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1 Executive Summary

The GREENE 4.0 project aims to help small and medium-sized enterprises (SMEs) adopt green and digital technologies. The project has specific objectives, challenges and strategies.

Objectives of the GREENE 4.0 User Acceptance Model (UAM):

- Accelerate Adoption: Speed up the adoption of green and digital technologies among SMEs to transition them smoothly to sustainable and digital operations.
- Sub-objectives:
  - Raise Awareness: Increase SME's understanding of the benefits and importance of adopting green and digital technologies.
  - Identify Barriers: Recognize and categorize the main obstacles SMEs face when adopting new technologies and sustainable practices.
  - Leverage Enablers: Identify and make use of existing factors that can help SMEs transition to green and digital technologies.
  - Develop Action Plan: Create targeted measures and actions to overcome barriers and leverage enablers.
  - Validate and Refine: Test and improve the UAM through stakeholder engagement, workshops, and pilot testing based on feedback and performance metrics.

Key Barriers Addressed by the UAM:

- Lack of Awareness: Many SMEs are not fully aware of the benefits of green and digital technologies, which hinders their adoption.
- Resistance to Change: SMEs may be hesitant to change their existing processes and face organizational intertia.
- Cost Concerns: The significant initial investment required for green and digital technologies can deter SMEs due to perceived high costs and uncertain long-term returns on investment.

Key Enablers Leveraged in the UAM:

- Governmental Support: Financial incentives like grants, green bonds, and regional development EU funds facilitate the transition to green and digital technologies.
- Facilitating Access to Financial Incentives: Creating a centralized section under the GREENE 4.0 Innovation Platform to provide information on available financial support mechanisms.

Measures and Actions for Enhancing UAM:

- Mitigating Barriers
  - Raise Awareness: Conduct informational campaigns using webinars and seminars.
  - Address Resistance to Change: Implement change management programs.
  - Overcome Cost Concerns: Provide detailed cost-benefit analyses to SMEs.
- Facilitating Enablers:
  - Develop target green bonds and personalized green financing instruments.
  - Offer a mix of grants, equity instruments, and loans.
  - Create interregional green bonds and financial instruments to support joint green value chain developments.

The GREENE 4.0 project uses a comprehensive strategy, known as the User Acceptance Model (UAM), to encourage SMEs to adopt green and digital technologies. By addressing barriers such as lack of awareness, resistance to change, and cost concerns, and leveraging enablers like governmental support and access to financial incentives, the UAM aims to facilitate a smooth and effective transition for SMEs to more sustainable and technologically advanced operations. This approach ensures that the model is practical, adaptable, and robust in real-world applications.

The project's objectives include accelerating the adoption of green and digital technologies among SMEs, raising awareness about their benefits, identifying and mitigating barriers, leveraging enablers, and continuously improving the UAM through stakeholder engagement and validation. By addressing these objectives, the GREENE 4.0 project seeks to drive the adoption of sustainable and digital practices in the manufacturing sector, contributing to long-term competitiveness, resilience, and innovation.

1.1 Addressing Supply Chain Disruptions

GREENE 4.0 aims to tackle the challenges faced by manufacturing companies, particularly SMEs, that are significantly affected by disruptions in global supply chains. These disruptions hinder their ability to effectively produce and deliver products.

Manufacturing companies, especially small and medium-sized enterprises (SMEs), are increasingly connected to global supply chains, which makes them vulnerable to disruptions. These disruptions can be caused by various factors like geopolitical tensions, economic shifts, natural disasters, and pandemics like COVID-19. Such disruptions affect manufacturers' ability to get raw materials, manage inventory, maintain production schedules, and deliver products efficiently.

SMEs face greater challenges in dealing with these disruptions compared to larger enterprises, as they have less financial resources, fewer supply sources, and less bargaining power. This impact is particularly significant in Central Europe, where manufacturing is crucial to the economy, and many SMEs play important roles in supply chains.

To tackle these challenges, the GREENE 4.0 project aims to develop innovative approaches that make supply chains more resilient, flexible, and sustainable. It provides tools and methodologies to help companies, especially SMEs, anticipate, respond to, and recover from supply chain disruptions.

The strategies for strengthening supply chains include:

1. Digitalization: Implementing digital tools and platforms to improve supply chain visibility, enabling companies to monitor and respond to changes in real-time.
2. Diversification: Encouraging SMEs to diversify their supply sources to reduce dependence on a single supplier or region.
3. Collaboration and Networking: Facilitating collaboration and networking among companies to share resources, information, and best practices for supply chain management.
4. Sustainability Integration: Promoting the integration of sustainable practices into supply chain operations to ensure long-term viability and resilience.

By implementing these strategies, companies, particularly SMEs, are expected to build more resilient supply chains that can withstand various disruptions. The project aims to equip these companies with the knowledge and tools to navigate the complex global supply chain landscape effectively.

Transnational cooperation is crucial for addressing these challenges comprehensively. By collaborating across borders, companies can access a wider pool of resources, expertise, and markets, further strengthening their supply chain resilience. GREENE 4.0 project focuses on empowering manufacturing companies, especially SMEs, to overcome global supply chain disruptions. The project aims to achieve this by using digitalization, diversification, collaboration, and sustainability integration to foster stronger and more efficient supply chains. This will enhance the overall competitiveness and sustainability of the manufacturing sector in Central Europe.

1.2 Developing New Value Chains

The project's central goal is to create and test two new smart and green manufacturing value chains. This is important for large enterprises, SME business support organizations, and regional public authorities in countries like the Czech Republic, Slovenia, Austria, Italy, Germany, Poland, and Hungary

The goal of the GREENE 4.0 project is to create and test two innovative value chains in the manufacturing sector. These value chains will incorporate digital technologies and sustainable practices to meet the demands of the evolving global market. The project primarily targets large enterprises, small and medium-sized businesses (SMEs), business support organizations, and regional public authorities in several Central European countries.

To achieve this, GREENE 4.0 promotes collaboration among various stakeholders, including business support organizations, higher education institutions, research organizations, sectoral agencies, and national public authorities. By bringing together these diverse stakeholders, the project aims to foster an environment of open innovation and shared expertise.

The project includes several components to support the development and implementation of the new value chains. These include the GREEN 4.0 Digital Innovation Platform, which helps integrate digital technologies into manufacturing processes. There are also Transnational Digital Transformation Sites, which allow companies to access and test digital technologies for their operations. Open Innovation Toolkits are provided to assist in innovation processes, such as product development, process improvement, and supply chain management. Additionally, a Private Equity Tool is available to support investments in smart and green technologies.

The implementation process begins with the development of a joint methodology to improve user acceptance of new technologies. Following this, an "open knowledge box" containing innovation toolkits is created. The project then focuses on deploying transnational digital transformation sites and running three innovation programs. Ultimately, the project aims to aggregate, pilot, and deploy the GREENE 4.0 innovation platform, along with generating and piloting two new value chains.

Participating companies are expected to enhance their capacities in innovation, development, and application of smart and green solutions and technologies. Over three years, the project aims to co-create and co-develop innovative products and services, leading to the creation of new sustainable supply chain models using open innovation approaches. These developments are anticipated to significantly contribute to the resilience, competitiveness, and sustainability of the manufacturing sector in Central Europe.

1.3 Innovative Solutions for Sustainable Business Models

The project seeks to innovate within the manufacturing industry ecosystems by supporting the transition to sustainable business models. It involves a digital innovation platform called GREEN 4.0, establishing Transnational Digital Transformation Sites, Open Innovation Toolkits, and a Private Equity tool.

GREENE 4.0 is focused on promoting innovation in the manufacturing sector, specifically by transitioning to business models that are sustainable and digitally integrated. The project takes a holistic approach by combining green manufacturing practices with digital transformation.

There are several key innovative components within GREENE 4.0:

1. The GREEN 4.0 Digital Innovation Platform: This platform serves as a central hub for integrating digital technologies in manufacturing processes. It provides information, tools, and opportunities for collaboration.
2. Transnational Digital Transformation Sites: These sites, whether physical or virtual, allow manufacturers to access and test digital innovations. They provide firsthand experience of how these technologies can enhance their operations.
3. Open Innovation Toolkits: These toolkits contain resources and tools that assist companies in developing innovative products and improving processes. They focus on both sustainability and digital efficiency.
4. Private Equity Tool: This tool is a financial mechanism that supports investments specifically in green and digital technologies. It aims to foster economic growth alongside environmental responsibility.

GREENE 4.0 also aims to enhance the innovation capacities of regional ecosystems in the Central European manufacturing sector. The project supports the transition to business models that are economically viable and environmentally sustainable. By doing so, it contributes to the resilience and adaptability of the manufacturing sector in the face of global challenges like climate change and technological disruption.

Transnational collaboration is a key aspect of GREENE 4.0. By fostering collaboration across borders, the project facilitates the sharing of knowledge, resources, and best practices, amplifying its impact. Various stakeholders, including business support organizations, higher education institutions, sectoral agencies, and public authorities, are involved in this cooperation.

The expected outcomes of GREENE 4.0 include improved capabilities for participating companies in developing and applying smart and green solutions. The project aims to co-create and co-develop innovative products and services that pave the way for new sustainable supply chain models, utilizing open innovation methodologies. Ultimately, these outcomes will make the manufacturing sector more innovative, sustainable, and globally competitive.

1.4 Improving User Acceptance

GREENE 4.0 focuses on developing a joint methodology to improve the acceptance of green and digital technologies among companies. This is crucial for ensuring that companies are open to adopting new technologies and practices.

GREENE 4.0 project aims to facilitate and support manufacturing SMEs to accept and use green production methods and digital technologies. User acceptance plays a crucial role in successfully adopting and implementing these new technologies.

To achieve this goal, the project is developing a comprehensive methodology that addresses different factors influencing acceptance, such as awareness, perceived usefulness, and ease of use. This methodology considers the specific barriers and enablers identified through regional mapping analysis.

To support user acceptance, the project will provide SMEs with Open Knowledge Box Toolkits. These toolkits contain information, guidelines, and best practices to help SMEs understand and adopt green and digital technologies. Additionally, a User Acceptance Model (UAM) will be developed as a framework to guide companies in adopting new technologies. The UAM includes strategies to overcome resistance to change and enhance the perceived value of green and digital innovations.

It is essential to involve a wide range of stakeholders, including SMEs, business support organizations, and technology experts, in the development of the user acceptance strategy. Their input ensures that the UAM is practical, relevant, and responsive to the specific needs and challenges faced by SMEs.

The UAM will be tested and piloted across various 70 SMEs in different contexts to assess its effectiveness in real-world scenarios. The feedback gathered during this phase will help refine the model and ensure its adapt effectiveness across various manufacturing settings.

By improving user acceptance, the project aims to accelerate the integration of green and digital technologies in the manufacturing sector. This integration is expected to lead to enhanced operational efficiency, reduced environmental impact, and increased competitiveness for SMEs.

The success of the UAM in enhancing user acceptance will be a critical factor in the overall impact of the GREENE 4.0 project. It will determine the extent to which SMEs can transition to more sustainable and technologically advanced practices. GREENE 4.0 project emphasizes the importance of user acceptance in the transition to green and digital manufacturing. Through the development of a tailored methodology, practical tools, and stakeholder collaboration, the project aims to create a supportive environment for SMEs to embrace and effectively implement green and digital technologies.

1.5 Deployment of Digital Transformation Sites and Innovation Programs

The project includes deploying Transnational Digital Transformation Sites and organizing three innovation programs. These efforts aim to gather, test, and implement the GREENE 4.0 innovation platform to support the development of new value chains.

Transnational Digital Transformation Sites: These sites are designed to be physical or virtual spaces where small and medium-sized enterprises (SMEs) can access and integrate digital technologies into their operations. They serve as hubs for innovation, providing the necessary resources and infrastructure for companies to experiment with and adapt digital solutions in a controlled environment. The goal is to make it easier for SMEs to adopt advanced technologies by allowing them to have hands-on experiences and see tangible benefits.

Running Innovation Programs: GREENE 4.0 includes the implementation of three separate innovation programs. These programs are specifically designed to foster creativity, problem-solving, and technological advancement within the manufacturing sector. Each program focuses on different aspects of digital and green innovation, providing targeted support and resources to participating SMEs. These programs are crucial for building the capacity of SMEs, enhancing their skills, and facilitating the exchange of knowledge and best practices.

Aggregating and deploying the GREENE 4.0 Innovation Platform: One important outcome of the project is the development and deployment of the GREENE 4.0 innovation platform. This digital platform will bring together various tools, resources, and information relevant to smart and green manufacturing. The platform aims to be a comprehensive resource for SMEs looking to transition to more sustainable and technologically advanced operations. It will provide access to the latest research, case studies, technology updates, and potential funding sources, acting as a one-stop-shop for SMEs' innovation needs.

Generating and Piloting New Value Chains: A crucial aspect of the project is the creation and testing of two new value chains within the smart and green manufacturing domain. These value chains will serve as examples of how integrating digital technologies and sustainable practices can lead to more efficient, resilient, and competitive manufacturing processes. The pilot phase will provide practical insights and data, helping to refine and optimize the value chains for broader application.

Expected Outcomes and Impact: Collectively, the digital transformation sites, innovation programs, and the innovation platform aim to enhance the innovative capabilities of SMEs in the manufacturing sector. By participating in these initiatives, companies are expected to develop a deeper understanding of green and digital technologies, leading to the adoption of more innovative, efficient, and sustainable business models. The project aims to create a ripple effect, where successful adoption by some SMEs encourages wider adoption across the sector.

GREENE 4.0 project focuses on facilitating the digital and green transformation of the manufacturing sector in Central Europe. This is achieved through the establishment of digital transformation sites, the execution of innovation programs, and the deployment of a comprehensive innovation platform.

The transnational digital transformation sites serve as spaces where SMEs can access and integrate digital technologies into their operations. These sites provide the necessary resources and infrastructure for companies to experiment with and adapt digital solutions in a controlled environment. The goal is to make it easier for SMEs to adopt advanced technologies by allowing them to have hands-on experiences and see tangible benefits.

The innovation programs run by GREENE 4.0 are designed to foster creativity, problem-solving, and technological advancement within the manufacturing sector. These programs provide targeted support and resources to participating SMEs, focusing on different aspects of digital and green innovation. By participating in these programs, SMEs can enhance their capacity, develop new skills, and benefit from the exchange of knowledge and best practices.

The GREENE 4.0 innovation platform plays a crucial role in aggregating various tools, resources, and information relevant to smart and green manufacturing. This platform serves as a comprehensive resource for SMEs looking to transition to more sustainable and technologically advanced operations. It provides access to the latest research, case studies, technology updates, and potential funding sources, acting as a one-stop-shop for SMEs' innovation needs.

Alongside these initiatives, the project also focuses on generating and piloting new value chains within the smart and green manufacturing domain. These value chains exemplify how the integration of digital technologies and sustainable practices can lead to more efficient, resilient, and competitive manufacturing processes. The pilot phase provides practical insights and data, helping to refine and optimize the value chains for broader application.

Overall, the deployment of digital transformation sites, the execution of innovation programs, and the development of the innovation platform collectively aim to enhance the innovative capabilities of SMEs in the manufacturing sector. Through these initiatives, participating companies can develop a deeper understanding of green and digital technologies, leading to the adoption of more innovative, efficient, and sustainable business models. The project aims to create a ripple effect, inspiring wider adoption of these technologies and practices across the sector.

1.6 Co-Creation and Development of Products and Services

Over a three-year collaboration period, the project expects to co-create and develop innovative products and services. These innovations aim to generate new sustainable supply chain models using open innovation approaches.

Co-Creation and Development of Innovative Products and Services: The main goal of this aspect of the project is to collaboratively create innovative products and services that align with green and digital manufacturing principles. This involves bringing together different stakeholders, such as SMEs, research institutions, industry experts, and potentially end-users, to share ideas, knowledge, and resources. By adopting an approach called open innovation, the project aims to leverage external ideas and technologies while also sharing internal resources beyond organizational boundaries. This collaborative and open approach leads to more innovative, user-centric, and practical solutions. The expected outcomes of this process are the development of new products and services that are not only innovative but also sustainable and efficient. These outcomes are intended to address current market demands and future challenges in the manufacturing sector. Additionally, this collaborative approach is anticipated to generate new business models and practices that are both environmentally friendly and economically viable.

Generation of New Sustainable Supply Chain Models: A significant part of the project's objective is to develop supply chain models that are sustainable, reducing the environmental impact while maintaining or improving efficiency and profitability. This requires rethinking and redesigning traditional supply chain practices to integrate green practices such as resource efficiency, renewable energy use, and waste reduction. Digital technologies play a vital role in these new supply chain models, providing tools for better resource management, data analysis, and process optimization, resulting in more agile and responsive supply chains. Technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), and blockchain can be utilized for more effective tracking, predicting, and managing supply chain activities. The development of these sustainable supply chain models necessitates extensive collaboration and networking among different stakeholders including manufacturers, suppliers, logistics providers, technology providers, and regulatory bodies. Networking events, workshops, and collaborative platforms facilitated by the GREENE 4.0 project can help build these essential connections and foster a shared vision for sustainable supply chains. These new supply chain models are expected to significantly reduce the environmental footprint of manufacturing activities while providing economic benefits such as cost savings, risk mitigation, and new market opportunities. In the long term, these models can set new industry standards and drive broader adoption of green practices and technologies.

GREENE 4.0 project focuses on collaboratively developing innovative products and services aligned with green and digital manufacturing principles. Through open innovation and the creation of sustainable supply chain models, the project aims to bring about transformative changes that align.

1.7 Transnational Collaboration

An essential aspect of GREENE 4.0 is transnational cooperation, which is crucial for addressing the widespread challenges in the manufacturing sector and leveraging resources and expertise across borders.

