raw textiles and garments. The United States is the leading producer and exporter of raw cotton, while also being the top importer of raw textiles and garments. India is the third-largest textile manufacturing industry and is responsible for more than 6% of the total textile production, globally. The textile industry of the European Union comprises Germany, Spain, France, Italy, and Portugal at the forefront with a value of more than 1/5th of the global textile industry. The rapid industrialization in the developed and developing countries and the evolving technology are helping the textile industry to have modern installations capable of high-efficient fabric production.

Member state share in total EU (Source: Euratex)

The global textile market size is anticipated to reach $1,420.3 billion by 2030, registering a CAGR of 4.0% over the forecast period. The rising consumer awareness levels coupled with rapidly changing trends in the fashion industry are projected to drive market growth.

The rise in the e-commerce platforms that support sales and distribution of different types of products manufactured by the textile industry is also expected to drive the demand for textile-related products, thereby augmenting the market growth. In addition, stringent regulations to ensure labour or worker safety in various application industries are propelling the demand for Personal Protective Equipment (PPE), which requires wool or treated cotton as a raw material.

The global textile market grew from $530.97 billion in 2021 to $577.83 billion in 2022 at a compound annual growth rate (CAGR) of 8.8%. The Russia-Ukraine war disrupted the chances of global economic recovery from the COVID-19 pandemic, at least in the short term. The war between these two countries has led to economic sanctions on multiple countries, surge in commodity prices, and supply chain disruptions, affecting many markets across the globe. The textile market is expected to grow to $722.32 billion in 2026 at a CAGR of 5.7%.

Market Evolution: Past, Present and Forecasts

The textile industry is one of the oldest and most important industries in the world. It is also one of the most globalized, with production and consumption happening all over the world. The global textile industry is worth an estimated $1.3 trillion USD and employs over 60 million people around the world. The industry is forecast to grow at a rate of 3-4% per year over the next few years. The global economy is also having an impact on the textile industry. The rise of China and other Asian countries as manufacturing powerhouses has led to increased competition for market share. Additionally, the ongoing trade dispute between the United States and China has led to tariffs on a number of textile products, making them more expensive for American consumers[1].

Natural fiber composites are relatively lighter and have more strength than conventional fibers, and therefore, find extensive application in the automotive industry for interior and exterior applications. Natural fibers obtained from plants and animals include cotton, silk, linen, wool, hemp, jute, and cashmere. These fibers are widely used to manufacture garments, apparel, construction materials, medical dressings, and interiors of automobiles, among others. The abundance of natural fibers, especially cotton, in China, India, and the United States, is contributing significantly to the growth of the global textile market. Silk is used in upholstery and apparel, as it is available in both variations fine as well as coarse. Wool and jute are used as textile materials for their resilience, elasticity, and softness. The increasing consumption of natural fibers, such as cotton, silk, wool, and jute, will drive the global textile market during the next period.

[1] https://www.indexbox.io/blog/World-Textile-Industry-Trends-Technology-and-Forecast/

Green transition

In the last decades, we observed the mass production industry shifting to countries with low labour costs. The European Textile and Clothing industry was probably the most affected sector due to the increasing low-cost business sourcing from overseas as the only way to compete with inexpensive products imports. European manufacturers understood that moving to cheap-labour countries would allow their businesses to stay competitive.

Further, the debate over whether offshore manufacturing is good for Europe, a new argument is now in place, related to the carbon footprint created when shipping goods overseas that could be produced locally in a closed value chain. In their rush to save money, managers often lose sight of the high penalties of moving abroad, namely the environmental impact that they are generating.

In 2019, the European Commission identified textiles (apparel and fabrics) as a 'priority product category for the circular economy' in Sustainable products in a circular economy - towards an EU product policy framework contributing to the circular economy. Furthermore, the new European Commission President announced in "My agenda for Europe" that she 'will propose a new circular economy action plan focusing on sustainable resource use, especially in resource intensive and high-impact sectors such as textiles and construction'.

The choice of materials and the design influence the environmental and climate impacts of textiles and the end-of-life options available in future. Circular business models need to be systematically scaled – and supported by policies - to enable sustainable sourcing of synthetic and natural fibres, including recycling and reuse of materials. When creating a circular economy for textiles, design choices are key.

Overall, we can observe 4 main business model types in the textiles system, each supporting the shift towards a circular textiles system:

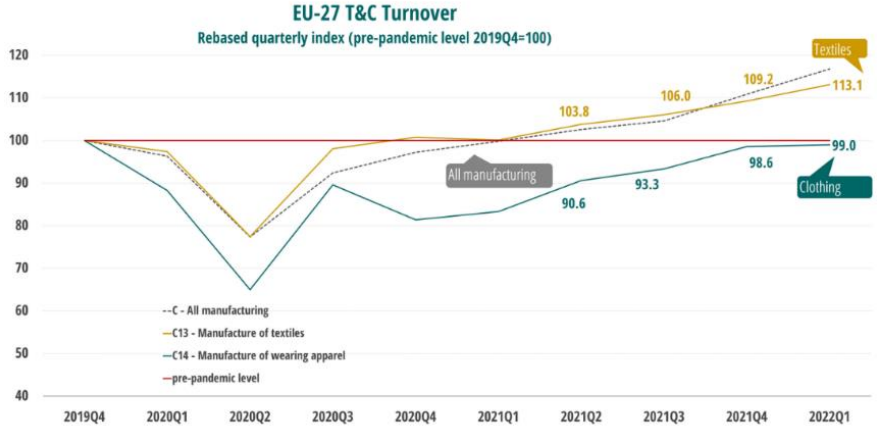
- **Longevity and durability**: selling durable textile products, focused on delivering longer product lives, for example, by using sturdy, high quality materials and repairable designs.
- **Access-based models, based on renting and leasing** (business-to-business/business- to-consumer) or sharing (mostly consumer-to-consumer): the textile products remain in the ownership of the company running the system, while the customer pays for having access to them.
- **Textile collection and resale**: business models related to resale, focusing on extending the useful life of textiles beyond the first user.
- **Recycling and material reuse**: this model focuses on closing the loop for textiles, by turning waste textiles into raw materials for new production chains.

