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The Roadmap for the Twin Transition of Ukrainian Textile Industry SMEs

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Terminology

The document uses the following abbreviations and terms:

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Abbreviation	Full Name	Description
RM	**Roadmap**	A strategic planning tool that outlines key directions and stages necessary to achieve goals in a specific field.
EDIH	**European Digital Innovation Hub**	Organizations that provide services to SMEs in their digital transformation. EDIHs have four key roles: strengthening regional ecosystems, demonstrating modern technologies in practice, innovation fundraising, and providing training and education.
SME	**Small and Medium Enterprises**	Commercial organizations with 10 to 250 employees and turnover under 50 million euros.
DT	**Twin Transition**	A twin (digital and green) transition that involves systemic measures in digitalization and the implementation of ecological and green initiatives aimed at climate neutrality, energy efficiency, and circular production.
–	**Blockchain**	A "chain of blocks"—a distributed database storing an ordered chain of records (blocks) that is continuously growing. Each block contains a timestamp, a hash of the previous block, and transaction data presented as a Merkle tree. In industry, blockchain is often used for

		supply/value chain traceability, ensuring the authenticity of energy and material origins, compliance with quality standards, and product certifications.
DPP	**Digital Product Passport**	Unique, product-specific digital information contains data about a product from creation to disposal (or recycling). It includes material use, energy consumption, environmental impact, and disposal instructions.
	Digital Twin	Virtual replicas of physical products or processes, enabling testing and optimization without intervening in real processes.
CAD	**Computer-Aided Design**	Software used for creating high-precision models and drawings. In the textile industry, it facilitates quick pattern development, accuracy, and 3D visualization.
CAM	**Computer Aided Manufacturing**	Software automating toolpath calculations for CNC machines or other automated equipment.
CAE	**Computer Aided Engineering**	Software used for material analysis, product design optimization, and simulations.
ESPR	**Ecodesign for Sustainable Product Regulation**	European Commission regulation setting eco-design requirements for products sold in the EU. Products not meeting these standards cannot be imported or sold in the EU. It specifies eco-design requirements and necessary documentation, including Digital Product Passports.

ERP	**Enterprise Resource Planning**	Systems for planning, accounting, and controlling non-production business processes such as finance, logistics, inventory management, HR, and other administrative processes.
	Digital Lean	Integration of Lean principles with digital technologies like automation and data analytics to reduce production costs and increase efficiency. Digital Lean goes beyond traditional Lean practices by incorporating IoT, machine learning, and data-driven optimization approaches.
MES	**Manufacturing Execution System**	Unlike ERP, MES focuses on managing production processes in real time, including quality control, production scheduling, monitoring production stages, managing maintenance, and more.
PLM	**Product Lifecycle Management**	Software that centralizes the management, coordination, and integration of all stages (links) of a product's lifecycle—from concept to production and sales.

Executive Summary

The **Roadmap for the twin Transition of Ukrainian textile Industry SMEs** serves as a strategic development tool, outlining the key directions and initiatives for the digital and green transformation of the sector. The document is based on international methodologies (ADMA) and incorporates European experience, particularly the **Textile Pathway** recommendations and the reports of **Twin Revolution** project. It addresses the industry's major challenges, including low labor productivity, waste management, and innovation. These factors, alongside other industry-wide issues, have directly contributed to the declining competitiveness of Ukrainian producers on the global market and a drop in exports over the past seven years. Furthermore, the mandatory transition to new eco-design regulations by 2025 presents another significant challenge for the sector.

The roadmap is the result of the **GDT Textile project**, executed by a consortium of three participants (APPAU – project leader, Ukrlegprom Association, and Ivano-Frankivsk Chamber of Commerce and Industry) with the support of **UNDP Ukraine**. The development also involved experts from two clusters (Podillia Fashion Cluster and Circular Economy Cluster), two EDIHs (Clotex HUB and KyivHitech), the Institute for Economics and Forecasting, APPAU members (IT developers), and leading textile Industry enterprises.

The roadmap specifies detailed goals, strategic initiatives, and tasks across six categories or transformation areas: the development of the innovation ecosystem, technologies, production methods, personnel training, eco-factories, and support tools.

Key Tasks Defined in the Roadmap

- **Production Modernization**: Accelerating the modernization of production facilities with modern equipment, implementing Industry 4.0 technologies focusing on ERP, MES, and CAD-CAM systems, and integrating circular production technologies.
- **Ecological Transformation**: Accelerating the adoption of digital product passports and transitioning to energy-efficient and sustainable production practices.
- **Human Capital Development**: Training and reskilling employees to master Industry 4.0 technologies and green practices.
- **Innovation Ecosystem**: Expanding the roles of clusters, EDIHs, R&D centres, and other infrastructure elements while significantly increasing market promotion and innovation awareness activities.
- **Support Tools**: Adapting existing grant programs, loans, and international financing mechanisms to stimulate the twin transition.

Monitoring Indicators

The proposed monitoring system includes the following metrics:

- **SME Coverage**: At least 150 enterprises receiving twin transition services.
- **Pilot Projects**: 50+ pilot projects in digitalization, green energy, and waste management.
- **Productivity Growth**: A 25% increase in productivity among pilot enterprises.
- **Innovation Infrastructure Expansion**: Establishment of at least seven expertise centers (EDIHs, R&D hubs, incubators).

Overall, the roadmap offers **80 initiatives across six transformation categories** to be implemented throughout the three-year program.

Implementation Recommendations

The roadmap emphasizes the need for stakeholder consolidation as a key success factor. Government agencies, international donors, business associations, and clusters must be actively involved. Among the 80 initiatives, the following are considered top priorities:

1. **Deploying effective Twin transition support tools**, including grant programs, incentives for SMEs to adopt modern software, and assistance with implementing Digital Product Passports.
2. **Fostering collaboration between clusters and EDIHs** to establish consistent and high-quality service offerings for SMEs, focusing on innovation fundraising, training, Industry 4.0 pilot projects, and strengthening regional innovation ecosystems.
3. **Launching innovation competitions, hackathons, and, where possible, incubators and accelerators** to develop startups meeting market needs quickly.
4. **Organizing annual conferences** on "Twin Transition and Innovation in Textile Industry" and creating a web platform to enhance exchanges, monitor projects, and engage market participants.

The project consortium and associated partners express gratitude to the **"Strengthening Membership-Based Business Organizations of Micro, Small, and Medium Enterprises in Ukraine" project**, implemented by **UNDP Ukraine** in cooperation with the Ministry of Economy of Ukraine and with the support of Switzerland government.

Introduction – What is a Roadmap?

A roadmap (hereinafter referred to as RM) is a strategic planning tool that outlines the key directions and stages necessary to achieve goals in a specific area—in this case, the digital and green transformation of a particular sector. Roadmaps typically guide industry participants, helping them understand directions, priorities, timelines, and the interconnections between various components of change. They generally include descriptions of overarching goals and desired outcomes, timeframes, key factors, change areas, progress indicators (metrics), and action recommendations.

Compared to detailed medium-term strategies, roadmaps emphasize “what needs to be done and in which direction to proceed”. In contrast, the strategy focuses on “how exactly to do it” with clear instructions, budgets, responsibilities, and schedules. Thus, the roadmap serves as a foundation, while the strategy provides detailed implementation.

Since 2018, APPAU has positioned roadmaps as the main tool for guiding sectoral development in the era of the Fourth Industrial Revolution. At that time, the Industry 4.0 strategy project envisioned the creation of at least five roadmaps in Ukraine for key sectors critical to the economy—food processing, mechanical engineering, defence, energy, and metallurgy. For various reasons, this did not materialize. Over the following years, APPAU expert groups independently developed several position documents, among which the Guideline for Developing Roadmaps and the Draft Digital Transformation Roadmap for Ukrzaliznytsia (both dated 2019) remain relevant.

With the support of UNDP, 2024 marks the first-ever development of a sectoral twin transition roadmap in Ukraine. The working group for the textile Industry roadmap included leaders and experts from two national associations (Ukrlegprom and APPAU), two clusters (Podillia Fashion Cluster and Circular Economy Cluster, both members of the Ukrainian Cluster Alliance), two EDIHs (Clotex HUB in Khmelnytskyi and KyivHitech in Kyiv, based at leading universities in these cities), the Institute of Economics and Forecasting (NASU), and leading textile Industry companies such as Hipanis, Edelvika, Inteltex, and Lectra-Ukraine. Figure 1 illustrates the main framework and roles of the roadmap for stakeholders.

The roadmap specifies concrete initiatives and actions for industry participants across six categories (or areas of transformation): Ecosystems, Technologies, Methods, Workforce, Environmental and Green Initiatives, and Support Tools.

The document argues that systemic changes must begin with transforming the innovation ecosystem infrastructure, including its key actors and the relationships between them. This is the primary factor enabling changes in tools and institutions, balancing them to support transformations in other areas—technologies, production methods and approaches, ecological initiatives, and workforce potential.

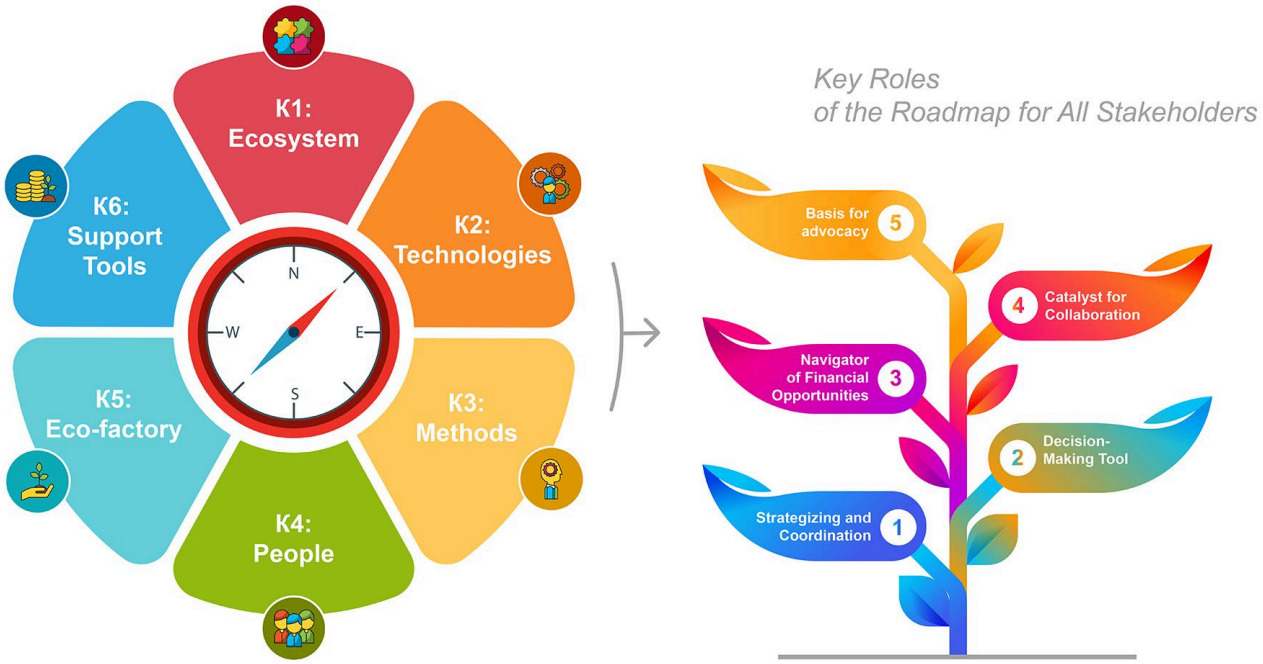


Figure 1. Framework for the twin Transition (DT) Roadmap for the textile Industry Sector

The authors of this document are unaware of any existing roadmaps for real economic sectors in Ukraine. Regarding industrial sectors, this roadmap is the **first in Ukraine** to comprehensively address the twin transition of SMEs on such a scale, with a three-year implementation perspective.

As such, the significance of this roadmap cannot be overstated. If successfully implemented, it could transform hundreds of SMEs in the sector, significantly enhancing their competitiveness in international markets. Furthermore, the roadmap can easily be scaled to other industries, making the engagement of ecosystem actors, government bodies, and international organizations crucial for the tool, its methodology, and scalability opportunities.

Section 1. Current State of Enterprises in the twin Transition – Key Challenges for Ukrainian SMEs

Overview of Ukraine's Textile Industry

Ukraine's textile Industry contributes approximately 1% to the country's GDP. According to various estimates, the sector employs 90,000 to 120,000 people. As of 2023, the total number of business entities primarily engaged in textile production, clothing, footwear, leather, leather goods, and other materials amounted to 14,600. Of these, 12,300 were indivitwin entrepreneurs (IEs) (Figure 1).

In addition, for approximately 5,000 other business entities, this type of activity is not their primary focus[1].

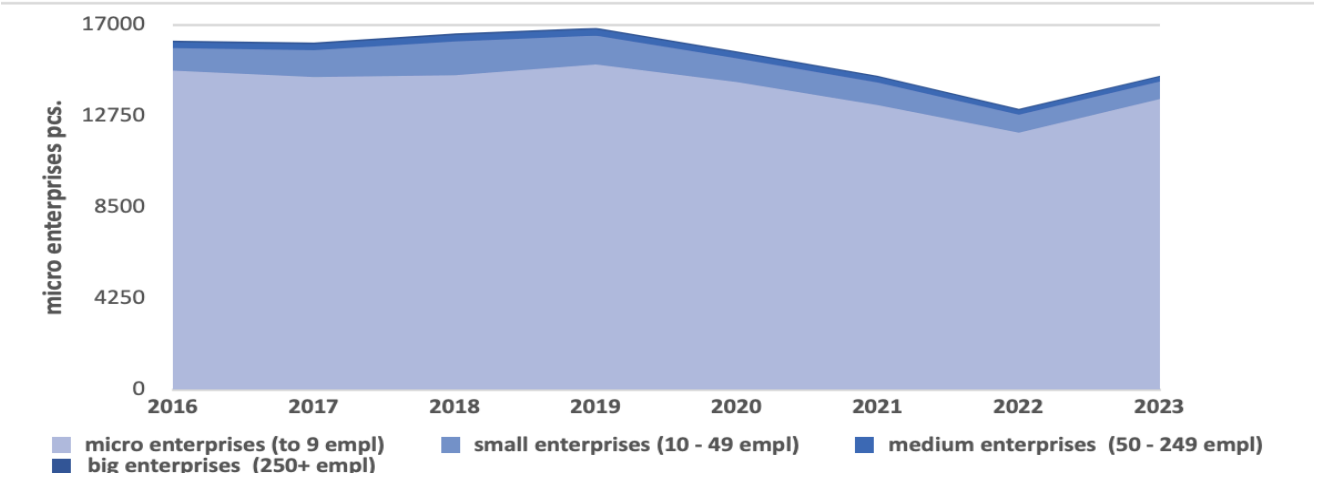


Figure 2. Number of Active Business Entities in the Textile Industry, 2016–2023
(Based on data from the State Statistics Service of Ukraine)

The **textile industry** is dominated by micro-enterprises and indivitwin entrepreneurs (IEs), which account for over 90% of all business entities (Figure 3).

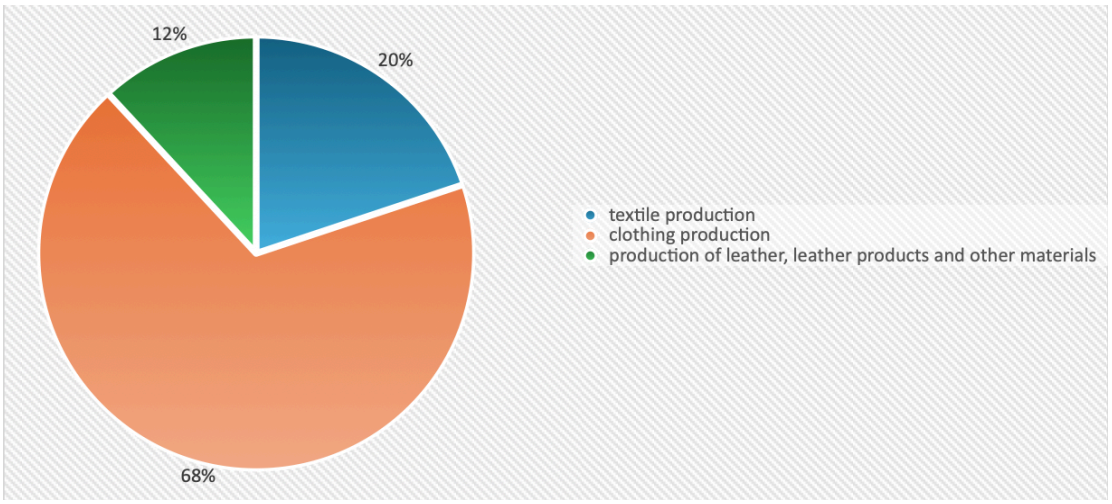
In 2023, micro-enterprises outperformed all other categories in terms of productivity, generating approximately 1.2 million UAH per employee. In contrast, the lowest productivity was observed among large enterprises, at 910,000 UAH per employee in 2023.

Meanwhile, in the EU-27, net turnover per employee increases with the size of the enterprise:

- **Micro-enterprises**: €70,000
- **Small enterprises**: €105,000–€110,000
- **Medium enterprises**: €140,000
- **Large enterprises**: Over €230,000

[1] https://fama.agency/wp-content/uploads/2024/07/Analiz-legkoyi-promyslovosti.pdf

As a result, the productivity gap between Ukrainian SMEs and their EU-27 counterparts averages **fourfold**.



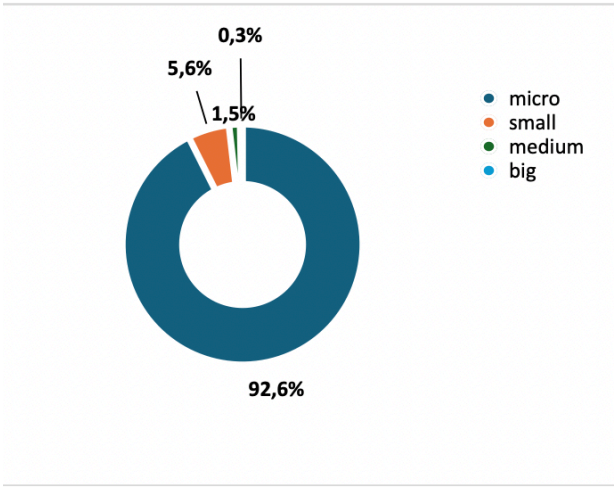


Figure 3. Distribution of Business Entities in the Textile Industry by Size and Type of Activity, 2023

In Ukraine's textile industry, enterprises specializing in clothing production dominate, accounting for nearly 70% of the total. In comparison:

- Textile production represents only 12%.
- Leather, leather goods, and other materials production (including footwear) accounts for 20%.

In recent years, there have been no significant changes in this structure.