Transnational cooperation is a vital aspect of the GREENE 4.0 project. It involves collaborating across borders to bring together different expertise, resources, and perspectives from various Central European nations. This collaboration is crucial for tackling complex challenges in the manufacturing sector that extend beyond national boundaries. These challenges include disruptions in global supply chains, advancements in technology, and the need for sustainable practices.

Benefits of Transnational Collaboration:

- Pooling Resources and Knowledge: By working together across borders, the project can gather a wider range of resources and knowledge. This collective approach leads to more robust solutions that individual countries couldn't achieve alone.
- Harmonizing Standards and Practices: Transnational cooperation helps ensure that standards and practices are aligned across the region. This makes it easier for companies to operate in different markets and promotes economic integration within the region.
- Shared Learning and Innovation: Collaboration allows countries to learn from each other's successes and challenges. This environment fosters innovation, as ideas from different cultures and backgrounds can inspire new solutions.

Implementation in GREENE 4.0: GREENE 4.0 brings together stakeholders from various Central European countries, including manufacturing companies, business support organizations, regional public authorities, research institutions, and sectoral agencies. Together, they engage in joint activities such as co-creation camps, digital transformation sites, innovation programs, and the development of the GREENE 4.0 innovation platform.

Tackling Regional and Global Challenges: Transnational cooperation is particularly effective in addressing challenges that impact the manufacturing sector on a regional and global scale. These challenges include adapting to global market trends, meeting international sustainability standards, and responding to disruptions in global supply chains.

Fostering a Unified Approach to Sustainability and Innovation: By collaborating transnationally, the GREENE 4.0 project aims to foster a unified approach to sustainability and digital transformation in the manufacturing sector. This ensures that advancements in green and digital technologies are not isolated but are part of a broader movement across the region towards innovation.

Long-term Strategic Relationships: The project also seeks to establish long-term strategic relationships among participating countries. These relationships can extend beyond the project's lifespan and create a lasting network of collaboration and support in the region. In summary, point 7 of the GREENE 4.0 projects emphasizes the crucial role of transnational collaboration in addressing challenges and seizing opportunities in the manufacturing sector. Through this collaborative approach, the project aims to achieve greater impact and sustainability, driving innovation and growth that transcends.

GREENE 4.0 aims to revolutionize the manufacturing sector by promoting the acceptance and integration of green and digital technologies among SMEs. It focuses on creating sustainable business models, developing new value chains, improving user acceptance, and fostering innovation through transnational collaboration.

2 Key findings from the regional mapping analysis

…emphasizing trends in the adoption of green and digital technologies, challenges and barriers faced, and the perceived usefulness and acceptance of change.

The **GREENE 4.0 project** conducted a regional mapping analysis to understand the current state and potential for innovation in the sustainable business sector across Central European (CE) regions, focusing on small and medium-sized enterprises (SMEs) in the manufacturing industry. A comprehensive survey was conducted with **422 manufacturing SMEs** across 7 CE countries to develop a holistic view of the adoption levels of green and digital technologies, and the key barriers inhibiting further adoption. The survey aimed to understand current adoption rates of green/digital technologies, perceived barriers, risks and uncertainties, future plans and innovation interests, and required resources and supports.

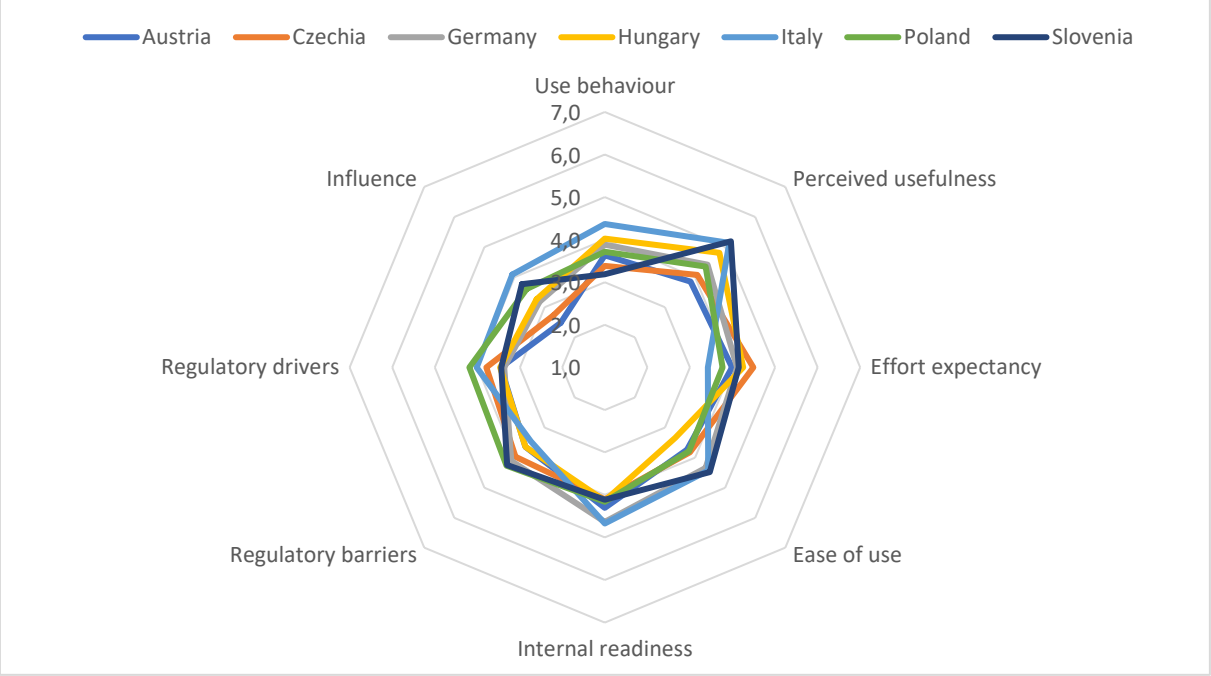
The quantitative data indicates that the acceptance of green practices in companies is currently moderate. On a scale of 1 to 7, the average use of green practices is 3.7, with Slovenia having the lowest score at 3.2 and Italy the highest at 4.4.

However, the perceived benefits of these practices are quite high. Companies agree that adopting green practices would improve their sustainability (average score: 4.6), reduce waste and improve environmentally friendly production processes (4.3) and increase their capacity to green the supply chain (4.3). However, fewer companies believe that these practices would improve the quality of their products (3.9). The perceived benefit is highest in Slovenia (5.2) and Italy (5.1), but lower in Austria (3.8) and the Czech Republic (4.1).

Companies anticipate considerable efforts when introducing green innovations, e.g. high costs (4.3) and complications for current employees (4.0). They believe that they are internally prepared for the transition (average score: 4.3 on a scale of 1 to 7). However, they also see regulatory obstacles that make their task more difficult (average score: 3.8, highest in Poland (4.3) and Slovenia (4.2)). This discrepancy between internal willingness and external constraints suggests that while companies recognize the potential environmental benefits of green innovation, their behaviour is not fully aligned with their aspirations. In Slovenia, for example, where companies rate the benefits highest, there are significant regulatory barriers, especially when regulatory factors are low. Hungary perceives the efforts to implement green innovation as the most challenging among all countries. These different results emphasise the diversity of experiences in the individual countries.

Despite these challenges, the outlook seems promising. Almost two-thirds of companies believe it is at least somewhat likely that they will integrate or expand environmentally friendly manufacturing processes into production or switch to energy-efficient machinery in the next five years. Half of them believe it is quite likely that they will integrate digital technologies such as AI and blockchain into their processes. This optimism points to a positive trend towards a greener and more sustainable future.

Quite similar, yet more detailed data, are provided also by open-ended questions in a survey. The data shows that the adoption of green innovation in Central Europe is influenced by a variety of factors that vary from country to country. Across Central Europe, countries are facing challenges of transitioning to green manufacturing practices. While the motivations and drivers for this transition vary, several common barriers impede progress. Most commonly identified barriers, found in all 7 analysed countries) were financial, related to cost, significant capital investments and high additional post-implementation costs. Some of them fear that adopting green technologies will increase unit costs – and competitors, using traditional methods, will gain an advantage.



Companies often struggle with the challenge of adapting to complex and dynamic regulations that can create barriers to the integration of green technologies. In Austria, the Czech Republic, Hungary, Poland and Slovenia, for example, there is a lack of sufficient government support and subsidies. This and the lack of human resources in Austria, Germany, Italy and Poland exacerbate the difficulties.

Resistance to change is another obstacle. Companies have found that more experienced employees may be reluctant to accept the green and digital transformation. This resistance is often due to a reluctance to change long-established ways of working. For example, in a manufacturing company, the introduction of a new green technology might require retraining employees and changing production processes, which can be met with resistance from employees used to traditional methods.

Cultural factors also play a role in the slow adoption of green technologies. There is a tendency to prioritise cost over quality. This mentality can hinder the introduction of green technologies, which are initially more expensive but offer long-term benefits. In Germany and Austria, there are also concerns about the quality of green technologies, which could be perceived as less reliable or efficient than conventional technologies.

There are also technical obstacles. In Austria and Hungary, companies face challenges due to a lack of technological readiness. In Italy, companies report a lack of access to green technologies. Other barriers include lack of time (Austria), infrastructure problems (Hungary) and unclear benefits (Hungary).

Despite these challenges, there are numerous motivators or enablers of green innovation. Companies are motivated by a combination of ethical, environmental, and economic factors. The balance between these factors reflects a company's commercial pragmatism, environmental responsibility, and responsiveness to market dynamics. Highlighted are environmental protection, ethical responsibility, and environmental idealism (commitment to protecting the environment), as can be seen in Austria and Germany. Cost savings are an important motivator in Austria, the Czech Republic, Germany and Italy. Market demand, particularly in the Czech Republic, is also driving companies towards green innovations.

Attracting customers who favour environmentally friendly products is another motivator, particularly in Austria, Germany and Italy. Regulatory pressure, government requirements or subsidies also serve as motivators in Austria, the Czech Republic, Slovenia, Germany and Italy. The opportunity for innovation and better health benefits are also driving companies in Austria towards green innovations.

3 Approaches and innovative methods engaged for facilitating SMEs‘ transition to sustainable and technologically advanced business models.

GREENE 4.0 employs a highly collaborative and innovative approach to support small and medium enterprises (SMEs) in Central Europe in their transition towards more sustainable and technologically advanced business models. The project recognizes the critical role SMEs play in the European economy and the challenges they face in adopting green and digital technologies. By fostering transnational cooperation, engaging diverse stakeholders, co-creating solutions with SMEs, and providing them with practical tools and support, the project aims to accelerate the green and digital transformation of the manufacturing sector in Central Europe.

3.1 Collaborative Approach

At the core of the GREENE 4.0 is a strong emphasis on collaboration at multiple levels. The project brings together a consortium of partners from seven Central European countries: Slovenia, Italy, Austria, Germany, Hungary, Poland, and the Czech Republic. This transnational cooperation is essential for addressing the common challenges faced by SMEs across the region, leveraging shared resources and expertise, and promoting the exchange of best practices. By working together, the project partners can develop solutions that are applicable and scalable across borders, thereby amplifying the impact of their efforts.

The project actively engages a wide range of stakeholders throughout its lifecycle, using a quadruple helix approach. This means involving not only SMEs but also research organizations, business support organizations, policy makers, and other relevant entities in the co-creation and implementation of solutions. The input and participation of these diverse stakeholders are actively sought and incorporated at various stages of the project, ensuring that the outcomes are practical, relevant, and responsive to the real needs of SMEs.

A key example of this collaborative approach is the organization of three co-creation camps to jointly develop the User Acceptance Model (UAM), which is the central output of the project. These camps provide a platform for project partners and external stakeholders to come together and collaborate intensively on designing a UAM that effectively addresses the barriers faced by SMEs in adopting green and digital technologies while leveraging the enablers that can facilitate this transition. The camps involve interactive workshops, brainstorming sessions, and knowledge sharing, allowing participants to contribute their insights, experiences, and ideas to shape the UAM.

The development of the UAM itself follows a co-creation approach, where the project partners work closely with SMEs to understand their specific challenges, needs, and aspirations. Through surveys, interviews, and focus group discussions, the project gathers detailed insights into the factors that hinder or enable the adoption of sustainable and digital practices by SMEs. This deep engagement with SMEs ensures that the UAM is grounded in their realities and can offer targeted strategies and support mechanisms that resonate with their context.

The UAM aims to establish common goals and foster coordination among the key actors in the green and digital transition of SMEs, including industry associations, academia, government agencies, and the SMEs themselves. By aligning these stakeholders around shared objectives and providing a framework for collaboration, the UAM facilitates a collective effort towards creating an ecosystem that is conducive to the transformation of SMEs.

Once the UAM is developed, it undergoes a rigorous testing phase to validate its effectiveness and refine its components based on real-world feedback. The testing involves the participation of 10 SMEs in each of the seven countries, totalling 70 SMEs across the region. A structured feedback mechanism is employed, where SMEs provide input on their experience with the UAM through consistent templates. This feedback is then analysed and discussed during three interregional seminars, where project partners exchange their insights, address challenges encountered during the testing, and collaboratively iterate on the UAM based on the lessons learned. This iterative refinement process ensures that the final version of the UAM is robust, practical, and adaptable to the diverse contexts of SMEs in Central Europe.

To ensure the long-term sustainability and impact of the project results, a transnational memorandum of understanding (MoU) is signed between the project partners and associated partners. The MoU establishes a framework for continued cooperation and collaboration beyond the initial three-year duration of the project. It outlines joint action plans for scaling up the project results, disseminating best practices, and supporting the wider adoption of the UAM by SMEs in the region. The MoU demonstrates the commitment of the partners to maintain and expand the collaborative ecosystem created by the project, ensuring that the benefits extend well into the future.

3.2 Innovative Methods

The GREENE 4.0 project employs a range of innovative methods to support SMEs in their green and digital transformation journey. At the heart of these methods is the User Acceptance Model (UAM), which provides a comprehensive framework that combines evidence-based strategies with practical tools to increase SMEs' acceptance and adoption of green and digital technologies. The UAM is specifically tailored to the manufacturing sector in Central Europe, taking into account the unique challenges and opportunities faced by SMEs in this region.

One of the innovative aspects of the UAM is its use of scenarios based on seven key categories: organizational, technological, skills, financial, informational, market, and governmental. These categories reflect the multi-dimensional nature of the challenges and enablers influencing SMEs' adoption of sustainable and digital practices. By considering these seven categories, the UAM allows for a holistic assessment of an SME's readiness and needs, enabling the development of targeted interventions and support mechanisms.

Furthermore, the UAM incorporates a novel approach of mapping these seven categories against seven manufacturing sectors and three maturity levels. This granular segmentation recognizes the heterogeneity of SMEs and allows for a highly customized approach that aligns with the specific context and stage of development of each SME. By providing sector-specific insights and recommendations based on the maturity level of an SME, the UAM offers a more relevant and actionable roadmap for green and digital transformation.

Within the broader framework of the UAM and the overall project, several innovative tools and methodologies are employed to support SMEs in their transition:

1. Co-creation workshops: These workshops bring together SMEs, technology providers, domain experts, and other relevant stakeholders to collaboratively design and prototype solutions that address specific challenges faced by SMEs in adopting green and digital technologies. By fostering a participatory and iterative approach, co-creation workshops ensure that the solutions developed are user-centric, technically feasible, and economically viable.

2. Transition Road mapping: The project provides SMEs with structured frameworks and tools for developing customized transition roadmaps towards sustainable and digitally enabled business models. These roadmaps help SMEs break down the transformation process into manageable stages, set clear milestones and targets, and align their strategies, processes, and capabilities accordingly. The road mapping process is supported by expert guidance, best practice sharing, and peer learning opportunities.

3. Capacity building programs: Recognizing the critical role of skills and knowledge in driving the green and digital transition, the project offers a range of capacity building programs tailored to the needs of SMEs. These programs include training modules, workshops, and e-learning resources covering topics such as sustainable manufacturing practices, digital technologies, change management, and innovation strategies. By equipping SMEs with the necessary competencies, these programs enhance their ability to effectively implement and leverage green and digital solutions.

4. Cost-benefit analysis templates: To support SMEs in making informed decisions about investments in green and digital technologies, the project provides standardized cost-benefit analysis templates. These templates help SMEs systematically assess the financial viability of different technology options, considering factors such as upfront costs, operational savings, productivity gains, and environmental benefits. By providing a structured approach to evaluating the business case for sustainability and digitalization, these templates enable SMEs to prioritize investments and justify their decisions to stakeholders.

5. Matchmaking between SMEs and solutions: The project establishes a matchmaking platform that connects SMEs with providers of green and digital solutions, including technology vendors, service providers, and research institutions. This platform facilitates targeted introductions, enabling SMEs to identify and access the most relevant solutions for their specific needs. By bridging the gap between supply and demand, the matchmaking mechanism accelerates the adoption of sustainable and digital practices by SMEs.

In addition to these specific tools and methodologies, the GREENE 4.0 project places significant emphasis on awareness building, change management support, and skills development for SMEs. Recognizing that the transition to green and digital business models requires a shift in mindset and organizational culture, the project employs creative means to engage and empower SMEs in the transformation process.

Peer coaching circles are established, where SMEs can learn from and support each other in implementing sustainable and digital practices. These circles provide a safe space for SMEs to share their experiences, challenges, and successes, fostering a sense of community and mutual learning. Through structured discussions and problem-solving sessions, SMEs can leverage the collective knowledge and expertise of their peers to overcome barriers and accelerate their transformation journey.

Benchmarking visits are organized, allowing SMEs to learn from best practices and successful case studies of companies that have already embraced green and digital technologies. These visits provide SMEs with tangible examples of how sustainability and digitalization can be implemented in practice, inspiring them to adopt similar approaches in their own organizations. By seeing the benefits and outcomes firsthand, SMEs gain confidence and motivation to embark on their own transformation initiatives.