Each of these four pathways tap into different societal opportunities but face different systemic challenges. Specific opportunities and challenges related to business models, social and technical innovation can be highlighted for each pathway. This creates a new perspective on the possibilities and limitations of business model innovation in driving the transition to a circular economy. It makes clear which action is needed to mainstream

a certain type of circular business model. Equally important, it also shows that different pathways can be useful, depending on the technical, social and policy context.

Covid-19 and war in Ukraine Impact

The outbreak of Coronavirus disease (COVID-19) has acted as a massive restraint on the textile manufacturing market as supply chains were disrupted due to trade restrictions and consumption declined due to lockdowns imposed by governments globally. The textile and clothing companies are still recovering from a strong contraction, due to the Covid-19 pandemic.



T&C industry turnover evolution (Source: Euratex)

Tougher market conditions did not yet impact T&C turnover in the second quarter of 2022. However, business expectations for the months ahead fell sharply, reflecting energy-related challenges and increased economic uncertainty in the T&C industry.

Compared with the same period of 2021, economic performances in the textile & clothing industry continued to improve significantly in the first half of 2022. The clothing segment recorded a 10,1% growth in turnover in the 2nd quarter, while textiles turnover grew by 2.2%. Export performance improved as well, with +8.4% for textiles and 0.7% for clothing. Imports remained more or less stable, with a remarkable shift from China to Bangladesh taking over as our main supplier of apparel products. This growth in turnover did not result in any significant changes in the employment situation.

Looking forward into the business expectations, the boosting effect of reopening of the economy after the Covid-pandemic is clearly fading. All sectors of the economy are being negatively affected by high inflation and persistent uncertainty, notably related to gas supply disruptions and the broader geopolitical repercussions of a long-lasting war in Ukraine. The same factors are expected to continue to weigh on EU activity during the winter of 2022/23.

Innovation: major trends in the textile sector

A tangible digital shift is taking place throughout the whole industry value chain, from the moment of inspiration to the point of sale. Every component of the business ecosystem will change as a result. Supply chain disruption, inflationary growth, and sustainability regulations are just a few of the global concerns that brands, suppliers, manufacturers, and retailers must prepare for. The most profound and pervasive transformative movement of the twenty-first century is probably the transition from a predominantly analog and physical to an increasingly digital and virtual world. Foundational technologies and business across almost all industries are being disrupted at an unprecedented rate thanks to the exponential innovation and efficiency improvements of digital hardware and software. Businesses who are not prepared to adapt to the brave new digital world are likely to be quickly surpassed and pushed to the sidelines by more adaptable and resilient rivals. The textile and apparel sector is not exempt from this trend, and a number of technical building blocks, such 3D virtual fabric and fashion design, digital printing, supply-chain management, or e-commerce, are now established. Other technological advancements have seen a significant increase during the Covid pandemics, including remote monitoring and assisted maintenance, IIoT and digital twins, supply-chain data integration, virtual showrooms, direct-to-consumer made-to-measure, and made-to-order business models. Others are still in the early stages of development but have enormous potential for the near future, including big data analytics and machine learning, extended reality, blockchain for supply-chain trustful interactions, NFTs, and other distributed security systems.

Construction Market

Global key facts (World, Europe)

In regard to potential applicants and beneficiaries of xBUILD project, the green and digital transition in construction refers to not only to industrial ecosystems of construction but also some other industrial systems defined in the New industrial strategy (2020) and as described in the Annual Single Market Report 2021. The construction ecosystem includes activities carried out during the whole lifecycle of buildings and infrastructures[1]. As such, it covers the design, construction, maintenance, refurbishment and demolition of buildings and infrastructure (e.g., transport infrastructure).

The activities included in the ecosystem are:

- On site construction, renovation, refurbishment and demolition, including development of building projects, on-site construction of building and infrastructure projects, and specialised activities: site preparation, electrical, plumbing and other installation, roofs, and other forms of building completion and finishing.

- Other services, e.g. engineering and architectural services, and activities supporting the operation of buildings, including facility management and landscaping activities.

In addition to the above, the definition of the ecosystems in the updated Industrial Strategy includes a share of manufacturing activities or services labelled as 'horizontal sectors' such as the use of installations and machines, repair and installation of machinery and equipment', 'manufacturing of fabricated metal products', waste collection, treatment, disposal and management', 'water collection, treatment and supply'. For example, 10.41% of the sector 'scientific research and development' is allocated to the construction ecosystem, too.

Due to its complex nature, the construction ecosystem is linked to and dependent on other industrial ecosystems. The manufacturing of the **most essential building materials is not included within the construction ecosystem** as many of them are part of the **Energy Intensive Industries (EII) ecosystem**. These include many products used for new construction and for energy renovations: the manufacture of wood and products of wood and cork, refined petroleum products, chemical products, plastic products, and mineral products. In the field of nature and biobased product, it is linked with the agri-food ecosystem.

With respect to the twin transition of the construction ecosystem, including the renovation and digitalization of the built environment, there are strong links to **the Digital Ecosystem:** not only the production of electronic products or robots used in construction, but also the telecommunication and information activities to digitalize the construction industry and the built environment; and to **the Energy-Renewables Ecosystem** manufactures several products that are used in low-carbon new buildings and in making the built environment more sustainable: manufacturing of electrical equipment used in buildings, infrastructure and construction machinery, and manufacturing of photovoltaics, heat pumps and other such equipment used in buildings.