Twin Transition in the Textile Industry

Digital Transition

Official statistics on the use of digital technologies by textile industry enterprises in Ukraine provide insight into the current state of the twin transition. For benchmarking against EU

countries, several indicators were selected to characterize the digital transformation of textile enterprises (Table 1).

Across most indicators, Ukraine lags significantly behind the EU average and the “weakest” EU countries. For example:

- In 2022, only 6.5% of textile enterprises in Ukraine purchased cloud computing services, compared to over 38% in the EU-27.
- ERP systems are used by 38% of enterprises in the EU textile industry, while in Ukraine, this figure is less than 6%.
- CRM systems have been implemented by only 3% of Ukrainian enterprises, compared to 23.3% in the EU.

The situation in Ukraine is better regarding the use of Industry 4.0 technologies, particularly artificial intelligence (AI). While only 3% of Ukrainian enterprises used robotics in 2023, 7% reported using AI technologies. By comparison, the EU's figures were 7% for robotics and 6% for AI, respectively.

Table 1 – Textile Industry Enterprises Using Digital Technologies (% of Total Enterprises)

Technology	Ukraine	EU-27 Average	Minimum Value in EU-27 Countries
Purchasing cloud computing services	6.5	38.1 (2023)	7.1 (Bulgaria)
Enterprise Resource Planning (ERP) software	5.6	38.0	11.9 (Bulgaria)
Customer Relationship Management (CRM)	3.1	23.3 (2021)	4.5 (Hungary)
Internet of Things (IoT)	6.4	19.8 (2021)	6.0 (Poland)
Artificial Intelligence (AI)	7.0	6.0 (2024)	1.2 (Romania)

Robotics	3.0	7.1	0 (Cyprus), 2.2 (Greece)

Note: Data is from the most recent available year: 2022 or 2023.

Green Transition

Official statistics on the share of enterprises implementing environmental measures provide insights into the state of the **green transition** in Ukraine's textile industry (Table 2).

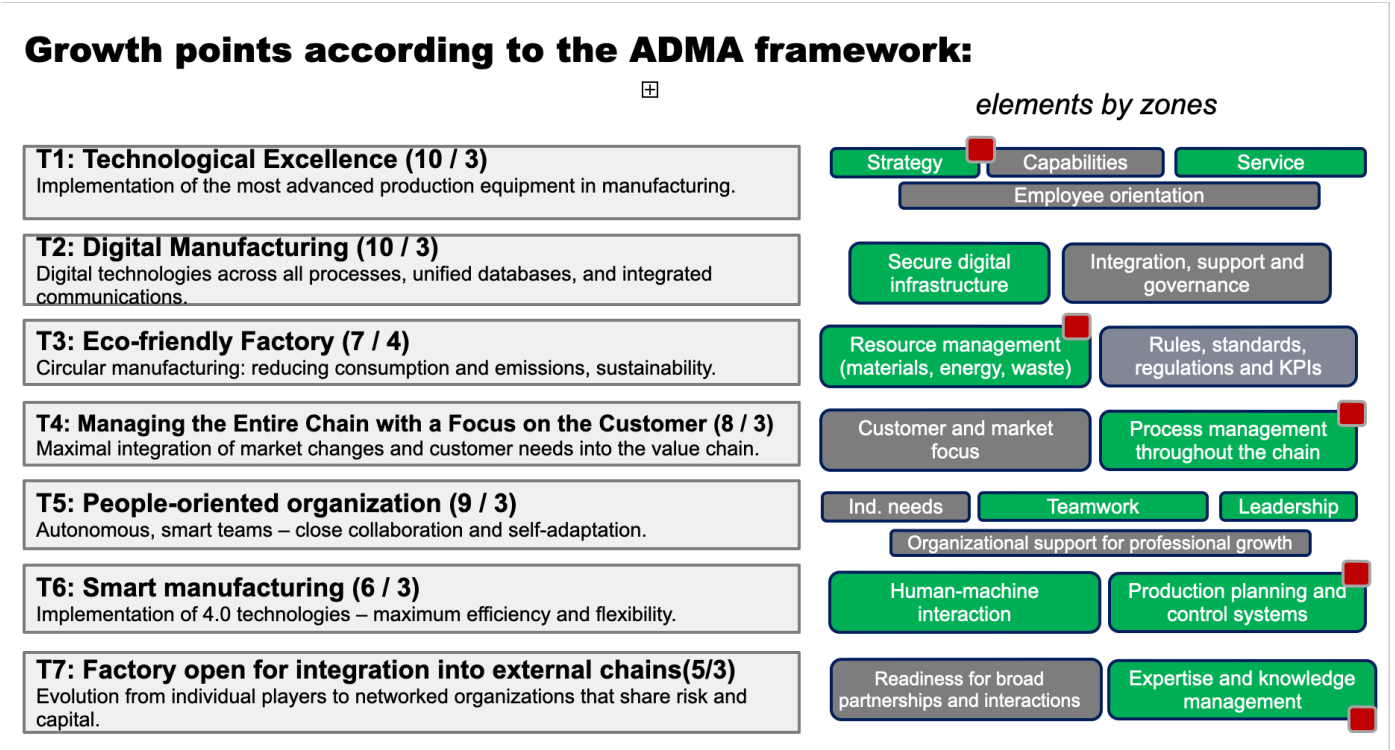
Table 2 – Share of Enterprises Implementing Environmental Measures (% of Total Enterprises)

Measure	Ukraine 2023	EU-27 Average 2022
Impact on the amount of paper used for printing and copying	45.0	61.1
Impact on energy consumption by computer equipment and electronic communication tools	35.4	39.3
Disposal of obsolete ICT equipment through e-waste collection/recycling	20.3	76.6
Storage of obsolete ICT equipment on-site	64.6	45.2
Sale, return to leasing companies, or donation of obsolete ICT equipment	16.0	20.0

The share of Ukrainian textile enterprises reducing paper usage is 16 percentage points lower than the EU average, and the share of disposal of ICT equipment through e-waste collection or recycling is 56 percentage points lower. Therefore, Ukraine's textile industry requires increased attention to resource efficiency and greening its operations.

The results of a survey **conducted as part** of the GDT Textile project provide further insights into the twin transition of SMEs in the **textile industry**. The survey followed the European **ADMA (Advanced Manufacturing)** methodology and included **139 respondents**, primarily industrial enterprises from various sectors, focusing on **textile industry** enterprises.

A consolidated analysis across the **seven zones of the ADMA methodology** (Figure 4) presents a comprehensive picture of the respondents' state.



The primary focus and priority for SMEs in the textile industry are **production modernization** and **finding or retaining skilled personnel**. Digital technologies receive attention mainly when they deliver **quick, tangible results**. While there is some understanding of automation, significant progress requires **substantial capital investments**, which is a challenge in Ukraine. Areas like **waste management, cybersecurity, and innovation management** are not priorities, as businesses lack the necessary management capacity, workforce, and often the motivation of their leadership to address these issues.

This “average state” represents a typical Industry 3.0 level, but varies by category. Responses differ significantly depending on the size of the enterprise and its leadership policies:

- Large enterprises with forward-thinking leaders perform much better across all areas.
- Small and medium enterprises (SMEs) often lack an understanding of modern trends and alignment with global markets. Most small enterprises rely on manual labor for the majority of production operations.
- Digital tools in smaller enterprises are primarily used in marketing, accounting, and product design (CAD systems).

The areas with the greatest potential for enhancing competitiveness and achieving business growth with minimal effort have been identified across the respondent group. These areas are highlighted with red squares in Figure 4.

More detailed survey findings, including focus interviews and strategic sessions, are presented in a separate **Analytical Report**. Typical business cases with solutions are included in Appendix 1 of this document.

Overall, these conclusions support the arguments regarding the weaknesses (underdevelopment) of the industry's innovation ecosystem and the insufficient consolidation of key actors in the direction of the twin transition. These are the main reasons for the sector's relative lag behind leading industries in Ukraine and the textile industries of EU countries. At the same time, the report notes and states that a more active position of market leaders and large enterprises in scaling their best practices (of which there are many), along with the emergence of innovation clusters and EDIHs, could become triggers for positive changes.

The recommendations of the Analytical Report emphasize the need for significant improvement in the consolidation and collaboration of ecosystem actors, enterprises, and governmental and international organizations regarding the sector's innovation development. At the same time, this state of the industry is quite typical for most industrial sectors, where the main challenges faced by Ukrainian industrial SMEs in the twin transition are as follows:

1. Lack of systemic policies and tools for the twin transition on the part of policymakers, primarily government organizations—this includes access to financing, incentives, and benefits, attracting investors, consulting services, and SME support in the twin transition. Although the number and quality of tools have significantly improved over the past five years, industries are still experiencing a deficit of systematic approaches, awareness, and orientation within these policies.
2. There is a shortage of qualified resources, sufficient competencies, and skills among SME personnel. The workforce crisis, which has affected many sectors in previous years, significantly worsened in 2023–2024 due to the demographic crisis, the migration of women abroad, and the mobilization of men into the Armed Forces of Ukraine.
3. There is a low level of innovation culture, skills, and willingness to collaborate broadly within their sectoral ecosystems. According to numerous surveys conducted in 2022–2024, the development of innovations, including digital and green ones, remains on the agenda only for certain large industrial enterprises, while it is not among the top priorities for SMEs.
4. Weakness of the innovation ecosystems and their participants, particularly the lack of Centers of Expertise where SMEs could observe and adopt the necessary digital and green innovations in practice.
5. Lack of strong business and use cases adapted to the sector and enterprise size. Specifically, the GDT Textile project team identified a significant deficit of such cases in the textile industry. The issue is not so much the absence of successful implementations as the lack of their documentation and accessibility to the public.

This Roadmap is a systemic tool for strategic planning at the industry level and is designed to address several of the challenges outlined above.

Section 2. Key Trends and Drivers of Industry Development

The export volume of the textile industry in 2023 amounted to 460 million USD. 40% of textile industry products are exported, and there is also significant dependency on raw materials, equipment, and technologies imports. Thus, it can be argued that Ukraine's textile industry is highly integrated into European and global value chains.

As a result, the sector faces the same general challenges as other EU countries and the world:

- Increased regulatory pressure to reduce emissions and manage waste, as the industry is one of the largest industrial polluters globally.
- Supply chain disruptions began during the COVID-19 pandemic and were significantly exacerbated by the war in Ukraine and general instability. This has led to reshoring processes and a greater focus on strengthening local ecosystems and supply chains.
- The impact of the Fourth Industrial Revolution, as new Industry 4.0 technologies rapidly penetrate all aspects of production and enterprise management. Large corporations spend millions of euros annually to improve their operational efficiency.
- Rising materials and energy costs force enterprises to reconsider cost factors and existing business models.

The war in Ukraine has introduced additional challenges, including:

- A worsening labor shortage,
- A sharp increase in energy prices and reduced energy availability,
- More significant difficulties in accessing consumers and markets.

These challenges significantly affect the traditional set of competitiveness factors for industrial sectors, including the textile industry:

1. **Product quality**:
    - In addition to traditional consumer demands, new regulatory rules regarding the origin of energy and materials are being enforced.
    - Implementing these rules involves **additional and significant costs** for new certification processes, workforce training, and new technologies.
2. **Product cost**:
    - Influenced by rising labor costs, higher prices for energy and raw materials, and new regulatory requirements.
    - While Ukraine still holds **some competitive advantages** due to lower labor costs, these advantages gratingly diminish.
3. **Time-to-market**:
    - Reflects the ability of enterprises to **quickly adapt** to market and customer changes and produce new products.
    - This is particularly critical in the fashion market.

4. **Market access**:
    - Refers to a company's ability to ensure that its products comply with the **regulatory policies of export countries** (meeting norms and standards) and **specific consumer preferences** and manage distribution channels effectively.
5. **Production flexibility**:
    - The ability to **reconfigure production** for new product types, expand product ranges, and manage volumes flexibly, even to the point of accommodating individual orders.
6. **Productivity**:
    - The capability to **scale up production volumes** quickly in response to rising demand.

Undoubtedly, these competitiveness factors (drivers) are closely linked to technologies. As highlighted in the GDT Textile Analytical Report, modernizing production through procuring advanced equipment is a top priority for enterprises. At the same time, the demand for digital and green innovations in Ukraine remains low, and the country lags significantly behind EU nations (Table 1). How can this gap be explained?

The Value Drivers Framework, proposed in Ukraine's Industry 4.0 Strategy, explains this phenomenon (Figure 5) as follows.

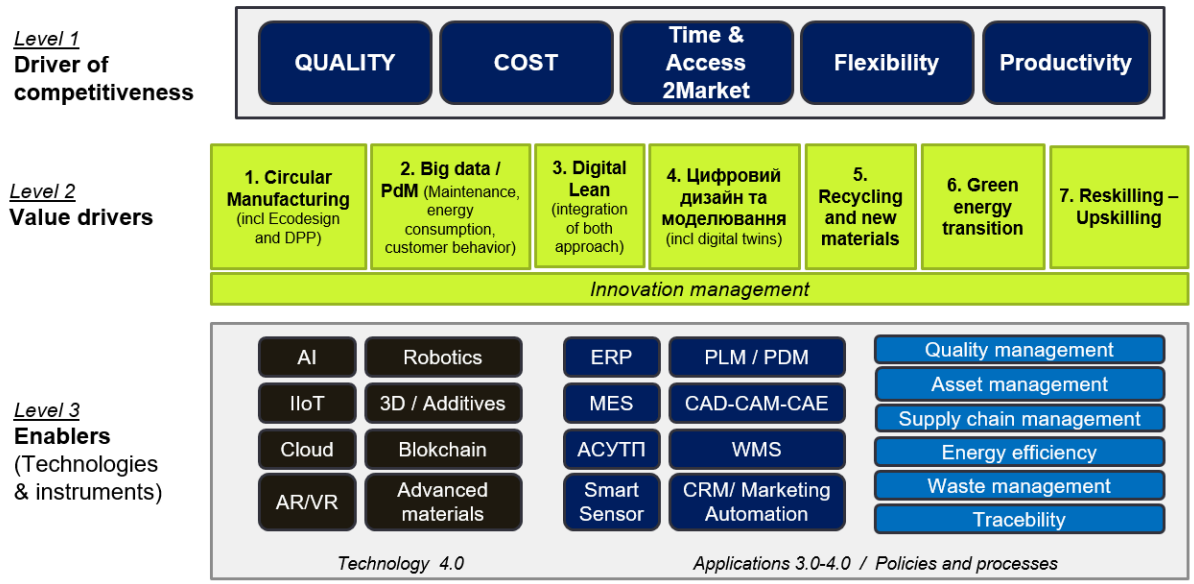


Figure 5. Value Drivers Framework

A key aspect of this approach is understanding the **second level – "Value Drivers."** According to McKinsey, value drivers create the most significant value and influence well-known competitiveness factors (price, quality, flexibility, etc.). Without this

understanding, the relevance of technologies (level 3) “floats in the air,” as technologies are merely tools.

Thus, the value drivers listed in Figure 5 logically complement the competitiveness factors and create a bridge to technologies. Let us consider each of them:

- **Circular production** (including eco-design and digital passports) is already a must-have paradigm of sustainable development in developed countries, and global trends and regulatory rules dictate it. Digital product passports promote transparency and traceability of materials, raw resources, energy, and the production process itself, while eco-design helps reduce costs through more efficient use of materials.

- **Big Data / Predictive Analytics.** The application of big data and its analysis for **maintenance and repair (MRO)**, energy consumption, and customer behavior analysis directly impacts productivity and quality, enabling proactive measures.

- **Digital Lean** (integration of digital and Lean approaches). Lean methodology is highly effective for **cost reduction**, while digitalization adds new capabilities for automation and precision. Together, they form a powerful tool for improving efficiency.

- **Digital Design and Modeling** (including digital twins). These approaches help reduce **time-to-market**, optimize product development, and lower costs. **Digital twins** add value by enabling realistic testing of virtual models.

- **Recycling and New Materials.** The use of innovative materials and secondary raw materials aligns with the requirements of the circular economy and helps reduce costs while also ensuring business sustainability.

- **Transition to Green Energy.** Energy efficiency affects both costs and competitiveness. This path appears increasingly evident given the loss of energy generation capacities in Ukraine.

- **Reskilling and Upskilling Personnel.** The growing complexity of technologies requires retraining workers to address skills shortages, improve quality, and enhance productivity.

The examples below demonstrate how these factors are connected to technologies.

Example 1: Circular Production

The transition to circular production can initially increase product costs, as implementing waste management, recycling, certification, and traceability measures requires significant investments and adds additional operational steps. However, in the 3–5 year perspective, this approach provides substantial advantages in terms of its impact on competitiveness factors, such as:

- Market Access: Manufacturers that do not comply with green standards (e.g., lack of digital product passports) will be unable to enter the EU market.

- Improved Quality and Productivity: Achieved partly through new “green investments”, as the overall trend among investors is becoming increasingly ESG-oriented. Green companies will have significantly better access to investors and, consequently, to new technologies.

- Gratwin Cost Reduction: Enabled by more efficient energy management, implementing lean manufacturing practices, and digitalization.

Key technologies in the implementation of circular production approaches include:

- Blockchain: For tracking the origin of materials and energy resources.
- IoT: For real-time monitoring of production status and automated waste management systems, such as sorting systems.
- CAD-CAM: For developing eco-design solutions.

MES systems play a crucial role at the application level. They allow the integration and real-time tracking of data on materials, energy, and resources, combined with controlling production operations, making them a key priority.

Example 2: Big Data / Predictive Analytics

Big Data analytics has been used in various industries for over 10 years to predict equipment failures, optimize maintenance costs, and improve product quality. This value driver is directly related to increasing productivity and quality while reducing production costs.

Another trend is predicting consumer preferences, which impacts time-to-market by enabling the release of new products faster than competitors.

Key technologies include:

- AI and machine learning algorithms for failure prediction.
- IoT for collecting data from equipment sensors.

Applications and solutions:

- Asset management processes, such as Predictive Maintenance.
- Consumer experience analytics through systems like ERP/MES (including maintenance modules) and CRM for analyzing consumer behavior.

Example 3: Digital Lean

Lean approaches (lean manufacturing) focus on reducing costs across all stages of production, optimizing excess inventories and resource use, and increasing flexibility in production processes. Digital technologies enhance these methods by providing better

accuracy and additional optimization through data usage. They directly impact cost, quality, and productivity: “you cannot optimize what is not accurately measured.”

Key technologies include:

- Cloud computing for real-time inventory management.
- IoT for monitoring production processes.

Applications:

- Optimizing the supply chain through digital visualization of material flows.
- Integrating MES with automated planning systems (APS).
- Using WMS (Warehouse Management Systems) for Lean warehouse management.

Example 4: Digital Design and Modeling

Digital models reduce prototype creation time and minimize design errors, directly impacting factors like time-to-market, productivity, flexibility, and quality.

Level 2: Digital Design and Modeling (including Digital Twins)

Digital twins enable the virtual testing of new products before physical production.