Online training academies are established to provide SMEs with flexible and accessible learning opportunities. These academies offer a wide range of courses, modules, and resources covering various aspects of green and digital transformation, such as sustainable product design, energy efficiency, data analytics, and Industry 4.0 technologies. By leveraging digital platforms and self-paced learning formats, the academies enable SMEs to acquire the necessary skills and knowledge at their own convenience, overcoming the time and resource constraints often faced by smaller organizations.

To address the financial barriers that SMEs often encounter in adopting green and digital technologies, the GREENE 4.0 project provides targeted support mechanisms. Access to finance is facilitated through advisory services that help SMEs navigate the complex landscape of funding options, including grants, loans, and investment schemes. The project partners work closely with financial institutions, government agencies, and impact investors to develop and promote financing instruments that are tailored to the needs of SMEs in the green and digital transition.

Moreover, the project explores innovative financing models, such as pay-for-performance schemes, where the repayment of investments is tied to the achievement of specific sustainability or digitalization outcomes. These models align the interests of SMEs and investors, reducing the risk and upfront burden for SMEs while incentivizing the adoption of impactful solutions. By aggregating funding pools and de-risking investments, the project aims to catalyse greater flows of capital towards SMEs' green and digital transformation efforts.

To ensure that the solutions developed by the project are truly market-driven and aligned with the evolving needs of customers, GREENE 4.0 innovation platform will be established to facilitate continuous dialogue and co-creation. This platform enables SMEs to engage directly with their customers, suppliers, and other stakeholders to gather insights, validate ideas, and collaboratively design products and services that meet the growing demand for sustainable and digitally enabled offerings.

Through online forums, social media channels, and virtual focus groups, SMEs can tap into the collective intelligence of their stakeholders, gaining valuable feedback and suggestions for improvement. This ongoing engagement allows SMEs to stay attuned to changing market dynamics, customer preferences, and emerging trends, enabling them to adapt their strategies and offerings accordingly.

Furthermore, the project actively promotes the solutions developed by SMEs to green-oriented buyer segments, leveraging targeted marketing and communication efforts. By highlighting the environmental and social benefits of these solutions, along with their technical and economic advantages, the project helps SMEs differentiate themselves in the market and attract customers who prioritize sustainability in their purchasing decisions. This demand-driven approach ensures that the green and digital transformation of SMEs is not only feasible but also commercially viable and competitive.

In conclusion, the GREENE 4.0 project demonstrates a comprehensive approach to enabling the green and digital transformation of SMEs in the manufacturing sector in Central Europe. By fostering transnational collaboration, engaging diverse stakeholders, co-creating solutions with SMEs, and providing them with innovative tools, frameworks, and financing options, the project aims to address the real challenges faced by SMEs while catalysing a participatory and peer-driven change process.

The project's strong focus on awareness building, capacity building, and customized practical guidance lays a solid foundation for long-term impact and sustainability of the greener, smarter business models adopted by SMEs. By empowering SMEs with the knowledge, skills, and resources they need to embrace sustainable and digital practices, the project contributes to the creation of a more resilient, competitive, and future-proof manufacturing ecosystem in Central Europe.

Moreover, the collaborative approach and innovative methods employed by the GREENE 4.0 project serve as a model for other regions and sectors seeking to drive the green and digital transition of their SMEs. The lessons learned, best practices established, and solutions developed through this project can be adapted and replicated in different contexts, multiplying the impact and reach of the initiative.

Ultimately, the success of the GREENE 4.0 project lies in its ability to mobilize and empower SMEs as key agents of change in the transition towards a more sustainable and digitally enabled economy. By providing them with the necessary support, tools, and platforms to innovate, collaborate, and thrive, the project contributes to the realization of the European Union's ambitions for a green and digital future, while ensuring that SMEs remain at the heart of this transformative journey.

4 Context and necessity of the GREENE 4.0 project within the Central European manufacturing sector.

The manufacturing landscape in Central Europe is at a critical juncture. Small and medium enterprises (SMEs) comprise over 99% of all businesses and employ around 100 million people. However, competitive pressures and evolving policy environments necessitate a transformation towards smarter, greener, and more digitally integrated operations.

On one hand, disruptive technologies like automation, IoT, and AI are reshaping factory floors, supply networks, and customer engagement models. Legacy processes risk redundancy. On the other, cross-sectoral imperatives like the European Green Deal are driving a sustainability focus through stricter compliance, market pressures, and climate consciousness.

However, regional SMEs struggle on both fronts — digital and green. Surveys by GREENE 4.0 project partners in 7 Central European countries highlight prevalent gaps. Only 60% of SMEs use basic cloud computing tools while advanced technologies like sensors and blockchain remain underutilized. Uneven green practices and risk perceptions further hamper the transformation.

Bridging these adoption gaps requires understanding localized barriers around financing constraints, technical skills, poor infrastructure, and change inertia. Without coordinated efforts to educate, incentivize and equip SMEs to innovate, the competitiveness and responsiveness of the entire regional manufacturing ecosystem lags. Foreign players dominate value chains. Climate contributions falter.

This imperative catalysed the launch of the GREENE 4.0 project spanning 7 Central European countries — Slovenia, Italy, Austria, Germany, Hungary, Poland and the Czech Republic.

Through its pioneering framework, GREENE 4.0 aims to facilitate the smart and green transition for SME manufacturers. By mobilizing a cross-section of stakeholders, the project seeks to propagate technology literacy, demonstrate solution viability, and formulate policy interventions tailored to the SME context.

Initiatives like informational campaigns, regulatory easing, innovation vouchers, adopting sustainability KPIs and public-private investment vehicles form solution contours that resonate with ground realities. Participative events foster co-created and community-led paradigms focused on realizing the twin goals of competitive excellence and climate resilience.

As a unifying force between solution seekers and providers, academia and government, the GREENE 4.0 project is positioned to reshape the Central European industrial narrative — channelizing collaboration to uplift its vulnerable yet vibrant SME fuels into a globally sustainable and leadership manufacturing destination.

4.1 Key role of User Acceptance Model

The GREENE 4.0 User Acceptance Model (UAM) plays a crucial role in speeding up the integration of sustainable solutions and digital tools for small and medium-sized manufacturers in Central Europe. It is designed to align with the real-world challenges and needs of these businesses, fostering collaboration among stakeholders.

The UAM is a framework that brings together evidence-based strategies and practical tools, developed in collaboration with SMEs themselves. It provides clarity for manufacturers who may feel overwhelmed by the complexity of the transition to smart manufacturing. By establishing common objectives, the UAM promotes

coordination among industry leaders, solution providers, research institutions, and policymakers, injecting a personalized touch into transformation efforts.

One of the significant aspects of the UAM is its focus on addressing barriers and leveraging enablers to facilitate change. It recognizes that genuine transformation requires breaking down external obstacles and triggering internal motivators simultaneously. By identifying and mitigating financing constraints, talent shortages, and regulatory conflicts, the UAM removes roadblocks that have hindered sustainability and technology adoption in the past. At the same time, it activates accelerants such as transparency, community participation, and leadership commitment. These catalysts facilitate change by fostering collaboration, building collective capabilities, and creating supportive systems.

The UAM's multi-level approach ensures that a wide range of inhibitors and motivators are targeted, leading to the development of ecosystems where innovative ideas can quickly translate into responsible actions. By embracing co-creation and inclusivity, the UAM transforms traditional paradigms while respecting regional and cultural differences. Its participative nature promotes buy-in from all stakeholders and enables the structural remodelling of existing constructs through collaboration, rather than forceful imposition.

In conclusion, the GREENE 4.0 UAM is an essential tool that guides and supports SME manufacturers through the transition to sustainability and digitalization. Its significance lies in incorporating participatory principles into established frameworks, ensuring a progressive and seamless transformation process. The model acknowledges the importance of dismantling external barriers while activating internal drivers, fostering a sense of collectivism in nurturing sustainability as an opportunity for all.

5 Developing methods and measures for improving user acceptance (SME's acceptance for green and / or digital transformation)

Green manufacturing, characterised by systematic ecological prevention, economic compliance and increased effectiveness, is in line with the principles of sustainable development (Jansson, 2011; Shahzad et al., 2020; Shahzad et al., 2022). Innovation is a key driver of business growth, provides a competitive advantage and improves environmental efficiency (Cillo et al., 2019). Companies are increasingly turning to green innovations to mitigate the negative consequences of traditional growth models. They enable the production of environmentally friendly products by minimising the use and waste of resources (Shahzad et al., 2022).

Although SMEs are of crucial importance for the economy and social structures, they receive little academic attention, as research is mainly focussed on large companies (Adelaide et al., 2022). The diversity of SMEs, which differ in size and characteristics, brings challenges and opportunities for sustainability-oriented measures. While SMEs make a significant contribution to economic development, their specific characteristics, such as limited resources and informal structures, set them apart from larger corporations. The importance of SMEs in the OECD area, which account for 99% of enterprises and make a significant contribution to employment and value creation, emphasises their role in sustainable economic growth (OECD, 2019; Adelaide et al., 2022). However, research shows that SMEs also have a large environmental footprint (Koirala, 2019). Overcoming barriers to sustainability management activities, such as lack of institutional support and perceived business benefits, remains a challenge for SMEs.

The unique characteristics of SMEs, including owner leadership and limited access to financial resources, influence their management approaches to sustainability (Adelaide et al., 2022), and the use of sustainability management tools and frameworks is underdeveloped in SMEs as they were primarily developed for larger organisations and do not meet SME-specific needs (ibid.). Despite their importance, SMEs therefore face a lack of research on sustainability and the existing sustainability tools are inadequate. In order to close this gap, a thorough examination of the current state of research and the formulation of a future research agenda is required.

The key steps in developing methods and measures for improving/increasing user acceptance (SME's acceptance for green transition and/or digital transformation) are:

1. Identify Major Barriers for User Acceptance

- Pinpoint obstacles like lack of awareness, resistance to change, and cost concerns that hinder adoption of green and digital technologies among SME manufacturers.

2. Recognize Existing Enablers for Facilitation

- Identify enablers such as governmental incentives, access to finance, training programs and consumer demand that can ease and encourage technology adoption.

3. Develop Targeted Mitigation Methods

- Formulate awareness building campaigns, change management structures and cost-benefit analysis approaches specifically to dismantle identified barriers to user acceptance.

4. Outline Enabler Operationalization Measures

- Define implementation mechanisms for enablers such as streamline incentive access, public-private financing vehicles, specialized skill development initiatives and buyer immersion programs.

5. Integrate Mitigation Methods and Enabler Measures

- Develop an integrated framework with linkages across methods and measures for a synchronized and mutually reinforced approach to diminish barriers and activate enablers.

6. Incorporate User Validation

- Embed feedback loops by testing acceptance model with target user groups through varying scenarios and iterating based on empirical evidence around impact.

5.1 Key enablers

a) Governmental Incentives: Government policies, programs, and incentives can play a vital role in promoting the adoption of green and digital technologies among SMEs. These incentives can take various forms, such as tax breaks, subsidies, grants, and low-interest loans, which can help offset the initial costs and risks associated with technology investments.

b) Access to Finance: Improving SMEs' access to finance is crucial for enabling technology adoption. This can involve developing tailored financial instruments, such as green bonds, sustainability-linked loans, and innovation vouchers, which provide SMEs with the necessary capital to invest in green and digital technologies. Collaborations with financial institutions, investors, and public funding bodies can help create a more supportive financing ecosystem for SMEs.

c) Training Programs: Providing SMEs with access to relevant training programs can help bridge the skills gap and build the necessary capabilities to effectively adopt and utilize green and digital technologies. These programs can cover a range of topics, including technical skills, change management, innovation processes, and sustainability practices. Collaborations with educational institutions, industry associations, and technology providers can help design and deliver tailored training programs that meet the specific needs of SMEs.

d) Consumer Demand: Growing consumer awareness and preference for sustainable and digitally-enabled products and services can create a strong market pull for SMEs to adopt green and digital technologies. By responding to this demand, SMEs can differentiate themselves, access new market segments, and enhance their competitiveness. The project can help SMEs understand and capitalize on these market opportunities through market intelligence, consumer research, and green branding support.

Other enablers identified include collaborative networks, technology demonstration projects, and best practice sharing platforms. By recognizing and leveraging these enablers, the project can create a more supportive ecosystem that encourages and facilitates technology adoption among SMEs.

5.2 Develop Targeted Mitigation Methods

Based on the identified barriers and enablers, the next step is to develop targeted mitigation methods that specifically address the challenges faced by SMEs in adopting green and digital technologies. These methods aim to dismantle the barriers and create a more conducive environment for technology acceptance and implementation.

- Key Mitigation Methods

a) Awareness Building Campaigns: To address the lack of awareness and understanding of green and digital technologies among SMEs, the project designs and implements targeted awareness building campaigns. These campaigns aim to provide SMEs with clear, relevant, and compelling information about the benefits, applications, and best practices related to these technologies. The campaigns can take various forms, such as workshops, webinars, case studies, and media outreach, and are tailored to the specific needs and contexts of different SME segments.

b) Change Management Structures: To overcome resistance to change and facilitate the smooth adoption of new technologies, the project develops change management structures and processes. These structures aim to support SMEs in managing the organizational, cultural, and operational changes associated with technology implementation. This can involve providing guidance on communication strategies, employee engagement, training and development, and performance management. The project also establishes change agent networks and peer learning groups to facilitate knowledge sharing and mutual support among SMEs undergoing similar transitions.

c) Cost-Benefit Analysis Approaches: To address cost concerns and help SMEs make informed investment decisions, the project develops cost-benefit analysis approaches and tools. These approaches aim to provide SMEs with a clear and comprehensive understanding of the financial implications, risks, and returns associated with adopting green and digital technologies. This can involve developing customizable cost-benefit templates, ROI calculators, and scenario planning tools that allow SMEs to assess the viability and impact of different technology options based on their specific circumstances.

Other mitigation methods developed by the project include technology readiness assessments, innovation audits, and regulatory compliance support. By providing SMEs with these targeted and practical tools and approaches, the project aims to build their confidence, capacity, and motivation to adopt green and digital technologies

d) Outline Enabler Operationalization Measures: To fully leverage the identified enablers and create a supportive ecosystem for technology adoption, the project outlines specific operationalization measures. These measures focus on defining the implementation mechanisms and processes that can effectively translate the enablers into tangible actions and outcomes.

5.3 Identify key operationalization measures

a) Streamlined Incentive Access: To ensure that SMEs can easily access and benefit from available governmental incentives, the project works on streamlining the application and approval processes. This can involve creating online portals, simplified forms, and dedicated support services that guide SMEs through the incentive landscape and help them navigate the administrative requirements. The project also advocates for more flexible and inclusive eligibility criteria that cater to the diverse needs and capacities of SMEs.

b) Public-Private Financing Vehicles: To improve access to finance for SMEs, the project develops and promotes innovative public-private financing vehicles. These vehicles aim to mobilize and blend different sources of capital, including public funds, private investments, and philanthropic grants, to create tailored and accessible financing options for SMEs. This can involve establishing green investment funds, technology leasing schemes, and risk-sharing mechanisms that reduce the financial barriers and uncertainties faced by SMEs.

c) Specialized Skill Development Initiatives: To address the skills gap and build the necessary capabilities for technology adoption, the project designs and implements specialized skill development initiatives. These initiatives aim to provide SMEs with targeted and practical training programs that focus on the specific skills and competencies required for implementing green and digital technologies. This can involve collaborating with technical schools, universities, and industry experts to develop curricula, training modules, and certification programs that are tailored to the needs of SMEs in different sectors and regions.

d) Buyer Immersion Programs: To help SMEs understand and respond to the growing consumer demand for sustainable and digitally enabled products, the project develops buyer immersion programs. These programs aim to facilitate direct interactions and collaborations between SMEs and their potential buyers, including large corporations, public procurement agencies, and end-consumers. This can involve organizing matchmaking events, product demonstrations, and co-creation workshops that allow SMEs to showcase their innovations, gather feedback, and establish commercial partnerships.

Other operationalization measures outlined by the project include establishing regional innovation hubs, creating online knowledge-sharing platforms, and developing impact measurement frameworks. By defining these concrete implementation mechanisms, the project aims to ensure that the enablers are effectively leveraged and translated into tangible actions that support SMEs in their technology adoption journey.

e) Integrate Mitigation Methods and Enabler Measures: To create a holistic and synergistic approach to improving user acceptance, the project integrates the mitigation methods and enabler measures into a coherent framework. This integration aims to ensure that the different elements of the approach are mutually reinforcing and contribute to a common goal of overcoming barriers and activating enablers for technology adoption.

5.4 Developing an integrated framework that combines the mitigation methods and enabler measures across three key dimensions

a) Awareness and Motivation: This dimension focuses on integrating the awareness building campaigns with the buyer immersion programs and market intelligence support. By providing SMEs with a clear understanding of the benefits and opportunities associated with green and digital technologies, while also exposing them to the growing market demand and consumer preferences, the project aims to create a strong motivation for technology adoption.

b) Capacity and Resources: This dimension focuses on integrating the change management structures with the specialized skill development initiatives and public-private financing vehicles. By providing SMEs with the necessary organizational support, technical capabilities, and financial resources to effectively implement and utilize green and digital technologies, the project aims to build their capacity to overcome the adoption barriers.

c) Ecosystem and Networks: This dimension focuses on integrating the cost-benefit analysis approaches with the streamlined incentive access and collaborative innovation networks. By providing SMEs with the tools to assess the viability and impact of technology investments, while also connecting them with the relevant stakeholders, resources, and opportunities in the broader ecosystem, the project aims to create a supportive and enabling environment for technology adoption.

The integrated framework also includes cross-cutting elements, such as monitoring and evaluation mechanisms, continuous improvement processes, and stakeholder engagement strategies. These elements ensure that the framework remains adaptive, responsive, and aligned with the evolving needs and contexts of SMEs.