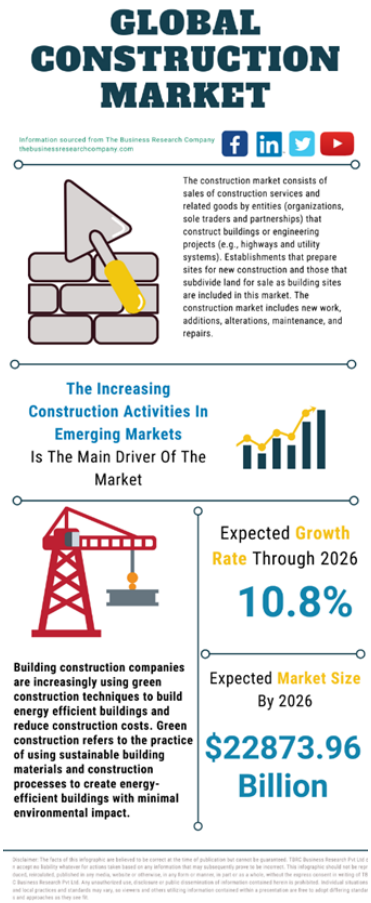
The European industrial construction ecosystem (basic definition in EU industrial strategy) employs approximately 24.9 million people in the EU and provides a value added of EUR 1 158 billion (9.6% of the EU total). In terms of employment and value added, this ecosystem is the second most important of the 14 identified ecosystems, with retail as the only ecosystem with higher employment (29.8 million) and value added (11.5%).[1]

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.

Market Evolution: Past, Present and Forecasts

The global construction market size[1] is expected to grow from $13.57 trillion in 2021 to $15.17 trillion in 2022 at a compound annual growth rate (CAGR) of 11.8%. The growth in the construction market is mainly due to the companies rearranging their operations and recovering from the COVID-19 impact, which had earlier led to restrictive containment measures involving social distancing, remote working, and the closure of commercial activities that resulted in operational challenges. The construction market is expected to reach $22.87 trillion in 2026 at a CAGR of 10.8%.



Global Construction Market (Source: Business Research Company)

The Russia-Ukraine war disrupted the chances of global economic recovery from the COVID-19 pandemic, at least in the short term. The war between these two countries has led to economic sanctions on multiple countries, surge in commodity prices, and supply chain disruptions, effecting many markets across the globe.

The increasing construction activities in emerging markets is expected to propel the growth of the construction market over coming years. Emerging markets which registered robust construction activity included China, Brazil, India, Saudi Arabia and Indonesia.

Construction costs have increased steadily due to rising material costs in the historic period. Companies in the industry experienced subdued growth in their profits with rising prices of materials such as crude oil, a key component of asphalt reached $41.96 per barrel in 2020, softwood lumber, a major component used for buildings construction, rose by 112% in February 2021 compared to 2020. Therefore, high material prices adversely affected the construction market during historic period.

Building construction companies are increasingly using green construction techniques to build energy efficient buildings and reduce construction costs. Green construction refers to the practice of using sustainable building materials and construction processes to create energy-efficient buildings with minimal environmental impact. According to World Green Building Trends Survey, about 60% of construction firms across the globe were involved in green construction projects

The European construction sector is expected to grow by 2.5% in 2022, as a result of “fresh investment from the EU recovery fund, according to global economic analysis specialist ING.

In its latest EU Construction Outlook report, the company said that despite price pressures, business confidence at the beginning of 2022 was positive among most contractors in the European Union, and back to pre-covid levels.

The research also revealed that the EU infrastructure sector grew by 1.5% (year on year) in November 2021. This is after almost no growth (+0.2% year-on-year) for the same period a year earlier.

While there are large differences between countries, the report said that production levels in the infrastructure sector across the whole of the European Union have been quite stable for the last 10 years.

Currently building volumes are being boosted by new investments from the EU Recovery fund whilst ongoing housing shortages and high house prices provide structural demand for new residential construction. Furthermore, non-residential construction will see a rebound as the Covid-crisis fades, and entrepreneurs are less reluctant to invest in new company premises or renovate their existing properties, said ING.

A record number of building companies are planning to increase their prices at the beginning of 2022. On balance, 36% of EU building firms plan to increase prices in January 2022. It is said that German, Austrian and Dutch construction firms, in particular, are expected to raise their sales prices. The construction sector in Germany has been quite resilient during the Covid crisis, said ING, but for Spain, they forecast recovery of

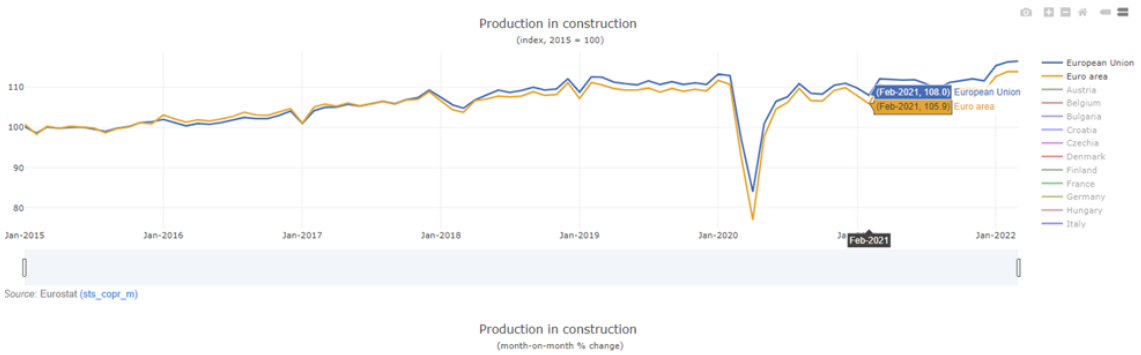
construction volumes this year and next, but it won't make up for the large drop from the last two years. ING also forecasts further recovery in France and Belgium this year and next year.