Achieving a new technological level involves:

- Digital twins are used to simulate products in a virtual environment.
- AR/VR for modelling products in real-world settings.
- Big Data processing and AI are used to enhance decision-making.

These technologies are foundational for digitalizing product lifecycle management (PLM) by integrating design, testing, and manufacturing stages.

Key applications, products, and solutions include:

- **CAD-CAM-CAE/PLM-PDM** for modeling and load analysis.
- **APS** for production planning.
- **ERP-MES** is used to integrate design data with production plans and client-driven changes.

Example 5: Reskilling/Upskilling Personnel

New employee skills directly impact labor productivity growth and enable quicker adaptation to market changes. Mastering a wide range of new software products, solutions, and production methods is impossible without systematic retraining and skill enhancement for employees.

At the same time, technologies today influence the methods of reskilling and upskilling, as well as overall knowledge management within an enterprise. This includes:

- E-learning platforms,

- Simulations based on AR/VR,
- Development of new educational programs to prepare employees for Industry 4.0,
- Use of Learning Management Systems (LMS) for managing training courses.

Summary

These examples demonstrate how the logical connection between the three levels (Figure 5) allows for more conscious planning and implementation of strategic initiatives, integrating value drivers into operational processes through modern technologies.

Market education on value drivers, their connection to new technologies, and the well-known competitiveness factors remain a significant challenge for all actors in the Industry 4.0-5.0 innovation ecosystems. Educational initiatives require high-quality coordination, substantial investments, and concerted efforts from all key actors, including:

- Leading providers of technologies and solutions,
- Centers of expertise (including new EDIHs),
- Professional community hubs (clusters and associations).

These actors must collaborate to:

- Promote new technologies and concepts,
- Develop dozens of use cases,
- Organize promotional events, training sessions, and qualification enhancement courses,
- Update student curricula, among other efforts.

The experience of the **GDT Textile project** clearly shows that this challenge is equally significant in the textile industry.

Section 3. Digital and Green Transformation in the Textile Industry

3.1 The Role of Technologies – Examples of Application

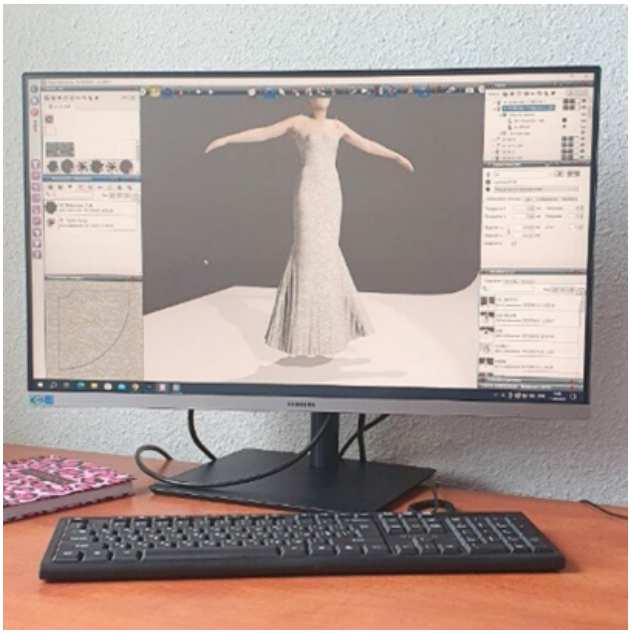
Technologies are embedded in business processes, enabling automation, efficiency, and new opportunities for innovation. The world of technology is vast and constantly evolving, with new advancements emerging regularly. These technologies serve various purposes and applications, but collectively, they can create a synergy that ultimately allows businesses to remain competitive and adaptable.

This section showcases specific examples of how technologies impact textile industry enterprises' economic and business performance.

1. Increasing Production Efficiency

Computer-Aided Design (CAD), Manufacturing (CAM), and Engineering (CAE) Systems

CAD (Computer-Aided Design): CAD systems enable the creation of high-precision models and drawings for textile industry products. They allow for rapid pattern development, high accuracy, and 3D visualization. CAD reduces product development time and minimizes the risk of errors.



CAM (Computer-Aided Manufacturing): CAM software automates the tool path calculations for CNC machines or other automated equipment. Implementing CAD-CAM systems is moderately complex and requires personnel training.

CAE (Computer-Aided Engineering): CAE is used for material analysis, product design optimization, and simulations. Its main value is reducing physical tests and ensuring higher product reliability. However, it is relatively complex and requires technical expertise and access to advanced software.

In 2022, Intelltex implemented a project to digitize all the patterns of the Ricca Sposa company using CAD Assyst. The process took several months, and since then, all model designs have been created exclusively in the CAD Assyst software. Brides from over 50 countries now order dresses tailored to their specific measurements.

The product has significantly enhanced Ricca Sposa's **competitive advantages**, including:

- Precise customization of indivitwin sizes.
- Designing exclusive models.
- Virtual fitting capabilities.
- Accurate production.

Specific production KPIs improved by the solution:

- “Right the first time” rate.
- Reduced time for design approval, development, and showcasing new collections.
- Waste reduction.

Today, the company relies heavily on the **VIDYA 3D visualizer**, which is now indispensable for its operations. *Source*

Internet of Things (IoT)

IoT enables businesses to integrate sensor networks for real-time data collection. In manufacturing, this technology provides:

- Monitoring of equipment status.
- Control over resource consumption.
- Identification of potential failures before they become critical issues.

With IoT, businesses can reduce downtime, optimize energy usage, and improve the productivity of manufacturing processes. Additionally, IoT can track product development stages and the product itself throughout its lifecycle.

Implementation complexity: IoT implementation is typically moderately complex. It requires installing sensors and integrating data into a centralized system. A video by **Positec RFID** demonstrates the detailed, step-by-step technological process of embedding **RFID tags into clothing**. Implementing such a system results in:

- Reduced staffing needs.
- Increased precision.
- Enhanced sorting systems.
- Improved customer service.

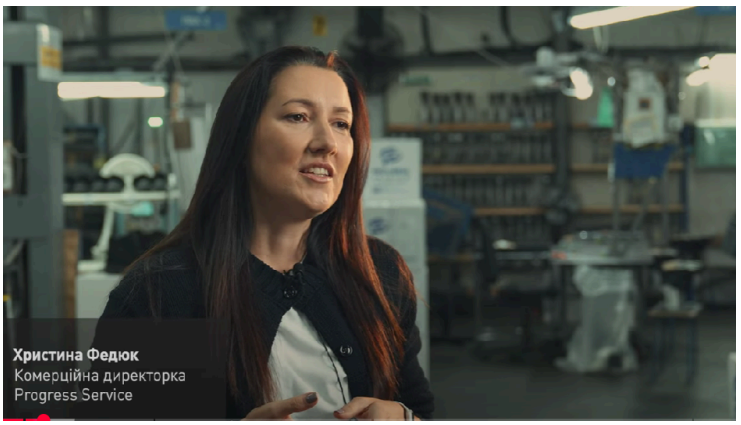
Payback period: 18 months.

RFID tags are one of the standard sensor technologies in IoT. Another example illustrates the implementation of a large-scale IoT system based on **Nexio.**

ERP (Enterprise Resource Planning) and MES (Manufacturing Execution Systems)

ERP systems provide planning, accounting, and control over all key business processes, including finance, logistics, inventory management, and human resources. Unlike ERP, MES focuses on managing real-time production processes, including:

- Quality control,
- Tracking production stages,
- Managing operations.



MES uses data collected from IoT sensors to enable businesses to automate routine tasks, identify process bottlenecks, and quickly resolve them. This approach minimizes material losses and increases productivity.

Implementation complexity: Implementing MES is of moderate complexity, requiring integration with equipment and employee training.

A promotional video by IT-Enterprise highlights the benefits of implementing an ERP system with MES components at the Lviv-based shoe manufacturing company "Progress-Service".

As a result of the integrated system's implementation, the company significantly improved:

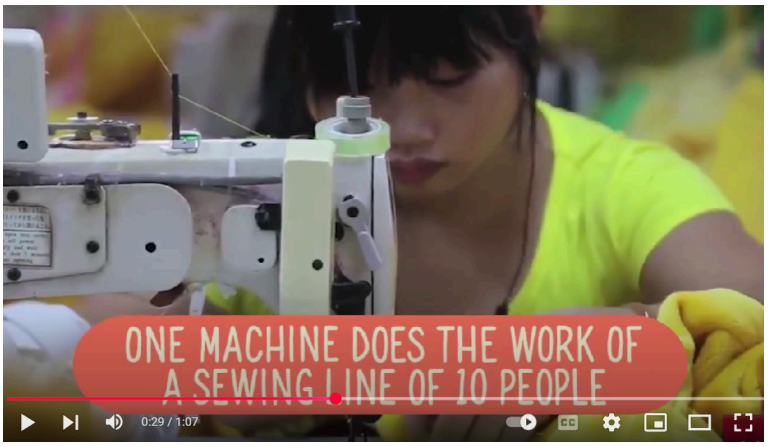
- Production planning,
- Accounting for material flows,
- Inventory and warehouse management,
- Customer service operations.

Robotics

Robots are actively used to automate repetitive tasks, such as fabric cutting, garment assembly, or packaging of finished products. In the textile industry, robotics helps to:

- Reduce labor costs,
- Increase productivity,
- Ensure consistent quality.

However, implementing robotics can be challenging due to the high initial equipment cost and the need to customize robots for specific processes.



A promotional video by Tech in Asia highlights the advantages of robotic manufacturing, such as:

- A 10-fold reduction in the number of workers needed for routine operations.
- A twofold increase in productivity.

However, this can lead to unemployment. In the global textile industry, job losses are expected to impact 50 to 70 million workers.

A report by the Wall Street Journal focuses on this trend as a threat and highlights the massive changes already underway in the textile industry. These include processes of reskilling and upskilling workers, which must accompany the adoption of robotics.

The report also demonstrates that in the global race for competitiveness, automation, and robotics are inevitable processes shaping the future of manufacturing.

Artificial Intelligence (AI) for Predictive Maintenance

Artificial Intelligence enables predictive maintenance by analyzing data from IoT sensors, maintenance history, and operational records. For example, AI can identify potential failures in cutting machines, sewing equipment, or dyeing machinery before they occur.

AI analyzes parameters such as vibration, temperature, and pressure and compares them with historical failure patterns to alert staff about maintenance needs.

Benefits of AI for Predictive Maintenance

- Reduces the risk of production downtime.
- Ensures operational stability.
- Avoids unexpected repair costs.
- Extends the lifespan of machines by preventing critical damage through timely maintenance.

Implementation complexity:
AI requires:

- IoT sensors for real-time data collection,
- Access to historical equipment performance data,
- Training AI models to detect specific failure patterns.
  Due to these requirements, implementation is **not simple**.

Ukrainian developers and integrators are increasingly using AI-based predictive models for equipment maintenance. Members of APPAU, such as IT-Enterprise, a-Gnostics, and Waites, are actively applying these technologies.

- A video highlights a solution from a-Gnostics that diagnoses equipment using sound data from an ordinary smartphone. Such solutions are gaining popularity.
- Waites data show that its solutions, used by large international corporations, save millions of dollars annually by avoiding downtime.
- **Lectra-Ukraine** applies similar models to service textile industry enterprises directly from their **service center in France**. Currently, **11 machines** at Ukrainian enterprises are maintained **24/7**.

2. Improving Product Quality

Artificial Intelligence (AI) for Enhancing Product Quality

AI is widely applied to automate complex tasks, such as automatic defect detection, demand forecasting, and logistics optimization.

Applications in the Textile Industry:

- Defect Detection: AI systems analyze fabric images to identify defects, reducing waste and improving product quality.
- Market Trend Prediction: AI helps businesses better predict market trends, enabling more strategic decision-making.

Implementing AI requires high-quality data and technical expertise, making it moderately to highly complex to integrate.

A video demonstrates the use of AI for fabric inspection in Hong Kong. By combining machine vision, big data, and AI, defect detection in fabric structures was improved to 95% accuracy.

3. Optimization of Specific Business Processes

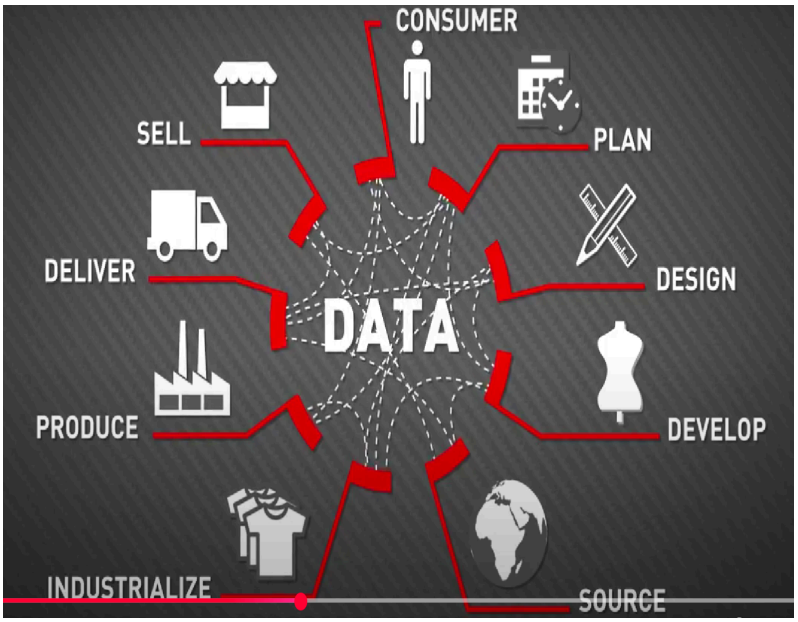
PLM (Product Lifecycle Management)

PLM provides centralized management of all stages of a product's lifecycle, from concept to production. It minimizes errors, accelerates the specification approval process, and reduces time-to-market.

In the textile industry, PLM is used for:

- Creating and managing collections.
- Tracking design changes.
- Organizing collaboration between teams.

The full-scale implementation of PLM is highly complex and costly. It requires **process adaptation** and **highly qualified personnel** to support the system.



Lectra is a global leader in **Industry 4.0 for the textile industry. It** produces equipment and various software solutions, including PLM systems.

A promotional video illustrates how a PLM system:

- Integrates data from other software,
- Automates processes and team workflows,
- Ultimately optimizes the entire product lifecycle.

4. Improving Customer Experience

Artificial Intelligence (AI) for Demand Forecasting

AI is effectively used for demand forecasting by analyzing large volumes of data, including sales history, customer behavior, market trends, and seasonality.

In the textile industry, AI processes data such as:

- Order history,
- Customer preferences,
- Shifts in fashion trends,
- Weather conditions,

to predict which products will be in demand during specific periods.

Benefits of AI for Demand Forecasting:

- Optimized inventory management, reducing overproduction and excess stock.
- Avoidance of shortages of popular products, improving customer satisfaction and increasing profits.

The technology requires:

- High-quality sales and customer behavior data,
- Big data processing infrastructure,
- Integration with ERP or CRM systems to access necessary information and generate forecasts.

Due to these requirements, the complexity of implementation is assessed as above average.

A video provides an overview of how AI enters the demand forecasting market, leveraging data from diverse sources to deliver more accurate and reliable predictions of demand and market changes.

CRM (Customer Relationship Management)

CRM systems are designed to manage customer interactions, including personalized service, tracking sales history, and automating marketing campaigns. In the textile industry, CRM is an essential tool for increasing customer loyalty and encouraging repeat purchases. The implementation complexity of CRM is low, especially given the availability of cloud solutions that do not require significant initial investments.

AR/VR (Augmented and Virtual Reality)

AR/VR enables businesses to create **interactive showrooms** where customers can interact with digital versions of products. In the textile industry, these technologies are valuable for presenting collections, customizing items, and

reducing costs associated with physical samples. The complexity of implementing AR/VR varies depending on the technology and purpose; advanced applications may require specialized equipment and the development of interactive content.

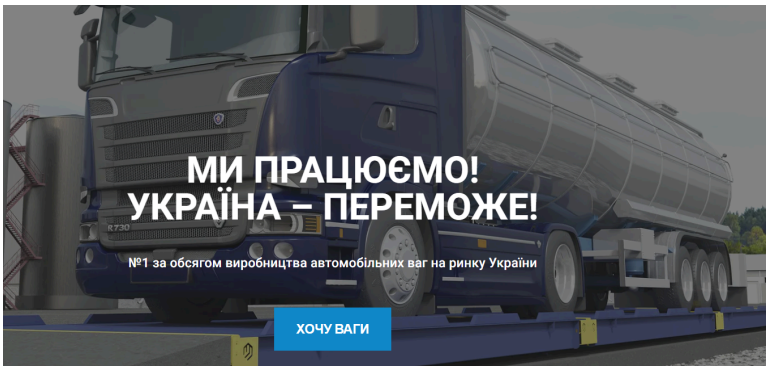
A video overview highlights trends in AR/VR in the fashion market, emphasizing rapid growth, use for diverse consumer needs, personalized choices, virtual event attendance (replacing physical travel), and integration with other technologies. These innovations provide a completely new **consumer experience**, effectively creating new patterns of behavior and purchasing habits.

The AR/VR application market is rapidly expanding—according to various sources, it reached **$90 billion**, with an **annual growth rate of 37%**.

5. Sustainable Development

Energy-Saving Technologies

Energy-saving technologies help businesses reduce energy costs and minimize the environmental impact of production. These include energy-efficient equipment, water recycling systems, and the use of renewable energy sources. In the textile industry, energy-saving technologies are a vital component for companies focused on sustainable development. Implementation complexity: The adoption of such technologies is of moderate complexity but requires significant initial investments.



In 2024, the **Ukrainian Weighing Company** transitioned entirely to an **autonomous, off-grid energy supply system**.

As part of this strategy, the company installed:

- **Two diesel generators** (400 kW and 100 kW),
- **Solar panels** with a capacity of 167 kW (planned expansion to 500 kW),
- **Fronius inverters** (one per 30 kW of solar panels),
- An **Automatic Transfer Switch (ATS)** for seamless switching between the grid and self-supply.

Future plans include the installation of additional **battery storage systems**, ensuring no downtime, even for a few seconds.

Data Space and Blockchain

Data Space, Distributed Ledger Technology (DLT), and Blockchain represent a new class of socioeconomic technologies used to create a socioeconomic environment (cluster, platform, ecosystem) where social and market institutions (rules, regulations) and corresponding external transactions (as per Coase's theorem) are replaced with internal

regulations and transactions among participants in the value creation chain (producers, consumers, investors, local communities, and other stakeholders).

For example, Blockchain ensures traceability in the supply/value chain, guaranteeing the authenticity of energy and material origins, compliance with quality standards, and product certification.

Another use case for Blockchain is its application in an end-to-end accounting and management system for carbon emissions (primarily Scope 3), which builds trust among value chain participants and addresses the issue of "double-counting" carbon emissions. The economic effect of implementing such solutions is nonlinear and is achieved by reducing or completely eliminating market transactions.