By integrating the mitigation methods and enabler measures into a coherent framework, the project aims to create a comprehensive and targeted approach that addresses the multifaceted challenges and opportunities faced by SMEs in adopting green and digital technologies. This integrated approach allows for a more efficient and effective allocation of resources, a greater impact on user acceptance, and a more sustainable and scalable model for technology adoption.

5.5 Incorporate User Validation

To ensure that the developed methods and measures are effective, relevant, and user-centric, the project incorporates user validation as a key step in the process. User validation involves actively engaging SMEs in testing, providing feedback, and co-creating the solutions that aim to improve their acceptance and adoption of green and digital technologies.

User validation incorporation is planned through several mechanisms, including:

a) Pilot Testing: The project conducts pilot testing of the developed methods and measures with a diverse group of SMEs across different sectors, regions, and technology readiness levels. The pilot testing aims to assess the feasibility, usability, and impact of the solutions in real-world settings, and to gather user insights and feedback for further refinement and improvement.

b) User Feedback Loops: The project establishes regular feedback loops with SMEs throughout the development and implementation process. These feedback loops can take various forms, such as surveys, interviews, focus groups, and online forums, and are designed to capture the experiences, challenges, and suggestions of SMEs in relation to the proposed solutions. The feedback is systematically analyzed and incorporated into the iterative design and improvement of the methods and measures.

c) Co-Creation Workshops: The project organizes co-creation workshops that bring together SMEs, technology providers, policy makers, and other relevant stakeholders to jointly develop and refine the solutions. These workshops provide a collaborative platform for ideation, prototyping, and testing of the methods and measures, ensuring that they are aligned with the needs, preferences, and constraints of the end-users.

d) Impact Assessment: The project conducts rigorous impact assessments to evaluate the effectiveness and outcomes of the implemented methods and measures. These assessments use a combination of quantitative and qualitative indicators, such as technology adoption rates, user satisfaction scores, cost savings, and environmental benefits, to measure the success and identify areas for improvement. The results of the impact assessments are transparently communicated to SMEs and used to inform the continuous adaptation and scaling of the solutions.

By incorporating user validation as an integral step in the development process, the project aims to create solutions that are not only theoretically sound but also practically relevant and valuable for SMEs. The active involvement of SMEs in testing, providing feedback, and co-creating the methods and measures helps to ensure their buy-in, ownership, and sustained engagement in the technology adoption journey.

Moreover, the user validation process helps to identify and address any unintended consequences, barriers, or limitations of the proposed solutions, allowing for timely adjustments and improvements. It also helps to build trust, credibility, and legitimacy of the project among the SME community, as they see their inputs and needs being actively considered and incorporated.

Ultimately, the incorporation of user validation helps to create a more demand-driven, user-centric, and evidence-based approach to improving SMEs' acceptance and adoption of green and digital technologies. It ensures that the solutions are not imposed from the top-down but rather co-created and validated from the bottom-up, leading to more sustainable and impactful outcomes.

5.6 Importance of addressing specific challenges faced by SMEs in adopting green and digital technologies

Measuring and assessing the challenges that SMEs face when adopting green and digital technologies is important for many other reasons. Central to this is recognising the environmental impact of SMEs' collective activities. This change would lead to a significant reduction in carbon footprint, conservation of resources and an overall positive environmental impact that is in line with global sustainability goals. Overcoming barriers enables SMEs to move towards sustainable practises, contribute to a circular economy and align with global sustainability goals. Overcoming obstacles to green and digital innovation is crucial to boosting the economic growth of SMEs. Utilising digital technologies increases productivity, efficiency and competitiveness and opens up new avenues for growth. By overcoming financial constraints and promoting sustainable practises, SMEs contribute significantly to economic dynamism. The introduction of green and digital technologies also stimulates innovation in SMEs and promotes the development of new business models, products and services. Overcoming barriers to technology adoption creates an environment that favours creative thinking and adaptive strategies, which both improves the competitiveness of SMEs and contributes to broader progress in sustainable practises.

Measuring acceptance factors, which were the focus of our study, has proven to be important as understanding the subjective and behavioural dynamics sheds light on how SMEs perceive and adopt technological innovations, supporting the development of effective strategies. The approach we took was already proven successful in other studies (see. eg. Anser et al, 2020 Shahzad et al., 2022). By considering dimensions such as perceived benefit, effort expectation, ease of use and attitude towards change, the UTAUT model provides a systematic lens for analysing cognitive and emotional factors that influence SMEs' decisions to adopt green technologies. Measuring acceptance factors using the UTAUT model enables a customised approach to developing strategies for green innovation adoption in SMEs. Understanding the level of acceptance enables the development of targeted interventions. This research is invaluable for policy makers, industry leaders and support organisations seeking effective strategies that address the cognitive and behavioural nuances of SMEs.

6 Process for Elaborating Methods and Measures

6.1 Regional mapping analysis

The study employed a mixed-method approach that integrated both qualitative and quantitative methodologies. The main aim of our study was to assess the present adoption levels of green manufacturing practices and digital technologies among SMEs and understand the perceptions, attitudes, and barriers companies face in transitioning to greener and more digitally integrated business models. All 7 GREENE 4.0 countries were included to a study.

The target group for the survey and mapping analysis comprises small and medium-sized enterprises (SMEs) across seven Central European countries. According to the SME definition used in the survey, the target companies have:

- Less than 250 employees
- Annual turnover not exceeding EUR 50 million
- Annual balance sheet total not exceeding EUR 43 million

We incorporated quantitative methods through structured survey questions, systematically collecting numerical data on various aspects related to acceptance factors and barriers. The survey covered an array of key topics, including detailed information about the participating companies such as company size, financials, and company-specific details. Additionally, we added open-ended questions within our survey, allowing respondents to provide detailed and unstructured insights into their experiences, challenges, and motivations regarding the adoption of environmentally friendly practices. This qualitative component aimed to capture the richness of SME attitudes, offering a nuanced understanding of the factors influencing their decision-making processes.

The survey and interview questions focused on gaining insights across the following dimensions:

1) Company details
2) Company size and financials
3) Technology and innovation adoption rate
4) Supply chain and partnerships
5) Acceptance of green digital innovation
6) Enablers and barriers
7) Details of the respondent

The data collection process of this study followed a country-specific approach that allowed the different countries to define their own sampling procedures. The primary aim was to include as many small and medium-sized enterprises (SMEs) as possible, with limited involvement of larger companies considered important to the project. We, however, allowed for a few exceptions, in case a company was relevant also for our future collaboration together. The primary methods of data collection were face-to-face interviews and online surveys conducted via the 1ka.si platform. It the companies were interviewed in person; their data was later-on added to 1ka portal. The analyses were conducted with IBM SPSS by University of Ljubljana.

The 1ka.si platform was chosen as the tool for the online surveys because it provides a standardised and accessible platform for data collection. The local partners carefully translated the survey tool into all major national languages and then tested it thoroughly.

Throughout the data collection period, the survey was regularly monitored to ensure the integrity and quality of the data.

The survey was conducted from 24th of July 2023 to 2nd of November 2023. The partners actively participated in dissemination activities to increase industry participation. This was done through a variety of channels, including company websites, social media platforms, and personal phone calls and utilising the partners' professional networks.

In total, we received 927 clicks on the survey from July 24, 2023, to November 2, 2023. Among these, surveys that aligned with the below definition of SME, provided consent for collecting personal data, were completed up to Q8, and were obtained in countries involved in the GREENE 4.0 project were considered valid. Partners reviewed the data for validity and repetition.

In total, there were 422 valid surveys. The highest percentage came from Austria (43.8%, N=185); other countries were more evenly distributed, with the Czech Republic at 11.6% (N=49), Germany and Hungary each at 10.2% (N=43), Italy at 9.5% (N=40), Slovenia at 7.8% (N=33), and Poland at 6.9% (N=29).

In the analytical phase of our study, we employed frequencies and descriptive statistics (means, minimum values, maximum values, and standard deviations).

Factor analysis was a statistical approach used to check the accuracy of the estimated indicators within each domain of the Unified Theory of Acceptance and Use of Technology (UTAUT) model.

6.2 UTAUT model and integration of findings from relevant studies to understand technology acceptance and identify facilitators and barriers.

Our questionnaire design was grounded in the Unified Theory of Acceptance and Use of Technology (UTAUT), a comprehensive model synthesizing eight influential technology theories. These include the Theory of Reasoned Action, Technology Acceptance Model, Motivational Model, Theory of Planned Behavior, Model of PC Utilization, Innovation Diffusion Theory, and Social Cognitive Theory (Venkatesh et al., 2003; Wedlock et al., 2019). UTAUT identifies four core constructs influencing user behavior: performance expectancy, effort expectancy, social influence, and facilitating conditions. It has been broadly validated across diverse contexts, including e-government, e-banking, e-learning, e-commerce, recently also green innovation (Anser et al., 2020; Shahzad et al., 2022). Extensions of UTAUT, such as integrating factors like compatibleness expectancy, sustainable innovativeness, and environmentalism in adopting green household technology, have enriched its applicability (Ahn et al., 2016).

Our study initially focused on four key elements derived from UTAUT: perceived usefulness, facilitating conditions, ease of use (effort expectation), and social influence.

Perceived Usefulness: Perceived usefulness gauges the belief in a technology's capability to enhance performance or work efficiency. In our survey, we explored the impact of introducing environmentally friendly production processes on business operations and productivity.

Facilitating Conditions: Facilitating conditions assess the perceived organizational and technical support for adopting new technology. We inquired about existing conditions that could either facilitate or hinder the integration of green production processes.

Ease of Use (Effort Expectation): Ease of use and effort expectation evaluate the perceived ease or difficulty of using a technology. In the context of adopting green production practices, our survey delved into participants' perceptions of the ease or difficulty in adopting such practices.

Social Influence: Social influence measures the impact of social factors on a person's decision to adopt a technology. Our survey investigated how social factors, including the opinions and feedback of others, influenced participants' attitudes and actions towards adopting environmentally friendly production practices.

In addition, we have considered findings from the study "Barriers and Enablers for the Adoption of Sustainable Manufacturing by Manufacturing SMEs" by Alayon et al. (2022). This study provided valuable perspectives on the facilitators and barriers for small and medium-sized enterprises (SMEs) in adopting sustainable manufacturing practises. The integration of these findings has broadened our understanding and enabled us to identify constraints and parameters beyond UTAUT.

We combined both studies and created a questionnaire that we tested with a factor analysis. The main purpose of using factor analysis was to assess the internal structure of the data and to check the accuracy of the calculated indicators within each domain of the UTAUT model. By examining the relationships between the observed variables, factor analysis allowed us to identify latent factors that shed light on the underlying constructs contributing to the observed patterns. It allowed us to check whether the indicators within each domain adequately corresponded to the intended constructs, which contributed to the overall reliability and validity of our analytical results.

The results of the factor analysis underpinned the robustness of the UTAUT model as they revealed different factors for each domain. The only exception was a factor *facilitating conditions,* which focused on three different dimensions, which were further analysed as such: internal readiness and support for green manufacturing; regulatory and external technical barriers to green manufacturing and regulatory drivers on green manufacturing.

The final list of UTAUT factors used in the survey therefore included perceived usefulness, effort expectation and ease of use, internal readiness, regulatory barriers, regulatory drivers and influence.

6.3 Designing methods and measures

The process of designing methods and measures was:

- Regional Mapping Analysis survey design using the UTAUT (Unified Theory of Acceptance and Use of Technology) framework to understand key factors influencing user acceptance of technologies. Dimensions covered include company details, technology usage, green manufacturing practices, supply chains, perceived usefulness, effort expectancy, facilitating conditions, ease of use, external influence, and attitudes towards change. Both quantitative (rating scales) and qualitative (open-ended) questions were incorporated to gather comprehensive insights.
- Survey administration and data collection. Target group was manufacturing SMEs across 7 Central European regions. Multichannel outreach was done via emails, calls, intermediary networks etc. to gather responses. 422 valid survey responses collected over 3 months to ensure representative and unbiased data.
- Mid-term co-working workshop organized by FH Kufstein in Tirol on the 5th October 2023 for designing methods and measures dedicated to mitigating barriers and facilitating enablers for SME's user acceptance model, based on preliminary results of regional mapping analysis – survey data preliminary analysis and based on PP's contribution and input.
- Performed the complete analysis and finalized the regional mapping analysis. Quantitative data analyzed using statistical techniques like frequencies, means comparisons, factor analysis etc.

Qualitative data coded into key themes/factors driving technology adoption and challenges faced. Findings on major barriers like financial constraints, resistance to change, and lack of awareness were incorporated into UAM to develop targeted mitigation methods and measures. Key enablers identified like incentives, training, and partnerships were integrated as measures to leverage adoption.

- UL organized a 2nd co-working workshop for designing and finalizing the set of methods and measures dedicated to mitigating barriers and facilitating enablers for SME's user acceptance model based on regional mapping analysis results and based on PP's contribution and input.
- PP4 organized a joint technical meeting with LP, PP2, PP4, PP6, PP7 and PP8 where it presented the developed methods, measures. PP's provided input, recommendations were collected and PP4 refined the final version of the Methodology Report incorporating the designed methos and measures dedicated to mitigating barriers and facilitating enablers for SME's user acceptance model.
- UAM is designed through a co-creation approach (3 co-creation camps), incorporating regional barriers, user attitudes, and viable enablers into an empiric framework for increasing technology acceptance among SMEs.
- The methods focus on awareness building, change management, and cost-benefit analysis to address adoption barriers. The measures identify mechanisms to operationalize enablers like policy incentives, access to finance and skill development programs.

6.4 Description of Elaborated Methods and Measures

- Present the developed methods and measures based on the analysis' findings, focusing on systematic integration of sustainability, development of digital and green skills, and promotion of green and digital solutions.

Based on the barriers and enablers identified through the regional analysis we provided 1st a short overview of the key methods for mitigating barriers:

Category	Methods to Mitigate Barriers
Awareness Building	- Multi-Channel Informational Campaigns (webinars, social media, print material, industry events, executive roundtables); - Localized Use Cases Repository. - Adoption Guidance Portal on GREENE 4.0 innovation platform (personalized assessments, customized roadmaps, notifications on regulations).
Change Management	- Transition Roadmapping (structured frameworks, milestone settings, analytics dashboards) - Employee Participation (shopfloor innovation circles, co-creation workshops, hackathons)

	- Capability Development (immersive simulations, augmented walkthroughs, remote virtual training) - Executive Coaching (external advisory services, peer learning, benchmarking visits). - Training and education
Cost-Benefit Analysis	- Financial models for long-term savings and ROI assessments - Cost Modelling (quotes from vendors, modeling Capex requirements, factoring expenses for capability building, change management, and external advisory) - Benefit Quantification (product quality enhancement, revenue expansion, savings from asset optimization, process improvement metrics) - Risk Scenarios Evaluation.

In the following chapter we provide a detailed description of the key methods and measures developed for mitigating barriers for SME's transition/adoption of green production processes, technologies, and digital transformation.

7 Methods to Mitigate Barriers

Method	Description of action plan
Awareness Building - Informational campaigns via webinars, seminars, and social media to highlight benefits. - Dedicated section in GREENE 4.0 Innovation Platform covering technology advantages. - Case studies and success stories showcasing operational improvements.	**<u>1. Multi-Channel Informational Campaigns</u>** ▪ Webinars/Virtual Seminars: Interactive webinars tailored to different user segments covering technology topics like IoT, data analytics, AI etc. ▪ Digital Content Series: Social media campaigns with infographics, interviews and videos simplifying complex topics. ▪ Print Material: Brochures, leaflets and visualization guides using formats suitable for shopfloor, on-field contexts. ▪ Industry Events: Panels, workshops and immersive demonstrations at trade events, conventions and technology symposiums. ▪ Executive Roundtables: Closed-door leadership sessions focused on sustainability imperatives and technology integration.
	<u>2. Localized Use Cases Repository</u> ▪ Structured database classifying reference implementations based on location, company size, sector, technology stack etc. ▪ Option to filter case studies by targeted outcomes like waste reduction, energy savings, quality improvement etc. ▪ Interactive case viewer linking data analytics with operational metrics.
	<u>3. Adoption Guidance Portal (webpage – GREENE 4.0 innovation platform)</u> ▪ Personalized assessments identifying applicable technologies based on sector, processes etc. ▪ Customized roadmaps outlining integration steps tailored to company priorities and capacities. ▪ Notification features on new regulations, policy changes impacting adoption considerations.
Change Management	1. Transition Road mapping ▪ Structured frameworks with clearly defined stages, timelines, targets and success metrics.

- Programs to guide employees through the transition, addressing fears and uncertainties - Training interventions focused on new skill development - Implementation roadmaps clearly defining timelines and measures	▪ The roadmap would have clearly defined phases for the adoption journey, spanning awareness, selection, integration, assimilation, and optimization. ▪ Each phase outlines the objectives, activities, targets and success indicators that need to be accomplished before moving to the next stage. ▪ There is flexibility to iterate between stages based on feedback. ▪ Options for setting gradual milestones accommodating flexibility requirements. ▪ Dashboards to monitor progress aligned to roadmaps.
	2. Employee Participation ▪ Shopfloor innovation circles to contribute ideas and provide feedback on technology integration. ▪ Co-creation workshops involving cross-functional teams for solution scoping. ▪ Hackathons focused on developing adoption optimization tools leveraging worker insights.
	3. Capability Development ▪ Immersive simulations modelling integrated technology usage across operations. ▪ Augmented walkthroughs representing visual overlays of hardware/software functionality. ▪ Remote self-service access to virtual training environments for self-paced learning.
	4. Executive Coaching ▪ External advisory services providing sustainability leadership coaching. ▪ Peer learning through managed networking amongst leadership teams. ▪ Benchmarking visits to companies with mature technology integration.
Cost-Benefit Analysis - Financial models quantifying longer term savings through	1. Cost Modelling - Gather granular quotes from vendors regarding upfront investments, maintenance costs and licensing fees on prioritized solutions. - Model Capex requirements for additional hardware, connectivity upgrades and end-point infrastructure if needed.

efficiency gains and waste reduction - Assessments projecting return on investment periods under different adoption scenarios	- Factor in expenses for capability building, change management and external implementation advisory.
	2. Benefit Quantification - Estimate product quality enhancement and revenue expansion potential from incorporating real-time analytics and defect reduction algorithms. - Value savings from optimizing asset utilization, lowering scrap waste and right-sizing inventory through data-driven manufacturing. - Assess process improvement magnitude in cycle times, carbon footprint, energy consumption by green technology integration.
	3. Risk Scenarios Evaluation - Stress test business case by simulating delayed adoption curves or muted efficiency gains after rollout. - Conduct sensitivity analysis by varying assumptions across critical variables like solution performance, user activation timeline and feature consumption. Example: An automotive supplier evaluating automated visual inspection solutions can model total cost of ownership, project quality and compliance improvements based on defect detection rates and then discount benefits across probable best, medium and worst case adoption scenarios. Incorporating probabilistic modelling, intangible metrics quantification and risk-adjusted perspectives provides greater viability confidence for sustainability technology investments. Still, the long-term orientation must supersede short-sighted assessments.