France has recently implemented a new law requiring half of the materials used in public buildings to be timber or other bio-based materials. This has led to increasing demand for these specific materials and shortages, especially as timber is still scarce.

Shortages are also said to be high in Germany, Austria and the Netherlands as production levels have remained high in these countries. ING expect that building material shortages will continue for a while, not least because of China's 'zero-Covid' strategy and restrictions put in place to contain the virus in cities and ports that are very important to global production chains.

In general, ING said their EU Construction Outlook remains optimistic. Despite the shortages of building materials and structural shortages of labour, they expect further growth in the EU construction sector in 2022 and 2023.

In March 2022 compared to February 2022, seasonally adjusted production in the construction sector remained stable in the euro area and rose by 0.2% in the EU. In February 2022, production in construction rose by 1.1% in the euro area and by 0.8% in the EU.



Production in Construction (source : Eurostat)

Green transition

Our world is only 9% circular, and the trends are negative. The circularity gap is not closing. Buildings still account for 45% of worldwide energy but also for enormous resource consumption. For example, the construction industry and the EU28 renovation segment is the largest single waste source being generated (42% covering 461 Mt/year of CDW and expected to reach close to 570 Mt/year in 2030). For example, in EU, almost one-half final energy consumption and extracted materials, and about one-third of water consumption, is related to the construction and occupancy of buildings. The sector also

generates about one-third of all waste. Nowadays, most of the EU countries are only recycling about 50% of their CDW.

Transition to a more circular economy requires changes throughout value chains, from product design to new business and market models, from new ways of turning waste into a resource to new models of consumer behaviour". Circular construction adopts the principles of circular economy along the life cycle of buildings. Design and construction of resource efficient, smart, modular, durable, easy to dismantle buildings, building as a service, off-site production, integration with mobility services, re-use of components, use of recycled materials, reduction of waste at retrofitting and demolishing, CDW management - are some of the challenges of the circular construction. Circular construction involves the entire supply chain, it changes many traditional business models and requites cross sector collaboration with different business actors which need to integrate their products and services in a complex product such as smart building.

Task Force 2 of Industrial Forum to support the development of transition pathway has identified seven such building blocks:

Sustainable Competitiveness	Assessing how the ecosystem is performing on green and digital relative to other ecosystems and to similar ecosystems in third countries, including whether there is a dynamic SME and start-up community that is contributing to the transition and resilience.
Regulation and Public Governance	Assessing the extent to which the regulatory framework is helping or hindering the transition and move to greater resilience and identifying both regulation or public initiatives that can help and existing situations that can create barriers.
Social Dimension	Assessing both the social implications of the green and digital transition and the measures that can be taken mitigate these, social market economy practices and institutions, i.e. the social dialogue.
R&D, Techniques and Technological Solutions	Looking at how research and innovation and the promotion of sustainable and advanced techniques and key enabling technologies can help the transition and move to greater resilience.
Infrastructure	Looking at the changes needed for the physical infrastructure to best support the green and digital transition or to overcome potential barriers.
Skills	Assessing the skills needs in making the green and digital transition, and how these can best be met; including through social dialogue.

All these building blocks should in turn help identify the **Investments and Funding** needed in the ecosystem to make the transition and ensuring greater resilience, coupled

with a mapping of possible sources of appropriate public and private financing at local, regional, national and EU.

Covid-19 and war in Ukraine Impact

Construction is one of the EU industrial ecosystems that has been the most heavily affected by the COVID-19 crisis and the war in Ukraine and faces the most important challenges as a result. The construction ecosystem suffers especially from shifts in supply and demand for materials, finished products and skilled workforce shortage.

The pandemic has laid bare the entrenched shortcomings of construction and other value chains related to the built environment (AEC = Architecture, engineering, and construction): underscoring the prevalence of low-quality buildings, issues around the affordability of decent housing and the lack of adaptability of our current building stock. These issues, coupled with the growing concern around the industry's highly wasteful and resource-intensive nature, present a strong impetus for the sector's transformation. From the other side, as response to the COVID-19 emergency trillions of dollars of economic stimulus have been made available around the world while calls for a recovery in alignment with other global challenges like global warming have never been louder. We should see beyond the pandemic a rare opportunity to recover by taking big steps towards digital and green transition.

Innovation: major trends in the construction sector

The fields of innovation needed or applicable in reaching more circular built environment, and being developed, adopted or just simply used are many. Not only innovation related to materials, product or technologies, but also in processed, business models, and social ones should be addressed and will be eligible within xBUILD FSTP applications. The major fields where innovation in circularity in construction sector can find place are listed below with a short description.

1. Circular design / design thinking

Circular design focuses on creating products and services for the circular economy. Specifically, this form of design advocates rethinking the process of creating a product from the beginning and, to do so, designers must adopt sustainability and respect for the environment as a starting point. Circular design incorporating the principles of the circular economy through life cycle of built environment. Innovativeness, replicability, market feasibility, circular impacts, sustainability of circular design can be evaluated with applications for xBUILD FSTP.

2. Nature based materials and solutions, biobased materials

Nature-based solutions are actions to protect, sustainably manage, or restore natural ecosystems, that address societal challenges such as climate change, human health, food and water security, and disaster risk reduction effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. NBS enables reduction of raw materials, replacement with renewable materials, support regeneration of built environment, positive social and climate impacts.

3. Advanced Building Materials

Advanced building materials can improve the performances of products, components and buildings at large. This material can offset the non-circular performances, improve the durability, use life extension, support in maintenance, improve recyclability of materials.