An example of the industrial implementation of such systems is the Electrodo platform, developed by the Ukrainian company 482.solutions. It showcases the potential of synergistic use of Data Space and Blockchain technologies for creating economic platforms to manage sustainable value chains. As part of the innovative i4Trust program, the Blockchain4ESG project was implemented. The platform accelerates the transition of industrial enterprises to a low-carbon and sustainable economy based on ESG data and TCFD Recommendations for climate risk management. Electrodo leverages i4Trust Data Space solutions and the Hyperledger Fabric Blockchain framework to create an ESG data and asset space/market.

Another Electrodo implementation is a unique pilot project involving the Ukrainian Weighing Company, which manages ESG reporting and issues corporate ESG assets (corporate ESG commitments and investment instruments) using the Solana Blockchain.

The Electrodo platform serves as a key technological component of the ESG Cluster Hub project, initiated in collaboration with the Ukrainian Cluster Alliance. This initiative aims to facilitate an effective green transition for Ukrainian industrial clusters and SMEs, with subsequent integration into EU value chains. Notably, this solution was selected as the best regional ESG practice (ESG Cluster Hub - Interreg Good Practice) for the Interreg Europe program.

Interreg Europe is a critical instrument for strengthening cooperation between EU regions and countries. Within the framework of the EU Cohesion Policy, Interreg plays a vital role in promoting regional development, cohesion, and reducing economic disparities.

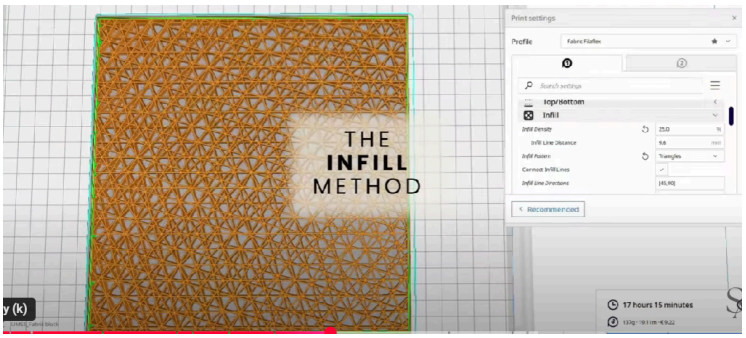
These examples demonstrate that Blockchain technology is a key enabler for supporting the twin green and digital transition—from the enterprise and value chain levels to sectoral and regional scales.

In the textile industry, these technologies help strengthen and capitalize on customer trust, particularly among brands committed to adhering to responsible production standards. However, Blockchain implementation is highly complex due to the need for end-to-end integration with suppliers and the creation of a unified data ecosystem.

6. Innovations and Rapid Prototyping

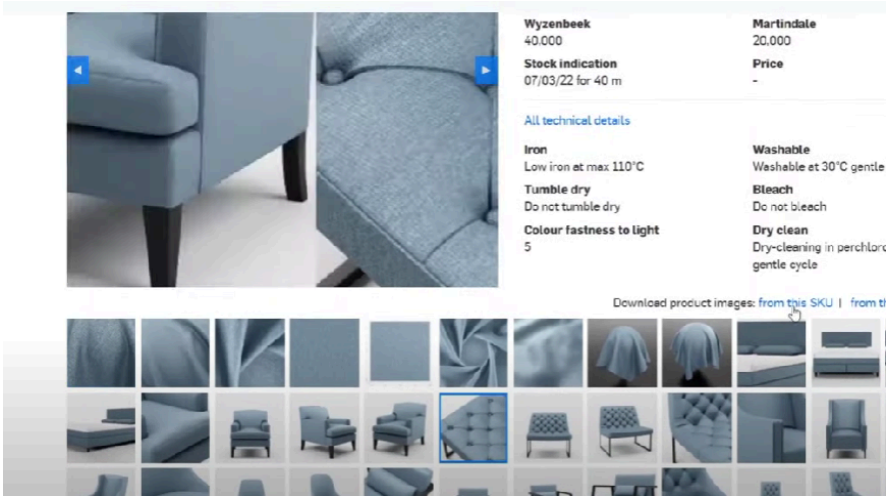
Additive Technologies

3D printing opens up new opportunities for rapid prototyping and product customization. In the textile industry, this technology is used for creating unique accessories, fabric prototypes, or decorative elements. It allows businesses to save on the production of physical samples and testing. The adoption of 3D printing is of moderate complexity due to the need for expensive equipment and staff training. A review article by researchers at Khmelnytskyi University back in 2016 predicted the use of 3D printing for manufacturing accessories, footwear, clothing, and more. Today, there are numerous examples of such implementations worldwide.



A video provides a clear demonstration of various methods and technologies of **3D printing** for producing fabrics, clothing, and accessories. In Ukraine, **3D printers** are already widely available for purchase, making the technology accessible for businesses interested in adopting it.

Digital Twins



Digital twins create virtual replicas of manufacturing processes or physical products, enabling businesses to test and optimize them without directly interfering with real processes. In the textile industry, digital twins are used to simulate machine operations or analyze fabric behavior. This reduces testing costs, increases efficiency, and minimizes downtime. Digital twin technology is complex to implement, as it requires access to high-quality data and specialized equipment.

The company TwinBru has developed a collection of **12,000 digital twins** of various fabrics. Each twin contains dozens of parameters, including **color, texture, transparency**,

and more, which can be visualized on specific accessories or furniture. The software also allows the twin to be placed in a specific environment, such as a room, enabling customization to suit consumer preferences. An overview video featuring the company's CEO explains the entire process and the benefits of digital twin technology.

3.2 Landscape of Innovators in the Textile Industry in Ukraine

The landscape is a classic tool for promoting and selecting innovative companies that offer products and solutions in a particular industry. The landscape of innovative firms in the textile industry, presented in Figure 6, was developed as part of the GDT Textile project. It should be considered as a first version, far from complete and comprehensive.

This version was created over several weeks and includes data that the project experts were able to gather from available sources. A more comprehensive and detailed map of textile industry innovators in Ukraine will require a separate, in-depth study.

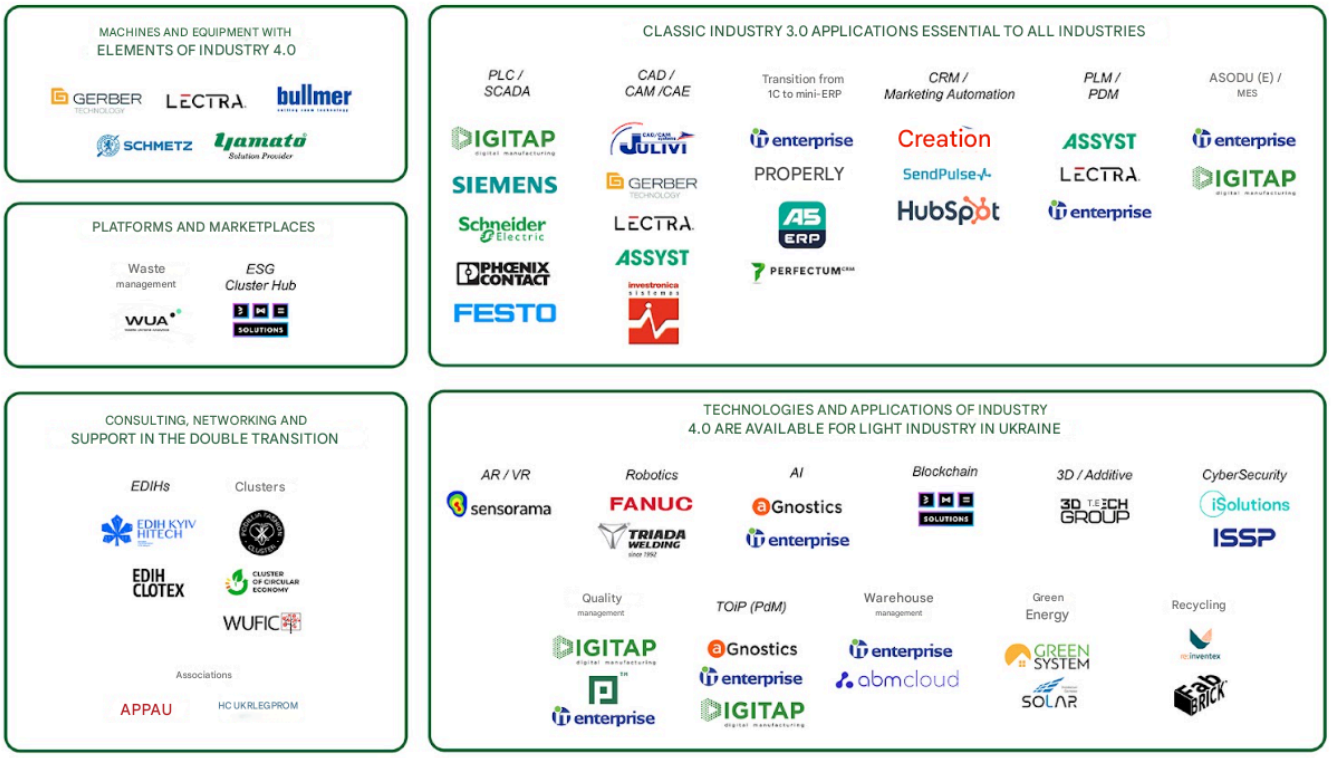


Figure 6. Landscape (Map) of Innovative Firms and Agencies in the Textile Industry

As shown in the figure, the landscape highlights four segments:

1. Manufacturers of modern, highly automated equipment that have transitioned to Industry 4.0 principles.
2. Classic Industry 3.0 applications.
3. Solutions and applications based on Industry 4.0 technologies.
4. Platforms and marketplaces relevant to the textile industry.

Additionally, there is a separate list of ecosystem agencies and clusters that participate in the project and are ready to provide services to the textile market.

Considering the limitations, it should be noted:

- **Software penetration levels** in the industry are not high. Familiarity with leading CAD providers (such as **Assyst** or **Lectra**) or ERP systems (e.g., Ukraine's

IT-Enterprise, which also replaces 1C) is highly recommended for medium and large enterprises. These are **market leaders** with significant resources and comprehensive service packages, whose solutions are already widely adopted in Ukraine.

- **Other applications** require further research, but a minimum list of manufacturers is provided in the landscape, and textile companies can reach out to them as needed.

- If there is interest and support, project experts can continue researching specific solutions in the market.

- Experts from **EDIHs in Kyiv and Khmelnytskyi** are available for consultations on selecting potential innovative solutions and products.

- Several innovators and their solutions are detailed in **Appendix 1: Business Cases and Their Solutions.**

Key Recommendations for Stakeholders in Developing Digital and Green Innovations

The examples of innovative digital and green solutions, along with the experience gained from the GDT Textile project, clearly demonstrate that the industry has:

- A significant unrealized potential for innovation development.
- A high potential demand for innovations.
- A substantial presence of solution providers.

However, a major challenge is the low awareness among the market and SME leaders regarding these advanced solutions.

Recommendations for Key Stakeholders

Primarily aimed at members of the 3T Alliance, the recommendations include:

1. Significantly increasing promotional campaigns and events to popularize digital and green innovations among SMEs.
2. Improving collaboration with leading solution providers identified during the GDT Textile project and connecting them with SMEs by organizing joint promotional and educational events.
3. Strengthening partnerships with external organizations, including international entities that support the twin transition. These partnerships will help market participants better align with European and global trends.

   For additional case studies of Ukrainian Industry 4.0, we recommend exploring:

- The Industry 4.0 in Ukraine website,
- The 4.0 Marketplace (in English)

  Or contacting APPAU via email at **info@appau.org.ua**

Section 4. Integration into Innovative Ecosystems

The analysis of the textile industry's innovative ecosystem employs a model described in APPAU's 2019 position paper. This model serves as a foundation for similar analyses at the industry, regional, or sectoral levels within Ukraine's Industry 4.0 framework.

The model explains how innovations enter the market (through specific elements and drivers of development) and, consequently, why some industries are more innovative than others.

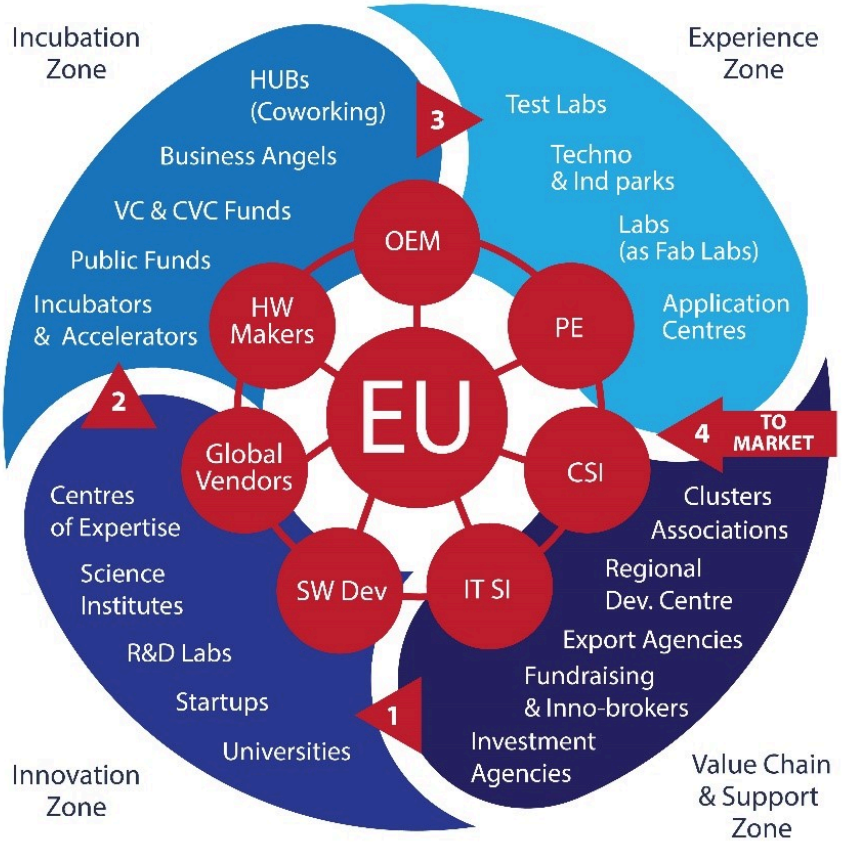


Figure 7. Model of the Innovative Ecosystem for Industrial High-Tech.The central elements of the model include end users (EU), Original Equipment Manufacturers (OEM), process engineering companies (PE), Control System Integrators for industrial automation (CSI), IT system integrators (IT SI), software developers (SW Dev), and hardware makers (HW). These components collectively represent the key players in the industrial high-tech innovation ecosystem.

A complete description of this model as it relates to the textile industry is available via the provided link.

In practical application, this model is used as a simple checklist to assess the state of any level—be it industry-wide, regional, or sectoral. To better understand the situation in the Ukrainian textile industry. It is useful to compare the quantity and quality of elements in each

zone with those of other sectors, such as Ukraine's agri-food industry, as well as with similar industries in developed countries like Germany and Italy.

Comparative Analysis with Ukrainian Agri-food

In the area of innovation management, the textile Industry does not significantly lag behind the agri-food sector. However, the latter is characterized by a notably larger number of sectoral associations. For example, in dairy, meat processing, organic products, and other niches, agri-food businesses have established separate associations that advocate for their producers' interests. For instance, one source mentions 27 such business associations.

The number of strong clusters in the agri-food sector is roughly comparable to that in textile Industry. According to incomplete data from the Ukrainian Cluster Alliance (UCA), the textile Industry has been more active in recent years. Key players include the Podillia Fashion Cluster (PFC), the textile Industry Cluster (Association) of Rivne Region, and the Western Ukrainian Fashion Cluster, which are currently the most active.

At the same time, it is still premature to speak of a significant role for specific business associations in driving innovation. The PFC stands out as a notable exception, holding a leading position with a clear focus on innovation. Thanks to its efforts, Ukraine established its first European Digital Innovation Hub (eDIH), **CloTex HUB**, specializing in textile Industry. This achievement underscores the arguments presented in this model and other UCA policy documents regarding the role of clusters as drivers of innovation.

In other areas of the model, however, the agri-food sector significantly outpaces the textile industry across several indicators of innovation development. These include the number of startups, the availability of supporting elements such as incubators and corporate accelerators, the presence of consistent ecosystem partners, leadership by major holdings, and effective use of existing support programs.

Comparative Analysis with the textile Industry Sectors of Germany and Italy

A comparative analysis of the innovation ecosystems in the textile Industry sectors of Italy and Germany reveals the presence of most elements illustrated in the accompanying diagram. Simply put, both countries boast robust innovation ecosystems, featuring elements that are largely absent in Ukraine's textile Industry. These include techno parks, advanced research centers and laboratories, competence and development centers, European Digital Innovation Hubs (EDIHs), and more.

Clusters play a crucial role in driving innovation in the textile Industry in both countries. Italy hosts approximately 30–40 clusters, while Germany has about 15–20 clusters in this sector. Clusters in the EU tend to be medium-sized organizations with an average of 100 member entities, whereas Ukrainian clusters typically comprise 15–20 members.

In terms of focus, Italian clusters are predominantly centered around traditional textiles, fashion, and ecological innovations, whereas German clusters emphasize technical

textiles and Industry 4.0 technologies. Both countries have numerous examples of implementing Industry 4.0 and 5.0 solutions, such as:

- IoT platforms for production optimization.
- Artificial Intelligence (AI) applications in design and manufacturing.
- Textile waste recycling systems and the integration of circular economy principles.
- B2B platforms for automating fabric procurement and client searches.
- 3D printing for textile production.
- Augmented Reality (AR) tools for digital clothing design.

Such solutions and startup initiatives are currently absent in Ukraine's textile Industry sector. A deeper analysis is needed regarding the participation of Ukrainian enterprises and universities in European innovation programs. Around 30 programs have been or are accessible through initiatives such as Horizon Europe, Digital Europe, EIT, COSME, and Interreg. Notably, the Textile ETP platform features nine projects of significant interest to Ukrainian communities, offering opportunities for collaboration and learning.

Key recommendations for stakeholders

The analytics from the GDT Textile project demonstrate that without the systematic inclusion of key elements of the innovation model, innovation development in the textile Industry will not occur. Actors within the value chains themselves, such as vendors or integrators, are unable to drive the development dynamics required to compete in global markets. This dynamic is created by external circle actors (see Figure X) such as clusters, EDIHs, industry incubators and accelerators, centers of expertise and certification, and similar entities.