8 Detailed presentation of change management tools

8.1 Transition Road Mapping

The road mapping approach accommodates flexible staging while embedding data-driven rigor regarding advancement to sequentially enhance change leadership. The sample roadmap below illustrates how phased progression, configurable milestones and data-driven tracking sustains technology assimilation momentum. Timeframes, metrics, and targets can be tailored to company contexts.

Phased frameworks	Milestone settings	Analytics Dashboards
Phase 1 - Evaluate (Months 1-2) - Assess current technology infrastructure - Identify sustainability gaps in operations - Shortlist solution options - Build business case projections	Quick Wins (Months 1-3) - Completed assessment of infrastructure gaps - Shortlisted vendors for trial solution - Developed frosted roadmap with cost projections	Milestone Completion Rate
Phase 2 – Pilot (Months 3-5) - Procure trial license for selected solutions - Set up small-scale implementation - Test integration with legacy systems - Gather user feedback	Adoption Milestones (Months 6-12) - Live deployment of software across sites - 70% of employees trained on solution usage - Minimum 50% features utilization	Milestone Completion Rate Usage Trends: Adoption percentage across solution modules - Productivity Impact: Automation influence on manufacturing output - Sustainability Index: Composite metric measuring emissions, waste, water usage metrics - Forecast Models: Regression analysis predicting ROI realization
Phase 3 – Deploy (Months 6-8) - Roll out full solution across facilities	Adoption Milestones (Months 6-12) - Live deployment of software across sites	Milestone Completion Rate Usage Trends: Adoption percentage across solution modules

- Conduct training programs on usage - Ramp up utilization through promotions - Track adoption patterns	- 70% of employees trained on solution usage - Minimum 50% features utilization	- Productivity Impact: Automation influence on manufacturing output - Sustainability Index: Composite metric measuring emissions, waste, water usage metrics - Forecast Models: Regression analysis predicting ROI realization
Phase 4 – Optimize (Months 9+) - Identify new use cases via data insights - Pursue integration with complementary solutions - Institutionalize sustainability practices - Benchmark performance periodically	Sustainment Milestones (Months 15-18) - 360-degree integration with peripheral systems - Development of two new solution use cases - 80% recycling rate for manufacturing scrap	Milestone Completion Rate Usage Trends: Adoption percentage across solution modules - Productivity Impact: Automation influence on manufacturing output - Sustainability Index: Composite metric measuring emissions, waste, water usage metrics - Forecast Models: Regression analysis predicting ROI realization
Next-Generation - Roadmap future developments - Budgeting for scale up or migration	Development roadmap, Budget approval	Milestone Completion Rate

8.2 Key steps in transition road mapping

Steps	Description
Phased framework	- The roadmap would have clearly defined phases for the adoption journey, spanning awareness, selection, integration, assimilation and optimization. - Each phase outlines the objectives, activities, targets and success indicators that need to be accomplished before moving to the next stage.

	- There is flexibility to iterate between stages based on feedback.
Milestone Settings - Within each phase, interim milestones provide a pathway for incremental progress aligned to the company's priorities. - The milestones and timelines across strategy, process, technology and capability building dimensions can be customized based on adoption capacities. - Early quick-win milestones prevent change inertia and sustain momentum during long-haul initiatives.	- Within each phase, interim milestones provide a pathway for incremental progress aligned to the company's priorities. - The milestones and timelines across strategy, process, technology and capability building dimensions can be customized based on adoption capacities. - Early quick-win milestones prevent change inertia and sustain momentum during long-haul initiatives.
Analytics Dashboards	- Integrated dashboards track milestone progression using metrics like pilot completion rates, feature usage levels, employee productivity etc. - Data-driven assessment of milestone achievement ensures progress transparency and course corrections. - Leading indicators forecast runway viability for next steps while lagging indicators validate phase transitions. The road mapping approach accommodates flexible staging while embedding data-driven rigor regarding advancement to sequentially enhance change leadership.

Below we provide an example of transition roadmap for adopting green and digital technologies with defined phases, milestones, and dashboards:

Phased framework	Milestone Settings	Analytics Dashboards
Phase 1 - Evaluate (Months 1) - Assess current technology infrastructure - Identify sustainability gaps in operations	Quick Wins (Months 1-3) - Completed assessment of infrastructure gaps - Shortlisted vendors for trial solution	- Usage Trends: Adoption percentage across solution modules - Productivity Impact: Automation influence on manufacturing output

- Shortlist solution options - Build business case projections Phase 2 – Pilot (Months 2-3) - Procure trial license for selected solutions - Set up small-scale implementation - Test integration with legacy systems - Gather user feedback Phase 3 – Deploy (Months 3-4) - Roll out full solution across facilities - Conduct training programs on usage - Ramp up utilization through promotions - Track adoption patterns Phase 4 – Optimize (Months 4+) - Identify new use cases via data insights - Pursue integration with complementary solutions - Institutionalize sustainability practices - Benchmark performance periodically	- Developed frosted roadmap with cost projections Adoption Milestones (Months 6-12) - Live deployment of software across sites - 70% of employees trained on solution usage - Minimum 50% features utilization Sustainment Milestones (Months 15-18) - 360-degree integration with peripheral systems - Development of two new solution use cases - 80% recycling rate for manufacturing scrap	- Sustainability Index: Composite metric measuring emissions, waste, water usage metrics - Forecast Models: Regression analysis predicting ROI realization

8.3 Employee Participation

Shopfloor Innovation Circles	Co-Creation Workshops	Optimization Hackathons
Self-managed teams of 8-10 employees from production floor and junior supervisory levels. - Mandate to contribute ideas regarding technology integration, solve adoption challenges and provide implementation feedback. - Example: A circle focusing on reducing scrap from the CNC machines can analyze root causes through process data, conduct surveys/interviews to gather pain points and provide suggestions to streamline workflows.	- Cross-functional teams with representation from production, maintenance, quality, and engineering collaborate on identifying use cases. - Jointly develop minimum viable solutions addressing high priority adoption barriers. - Example: A rapid-iteration workshop can conceptualize an add-on sensor network module connecting legacy equipment to real-time analytics platforms.	- Time-bound collaborative events for employees to develop digital solutions using available data streams and infrastructure APIs. - Showcase innovative prototypes optimizing green technology usage. - Example: Teams can compete to create monitoring tools projecting the ROI impact from efficiently scheduling energy-intensive machinery.

8.4 Capability Development

Immersive Simulations/Process simulation models	Augmented Assimilation	Flexible Virtual Labs
- High visual fidelity 3D walkthroughs providing simulated experience of technology integrations. - Allows safe, cost-effective and repeated hands-on experimentation supporting accelerated capability ramp up.	- Bluetooth enabled tablets projecting animations demonstrating tech functionality onto physical assets. - Eliminates need for separate learning environments enhancing in-context and spatial understanding of solutions.	- Browser-based virtual labs with interactive equipment and functionality access for self-driven learning. - Flexible access removing dependency on fixed training schedules and high-cost immersive set ups.

Example: Digital twin modelling of packaging equipment with embedded connectivity tracking individual box processing parameters.	Example: Ring scanners detecting QR codes on machinery to visually overlay operating procedures.	Example: 3D models of renewable energy systems allowing manipulation of use case scenarios to experiment principles.

8.5 Executive Coaching

Strategic Sustainability Consulting	Leadership Assimilation Cohorts	Immersion Visits	Advisory Panel Assimilation
- External experts provide specialized advisory services to leadership teams on sustainability integration. - Focus areas span goal setting, metrics establishment, technology utilization roadmaps and capability development. - Example: A strategic consulting firm can advise the executive committee on drafting emission reduction targets, selecting tracking metrics and prioritizing green technology investments.	- Facilitated peer learning clusters for business heads and function leads to collectively work through adoption challenges. - Share experiences, insights and recommendations on overcoming barriers. - Example: A sustainability director learning cohort can be created for participants across sectors to exchange notes on change management hurdles and mitigation strategies.	- Structured site visits to companies with mature environmentally sustainable operations. - Witness implementations covering technology integration, process redesign, culture transformation etc. - Example: Executives can attend demonstrates at factories with well-established waste management frameworks to witness operationalization first-hand.	- Participation in leadership forums guiding companies undergoing sustainability transitions. - Opportunity for senior leaders to gain direct contextual recommendations. - Example: Joining an advisory council supporting companies adopting cleaner energy sources as they overhaul infrastructure and consumption workflows.

8.6 Cost-Benefit Analysis

Performing robust financial analysis is imperative for building the business case to justify investments in sustainability solutions and alleviate cost-related adoption barriers. This requires factoring both tangible and intangible benefits across ownership lifecycles through methodical projections.

Cost Model Canvas

By providing structured cost factors and variable assumptions, the following template cost model canvas allows financial projections customization aligned to the sustainability technology solution and sector contexts. The modular framework accommodates reliability by incorporating dynamic operating considerations.

Customization Levers:

- Modify entries under cost items to reflect anticipated expense categories.
- Adjust cost ratios across hardware-software, services, auxiliary capabilities to match solution specifics.
- Incorporate cost savings from consolidations or shared capabilities.
- Simulate licensing, servicing models for scenario analyses.
- Define ownership timelines based on expected solution lifecycles.

Technology Solution:	Infrastructure: (structural changes, electrical works, HVAC)
Key Cost Items	Training & Change Management: (user workshops, simulation kits, external advisory)
Hardware/Software: (sensors, meters, controllers, platforms)	Certification & Compliances: (audits, regulatory reporting, permits & taxes)
Integration & Deployment: (IoT connectivity, network upgrades, endpoint interfaces, vendor implementation services)	Maintenance & Servicing: (annual system checks, part replacements, downtime provisions)

Benefit Quantification Canvas

Below we provide a customizable benefit quantification model that can be adapted to evaluate sustainability technology returns across manufacturing sectors. The customizable framework allows manufacturing companies to systematically map sustainability technology value across tangible and intangible dimensions. Metric-driven rigor and variability-based modelling provides balanced perspectives.

Technology Solution:	Productivity Enhancements: (improved equipment utilization, faster processing)
Benefit Items	Risk Mitigation: (regulatory compliance, certifications)
Revenue Expansion: higher quality products, new revenue streams)	Intangible Returns: (brand equity, social goodwill, employee experience)
Cost Optimization: energy, inventory, waste reduction)	

Customization Levers:

- Populate relevant benefit categories and spanning operations, finance, marketing dimensions.
- Attach measurable metrics like defect rates, carbon emissions, output rates.
- Set benchmark levels for metrics based on company baseline performance.
- Define improvement targets across metrics aligned to solution value proposition.
- Incorporate multiplier for second order benefits.
- Assign confidence weightings to benefit forecast lines.

Production Efficiency	- Technologies like IoT sensors, machine learning and digitized shopfloor connectivity provide granular visibility into asset utilization, process performance, output quality and supply chain visibility. - Metrics: OEE scores measuring production efficiency gains, defect rate reductions, FPY improvements indicating yield gains. - Monetization: Production optimization related savings, revenue gains from quality improvements quantified in financial terms.
Sustainability Impact	- Solutions like renewable energy, EV fleet, automated lighting save costs while reducing environmental footprints. - Metrics: Carbon emission decline, renewable energy share, decrease in hazardous effluents. - Monetization: Operational savings from energy optimization, certification and regulatory compliance-related cost avoidance.
Organizational Agility	- Faster assimilation of emerging technologies like AI, ML, automation etc improves organizational responsiveness to market changes. - Metrics: Reduction in new product introduction cycle times, faster incorporation of new analytics use cases. - Monetization: Second order revenue gains quantified from the impact of accelerated solution development and deployment.

In summary, factoring metrics spanning efficiency, sustainability and agility maps technology benefits to financial returns while also quantifying critical intangible dimensions.

Risk Scenarios Evaluation

While cost-benefit projections provide expected value from sustainability technology investments, modelling different risk scenarios helps stress test business case resiliency.

Adoption Delays	- Evaluate business case viability by simulating slower employee activation curves post technology rollout. - Assess implications of limited feature consumption given change inertia among certain user subgroups. - Mitigation: Expand training timelines, customize engagement approaches for reluctant user clusters.
Muted Efficiency Gains	- Factor viable scenarios of suboptimal process improvements despite adoption across intended features. -legacy hardware compatibility issues, inadequate integration touchpoints can constrain efficiency gains. - Mitigation: Engineer additional integration points, allow longer stabilization periods.
Deployment Setbacks	- Consider effects of partial rollout failures requiring stabilization sprints before site-wide deployments. - Complex integrations with old equipment can delay full adoption across facilities. - Mitigation: Prioritize rollouts across newest facilities first, implement modular approach to isolate failures.

Evaluating risk scenarios provides data-driven visibility into contingencies and pre-emptive mitigation response planning. While the assessments orient leadership teams for agile course corrections, realistic timelines setting milestones help balance urgency with pragmatism on the transformation journey. SME's must underscore sustainability capability building as a continual and cumulative exercise - forging ahead with vision while continuously educating, empowering, and inspiring stakeholders at each milestone through the volatility.

9 Measures to Leverage Enablers

Category	Detailed Measures to Leverage Enablers
Financial Incentives	- Governmental Grants and Subsidies: Providing access to information on various grants and subsidies available for green technology adoption. - Funding Advisory Desks: Establishing specialized desks to guide SMEs on accessing financial instruments like green loans, sustainability-linked bonds, and regional development funds. - Incentive Programs: Designing specific incentive programs that offer tax reliefs, fast-tracked licensing, or reduced tariffs for adopting green technologies.
Training & Education	- Certification Programs: Collaborating with educational institutes to offer certification programs in green technologies, digital transformation, and sustainable practices. - Mentorship Initiatives: Setting up mentorship programs that pair SMEs with experienced professionals in green technology for practical, on-the-job learning. - Workshops and Seminars: Organizing workshops and seminars to educate SMEs about the latest trends, practices, and benefits in green and digital technologies.
Market Demand Alignment	- Consumer Feedback Platforms: Developing platforms for SMEs to collect and analyse consumer feedback, enabling them to tailor products to market demands. - Collaborative Product Development: Facilitating partnerships with industrial design agencies and technology experts to conceptualize and develop green products that meet consumer needs. - Market Analysis Tools: Offering tools and services for market analysis to help SMEs identify trends and opportunities in green technology adoption.

Detailed description of methods for leveraging enablers:

Financial Incentives	1. Innovative Access Instruments	2. Public-Private Participation Vehicles	3. Advisory on Emerging Models
Access to capital remains a frequently cited adoption barrier, especially for smaller manufacturers lacking assets or credit history. Financial incentives can strategically	- Popularize specialty offerings like sustainability-linked loans, green bonds, SDG loans, and social impact funds that tie financing costs to	- Aggregate funding pools combining government and commercial capital to directly invest in pilot demonstrations of high-impact solutions	- Help manufacturers navigate emerging result-based financing mechanisms like payment-by-results and revenue-based financing that link

alleviate initial investments and ongoing costs associated with sustainability solutions.	verified ESG(environmental, social and governance) goal achievements. - Guide SMEs through flexible instruments with discounted interest rates and elongated tenures for assets like EV fleets, renewable energy infrastructure. - Simplify access by streaming applications via digital platforms.	like carbon capture equipment. - Ensure continued financing for successive stages contingent on successful pre-agreed milestones. - Capital participation distributes risks and aligns stakeholder groups for smoother funding flows.	repayments to actual project performances. - Provide independent advisories on constructing innovative models without disproportionate dilution. Accessible, affordable and appropriately structured financial channels can responsibly accelerate the actualization of eco-friendly solutions. Policy institutions must proactively shepherd enterprises by illuminating pathways and spearheading supportive instruments.
Training & Education	1. Applied Learning Platforms - Digital academies providing modular courses on topics like data analytics, IoT architecture, robotics operations, renewable energy fundamentals tailored for industrial shopfloor contexts. - Leverage interactive formats like simulations, augmented walkthroughs, and	2. Structured Apprenticeships - Facilitated cohort-based apprenticeships for skill building across green technology domains involving rotations across planning, maintenance and quality assurance. - Integrate theory and on-job application through supervised guidance from subject matter experts.	3. Peer Coaching Circles - Facilitate experienced peer cohorts to coach each other on real-time troubleshooting and use case identification for recently deployed solutions. - Accelerates self-sufficiency through informal alignments based on internal credibility.

	virtual case studies for immersive learning. Example: A cloud-based academy offering an AI model development course allowing hands-on experimentation with sample manufacturing data sets.	Example: A 6-month smart grid management apprenticeship with the local utility involving classroom and field training.	Example: Circles of EHS (Environment, Health & Safety) engineers sharing experiences on optimizing sustainable material waste workflows. Formal institutions must take the lead in nurturing specialty skills but sustainable success depends hugely on fostering motivated grassroots networks for propagation. Hence the measures must spur self-sustaining pools.
Market Demand Alignment	1. Crowdsourced Co-Creation - Enable collaborative product design workbenches allowing participative development of eco-friendly products and packaging innovations. - Co-create minimum viable prototypes aligned to trends spotted from analyzing social media narratives, search patterns and survey data.	2. Living Labs for Rapid Experimentation - Provide shared lab infrastructure for rapid prototyping of sustainable material innovations and responsible end-of-life treatment pathways. - Encourage testing concepts inspired from consumer sentiment mining and grassroots innovation ecosystems. Example: A furniture maker leveraging a circular economy lab	3. Segmented Customer Acquisition - Develop micro-segment profiles identifying consumer tribes based on environmental consciousness levels and willingness to adopt for premiums. - Craft differentiated value proposition, customer journey and pricing strategies tailored for targeted segments. Example: An appliance brand designing a

	Example: An outdoor gear company inviting customer teams to jointly conceptualize recyclable alternatives for non-degradable product components.	facility to develop recyclable plastic-substitute compounds extracted from organic waste.	solar-powered fridge with connectivity features targeted at the sustainability-aware premium category.