4. BIM / digitalisation, digital twins

Building information modelling (BIM) is an innovative digital tool that communicates information relating to all phases of an asset's lifecycle [1]. It can be used by stakeholders throughout the supply chain – including designers, contractors and building operators. Replacing physical products and services with virtual services (virtualisation) can bring many savings withing the life cycle of the building, and digital twins' basis for circular markets, where in advance the information on end-of-life reusable and recyclable components is available. It is also the basis for effective maintenance of building as bank of resources, prolonging the use life of the building. Using embedded sensors and smart monitoring devices that anticipate problems and carry out maintenance works can extend the life of built environment assets.

5. Construction Robotics

The construction industry lags many other sectors when it comes to adopting technology. Experts report strong growth in the global construction robots' market between 2015 and 2020, with further growth of more than 10% in the coming years. Robotics can benefit construction and have been in our factories for many years. This technology is now appearing on building sites where the objective is to relieve workers from repetitive, strenuous, and unsafe tasks, thereby further improving workers' safety [2]. They can have important role in the production and erection of buildings, saving different resources (reducing construction waste generated by traditional, manual technologies), can be used in waste treatment with combination for sensor-based systems.

6. Green/Sustainable Building

Green building or sustainable construction is referred to structures that are environmentally responsible and energy-efficient throughout its life cycle. Green building practices aim to reduce the environmental impact of a building. Most of the materials used in green buildings such as lumber, recycled metal, fiberglass, and mineral wool are

renewable and non-toxic in nature. Green buildings use onsite generation of renewable energy through biomass, solar power, hydropower and wind power. These practices make a building reduce its operating energy usage. Furthermore, low energy consumption appliances are used in green buildings to keep energy costs low. Most of the green building materials including cellulose and fiberglass are being used in green buildings owing to their superior insulating properties. Methods such as rainwater harvesting are adopted in green buildings to conserve reduce wastage of water. Green buildings also seek to reduce wastage of energy and materials thus reducing the overall environmental impact. Green buildings are widely used for residential, commercial, and industrial purposes owing to their low operational costs, energy efficiency, and low carbon footprint. Focus on sustainability and the imperative need for nations to reduce their carbon footprint are anticipated to push market growth throughout the forecast period. Supportive government policies to support the construction of green buildings, combined with sustainable certifications such as the Leadership in Energy and Environmental Design (LEED), are expected to boost industry demand.

7. Offsite Construction, modular buildings

Offsite construction refers to the manufacturing, planning, design, fabrication, and assembly of building elements at a location other than their final installed location to support the rapid speed of, and efficient construction of a permanent structure. Such building elements may be prefabricated offsite in a different location and transported to the site or prefabricated on the construction site and then transported to their final location. Offsite construction is characterized by an integrated planning and supply chain optimization strategy. Offsite manufacturing (OSM), offsite production (OSP) and offsite fabrication (OSF) are used when referring primarily to the factory work proper. Modularity of building components can add additional circularity performances of the building.

Construction Monitoring, Construction Project Management, Connected Construction Site, Digitalisation of construction processes can lead to circularity, reduction of different resources (materials, time, human resources, transport) which are exploited along these processes, and reducing of waste which is generated.

8. 3D Printing / additive manufacturing

3D printing is a process where 3D objects are created from a digital file. It's also known as additive manufacturing, because unlike traditional manufacturing which involves cutting out and removing material from a piece of metal or plastic, 3D printing adds successive layers of material until the object is created [3]. The construction industry currently generates a vast amount of waste, and progress towards sustainability is slow. Due to the complexity of supply chains in the construction industry, green management interventions have had a limited impact. It brings shorter supply chain and quicker design process, fewer logistical processes and less waste. And waste, e.g. secondary raw materials from other sectors can be utilized. 3D printing also enables a new level of customisation and adaptability of buildings to different end user needs.

9. Net zero buildings / decarbonisation

It is becoming clear that embodied carbon makes a significant contribution – between 30% and 70% of a typical building's total lifecycle emissions. Our goal has to be for the whole lifecycle emissions of our buildings to be net zero, not just operational emissions [4]. Passive design, reusing materials, offsite prefabrication, minimizing waste, repurposing existing buildings – different circular solutions are key to decarbonisation of built environment.

10. Deep / Circular Building Renovation

Circular renovation projects play a notable role in helping meet climate targets. Building construction and the production of building materials currently account for 11% of the world's energy-related carbon emissions. Simply choosing to renovate rather than demolish and construct new buildings can lower these emissions. Different solutions and innovations are needed to make renovation more circular, not only improving energy efficiency, and being applicable for different segments of the buildings, such as cultural heritage ones. Adopting circular economy principles in building renovation can reduce the use of materials in existing buildings and minimise emissions embedded in building materials [5].

By avoiding or delaying the use of new materials in buildings, circular economy-based approaches to renovation can help to reduce embedded greenhouse gas emissions. It is estimated that 20-25% of the life cycle emissions of the current EU building stock are embedded in building materials. The most effective circular renovation actions to reducing embedded emissions are extending the lifespan of existing buildings and increasing the intensity of building use. This reduces the demand for new construction, which consumes more materials than renovating existing buildings.

Ambitious circular renovation strategies could save up significant amounts of greenhouse gas emissions between 2022 and 2050, depending on the scale of renovation. Building renovation based on circular principles can contribute in important ways to achieving climate neutrality.

11. Smart buildings

A smart building is one that uses technology to enable efficient and economical use of resources, while creating a safe and comfortable environment for occupants [6]. Internet of Things (IoT) sensors, building management systems, artificial intelligence (AI), and augmented reality are amongst some of the mechanisms and robotics that may be used in a smart building to control and optimize its performance, prolonging use life, reducing needed resources for maintenance, and improving end-of-life processes.