Therefore, stakeholders in Ukraine's textile Industry need to focus on increasing both the quantity and quality of actors in the following categories:

1. **Innovative Clusters**
   The Podillia Fashion Cluster (PFC) is a "pioneer" in this area. Its experience and achievements, such as collaboration with the local university to establish an eDIH, developing a waste management roadmap, attracting investments, etc., should be scaled across other regions and sectors.
2. **Industry Incubators and Accelerators**
   These entities must become central to the growth of innovative startups and the demand for innovation within the textile Industry.
3. **Better Utilization of Existing Funds, Innovation Platforms, and European Networks**
   Programs like **EIT**, **Horizon Europe**, and **Digital Europe** illustrate that funding for innovation does not necessarily need to come from Ukrainian enterprises alone. External resources already exist and are accessible to Ukrainian participants.
4. **Networking, Consolidation, and Collaboration Around Key Challenges**
   Addressing the challenges of the twin transition and developing new innovation-oriented talent is critical. To achieve this, key actors must organize systematic and regular events to promote Industry 4.0–5.0 solutions tailored to their sector.

5. **Proactive Internationalization**
   This includes study tours to advanced EU enterprises, visits to technoparks, research centers, specialized eDIHs, and innovative clusters. Such actions must be actively facilitated by key market actors.

Thus, the **Roadmap** provided in Appendix 2 includes specific indicators for the emergence of the above-mentioned elements of innovation development on the map of Ukraine.

Section 5. Tools to Support the twin Transition

5.1 Tools for Support in the EU

At the EU level, the twin transition in the textile Industry — integrating digital and green transformations — relies on various policy instruments, framework documents, and sectoral initiatives. Below are the key policy tools and strategies related to the twin transition:

EU Policy Frameworks

- European Green Deal[2]: This overarching strategy aims to achieve climate neutrality by 2050, with a particular focus on sustainable and circular textile Industry. Tools include the Circular Economy Action Plan and the Strategy for Sustainable and Circular Textiles.
- Digital Agenda for Europe: Promotes the adoption of Industry 4.0 technologies such as the Internet of Things (IoT), robotics, and artificial intelligence to drive the digitalization of production.
- EU Strategy for Sustainable and Circular Textiles[3]: This strategy aims to create a coherent framework for the green transition of the ecosystem and present its vision by 2030. According to this vision, textiles on the EU market will be durable and recyclable, largely made from recycled fibers, free from hazardous substances, and produced in compliance with social rights.

Standards and Certification

- EU Regulation on Eco design for Sustainable Products (ESPR[4]): This regulation came into force on July 18, 2024. It establishes requirements for the environmental performance of products placed on the EU market. Under this regulation, products that do not meet the established environmental standards cannot be imported or sold in the EU. Textiles, clothing, footwear, and related items are among the product groups prioritized for regulation.

For Ukrainian exporters, this means ensuring that their products comply with eco design requirements and have the necessary documentation, including Digital Product Passports (DPPs), to gain seamless access to the EU market.

Timeframes for the Implementation of the ESPR Regulation.
— 2025: The ESPR Regulation comes into effect in April for the first group of products, which includes textiles.
— 2027: Initiation of detailed sector-specific requirements for sustainability and Digital Product Passports (DPPs).

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[2] https://commission.europa.eu/document/download/daef3e5c-a456-4fbb-a067-8f1cbe8d9c78_en
[3] https://environment.ec.europa.eu/publications/textiles-strategy_en

[4]https://commission.europa.eu/energy-climate-change-environment/standards-tools-and-labels/products-labelling-rules-and-requirements/ecodesign-sustainable-products-regulation_en

— 2030: Completion of the legislative process and full implementation of DPPs. All textiles must comply with new environmental standards and include digital product passports.

- **EU Ecolabel**
  Voluntary certification of the environmental performance of products, encouraging the adoption of green practices.

Financial Mechanisms

- Horizon Europe: Funds research and innovation projects, including those aimed at promoting sustainable textile Industry and digital technologies for the circular economy. For example:
- SOLSTICE[5]: Demonstrates practical solutions for the textile Industry, providing a holistic approach to ensuring scalability and replicability while striving to establish new governance for the circular economy.
- CITE[6]: Focused on creating an ecosystem between companies and higher education institutions to enhance innovation and entrepreneurial capabilities.
- LIFE Programme: Supports environmental and climate projects, including initiatives for improving textile recycling and reducing waste. For instance:
  LIFE22-ENV-ES-LIFE-CIRTECHTEX: Aims to reduce textile waste and recycle it into high-quality fabrics for personal protective equipment (PPE[7]).
- European Regional Development Fund (ERDF): Provides support for regional initiatives focused on digital infrastructure and green transitions.
- EIT Manufacturing and other innovation funds: Promote sustainable innovations in the manufacturing sector, reducing emissions, fostering growth, and equipping people with skills and support to create factories of the future.

Skills and Education

- EU Pact for Skills: Addresses skill shortages by upskilling workers for green and digital jobs. Joint training programs with vocational institutions enhance workforce adaptability.
- EU projects focused on developing twin transition skills for the textile Industry, such as: TwinRevolution[8]: Designed for small and medium-sized enterprises (SMEs), includes training modules on circular economy principles and digital transformation technologies tailored to the textile industry.

Regional and Sectoral Tools

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[5] https://www.solstice-project.eu/

[6] https://eit-hei.eu/projects/cite/

[7] LIFE22-ENV-ES-LIFE-CIRTECHTEX/101113876 - LIFE22-ENV-ES-LIFE-CIRTECHTEX: https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE22-ENV-ES-LIFE-CIRTECHTEX-101113876/implementation-of-circular-economy-processes-to-reduce-textile-waste-in-the-manufacture-of-personalprotective-equipment

[8] https://twinrevolution.eu/

- Digital Innovation Hubs: Focus on joint efforts for circular and digital transformation, addressing specific local challenges such as waste management.
- ADMA and DMA methodologies: Diagnostic tools for assessing and enhancing SMEs' readiness for the twin transition, focusing on production modernization and the adoption of smart technologies.

EU policy focuses on creating solutions for the twin transition and ensuring their accessibility to businesses. This is implemented through initiatives such as establishing specialized platforms (e.g., the European Technology Platform for the Future of Textiles and Clothing) and supporting the activities of Digital Innovation Hubs.

5.2 Tools for Support in Ukraine

Policy Documents

Ukraine has several strategic documents and plans that define the twin transition as one of the strategic goals of domestic state policy. The main ones include:

- The National Economic Strategy of Ukraine until 2030 [9] outlines key directions for economic development, including ecological transition and digitalization. Its primary objectives include developing a green economy, sustainable development, and technological modernization of Ukraine.
- The Strategy for Recovery, Sustainable Development, and Digital Transformation of Small and Medium Enterprises (SMEs) for the period until 2027[10] identifies promoting digital transformation and the green transition of SMEs as one of its four strategic goals.

Financial Instruments

Ukraine implements several government financial instruments accessible to SMEs for purchasing modern equipment and upgrading production facilities. However, they have not gained significant popularity among enterprises in the textile Industry, partly due to a lack of informational and consulting support.

- **The Government Program "Affordable Loans 5-7-9":**
  The program aims to reduce the cost of loans related to economic activities conducted by small, including micro-, and medium-sized enterprises (MSMEs).
  The maximum loan amount under this program is 150,000,000 UAH for a period of up to 10 years.
  MSMEs' obligations under loan agreements with Authorized Banks can be secured by assets, property rights, financial guarantees, etc.
- **The Government Project "eRobota" — Grant-Based Non-Repayable Assistance**:
  This initiative supports the restoration, creation of new businesses from scratch, implementation of ambitious projects, generation of new jobs, and acquiring in-demand labor market skills. It is part of the policy to develop Ukrainian

[9] https://nes2030.org.ua/

[10] https://zakon.rada.gov.ua/laws/show/821-2024-%D1%80#Text

manufacturers under the "Made in Ukraine" initiative. For processing industries, grants of up to 8 million UAH are provided for purchasing equipment to create or expand production capacities, including furniture, building materials, clothing, accessories, metalworking lines, and agricultural processing[11].

One condition for receiving a grant is the obligation to create 5 to 25 jobs, which is challenging for most textile Industry enterprises, as their average size is less than 30 employees. As of September 2024, 743 grants totaling 3.7 billion UAH have been issued for the development of processing enterprises, averaging about 5 million UAH per grant[12].

In addition to state support, international donors have been active in supporting Ukrainian entrepreneurship. In recent years, relevant programs funded by the USA, Canada, the EU, and indivitwin European countries have been implemented. Among the current programs are:

- **The Financial Inclusion Program:** Funding source — European Bank for Reconstruction and Development.
    - **Grant size:** up to €300,000 (total program budget of €2 million).
    - **Purpose:** Partial compensation for the cost of equipment purchased on credit to implement “green economy” solutions.
    - **Features:** For veterans, up to 30% of the project cost; for relocated businesses, up to 25%.
    - **Duration:** Until October 2029.
- **The Program “Access to Finance and Support for MSME Resilience in Ukraine”** funded by the German Government: Implemented by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) in partnership with the German Sparkassenstiftung für Internationale Kooperation (DSIK) and the Entrepreneurship Development Fund.
    - **Program objectives**: To enhance the competitiveness and financial stability of micro-, small-, and medium-sized enterprises (MSMEs) in Ukraine and foster the continuous development of entrepreneurial potential and competencies. The program provides investment loans for the purchase, modernization, or reconstruction of MSME assets. The grant portion can constitute up to 20% of the project cost for MSMEs and up to 30% for relocated MSMEs.
    - **Maximum grant size:** €20,000 for standard MSMEs and €30,000 for relocated MSMEs.
    - **Maximum project cost:** €240,000 (excluding VAT).
    - **Minimum loan term:** 1 year.
    - **Interest rate:** Set at the average market level in Ukraine.
- **The Greencubator Climate Innovation Vouchers Program** annually allocates approximately €1.5 million for SMEs and startups (up to €50,000 each) for green innovations, which are also available to the textile Industry.

[11] https://erobota.diia.gov.ua/

[12] https://www.kmu.gov.ua/news/yerobota-93-mlrd-hrn-investuvala-derzhava-v-rozvytok-maloho-i-serednoho-biznesu-cherez-hranty

Skills and Education

The Educational Course “Circular Economy”: The course is being developed for the Economy of Trust Academy educational platform as part of the Club of Mayors initiative. Objective: To provide communities with practical knowledge about implementing circular economy principles; to develop skills in waste management, material reuse, and reducing environmental impact.

5.3 Priority Support Tools for 2025–2027

National Level The primary policy document guiding the twin transition of SMEs in Ukraine in the coming years is the Strategy for Recovery, Sustainable Development, and Digital Transformation of Small and Medium Enterprises (SMEs) for the period until 2027. The Strategy was approved by the government in August 2024, along with the Action Plan for its implementation 2024–2027.

One of the goals of the Strategy is Innovative Development, Digital Transformation, and the “Green Transition”. To support the twin transition of SMEs, the Strategy includes the following measures:

- Provision of vouchers: Creating incentives for digital transformation by providing vouchers or grants for investments in digital technologies and supporting digital skills training. This measure is included in the Action Plan for 2024–2027.
- Introduction of an online tool for self-assessment of enterprises’ carbon footprint to promote the green transition.
- Implementation of professional energy audits.
- Financing energy-efficient investments for SMEs and creating eco-industrial parks.

European Level

Under European programs for supporting investments and funding the green, digital, and sustainable ecosystem of the textile Industry, the following measures are planned:

- Raising awareness about funding opportunities for the textile Industry ecosystem. Through programs such as Horizon Europe, Digital Europe, LIFE, European Social Fund+ (ESF+), European Institute of Innovation and Technology (EIT), InvestEU, Innovation Fund, Single Market Programme, Cohesion Policy Fund, and the Recovery and Resilience Facility. This can be implemented through specialized platforms and online tools, such as the European platform for supporting stakeholders involved in the twin transition. However, business associations and clusters can be more effective in facilitating the integration of SMEs into international consortia.
- Promotion and use of Green Public Procurement (GPP) criteria, which will include “green requirements” in government tender documents.
- Reforms to support sustainability, digitalization, resilience, and the social dimension of the textile Industry: These changes should be implemented through the Technical Support Instrument (TSI), an EU program providing specialized expertise to EU member states for the development and implementation of reforms.

- Businesses also welcome the development and introduction of financial incentives for implementing digital passports and textile waste recycling in the textile Industry[13].

These measures aim to strengthen the textile Industry sectors by transitioning to environmentally, socially, and economically sustainable models.

Considering European experience, particularly the 2023[14] report "Transition pathway for the textile's ecosystem," the following key directions can be outlined to support the twin transition in Ukraine's textile industry:

1. **Implementation of the EU Eco design[15] Regulation**
   The EU is strengthening eco design requirements for most products concerning durability, circularity, and overall reduction of their environmental and climate impact. A critical element of this effort is the introduction of **Digital Product Passports (DPPs)**, which will contain comprehensive information on composition, disposal instructions, and repairability of textile products, promoting transparency and circular practices.
2. **Development of an Innovative Ecosystem**
   In 2004, the EU established the **European Technology Platform for the Future of Textiles and Clothing (Textile ETP)**. Its objective is to align the research and innovation needs and priorities of European industry (represented by companies, associations, and clusters) with the knowledge and technological capabilities of universities, research organizations, and technology developers to enhance the sector's competitiveness through intensified collaborative research and innovation. The platform includes a number of **innovation hubs**, offering services for the digitalization of the textile industry, the development and adoption of new technologies for circular and biotextiles, and more.
3. **Circular Waste Management**
   The EU encourages discussions on sustainable waste management mechanisms, including **Extended Producer Responsibility (EPR)**, ensuring producers are accountable for product disposal after its use.
4. **Raising Consumer Awareness**
   Revisions to the Textile Labelling Regulation and measures against **greenwashing** will enable consumers to make informed choices and support sustainable brands.
5. **Sustainability Assessment Methods**
   The EU is developing standardized methods to assess the environmental performance of textile products, facilitating comparisons and fostering innovation.
6. **Supply Chain Transparency**
   With the introduction of DPPs, the textile industry will be able to track the lifecycle of products more effectively and verify sustainability claims.

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[13] https://www.alpine-space.eu/project-news/cradle-to-cradle-industrial-transformation-roadmap-textiles/

[14] European Commission: Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, *Transition pathway for the textiles' ecosystem*, Publications Office of the European Union, 2023, **https://data.europa.eu/doi/10.2873/86186**

[15] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32024R1781&qid=1719580391746

7. **Monitoring Progress**
   The EU is designing **key performance indicators (KPIs)** to evaluate progress in the digital and green transformation of the textile industry.

Recommendations for Stakeholders

- **Producers**: Integrate eco design into processes, utilize digital tools for transparency, and participate in informational events and consultations.
- **Government Authorities**: Develop supportive policies, promote research, and encourage collaboration between small and large enterprises.
- **Consumers**: Use the information provided to make conscious choices and support circular initiatives.

The Role of Clusters in the twin Transition

Clusters play a crucial role in implementing policies aimed at achieving climate goals and digital transformation as they:

- Provide support to SMEs, which often lack resources for large-scale innovation or transformation.
- Offer access to funding, expertise, and technological tools for adopting green and digital solutions.
- Help adapt supply chains to meet environmental standards, facilitating the transition to a circular economy.
- Invest in education, retraining, and upskilling workers, aligning them with the demands of green and digital sectors. They also organize experience exchange programs between EU countries and regions.
- Simplify the integration of SMEs into larger ecosystems, enabling their participation in international projects.

Section 6. Roadmap — Presentation, Key Directions, and KPIs through 2027

Roadmaps (hereafter referred to as "RMs") in any strategic planning context are planning tools that describe the key directions and stages necessary to achieve goals in a specific area—in this case, the digital and green transformation of a particular industry. An RM typically serves as a guide, enabling industry participants to understand priorities, timelines, and the interconnections between various components of change. Roadmaps generally include descriptions of overall directions and desired outcomes, timelines, key drivers and areas of change, progress indicators (metrics), and actionable recommendations.

In comparison to detailed medium-term strategies, RMs focus more on “what needs to be done and in which direction to move”, whereas strategies emphasize "how exactly to achieve it", with clear instructions, budgets, responsibilities, and timelines. Thus, a roadmap serves as the foundation, while a strategy provides its detailed elaboration.

Since 2018, APPAU has positioned roadmaps as a key tool for orienting industry development in the era of the Fourth Industrial Revolution. At that time, the Industry 4.0 Strategy Project envisioned creating at least five roadmaps for Ukraine’s key sectors strategic to the economy—food processing, machine-building and engineering, defense, energy, and metallurgy. However, these plans were not adopted by stakeholders, as was the case with most of the proposals from that project.

In the following years, APPAU’s expert groups independently prepared a number of position papers, two of which remain relevant: the Guide to Roadmap Development and the Digital Transformation Roadmap for Ukrzaliznytsia, both dated 2019.

Thanks to support from UNDP, work on developing an industry-wide roadmap in Ukraine began for the first time in 2024. Unlike in previous years, this initiative stands out for its much higher level of stakeholder consolidation, which is further discussed below.

Methodology for Developing the Roadmap in the GDT Textile Project

The GDT Textile Roadmap was developed by a working group comprising leaders and experts from key national associations (Ukrlegprom and APPAU), two clusters (Podillia Fashion Cluster and the Circular Economy Cluster), two European Digital Innovation Hubs (Clotex in Khmelnytskyi and KyivHitech in Kyiv, both affiliated with leading universities in these cities), the Institute for Economics and Forecasting of the National Academy of Sciences of Ukraine, and leading textile enterprises such as Hypanis, Edelvika, Inteltex, Lectra-Ukraine, and Re:inventex.

Apart from the consolidation of stakeholders, the roadmap's development methodology includes the following key features:

- Integration of the best European practices and methodologies, particularly ADMA and SIRI.

- A series of benchmarking analyses and studies of European programs, including Textile Pathway and the Twin Revolution project.
- Broader and gratwin integration of stakeholders into discussions about the future of the textile industry, achieved through a series of online and offline discussions.
- Consideration of previous efforts by APPAU and the Industry4Ukraine platform, specifically incorporating recommendations from the "Industrial Policy Tools" manual published in 2020.

Overview of the Roadmap

Figure 8. Framework of the Roadmap for the twin Transition (DT) in the Textile Industry

The components represent the main strategic areas of activity for participants, where changes are necessary. Below is a brief description of each component.

Component 1 (C1): The Textile Industry as an Industrial Ecosystem

This component describes the state, challenges, and priorities for changes in the innovation ecosystem and its close connection with the value chains in textile industry sectors. Key directions for change involve significant strengthening and development of hard

elements (see Section 5), such as EDIHs, R&D centers, certification laboratories, etc.; soft elements (measures and tools to enhance collaboration); and improved networking among ecosystem actors. This component encompasses 19 initiatives and is considered critical, as its success greatly influences the realization of subsequent components.

C2: Production and Technologies

This component integrates production (equipment) and digital technologies, highTextileing drivers for accelerating production modernization and the transition from Industry 2.0-3.0 to 4.0. C2 covers 9 initiatives (considering that digital initiatives are also indirectly presented in other components).

C3: Production Approaches and Standards

This area focuses on analyzing current and prospective trends in production management, business models, and technical standards. Priorities include the adoption of **Digital Lean** and shared services (XaS). C3 includes 6 strategic initiatives.