Concluding, integrating mechanisms to systematically capture evolving customer requirements, co-create with product users, and assemble segment-specific green value packages fosters greater market receptivity towards environmentally conscious offerings. The methods and measures cover a holistic range spanning awareness, mindsets, capabilities, funding, and market links to drive technology acceptance in a sustainable manner.

The methods for mitigating barriers and measures for leveraging enablers in the GREENE 4.0 project are specifically designed to address the identified challenges and barriers faced by SMEs, including financial constraints, regulatory uncertainties, and talent shortages. Here's how these methods and measures are tailored to these specific challenges.

9.1 Financial constraints

Methods for Mitigating Barriers

- Cost Modelling: Detailed cost models encompass upfront investments, integration expenses, capability building costs, and ongoing operational expenses across the technology ownership lifecycle.
- Benefit Quantification: A framework to systematically map financial returns across dimensions like enhances revenues, cost optimizations, improved regulatory compliance and intangible gains.
- Risk Scenarios Evaluation: Sensitivity analysis by simulating muted adoption trajectories, suboptimal efficiency gains and delayed ROI realization provides a prudential perspective.

These financial analysis techniques provide clarity into cost and benefit trade-offs across probable scenarios.

Measures for Leveraging Enablers

- Accessible Finance Information: Consolidated intelligence on emerging instruments like sustainability-linked loans, green bonds, payment-by-results financing that tie costs to sustainability KPI achievements.
- Investment Matching Assistance: Support with identifying and utilizing appropriate financing vehicles from an expanding range of specialized facility types.
- Vendor Engagement Initiatives: Aggregated marketplaces connecting technology developers and implementers with ready funders like impact investors.

The measures bridge information gaps and alleviates uncertainty for SMEs around tailoring and securing financial resources to match adoption needs. By interplaying analytical and advisory mechanisms to build investment confidence, the methods and measures provide a structured approach for SMEs with limited financial flexibility to traverse the complex sustainability financing landscape.

9.2 Regulatory pressure and uncertainty

Methods for Mitigating Barriers

- Compliance Guidelines Communication: Informational campaigns apprise companies on evolving compliance standards across focus areas like emissions, waste management, and circularity principles.
- Administrative Procedures Assistance: Consultative services assist with permit applications, licensing documentation, audit preparations and incentive qualifications.
- Regulatory Mandate Roadmaps: Timebound projections on upcoming policy revisions help companies proactively adapt systems and operations.

Measures for Leveraging Enablers

- Fast-track Licensing Pathways: Accelerated routes for granting approvals, certificates and patents for technologies contributing to sustainability metrics.
- Tax Relief and Duty Waivers: Incentives reducing financial outlays for compliant establishment across focus areas like renewable energy adoption, waste recycling etc.
- Regulatory Sandboxes: Structured testing environments enabling innovators to validate solutions, business models without excessive compliance overhead during development stages.

By combining informational support with incentive-based compliance mechanisms, SMEs are coached to turn regulatory mandates into sustainability transformation motivations.

9.3 Skills and talent shortages

Methods for Mitigating Barriers

- Transition Road mapping: Phased transformation plans comprising milestones for capability enhancement spanning technology, process and culture dimensions. Milestones pegged to maturity stage addresses incremental sophistication needs.
- Participative Training: Shopfloor-driven innovation circles for collaborative education on overcoming existing integration pain points through data-driven optimization prototypes. Structured mechanisms foster autonomous and accelerated technology assimilation across employee groups.

The methods activate existing workforces through structured and participative reskilling.

Measures for Leveraging Enablers

- Applied Learning tools: On-demand interactive courses on topics like sensor applications, data analytics, equipment connectivity tailored for the shopfloor through simulation models and virtual case studies to maximize retention.
- Satellite Skills Development: Localized industry-academia partnerships offer flexible periodic upskilling programs via virtual classrooms and laboratory rotations at vocational training centers to maximize reach.
- Peer Leader Networks: Voluntary cells of motivated employees guide and assist teammate adoption issues in a rapid response, relatable and non-intimidating environment through informal community support mechanisms.

The measures expand specialized capability building avenues customized for worker limitations to nurture transition self-sufficiency at scale. The approach combines structured assimilation planning with democratized, decentralized, and simplified training mechanisms for smoother workforce transformation.

The GREENE 4.0 project incorporates several innovative mechanisms to accelerate the green and digital technology adoption by SME manufacturers:

1. Matching Solutions to SME Requirements

- Competitive Scouting: Proactively identify promising solutions through structured innovation scouting across priority impact areas.
- Contextual Validation: Evaluate shortlisted technologies based on specified use cases reflecting granular industry operating conditions.
- Interactive Needs Alignment: Platforms that allow SMEs to directly provide input on operational pain points to guide solution developers in tailoring offerings.

2. Co-Creation Tools

- Joint Contouring Workshops: Cross-functional teams with SME participation collaborate on shaping minimum viable solutions spanning hardware, software, and workflow dimensions.
- Hackathons: Rapid collaborative events to build innovative prototypes addressing adoption hurdles leveraging insights from technology users.
- Integration Simulation: Tools that enable companies to experiment combining digital tools with physical assets through 3D modelling allowing configuration testing before actual deployment.

3. Incentivization Programs

- Innovation Vouchers: Allocate fixed amount funding packages for SME manufacturers that can be utilized only for procuring innovation services from accredited regional providers after needs validation.
- Sustainability Funding advisory packages: Green advisory packages offered in return for demonstrated improvements against pre-identified environmental impact metrics.

- Regulatory Sandboxes: Structured testing environments with eased compliance requirements to validate sustainability contributions of new solutions, allowing refined calibration alignment before scaled deployment.

10 Conclusion

The methods and measures developed by the GREENE 4.0 project have the potential to significantly enhance SMEs' acceptance of green and digital technologies, leading to a transformative impact on the manufacturing sector in Central Europe. By addressing the key barriers, leveraging the existing enablers, and creating a supportive ecosystem for technology adoption, the project can accelerate the transition of SMEs towards more sustainable, resilient, and competitive business models.

One of the primary impacts of the project's methods and measures is the increased awareness and understanding of the benefits and opportunities associated with green and digital technologies among SMEs. Through targeted awareness-building campaigns, such as workshops, webinars, and case studies, the project can effectively communicate the value proposition of these technologies to SMEs, highlighting their potential to improve efficiency, reduce costs, enhance product quality, and meet the growing market demand for sustainable solutions. By providing SMEs with clear, relevant, and compelling information, the project can help to overcome the knowledge gaps and misconceptions that often hinder technology adoption.

Moreover, the project's methods and measures can help to build the necessary capacity and capabilities within SMEs to successfully implement and utilize green and digital technologies. Through specialized skill development initiatives, such as training programs, certification schemes, and peer learning networks, the project can equip SMEs with the technical, managerial, and operational competencies required to effectively integrate these technologies into their processes and products. By fostering a culture of continuous learning and innovation, the project can help SMEs to develop the agility and adaptability needed to thrive in the rapidly evolving technological landscape.

Another significant impact of the project's methods and measures is the improved access to financial resources and support for SMEs. By developing and promoting tailored financing mechanisms, such as green investment funds, technology leasing schemes, and risk-sharing instruments, the project can help to reduce the financial barriers and uncertainties that often prevent SMEs from investing in green and digital technologies. By leveraging public-private partnerships and blended finance models, the project can mobilize the necessary capital to support SMEs' technology adoption journey, while also creating a more sustainable and inclusive financing ecosystem.

The project's methods and measures also have the potential to foster a more collaborative and innovation-friendly environment for SMEs. By establishing regional innovation hubs, online knowledge-sharing platforms, and co-creation workshops, the project can facilitate the exchange of ideas, best practices, and resources among SMEs, technology providers, research institutions, and other relevant stakeholders. These collaborative networks can help to accelerate the development, testing, and scaling of innovative solutions, while also creating new business opportunities and partnerships for SMEs.

Moreover, the project's focus on user validation and continuous improvement can help to ensure the relevance, effectiveness, and sustainability of the proposed methods and measures. By actively involving SMEs in the design, testing, and refinement of the solutions, the project can create a more demand-driven and user-centric approach to technology adoption. This approach can help to build trust, legitimacy, and ownership among SMEs, while also ensuring that the solutions are tailored to their specific needs, preferences, and constraints.

The integration of the mitigation methods and enabler measures into a coherent framework is another key impact of the project. By providing a holistic and systematic approach to technology adoption, the framework can help SMEs to navigate the complex and often fragmented landscape of green and digital technologies. The framework can serve as a roadmap for SMEs, guiding them through the different stages of the adoption process, from awareness and assessment to implementation and optimization. By providing a structured yet flexible approach, the framework can help SMEs to prioritize their investments, align their strategies, and measure their progress towards sustainability and digitalization goals.

In the long term, the successful implementation of the project's methods and measures can lead to a significant transformation of the manufacturing sector in Central Europe. By enabling SMEs to adopt green and digital technologies, the project can contribute to the creation of a more sustainable, circular, and competitive economy. The increased uptake of these technologies can help to reduce the environmental footprint of manufacturing activities, while also improving the efficiency, productivity, and resilience of SMEs. Moreover, the project can help to create new green jobs, skills, and business models, contributing to the overall socio-economic development of the region.

However, realizing the full potential impact of the project's methods and measures will require a sustained and collaborative effort from all stakeholders involved. SMEs will need to demonstrate leadership, commitment, and openness to change, while also actively seeking out the support and resources available through the project. Governments, financial institutions, and technology providers will need to create an enabling policy and market environment, with the right incentives, regulations, and infrastructure to support SMEs' technology adoption. Research institutions and academia will need to continue to develop and disseminate cutting-edge knowledge and solutions, while also engaging in ongoing dialogue and collaboration with SMEs and other stakeholders.

Moreover, the project's impact will need to be continuously monitored, evaluated, and communicated to all stakeholders, in order to build momentum, showcase success stories, and identify areas for improvement. The project will need to establish robust impact measurement frameworks, with clear indicators, targets, and data collection methods, to track the progress and outcomes of the implemented methods and measures. The results of the impact assessment should be transparently shared with SMEs and other stakeholders, in order to foster accountability, learning, and continuous improvement.

In conclusion, the methods and measures developed by the GREENE 4.0 project have the potential to significantly enhance SMEs' acceptance of green and digital technologies, leading to a transformative impact on the manufacturing sector in Central Europe. By addressing the key barriers, leveraging the existing enablers, and creating a supportive ecosystem for technology adoption, the project can accelerate the transition of SMEs towards more sustainable, resilient, and competitive business models. The project's focus on awareness-building, capacity-building, access to finance, collaborative innovation, and user validation can help to create a more demand-driven, user-centric, and evidence-based approach to technology adoption.

However, realizing the full potential impact of the project will require a sustained and collaborative effort from all stakeholders involved, including SMEs, governments, financial institutions, technology providers, research institutions, and academia. The project's impact will need to be continuously monitored, evaluated, and communicated, in order to build momentum, showcase success stories, and identify areas for improvement. By establishing robust impact measurement frameworks and transparently sharing the results with all stakeholders, the project can foster accountability, learning, and continuous improvement.

The success of the GREENE 4.0 project in enhancing SMEs' acceptance of green and digital technologies can have far-reaching implications for the future of the manufacturing sector and the broader economy in Central Europe. By enabling SMEs to adopt these technologies, the project can contribute to the creation of a more sustainable, circular, and competitive economy, with new green jobs, skills, and business models. The lessons learned and best practices generated from this project can also inform and inspire similar initiatives in other sectors and regions, contributing to the global goal of achieving a net-zero and digitalized future.

The importance of collaborative efforts between industries, academia, technology developers, and policy-makers in facilitating the transition of SMEs towards green and digital technologies cannot be overstated. The complex and systemic nature of this transition requires a multi-stakeholder approach that leverages the unique strengths, resources, and expertise of each actor. By working together in a coordinated and synergistic manner, these stakeholders can create a more enabling and supportive environment for SMEs to adopt and benefit from these technologies.

Industries, particularly SMEs, are at the heart of this transition, as they are the ones who will ultimately implement and use green and digital technologies in their operations. However, SMEs often face significant barriers and challenges in this process, such as limited awareness, skills, financial resources, and capacity to take risks. Therefore, industries need to actively engage and collaborate with other stakeholders to overcome these barriers and drive the transition forward.

Academia and research institutions play a critical role in generating and disseminating the knowledge, insights, and innovations needed to support the transition. Through their research and development activities, they can help to identify the most promising green and digital technologies, assess their potential impacts and benefits, and develop new solutions and applications tailored to the needs of SMEs. Moreover, academia can provide SMEs with access to cutting-edge expertise, facilities, and networks, as well as contribute to the development of the necessary skills and competencies through education and training programs.

Technology developers, including start-ups, established companies, and research centers, are the key drivers of innovation in green and digital technologies. They are responsible for creating, testing, and commercializing the new products, services, and solutions that can help SMEs to improve their environmental and economic performance. However, technology developers often face challenges in reaching and engaging with SMEs, who may have different needs, priorities, and constraints compared to larger firms. Therefore, technology developers need to collaborate with other stakeholders to better understand the SME market, co-create solutions with SMEs, and develop viable business models and value propositions.

Policymakers, including governments, public authorities, and international organizations, play a crucial role in creating the enabling conditions and incentives for the transition. Through their policies, regulations, and support programs, they can help to level the playing field, reduce the risks and costs, and stimulate the demand for green and digital technologies. Moreover, policymakers can foster collaboration and knowledge-sharing among different stakeholders, by creating platforms, networks, and funding mechanisms that bring them together around common goals and challenges.

The importance of collaborative efforts between these stakeholders can be seen in several key areas:

1. Innovation and technology development: Collaboration between industries, academia, and technology developers can accelerate the development and commercialization of new green and digital technologies that are tailored to the needs of SMEs. By pooling their resources, expertise, and ideas, these stakeholders can co-create solutions that are more innovative, feasible, and impactful. For example, a collaboration between a manufacturing SME, a university research lab, and a technology start-up can lead to the development of a new energy-efficient production process that reduces costs and emissions.

2. Skills and capacity building: Collaboration between industries, academia, and policy-makers can help to build the necessary skills and capacities within SMEs to adopt and benefit from green and digital technologies. By working together, these stakeholders can design and deliver targeted training and education programs that meet the specific needs of SMEs, as well as create opportunities for knowledge-sharing and peer learning. For example, a collaboration between a sector association, a vocational school, and a regional development agency can lead to the creation of a training program on eco-design for SMEs in the furniture industry.

3. Access to finance and markets: Collaboration between industries, technology developers, and policy-makers can help to improve SMEs' access to finance and markets for green and digital technologies. By working together, these stakeholders can develop and promote new financing mechanisms, such as green bonds, technology leasing, or pay-per-use models, that reduce the upfront costs and risks for SMEs. Moreover, they can create new market opportunities, by aggregating demand, setting standards, or creating incentives for green and digital procurement. For example, a collaboration

between a group of SMEs, a technology provider, and a public authority can lead to the creation of a joint tender for the procurement of energy-efficient equipment.

4. Policy and regulation: Collaboration between industries, academia, and policy-makers can help to create a more supportive and coherent policy and regulatory framework for the transition. By working together, these stakeholders can identify the main barriers and opportunities, assess the potential impacts of different policy options, and develop recommendations for action. Moreover, they can ensure that the policies and regulations are based on sound evidence, take into account the diversity of SMEs, and are aligned with the broader sustainability and digitalization goals. For example, a collaboration between a business association, a research institute, and a ministry can lead to the development of a new eco-label for green and digital products and services.

5. Awareness and engagement: Collaboration between industries, academia, technology developers, and policy-makers can help to raise awareness and engagement among SMEs and other stakeholders about the benefits and opportunities of green and digital technologies. By working together, these stakeholders can develop and implement joint communication and outreach activities, such as events, campaigns, or demonstrations, that showcase the potential of these technologies and inspire SMEs to take action. Moreover, they can foster a culture of collaboration, trust, and shared vision among the different stakeholders, by creating spaces for dialogue, networking, and co-creation. For example, a collaboration between a chamber of commerce, a university, a technology cluster, and a local government can lead to the organization of a series of hackathons and innovation challenges for SMEs on circular economy.

The collaborative efforts between industries, academia, technology developers, and policy-makers are essential for facilitating the transition of SMEs towards green and digital technologies. By working together in a coordinated and synergistic manner, these stakeholders can create a more enabling and supportive environment for SMEs to adopt and benefit from these technologies, in terms of innovation, skills, access to finance and markets, policy and regulation, and awareness and engagement. The GREENE 4.0 project recognizes the importance of this multi-stakeholder approach and aims to foster and facilitate collaborations between these different actors, through its various activities and outputs, such as the co-creation camps, the user acceptance model, the innovation platform, and the policy recommendations. By doing so, the project can contribute to accelerating the green and digital transition of SMEs in Central Europe, and creating a more sustainable, competitive, and resilient manufacturing sector.