12. New European Bauhaus

The New European Bauhaus is a creative and interdisciplinary initiative that connects the European Green Deal to our living spaces and experiences. It is about leveraging

our green and digital challenges to transform our lives for the better. The New European Bauhaus initiative calls on all of us to imagine and build together a sustainable and inclusive future that is beautiful for our eyes, minds, and souls. It opts for more user focused, and resources conscious design and construction, clearly embracing circular economy principles, too.

13. Circular thinking

Circular thinking refers to changes in behaviour of different stakeholders in construction value chain practicing circular economy principle in their activities, being related to business actions or other. Social innovations, e.g. project activities which will outcome in a wider change and acceleration of circular thinking in particular segment of stakeholders can be eligible for FSTP funding.

Advanced Technologies Innovation Landscape

Innovation: major trends in Advanced Technologies

1. 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. 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). However, to take full advantage of this technological advantage, companies must now focus on new skills and training.

2. *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. In this work, x-BUILD-EU reviews the recent status of techniques related to the construction of digital twins. The aim is to provide detailed coverage of the current challenges and enabling technologies with a lens on the area of digital twins along with recommendations and reflections for various stakeholders.

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.

3. *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).

4. *Artificial Intelligence*

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. Under the right conditions, Artificial Intelligence (AI) are a suite of transformative technologies that can enable that future. 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 match 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.

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. 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.

5. 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

Cross-sectoral innovation

Examples of textile technology in construction

Today's era, people are more focused in building and construction design that receive more sunlight, are greener, high performance, cost saving and eco sustainable. Textiles used in build-tech, geotextiles, architectural, construction textiles, eco textile, green roofs, agro textile, all play a vital role in fulfilling these requirements.

Textiles used in building and construction application may be divided in two categories: Buildtech and Geotextile.

Buildtech: Textile fibers are used with concrete to enrich its properties, protection against UV and electromagnetic radiations, lowering the cost, eco-friendly and so on. Textile integrated LED and others electroluminescent material applications are increased due to green energy concept.

Today, textile reinforced concrete (TRC), a composite material with performances similar to steel reinforced concrete, enables lightweight structures with high durability and quality surfaces in a cost-effective way.

TRC and other textile composite materials are used in the construction of buildings, dams, bridges, and roads and collectively comprise the "Buildtex" sector. They provide mechanical properties such as lightness, strength, and resilience. They are also resistant to many factors such as creep, degradation by chemicals and pollutants as well as the effects of rain, sunlight, acid, and base, etc. In this way, buildtex plays a vital role in the modernization of infrastructure.

Geotextile: is a synthetic permeable textile material used to improve the soil characteristics. It has the ability to separate, filter, reinforce, protect and drain when used in association with soils. Geotextiles are ideal materials for many infrastructures works such as roads, harbours, landfills, drainage structures, and other civil projects

Application fields:

Application	Function			
	Reinforcement	Separation	Filtration	Protection
Roads	✓	✓	✓	
Railways	✓	✓	✓	
Foundations	✓	✓	✓	
Drainage system		✓	✓	

Erosion Control	✓	✓	✓	
Dams	✓	✓	✓	✓
Canals	✓	✓	✓	✓
Tunnels & underground work				✓
Solid waste	✓	✓	✓	✓
Liquid waste	✓		✓	✓

Examples of geotextiles in a tunnel construction. Own sources

Nano-tex

Both in buildtech and geotextiles, nanotechnology plays an important role in a different way. It improves existing textile properties and offers additional functional performance by increasing chemical, photochemical, biological, and mechanical properties.

Nanotechnology makes possible the arrangement of different functions in the same textile properties. Nanofibers and nanotubes are used to made lighter, stronger, acoustic insulation, thermal insulation, controlled light transmission, efficient energy management, cost effective concrete materials in buildtech. That's more sustainable, run longer and more capable to resist strong shocks generated by earthquakes.

Application of nanotextile in buildings:

- Self-healing concrete,
- Reinforcement of critical walls,
- Localized crack repair,
- Wrapping of existing columns,
- Explosive incidents and protection purposes
- Protection against earthquake or hurricanes, etc.

3D printing

3D printing technology is providing to make things in a new way. Main advantages of the 3D technology are built houses with cost savings, environmentally friendly, time saving

and very fast way. Different textile material including TRC, used to make durable construction at low cost.

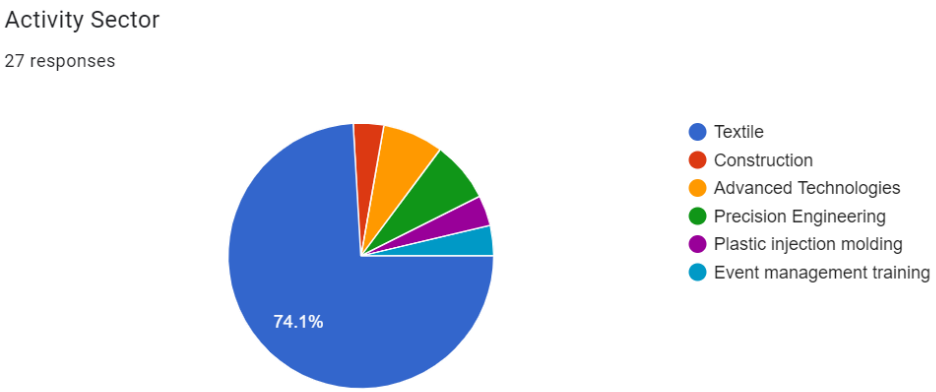
Gap Analysis

Results from the survey and workshop

Within the preliminary activities of the xBUILD-EU project, a survey has been conducted at Textile and Clothing (Portugal and Spain), Construction (Slovenia) and Advanced Manufacturing (Ireland) industries, driven by their respective sectorial and national/regional clusters. The survey aimed at collecting new inputs about companies' needs and testing the specific directions that experts and stakeholders have drafted to become more resilient after the pandemic and to drive the recovery of those industries.