C4: Human Capital – Human-Centered Focus

This component emphasizes changes in workforce training, highTextileing areas such as reskilling, retraining, organizational changes, and fostering a culture of collaboration. C4 includes 16 initiatives that address current personnel issues while also considering future challenges in the textile industry.

C5: Eco-Factory

Following the ADMA methodology, this component focuses on circularity, energy efficiency, clean materials and resources, and digital product passports. It includes 20 initiatives, reflecting significant alignment with the high priority placed by European institutions on this direction, given the substantial pollution impact of this industry.

C6: Tools

This component emphasizes measures to develop the most critical support tools for the initiatives mentioned above. These include support for transitioning to new ESPR and DPP regulations, stimulating the adoption of new software products, and developing innovation and internationalization infrastructure, covering a total of 10 initiatives.

All initiatives are detailed in Appendix 2.

General goals for the three-year period (by the end of 2027):

- Coverage of twin transition services: at least 150 enterprises in the industry.
- Implementation of twin transition pilot projects: at least 50 enterprises in the industry.
- Growth in labor productivity and OEE indicators at pilot enterprises: at least 25%.

The main KPIs for monitoring and tracking the progress of the Roadmap are as follows:

Performance Indicators	2025	2026	2027
C1. Industry as an Ecosystem			
Number of collective service Centers of Excellence (including EDIHs, incubators, R&D centers, etc.)	3	5	7
Number of promotional and networking events at regional and national levels focused on the twin transition	10	15	20
Number of organizations joining the 3T Alliance	10	15	30
C2. Technologies			
Number of pilot projects implemented with the purchase of modern equipment featuring 4.0 technologies	5	7	8
Number of pilot projects implemented with 4.0 technologies	7	10	13
SMEs covered by key products (replacing 1C with ERP, implementing modern CAD systems)	20	35	45
C3. Production Approaches and Methods			
Number of pilot projects implemented with Digital Lean	3	5	12
Number of pilot projects implemented with XaaS	2	5	7
C4. Human Capital			

Reskilling-Upskilling: number of new training programs for specialists and managers	3	5	7
Annual coverage of workers trained in new competencies and professions	50	70	100
C5. Environmental and Green Initiatives			
Scaling projects: number of enterprises processing textile waste	5	12	15
Number of pilot enterprises achieving full energy autonomy	5	7	12
Number of pilot projects implementing DPP (Digital Product Passports)	3	9	25
C6. Support Tools			
Amount of funding attracted to support roadmap initiatives through government structures (k Euro)	200	500	1000
Number of central and regional government bodies engaged in supporting program implementation	2/3	3/5	4/6

Until the government adopts a targeted program, monitoring of the KPIs can be undertaken by the **3T Alliance**, depending on the number of initiatives that receive funding.

The developers paid significant attention to balancing initiatives across zones, their cross-connections, and aligning them with potential project initiatives. In other words, certain initiatives may be implemented in 2025 independently of others, but it is crucial to monitor their effects and interlink the outcomes of different initiatives to achieve **synergy and mutual reinforcement**.

This coordination across the entire roadmap is impossible without the support of government structures. Consequently, one of the key roles of this roadmap is to serve as a **communication and coordination tool** with stakeholders.

Section 7. Recommendations for Implementing the Roadmap

This document serves as just the **starting point** on the journey toward a twin transition. In its full scope, the roadmap can become an effective tool for planning, coordinating, and deploying specific industry initiatives. However, it may also remain a static PDF file without any coordinated action. Over the past decade, dozens of “paper” strategies have been created in Ukraine—these dominate at all levels, particularly in industrial and high-tech sectors. To date, we know of no strategy that has truly become a shared tool for all market participants, including the government.

Given this negative trend, what should the priorities be for deploying this roadmap?

Key Priorities for the Initial Rollout of the Roadmap in 2025

Achieving genuine **consensus and consolidation** among key stakeholders should be a top priority. The **3T Alliance**, currently comprising five ecosystem actors, is merely the first step—a small initiative under the GDT Textile project demonstrating the capacity of UCA clusters to act swiftly and collaboratively. However, there are many other actors, including powerful business associations and large companies, that could join the memorandum and contribute resources. Special attention should be given to consolidating **government organizations** and **international donors**, as they play a critical role in funding strategic initiatives. Public-private dialogue should continue and culminate in agreements to support this roadmap as an industry strategy for the twin transition.

Swift actions are required to **launch specific initiatives in 2025**, ideally coupled with the creation of a **state-targeted program**. Support from the Ministry of Economy is crucial, including prioritization of specific initiatives, their integration into a unified targeted program, and overseeing such a program at the state level. This would lend credibility and signal “green Textile” approval to a range of international partners and investors.

Applying flexible collaboration and networking approaches, already proven effective in UCA cluster partnerships, is critical for achieving early wins and motivating participants in the **3T Alliance** and beyond. These approaches include:

- **Connecting the dots** and effective matching: Partners already have several promising business opportunities for partnerships and even commercial agreements. Cluster coordinators and business development managers should take the lead in swiftly connecting opportunities with potential SME consumers and large companies.
- **Quick experiments:** Industrial companies must adopt new perspectives and approaches to digital technologies. The market offers ample opportunities for rapid experiments in categories such as Industry 4.0 technologies, workforce training, and new methodologies.
- **Participation in international consortia:** This is essential for aligning with advanced EU practices and motivating market participants.

Internationalization must continue with regular exchanges with foreign partners. Although exchanges with EU colleagues in fall 2024 were unsuccessful for various reasons, UCA’s experience underscores their value. Special attention should be paid to **coordination**

and synchronization points between Ukraine's **CoP 5.0 UA** community and the European SoR 5.0 community, as this roadmap is the first of its kind in Ukraine's 5.0 community.

Focusing on priorities is essential. The roadmap includes 80 initiatives, but initial priorities must be defined:

- Activating the most effective **support tools for the twin transition**, such as grant programs, SME incentives for adopting modern software, and assistance in implementing **Digital Product Passports**.
- Collaboration between **clusters and EDIHs** to develop regular and high-quality service offerings for SMEs, focusing on **innovation fundraising**, training, pilot projects for Industry 4.0, and strengthening regional innovation ecosystems.
- Launching the first **innovation contests, hackathons,** and, where possible, creating **incubators and accelerators** to rapidly grow startups aligned with market needs.
- Organizing annual conferences, such as **"twin Transition and Innovation in the Textile Industry,"** to progress in innovative solutions, workforce development, technology implementation, and the green transition.

Implementing these recommendations in 2025 could provide significant momentum for realizing the other initiatives outlined in the roadmap.

This publication has been produced within the framework of the Swiss-Ukrainian Project "Strengthening Business Associations of Micro, Small and Medium Enterprises in Ukraine", implemented by the United Nations Development Programme in Ukraine (UNDP) in cooperation with the Ministry of Economy of Ukraine and with the support of Switzerland.

Appendix 1. Detailed Business Cases and Their Solutions

Business Cases are problematic and typical situations related to the twin transition, identified during the GDT Textile project through focused surveys of textile industry respondents and site visits to enterprises. The solutions to these cases are based on expert consensus reached during strategic sessions and within the GDT Textile Project Working Group. These solutions are purely advisory in nature.

Case 1: How to Accelerate and Scale the Procurement of Modern Equipment and Innovative Solutions Using Existing Financial Instruments

Despite the availability of modern automated equipment for the technological processes of textile industry enterprises, adoption levels remain low. For example, many small enterprises cannot afford to purchase automated cutting machines due to their high cost. Another obstacle is the lack of qualified personnel to manage and maintain such machines. SMEs also frequently overlook grant opportunities due to low awareness and insufficient expertise in grant writing.
According to GDT Textile project experts, this case exemplifies an "ecosystem" problem, requiring the involvement of multiple institutions and elements of education, consultation, and awareness. The solutions are outlined in three areas:

1. **Market Awareness of Existing Financial Instruments and the Creation of New Ones**
    - All ecosystem actors working in the textile industry must improve information support for SMEs, disseminate information about existing opportunities, and provide consultations. Many SMEs ignore these opportunities, thereby missing out on available resources. Examples include:
    - The “New Level” grant for manufacturing under the government's *eRobota* project provides up to 8 million UAH for creating 5–25 jobs, with 50% co-financing (20%[16] for certain categories).
    - The government program "Affordable Loans 5-7-9%" aims to reduce the cost of loans for micro-, small-, and medium-sized enterprises (MSMEs). The maximum loan amount is 150 million UAH for a term of up to 10 years, secured by property, financial guarantees, or other means.
    - International grants and programs, such as the USAID competition in 2024, provided modern textile industry equipment[17]. Winners included companies like PrJSC "Kalyna" and LLC "TC-Domashniy Tekstyl."
    - Vouchers and grants for investments in digital technologies, scheduled for 2025 under the Strategy for Recovery, Sustainable Development, and Digital Transformation of SMEs through 2027.
2. **Training and Retraining Enterprise Personnel.** Opportunities already available through educational institutions should be maximized. For example, the Fashion Training Center in Khmelnytskyi prepares industry professionals and offers

[16] https://zakon.rada.gov.ua/laws/show/739-2022-%D0%BF#Text
[17] https://grant.market/opp/usaid-textile

pre-professional training for high school students. This center was established through the efforts of the Podillia Fashion Cluster, including the Sustainable Development Agency ASTAR, Khmelnytskyi National University, and the Katran Business School. Additionally, major vendors like Intelltex periodically provide training on using modern European equipment from various brands.

3. **Improving Service Support within Business Associations.** Enterprises within clusters can leverage mechanisms for bulk purchases through their cluster, including special preferential loan offers from banks. Advanced clusters also provide service support to their members by regularly sharing information about the best grant and financial opportunities and assisting in writing grant applications.

Success Story: “How to Organize Fundraising Services for SMEs”

According to the European Cluster Collaboration Platform (ECCP), SMEs that are part of strong, advanced clusters achieve twice the productivity and innovation levels compared to those not in clusters. The experience of the Ukrainian Cluster Alliance (UCA) partially confirms this.

The APPAU Association launched a systematic fundraising service for its members back in 2021. By the end of 2022, 12 members of the association had utilized grant financing services, receiving support totaling approximately €1 million to develop their innovations.

A similar service was organized by the ASTAR NGO for members of the Podillia Fashion Cluster. Between 2022 and 2024, 12 cluster members secured grant funding under 16 programs, covering areas such as:

- Diagnosis of the current state of companies.
- Increasing company resilience.
- Orders for clothing production for the needs of internally displaced persons (IDPs).
- Internships abroad.
- Equipment upgrades.
- Development of policies, strategies, and regulations.
- Website creation.
- Training programs for workforce development.
- Indivitwin consulting.
- Participation in international public events.
- Entry into foreign markets.

Both clusters are now integrating these services into the structure of EDIHs (European Digital Innovation Hubs). APPAU integrates into EDIH KyivHitech, while ASTAR integrates into EDIH Clotex Hub. According to the operational mandates of these new institutions supporting SME digital innovation, they are required to provide innovative fundraising services for SMEs on an ongoing basis.

Currently, both UCA partners use the resource Grant.market for analyzing and selecting financial opportunities. This platform was created by another partner organization, the Network of Business Information Support Centers (BISC).

Contact Information for Fundraising Services:

- APPAU: info@appau.org.ua
- Podillia Fashion Cluster: pfc.cluster@gmail.com

Case 2: Waste Management within Regional Hubs

Enterprises generate dozens of tons of waste daily in developed industrial centers with a high concentration of manufacturers. According to statistics, more than 200 sewing workshops and companies operate in Khmelnytskyi, of which 30 produce post-production textile waste in volumes and structures represented in Fig. 9.

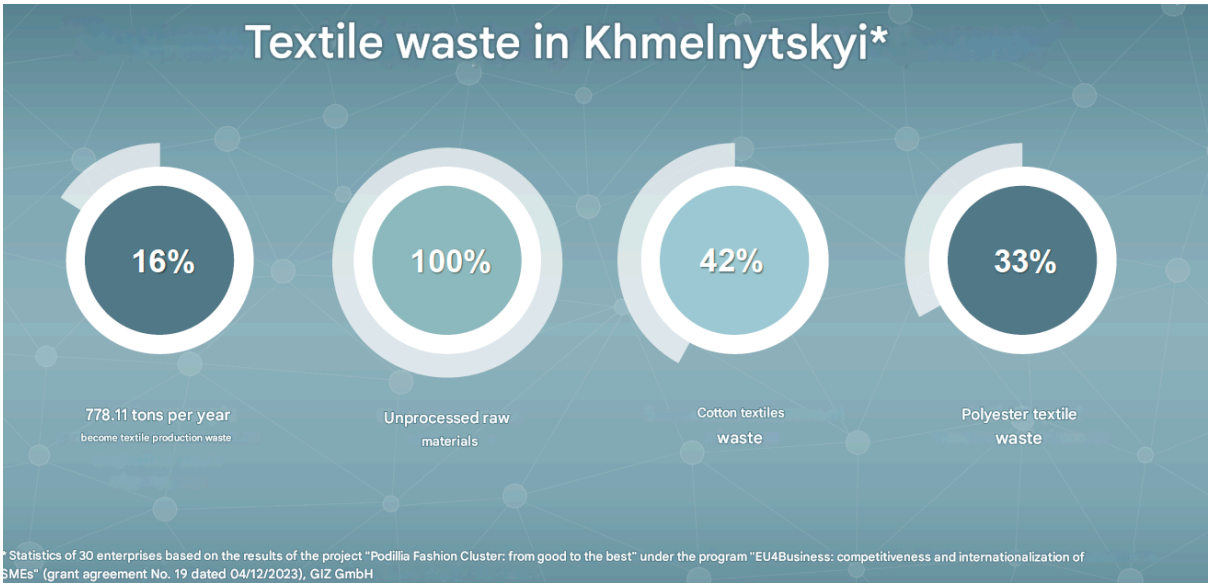

Fig. 9 Data on waste in Khmelnytskyi based on 2023 surveys conducted by the Podillia Fashion Cluster.

Addressing this issue is complex and requires a multi-faceted approach, hindered by the lack of a waste management infrastructure. This depends primarily on municipal authorities and the presence and enforcement of regulatory acts concerning producer responsibility at regional and national levels. As a result, 95% of this waste is dumped in household waste landfills, while only 5% is utilized (through shredding or incineration). Such comprehensive and ecosystemic problems, which extend far beyond the capabilities of a single enterprise, must be solved at an industry-wide level with the involvement of all stakeholders—government, local authorities, suppliers, manufacturers, and business associations.

In the case of Khmelnytskyi, a solution is proposed at the regional-industry ecosystem level by implementing a series of measures that together form a Waste Management Roadmap. The cluster is responsible for its implementation, and efforts to secure funding for its execution are already underway.

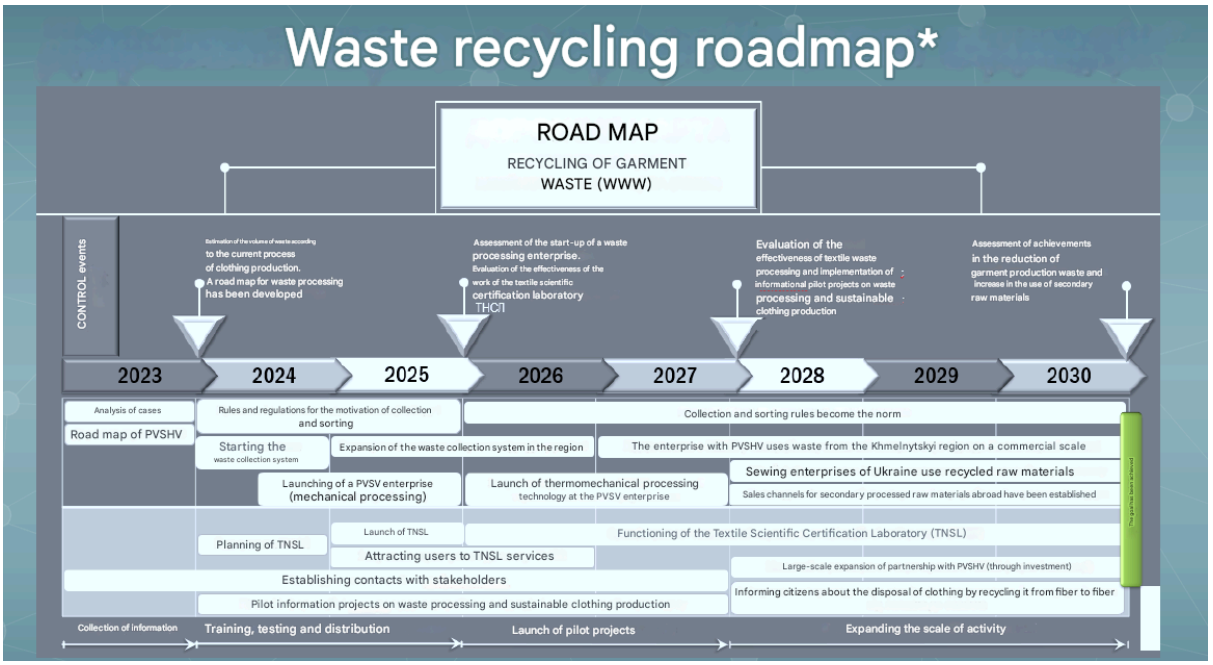

Fig. 10 Representation of the Waste Management Roadmap by the Podillia Fashion Cluster.

Success Story: "Recycling Textile Industry Waste at Re:inventex"

According to analysts based on data from the State Statistics Service and the State Customs Service, **textile industry waste** in Ukraine amounts to at least **15,000 tons per year**. In contrast, consumer waste, such as used clothing, exceeds **150,000 tons annually**. Secondary recycling has not been well-developed, and Re:inventex is one of the first enterprises to launch production facilities for recycling textile waste.
The company already processes **2,500 tons of waste** and plans to double its capacity by 2025. Re:inventex has a clear strategy for further scaling and advocates for the entire textile industry to transition to a **circular economy** (**Fig. 11**).

At the same time, the company's leadership urges **government bodies and market participants** to intensify efforts toward adopting circular economy practices. The challenges of waste recycling exist on at least three levels: **legislation**, **economic incentives**, and **consumer behavior**. As a result, investors entering this market require comprehensive and coordinated support.