The GREENE 4.0 project has significant implications for driving innovation capacity among SMEs in Central Europe, enabling them to adopt sustainable and technologically advanced business models. By providing a comprehensive framework, practical tools, and collaborative platforms, the project can empower SMEs to overcome the barriers and leverage the opportunities of the green and digital transition. The insights and lessons learned from this project can have far-reaching impacts on the future of the manufacturing sector and the broader economy in the region.

One of the key implications of the GREENE 4.0 project is the creation of a more innovation-friendly and technology-oriented culture among SMEs. Through its awareness-raising and capacity-building activities, the project can help SMEs to recognize the value and potential of green and digital technologies, and to develop the necessary skills, mindsets, and strategies to adopt them. Moreover, by showcasing successful examples and providing hands-on support, the project can inspire and motivate SMEs to experiment with new ideas, take calculated risks, and continuously improve their processes and products. This cultural shift towards innovation and technology can have a transformative effect on the way SMEs operate and compete in the market, making them more agile, resilient, and future-proof.

Another important implication of the project is the strengthening of the innovation ecosystem for SMEs in Central Europe. By fostering collaborations and knowledge-sharing among industries, academia, technology developers, and policy-makers, the project can create a more supportive and integrated environment for SMEs to innovate and grow. The co-creation camps, innovation platform, and policy dialogues organized by

the project can serve as catalysts for new partnerships, investments, and initiatives that benefit SMEs and the wider ecosystem. Moreover, by identifying and promoting the most promising green and digital solutions and business models, the project can help to attract more resources, talents, and customers to the region, positioning it as a leading hub for sustainable and advanced manufacturing.

The GREENE 4.0 project also has the potential to drive systemic change in the manufacturing sector and beyond, by influencing the policies, regulations, and standards that shape the transition. Through its policy recommendations and advocacy efforts, the project can help to create a more coherent and ambitious policy framework that supports the adoption of green and digital technologies by SMEs, while also ensuring a fair and inclusive transition. Moreover, by engaging with other stakeholders and initiatives at the regional, national, and European levels, the project can contribute to the development of common visions, roadmaps, and action plans for the future of manufacturing, in line with the broader sustainability and digitalization agendas.

In the long term, the success of the GREENE 4.0 project in driving innovation capacity among SMEs can lead to a more competitive, sustainable, and resilient manufacturing sector in Central Europe. By enabling SMEs to adopt green and digital technologies, the project can help to create new value chains, business models, and market opportunities that benefit the economy, society, and environment. Moreover, by fostering a culture of innovation and collaboration, the project can help to attract and retain talents, investments, and know-how in the region, contributing to its overall development and prosperity.

However, to fully realize these implications, the project will need to ensure the sustainability and scalability of its outputs and outcomes beyond its lifetime. This will require a strong commitment and ownership from all stakeholders involved, as well as a clear strategy for dissemination, exploitation, and replication of the project's results. The project will need to establish effective mechanisms for monitoring, evaluating, and communicating its impact, as well as for engaging and empowering SMEs and other stakeholders to take action and ownership of the transition.

Moreover, the project will need to be aware of and responsive to the changing context and challenges of the green and digital transition, such as the evolving policy landscape, the emergence of new technologies and business models, or the shifting market and societal demands. The project will need to maintain a flexible and adaptive approach, continuously updating and improving its tools, methods, and collaborations based on the feedback and needs of SMEs and other stakeholders.

In conclusion, the GREENE 4.0 project has significant implications for driving innovation capacity among SMEs in Central Europe, enabling them to adopt sustainable and technologically advanced business models. By providing a comprehensive framework, practical tools, and collaborative platforms, the project can empower SMEs to overcome the barriers and leverage the opportunities of the green and digital transition. The insights and lessons learned from this project can have far-reaching impacts on the future of the manufacturing sector and the broader economy in the region, leading to a more competitive, sustainable, and resilient manufacturing ecosystem.

However, to fully realize these implications, the project will need to ensure the sustainability and scalability of its outputs and outcomes, by establishing effective mechanisms for monitoring, evaluating, and communicating its impact, as well as for engaging and empowering SMEs and other stakeholders to take action and ownership of the transition. Moreover, the project will need to be aware of and responsive to the changing context and challenges of the green and digital transition, maintaining a flexible and adaptive approach based on the feedback and needs of SMEs and other stakeholders.

In conclusion, the GREENE 4.0 project provides a valuable and innovative framework for developing methods and measures to improve user acceptance of green and digital technologies among SMEs. By following the six key steps and leveraging the collaborative and evidence-based approach, the project has the potential to create significant and lasting impact on the technology adoption and sustainability performance of SMEs in the manufacturing sector. The lessons learned and best practices generated from

this project can also inform and inspire similar initiatives in other sectors and regions, contributing to the broader goal of accelerating the green and digital transformation of the economy. The success of the GREENE 4.0 project in driving innovation capacity among SMEs can serve as a model and inspiration for other regions and sectors facing similar challenges and opportunities. By showcasing the potential and benefits of a collaborative, inclusive, and transformative approach to the green and digital transition, the project can contribute to the broader goals of the European Union and the global community, towards a more sustainable, resilient, and prosperous future for all.

Annex 1

to D.1.2 - Regional Mapping Analysis

Contents

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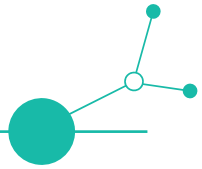
1.1 Workshops for designing and validating methodological structure

1ST WORKSHOP FOR DESIGNING AND VALIDATING METHODOLOGICAL STRUCTURE

Event report



WP1 Design, test and deploy a user acceptance model

Activity 1.2 Design methods and measures for improving user acceptance

Partner:	FH Kufstein Tirol 7.6.2023
Contact Person:	Prof. (FH) DDr.Mario Situm, MBA, Mario.Situm@fh-kufstein.ac.at

Title of Event:	1st Workshop in Tirol (Austria) for designing and validating methodological structure
Date:	04.10.2023_13:30-16:30
Venue:	FH Kufstein Tirol
Language:	English
Type of Event:	Co-creation session, active participation
No. of Attendees	29 persons representing 9 Project Partners

Summary of the event (max 500 characters)

PP3/FHK organized a workshop in Tirol on the development of the User Acceptance Model as planned in A1.2. In close cooperation with PP4 (UL) which leads on the development of the methodological structure (D1.2.1) capitalizing on the mapping analysis results (D1.1.1), PP3 has co-created a workshop session aiming at:

- Increasing awareness of challenges and enablers towards greening value chains
- Gathering PPs experience on User Acceptance Models
- Supporting PP4/UL drafting the methodology

This co-creation session is built on an Academic Scientific Paper Barriers and Enablers for the Adoption of Sustainable Manufacturing by Manufacturing SMEs, Claudia Lood Alayón, Kristina Säfsten and Glenn Johansson, 2022

All 9 PPs were represented and split among 7 Teams enabling each Person to ideate in a dynamic working group on tools/instruments and methods they've been exposed to, to promote the enablers or to overcome the barriers mentioned in the Academic Paper on the 7 thematic fields: Organisational, Training, Technological, Financial, Informational, Market & Government.

The 7 boards have been digitalised to enable further capitalisation (Hyperlink to the Boards on Mural)

Final Agenda (English Version)

AGENDA		
Time	***Activity***	***Speaker***
13:30-13:50	Presentation from UL on User Acceptance Model Concept	UL
13:50-14:00	Activity presentation from FHK	FHK
14:00-14:15	Finalize the pre-work on User Acceptance Model Experiences and transferring key ideas to Post-its	All PPs
14:15-14:35	PPs stick their post-its and look at others post-its	All PPs
14:35-16:20	Pairing exercise – Each Groups navigate among 7 boards	All PPs
16:20-16:30	Summarizing and Next Steps	FHK

Photos / Screenshots

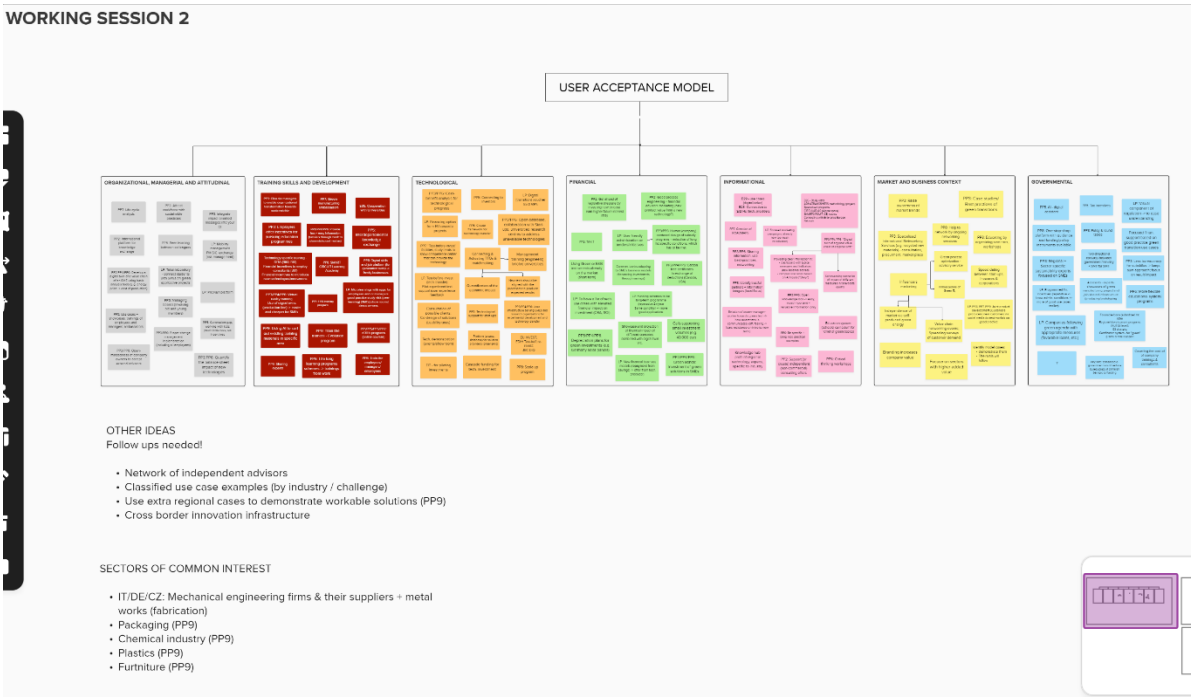


Figure 1 - Screenshot of the 7 boards digitalised after the session (Hyperlink to the Boards on Mural)

Figure 2 - Visualisation of the working space and exercise

Signature List / Online attendance sheet

No.	Name	Organization	Country	E-mail	Signature*
1.	Achs Petr ~~(online)~~	Innovation Centre of Usti Region	Česko (CZ)	Achs@icuk.cz	
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2ND WORKSHOP FOR DESIGNING AND VALIDATING METHODOLOGICAL STRUCTURE

Event report

WP1 Design, test and deploy a user acceptance model

Activity 1.2 Design methods and measures for improving user acceptance

Partner:	PP4 - UL	16.12.2023
Contact Person:	Lea Lebar	

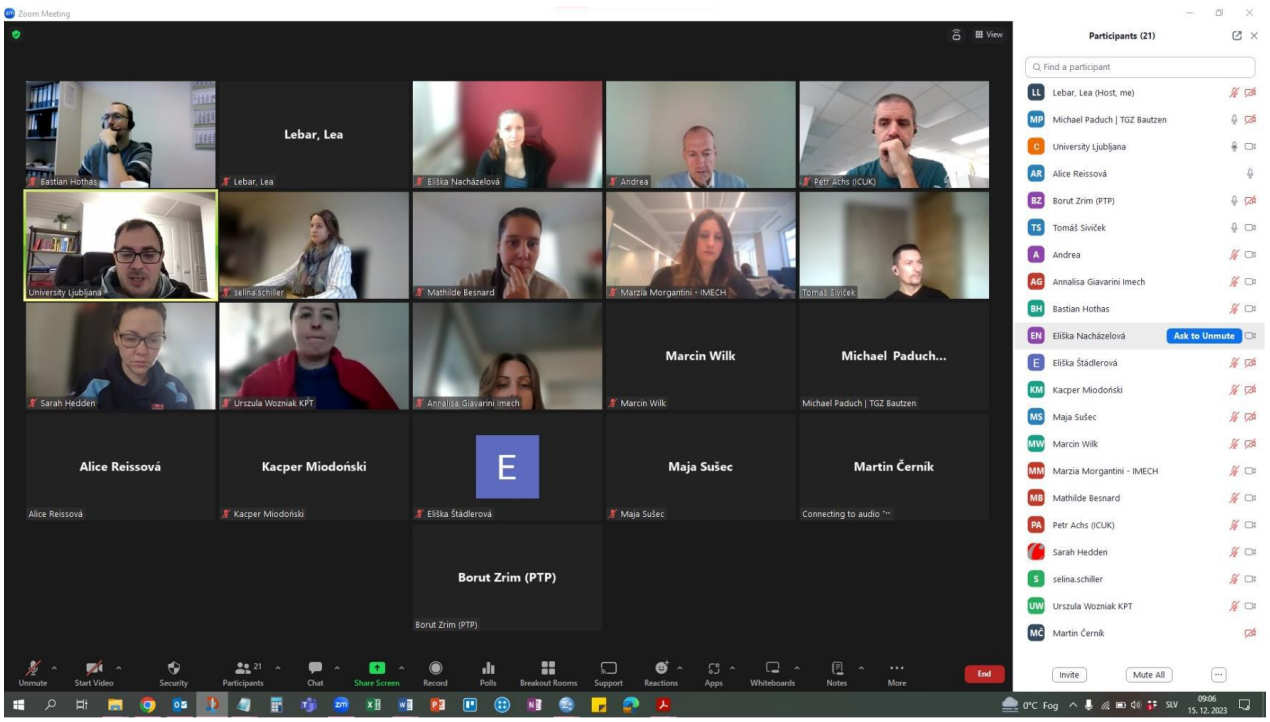
Title of Event:	1st Workshop in Ljubljana (Slovenia) for designing and validating methodological structure
Date:	15.12.2023
Venue:	Online (*Zoom*)
Language:	English
Type of Event:	Internal partner event
No. of Attendees	23

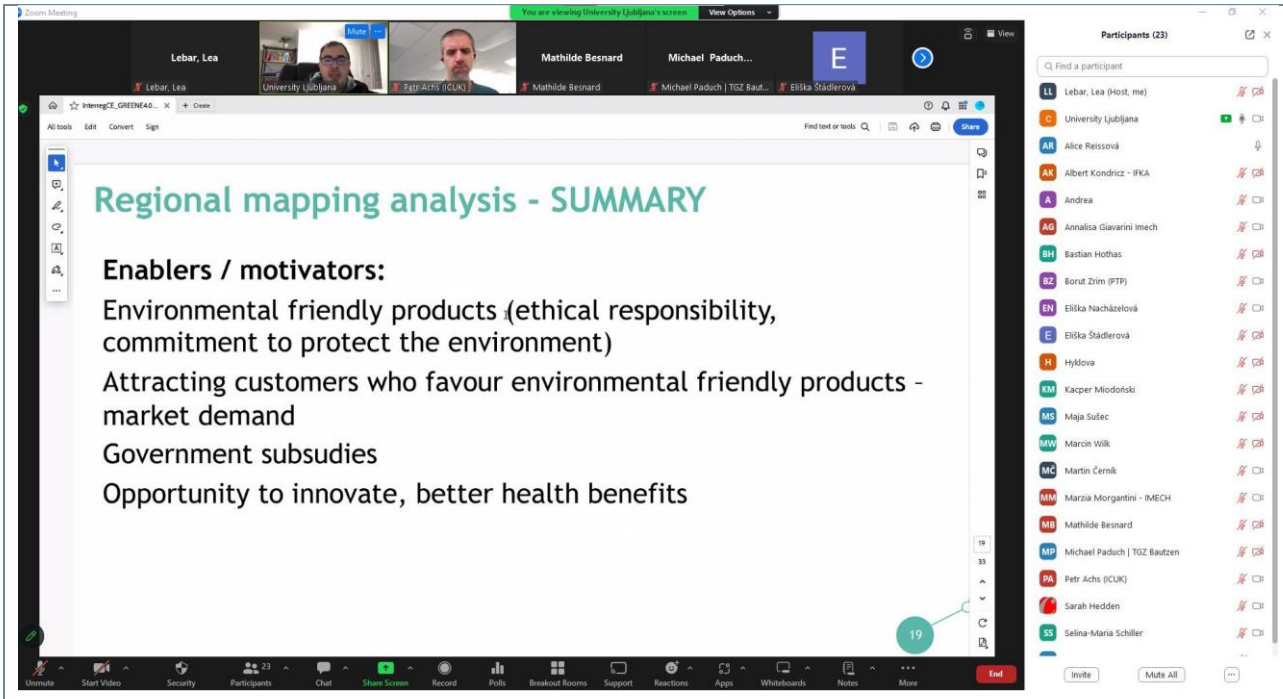
Summary of the event (max 500 characters)
UL team prepared and organized an online workshop for presenting the methodology for designing the specific methods and measures which will support the process of user acceptance and twin transition (digital and green) for manufacturing companies in CE. UL Team presented and described the methodology used for developing a set of key measures and methods for minimizing barriers and leveraging the enablers to increase SMEs acceptance and adoption of green and digital innovation. At the workshop participated PP3, PP5, PP7 but also representative form other consortium partners.