The poll has been set up to classify the needs and gaps of businesses, particularly SMEs, and to rank the assistance provided and the steps taken to address both recent and anticipated issues. Additionally, the findings from an internal workshop with partners' expertise were gathered to determine strategic directions and solutions.

A total of 27 businesses, 77.8% of which are SMEs, from Ireland, Portugal, Slovenia, and Spain have responded to the survey. 74.1% of the businesses are in the textile industry. Construction, precision engineering, plastic injection moulding, training for event management, and sophisticated technologies are some additional activity areas.

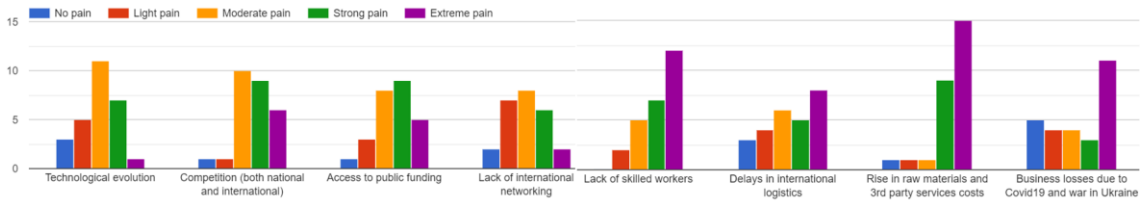


Surveyed companies' activity sector distribution

It is important to notice that companies are still struggling with the **Covid-19 pandemic effects** on business, having not fully recovered from its impact and are now facing the new challenges of the **war in Ukraine**.

Both the poll and the workshop made it clear that the greatest challenge facing businesses right now is the **uncontrollable and exponential rise in raw material and**

energy expenses. Companies are dealing with regular and ongoing increases, which have an impact on the price of raw materials as well.



Survey results: current challenges

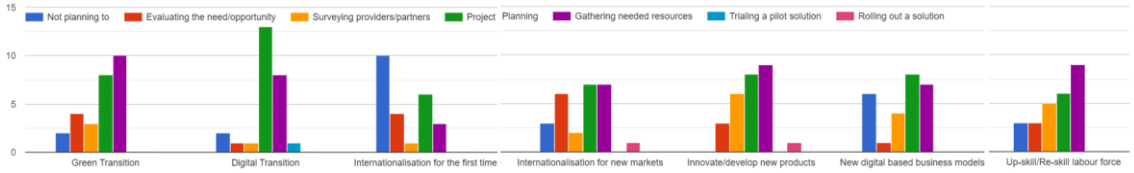
Lack of skilled workers seems to be the 2nd most painful pain point faced by companies in the sample. This pain point is closely related, as an additional cause, to the challenge of coping with the **permanent and fast technological evolution,** where 18 out of 24 companies mention it from moderate to extremely painful.

Fierce **competition**, both from national and international players is also a hot topic when it comes to current pain points. The entry of new competitors and new nations that joined the global market poses a danger to EU businesses. In this way, persistent issues have come to light, including a constrained supply network, a lack of global linkages, exports that are primarily directed towards the EU internal market, and a lack of appeal to young people entering the labour market from these industries (mainly T&C and construction).

Access to public funding for investment is considered painful for more than 90% of companies.

All businesses are aware of the opportunities the global market has to offer, but their biggest challenge is figuring out **how to get in**. The gap relates to both how to enter and what to do once inside as well. The necessity for **easier access to new markets** and greater **engagement with new suppliers and customers** was emphasized. In this regard, it's crucial for businesses to present themselves as **networked and clustered** rather than autonomously. Sectorial cluster should provide specialized services to help EU businesses enter new markets. In addition to competent contacts and pertinent market data, cluster can also report on financial and technical opportunities inside European projects.

In addition to the present issues, we must consider the obstacles and challenges that companies will probably face in the near future. Based on the answers to the survey we can observe that, regarding the **Green Transition** process, it seems that most sample companies are already taking measures to tackle it, but most are still in a preparatory stage.



Survey results: near future challenges

When it comes to **digital transition** the scenario seems a bit better but most companies are still in planning stage.

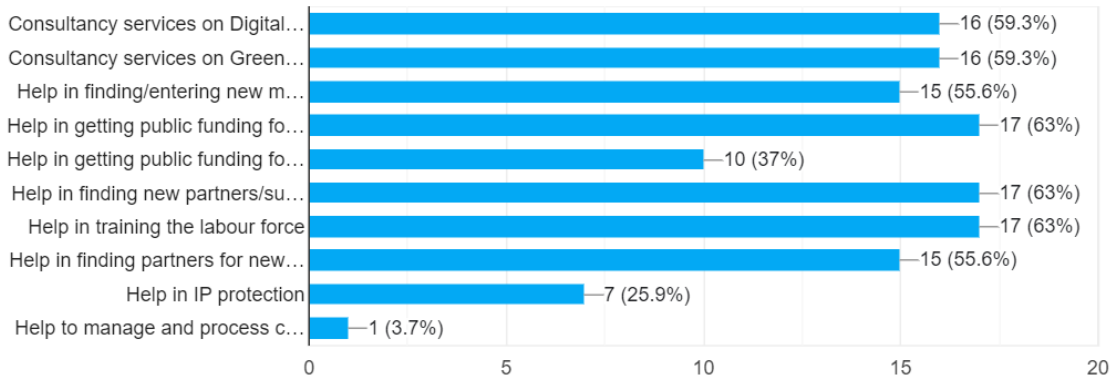
Reaching new international markets seems to be in the agenda of most companies but in a very early stage. When asked about what new markets would be of interest to them, in the middle East region, the **United Arab Emirates** represent the most wanted new market to reach by our companies, followed by Saudia Arabia and Israel. When considering America's region, the **USA hits the top preference**, closely followed by Canada.