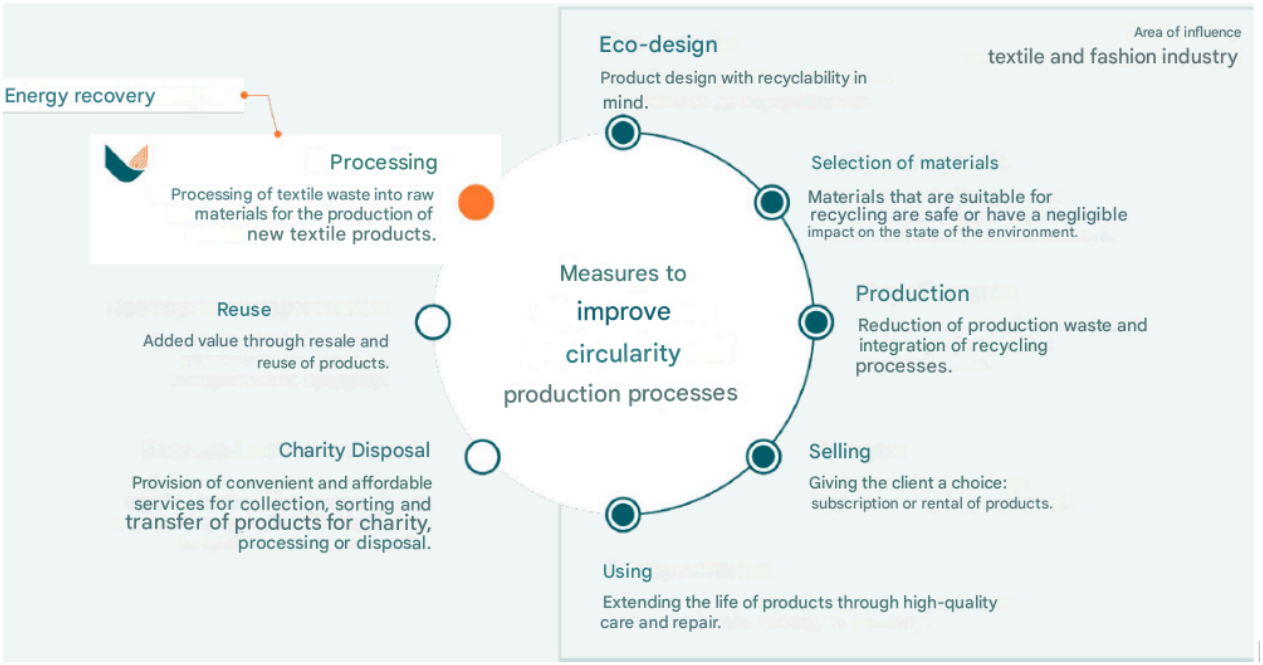

Fig. 11 Vision of Re:inventex for the Circular Product Cycle in the Textile Industry.

Case 3: Digitalization of the Product Lifecycle Adapted for Ukrainian SMEs (or How to Implement PLM Without PLM)

The digital transformation of small and medium-sized enterprises (SMEs) in the textile industry often begins with automating indivitwin processes, such as product design and development, through CAD-CAM systems. Over time, businesses recognize the need to digitalize the entire product lifecycle to achieve greater transparency, alignment, and speed in bringing new products to market.

An ideal scenario involves client requirements from sales and marketing quickly reaching product managers and R&D, then designers, and being coordinated with constructors, technologists, procurement, and logistics departments. The information then loops back to marketing and sales. Such a workflow is essential in the context of rapid market changes and the growing need for product customization. The question of how to implement this scenario has long occupied the minds of leading companies worldwide.

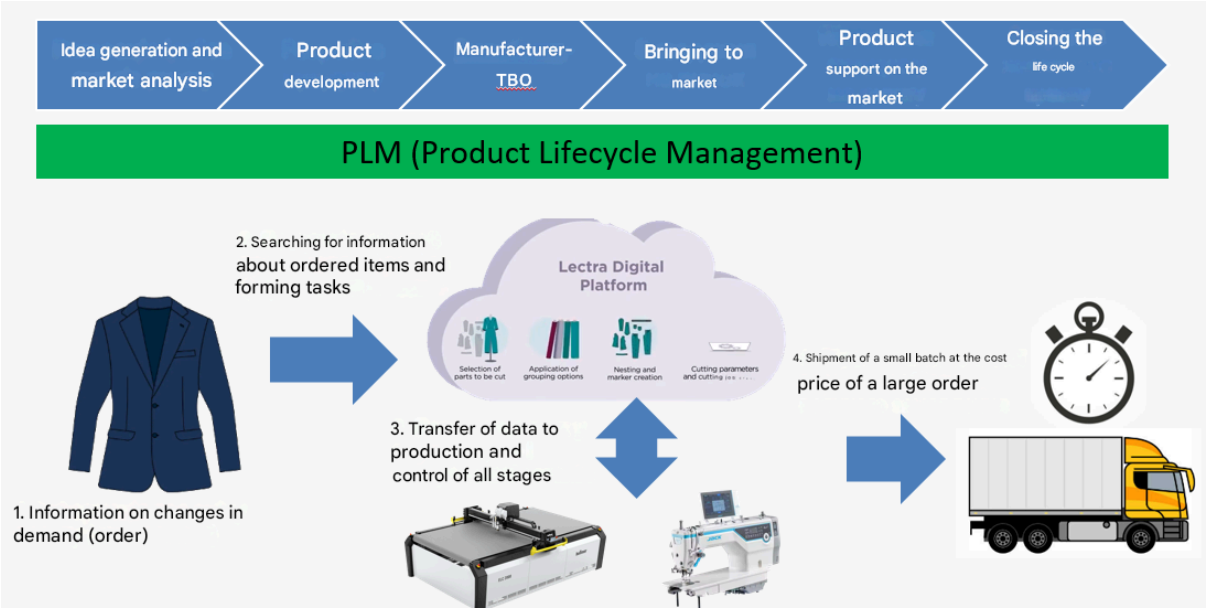

Fig. Integration of Various Products into a Unified PLM (Example)

It is essential to distinguish between PLM (Product Lifecycle Management) as a **concept** and as a **technical solution**. PLM systems have been available on the market for a long time, but for most Ukrainian SMEs, they remain inaccessible due to their high cost and significant resource requirements for implementation.

Branded PLM systems are characterized not only by the integration of various software tools across multiple stages (CAD-CAM-CAE, PDM, CRM, WMS, etc.) but also by creating new options to facilitate collaboration among different teams (departments). The goal is to establish a seamless, efficient process for data transfer with minimal errors and quick approvals. However, such integrated systems are expensive and complex. A PLM license from globally recognized brands like **Lectra** can cost several hundred thousand euros per year.

Implementing PLM also requires deep adaptation of existing business processes, the involvement of specialists, and extensive staff training. As of today, such implementations do not exist in Ukraine's textile industry. Even less complex products, like CAE (modeling, simulation, and calculations), remain inaccessible due to the same challenges—high cost and the need for qualified specialists.

Drawing parallels with the machine-building sector, where similar market issues exist, Ukraine has only two cases of PLM implementation in previous years: **Antonov State Enterprise** and **Pivdenmash**.

In Ukraine's challenging economic environment, such expenditures present a significant barrier not only for small businesses but also for medium and large enterprises. Despite the potential benefits, many cannot afford large-scale automation. However, implementing PLM is a critically strategic necessity for dozens of Ukrainian medium and large enterprises. This solution aligns perfectly with their competitive strategies of flexibility, adaptability, customization, and enhanced service support.

According to **GDT Textile experts**, such flexibility is deeply ingrained in Ukrainian businesses (not just in the textile industry), giving them an advantage over European and Asian competitors. However, without the digitalization of these strategies, Ukrainian manufacturers risk losing this edge.

GDT Textile Solution

Our solution concept is based on practical experience within **APPAU** and has been tested across various cases in other industries. This involves gratwinly integrating accessible digital tools within a unified **ERP** system. Existing products and systems like CAD, CRM, procurement modules, materials management, order tracking, and production workflows (part of MES) can be effectively integrated into a single ERP platform.

Such an approach was implemented, for example, in **2017–2018** at the **Interpipe** enterprise (see case study below) and in other projects by **IT-Enterprise**. According to APPAU, other manufacturers in various industries also apply similar approaches.
In this setup:

- ERP handles resource management.
- CAD automates the creation of patterns and specifications.
- MES enables real-time control of production processes.
- CRM facilitates personalized customer service.

The key advantage of this approach lies in the ability to implement these systems incrementally, allowing businesses to adapt to new tools without significant financial strain. It is especially crucial to ensure the accessibility of such integrated tools for **SMEs**, making their adoption feasible for a wide range of enterprises. Cost, availability of local support, ease, and speed of implementation, and flexibility of solutions should become primary criteria when developing and selecting such systems.

As a result, enterprises will gain the core benefits of PLM—**transparency, centralized data management, and process automation**—without expensive software. This will enable companies to adapt to modern challenges and remain competitive in both domestic and international markets.

Success Story: “From Procurement to Production: Smart.Factory at Interpipe”

Interpipe, a leader in Ukraine’s pipe manufacturing and a prominent global exporter, faced challenges when entering European markets. While the company had previously relied on high-volume production distributed through large warehouses worldwide, European clients required **small, specific batches** of products delivered quickly (just-in-time). These batches needed to meet exact specifications, such as pipe size, steel grade, and other parameters.

This shift created significant hurdles in managing hundreds of small orders, inventory, and logistics (direct delivery instead of warehouse storage).

The **Smart.Factory** solution by **IT-Enterprise** enabled the integration of order registry management into a single **ERP system**, providing:

- Indivitwin tracking of each pipe via **QR code labeling**, ensuring complete transparency and coordination across multiple company plants.
- Alignment of data between the CRM system and design departments.

As a result of this implementation, order processing time was **cut in half**, errors in documentation and order tracking were drastically reduced, and the company achieved **full traceability** of every product—from raw material to delivery to the client.

In Industry 4.0 terminology, such solutions are referred to as **"horizontal integration"**, which focuses on managing the product lifecycle (PLM).

It is noteworthy that, according to experts, similar solutions from competing Western brands (such as SAP) would cost **5–10 times more**, and their implementation timelines would also be **2–3 times longer**.

Case 4: Implementing Real-Time Production Management Systems

Ninety percent of medium and large enterprises in Ukraine's textile industry lack integrated data from dozens of automated production units. Consequently, managers do not have accurate and reliable real-time information about production status, making it difficult to forecast and prevent potential bottlenecks or disruptions in order fulfillment.

Typical solutions to these issues include implementing modern production management systems specifically designed for these tasks, such as:

- **ERP (Enterprise Resource Planning):** A comprehensive system that manages all business processes across the enterprise.
- **MOM (Manufacturing Operations Management), formerly MES:** A system for real-time production management.
- **ASP (Advanced Scheduling Planning):** Systems designed for advanced production planning.

These systems are widely adopted in developed countries; however, their penetration rate in Ukraine's textile industry remains at only **5–10%**. Industry 4.0 technologies, such as the Internet of Things (IoT) and Artificial Intelligence (AI), are significantly enhancing the functionality of these software products and making them more accessible.

One of the main reasons for the low adoption rate is the limited awareness among business leaders about the availability of such solutions, including those developed in Ukraine, and the best practices and case studies associated with them. Many enterprises continue to modify or implement outdated software of Russian origin (such as 1C, BAS, and Bitrix24), which have limited functionality and pose potential risks due to sanctions.

The implementation of modern systems requires a **comprehensive approach**, which must include:

- **Proactive promotion** of cutting-edge solutions from Ukrainian and European developers.

- **Systematic education and awareness campaigns** to inform businesses about the benefits and capabilities of these solutions.
- **Training of personnel** and **a shift in production culture** to support and sustain the adoption of real-time production management systems.

These measures can pave the way for improved productivity, greater operational transparency, and enhanced competitiveness in both domestic and international markets.

Activities	Goals	Responsible Parties
A. Implementation of modern technical standards		
1. Adoption of ISO 22400 by enterprises	Transition to production KPIs accepted in the EU and globally	Enterprises, potential assistance from TC 185, specialized integrators, and EDIHs
2. Training on ISO 22400	Training technical staff, including technical directors and chief engineers	
3. Dissemination of best practices on OpEx	Increasing awareness of best practices, benchmarking, and accelerating implementation	
B. Information campaign		
1. Webinars, workshops, and conferences	Education and raising awareness about modern production management systems	APPAU and sectoral associations
2. Preparation of best use cases	Raising awareness about leading implementations in Ukraine and globally	Ukrainian vendors and integrators
C. Workforce training and skills development		

1. Training on specific solutions	Training enterprises on ERP, MOM, SCADA (E), and APS solutions	Ukrainian vendors and integrators
2. Integration into university curricula	Training students in technical universities	Ukrainian vendors and integrators
3. Integration into EDIH services	Demonstrating solutions to SMEs and sharing expertise	Vendors, integrators, and EDIHs
D. Democratization of solutions		
1. Market introduction of low-end products	Active promotion of accessible solutions, including IoT and cloud-based products	Ukrainian vendors, integrators, and startups
2. New sharing models and subscription services	Maximizing service outsourcing to integrators	Integrators together with customers

Donor funding for such programs (partial payment for implementation and/or comprehensive audits) would serve as additional incentives for faster adoption of these products by SMEs.

Success Story: Overcoming the Problem of “Equipment Zoos” in Manufacturing

In their approaches to production modernization, many medium and large enterprises focus on purchasing automated equipment based on the principle of "the cheaper, the better." As a result, over 5–10 years, many enterprises develop a "zoo" of diverse equipment, leading to challenges in maintenance and integration into a unified production management system. This equipment often features different controllers, communication interfaces, and data exchange protocols.

One such problematic case was resolved by the company **Digitap** (formerly Indusoft) at the pharmaceutical enterprise **Yuria-Pharm** in Cherkasy.

The task for the enterprise was to reach a new level of operational efficiency, particularly in integrating diverse subsystems into a unified production management system. Digitap's solution represents a modern “classic” in MES/MOM systems, starting with a dispatch module that immediately provides capabilities for monitoring key production efficiency metrics. As a result of the project's implementation, Yuria-Pharm fully integrated the MOM functionality into its ERP system. The Overall Equipment Effectiveness (OEE) metric increased by 20%, productivity losses decreased by 70%, and downtime was reduced by 80%.

For more details about the Yuria-Pharm case, follow this link.

Case #5: Improving Collaboration in Regional and Sectoral Innovation Ecosystems

This case emerged from the application of the ADMA methodology, particularly the assessment of Zone #7, "Innovation Management and Networking." ADMA evaluates the capacity of SMEs to consciously leverage external resources for innovation management (experts, consultants, universities, etc.), integrate them into their innovation programs, and build joint ecosystems and projects. Surveys revealed the initial level of SMEs in this zone, which did not come as a surprise to the project leadership. Very few enterprises in Ukraine are prepared to collaborate with external experts, involve them in innovation development, or engage in networking within entire ecosystems.

In contrast, the project had significantly higher expectations for expert collaboration among the nominated ecosystem participants, particularly national associations such as "Ukrlegprom" and APPAU, two clusters (Podillia Fashion Cluster and Circular Economy Cluster), and two EDIHs—Kyiv and Khmelnytskyi. Expert involvement was anticipated across all key project activities, with allocated funds.

However, the project revealed the limited availability and readiness (expertise, competencies, and number of experts) of all partners to support SMEs and work on analytical and consulting tasks.

The project highlighted specific symptoms (and causes) of the low capacity for collaboration among participants, including:

- Weak internal communications, particularly between clusters and EDIHs.
- The inability and lack of qualifications of certain cluster managers, evidenced by their misunderstanding of their responsibility for engaging experts and participants from their clusters.
- As a result, a significant gap was identified between the public positioning of young clusters and EDIHs and their actual capabilities in coordination, networking/matchmaking, and providing services in their areas of specialization.

The project's analytical report identifies this case as one of the key issues in GDT Textile. The roadmap highlights the factor of "Collaboration in the Innovation Ecosystem" as critical to implementing all five other components of the roadmap.

Possible Solutions

Case 5 was discussed during two sessions of the project's Working Group, and separately within the Ukrainian Cluster Alliance (UCA) leadership and with external consultants. The recommendations for this case are as follows:

1. **Strategic Perspective: Formalizing Relationships**
   Open dialogue and frank discussions of existing issues, transitioning to strategic negotiations and agreements, are essential for establishing long-term partnerships. At the final conference on December 17, a Memorandum of Cooperation for the "3T Alliance" was signed, involving APPAU, two clusters, and two EDIHs. This created a strategic perspective for jointly implementing the 2025 roadmap and neutralized certain tensions among project participants.

2. **Escalating Collaboration Challenges to Top Management**
   Raising collaboration issues within the Working Group, which included customers and end-user enterprises, prompted different reactions from certain cluster managers. For example, UCA top managers Oleg Demchuk and Oleksandr Yurchak managed to agree during working meetings and elevated the level of expert engagement within their respective organizations in Kyiv and Khmelnytskyi.

3. **Building a Strong Expert Community Together**
   UCA's new policy to create the CoP 5.0 practice community and strengthen the status of UCA Working Groups appears to be the right direction for resolving Case #5. Clusters and other business associations need to strengthen the consolidation of genuine experts who can create high value, including improving procedures for expert selection and onboarding, enhancing motivation and engagement systems, and planning activities.

4. **Better Systematization and Application of Project Management Practices**
   For similar projects, it is necessary to revise existing regulations and procedures for project initiation (with clearer role and responsibility distribution), value delivery, escalation processes, and retrospective reviews.

5. **Incorporating Development and Training Programs for Managers**
   This case demonstrates the importance of UCA's 2025 project initiatives aimed at

developing leadership and professional skills among cluster managers. These training programs are expected to yield results within 6–12 months. However, if they are not implemented, the solutions mentioned in points 1–4 will have limited impact, as skills and competencies are fundamental to any specialization.

The full version of Case #5 is available on the UCA website here.

Appendix 2. Roadmap: Strategic Initiatives

The Roadmap outlines strategic initiatives distributed over time across six components (categories): Industrial Ecosystems, Technologies, Manufacturing Methods and Approaches, Human Capital, Environmental and Green Initiatives, and Support Tools. Below are detailed initiatives for each component.

C1: Textile Industry as an Industrial Ecosystem

This component offers a European vision of the industry as an industrial ecosystem. Where the core value chain (VC) is highly integrated with the innovation ecosystem and its elements on one side, and with policies and regulatory tools that strengthen these links and overall integration on the other. In this roadmap, the emphasis is placed on developing the innovation ecosystem and its connection to the value chain.

Key drivers: Strategic options for analysis and development were performed based on the 2019 industrial high-tech innovation ecosystem model. Key drivers of development include “hard elements” such as technology parks, laboratories, and incubators, and “soft elements” that stimulate collaboration between industry stakeholders—events and tools that enhance networking, matchmaking, collaboration culture, and education.

Current state of the ecosystem: In Ukrainian Textile industry, “hard” elements like incubators, accelerators, strong R&D institutions, R&D centers, or technology parks are virtually absent. EDIHs are just entering the field, and overall interaction between universities, research centers, and businesses is weak. There are three regional clusters, but they operate independently. The industry association "Ukrlegprom" does not yet have its own twin-transition agenda. There are no international partnerships with leading textile innovation centers. A more detailed analysis of the current state, including benchmarking, is available here.