Final Agenda (English Version)

AGENDA		
Time	***Activity***	***Speaker***
9:00-10:00	*Presentation of the empirical methodology and proposed measures and methods for improving user acceptance and facilitating twin transition*	UL (Catalin Ilie, Lea Lebar)
10:00-10:30	*Feedback, inputs and debates*	All partners
10:30-10:50	*Development of next steps and planning*	UL (Catalin Ilie, Lea Lebar) all partners
10:50-12:00	*Q&A and conclusions*	UL (Catalin Ilie, Lea Lebar) all partners

Photos / Screenshots





Signature List / Online attendance sheet

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4. Andrea Jester
5. Michael Paduch
6. Eliška Nacházelová
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10. Mathilde Besnard
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12. Marzia Morgantini
13. Marcin Wilk
14. Sarah Hedden
15. Tomáš Siviček
16. Urszula Wozniak
17. Eliška Štádlerová
18. Annalisa Giavarini Imech
19. Maja Sušec
20. Martin Černík
21. Borut Zrim
22. Hyklova
23. Albert Kondricz

1.2 Joint technical meeting

JOINT TECHNICAL MEETING TO PRESENT THE DEVELOPED METHODS, MEASURES AND TO COLLECT RECOMMENDATIONS

Event report

WP1 Design, test and deploy a user acceptance model

Activity 1.2 Design methods and measures for improving user acceptance

16.12.2023

Partner:	PP4 - UL
Contact Person:	Lea Lebar

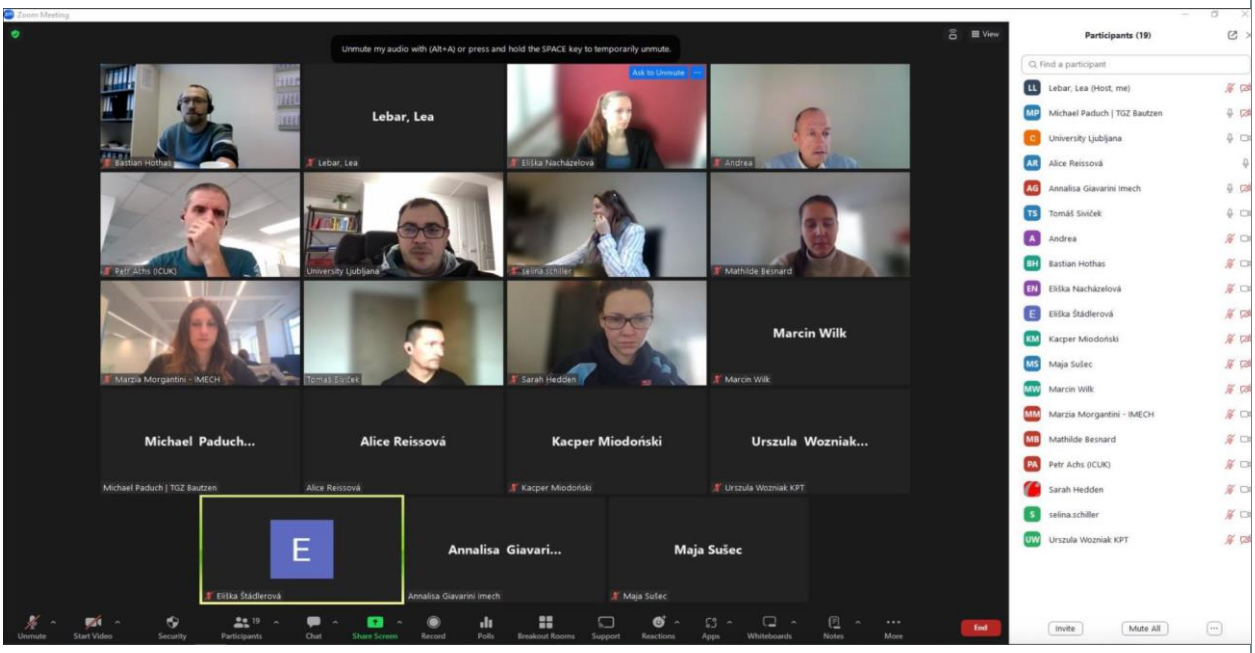
Title of Event:	Joint technical meeting to present the developed methods, measures and to collect recommendations
Date:	15.12.2023
Venue:	Online (Zoom)
Language:	English
Type of Event:	Internal partner event
No. of Attendees	23

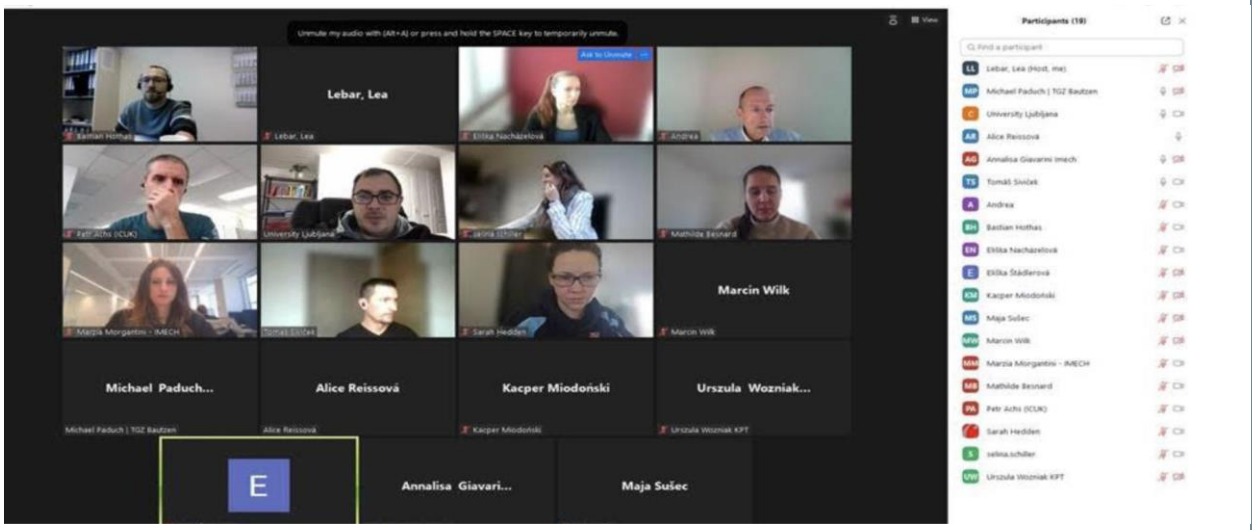
Summary of the event (max 500 characters)
UL team organized a joint technical meeting with LP, PP2, PP6, PP7 and PP8 for presenting the developed methods, measures for improving user acceptance (Twin transition journey for manufacturing companies) and to collect recommendations from consortium partners. At the event participated all consortium partners, even if the technical meeting was mandatory for LP, PP2, PP4, PP6 and PP8. During the event, UL team briefly presented the key enablers (Measures and methods) which will reduce the barriers and facilitate manufacturing companies acceptance as well as accelerate the twin transition journey. PP2, PP6, PP7 and PP8 addressed input and recommendations, to eliminate the measures which are not in the control of the ecosystem partners (Government regulations, financial incentives) and to focus on the measures/enablers which we can deliver as consortium/ecosystem actors in our regions and transnationally. Another key recommendation received from PP2 and PP7 was to include simple measures actions and to start with the basic level needed for any manufacturing company aiming to start the twin transition (digital and green) journey. Based on this recommendations, UL team will refine and adjust the final form of the methodology.

Final Agenda (English Version)

AGENDA		
Time	***Activity***	***Speaker***
12:00-12:20	*Key enablers which will reduce the barriers and facilitate manufacturing companies acceptance as well as accelerate the twin transition journey*	UL (Catalin Ilie, Lea Lebar)
12:20-12:30	*Q&A*	All partners
12:30-12:50	*Partners input and recommendations*	PP2, PP6, PP7, PP8
12:50-13:00	*Conclusions and next steps*	UL (Catalin Ilie, Lea Lebar) all partners

Photos / Screenshots





Signature List / Online attendance sheet

1. Lebar, Lea
2. Alice Reissová
3. Bastian Hothas
4. Andrea Jester
5. Michael Paduch
6. Eliška Nacházelová
7. Petr Achs (ICUK)
8. Selina-Maria Schiller
9. University Ljubljana (Catalin Ilie)
10. Mathilde Besnard
11. Kacper Miodoński
12. Marzia Morgantini
13. Marcin Wilk
14. Sarah Hedden
15. Tomáš Siviček
16. Urszula Wozniak
17. Eliška Štádlerová
18. Maja Sušec
19. Martin Černík

1.3 1ST External advisory board meeting

1ST INTRODUCTORY MEETING OF EXTERNAL ADVISORY BOARD

Event report

WP1: Design, test and deploy user acceptance model

A1.2: Designing methods and measures for improving user acceptance

A1.4: Deploy and test user acceptance model

20. 12. 2023

Partner:	Pomurje Technology Park
Contact Person:	Sarah Vidmar

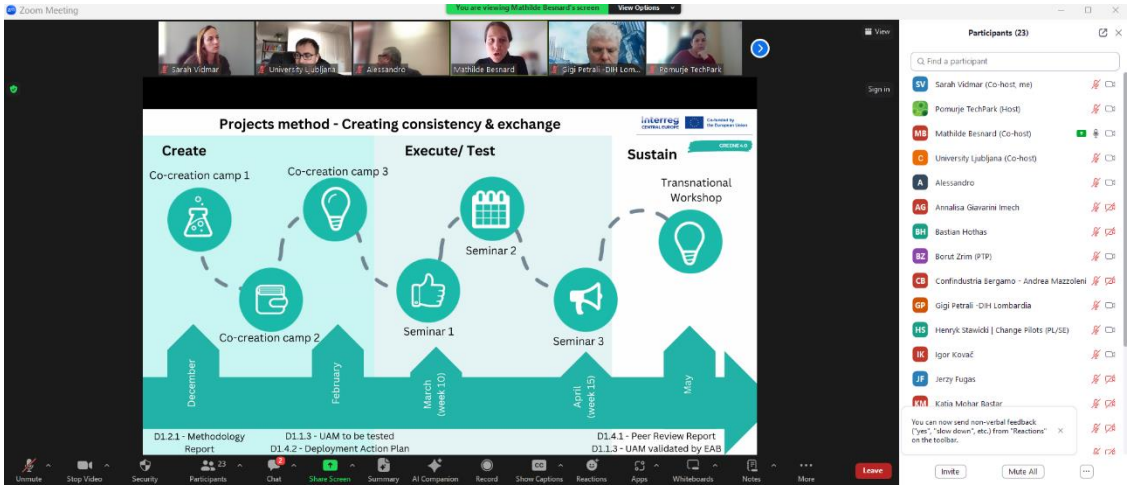
Title of Event:	1ST INTRODUCTORY MEETING OF EXTERNAL ADVISORY BOARD
Date:	18. 12. 2023
Venue:	Online - Zoom
Language:	English
Type of Event:	External Advisory Board meeting
No. of Attendees	27

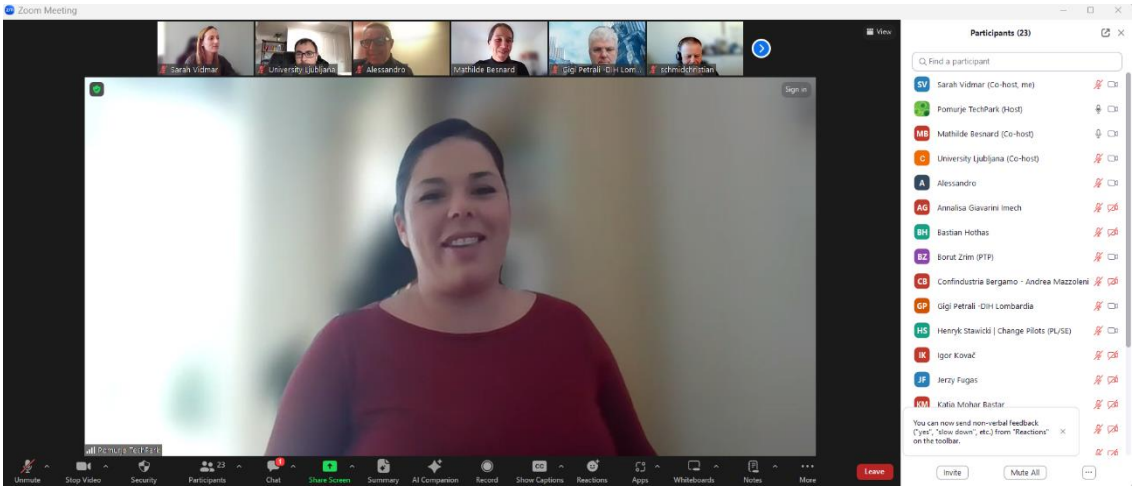
Summary of the event (max 500 characters)
The meeting began with the Lead Partner's presentation of the objectives, the foreseen results of the project and the anticipated work timeline. Next, University of Ljubljana presented the first deliverable to be validated by External Advisory Board – D1.2 – Methods and measures for improving user acceptance. Next, University of Applied Sciences Kufstein presented the rough structure of second deliverable to be validated by External Advisory Board – D1.4 - Deploy and test user acceptance model to gain feedback on the methodology to create the User Acceptance Model (UAM). This presentation only provided the main guidelines on how partners plan to implement/test the User Acceptance Model (UAM) as the final version of the deployment action plan was due in Period 2.

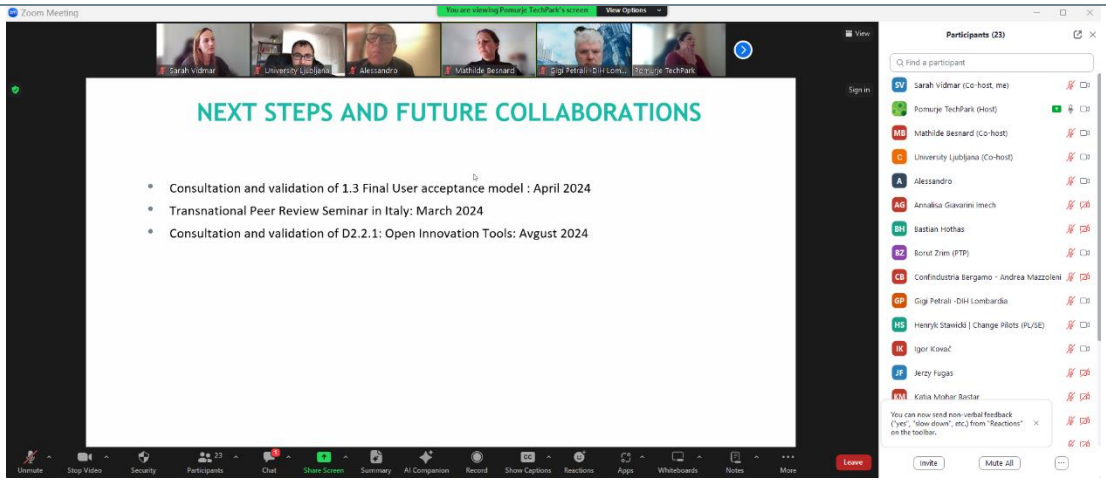
Final Agenda (English Version)

AGENDA		
Time	***Activity***	***Speaker***
11:00-11:05	Welcome and Introduction	Maja Sušec, Greene 4.0 Project Manager, Pomurje Technology Park, Slovenia
11:05-11:10	Overview of GREENE 4.0 Project	Maja Sušec, Greene 4.0 Project Manager, Pomurje Technology Park, Slovenia
11:10-11:20	Presentation of Methods and Measures for Improving User Acceptance	Catalin Ilie, University of Ljubljana, Slovenia
11:20-11:30	Validation Discussion	All participants, moderator: Catalin Ilie, University of Ljubljana, Slovenia
11:30-11:40	Presentation of Deployment Action Plan and Testing Scenarios	Mathilde Besnard, University of Applied Sciences FH Kufstein Tirol, Austria
11:40-11:50	Validation Discussion	All participants, moderator: Mathilde Besnard, University of Applied Sciences FH Kufstein Tirol, Austria
11:50-11:55	Next Steps and Future Collaborations	Maja Sušec, Greene 4.0 Project Manager, Pomurje Technology Park, Slovenia
11:55-12:00	Q&A	

Photos / Screenshots







Signature List / Online attendance sheet

		Meeting ID	Topic	Start Time	End Time	User Email	Duration (I	Participants
2		8,1E+10	GREENE 4.	########	########	info@p-tec	76	30
3								
4								
5		Name (Orig	User Email	Total Durat	Partner			
6	1	Pomurje T	info@p-te	76	LP			
7	2	Igor Kovač		74	LP		EAB member	
8	3	Sarah Vidmar		70	LP			
9	4	Borut Zrim (PTP)		69	LP			
10	5	Katja Mohar Bastar		45	LP			
11	6	Muhamed Turkanović		46	LP			
12	7	Bastian Hothas		75	PP2			
13	8	schmidchristian		72	PP3			
14	9	Sarah Hedden (MIND (		71	PP3			
15	10	Mathilde Besnard		70	PP3			
16	11	Selina-Maria Schiller		70	PP3			
17	12	University Ljubljana		71	PP4			
18	13	Tanja Golja		66	PP4			
19	14	Marek Hartych		70	PP5			
20	15	Tomas Sivicek		69	PP5			
21	16	Vojtech Jira (DEX IC		70	PP6			
22	17	Gigi Petrali -DIH Lomb		71	PP7			
23	18	Annalisa Giavarini Ime		69	PP7			
24	19	Alessandro		64	PP7			
25	20	Marzia Morgantini		55	PP7			
26	21	Confindustria Bergam		52	PP7			
27	22	Jerzy Fugas		73	PP8			
28	23	pawel mikolajczyk		13	PP8			
29	24	Urszula Wozniak KPT		68	PP8			
30	25	Henryk Stawicki | Cha		33	PP8			
31	26	kereszturi.zsolt		37	PP9			
32	27	Albert Kondricz - IFKA		43	PP9			
33								