Innovation is on the agenda of most companies but once again, the majority are still in the early stages of the journey.

A significant number of companies (6 out of 27) do **not plan to explore digital-based business models**. The ones that do are mostly in the planning /preparation stage. No one is actually running a pilot.

The need for **up-skilling and re-skilling the labour force** is in the agenda for most companies and most of them are already in the process of preparing or planning the necessary actions to undertake.

When asked **what support they would expect or wish for from the XBUILD-EU pro**ject, we find that there is a strong need for help in getting public **funding for innovation**, help in finding **business partners** and help in **training the labour force**, followed by consultancy services in green and digital transition and help in entering new markets and lastly, help in finding the right partners to innovate.



Survey results: Support needed from xBUILD-EU

Finally, considering the companies' input and the experts' judgement, the higher priority gap/opportunities to address within the scope of xBUILD-EU should be:

A) **Innovation -** The most crucial tool for achieving a swift and seamless twin changeover is innovation. It must be founded on a blend of both radical and incremental technological advancements in materials and processes, non-technological enhancements or transformations of business models, value chain operations, customer engagement, product life cycle management, and creative application by both industry professionals and consumers.

B) **Labour force -** Beyond the basic technological ability to create novel materials, products, processes, or business models, innovation can only thrive in an industry if employers have access to a sufficient pool of employees that are well-educated, talented, and motivated. The largest obstacle to the industry's change may be a constantly aging workforce mixed with the requirement to quickly pick up new competencies and skills. With few exceptions in labour-intensive jobs, digitalization and automation in manufacturing continue to displace manual labour; yet, demand is growing for job profiles that require both in-depth technological knowledge and creative and soft abilities. Companies are under pressure to up their game in terms of attracting and retaining young talent, including intra-company career development and training programs, as a result of a fast-ageing workforce and the retirement of highly qualified senior specialists.

C) **Funding** - Investment in green and digital technologies is expensive but, on the other hand SMEs awareness of national & international funding or projects to support SMEs growth is scarce. When they try to apply for they feel funding application is too complex for them and not suitable for small scale innovation projects.

D) **Markets -** Identifying and gaining access to new international markets is quite a challenge for SMEs. Finding the right market, the right partner and the right value proposition is hard. Support is needed in identifying high added-value niches that search for high quality, design and customization.

Cross-sectoral collaboration opportunities

Advantages of Textile in Building and Construction:
Viable tools for many civil and environmental engineering applications
Increased system performance & life
Value engineering
Reduce carbon footprint
Flexibility in design & selection methodologies
Specification based upon functional design intent
Make profitable in products for durability, cost, strength-to-weight ratio and environmental aspect as well.

Conclusions

The pace of change brought about by the digital revolution is unprecedented. The way that businesses run, how people communicate and exchange information, and how they engage with the public and private sectors have all altered as a result of digital technologies. To harness the huge value created by the digital economy and successfully implement digital transformation, European enterprises and citizens alike require an effective policy framework, as well as the necessary skills and infrastructures (EU Policies, 2019). The EU faces a 65-billion-euro annual investment shortfall in just digital networks and infrastructure. By 2030, putting reforms into place and scaling up R&D and technological deployment expenditures might result in an additional 14% GDP growth. Acting quickly would bring an additional 3.2% increase in GDP and positive job creation by 2030. This is a socio-economic boost that Europe cannot afford to miss. Investing in innovation is only part of the issue, however. A true digital transformation must start with European citizens and businesses trusting that their applications and products are secure (Shaping Europe's Digital Future, 2020).

In order to make the first steps towards green and digital transition in both textile and constructions, as well as for fostering cross-sectoral innovation, xBUILD-EU will invest 1,05M€ in the next two years with dedicated cascade funding mechanisms, aiming at solutions that can ease the pain of participating SMEs in the dimensions identified by the gap analysis.

References

1. Boschert, S., & Rosen, R. (2016). Digital Twin - The Simulation Aspect. Mechatronic Futures. Springer., 59-74.

2. Boss, B., Malakutiand, S., Lin, S.-W., Usländer, T., Clauer, E., Hoffmeister, M., & Stojanovic, L. (2020). Digital Twin and Asset Administration Shell Concepts and Application in the Industrial Internet and Industrie 4.0. OMG.

3. Digital Twinning (2019). "Change2Twin, www.change2twin.eu/.

4. EU Commission, Factories of the Future Report (2018). "Factories of the Future." EFFRA, 19 Nov. 2018, www.effra.eu/factories-future.

5. EU Policies (2019). "Delivering for Citizens: Digital Transformation | Think Tank | European Parliament." www.europarl.europa.eu, 28 June 2019, www.europarl.europa.eu/thinktank/en/document/EPRS_BRI(2019)633171. Accessed 11 Nov. 2022.

6. IBEC (2020)., "Smarter Technology for a Better Future – IBEC, www.ibec.ie/connect-and-learn/insights/insights/2020/02/20/smarter-technology-for-a-better-future.

7. Rasheed, A., San, O., & Kvamsdal, T. (2019). Digital Twin: Values, Challenges and Enablers. 1-31.

8. Shaping Europe's Digital Future (2020). "EU4Digital, eufordigital.eu/library/shaping-europes-digital-future/". Accessed 9 Nov. 2022.

9. Szczepański, M. (2021). "Resilience of Global Supply Chains." European Parliament, Nov. 2021, www.europarl.europa.eu/RegData/etudes/BRIE/2021/698815/EPRS_BRI(2021)698815_EN.pdf

10. Torrecilla-Salinas, C (2021). "WHAT FUTURE for EUROPEAN ROBOTICS?" European Commission, 29 Jan. 2021.