C1: Textile Industry as an Industrial Ecosystem – Key Development Initiatives (2025–2027)

Specialization, Collaboration, and Networking

1	**Hard elements of the ecosystem (infrastructure)**	**2025:** 1) Launch of 2 eDIHs (Clotex + KyivHitech): support for 50+ SMEs in implementing Industry 4.0, digital product passports, and circular models; hubs will focus on training, startup incubation, and attracting international grants. 2) Creation of the first Eco-Industrial Park focused on textile waste recycling and testing new materials (Khmelnytskyi). **2026:** 3) Creation of an industry accelerator: organizing the first accelerator focused on textile innovations (IoT in production, energy conservation, technical textiles). **2027:** 4) Systematic infrastructure network: launching at least 5 eDIHs, technoparks, or accelerators covering 50% of SMEs in the target industry program. 5) Government support for infrastructure: establishing a national fund to finance innovation infrastructure in the textile sector, with an emphasis on Industry 4.0 technologies and the green transition.

2	**Soft elements**	**2025:** 1) Innovation platform for networking: launching an online platform for SMEs, universities, investors, and international partners that facilitates idea exchange, partnerships, and investment search (or joining existing European platforms?). **2025-27:** 2) Promotion of innovations: organizing 5 conferences, exhibitions, or hackathons to popularize innovative technologies in the textile industry. Holding the annual "Textile Innovation Forum" with the participation of European and Ukrainian partners. 3) Integration of Ukrainian universities into European innovation programs such as Horizon / Digital Europe. 4) Sustainable educational programs: continuous updates to the curricula of 10 universities in response to the challenges of the dual transition. 5) Launch of the Leaders and Cluster Management School within the Ukrainian Cluster Alliance (UCA).
3	**Specialization, collaboration and networking**	**2024-25:** 1) Creation and expansion of the "3T Alliance" - a coalition of business associations, clusters, and international organizations supporting Twin Transition in Textile (3T). **2025-26:** 2) Cluster support: providing funding to scale the activities of 3 regional clusters focused on digital and environmental innovations. **2025-27:** 3) Internationalization: organizing 5 study tours to textile tech parks in Germany and Italy for knowledge exchange / first international projects: launching 2 joint initiatives with European clusters (e.g., in circular textiles or technical textiles). **2026-27:** 4) Scaling up clusters: establishing 7 active clusters with international partnerships. 5) Development of B2B platforms: creating 2 platforms to integrate Ukrainian manufacturers into global supply chains.

This component is key to initiating systemic changes in the industry. By consolidating and strengthening collaboration among key stakeholders, it becomes possible to accelerate the implementation of changes outlined in all other components below.

C2: Production and Technologies

General Context:

This component for SMEs is shaped by the dominant factor of production modernization—specifically, the capabilities and opportunities to acquire modern technological equipment. Typically, this area involves capital investments that are the primary focus of SME leadership. Digital technologies or green innovations are often far behind in priority, which presents a significant challenge.

Key Drivers:

Three main drivers of development have been identified in this area:

- **Rapid Modernization**: Exploring how production equipment and technologies can be quickly modernized. This area of change is evident given the industry's needs.
- **Transition from 2.0 to 4.0**: Outlining directions for transitioning from Industry 2.0-3.0 paradigms to 4.0.

- **Mass Customization of Products and Services**: Leveraging approaches and visions of Industry 5.0, which is increasingly becoming a priority in the EU agenda, laying the foundation for Industry 5.0.

Current State:

According to the ADMA survey, technological equipment modernization is the number one priority for Ukrainian enterprises. In the textile industry, suppliers from China and Turkey dominate; however, detailed research on supplier market shares and SME procurement priorities is lacking. It is known that the acquisition of modern equipment is challenging for most SMEs, which rarely utilize existing financial instruments. European-made modern equipment is primarily purchased by medium and large enterprises, which also tend to have more qualified personnel. Regarding the adoption of modern digital technologies, the initial GDT Textile analysis shows that the sector lags not only behind European industries but also behind many other Ukrainian sectors.

1	Production Technologies	**2025**: 1) Conduct a study on the status of SMEs (availability of modern equipment, manufacturers' database, production KPIs such as OEE, quality, waste). 2) Set specific modernization targets for production through the '3T' Alliance. **2025-26:** 3) Launch 20 pilot projects for the procurement of modern, automated technological equipment for SMEs using grant funding.
2	From I3.0 (Process Automation - ERP) to I4.0	**2025-26**: 1) Replace 1C with locally-developed mini-ERP solutions (30+ SMEs). **2026-27**: 2026-27: 2) Transition to dispatch systems – integration of production systems based on IIoT technologies (5 projects in 2025). 3) First pilots for other 5 KETs* (up to 10). *Note: KET – Key Enabling Technologies.
3	Масова кастемізація та федеративні платформи	**2025-27:** 1) Market awareness on I4.0-5.0 – awareness campaigns showcasing already completed projects in the EU in this field. 2) Emergence of the first 3 pilots with potential technology transfer.

Note:
*KET – Key Enabling Technology.

Additional Comments on the Factor "From 3.0 to 4.0"

- **On the transition from 1C to mini-ERP:** As highTextileed in the project's Analytical Report, many Ukrainian businesses continue to use the outdated and risky 1C accounting software of Russian origin, which remains prevalent among tens of thousands of SMEs. This persists despite at least five Ukrainian alternatives on the market. Therefore, a mass transition to locally developed solutions, accompanied by

an upgrade to mini-ERP systems, is a mandatory part of the Roadmap and requires no further justification.

- **On Key Enabling Technologies (KETs):** In the context of the Textile industry, there are numerous open questions regarding the adoption of cutting-edge technologies. The project working group has yet to adequately explore the potential and positions of local developers and integrators and their views on implementing advanced solutions like AI, additive manufacturing (3D printing), AR/VR, new materials, recycling, and blockchain in Ukraine's Textile industry.
- **Priority technological needs identified through ADMA:** Surveys conducted during the first phase of the project revealed two clear technological priorities for medium and large enterprises:
    1. **Broader adoption of CAD-CAM-CAE / PLM-PDM solutions:** To meet industry demands, the use of this class of products must be significantly expanded and scaled.
    2. **Increased need for dispatching and production management systems:** There is a substantial demand for modern production control solutions, including those utilizing IIoT technologies.

C3: Production Approaches and Standards

In this area, the focus of the developers is on analyzing current and prospective trends in production management, business models, and technical standards.

Key Drivers: Three primary development drivers are proposed:

- **Digital Lean:** Integration of classical Lean methodologies with digital technologies.
- **XaaS (Anything-as-a-Service):** Emphasis on "Manufacturing-as-a-Service" (MaaS).
- **Other Business Models:** Promotion of other advanced business models.

Current State in this Area:

Classical Lean (lean manufacturing) is implemented by approximately 5% of medium and large enterprises in the sector. However, it is not integrated with digital solutions in almost any instance, as these are typically parallel implementations. In developed countries, by contrast, Digital Lean is a strong and consistent trend. Discussion around new business models in the sector is limited to a few companies and clusters, such as K-tex in textile recycling. There are also isolated pilot projects involving shared production within the Western Ukrainian and Podillia Fashion Clusters. However, all these projects lack clear systematization and a strategic perspective.

Key Development Initiatives for 2025-2027:

1	Lean Manufacturing (Lean)	**2025** 1) Conduct 5 training sessions and 10 lean tours, engaging 50 enterprises. **2025-26** 2) Launch 5 pilot projects for implementing Digital Lean – integrating traditional Lean and digital approaches.

2	XaaS (Manufacturing-as-a-Service, Service-as-a-Service)	**2025** 1) Study the experience of XaaS in the textile industry (develop an analytical report), including existing pilot projects in Ukraine. **2026** 2) Develop 3 pilot XaaS projects for textile equipment (incorporating Industry 4.0 technologies – e.g., leasing CAD/CAM solutions from Lectra or Assyst).
3	Other New Business Models	**2025** 1) Assess the readiness of SMEs to experiment with new models (greater use of federated and other platforms, shared production, projects in Eco-Industrial Parks) as part of the aforementioned study. **2026-27** 2) Implement 5 pilot models for shared production or cooperation to reduce costs, including capital investments in equipment, R&D expenses, or market access (targeting areas of major SME lagging).

C4: Human Capital – Human-Centric Approach

In this category, there is a notable contradiction between applied European methodologies and the realities of Ukraine. The former emphasizes the role of humans in managing modern production systems by addressing their needs (technology for people, not the other way around). It creates autonomous, empowered teams that generate initiatives and innovations from the ground up, engage in continuous learning, and have the authority to make independent decisions. Meanwhile, Ukraine, a country grappling with the consequences of war, faces different priorities. Drawing parallels with Maslow's hierarchy of needs, the focus is on basic survival, where the primary concern is a shortage of personnel at all levels. Thus, for enterprise leaders, meeting indivitwin employee requires as advocated by Industry 5.0 takes a backseat to more traditional priorities from Industry 2.0-3.0, emphasizing economic performance in times of crisis.

Key Drivers

Considering this context, the Working Group identified drivers that are universally applicable across different levels of industrial evolution and relevant to Ukraine's economic crisis:

- **Reskilling and Upskilling**: Regardless of whether it's Industry 3.0 or 5.0, retraining and reskilling remain top priorities. Leaders widely recognize the need for change, with the roadmap focusing on new skills essential for the era of Industry 4.0-5.0.
- **Organizational Change**: This refers to comprehensive measures aimed at reshaping enterprises from within, with structural adjustments seen as a quick-win strategy.
- **Culture of Innovation and Adaptability**: Unlike organizational changes, this focuses more on mindset and worldview. While these transformations take longer, they are critically important.

Current State of the Ecosystem

The textile industry today is dominated by traditional training for vocational professions, which aligns with employer interests. However, there is almost no training in Industry 4.0 technologies, which is provided only by select vendors of Western technologies. Industry-wide competency standards for new technologies are also absent. Designated departments or specialists responsible for managing the twin transition, along with corresponding strategies, exist only at a handful of large enterprises. Overall, 90% of enterprises remain focused on survival rather than innovation or adaptation. The level of employee involvement in decision-making processes is low, with most leaders seeing no need for it, relying instead on cohesive top and middle management teams.

Key development initiatives for 2025–2027:

1	Reskilling-Upskilling	**2025**: 1) Organize 3 pilot training programs in partnership with technical universities and solution providers. Focus on advanced Industry 4.0 technologies (IoT, SCADA-MES-ERP, CAD/CAM systems) and basic ecological practices such as energy efficiency and textile recycling. **2025-27** 2) Develop a digital learning platform: Create an online course covering basic digital skills for workers and enterprise leaders. 3) Implement national standards for textile industry professions within the framework of twin transitions (I4.0 and green transformation). 4) Develop a “skills map” outlining key competencies for each employee level. 5) Scale reskilling programs: Cover at least 50% of employees from participating enterprises with courses on digital and ecological competencies.
2	Organizational Changes	**2025** 11) Introduce “change agents”: Train 5 key employees from each of 5 regional clusters (Kyiv, Khmelnytskyi, Lviv, Rivne, Chernihiv) as coordinators for digital and green transitions. **2025-27** 2) Develop short-term management training programs on managing transformations. 3) 3) Form network teams: Launch 5 pilot projects where employees from different enterprises collaborate to address common challenges (e.g., I4.0 adaptation or green certification). 4) Establish transformation departments: Medium and large enterprises organize departments responsible for implementing new technologies. 5) Involve international experts: Enable Ukrainian enterprises to participate in EU projects to access best practices in organizational change.
3	Innovation Culture & Adaptability	**2025-27** 1) Innovation leadership training: Management training on innovative thinking and change management. Introduction of mentorship programs where experienced innovators support young managers. 2) Communication strategy: Inclusion of explanations in information campaigns about the advantages of the twin transition and the role of each employee in this process. 3) Innovation motivation programs: Implementation of a reward system for ideas that improve productivity, efficiency, or ecological sustainability of production. 4) Integration of an innovation culture: Formation of internal teams focused on experimenting and evaluating new ideas. These teams can become the driving force for implementing Industry 4.0 technologies and the circular economy. 5) Platforms for internal entrepreneurship: Support and development of mechanisms that allow employees to launch innovative projects within the company, such as “internal startups” or special idea support funds.

C5: Eco-Factory

The overall context of this component is characterized by a significant fragmentation of numerous initiatives, with a complete lack of priorities and clarity within the sector. Ukraine generally aims to align with the European Green Transition, and the number of actors in this field, including those involved in Textile industry, is growing annually.

Key Drivers:

The Working Group identified four key drivers—forces of change and development:

- **Circular production**: Implementation of circular economy principles in manufacturing.
- **Energy efficiency**: This driver is evident given the country's overall issues with energy independence and significant losses of generating capacity.
- **Clean materials and resources**: A European trend, crucial due to waste management challenges in this sector.
- **Digital product passports (DPP)**: A critical component combining technological opportunities with regulatory changes. While part of circular and clean production, DPP is highlighted separately due to its importance and criticality for compliance with the European agenda.

Current Ecosystem Status:

- The textile industry has a few pilot projects for waste recycling and utilization, with the total number of identified implementations being small—around 10–20 across the sector.
- There are no large-scale initiatives or mandatory requirements for circular production.
- In terms of energy, large enterprises are dependent on electricity outage schedules, while only a few have transitioned to full autonomy. Small enterprises have addressed critical needs using generators.
- Issues surrounding product and raw material quality infrastructure are acute, with many counterfeits and materials of unclear origin.
- Although DPP discussions are underway at the government level, with corresponding resolutions being passed, no large-scale initiatives or pilot projects have been identified in this sector. SMEs generally lack the technical base for automatic data collection and integration into DPP.

Key Development Initiatives for 2025–2027:

1	**Circular Production and waste management**	**2025-26:** 1) Pilot projects: launching the first 5 pilots focused on organizing textile waste recycling and creating products from secondary materials. 2) Development of recommendations: creating guidelines and best practices for material recycling for enterprises. 3) Awareness campaign: informing SMEs about the economic and ecological benefits of circularity (cost reduction, potential certification opportunities). **2026-27:** 4) Scaling recycling: implementing waste collection and recycling systems at the industry level, creating logistical platforms to simplify transportation and material sorting. 5) Certification of enterprises: launching a certification program for enterprises using circular practices.

2	**Energy Efficiency**	**2025:** 1) Real-time energy consumption data: Implementation of energy consumption monitoring platforms in real-time at 10 enterprises. 2) Conducting energy audits for 30 SMEs to identify key points for improving efficiency. **2025-27**: 3) Employee training: Launching energy-efficient management courses for managers and technical staff. 4) Autonomous energy systems: Creating 10 pilot projects for implementing micro-energy systems (combined alternative sources with storage) – transitioning to full autonomy. 5) Encouraging SMEs to adopt energy efficiency: Providing subsidies or grants for the purchase of energy-efficient equipment.
3	**Clean Materials & Resources**	**2025**: 1) Pilots: 3 projects on the use of certified clean materials in production. **2026:** 2) Supplier database creation: Forming a register of suppliers of certified materials for the industry; integrating it into training programs. 3) Inclusion of modules on selecting and using clean materials in professional courses for textile workers. **2026-27:** 4) Expanding quality infrastructure: Establishing laboratories or certification centers to check materials for environmental friendliness. 5) Developing quality standards: Setting mandatory standards for materials used in the textile industry.
4	**Digital Product Passports**	**2025:** 1) Development of pilot DPPs: Implementation of the first 5 pilots using DPPs for the light industry, including: a) material composition (e.g., natural, synthetic, or recycled materials), b) source of raw material origin, c) energy footprint of each production stage, d) instructions for recycling or disposal. 2) Training and awareness campaign: a) Organization of training for SME employees on integrating digital passports into business processes, b) Information campaigns about the importance of DPPs for accessing EU markets. **2026-27:** 3) National DPP platform: a) Creation of a database for storing and exchanging information on DPPs according to EU standards, b) Connecting 10 enterprises for testing the platform. 4) Widespread implementation of digital passports: a) 30% of participants in the Government's Target Program use DPPs, b) DPP requirements become a standard for export to the EU. 5) Data collection automation: a) Use of IoT solutions and sensors for automatic updates of information in DPPs during production, logistics, and recycling stages.

This component is fundamental for driving sustainability in the textile industry, addressing critical challenges, and aligning with European environmental standards.

C6: Tools for Impact and Support

Despite the lack of high-quality analytics and targeted policies, the Working Group identified key factors influencing the twin transition of SMEs in the Textile industry.

Key Drivers:

The project identified five drivers of change and development:

- **Support for the accelerated transition of SMEs to the new eco-design regulation (ESPR)**: Effective in the EU in the first half of 2025, significantly limiting

market access for manufacturers without proper certifications and digital product passports (DPP).

- **Development of non-governmental institutions**: A major focus on this component is driven by past imbalances. Analytical materials from APPAU and Industry4Ukraine (2019–2021) demonstrate that "Institutions are more important than tools" and justify focusing on non-governmental institutions for sectoral programs.
- **Support for innovation infrastructure**: Must address the weakness of current infrastructure, mostly within universities and excluded from EDIH programs.
- **SME stimulation**: Needed for a broader and faster transition to modern software and solutions.
- **Integration into the EU**: A critical factor that accounts for Ukraine's reliance on EU support programs and funds, as well as commitments to integration.

	Key initiatives	**Events**	**Responsible Parties/Funding Sources**
1	**Support for ESPR and Eco-Design Implementation**	Adoption of regulations and technical standards for DPP usage	Government (2025–2026)
		Awareness campaigns on ESPR transition rules	Government (Green Transition Office), Ukrlegprom
		Vouchers for DPP support/subsidies – special grants, including for service provider payments	Government, International Technical Assistance (ITA)
		Implementation of pilot projects for DPP adoption	Ukrlegprom, ITA, Government
2	**Support for Innovation Infrastructure**	Creation of demonstration platforms (testbeds) within EDIHs providing services for Textile industry	ITA
		Establishment of a sectoral accelerator	Government, ITA
		Support for research and innovation to improve circularity in the textile industry through advanced sorting, recycling, and design for recyclability.	Government, Regional Authorities, ITA
3	**Stimulating SMEs for twin Transition**	Partial reimbursement for acquiring Industry 4.0 software	Government, Regional Authorities
		Partial reimbursement for SMEs transitioning from 1C to domestic software solutions	Government
		Access to financing (grants, preferential loans) for investments in modernizing production assets and implementing "green" technologies	Government, ITA

4	**Development of Non-Governmental Institutions**	Support for clusters, particularly those in the 3T Alliance	Government, Regional Authorities, ITA
		Promoting the growth of business-oriented NGOs focused on the twin transition	
5	**European Integration**	Awareness, support, and facilitation of participation in EU innovation development programs and networks (Horizon Europe, EIT, COSME, ENN, etc.)	3T Alliance
		Engagement and involvement in EU consortia under targeted programs and partnerships with European associations and clusters, including the European Technology Platform for the Future of Textiles and Clothing and the European Community of Practice for a Sustainable Textile Ecosystem	3T Alliance